Organisation Mondiale de la Santé Animale

World Organisation for Animal Health

Organización Mundial de Sanidad Animal

Biological disasters of animal origin

The role and preparedness of veterinary and public health services

Catastrophes biologiques d'origine animale

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Desastres biológicos de origen animal

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Preface

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A major concern when drafting any public document on bioterrorism is that it will instruct (potential) perpetrators on what to do and how to do it. And yet the reader must be made fully aware of the risks and the urgency of proper responses to this threat. The World Organisation for Animal Health (OIE) is very sensitive to that concern. The benefits of accurate information and informed awareness must outweigh the possible costs of the abuse of that information. It is a difficult balancing act. However, if governments respond to this threat by merely re-publishing existing disease control procedures with a few minor improvements, their veterinary and public health services will not be able to take the appropriate prophylactic actions and their countries will be inadequately defended.

It has been long accepted that the best defence against biological warfare is to have sufficient expertise in that field to out-manœuvre those using it offensively. Similarly, we must become virtual terrorists so as to better perceive risks and how to avert them. And because we start from a different place, there is a high probability that as virtual terrorists we will construct scenarios that any bioterrorist is unlikely to consider. The simpler these are, the more reason there is not to discuss them, at least in public.

Something that frightens security experts is the intellectual freedom and creativity of scientific researchers. But if it is not thought or imagined, how can appropriate prevention be planned? When developing successful defence strategies, multiple possibilities must be considered so as to discern the realistic probabilities, and to respond accordingly.

One of the outcomes of disease outbreaks can be panic. When the outbreak is intentional the risk of public panic is increased, and, unfortunately, it is fuelled by the media. When these outbreaks involve livestock the fears are multidimensional, involving farm finances, national economics, community coherence, and international trade. Public confidence comes from proven competence in successfully reducing the threat of natural outbreaks, from handling those that occur calmly and efficiently, mitigating the consequences, and facilitating a speedy recovery. These 'normal' natural disease outbreaks occur with a regular ferocity and pose huge health and economic risks if not faced proactively and effectively controlled. If government Veterinary Services demonstrate the capacity to manage this type of 'normal' event, the public will have increased confidence that they will also be able to handle the 'abnormal' – the intentional event.

The existing OIE international standards , which are democratically adopted by its 167 Member Countries (who also commit to their implementation), provide a firm basis on which to develop strategies for early detection, rapid response and transparency of information in the face of natural and intentional disease outbreaks. To convince all Governments to strictly implement these standards, e.g. by means of a United Nations Resolution, would be a very valuable first step in enhancing the capability of all countries to manage such outbreaks. The second step would be to convince developed countries to transfer finances and expertise to the Veterinary Services of developing countries that currently do not have sufficient resources to correctly implement OIE standards.

As agriculture increases in complexity and sophistication the potential costs of disease increase, even though its everyday costs decrease. Agriculture is increasingly using concentrated production methods, whether for poultry, pork, beef or eggs, and as densities increase, genetic diversity is decreased. Even in vertically integrated commercial farms

animals are constantly on the move. Modern farming practices raise the stress levels of livestock, making them more susceptible to infectious agents. Though livestock farming directly involves a small minority of the human population, it is so finely balanced that any upset can affect many times that number. For example, if a disease outbreak results in livestock products not being exported, the excess food cannot be absorbed and this triggers a chain reaction of serious consequences: growing animals in the pipeline have to be slaughtered and buried, so the feed and forage that would have fed them has to be dumped or is not sown and harvested, consequently, all those in the supplemental industries become unemployed, and farms and processing industries are bankrupted. In developing countries the loss of livestock results in starvation and political instability.

Animal husbandry, veterinary medicine, food production and food processing have all benefited from recent technical innovations, and, moreover, information and data can now be collected, analysed and disseminated in ever faster streams. However, since disease outbreaks have become less frequent, these advances are balanced by an increasing lack of veterinary experience in actually handling this type of situation. The health of livestock today is probably the best it has ever been, so as we learn to better manage that health, we must not lose our skills in managing disease in a world where mistakes are ever more costly.

In this respect, we anticipate that this special issue of the Scientific and Technical Review will be of considerable value and interest to the veterinary profession, and I wish to express my personal thanks and appreciation to the authors and to all those who contributed to the publication. I would also like to congratulate and express my sincere gratitude to Dr Martin Hugh-Jones for assuming the role of coordinating editor and reviewing all the papers contained in this important publication.

Bernard Vallat
Director General of the OIE

Préface

Catastrophes biologiques d'origine animale : le rôle et la préparation des Services vétérinaires et de santé publique

La préparation d'un ouvrage sur le thème du bioterrorisme ne se fait pas sans la crainte de livrer aux auteurs (potentiels) d'actes terroristes de précieuses indications sur ce qui peut être fait en la matière. Néanmoins, le public doit être tenu informé des risques et de la nécessité de contrer ces menaces par une réponse appropriée. L'Organisation mondiale de la santé animale (OIE) est extrêmement sensible à cette problématique. Les avantages apportés par des informations précises et par une prise de conscience lucide doivent l'emporter sur le coût éventuel d'une utilisation abusive de cette information. Il s'agit d'un équilibre difficile à atteindre. Si la seule réponse gouvernementale à cette menace est de rééditer les procédures existantes de contrôle des maladies infectieuses, sans y apporter d'améliorations notables, les Services vétérinaires et de santé publique nationaux seront désarmés pour prendre les mesures prophylactiques nécessaires et leurs pays resteront vulnérables.

Nous savons depuis longtemps qu'en matière de guerre biologique, la meilleure défense consiste à détenir l'expertise nécessaire pour devancer toute tentative hostile. De la même manière, nous devons apprendre à nous « identifier » aux terroristes, afin de mieux discerner les risques et la manière de les prévenir. Notre point de vue initial étant différent, il y a de grandes chances pour que les scénarios d'attaque biologique que nous imaginons dans notre rôle de terroristes virtuels s'éloignent fort de ceux envisagés par les terroristes réels. Plus ces scénarios sont simples, plus il importe de ne pas en parler, en tout cas publiquement.

La liberté intellectuelle et la créativité dont font preuve les chercheurs scientifiques suscitent un certain effroi chez les experts de la sécurité. Impossible cependant d'organiser la prévention d'un danger sans penser ou imaginer ce danger. Pour déployer des stratégies de défense efficaces, il faut étudier en même temps plusieurs possibilités, mesurer avec réalisme les probabilités que chacune d'elles se réalise, et se préparer en conséquence.

L'apparition d'un foyer de maladie peut susciter une réaction de panique. Lorsque le foyer a une cause intentionnelle, ce risque s'accroît, malheureusement alimenté par les média. Si, de surcroît, les foyers frappent les animaux d'élevage, le sentiment d'alarme se répand sur plusieurs dimensions, avec des répercussions sur les finances des exploitations, l'économie nationale, la cohésion de la communauté et le commerce international. La confiance du public repose sur la capacité avérée de réduire les menaces de foyers naturels, de maîtriser avec calme et efficacité ceux qui surviennent malgré tout, d'en limiter les conséquences et de rétablir promptement la situation sanitaire initiale. En l'absence d'une prophylaxie efficace et proactive, de nouveaux foyers naturels « ordinaires » apparaissent avec une régulière férocité en posant de graves problèmes sanitaires et économiques. Face à des Services vétérinaires officiels manifestement capables de gérer ces épisodes « ordinaires », le public aura davantage confiance en leur capacité de gérer les épisodes « extraordinaires », c'est-à-dire provoqués de manière intentionnelle.

Les normes internationales de l'OIE, approuvées démocratiquement par les 167 Pays membres de l'organisation, lesquels s'engagent, par leur vote, à les mettre en œuvre, apportent une base solide à la conception de stratégies pour la détection précoce, la réaction rapide et la transparence de l'information face à des foyers naturels ou intentionnels. Une première étape pour améliorer la capacité de tous les pays à gérer de tels foyers serait de persuader l'ensemble des gouvernements d'appliquer rigoureusement ces normes, par exemple au travers d'une résolution des Nations Unies. Une deuxième étape consisterait à convaincre les pays industrialisés de transférer des ressources financières et techniques vers les Services vétérinaires des pays en développement qui ne disposent pas actuellement des capacités suffisantes pour mettre en œuvre ces normes correctement.

Les coûts de production agricole diminuent à mesure que l'agriculture gagne en complexité et en sophistication, alors que le coût potentiel des maladies animales ne cesse d'augmenter. L'agriculture concentre de plus en plus ses méthodes de production, qu'il s'agisse de l'aviculture, de l'élevage porcin ou bovin ou de la production d'œufs, et cette intensification des élevages se solde par un appauvrissement de la diversité génétique. Même dans les exploitations industrielles à forte intégration verticale, les animaux sont constamment déplacés. Les pratiques d'élevage modernes font subir davantage de stress aux animaux et les rendent plus vulnérables aux agents pathogènes. Bien que l'élevage ne concerne directement qu'un faible pourcentage de la population active, l'équilibre est si ténu que le moindre incident multiplie ses effets néfastes bien au-delà de ce secteur. Par exemple, lorsqu'un foyer infectieux impose d'interrompre les exportations de produits d'origine animale, l'impossibilité d'écouler la production excédentaire entraîne toute une série de conséquences : les animaux en cours de croissance doivent être abattus et leurs cadavres enterrés, les fourrages et les aliments

qui leur étaient destinés doivent être vendus à perte ou ne sont ni semés ni récoltés, avec pour effets la perte d'activité des fournisseurs et la banqueroute des exploitations agricoles et des entreprises de transformation. Dans les pays en développement, les pertes de bétail provoquent des famines et des troubles politiques.

Les récentes innovations techniques ont été très bénéfiques pour l'élevage comme pour la médecine vétérinaire et l'industrie agroalimentaire ; de surcroît, la collecte, l'analyse et la diffusion des informations et des données se font à une vitesse inégalée. Or, justement parce que les foyers deviennent moins fréquents, ces bénéfices sont neutralisés par un manque grandissant d'expérience dans le traitement vétérinaire des incidents sanitaires. Si la santé des animaux d'élevage n'a probablement jamais été aussi bonne, les progrès que nous accomplissons pour gérer cette santé ne doivent pas nous faire négliger les compétences de gestion des problèmes sanitaires dans un monde où le prix de l'erreur est de plus en plus élevé.

Nul doute, en ce sens, que ce numéro de la *Revue scientifique et technique* sera accueilli avec intérêt par la profession vétérinaire en général. Je souhaite exprimer toute ma reconnaissance aux auteurs et à tous ceux qui ont contribué à cette entreprise. Je voudrais, pour finir, remercier et féliciter vivement le Docteur Martin Hugh-Jones qui a accepté de se charger de la coordination de ce numéro spécial de la *Revue scientifique et technique* et a consacré un temps si précieux à la révision de tous les articles réunis ici.

Bernard Vallat
Directeur général

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Prólogo

Desastres biológicos de origen animal
Papel y preparación de los servicios de sanidad animal y salud pública

Una de las principales preocupaciones con que se tropieza al redactar un documento sobre bioterrorismo que se hará público consiste en que también representará una fuente de información para los terroristas potenciales sobre qué puede hacerse, y de qué manera. Pero es preciso que los lectores dispongan de una información completa para que conozcan con exactitud los riesgos y las medidas urgentes adecuadas que deben tomarse ante esa amenaza. La Organización Mundial de Sanidad Animal (OIE) es plenamente consciente de esa dificultad. Pero los beneficios de una información precisa, y la consiguiente toma de conciencia, compensan la posibilidad de que se abuse de la información. Se trata de un equilibrio difícil de alcanzar. Pero si para enfrentar las amenazas bioterroristas, los gobiernos se limitan a reeditar los procedimientos de control de las enfermedades existentes, añadiéndoles unas pocas mejoras, los servicios veterinarios y de salud pública no podrán tomar las medidas profilácticas oportunas y los países carecerán de una defensa adecuada.

Hace largo tiempo que se ha llegado a la conclusión de que la mejor defensa contra la guerra biológica consiste en disponer de suficientes conocimientos sobre el tema para poder derrotar a los atacantes. Asimismo, para entender mejor los riesgos y la manera de evitarlos, es preciso reflexionar como terroristas virtuales. Y puesto que se parte de un punto de vista diferente, es sumamente probable que, en calidad de terroristas virtuales, se imaginen escenarios que no se le ocurrirían a ningún bioterrorista. Cuanto más sencillos sean, menos convendrá examinarlos, al menos en público.

La libertad intelectual y la creatividad de los investigadores científicos atemoriza a los expertos en seguridad. Pero, si no se reflexiona de manera imaginativa, no será posible planificar una prevención adecuada. Para que las estrategias de defensa sean eficaces, será preciso examinar múltiples posibilidades a fin de determinar las probabilidades reales y tomar las medidas oportunas.

Los brotes de enfermedades pueden producir pánico. Si el foco fue provocado con deliberación, el riesgo de pánico público es mayor, tanto más cuanto, desgraciadamente, los medios de comunicación lo exacerbarán. Cuando los focos afectan al ganado, la alarma cunde en sectores tales como las finanzas del sector agropecuario, las economías nacionales, la coherencia comunitaria y el comercio internacional. Los Servicios Veterinarios contarán con la confianza del público si han demostrado su competencia para mitigar la amenaza de brotes naturales con eficacia, reaccionar con calma y eficiencia ante los focos, reducir las consecuencias y facilitar una rápida recuperación. Los focos "normales" de enfermedades naturales aparecen con una cruel periodicidad y originan enormes riesgos sanitarios y económicos si no se ha previsto la manera de enfrentarlos, o no se los controla correctamente. Si los Servicios Veterinarios nacionales demuestran su capacidad para hacer frente a los acontecimientos "normales", el público tendrá mayor confianza en su competencia para afrontar los focos "anormales", es decir, los focos intencionales.

Las normas internacionales de la OIE, que sus 167 Países Miembros adoptan democráticamente comprometiéndose a aplicarlas, constituyen una sólida base para la elaboración de estrategias de detección precoz de brotes naturales o intencionales de enfermedades, así como de respuesta rápida ante los focos y de transparencia informativa. Convencer a todos los gobiernos de la necesidad de aplicar estrictamente esas normas, por ejemplo mediante una resolución de las Naciones Unidas, representaría un primer paso muy importante para mejorar la capacidad de todos los países para controlar esos focos. El segundo paso consistiría en convencer a los países desarrollados de la necesidad de transferir recursos financieros y competencias técnicas a los Servicios Veterinarios de los países en desarrollo que carecen de recursos suficientes para aplicar correctamente las normas de la OIE.

La actividad agropecuaria es cada vez más compleja y técnica; por consiguiente, pese a que los gastos diarios disminuyen, los costos potenciales de las enfermedades se incrementan. En las explotaciones, tanto las aves de corral como el ganado porcino, el bovino y las ponedoras, están cada vez más concentrados. Al aumentar la densidad, la diversidad genética disminuye. Asimismo; incluso en los establecimientos comerciales integrados verticalmente, los animales se desplazan continuamente. El estrés provocado por los métodos modernos de cría pecuaria lo torna más sensible a los agentes infecciosos. Si bien sólo una pequeña minoría de la humanidad se dedica a la cría de ganado, el equilibrio es tan delicado que cualquier alteración puede afectar a un número de seres humanos muchísimo mayor. Por ejemplo, si se produjera un brote de enfermedad que imposibilite la exportación de productos animales, no sería posible absorber el exceso de alimentos y esto provocaría una reacción en cadena de graves consecuencias: sería preciso sacrificar y enterrar a los animales que se estaban criando y, por consiguiente, habría que deshacerse de los piensos y forrajes con que se los hubiera alimentado, o se dejaría de sembrarlos y cosecharlos. Por consiguiente, los trabajadores de esos sectores quedarían en paro, y las explotaciones y plantas de procesamiento

quebrarían. En los países en desarrollo, la pérdida del ganado genera hambre e inestabilidad política.

La cría pecuaria, la medicina veterinaria, como la producción y el procesamiento de alimentos se han beneficiado con las recientes innovaciones técnicas; asimismo, ahora es posible consultar, analizar y divulgar informaciones y datos por vías aún más rápidas. Como actualmente los focos de enfermedades son menos frecuentes, esos avances se ven contrarrestados por una creciente falta de experiencia veterinaria para enfrentarlos con eficacia. Probablemente, nunca antes el ganado estuvo en tan buen estado sanitario; pero en un mundo en que los errores resultan cada vez más caros, aprender a ocuparse de la salud de los animales no debe conducir a la pérdida de la capacidad para afrontar las enfermedades.

Sin duda, la profesión veterinaria encontrará en este número especial de la *Revista científica y técnica* información de utilidad e interés. Deseo expresar mi gratitud y reconocimiento personal a los autores y a cuantos han ayudado a hacer realidad la publicación que el lector tiene entre sus manos. También quisiera expresar mi sinceros agradecimientos y felicitaciones al Doctor Martin Hugh-Jones por haber asumido la compilación de los artículos que integran este importante volumen y por la calidad y el esmero de su trabajo de revisión.

Bernard Vallat
Director General

ORGANISATION MONDIALE DE LA SANTÉ ANIMALE
WORLD ORGANISATION FOR ANIMAL HEALTH
ORGANIZACIÓN MUNDIAL DE SANIDAD ANIMAL

Office International des Épizooties

REVUE
SCIENTIFIQUE ET TECHNIQUE

SCIENTIFIC AND TECHNICAL
REVIEW

REVISTA
CIENTÍFICA Y TÉCNICA

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Co-ordinated by
Coordonné par
Coordinado por

Martin Hugh-Jones

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12, rue de Prony – 75017 Paris – France
Tél. : 33 (0)1 44 15 18 88 – E-mail : oie@oie.int – Fax : 33 (0)1 42 67 09 87

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Introduction

Biological disasters of animal origin
The role and preparedness of veterinary and public health services

We live in a time of change, with previously unimaginable tools for diagnosis and detailed pathogen identification, with the emergence of new virulent diseases but the persistence and resurgence of the old, and the development of mobile information technology but the continuing dependence on paper, maps and coloured pins in many countries. As we move forward, our past sometimes stays with us. This collection of articles is to encourage us to all progress, to all reach a more efficient way in handling and effectively controlling animal disease outbreaks, whether they occur from natural events or from the purposeful intentions of others.

Since October 2001 the possibility of intended disease outbreaks has been put forward repeatedly in many countries. The history of such events and their impacts are explored and the possibilities and uncertainty of the risk may surprise many. At the same time we can be sure that the 'old' diseases will continue to occur. In our global economy, what happens in one corner of the world can threaten us all, and sooner rather than later. The events of the present H5N1 avian influenza pandemic remind us that we do have to be concerned with the threats imbedded in global trade but also with migratory birds ignorant of international boundaries and regulations.

It is the efficiency with which we plan for and confront traditional and emerging disease outbreaks that will predict our ability and confidence in tackling intentional outbreaks if, when, and where they occur. The cost of disease increases even as the incidence may decrease. And as the health and productivity of livestock have increased, the more we depend on a veterinary corps with decreasing hands-on experience in handling epidemics. This means that planning and training must depend on valid models. To prevent public panic communications must be transparent. Laboratory support must be able to respond to surge demands as well as forensic investigations. These issues and many others (e.g. herd registration, inter-agency coordination, rapid field diagnostics and geographic information systems-based data entry) are covered by recognised experts in this timely publication. And while there is uncertainty as to the probability of intentional bioterrorist events, two certainties remain: if intentional attacks are suspected there must be the forensic capability to successfully and efficiently investigate them; and if such an attack is successful, there will be others, if only by imitators. Failure to efficiently control such outbreaks will encourage repetition.

To achieve these objectives there must be planning, investment in training and infrastructure, and defined and agreed standards to be met, questioned, redefined and striven for. In the shrinking global world we live in, we are only as strong as our weakest neighbour. Inability to control a transboundary disease in one country soon puts others at risk, which is only made worse by a lack of transparency. Plans must be co-ordinated nationally, regionally, and internationally, and the implementation of those plans should

be meaningfully supported and demanded. Similarly, actions must meet mid-term and long-term objectives otherwise we are locked into the present. And however difficult it might be to perceive the future we must be willing to try to predict what it can be – even if this model demands constant readjustment – and make it be what we want.

Martin Hugh-Jones
Professor Emeritus
Environmental Studies Department
School of Coast & Environment, Rm 2279,
Energy, Coast & Environment Building
Louisiana State University,
Baton Rouge, LA 70803-5705
United States of America

Introduction

Catastrophes biologiques d'origine animale : le rôle et la préparation des Services vétérinaires et de santé publique

Nous vivons une époque de changements, caractérisée par l'existence d'outils de diagnostic et d'identification détaillée des agents pathogènes que l'on n'aurait pas pu imaginer autrefois, par l'émergence de nouvelles maladies virulentes parallèlement à la persistance et à la résurgence des anciennes, et par l'essor de la technologie de l'information mobile avec de nombreux pays encore tributaires du papier, des cartes et des punaises de couleur. Le chemin du progrès est parfois pavé de reliques du passé. Ce recueil d'articles vise à nous encourager tous à avancer, à trouver un moyen plus efficace de gérer et maîtriser les foyers de maladies animales, qu'ils soient le fruit d'événements naturels ou d'actes intentionnels.

Depuis octobre 2001 la possibilité de foyers de maladie à des fins délibérées a été évoquée à maintes reprises dans de nombreux pays. Le déroulement de ces événements et leurs répercussions sont examinés ; nombreux sont ceux qui pourront être surpris par les possibilités et les incertitudes quant au risque. En même temps, nous pouvons être sûrs que les « anciennes » maladies continueront de se déclarer. Dans notre économie mondiale, ce qui survient dans une région du monde peut constituer à brève échéance une menace pour tous. Les événements liés à la pandémie actuelle d'influenza aviaire due au virus H5N1 nous rappellent que nous devons certes nous intéresser aux menaces inhérentes au commerce mondial, mais aussi aux oiseaux migrateurs qui ignorent les réglementations et les frontières internationales.

C'est l'efficacité avec laquelle nous prévoyons et affrontons les foyers de maladies traditionnelles et émergentes qui nous donnera la capacité et la confiance nécessaires pour lutter contre d'éventuels foyers d'origine intentionnelle, à l'endroit et au moment où

ils apparaîtront. Le coût de la maladie augmente même si sa fréquence diminue. Plus la santé et la productivité des animaux s'améliorent, plus nous dépendons d'une profession vétérinaire de plus en plus dénuée d'expérience concrète en matière de gestion des épidémies. La planification et la formation doivent donc se baser sur des modèles valides. Pour éviter de créer un climat de panique parmi la population, la communication doit être transparente. Les laboratoires doivent pouvoir répondre aux brusques augmentations de la demande et de la recherche médico-légale. Ces questions et de nombreuses autres (comme l'enregistrement des troupeaux, la coordination entre agences, le diagnostic rapide sur le terrain et la saisie de données dans un système d'information géographique) sont traitées par des experts reconnus dans cette publication d'actualité. Si la probabilité de survenue d'événements bioterroristes intentionnels reste incertaine, deux certitudes demeurent : si des attaques intentionnelles sont suspectées, il doit exister des capacités permettant de mener à bien l'enquête médico-légale ; si cette attaque réussit, d'autres suivront, ne serait-ce qu'ourdies par des imitateurs. L'incapacité à contrôler efficacement ces foyers encouragerait la récidive.

Pour atteindre ces objectifs, il faut une planification, des investissements en faveur de la formation et des infrastructures et des normes définies et convenues à satisfaire, à remettre en cause, à redéfinir et à mettre en œuvre. Dans le monde en contraction dans lequel nous vivons, notre force est égale à celle de notre voisin le plus faible. L'incapacité à contrôler une maladie transfrontalière dans un pays expose rapidement les autres, phénomène qu'un manque de transparence ne fait qu'accentuer. Les plans doivent être coordonnés à l'échelle nationale, régionale et internationale et leur mise en œuvre doit être judicieusement soutenue et exigée. De même, les actions doivent viser les objectifs à moyen et à long terme, faute de quoi nous restons enfermés dans le temps présent. Enfin, aussi difficile soit-il de percevoir l'avenir, nous devons être disposés à tenter de le prédire – même si ce modèle exige des réajustements constants – et de le façonner à notre convenance.

Martin Hugh-Jones
Professeur honoraire
Environmental Studies Department
School of Coast & Environment, Rm 2279,
Energy, Coast & Environment Building
Louisiana State University,
Baton Rouge, LA 70803-5705
États-Unis d'Amérique

Introducción

Desastres biológicos de origen animal
Papel y preparación de los servicios de sanidad animal y salud pública

Vivimos tiempos revueltos, marcados por la existencia de herramientas antaño inimaginables para diagnosticar patógenos y su identificación detallada, por la aparición de enfermedades nuevas y virulentas (sin que dejen de persistir y resurgir otras antiguas) y la creación de tecnologías móviles de información (aunque en muchos países se siga trabajando con papel, mapas y alfileres de colores). En ocasiones avanzamos llevando nuestro pasado a cuestas. Este conjunto de artículos nos alienta a todos a progresar y encontrar un modo más eficaz de afrontar y controlar realmente los brotes de enfermedades animales, ya se deban éstos a causas naturales o a actos malévolos.

Desde octubre de 2001 se viene hablando en muchos países de la posibilidad de brotes infecciosos de origen intencionado. En esta recopilación de artículos se examina la historia de este tipo de episodios y sus consecuencias. Las probabilidades e incertidumbres que rodean este peligro podrán sorprender a muchos. Al mismo tiempo, no nos quepa la menor duda de que las 'viejas' enfermedades seguirán acechando. En nuestra economía mundializada, lo que ocurra en un rincón del globo puede ser peligroso, y más temprano que tarde, para todos nosotros. La evolución de la actual pandemia de influenza aviar por la cepa H5N1 viene a recordarnos que no sólo las amenazas inherentes al comercio mundial, sino también las aves migratorias, que ignoran fronteras y reglas internacionales, deben ser objeto de atención y preocupación.

Nuestra capacidad y confianza para responder a eventuales brotes de origen intencionado vendrán determinadas por la eficacia con que planifiquemos y afrontemos los brotes de enfermedades tradicionales y emergentes. El costo de una enfermedad se incrementa aun cuando disminuya su incidencia. Sin embargo, la mejora de la sanidad y de la productividad del ganado se acompaña de una dependencia creciente de un cuerpo veterinario que cada vez cuenta con menos experiencia práctica en la gestión de epidemias. Por ello, es preciso que las actividades de planificación y formación se basen en modelos válidos. Para prevenir la posibilidad de que cunda el pánico, las comunicaciones públicas deben ser transparentes. Los servicios de laboratorio deben ser capaces de responder a un aumento súbito de la demanda y de estudios forenses. De estas y otras muchas cuestiones (tales como el registro de rebaños, la coordinación entre agencias, el diagnóstico rápido sobre el terreno o la entrada de datos basados en sistemas de información geográfica) se ocupan una serie de reputados especialistas en la presente y muy oportuna publicación. Y aunque las probabilidades reales de que se produzcan ataques de bioterrorismo sigan envueltas en un manto de incertidumbre, dos cosas están muy claras: si se sospecha la presencia de un ataque intencionado debe existir la capacidad forense necesaria para investigar la cuestión con eficacia y buenos resultados; y si uno de tales ataques tiene éxito, otros seguirán, aunque sólo sea por mimetismo. La incapacidad de controlar un episodio de tales características será una invitación a que se repita.

Para alcanzar esos objetivos se requieren planificación, inversiones en formación e infraestructuras y normas claras y consensuadas que deben cumplirse, cuestionarse, redefinirse y constituir un objetivo de referencia. En este planeta mundializado y cada vez más pequeño en el que vivimos, seremos tan fuertes como lo sea el más débil de nuestros vecinos. La imposibilidad de controlar una enfermedad transfronteriza en un país no tardará en poner a otros en peligro, situación que la opacidad informativa no hace más que empeorar. Es indispensable coordinar los planes a escala nacional, regional e internacional, y apoyar y exigir su aplicación de forma coherente. Tampoco podemos dejar que los problemas del presente nos abstraigan del futuro, y en este sentido hay que perseguir también objetivos a medio y largo plazo. Y por muy difícil que resulte, debemos esforzarnos por predecir el futuro (aunque ello suponga constantes reajustes) y por modelarlo conforme a nuestros deseos.

Martin Hugh-Jones
Profesor emérito de estudios ambientales
Environmental Studies Department
School of Coast & Environment, Rm 2279,
Energy, Coast & Environment Building
Louisiana State University,
Baton Rouge, LA 70803-5705
Estados Unidos de América

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Accidental and intentional animal disease outbreaks: assessing the risk and preparing an effective response

M. Hugh-Jones [1] & C.C. Brown [2]

(1) Department of Environmental Studies, Louisiana State University, Baton Rouge, LA 70808, United States of America
(2) College of Veterinary Medicine, 501 D.W. Brooks Drive, University of Georgia, Athens, GA 30602-7388, United States of America

Summary
Intentional animal disease outbreaks are infrequent, if not rare, yet they carry the potential for disastrous consequences. Normal but accidental outbreaks are not uncommon and they must be handled efficiently, effectively and economically. And whatever its origin a disease will then follow its usual epidemiology. Therefore, the effectiveness in dealing with the normal, and the practice, experience and confidence gained, will significantly aid a country in how it minimises the cost of an intentional disease outbreak. The response is what determines the financial and economic costs of a disease outbreak. This paper provides an overview of the various threats, targets, and possible government responses, all of which is then expanded upon in detail in the other papers in this issue of the *Review*.

Keywords
Bioterrorism – Bioweapon – Challenge – Emerging animal disease – Livestock – Post-harvest – Pre-harvest – Public health – Target – Threat.

Historical perspectives

While the future challenges facing veterinary medicine and public health will undoubtedly continue to revolve around natural introductions of animal and zoonotic diseases, the ever present, often overlooked, endemic diseases that relentlessly grind away at animal production, and emerging diseases that surface unexpectedly to threaten health (3), a growing concern is the intentional introduction of disease agents into animal populations. Such disruptive terrorist or criminal strikes might take the form of a deliberate introduction of a pathogenic agent into the food supply anywhere along the production line that runs from farm to fork (2, 7, 8, 9, 10, 19, 27, 28).

Recent terrorist attacks worldwide have focused on hitting soft targets with the intent of producing mass casualties and/or causing economic disruption, while simultaneously producing high psychological impact and government instability. Information from various national and international government agencies worldwide, including the United Nations, Interpol and the World Health Organization (5, 16, 29), have indicated that undermining agriculture may well be a course of action that fits this extremist pattern. This is because large-scale foreign animal disease outbreaks have profound impacts on a country's infrastructure, economy, and export markets, and erode consumer confidence in the safety of the food supply. In addition, such outbreaks, whether due to accidental or intentional introduction, generate questions concerning government preparedness with regards to the protection of its critical infrastructures. The World Organisation for Animal Health (OIE) (www.oie.int), along with its 167 Member Countries, shares a common concern regarding the potential misuse of pathogenic biological agents that could affect animal health, public health and food production. The OIE is presently engaged in

providing guidelines, regulations, and standards to help prevent, diagnose, manage, and recover from such incidents.

Certain countries and organisations proclaim agroterrorism as an inevitable, unavoidable pending catastrophe, while other countries and organisations appear to pay scant attention to the subject; often dismissing this possibility as hysteria and hyperbole. The Director General of the OIE, Dr Bernard Vallat, has clearly and accurately articulated that there are, at present, substantial differences between countries in the perception of national threats from the deliberate use of pathogenic biological agents against animal populations (25). At the 28th World Veterinary Congress, Dr Vallat indicated his fears regarding the intentional introduction of biological agents, such as avian influenza, anthrax or rabies by bioterrorists intent on harming both animals and the public. Dr Vallat further voiced his concern regarding the intentional introduction of biological agents that strictly affect animals, since agents such as foot and mouth disease (FMD) could totally destroy the production of milk in a country (26).

There is a long but relatively thin history of using biological warfare, and its subset bioterrorism (BT), as a weapon of intentional aggression. While natural disease has its certain place in history, its use as a weapon is essentially a footnote, it has sometimes been used successfully, usually against naive susceptible populations, but at other times it has not had a significant impact even if disease cases have occurred (11). There has been a wealth of field trial experience, with its innate potentials for intentional disaster, but when one examines actual events – the German use of *Burkholderia mallei* against Allied horses in Argentina and New Jersey during World War I, other events in World War I in Europe, the Japanese use of *Yersinia pestis* in China during World War II, the Soviet use of tularaemia and glanders in Afghanistan – all these and others had arguable tactical impacts but were irrelevant strategically. The one event with strategic impact now in billions of dollars – the five anthrax spore-laden letters of 2001 in the United States of America (USA) – had a limited tactical impact and this may have been the act of a mere opportunist rather than an organised group. Possibly this is because biowarfare is perceived, as with chemical warfare, as a weapon of uncertain impact as well as being ethically unacceptable to the international community and thus likely to initiate an unconstrained overwhelming counter-attack from a strong opponent and international opprobrium.

On the other hand there are many groups with a history of targeting animals and agriculture, e.g. the animal rights groups and eco-terrorists with definite political agenda and experience in arson, animal 'liberation', threats, extortion, assaults, break-ins and theft. They have targeted, among others, medical and veterinary research facilities, fast food facilities, butcher shops, intensive livestock operations, animal and poultry processing plants, and personnel involved with and employed in such establishments. The organisations involved have carried out hundreds of these acts at great cost to those targeted. For example, the US Federal Bureau of Investigation informed the US Congress in 2001 that two organisations, the Animal Liberation Front and the Earth Liberation Front, had committed over 600 criminal acts causing over US$ 43 million of damage to US animal industries. However, although animal rights groups regularly target the food industries, there are presently no indications that they are interested in tampering with the food supply to cause human or animal disease outbreaks to date, probably because of their stated concerns for the health of animals and the environment. This is not to say that such organisations might not unknowingly provide training for those with less benign intentions.

Each period in history has its own brand of terrorist. During 1880-1910 it was the anarchists, a bunch of zealots whose ideology now counts for practically nothing. Most anarchists were non-violent but they had their firebrands and an ideology that could be twisted to appeal to a non-empathetic minority of wounded utopians. Next were the hyper-nationalists and several other extremist groups but they too came and went. This wave of terror will pass just as the others have. But others will take the stage (4).

However, the threat remains, even if thus far no terrorist group has used bioweapons (BW), not least in the minds of those health professions committed to fighting and preventing disease in humans, animals and plants. Since World War I there has been an increasing body of biowarfare research, both offensive and defensive. Collectively the latter has amply confirmed the possibility time and again that biological pathogens can be powerful and effective weapons. This results in a conviction that biological aggression will be used by terrorists. It is not a case of 'if' but 'when'. The difficulty in combating this threat is that the terrorist does not have a defined base that can be attacked. They are a diffuse group frequently embedded in a large population that prevents simple military action. There is a large body of successful counter-insurgency policy, strategy and tactics but, covering that is not the purpose of this publication. Our purpose is to show how the impacts of a potential biological disaster can be efficiently minimised by proactive decisions and actions taken before they occur, to cost effectively deal with them when they do, and how to facilitate rapid recovery.

Also it must be remembered that once past the opening scenario how we control both natural and intentional events is essentially identical. In preparing for the one we prepare for the other. How efficiently we do this determines the total cost and economic impact.

For the purposes of this analysis, agroterrorism is defined as the deliberate introduction of a disease agent, either against livestock or into the food chain, for the purposes of undermining socio-economic stability and/or generating fear (9). The threat of biological weapons directed against crops and processed foods has been reviewed elsewhere (15).

Natural versus unnatural, accidental versus intentional

Thanks to the advances of veterinary medicine and modern herd health protocols the frequency of major epidemics is much reduced. One can claim that in developed countries the health of modern flocks and herds is far better than that of the humans looking after them. The impact and frequency of major health problems are much reduced to the point of being absent as they must if farming is to make a profit. Natural events though not random – epidemiology would have any outbreak follow from a prior pattern of events to a predetermined outcome which would be determined by Kendall's threshold theory – rarely coordinate nicely to produce an epidemic. But occasionally it comes together, such as in the United Kingdom (UK) in 2001 with the FMD epidemic, when the widespread disease in one host species, sheep, coincided with the emergence of a large national cohort of veterinary officers without any meaningful experience or practice of dealing with a national emergency, which transformed a difficult situation into an expensive disaster. The fear is that an intentional bioterrorist event through the careful selection of agent, place and time may have a similar impact; that the terrorist can stack the odds. The terrorist's power in this situation is drawn from the gnawing unpredictability of if, how and when an attack might be launched and the absolute certainty that whatever happens will be extremely costly. While modern management practices have reduced the probability of a natural accidental epidemic to a very low value (though the economic and social consequences may then be high), the fears are that an intentional event will occur and that the consequences will be high (Fig. 1).

'Because terrorists can attack anything, anywhere, any time, and governments cannot protect everything, everywhere, all the time, terrorists always retain a certain advantage. Over the years the spectrum of targets attacked by terrorists has expanded. This asymmetry also means an inequality of effort between terrorist attackers and antiterrorist defenders. The amount of resources required for defence against terrorism is determined not by the very small number of terrorists, but rather by the virtually unlimited number of targets to be defended. This makes terrorism a cheap way to fight and a costly kind of threat to defend against' (13).

Complexity versus simplicity, reality?

'It ain't so much the things we don't know that get us into trouble. It's the things we know that just ain't so' [Artemus Ward]. How do we know that what we know is true?

One of the problems is that we know too much and we know too little. If you ask any applied microbiologist he or she can confidently describe a terrorist scenario for initiating a disease outbreak with this organism or that. But that is based on expert knowledge and experience with that pathogen, how to handle it safely without becoming infected oneself, and its delivery. On the other hand the old bioweaponeers learnt by experiment and application that successfully weaponising a pathogen involved more than merely brewing it in large volumes. And they had accidents, sometimes fatal. Even experienced laboratories have exposure accidents with brucellae (30) and *Francisella tularensis* (18) (William Patrick, personal communication, 5 August, 2005). A terrorist group, unless it has good facilities and equal experience, will have accidents. The probability of that will determine which pathogens they are willing to work with, preferring those that are relatively apathogenic for humans or that can be protected against by vaccination and prophylactic antibiotics. This will allow the core terrorist team to build experience and 'live to bomb again'. Unless there is solid intelligence of specific terrorist group competence biodefence groups modelling terrorist capacity tend to errors of self-imaging under the excuse of 'worst-case scenario'. Predictions of what can be

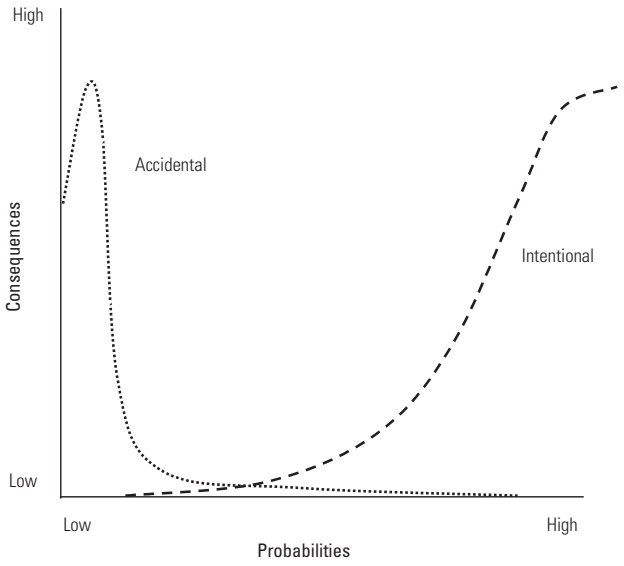

Fig. 1
Probabilities and consequences of accidental and intentional disease outbreaks

done are not the same as knowledge of true abilities. As stated by Representative Christopher Cox of California, latterly chairman of the US House of Representatives Committee on Homeland Security: 'Some experts believe that the hurdle for terrorist organisations to translate micro-organisms into biological weapons is relatively high. Others believe that this is a thin line of ignorance that can be easily crossed'.

The truth? Who knows. But once a group has a modest success, others may be encouraged to also attempt it. Which is why a fast, cost-efficient, effective response is important, nay, vital.

Responses

Unless there is a sudden change for the worst, disease outbreaks which are deliberately caused will remain rare and natural accidental outbreaks will continue to be the norm. These natural outbreaks must be prepared for; and when they occur, dealt with promptly, and the lessons learnt implemented to stop it happening again. By preparing for the norm, one is prepared for the abnormal. The methods for prevention, emergency management, mitigation and recovery are common to both circumstances. Spatially-targeted and industry surveillance systems must be in place and functional. Laboratory confirmation abilities need to be available and regularly tested. And tested plans should be in place to deal with surge demands in an emergency that flexibly reflect reality. Practice for the one is practice for the other.

One of the major problems in an emergency is inter-agency coordination and harmonisation, both national and international, of the necessary health, food and agricultural sectors. It is interesting how emergency post-mortems regularly point to shortcomings in coordination. And these failures increase the costs and delay effective responses. But the experience of a successful disease control programme builds confidence and generates collaborative ideas as to how it can be even better.

In the present day of interconnected global industries and economies, and the intercontinental transport of foodstuffs, both legal and illegal, pathogens are moved globally in spite of restrictions. Therefore policies have to be in place for the optimum control of novel diseases, whether by quarantine and slaughter, or by vaccination. And once past the opening days, the medical and veterinary responses are the same whatever the initiating cause. If vaccination is to be considered, there must be criteria for usage in place, tested and agreed, and sufficient stocks on hand of the perceived threat strains.

Emergency responses must be dual purpose.

Threats

There are three groups which can pose threats:

a) Nation states – those which have had or have offensive BW policies. Not only can they constitute a risk but employees and alumni from offensive programmes can take their skills and cultures elsewhere;

b) Non-state actors/terrorist groups – these groups have the potential to branch out from traditional weapons of improvised explosive devices and assassination to learn the details of constructing biological weapons. They take various forms, e.g. state-sponsored single-issue groups, nationalists, separatists, or apocalyptic cults. Their members include university graduates and it is only a matter of time until these groups will include or purposefully recruit individuals with advanced degrees in microbiology if they feel the need. Considerable discussion in recent bioterrorism literature has focused on the required educational expertise and technical skills needed to plan and execute a biological attack against humans, animals and plants. Several recent reports have clearly demonstrated that modern terrorist groups have many well-educated members, both senior and junior members (6, 20, 23) (Table I). However, most procedures necessitate only a modest education and careful mentoring. An example of a group such as this is the well known Al-Qaeda (see Appendix);

c) Disgruntled individuals – probably the most likely as they are opportunists.

For terrorism to occur there must be:

a) a vulnerable target

b) the technical and organisational capability to carry out an attack

c) the intent to attack.

Terrorists seek to express their anger, and show and project power and control, in lieu of their real feelings of powerlessness. Common characteristics can be their diffuse objectives making it hard to understand their ideology and to infiltrate their groups; a sense of grandiosity; an apocalyptic or paranoid conspiratorial world view leading to defensive aggression. Motivations include primarily getting attention, also economic terrorism, millennialism, revenge and public chaos, mimicking God, crusade, and creating an aura of mastership of science and technology. They frequently copy others. Repeated terrorist successes may in time beget political force. This leads to big impact events that they collectively can watch via the media. The latter is a stage on which they can wage their war by performing terrorist acts.

Table I
Educational level achieved by known members of the Global Salafi Jihad movement (17)

Origin	Less than secondary school	Secondary school completed	Completed some university courses	B.A./ B.Sc.	M.A./ M.Sc.	Doctorate	Total
Core staff[a)]	1	1	1	16	1	5	25
South-East Asia	0	2	3	8	4	0	17
Maghreb Arab	13	8	9	6	1	0	37
Core Arab	8	5	25	14	1	0	53
Total	22	16	38	44	7	5	132

a) the core staff of the organisation are not based in one particular region

The mere demonstration of capability is enough but a 'blast' plays better to the media. The data presented in Table II (17) highlights this fact in that, from 1968 to 2005, a vast majority (82%) of documented terrorist attacks involved bombings, armed attacks, kidnapping, and assassinations. These types of attack are more likely to draw media attention and increase publicity and notoriety for terrorist groups seeking to gain attention and popular support for their ideological or political goals.

The use of biological agents has been carefully reviewed (6) and these studies indicate that the use of biological agents against livestock and poultry populations has been rare when compared to other targets. Carus found only three instances of the use of biological agents against agriculture targets (Table III). Overall, confirmed instances of the actual terrorist use of biological agents against agriculture are rare (2, 6, 27, 28). From the standpoint of most extremist groups, such actions would probably be viewed as too dry and mundane in comparison to traditional tactics (Table II) such as random shootings, assassinations and bombings – all of which focus on more spectacular, human-directed atrocities – because they do not produce immediate, visible effects. The impact of bioassaults on livestock and the food chain, although potentially economically significant, is delayed, lacking a single focal point of reference for the media to highlight. More specifically, there is less instantaneous drama such as occurs from a major truck explosion or suicide strike, which is essential to creating the immediate panic and loss of confidence in government officials that such acts are designed to elicit. However, the public as a whole do not understand biological agents and therefore their false perceptions magnify the impact and fears of any bioterrorist event, and lead to over-responses.

To the terrorist, animal diseases have the advantages that some are apathogenic for humans and vaccine protection exists for other diseases; since the terrorist team itself remains unharmed they can carry out this sort of attack repeatedly and build experience. That the impact will include the financial bankruptcy of many targeted industry components – farmers, food processors, families of laid-off workers – is a 'collateral damage' similar to the many deaths of civilians caught in military cross-fire on 'legitimate targets'. But if urban bombers have no care for them, the agroterrorist will be similarly unconcerned and regard it as a bonus social component of the economic cost.

Table II
Tactics used in documented terrorist attacks carried out between 1968 and 2005 (17)

Tactic	The number of terrorist groups employing this tactic 1968-2005
Armed attack	198
Arson	88
Assassination	137
Barricade/hostage	56
Bombing	528
Hijacking	51
Kidnapping	170
Other	27
Unconventional attack	9

Table III
Criminal and terrorist objectives of all known bioterrorist attacks carried out between 1900 and 1998 (6)

Type of event	Terrorist	Criminal	Other/uncertain	Total cases
Murder	4	17	0	21
Terrorise	6	9	22	37
Extortion	0	13	3	16
Disruption	0	5	0	5
Anti-animal/crop	**1**	**2**	**0**	**3**
Mass murder	4	0	0	4
Revenge	0	3	0	3
Incapacitation	2	0	0	2
Political act	1	0	0	1

Various selection criteria for the most dangerous anti-livestock and anti-poultry biological agents have been suggested (28). The most dangerous pathogens would be:

– pathogenic for livestock or poultry

– available and easy to acquire or produce

– highly infectious and contagious

– not harmful to the perpetrator

– robust and able to survive in the environment

– easily disseminated

– predictable, with an expected clinical disease pattern (including morbidity and mortality)

– attributable to a natural outbreak, ensuring plausible deniability if that is desired.

Unless a rogue nation state is willing to provide a pathogen product in a form suitable to survive transport, handling, and dispersal, this has to be prepared and assembled by the group or individual. This is easy in theory and some scenarios may be simple for the experienced. Fortunately, finding a group with instructional documents is not proof of actual ability though it may be an indicator of future intent; rather like a copy of *Playboy* hidden under a mattress can signal hopes but not necessarily sexual competence. Anthrax has long held a weapon position, not because of its lethality, in spite of its reputation, but because the spores are simple to produce and have an easy survivability. A parallel can be drawn for certain viruses that can be grown in eggs or are environmentally robust when harvested in high titre from lesions. There is a need to grow a minimum volume in order for it to be deliverable and the product must be in a form that does not challenge viability. And lastly it has to be dispersed effectively. Archival military research emphasised aerosols but engineering for this is specialised. It is far easier to deliver pathogens via sprays, food, feed, and water, especially as the food processing industries throughout the world have become increasingly vertically integrated. A recent industrial processing error in Spain involving roast chicken resulted in 921 salmonellosis cases across 13/18 provinces and communities in the country (22). There was the intentional salmonella attack in Oregon in 1984 that resulted in 751 cases (24), as well as malicious attacks on smaller groups (1, 14, 21). And lastly, if a group were preparing to use a biological pathogen they would quickly discover the problems of accessing targets. It is not the same as putting a bomb on a metropolitan train or bus. There would be a need to develop this expertise and therefore one can expect that groups may well practice in countries where they are comfortable to gain experience before taking on their true targets.

Analyses show that the scientific expertise among terror groups is very variable (Table I), but that some members have backgrounds in medicine, microbiology and pharmaceuticals, up to and including the PhD level. For example, Table I shows a high degree of education for the terror groups aligned with the Global Salafi Jihad movement led by Al-Qaeda [AQ] in that over 60% of membership had at least some university education. As a group, their education level exceeds the worldwide average. The educational level and technical expertise of such groups are clearly adequate to plan and execute a biological attack against animals. Although recent military, economic and political actions in many countries may have blunted AQ and related groups, these movements will continue to include well-educated extremist members. What criminals and terrorists cannot obtain though formal, traditional educational programmes can often be obtained through online educational services or through international and national biological conferences and seminars. Additionally, the Internet is identified as of great utility for the collection of information about diseases.

Any initial threat is most likely to be from known biological agents and current accessible modest technologies which involve expertise, knowledge and processes already in the public domain. However, future technical advances may make novel or non-conventional pathogens and their delivery more attractive to terrorists and others, especially as defences increase in thoroughness and complexity.

Targets

Targets stretch from individuals, to families (and their farms), communities, government infrastructure, public health, and finally economic sectors, including food and agriculture. The strategic objectives of the perpetrator(s) determine the target and the pathogen. The extent of a group's production and operational capabilities will affect its choice of targets, since few knowingly select targets that they lack the abilities to attack successfully. Moreover, most groups have limited access to pathogens and resources of time, finances, and personnel needed to meet the costs involved with developing and implementing new technologies. Unless given confidence by the success of another group new technologies are uncertain while soft targets vulnerable to traditional terrorist weapons are plentiful. On the other hand there is the perceived need to stand out from the terrorist herds and be relevant. And some groups are well funded and are attracting members with advanced technical capabilities.

While many BW scenarios invoke massive casualties, the reality is that many objectives can be met by minimal

numbers of cases, sufficient to ensure diagnosis. One confirmed case of FMD can be as economically crippling as a thousand. The American anthrax incidents in 2001 involved only five deaths and 22 cases; there is more health damage from ethyl alcohol on any weekend in many major cities in the USA, but the anthrax letters had an impact in billions of dollars. Therefore one should be as aware of the potential for 'poisonous dwarf' incidents as well as of the 'monster' mass-casualty attacks that are the focus of so much response planning. The myopic focus on mass-casualties virtually nullifies the need for countermeasures, replacing proaction, prophylactics and cost-effective responses with bulldozers, body bags and bigger budgets.

In today's world agriculture is a global competitive industry. It is large. It is complex. In many countries it is highly concentrated, whether we consider beef feedlots, broiler hens, or soybeans. Many countries produce more of a product than they can consume domestically and therefore any stoppage on international trade will reverberate back onto the healthy stock in the national production pipeline and the farms producing feed for them. With industrialisation has come limited genetic diversity, which can add to the risk of disease spread. Some parts of the agriculture industry are easy to access; others are surprisingly complex even to those of us raised in the countryside. This latter point should be considered in tracing and tracking the activities of suspect groups. And lastly the risk from exotic pathogens, whether accidental or intentional, is compounded by poor initial recognition, the non-availability of vaccines, and absence of related control and eradication experience within the governmental Veterinary Services. More than anything else it is the efficiency and rapidity of their response that determines the economic impact of such an outbreak.

The threats to food and agriculture can be divided into two major groups: pre-harvest and post-harvest. Potential pre-harvest threats are to livestock – including aquaculture – and crops. For high response pathogens we should not exclude family farms or backyard breeders. 'Pre-harvest' outbreaks carry the risk of economic devastation compounded by international trade restrictions; financial disaster throughout the affected industry, associated industries (e.g. feed producers), and related communities (e.g. the UK FMD epidemic in 2001 severely impacted the rural tourist industry); and will be felt not just locally near affected farms but regionally and nationally. 'Post-harvest' events affect the food industries (processing, transportation, and delivery) and public health (possible human illness and death) impacting economic trade and can have social and political repercussions. Due to the vertical integration of many industries any direct interruption in just one part, much less a number, will have immediate and severe impacts on many others.

If one were to attempt to rank future potential bioterrorist attack scenarios, the following events may be considered as a guide:

a) threats and hoaxes (e.g. hoax letter sent to a Wellington newspaper in 2005 claiming that FMD virus had been released on Waiheke island, New Zealand)

b) murders and assassinations (e.g. the assassination of Bulgarian dissident Georgi Markov with a ricin-laden pellet fired from an umbrella)

c) unannounced unclaimed non-lethal attacks (e.g. intentional salmonella attack in Oregon, 1984 [6])

d) disruptions with few deaths (e.g. 2001 anthrax letters sent to a number of news organisations and two US Senators' offices)

e) localised lethal attacks (e.g. those which would have similar consequences to the accidental release of anthrax spores in Sverdlovsk in 1979)

f) campaign of mass casualty attacks on different targets at different times (e.g. those initiated by the Japanese biological weapons facility unit 731, which used human 'guinea pigs' in their weapons research and development)

g) lethal global outbreaks.

Only the last has yet to be witnessed.

Rules governing biological attacks

The following needs to be kept in mind when considering biological attacks:

– Rule 1: while theoretically easy to carry out, an effective agrobioterrorist attack is more difficult than the traditional bombing or murders;

– Rule 2: the true impact is determined not by the 'bang' but by the government(s) response(s);

– Rule 3: those involved in bioterrorism are not your average terrorists;

– Rule 4: in responding we have to be lucky all the time. They have to be lucky only once.

Similarly, there are certain characteristics shared by agroterrorist attacks:

– any human deaths may be coincidental;

– the full agricultural impact may be delayed;

– losses from the disease itself could be minimal but the indirect costs of controlling the disease, e.g. quarantine, surveillance, de-population, disposal, indemnity, etc., will be significant;

– an effective 'attack' does not necessitate massive death and destruction. It is the necessary responses to agricultural disease, to contain and clean up, to prevent further spread, and then to reclaim the previous level of disease control or freedom, lost exports and international recognition of freedom from disease and infection that eat up effort and funding with associated major economic and social costs. For example, FMD virus is a very robust virus which causes lesions on the feet and tongue, mammary glands and thyroid gland but in general it kills less than 1% of livestock affected – mainly calves from myocarditis – but the government response to FMD traditionally kills 100% of those affected.

Therefore, the desired results from an agricultural BT attack are much more complicated than the simple widespread terror induced in a human target population.

One cannot dismiss the possibility of agroterrorism emerging as a secondary tactic that is designed to complement and exacerbate the upheaval and social dislocation caused by more traditional tactics. Certainly the mechanics of executing an assault of this nature are relatively straightforward and far less complex than those associated with bioattacks against human populations. Factors contributing to this include:

– there is a large selection of animal biological agents from which to choose, with no less than 12 previous OIE 'List A' pathogens identified as having the potential to seriously impact animal health and/or trade;

– many exotic diseases are not zoonotic, so there is no risk of accidental human infection and therefore there are no requirements for elaborate personal protective equipment and containment procedures. However, advanced understanding of animal disease science would aid the perpetrator's efforts to implement an attack on the agricultural industry;

– animal diseases can be quickly spread over wide geographic areas affecting large numbers of animals and farms, due to the intensive and concentrated nature of contemporary farming practices in many western countries, especially the USA, many European Union countries, and Asian Rim countries. Modern, rapid means of animal and human transportation worldwide immeasurably assists in disease spread. Animals provide the primary means of transmission; sophisticated weaponisation is not required. Due to the endemic nature of many of these diseases in large geographic regions worldwide, samples of agents are readily available from clinical specimens collected from the field during natural outbreaks of disease;

– if the objective is human casualties, certain zoonotic diseases offer unique capabilities and the food chain offers a low-tech but highly conducive mechanism for disseminating a wide range of toxins and bacteria. This topic is discussed in full in other papers in this issue of the *Review*.

The ability to employ cheap and unsophisticated means to undermine a government's economic base and possibly overwhelm its resources, gives livestock and food-related attacks an attractive cost-benefit payoff that would be of considerable interest to any group seeking to overcome extant power asymmetries between itself and the State it is targeting.

Recommendations for identifying and/or avoiding future incidents, minimising economic damage, and containing the disease

These recommendations are only covered briefly here as they are discussed in greater detail in the other papers in this issue of the *Review*. The following suggestions are to reduce overall costs and to reduce any public hysteria and political over-reaction that might be engendered by a successful agricultural BW attack (12):

– develop 'early warning' indicators;

– define hypothetical goals and possible objectives of those likely to use agricultural BT/BW techniques;

– remember that the more developed the industry, the more likely that the target component will be exports via singular cases (e.g. in reaction to the diagnosis of a bovine spongiform encephalopathy-like case in the USA); similarly, the less developed, the more likely that it will involve cruder processes and large numbers (e.g. 'yellow rain', rinderpest); and plan accordingly;

– remember that the bioterrorist's preferred technique will involve a high impact–effort ratio, i.e. small effort with large impact, and therefore do not overlook possible unsophisticated preparations;

– be prepared without being paranoid; maintain an attitude of 'Informed Suspicion';

– have reliable rapid diagnostic tests released to the general agricultural community so as to reduce the frequency of false alarms;

– ensure that DNA testing kits are suitable for use in both natural and intentional situations;

– strengthen laboratory systems in the regions identified as being at risk;

– maintain field investigation team expertise and abilities. Try not to replace each ad hoc team with yet another. Rotate individuals in and out, not teams;

– the BT/BW team investigation should not interfere with the normal veterinary and agricultural responses to the emergency. Optimally it should be invisible to the public and silent, functioning in parallel and liaising closely with the emergency command. Unless the circumstances are blatant, any suspicions of BT/BW origin should not be voiced;

– do not give into the political temptation to suppress notification of disease outbreaks. It is far, far better to be proactive with the news thereby having some control of it and also insuring that it is accurate. Hiding information is a good way of ensuring that it is discovered and trumpeted without warning. Better to facilitate accurate news in a low-key manner than to suppress it. By providing prompt and accurate news releases to all the appropriate media one in fact controls the situation. Transparency nationally and internationally is vital. However, because of the implications – a true BW attack is an act of war – it is wise to not inform the news agencies of the BW nature of the suspected or confirmed source. That should be left to those responsible for national policy. Because of the risk of imitation by others, revealing a successful terrorist attack as 'BW' may be counter-indicated;

– do not be eager to publicise 'near-misses' firstly as any publicity would engender unnecessary excitement and speculation and secondly, a no-report indicates failure, something one might want the perpetrators to believe. Watch to see what happens, and note and act accordingly;

– preplan the agricultural, economic and policy response. If necessary, publicise one's intentions. Minimise self-inflicted economic wounds. The recovery must be rapid. Transparency engenders trust and respect by other countries and while it may not prevent punitive protective actions by other countries it can reduce their severity in the longer term and will aid negotiations;

– preplan tactics and operations, including legislation, for carcass/crop disposal, site disinfection, and compensation. Compensation at market value paid promptly, either from government or insurance sources, will significantly reduce delays in reporting suspect animals/crops and reinforce community support;

– develop effective public information on improved disease prevention methods, especially in relation to prophylactics, livestock vaccination, and increased animal physical security by reducing their unsupervised contact with the public;

– run field war games so that government staff and representatives of the professional public are rehearsed; by professional public we mean private veterinarians, feed and dairy companies, feedlot owners, farmer representatives, and such. These exercises should not be overtly anti-BW but a routine 'What do we do if there is an outbreak of FMD or Venezuelan equine encephalomyelitis or Newcastle disease or whatever'. They have drills for hurricanes and tornadoes, why not for agricultural emergencies? Reduce the potential for hysteria by widening the range of those involved in these exercises. With each year there is an increasing need to be prepared and rehearsed;

– if it is appropriate, maintain basic stocks of vaccines. While, for example, outbreaks of anthrax can be readily and efficiently stopped by vaccination, for other diseases it may be better to slaughter ones way out of them because of the knock-on effects of vaccination on international recognition of being disease free. It depends on circumstances. Thanks to the 2001 FMD epidemic the public acceptance of slaughter is now much reduced to the point that vaccination may be the preferred response for this and other diseases.

Conclusion

The 15th Century European explorers brought smallpox, measles and hepatitis to the American Indians with truly devastating results throughout the Hemisphere. They arguably returned with syphilis, which barely rates a footnote in subsequent European history. The disease that changed European history was plague from Central Asia. So it is not 'if', nor 'when' but 'what'. The subsequent severity of the 'what' is not the agent but the efficiency of how we control it before, during, and after its emergence.

Appendix

Al-Qaeda, biological weapons, and agroterrorism

Al-Qaeda and AQ affiliated groups have long expressed interest in the offensive employment of chemical, biological, radiological, nuclear, and high explosive (CBRNE) materials. Indeed, in an interview with 'Time Magazine' four months after the August 1998 US East African embassy bombings, Osama Bin Laden specifically

asserted that acquiring weapons of mass destruction was a religious duty for all Muslims and one that was fully in accordance with Islamic precepts as defined by Allah. Islamic scholars refute that claim but, nevertheless, there is a substantial following who have chosen to interpret the Koran in this unrealistic manner.

No evidence currently exists that AQ has yet been able to translate its undoubted interest in weapons of mass destruction to actual possession. Moreover, the group's current disaggregated and resource-depleted character would seem to preclude the option of it being able to independently manufacture CBRNE weapons for large-scale, strategic attacks in the short-to-medium term. These considerations notwithstanding, one should not discount the possibility of more limited strikes being carried out to generate psychological and/or economic (rather than physical) damage. Such assaults would probably fit with the group's general operational patterns post-9/11; that is, emphasising modalities that are directed against unprotected 'soft' targets and which are cheap, easy to mount and capable of being executed with a minimum of outside support. It is in this context that attacks against agriculture take on a certain degree of relevance.

An act of agroterrorism would fit well both with AQ's currently reduced operational potential to execute large-scale strategic strikes on the scale of 9/11, as well as with the network's general desire to deliver a crippling blow to the American economy. Introducing disease into livestock populations is very low tech. Because FMD is so contagious, and given the extremely concentrated and intensive nature of contemporary livestock farming practices in many western countries, a nationwide multi-focal outbreak may well ensue. Should such a catastrophe occur in the USA or many other countries, it would cost the affected country(ies) billions of dollars in lost livestock, livestock products, trade and tourism.

More importantly, various documents, manuals, letters and books (4) recovered in the wake of Operation Enduring Freedom in Afghanistan provide some empirical evidence that AQ was seeking to develop anti-animal agents as part of its general biological efforts. Figure 1A is a crude hand-drawn schema of their sophisticated interest in the acquisition, isolation, culture, identification and testing of various medically important bacteria. It is clear from the words 'Manpower' 'Vaccinated' and 'Antisera' in Boxes 1 and 1A that the author wanted to protect the scientists and laboratory technicians implementing this BW programme by vaccinating them or having antisera available in case of an exposure or infection.

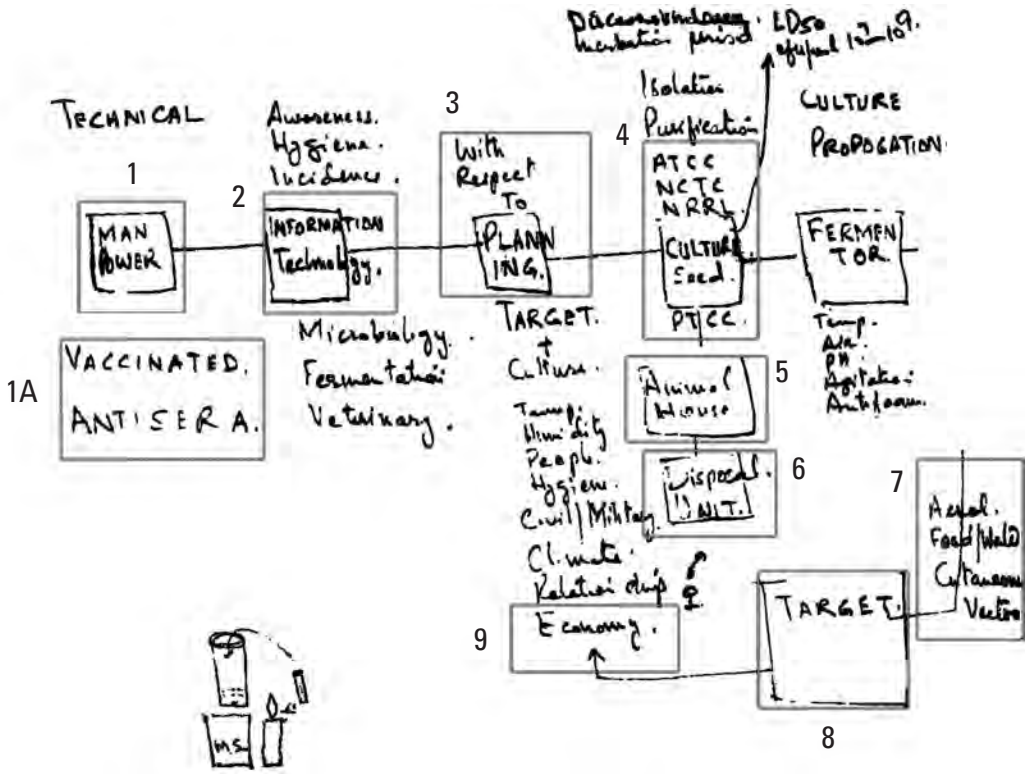

Fig. 1A

Crude hand-drawn schema recovered at a terrorist training camp in Afghanistan illustrating Al-Qaeda's sophisticated interest in the acquisition, isolation, culture, identification and testing of various medically important bacteria

Source: This document is available from government archives in the United States of America under the Freedom of Information Act

Foyers de maladies animales d'origine accidentelle et intentionnelle : évaluer le risque et préparer une riposte efficace

M. Hugh-Jones & C.C. Brown

Résumé
Les foyers de maladies animales d'origine intentionnelle sont peu fréquents, voire exceptionnels, mais leurs conséquences peuvent être désastreuses. Les foyers normaux mais accidentels ne sont pas rares, et doivent être pris en charge de façon efficace, efficiente et économique. Une fois déclarée, quelle que soit son origine, une maladie suivra son évolution épidémiologique habituelle. Par conséquent, l'efficacité de la prise en charge des foyers normaux et l'expérience et l'aisance acquises aideront considérablement un pays à trouver les moyens de réduire au minimum le coût d'un foyer de maladie d'origine intentionnelle. Ce sont les interventions destinées à faire face à un foyer de maladie qui en détermineront le coût économique et financier. Le présent article offre une description générale des menaces, des cibles et des réponses gouvernementales possibles ; chacun de ces points est ensuite repris et développé dans d'autres articles de ce numéro de la *Revue*.

Mots-clés
Arme biologique – Bétail – Bioterrorisme – Cible – Enjeu – Maladie animale émergente – Menace – Mesure après l'abattage – Mesure avant l'abattage – Santé publique.

Evaluación del riesgo de brotes zoosanitarios de origen accidental o intencionado y preparación de una respuesta eficaz

M. Hugh-Jones & C.C. Brown

Resumen
Los brotes de enfermedades animales de origen intencionado son algo inhabitual, incluso raro, aunque pueden dar lugar a auténticos desastres. Los brotes normales pero de origen accidental no son infrecuentes, y exigen una respuesta efectiva, eficaz y económica. De todos modos, sea cual su origen, una enfermedad va a propagarse conforme a sus pautas epidemiológicas. Por ello, la eficacia a la hora de enfrentarse a episodios normales y la práctica, experiencia y confianza que con ello se adquieren ayudarán mucho a un país a la hora de reducir al mínimo las consecuencias de un brote provocado. El costo financiero y económico de un brote zoosanitario depende de la respuesta que se le dé. Los autores describen sucintamente una serie de amenazas, objetivos y eventuales respuestas de los gobiernos, todo lo cual se aborda con más detenimiento en otros artículos de este número de la *Revista*.

Palabras clave
Amenaza – Arma biológica – Bioterrorismon – Desafío – Enfermedad animal emergente – Ganado – Medida posterior al sacrificio – Medida previa al sacrificio – Objetivo – Salud pública.

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The Biological and Toxin Weapons Convention

P.D. Millett

BWC Meetings Secretariat, Department for Disarmament Affairs, United Nations Office at Geneva, Palais des Nations, CH-1211 Geneva 10, Switzerland

Summary

The Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction prohibits the development, production, acquisition, transfer, stockpiling and use of microbial or other biological agents, or toxins in a manner which has no justification for prophylactic, protective or other peaceful purposes. It also bans weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict. It covers biological and toxin weapons against humans, animals and plants. This article provides a brief history of the Convention and presents an overview of its five Review Conferences; the 'Ad Hoc Group of Governmental Experts, open to all States Parties, to Identify and Examine Potential Verification Measures from a Scientific and Technical Standpoint' (usually referred to as VEREX); and efforts to develop a legally binding instrument to strengthen the Convention, as well as the annual meetings of experts and States Parties which have taken place over the last three years. Issues of particular relevance to the World Organisation for Animal Health (OIE) are highlighted throughout, demonstrating their longstanding and fruitful contributions to ensuring that veterinary science is used only for the benefit of mankind.

Keywords

Biological weapon – Bioterrorism – Deliberate disease – Disarmament – Geneva Protocol – International law – Non-proliferation – Poisoning – United Nations.

Introduction

The Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (the Biological and Toxin Weapons Convention – BTWC), despite being the primary multilateral forum embodying the norm against biological and toxin weapons, was not the first international instrument to tackle the weaponisation of poisons and disease. The potential for the intentional use of such agents for non-peaceful purposes has prompted revulsion throughout human history and efforts to prohibit such activities can be traced back to antiquity. The first instrument to address this issue was the 1925 Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (the Geneva Protocol). This prohibits the use in war of biological and chemical weapons. It does not prohibit their development, production, acquisition, transfer or stockpiling. The absence of international measures proscribing these preparatory steps became more apparent as scientific and technological developments made biological and toxin weapons more feasible.

As man prepared to take his first steps on the moon, States began to consider supplementing the 1925 Geneva Protocol. The first draft of a convention to prohibit activities which would provide a capability to use poisons and disease as a weapon was submitted, by the United Kingdom (UK), to the Eighteen Nation Committee on Disarmament on 6 August 1968. The proposal to develop

a convention to prohibit the research, development, production, transfer, acquisition and stockpiling of biological and toxin weapons garnered support and additional revisions to the original draft text were tabled in July 1969. Progress towards the BTWC received a considerable boost on the 5 August 1971, when the United States of America (USA) and the Soviet Union (USSR) proposed identical versions of a draft convention. After further negotiations, the final draft was presented at the Conference of the Committee on Disarmament on 28 September 1971. The BTWC emerged in its existing form on 16 December 1971, when the text was endorsed by the United Nations (UN) General Assembly (23). The Convention had three Depositaries: the governments of the USA, the UK and the USSR (now the Russian Federation). The BTWC opened for signature on 10 April 1972 and entered into force on 26 March 1975 with 46 States Parties. The numbers of States Parties rose steadily and as of July 2005 the BTWC had 155 States Parties and 16 Signatories.

This work provides a brief overview of the history of this important international instrument, spanning the thirty years since its entry into force in 1975 to the end of the follow-up process in 2005. It focuses, in particular, on those elements of most relevance to the activities of the World Organisation for Animal Health (OIE). The article begins by examining the Convention itself and discussing its key provisions. It then describes the additional understandings of the BTWC which have evolved through a series of five-yearly Review Conferences and outlines the current understanding of the Convention. Efforts to strengthen the BTWC and develop a supplementary legally-binding instrument are also considered. The author then examines the 'Ad Hoc Group of Governmental Experts, open to all States Parties, to Identify and Examine Potential Verification Measures from a Scientific and Technical Standpoint' (known as VEREX). The successful conclusion of this process prompted States Parties to call a Special Conference in 1994 to discuss further action based upon the findings of the VEREX report. The Special Conference mandated a further set of meetings to translate the scientific and technological findings of VEREX into a workable legally-binding instrument. An Ad Hoc Group of States Parties to the Convention (AHG) was established for this purpose and its activities are reviewed.

Unfortunately, efforts to develop a legally-binding instrument were unsuccessful and the events of 2001 marked a significant change of course for efforts to strengthen the BTWC. The article discusses the events which took place at the Fifth Review Conference, which saw these efforts evolve from the AHG to a new set of annual meetings of experts and States Parties, which have collectively become known as the follow-up process. The meetings, which took place in 2003, 2004 and 2005 are discussed in some depth, providing an overview of the current situation of the BTWC. The history detailed in this paper is then reviewed in order to draw from it some final conclusions.

The prohibition of the development, production, stockpiling and use of biological and toxin weapons

Despite being only four pages long, the BTWC contains a broad spectrum of obligations and prohibitions which bind its States Parties (the key articles are summarised in Table I). The continuing relevance of the BTWC to current

Table I
Key obligations on States Parties and signatories to the Biological and Toxin Weapons Convention (BTWC) (22)

Article	Obligation
Article I	Never in any circumstance to develop, produce, stockpile or otherwise acquire or retain biological and toxin weapons
Article III	Not to transfer biological and toxin weapons to any recipient whatsoever and not in any way to assist, encourage or induce anyone else to acquire them
Article IV	To take any necessary measures to implement nationally the obligations under the BTWC
Article V	To consult bilaterally and multilaterally to solve any problems which might arise with the implementation of the BTWC
Article VI	To request the United Nations Security Council to investigate alleged breaches of the obligations of the BTWC and to cooperate with any such investigation
Article VII	To assist States Parties which have been exposed to a danger as a result of a violation of the BTWC
Article X	To enhance international cooperation for the peaceful use of biology and to implement the BTWC in such a manner as to avoid hampering the peaceful use of such science and technology

events is apparent from the contemporary debate over the need to balance freedom of science with security measures designed to protect humans, animals, plants and the environment. This very concept lies at the heart of the BTWC, with Articles I and III prohibiting activities which would lead to the capability to use biological and toxin weapons, whilst Article X obliges States Parties to enhance international cooperation for the peaceful use of biology and specifies that the Convention is not to be implemented in a manner such as to hamper scientific, technological and economic advancement.

The differentiation between peaceful and prohibited activities is also encapsulated within the definition for biological and toxin weapons used in the Convention – there is an attempt to control intent, as opposed to tangible resources, avenues of research, or specific processes. The BTWC prohibits the application of the biological sciences for hostile or non-peaceful purposes.

In the Convention, biological and toxin weapons are described as:

a) microbial or other biological agents, or toxins, whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes

b) weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

This definition has become known as the general-purpose criterion, for its all encompassing, catch-all approach.

Prior to the BTWC's existence States bound by the 1925 Geneva Protocol had the right to research, develop, produce, stockpile and deploy (all of the steps up until the actual use of) biological and toxin weapons. Additionally, States bound by the 1925 Geneva Protocol were only prohibited from using these weapons against other States which had signed the instrument – all of the other States were 'fair game'. Furthermore, a number of States indicated that they would respond in kind with these weapons, even against other States which had signed the protocol, in cases where they had been attacked with them first. Other reservations permitted the use of such weapons against the allies (even if they were parties to the 1925 Geneva Protocol) of a State with which they were at war in cases where the primary enemy had not signed the instrument. This led to a significant erosion of the norm against the use of biological and toxin weapons and in retrospect may have been manifest in the large-scale offensive weapons programmes of a number of States during this period. Fears over the potential use of these weapons, based upon the concept that 'such use would be repugnant to the conscience of mankind' led to a belief 'that no effort should be spared to minimise this risk' (23). The apparent solution was to reduce the chance that these weapons would be used. This was attempted by prohibiting the processes necessary to develop a capability to use them in the first place. In effect, the norm against the use of biological and toxin weapons had expanded to encompass their development or possession. Through the BTWC, States Parties undertake 'never in any circumstances to develop, produce, stockpile or otherwise acquire or retain' biological and toxin weapons. Thus, it is argued, it is impossible to use a weapon that you do not have access to.

The inclusion of the phrase '…whatever their origin or method of production' in the first section of the definition of a biological or toxin weapon has ensured that developments in genetic engineering, genomics, proteomics and molecular biology, which were little more than science fiction in the early 1970s have remained within the remit of the Convention. It embodies the prohibition against the malign use of the biological sciences. Agents produced through recent developments, such as the synthetic chemical generation of live viruses, might, it could have been argued, not have been prohibited under a Convention which only dealt with biological agents of natural origin. This phrase also covers the biochemical manipulation of biologically active compounds, such as toxins, to produce analogues without a natural origin.

The expansion of the prohibition from the use of these weapons in war to encompass 'hostile purposes or in armed conflict' has also proved important. The current security environment where military action more often takes the form of peace keeping, peace enforcement, preventative defensive actions or even regime change (often without a formal declaration of war) has ensured that the prohibitions of the BTWC have remained as valid today as when they were drafted. It has also helped to ensure that the Convention is playing its part in preventing non-State actors from acquiring biological and toxin weapons.

Finally, it is important to note that in contrast with other regimes, such as those relating to nuclear weapons, the BTWC considers delivery devices as a part of a biological and toxin weapon. Thus, even in the absence of an agent, it is prohibited to attempt to acquire a delivery device and conversely, it is also prohibited to possess agents, under certain conditions, even if there is an absence of a delivery device. The focus of this treaty on sub-weapon capability makes it particularly pertinent to those pursuing scientific and technological activities. Even if these actors are not producing a complete weapon, they will still have to consider whether their activities are in compliance with the BTWC. After all, the obligation of ensuring compliance lies with those pursuing legitimate activities and not with an international verification body.

The review conference process: additional understandings of the Convention

The text of the BTWC, as endorsed by the UN General Assembly and as ratified by States Parties remains unchanged but the understanding of its intricacies has developed considerably over the years. The BTWC was never intended to be a static text, to be filed away on a dusty shelf; it is an evolving regime moulded to best fit the changing environments within which it is framed. It is intrinsically tied to the latent capabilities of contemporary science and technology. In order to facilitate this process, the BTWC initiated a series of Review Conferences which were charged with a dual mandate: 'to review the operation of the Convention, with a view to assuring that the purposes of the preamble and the provisions of the Convention… are being realised' and to 'take into account any new scientific and technological developments relevant to the Convention'. Although the text of the BTWC only called for a single Review Conference five years after the entry into force of the Convention, the First Review Conference (1) mandated a second, and the Second Review Conference (2) a third, the Third Review Conference (3) a fourth, the Fourth Review Conference (5) a fifth, and the Fifth Review Conference (9) a sixth, due to take place in 2006 (Table II).

The full texts of the five Final Documents extend to some 853 pages. Of greatest interest to this present work are the Final Declarations found within these documents. These Final Declarations contain an article-by-article review of the Convention which highlights both the contemporaneous views of States Parties as to the functioning of the Convention and any additional understandings they have reached. It should be noted that the Fifth Review Conference adopted a different format and produced no Final Declaration (the output of this Review Conference is considered in more depth later in this article). In this section, particular focus will be placed on seven articles identified as core provisions (see list in Table I). The development of confidence-building measures (CBMs) is also dealt with in the final subsection.

Table II
Dates of the Review Conferences for the Biological and Toxin Weapons Convention

Review Conference	Dates
First Review Conference	3-21 March 1980
Second Review Conference	8-26 September 1986
Third Review Conference	9-27 September 1991
Fourth Review Conference	25 November-6 December 1996
Fifth Review Conference (original session)	19 November-7 December 2001
Fifth Review Conference (resumed session)	11-22 November 2002
Sixth Review Conference	Due to be held in 2006

Article I

The Final Declarations made it clear, through numerous specific references, that the Convention covers biological and toxin weapons against humans, animals and plants – clearly linking its interests with those of the OIE. For example, the Final Declaration of the Fourth Review Conference reaffirmed that 'the Convention prohibits the development, production, stockpiling, or other acquisition or retention of microbial or other biological agents or toxins harmful to plants and animals, as well as humans, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes'.

The Second Review Conference concluded that 'the scope of Article I covers scientific and technological developments relevant to the Convention'. The Second and Fourth Review Conferences expanded upon this and identified a number of scientific fields in which there was a particular potential for activities inconsistent with the BTWC. These included: microbiology, genetic engineering, biotechnology, molecular biology, and genome studies, all of which are connected to some degree with the activities undertaken by the OIE.

Additionally, the Second, Third and Fourth Review Conferences reaffirmed the Convention's coverage of analogues and 'artificially created microbial or other biological agents or toxins whatever their origin or method of production'.

Furthermore, the Third and Fourth Review Conferences expanded upon specific scientific activities which were inconsistent with the purposes of the Convention, most notably, 'experimentation involving open-air release of pathogens or toxins harmful to man, animals or plants that has no justification for prophylactic, protective or other peaceful purposes'.

Article III

In a continuance of the process to balance the security and developmental aspects of the BTWC, the Second and Fourth Review Conferences noted that the provisions proscribing the transfer of, encouragement or assistance to acquire, prohibited capabilities should not be used to impose restrictions and/or limitations on the transfer for purposes consistent with the objectives and the provisions of the Convention of scientific knowledge, technology, equipment and materials to States Parties.

The Third and Fourth Review Conferences affirmed that whilst the contracting parties of the BTWC are States, their obligations to enact domestic measures to ensure internal compliance with its aims and provisions effectively covered the activities of non-State actors. Thus, States Parties confirmed that the BTWC not only addressed the issue of bioterrorism, but established the primacy of the Convention in this regard by asserting that it 'is sufficiently comprehensive to cover any recipient whatsoever at international, national or sub-national levels'.

Article IV

In regards to national implementation, in an effort to establish mechanisms through which States Parties were complying with the Convention, the First, Second, and Third Review Conferences invited States Parties to make texts of relevant legislation, regulations and guidelines available to the UN. The Fourth Review Conference indicated that States Parties should, as necessary, review these measures to ensure compliance with the Convention. The Second, Third, and Fourth Review Conferences built upon this initiative by highlighting the utility of certain specific measures including:

– legislative, administrative and other measures designed to enhance domestic compliance with the Convention

– legislation regarding the physical protection of laboratories and facilities to prevent unauthorised access to and removal of microbial or other biological agents, or toxins

– inclusion in textbooks and in medical, scientific and military education programmes of information dealing with the prohibitions and provisions contained in the BTWC and the Geneva Protocol of 1925.

The Fourth Review Conference also highlighted the fact that by prohibiting all the steps necessary to build a biological or toxin weapon, the use of such weapons is effectively prohibited by the Convention.

Article V

The review conference process has seen the development of a procedure for undertaking consultation and cooperation under this article. During the history of the BTWC, this procedure has only been used once, in 1997, and has not been updated since. The most significant mechanism for ensuring consultation and cooperation is a Formal Consultative Meeting, during which efforts are made to resolve 'any problem which may arise in relation to the objective of, or in the application of the provisions of, the BTWC' (3).

Article VI

The collective efforts of the Review Conferences have also added a number of details to the procedure for conducting an investigation, under the BTWC, into alleged breaches of the obligations of the Convention. Mention was also made at the Third and Fourth Review Conferences of an alternative mechanism for investigating the alleged use of biological and toxin weapons, namely UN Security Council resolution 620 of 1988, which encouraged the UN Secretary-General to carry out prompt investigations, in response to allegations brought to his attention by any Member State concerning the possible use of chemical and bacteriological (biological) or toxin weapons. The Fourth Review Conference expanded upon this point by recalling the technical guidelines and procedures contained in Annex I of UN Document A/44/561 (24), which are designed to guide the UN Secretary-General on the timely and efficient investigation of reports of the possible use of such weapons.

Article VII

To date, no similarly detailed mechanism has been established for providing assistance to States Parties in the case of the alleged use of biological and toxin weapons, or for suspicious outbreaks of disease. Two clarifications were made at the Third and Fourth Review Conferences: firstly, that should a request for assistance be made, that 'it be promptly considered and an appropriate response provided' – and that there was to be a coordinating role in such an event for the UN, with the help of the appropriate intergovernmental organisations, such as the World Health Organization (WHO) (and although not specifically named presumably the OIE); and secondly, States Parties reserved the right to provide emergency assistance prior to a decision from the Security Council, should the need arise.

Article X

This article has the most additional understandings of all the articles included in the Final Declarations. Measures of particular note include:

– requesting States Parties to promote and enhance scientific and technological cooperation, including through the transfer and exchange of information, training of personnel and transfer of materials and equipment on a more systematic and long-term basis

– urging the UN to ensure that all of its means and institutional mechanisms were used to further the implementation of this article

– requesting the promotion of technology transfer, in particularly to developing countries

– stressing the need to ensure that the implementation of the article remains consistent with the aims and provisions of the BTWC

– States Parties providing information on how they are fulfilling their obligations under this article, as well as a subsequent request that all States Parties provide such information to the UN for collation and distribution on an annual basis

– calling for an enhancement to existing institutional means of ensuring multilateral cooperation, in such areas as medicine, public health and agriculture, and urging the UN to include the issue in the agendas of its relevant bodies

– the preparation by the UN of documents containing information and suggestions on the implementation of the article

– the establishment of a world data bank under the supervision of the UN for facilitating the flow of information in the field of genetic engineering, biotechnology and other scientific developments.

In addition, the Fourth Review Conference identified a number of specific activities which States Parties could undertake in respect to this article. These included:

a) transfer and exchange of information concerning research programmes in bio-sciences and greater cooperation in international public health and disease control

b) wider transfer and exchange of information, materials and equipment among States on a systematic and long-term basis, in relevant fields

c) active promotion of contacts between scientists and technical personnel on a reciprocal basis, in relevant fields

d) increased technical cooperation, including training developing countries in the use of bio-sciences and genetic engineering for peaceful purposes through active association with UN institutions, including the International Center for Genetic Engineering and Biotechnology

e) facilitating the conclusion of bilateral, regional and multiregional agreements that provide, on a mutually advantageous, equal and non-discriminatory basis, for their participation in the development and application of biotechnology

f) encouraging the coordination of national and regional programmes and working out, in an appropriate manner, the means of co-operation in this field

g) cooperation in providing information on their national epidemiological surveillance and data-reporting systems, and in providing assistance, on a bilateral level and/or in conjunction with the WHO, Food and Agriculture Organization (FAO) and OIE, regarding epidemiological and epizootical surveillance, with a view to improvements in the identification and timely reporting of significant outbreaks of human and animal diseases

h) the promotion of programmes for the exchange and training of scientists and experts, and the exchange of scientific and technical information in the biological field between developed and developing countries.

Confidence-building measures

Contained mostly within the consideration of Article V in the Final Declarations, there has emerged from the review conference process, a politically-binding mechanism to prevent or reduce the occurrence of ambiguities, doubts and suspicions, in order to improve international cooperation in the field of peaceful biological activities. This mechanism consists of a series of seven confidence-building measures (CBMs) (Table III), each of which requests that States Parties share certain types of information on an annual basis. The relevant details are submitted by States Parties to the UN Department for Disarmament Affairs by 15 April each year and are then distributed to other countries.

Table III
Confidence-building measures for the Biological and Toxin Weapons Convention

Confidence-building measure	Content
A	Exchange of data on research centres and laboratories, and declaration of national biological defence research and development programmes
B	Exchange of information on outbreaks of infectious diseases and similar occurrences caused by toxins
C	Encouragement for the publication of results and the promotion of the use of knowledge
D	Active promotion of contacts
E	Declaration of legislation, regulations and other measures
F	Declaration of past activities in offensive and/or defensive biological research and development programmes
G	Declaration of vaccine production facilities

Of the seven CBMs (A to G), measure B, the 'Exchange of information on outbreaks of infectious diseases and similar occurrences caused by toxins' may be of the most relevance to the OIE, and is designed to focus on 'all such events that seem to deviate from the normal pattern as regards type, development, place, or time of occurrence'. Some indicators as to what constitutes a deviation from a normal disease pattern are provided in the CBMs. These include:

– when the cause of the outbreak cannot be readily determined or the causative agent is difficult to diagnose

– when the disease may be caused by organisms which meet the criteria for risk groups III or IV, according to the classification in the 1983 WHO Laboratory Biosafety Manual

– when the causative agent is exotic to a given region

– when the disease follows an unusual pattern of development

– when the disease occurs in the vicinity of research centres and laboratories subject to exchange of data under measure A

– when suspicions arise of the possible occurrence of a new disease.

It is interesting to note that although the WHO classification of higher risk pathogens is utilised for human diseases, no similar mention is made of the OIE or the FAO classification mechanisms for plant and animal pathogens. As there is no internationally agreed definition of what would constitute an unusual event, States Parties agreed 'to utilise fully existing national reporting systems on human diseases as well as animal and plant diseases, where possible'. Although specific mention is made to the work of the WHO in relation to human diseases in this measure, no similar details are provided for the OIE.

VEREX and the 1994 Special Conference

Supplementary to the additional understandings discussed above, there have been other, more formal, efforts to strengthen the Convention. As discussed previously, since the early stages of the negotiations to develop the Convention, there have been discussions as to the feasibility and merits of developing a verification mechanism. States Parties reached consensus on the value of assessing the technical feasibility of verification at the Third Review Conference, when it agreed to establish VEREX. VEREX held four meetings during 1992 and 1993, all of which were chaired by Tibor Toth, Hungarian Ambassador to the UN in Geneva, who was to play a central role in efforts to strengthen the BTWC for the next decade.

VEREX identified twelve off-site and nine on-site potential verification measures (Table IV) and the final report evaluated each of these (4). The conclusions reached by VEREX prompted the States Parties to assert that '…from the scientific and technical standpoint… some of the potential verification measures would contribute to strengthening the effectiveness and improve the implementation of the Convention, also recognising that appropriate and effective verification could reinforce the Convention'.

This assertion motivated the majority of States Parties to request the Depositary Governments to take the necessary steps to convene a Special Conference of States Parties to decide upon further action. This Special Conference, 19 to 30 September 1994, was once more chaired by Ambassador Toth, and came to the conclusion that there was indeed scope to strengthen the Convention but that '…the complex nature of the issues pertaining to the strengthening of the BTWC underlined the need for a gradual approach towards the establishment of a coherent regime to enhance the effectiveness of and improve compliance with the Convention'.

To accomplish this task, the Special Conference established the Ad Hoc Group of States Parties to the Convention (AHG), which was mandated '…to consider appropriate measures including possible verification measures, and draft proposals to strengthen the Convention, to be included as appropriate in a legally binding instrument to be submitted for the consideration of the States Parties. In this context, the AHG shall, *inter alia*, consider:

– definitions of terms and objective criteria such as lists of bacteriological (biological) agents and toxins, their threshold quantities, as well as equipment and types of activities where relevant for specific measures designed to strengthen the Convention

– the incorporation of existing and further enhanced confidence-building and transparency measures as appropriate into the regime

– a system of measures to promote compliance with the Convention including, as appropriate, measures identified, examined and evaluated in the VEREX Report. Such measures should apply to all relevant facilities and activities, be reliable, cost-effective, non-discriminatory and as non-intrusive as possible, consistent with the effective implementation of the system and should not lead to abuse

– specific measures designed to ensure effective and full implementation of Article X, which also avoid any restrictions incompatible with the obligations undertaken under the Convention, noting that the provisions of the Convention should not be used to impose restrictions and/or limitations on the transfer for purposes consistent with the objectives and provisions of the Convention of

scientific knowledge, technology, equipment and materials.'

The Ad Hoc Group of States Parties to the Convention

The AHG interpreted this mandate as an effort to develop a Protocol to strengthen the Convention. By the end of its deliberations, the AHG was developing a nascent regime comprised of a range of elements, including the following:

– legally-binding declarations to replace the CBMs

– detailed national implementation measures to support Article IV of the Convention

– more comprehensive clarification and investigation mechanisms to supplement Articles V and VI of the BTWC

– additional measures for assistance and protection against biological and toxin weapons, developing Article VII of the Convention

– additional developments for Article X of the BTWC in the form of technical cooperation and scientific and technological exchange for peaceful purposes

– an international organisation for implementing, as well as supporting and assisting States Parties in ensuring the efficiency of the Protocol.

During the course of the negotiations, which ran from 4 January 1995 to 17 August 2001, a text for a proposed Protocol was compiled from proposals made by States Parties. This document, entitled 'A Rolling Text of a Protocol to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction' (referred to hereafter as the Rolling Text), was to become the basis of future negotiations and was to be much amended, updated and altered throughout the AHG process. As the Fifth Review Conference drew closer, it became apparent that consensus on the Rolling Text would not be forthcoming. As a result, the Chairman took the step of releasing a 'clean' text of a possible Protocol, 'containing his compromise suggestions on all outstanding issues' (6). This document became known as the Composite (or Chairman's) Text, the contents of which are summarised in Table V. Despite reservations as to the precise content of some of the text, there were indications from a range of States Parties that it would be possible to work with this new text.

At the final session of the AHG, however, it was still not entirely clear that all States Parties had agreed upon the Composite Text as the basis of a future Protocol, with a number of States indicating a preference for continuing efforts with the Rolling Text. With States Parties being encouraged to provide any alterations they wished to see made to the Composite Text in writing, the records show

Table IV
Potential on-site and off-site verification measures identified by the VEREX process to strengthen the Biological and Toxin Weapons Convention

Off-site measures	On-site measures
Information monitoring	Exchange visits
Surveillance of publications	International arrangements
Surveillance of legislation	Continuous monitoring
Data on transfers and transfer requests and on production	By instruments (including ground-based surveillance)
Multilateral information sharing	By personnel
Exchange visits	Inspections
Declarations	Interviewing
Declarations (including notifications, data on transfers and transfer requests and on production)	Visual inspections (including observation and surveillance by aircraft)
	Identification of key equipment
Remote sensing	Auditing
Surveillance by satellite	Sampling and identification
Surveillance by aircraft	Medical examination
Ground-based surveillance	
Inspections	
Sampling and identification	
Observation	
Auditing	

VEREX: Ad hoc Group of Governmental Experts, open to all States Parties, to Identify and Examine Potential Verification Measures from a Scientific and Technical Standpoint

Table V
Elements of the draft Protocol to the Biological and Toxin Weapons Convention (agreement was not reached among States Parties and the Protocol was not adopted)

Element	Title
Article 7	Measures to strengthen the implementation of Article III of the Convention
Article 8	Consultation, clarification and cooperation
Article 9	Investigations
Article 10	Additional provisions on declarations, visits and investigations
Article 11	Confidentiality provisions
Article 12	Measures to redress a situation and to ensure compliance
Article 13	Assistance and protection against bacteriological (biological) and toxin weapons
Article 14	Scientific and technological exchange for peaceful purposes and technical cooperation
Article 15	Confidence-building measures
Article 16	The organisation
Article 17	National implementation measures

that even those States Parties which were happy to work with it realised there was still some distance to go before a text of a Protocol would exist, a challenge compounded by the mandate which specified that the output of the AHG had to be agreed by consensus – disagreement by a single State Party would be sufficient to prevent the creation of a Protocol.

On 25 July 2001 a State Party, the USA, indicated it would not be able to support the proposed text and added that it could envisage no changes or alterations which would alter this position. This declaration effectively precluded consensus and prevented the AHG from completing its mandate. As the number of outstanding issues on the table (and the still debatable acceptance of the Composite Text as the basis of negotiations) indicates, it is not clear that consensus could have been reached, even if the USA had supported the text. Following the US statement, efforts turned to the report the AHG was due to make to the Fifth Review Conference. During discussions on the content of this report, it was proposed that this document should be based around an unambiguous statement that the AHG had been unable to fulfil its mandate. Disagreements emerged as to whether this statement should specifically name the State Party involved. It proved impossible to resolve this issue during the remaining time and the AHG closed without a final report, marking the end of almost a decade of activities to develop a Protocol for the BTWC (21).

The nascent regime being developed by the AHG (as represented both in the Rolling Text and Chairman's Text), in line with the additional understandings discussed above, was to cover humans, animals and plants. Of particular note regarding animal diseases, was the inclusion within the lists of relevant agents and toxins of a section devoted to animal disease pathogens, including (7):

– African swine fever virus
– African horse sickness virus
– bluetongue virus
– foot and mouth disease virus
– Newcastle disease virus
– rinderpest virus.

It was also asserted that pathogens causing zoonotic diseases appearing in the section on human and zoonotic pathogens should also appear in the section on animal pathogens, and vice versa. Thus the list of animal disease pathogens also included such microbes as *Bacillus anthracis, Brucella* sp., *Burkholderia* sp., monkeypox virus, equine encephalomyelitis viruses (both Venezuelan and Western), *Yersinia pestis* and *Coxiella burnetii*.

The inclusion of animal diseases on this list would have had profound implications had the Protocol entered into force, as it would have necessitated annual declarations of any facility which had produced large quantities of; genetically manipulated; inserted into another organism genetic material from; or aerosolised any of these agents. In addition, annual declarations would also have been required detailing production facilities for animal vaccines. The Protocol organisation would also have been mandated to investigate suspicious outbreaks of disease – those which fell outside expected disease events but for which there was no obvious deliberate origin, as well as alleged attacks with such agents.

The Protocol specifically mentioned the OIE. Had it entered into force, the implementing organisation would have established a formal relationship with the OIE. To date, no formal memorandum of understanding has been developed (mainly due to the institutional shortcomings of the BTWC regime), however, the OIE has a long history of making constructive contributions to the various processes initiated by the Convention (see next section). In addition, the Executive Council of the organisation to support the Protocol, when taking a decision to investigate suspicious outbreaks of disease reserved the right to seek information about these outbreaks from the relevant intergovernmental organisations; the indicative list of which specifically mentions the OIE.

The Fifth Review Conference and the follow-up process

The Fifth Review Conference of the Convention took place in two stages: 19 November to 7 December 2001 and 11 to 22 November 2002. It marked a change of direction in efforts to strengthen its efficiency in preventing the weaponisation of disease. It marked a shift away from the formal Cold-War era arms control treaties towards a more holistic, synergistic approach for the contemporary security environment. This section examines the series of meetings mandated, in 2002, to address specific elements in the period leading up to the Sixth Review Conference in 2006. These meetings became known as the follow-up process.

The Fifth Review Conference

The failure of the AHG to produce a report produced several procedural complications for the Fifth Review Conference and resulted in the emergence of divergent views as how best to proceed with the review of the elements within the Convention under which efforts to strengthen it are pursued. Whilst significant progress was made in other areas, such as the review of relevant scientific and technological developments, it became clear towards the end of the allotted three weeks that no agreement on the outstanding issues would be forthcoming and as a result there was a strong possibility that it would not be possible to adopt a Final Declaration. To facilitate further discussions on the possible outcome of the Review Conference, its President, Ambassador Tibor Toth, suspended the meeting until November 2002.

During the course of numerous bilateral, plurilateral and informal preparatory meetings in anticipation of the resumed Review Conference, it became clear that consensus on the content of a Final Declaration would still not be forthcoming. During this process, there emerged out of necessity a radical proposal for an outcome different in format and substance to those previously adopted. The President eventually tabled a draft decision document at the start of the resumed session (8). This draft, according to analysts, 'was not a document to be discussed, debated, revised and negotiated' (19). With no other alternatives on the table, it was eventually adopted as the substantive outcome of the Fifth Review Conference, but opinions as to its comprehensivity were mixed. The Western Group (WG) (a regional group of States Parties to the BTWC, largely comprised of developed States) issued a statement welcoming its adoption (11). The Group of the Non-Aligned Movement and Other States (NAM) (a regional group largely comprised of developing States) issued a statement to the effect that whilst they had 'gone along with' the decision, they felt it possessed 'limited goals' (10).

The decision, as included in the Final Document of the Fifth Review Conference, mandated a series of annual Meetings of States Parties from 2003 until 2005 (9). It established that each Meeting of States Parties would be of one week's duration and be preceded by a two week Meeting of Experts. Furthermore, the decision stated that these meetings were 'to discuss, and promote common understanding and effective action on' specific topics. The 2003 meetings were to address 'the adoption of necessary national measures to implement the prohibitions set forth in the Convention, including the enactment of penal legislation and national mechanisms to establish and maintain the security and oversight of pathogenic microorganisms and toxins'. The 2004 meetings were to address 'enhancing international capabilities for responding to, investigating and mitigating the effects of cases of alleged use of biological or toxin weapons or suspicious outbreaks of disease and strengthening and broadening national and international institutional efforts and existing mechanisms for the surveillance, detection, diagnosis and combating of infectious diseases affecting humans, animals, and plants'. The 2005 meetings were to address the sole topic of 'the content, promulgation, and adoption of codes of conduct for scientists'. It was also decided that these meetings would operate on the principle of consensus, that they would prepare factual reports describing their work and that their work would be considered by the Sixth Review Conference.

The 2003 Meetings

It had been established at the Fifth Review Conference that each of the meetings would be chaired in turn by representatives of the Eastern Group, the NAM and the WG respectively, this first set of meetings was chaired by Ambassador Tibor Toth. At the Meeting of Experts, from 18 to 29 August 2003, the topics under discussion were dealt with one after the other – with national implementation being dealt with in the first week and the security and oversight of pathogens and toxins in the second. The Secretariat of the meeting compiled a large quantity of data on the two topics under consideration. This was distributed to States Parties electronically in the form of an Information Repository. The information repository included useful background information, such as the OIE *Terrestrial Animal Health Code, Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Aquatic Animal Health Code* and *Manual of Diagnostic Tests for Aquatic Animals.*

The two topics under consideration were broken down into a number of issues. Each issue was the focus of a working session. The meeting heard a large number of statements, presentations and contributions on these issues, which were collected and collated by the Secretariat and made available to those participating in the meeting on

a daily basis. The results of the meeting, in the form of these daily collations, were transmitted to the Meeting of States Parties by being annexed to the Report of the meeting (12). The OIE contributed a detailed paper to this meeting, entitled 'The Role of the OIE in the Fight Against Bioterrorism'. This paper laid out the principle missions of the OIE and explained how theses aims related to the topics under discussion. It went on to outline the structure of the OIE and the roles of the various constituent bodies. Finally, the OIE recommended to the meeting that:

– effective planning for responses to an exotic disease incursion should accord wildlife the same degree of attention that is now given solely to domestic livestock

– interdisciplinary and international efforts to increase the surveillance and identification of disease pathogens and to improve mechanisms for interagency and intergovernmental cooperation and collaboration would be necessary to combat the threat of disease agents likely to be used as bioweapons

– national preparedness for the possible incursion of exotic diseases must include the assembly of up-to-date information on the population size, demography and susceptibility of indigenous wild animal species and should include the development of feasible procedures for the early recognition and diagnosis of a disease outbreak, the subsequent prevention of disease transmission between wildlife and domestic livestock and the spread of disease within wild animal populations

– a national consultative network of wildlife expertise should be created and deployed in order to develop a range of techniques that could be used to reduce the risk of the transmission of disease from livestock to wildlife (or vice-versa) in the event of an exotic disease outbreak.

The Meeting of States Parties, 10 to 14 November 2003, was structured slightly differently, as the topic of national implementation was broken down into issues of: 'Incorporation of the Prohibitions Contained in Article I of the Convention, including the Enactment of Penal Legislation; Licensing; and Enforcement'. The security topic was broken down into: 'Biosecurity Evaluation and Implementation of Biosecurity Procedures; Identification and Licensing/ Registration'; and 'Efforts by Relevant International Bodies'. In a similar format to the Meeting of Experts, however, statements, presentations and contributions were collected and collated, made available on a daily basis and were also annexed to the report of the meeting (13). After considering all of these issues, the States Parties agreed upon the value of:

– '…review[ing], and where necessary, enact[ing] or updat[ing] national legal, including regulatory and penal, measures which ensure effective implementation of the prohibition of the Convention, and which enhance effective security of pathogens and toxins.

– The positive effect of cooperation between States Parties with differing legal and constitutional arrangements. States Parties in a position to do so may wish to provide legal and technical assistance to others who request it in framing and/or expanding their own legislation and controls in the areas of national implementation and biosecurity.

– The need for comprehensive and concrete national measures to secure pathogen collections and the control of their use for peaceful purposes. There was a general recognition of the value of biosecurity measures and procedures, which will ensure that such dangerous materials are not accessible to persons who might or could misuse them for purposes contrary to the Convention'.

The 2004 Meetings

The 2004 meetings were chaired by Peter Goosen from South Africa, who was appointed by the NAM. The Meeting of Experts was held from 19 to 30 July 2004, but before it even began, the Chairman 'encourage[d] States Parties to… focus their preparations for the meeting of experts on… what the States Parties can agree to do' (20).

The Secretariat produced three background papers for the meeting covering:

– mechanisms being implemented for disease surveillance by intergovernmental organisations and significant mechanisms being implemented for disease surveillance by non-governmental organisations (NGOs) (15)

– mechanisms being implemented for response to outbreaks of disease by intergovernmental organisations (16)

– mechanisms available to States Parties to investigate the alleged use of biological or toxin weapons and to provide assistance in such cases (14).

Unsurprisingly, the first two papers covering intergovernmental disease surveillance and response mechanisms were developed in close concert with the WHO, the OIE and the FAO, who provided a great deal of the information and were active in ensuring that these papers best represented their activities. In addition to contributing to these papers, all three organisations were active during the meeting: the WHO made a presentation entitled 'Epidemic alert and response', the International Plant Protection Convention (IPPC) presented a paper entitled 'Current mechanisms for pest surveillance, monitoring and outbreak response under the IPPC', the FAO gave a presentation on the 'Emergency prevention system for transboundary animal and plant pests and diseases' and the OIE presented a paper entitled 'The challenge of international biosecurity: the OIE standards and FAO/OIE actions'.

Tasking the Secretariat to develop substantive papers in this manner was one of the new developments that evolved from these meetings. The approach provided delegations with a great deal of descriptive information, designed specifically to facilitate their discussions. The papers proved to be a success and a number of States Parties expressed their appreciation.

In a similar style to that adopted in 2003, the topics were broken down into a number of issues (Table VI) and working sessions were set aside to specifically address them. During these sessions States Parties and invited organisations made presentations and statements on these issues. Other sessions were set aside for general statements, briefings from international organisations (made by the WHO, FAO and OIE), and a discussion of the report of the meeting.

The deliberations of the meeting were summarised in a listing of the considerations, lessons, perspectives, recommendations, conclusions and proposals developed by the Chairman. This document was annexed to the report of the meeting (17). It contained ten recommendations by the WHO, OIE and FAO (Table VII).

The Chairman opted to begin his preparation for the Meeting of States Parties early in the interim period. On 23 September 2004, he wrote to States Parties highlighting seven areas for each of the two topics (i.e. strengthening institutional mechanisms to detect infectious diseases and enhancing capabilities for responding to the alleged use of biological and toxin weapons), under which the statements, proposals and interventions from his list could be grouped.

Table VI
Numbers of statements, presentations and interventions made under different issues considered at the 2004 Meeting of Experts of the Biological and Toxin Weapons Convention

Issue	Number
General surveillance, detection, diagnosis and combating of infectious diseases	15
Surveillance, detection, diagnosis and combating of infectious diseases affecting humans	47
Surveillance, detection, diagnosis and combating of infectious diseases affecting animals	28
Surveillance, detection, diagnosis and combating of infectious diseases affecting plants	9
Outbreak response in/for humans	57
Outbreak response in/for animals	16
Outbreak response in/for plants	5
Investigations	36

In a further letter to States Parties, dated 30 October 2004, the Chairman provided a synthesised version of the lists of statements, proposals and interventions which he stressed '…continue[d] to be based on the presentations, statements, working papers and interventions made by delegations, and does not include any new ideas. All that has been done is to remove repetitions and merge similar concepts'.

This cut the document from 35 pages down to 6. In this document, the two topics were each broken down into the seven areas identified in the Chairman's letter of 23 September 2004. The consideration of each of these areas contained a general paragraph followed by three or four specific actions drawn from the annex to the 'Report of the Meeting of Experts'. This document was successful in prompting discussion during the Meeting of States Parties, 6 to 10 December 2004.

Once again, intergovernmental organisations made valued contributions to the meeting. The FAO presented a paper entitled 'Food and Agriculture Organization of the United Nations', the OIE presented 'The challenge of international biosecurity and the OIE standards and actions', and the WHO presented 'Preparedness for deliberate epidemics – WHO Approach'.

The outcome of the meeting was to provide a number of common understandings, as well as agreeing upon the value of a number of effective actions for the two topics under consideration. In regard to the strengthening and broadening of national and international institutional efforts and existing mechanisms for the surveillance, detection, diagnosis and combating of infectious diseases affecting humans, animals, and plants, the States Parties recognised that:

a) infectious disease outbreaks can be contained and suppressed through early-detection, immediate response and cooperation and support at the national and international level

b) strengthening and broadening national and international mechanisms for the surveillance, detection, diagnosis and combating of infectious disease could support the object and purpose of the Convention

c) the primary responsibility for the surveillance, detection, diagnosis and combating of infectious diseases rests with States Parties, while the WHO, FAO and OIE have global responsibilities, within their mandates, in this regard. The respective structures, planning and activities of States Parties and the WHO, FAO and OIE should be co-ordinated with, and complement, one another

d) scientific and technological developments have the potential to significantly improve disease surveillance and response.

Table VII
Recommendations made by the Food and Agriculture Organization (FAO), World Organisation for Animal Health (OIE) and World Health Organization (WHO) at the 2004 Meeting of Experts of the Biological Weapons Convention

Recommendations
Effective global biosecurity can only be achieved if all OIE and FAO Member Countries conscientiously comply with the standards and guidelines of the OIE, effectively train stakeholders and ensure the availability of adequate human and material veterinary resources
An improvement in the quality and efficiency of Member Countries' Veterinary Services will guarantee vigilance in disease monitoring, surveillance, detection and early warning, and will ensure a timely and rapid response to any emergency
The WHO's surveys of military health programmes should be enhanced for use as potential public health resources
Enhanced harmonisation with other global players is needed (including the World Trade Organization, the United Nations High-Commissioner for Refugees, the International Civil Aviation Organization, the European Union, the Group of 7, Médecins Sans Frontières, the International Federation of the Red Cross and Red Crescent Societies, the International Air Transport Association, the International Maritime Organization, the World Trade Association, the International Federation of Pharmaceutical Manufacturers and Associations, etc.)
Global alert and response operations (are) required
The importance of healthy animals for food production and public health needs to be brought to the attention of relevant ministries and prioritised so that a long term commitment to this public good is achieved
The OIE standards designed to control disease and to prevent the introduction of pathogens should be used as a basis for the harmonisation of legislation
With regard to surveillance and the prompt notification of diseases (including zoonoses) of domestic livestock and wild animals, OIE and FAO Member Countries should comply with OIE guidelines, standards and recommendations and with the principles of the FAO 'Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases'
Many countries share a common concern about the natural occurrence or deliberate misuse of biological pathogens that could affect public health, food and animal production. Existing methods of disease prevention and containment, regulations, international guidelines and standards should be further extended at both national and international levels to improve the ability of countries to prevent, manage and recover from natural, accidental or deliberate introduction of animal diseases. In this regard there are, at present, substantial differences amongst countries in the perception of the national threat from the deliberate use of pathogenic biological agents. These differences should be addressed
The OIE guidelines relating to the biosecurity of laboratories (which are based on expertise provided from researchers in human and animal health) are recommended for the safe management of biological agents used in those laboratories

States Parties consequently agreed on the value of:

a) supporting the existing networks of relevant international organisations for the surveillance, detection, diagnosis and combating of infectious diseases and acting to strengthen the WHO, FAO and OIE programmes, within their mandates, for the continued development and strengthening of, and research into, rapid, effective and reliable activities for the surveillance, detection, diagnosis and combating of infectious diseases, including in cases of emergencies of international concern

b) improving, wherever possible, national and regional disease surveillance capabilities, and, if in a position to do so, assisting and encouraging, with the necessary agreement, other States Parties to do the same

c) working to improve communication on disease surveillance, including with the WHO, FAO and OIE and among States Parties.

In regards to enhancing international capabilities for responding to, investigating and mitigating the effects of cases of alleged use of biological or toxin weapons or suspicious outbreaks of disease, the States Parties recognised that:

a) capabilities for responding to, investigating and mitigating the effects of cases of alleged use of biological or toxin weapons or suspicious outbreaks of disease promote the object and purpose of the Convention

b) the national preparedness of States Parties substantially contributes to international capabilities for responding to, investigating and mitigating the effects of cases of alleged use of biological or toxin weapons or suspicious outbreaks of disease

c) the Secretary-General's investigation mechanism (set out in a report by the Secretary-General to the 1989 General Assembly [A/44/561] and endorsed the following year by resolution A/Res/45/57 [25]) is an international institutional mechanism for investigating cases of alleged use of biological or toxin weapons.

States Parties consequently agreed on the value of:

a) continuing to develop their own national capacities for response, investigation and mitigation, in cooperation with the relevant international and regional organisations, and, if in a position to do so, assisting and encouraging, with the necessary agreement, other States Parties to do the same

b) the Sixth Review Conference considering, *inter alia*, the further development of current procedures for the provision of assistance, by those in a position to do so, to States Parties in cases of alleged use of biological weapons or suspicious outbreaks of disease.

Both the full list of statements, proposals and interventions from the Meeting of Experts and the synthesised list were annexed to the Report of the Meeting of States Parties (18).

The 2005 Meetings

The Chairman for the 2005 meetings, Ambassador John Freeman from the UK, appointed by the WG, wrote to States Parties on 24 March 2005 highlighting that due to the nature of the topic under discussion (codes of conduct for scientists), it would be necessary '…to hear from all those considering the issue of codes of conduct… States Parties; International Organisations; NGOs; and other organisations outside government (be it in academia, industry or science's professional bodies) whose work or interest is relevant, or could be impacted, by our discussions'. To this end, the Chairman invited States Parties to inform him of organisations which were felt to be relevant to their deliberations. In total, the Chairman invited around 50 organisations to participate, 23 of which attended.

The Meeting of Experts, 13 to 24 June 2005, once again benefited from substantive documents prepared by the Secretariat. The meeting included presentations by States Parties, international organisations, and government scientists and expert contributions from universities, donors, industry, research institutions and professional bodies. Following on from the previous years meeting and at the request of the Chairman, the Secretariat collated the considerations, lessons, perspectives, recommendations, conclusions and proposals drawn from the presentations, statements, working papers and interventions. These were annexed to the report of the Meeting of Experts.

The OIE provided a substantive presentation on its relevant activities. This detailed the mission of the OIE and its international relationships, and outlined a variety of its standards in the light of codes of conduct, including: disease reporting; preventing disease transmission through trade; security and biosafety of pathogens; and reference laboratories and collaborating centres. The OIE also provided details of a proposed new initiative entitled 'Technical standards for regulation of biotechnology-derived animals or animal products'.

The Meeting of States Parties will take place in the Palais des Nations in Geneva from 5 to 9 December 2005. Although it is unlikely this meeting will attempt to develop either a framework for, or the content of, a code of conduct, it is hoped that in a format similar to previous years, it will highlight common elements of understanding and the value of future activities on the content, promulgation and adoption of codes of conduct for scientists.

Conclusions

The BTWC dates back to the middle years of the twentieth century; it is the original disarmament treaty banning an entire class of weapons and from the outset was intended to ensure the biological sciences are utilised solely for the benefit of mankind. It expands upon long-standing norms against the weaponisation of disease and embodies the abhorrence felt over the malign use of biological and toxin agents. The Convention encapsulates the long-running debate over the correct balance between scientific freedom and security concerns and has successfully ensured that such a balance has been maintained to date. It relies not only on the continued dedication of States Parties but also on the commitment shown by intergovernmental organisations, specialised agencies, NGOs, industry and the general public. It remains, ultimately an instrument constructed for the benefit of all, designed for the sake of all mankind, to exclude completely the possibility of bacteriological (biological) agents and toxins being used as weapons. It is based upon the conviction that such use would be repugnant to the conscience of mankind and that no effort should be spared to minimise this risk.

The history of the BTWC, as summarised in this work, highlights a number of issues of which we need to be aware and to be able to pass on to others, including that:

– the BTWC prohibits the development, production, stockpiling, acquisition or retention of microbial or other biological agents or toxins harmful to plants and animals, as well as humans, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes

– the provisions of the BTWC regulate intent and do not proscribe specific resources, research, activities or processes

– the terms of the BTWC cover all actors whatsoever at the international, national and sub-national levels

– the obligation of complying with the provisions of the BTWC lies ultimately with the individual

– the CBMs are important as annual declarations facilitating transparency and trust amongst States Parties, especially through the exchange of information on outbreaks of infectious diseases and similar occurrences caused by toxins

– there are benefits to ensuring the existence of effective measures to implement the BTWC, to protect laboratories and facilities handling agents or toxins covered by the Convention, and educating health professionals, scientists and the military about the prohibitions and provisions of the 1925 Geneva protocol and the BTWC

– the OIE could play a coordinating role in any response to the alleged use of such agents or toxins or suspicious outbreaks of disease.

It is clear that States Parties must continue to work together to:

– support the efforts of international organisations (including the OIE) in the surveillance, detection, diagnosis and combating of infectious disease

– strengthen WHO, FAO and OIE programmes

– improve, wherever possible, national and regional disease surveillance capabilities

– improve communication on disease surveillance, including communication with the OIE.

The history discussed here illustrates that the objectives and provisions of the BTWC remain as valid today as when they were drafted over thirty years ago. There has been a long and enthusiastic record of efforts to strengthen the Convention. Some of these labours have proven fruitful whilst others have been useful in highlighting alternative paths to development. It is clear that the BTWC underwent a profound conceptual shift in 2001, but the process of metamorphosis is coming to an end; having shed, caterpillar-like, its Cold War history and undergone a lengthy and difficult pupation, it is emerging butterfly-like to address the security concerns of the twenty-first century.

■

La Convention sur l'interdiction des armes biologiques et à toxines

P.D. Millett

Résumé

La Convention sur l'interdiction de la mise au point, de la fabrication et du stockage des armes bactériologiques (biologiques) ou à toxines et sur leur destruction interdit la mise au point, la production, l'achat, le transfert, le stockage et l'utilisation d'agents microbiens ou autres agents biologiques ou toxiniques non justifiés par des visées prophylactiques, protectrices ou toute autre visée pacifique. Elle interdit également les armes, le matériel ou les dispositifs destinés à utiliser ces agents ou toxines à des fins hostiles ou dans le cadre de conflits armés. Elle porte sur les armes biologiques et à base de toxines dirigées contre l'homme, les animaux et les végétaux. L'article brosse un court historique de la Convention et décrit succinctement ses cinq Conférences d'examen, le « Groupe spécial d'experts gouvernementaux, ouvert à tous les États Parties, chargé de définir et d'étudier du point de vue scientifique et technique les mesures de vérification éventuelles » (généralement appelé VEREX), enfin, les activités du groupe spécial visant à élaborer un instrument

juridiquement contraignant pour renforcer la Convention, ainsi que les réunions annuelles des experts et des États Parties qui ont eu lieu ces trois dernières années. Les questions qui présentent un intérêt particulier pour l'Organisation mondiale de la santé animale (OIE) sont soulignées, témoignant de son action prolongée et fructueuse en faveur d'une utilisation de la science vétérinaire au service des intérêts de l'humanité.

Mots-clés
Arme biologique – Bioterrorisme – Désarmement – Intoxication – Loi internationale – Maladie résultant d'un acte délibéré – Nations unies – Non prolifération – Protocole de Genève.

La Convención sobre armas biológicas y toxínicas

P.D. Millett

Resumen
La "Convención sobre la prohibición del desarrollo, la producción y el almacenamiento de armas bacteriológicas (biológicas) y toxínicas y sobre su destrucción" prohíbe concebir, fabricar, adquirir, transferir, almacenar y utilizar agentes microbianos o biológicos en general, así como toxinas, sin que esté justificado por motivos de profilaxis, protección u otros fines pacíficos. También prohíbe las armas, el material o los medios destinados a liberar tales agentes o toxinas con fines hostiles o en el curso de un conflicto armado. Ese instrumento normativo se aplica a todo tipo de armas biológicas o toxínicas contra el ser humano, los animales y los vegetales. Tras repasar brevemente la historia de la Convención y sus cinco conferencias encargadas del examen del texto, el autor describe también el 'Grupo Ad Hoc de expertos gubernamentales, abierto a todos los Estados Partes, para definir y estudiar posibles medidas de verificación desde un punto de vista científico y técnico' (conocido habitualmente como el VEREX) y los esfuerzos de este grupo por elaborar un instrumento jurídicamente vinculante que refuerce la Convención, así como las reuniones anuales de expertos y Estados Partes que se han venido celebrando en los últimos tres años. A lo largo del artículo el autor va indicando los temas que revisten especial interés para la Organización Mundial de Sanidad Animal (OIE) y poniendo de relieve su dilatada y fructífera contribución para intentar que la ciencia veterinaria sea utilizada exclusivamente en beneficio de la humanidad.

Palabras clave
Arma biológica – Bioterrorismo – Derecho internacional – Desarme – Enfermedad de origen intencionado – Envenenamiento – Naciones Unidas – No proliferación – Protocolo de Ginebra.

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Misperceptions in preparing for biological attack: an historical survey

M. Furmanski

Arms Control Center Scientists' Working Group on Biological and Chemical Weapons, 1333 Beachmont Street, Ventura, CA 93001, United States of America

Summary

Preparing for a biological attack involves analysing and co-ordinating information and events in the scientific, political and social arenas. The information that must be evaluated is, by definition, incomplete. It is not surprising that such interactions have regularly resulted in erroneous conclusions and flawed interventions. This historical survey examines instances where significant errors have occurred. The author describes several examples in each of three broad categories: misapprehensions of the risk of biological attack; misappraisals of an anomalous event as a biological attack; and misadventures in pre-emptive action to protect against a biological attack. The study identifies significant common elements in each of these errors that may be useful in avoiding future mistakes. In evaluating the effects of these errors, the study concludes that such mistakes often increase the dangers that they seek to avoid.

Keywords

Anthrax – Biological weapons – Botulinum toxoid – Disinformation – Germ warfare – History – Immunisation – Military medicine – Misinformation – Misperception – Propaganda – Smallpox – Vaccine – Yellow fever – Yellow rain.

Introduction

Biological scientists are sometimes asked to advise political policy-makers on the appropriate responses to threats of biological attack. Such decisions can only partly depend on orthodox biology, in which established scientific principles are applied to reliable data. The science applied to possible biological attack is, of necessity, somewhat tentative. Empirical field data on biological attacks are scarce, laboratory experience does not reliably translate into field behaviour, and many hypotheses on the sequelae of biological attacks must be speculative. Equally importantly, biological attacks and the threat of attack are political as well as biological events. History demonstrates that political perceptions play an important role in decisions on the magnitude of the threat.

In this paper, the author surveys a number of episodes in which science and politics were deciding factors in assessing the threat of biological attack. Since both the scientific and political aspects of any attack involve much uncertainty, it is not surprising that significant errors have occurred. These errors will be examined as 'cautionary tales'.

This paper will address three broad areas of scientific/political interaction:

– estimating the risk of a biological attack

– evaluating whether an outbreak is the result of a biological attack

– taking pre-emptive measures to counter the threat of a biological attack.

Since examples involving animal diseases are rare, this survey will rely on the more plentiful examples involving human disease.

Global misapprehensions in risk evaluation

The specific nature and probability of biological attacks are crucial elements in all decisions on possible attack. On four occasions, major powers have mistakenly concluded that an adversary posed a risk of using biological weapons when, in fact, no such risk existed.

These conclusions were by no means unreasonable. In each case, the adversary had a 'suspect history'. In each case, the adversary used force to promote basic policy. In the case of 'suspect' countries, each had previously developed and used chemical weapons in violation of international law, and already had a biological weapons capability. Unfortunately, such misapprehensions have not been harmless and cannot be accepted uncritically as 'erring on the side of caution'. They have diverted vital scientific resources, both human and economic, from actual threats of natural disease, and have had the paradoxical effect of increasing, rather than decreasing, the risk of biological warfare (BW).

One important element in these global failures of risk evaluation is that, in each case, the most important intelligence indicating a BW programme came from sources that were ultimately proved to be deliberately fabricated. In two cases, pivotal information came from émigrés who invented evidence that a regime they opposed actually held biological weapons. In another instance, a 'friendly' agent apparently made a biological attack on his or her own country to raise the level of concern and stimulate defensive measures. Such agents may be termed 'alarmist hoaxers'. In two cases, a government disseminated erroneous 'incriminating' information on its own capability as part of a disinformation or psychological warfare campaign. Important supporting fabrications have been created by opportunists who wish to profit by producing marketable espionage information.

The misapprehension of a German biological warfare threat during World War II

In World War I, Germany had initiated both chemical and biological warfare in violation of existing arms control treaties. When Nazi Germany re-armed, it withdrew from arms control negotiations and the League of Nations, and soon made territorial demands on its weaker neighbours. It was clearly a suspect regime.

The governments of France, Britain, Canada and the United States of America (USA) eventually concluded that Germany had pursued a biological weapons programme since the early 1930s. As a direct consequence, these countries established or expanded their own biological weapons programmes. However, in reality, Hitler had forbidden any development of offensive biological weapons. In fact, the German BW programme was insignificant and posed no threat to the Allies (30).

A central event in the Allied conclusion that Germany was developing biological weapons occurred in 1934, when Wickham Steed, a respected British investigative journalist and one-time editor of *The Times*, published a series of allegations on the subject (79). These allegations were based on documents supplied by an anti-Nazi German émigré. The documents were claimed to be German military reports from 1931 to 1933, describing an active BW programme, both before and after the rise of Hitler. These papers also reported the results of alleged German field trials in the subway system of Paris in August 1933. (These trials apparently used *Serratia marcescens*, a bacterium then commonly used to trace airborne microbial contamination, which was considered harmless at the time.) Steed appeared convinced of the validity of the documents, and shared them with British intelligence before publication (35).

Investigators have always felt that, because of internal scientific blunders, all or some of the Paris subway data were likely to have been fabricated (13, 30, 35). Access to German military archives after re-unification has allowed clarification of the remaining Steed documents. Writing before these archives were opened, Hugh-Jones felt that the Steed documents describing a German BW programme between 1931 and 1933 were probably genuine, based on their concurrence with statements by German BW advocates in the public literature and with independent British intelligence reports of German BW activity. Geissler, working in the German military archives, found a significant body of discussion on BW from the early 1930s, but these official deliberations expressed considerable scepticism about the military usefulness of BW. Geissler failed to find evidence of an active BW programme as described in the Steed documents. No records of subway field tests in foreign countries were found and tests and lectures cited in British intelligence reports could not be corroborated in German records. Indeed, Geissler found indications of an internal German military investigation of the Steed allegations in 1934 that found no evidence for their validity. Geissler concludes that Steed was the victim of a hoax (30).

The Steed documents were part of a larger campaign mounted by anti-Nazi émigré writers to alert the world to the dangers of German re-armament. Allegations that the Nazis were developing biological weapons occupied a prominent place in this campaign. The BW element may have been motivated by a genuine concern that Germany was indeed pursuing such weapons, or a desire to associate the Hitler regime with outlawed weapons that threatened European civilian populations, or a combination of these

motives. Certainly, this campaign progressed to clearly erroneous, fabricated allegations. Helmut Klotz raised the alarm in 1934 (49), when he reported that the German Army had developed BW before Hitler came to power, and that Hitler supported BW as a military tactic. These charges mirror those in the documents given to Steed in 1934. Klotz published a series of books with progressively more threatening descriptions of Nazi BW capability. In 1934, he added a *bona fide* citation of a Nazi publication advocating BW (48). However, in 1935, he made the unlikely (and, in retrospect, clearly wrong) allegation that an aerosol-generating 'Himmler Bomb' had been developed within six weeks of the Nazi Party gaining power, and that a single bomb, only 25 cm tall and 16 cm in diameter, could infect between 500,000 and 800,000 urban inhabitants (50). In 1937, Klotz described additional erroneous German BW capabilities, identifying anthrax as a BW agent and describing glass aerial bacteriological bombs (51). Otto Lehmann-Russbueldt (who supplied the German documents to Steed in 1934) published *Germany's Air Force* in 1935 (53), with a chapter devoted to German preparations for chemical and biological warfare. Moreover, he reprinted the articles written by Steed in an appendix. Heinz Liepmann, who had examined the Steed documents in 1936, echoed the Klotz allegations in his 1937 book, *Death from the Skies* (58).

These warnings resulted in the acceleration of the small French BW programme (57) and the establishment of a British BW programme. The British programme initially concentrated on defensive measures, such as establishing a national system of Public Health laboratories, but later began offensive research as well (8).

With the beginning of World War II in 1939, opportunists began to capitalise on the Allied concern regarding German BW, and created false reports of German BW activities. Some reports were public, such as that of Hermann Rauschning, who began his 1940 memoir by recounting that Hitler had advocated using bacteriological weapons in 1932 (68). Others, including a report by Rauschning in 1941 of German plans for BW attacks on British ports, were provided directly to British intelligence for payment or favourable treatment as refugees. These reports in general, and the work of Rauschning in particular, have been discredited by recent scholarship (30, 45).

After 1941, there were few reports of German BW efforts (59), except for several in early 1944, before the Normandy invasion, which warned that:

– rats were being collected and infected with rabies to be dropped on Britain

– BW warheads would be used on the new V-1 and V-2 missiles

– BW attacks would be used against the expected Allied invasion of Europe (5, 87).

All of these reports were initially treated seriously, but soon appeared to be part of a German psychological warfare disinformation campaign to seed fear of BW attack. The validity of these reports was strongly doubted before the invasion, and discredited afterwards (88).

Throughout the war, the intelligence branch of the US BW programme remained convinced that Germany was pursuing the development of biological weapons. Those in the British and Canadian programmes concurred. This was despite the fact that other sources of information consistently failed to indicate any German preparations for BW, either offensive or defensive. Revision of the standard German gas masks did not increase their protection against BW agents. Moreover, monitoring the immunisation records and serum antibodies of captured German troops gave no indication of any immunisation programme to protect against potential BW agents (88).

When Germany fell, Allied intelligence services rigorously investigated German BW efforts, and found that all research on offensive BW weapons had been forbidden by Hitler. Some defensive research had been conducted following the German discovery of the French BW programme. What little offensive research existed had been conducted against the order from Hitler. The German BW programme was insignificant and posed no threat (30).

This global intelligence failure had ironic, unintended consequences. Biological weapons had been considered militarily impractical by a League of Nations expert panel in 1925, and the military of most countries had agreed. Only France, Japan and the Union of Soviet Socialist Republics (USSR) had BW programmes before the Steed publications. The Steed and associated émigré publications served to stimulate the establishment of offensive BW programmes in the USA, Britain and Canada. These large, well-funded, national military BW programmes ultimately developed the very weapons that the alarmist hoaxers had raised such concern over.

The Soviet misapprehension that the United States of America continued an offensive biological warfare programme post 1969

In 1969, the USA unilaterally renounced biological weapons and dismantled its offensive BW programme. The USA ratified the 1925 Geneva Protocol (4) and promoted the Biological Weapons Treaty (6) (later passed in 1975), which outlawed the production or possession of biological weapons. The US BW programme was limited to defensive research. At least until the 1990s, no classified or clandestine BW research seems to have occurred. However,

in the 1970s, 1980s and 1990s, despite signing the Biological Weapons Treaty, the USSR began a massive clandestine programme to expand and modernise its offensive BW capability. This campaign was motivated, at least in part, by the conviction that the USA was also pursuing an offensive BW programme, in violation of the Treaty (1). It is true that the polarisation of these two superpowers during the Cold War supplied ample reason for mutual distrust, and that the USSR might well have decided to violate the Treaty in any case. Nevertheless, the Soviet belief that the USA was already violating the Treaty allowed BW advocates in the USSR to cite this supposed BW arms race to justify placing a high priority on the Soviet BW programme.

From the Soviet viewpoint, the USA met the criteria for a suspect regime. The USA was willing to make military interventions in areas of vital interest, such as Vietnam and Latin America. The USA had used very large amounts of chemical defoliants and riot control agents (tear gases) during the Vietnam War. Most countries considered these agents to be violations of the 1925 Geneva Protocol banning chemical warfare, as expressed in an 83-to-3 vote in the United Nations (UN) General Assembly Resolution in 1969 (64). Only the USA and a few other close allies maintained that use of non-lethal riot control agents and herbicides in war was not prohibited by the 1925 Geneva Protocol. The USA had acknowledged the existence of an offensive BW programme before the 1969 disavowal. The effectiveness of the order by President Nixon, disavowing biological and biotoxin weapons, was called into doubt in 1975 when it was discovered that the Central Intelligence Agency (CIA) had maintained a stockpile of biotoxins, in defiance of his intent (96).

Suspicion that the USA might be breaking the Treaty increased when the USSR received espionage information that the USA was indeed continuing to pursue an offensive BW programme. This information was part of an ill-considered disinformation campaign of the CIA, which was intended to divert Soviet resources into unrewarding paths (29). Not until the early 1990s, when the Trilateral Agreement (7) for mutual inspection of BW facilities allowed direct Soviet access to suspected US BW facilities, did the Soviets begin to doubt that the USA had a secret programme. Inspections revealed only facilities that had been abandoned for over 20 years (1).

The erroneous Soviet belief that the USA was continuing its offensive BW programme resulted in the following:

– a massive expansion of Soviet BW facilities

– the development of effective anthrax and smallpox biological weapons

– the training of a large cadre of technical personnel in bioweapons skills.

This legacy complicates efforts to control biological weapons to this day.

The 2001 postal anthrax attacks in the United States and the misapprehension that Al-Qaeda possessed a biological warfare capability

Immediately after the attacks of 11 September 2001, the US Government stated that it believed Al-Qaeda may already have the capability to use biological weapons in terrorist attacks (23). In October, the USA launched its military operations against Al-Qaeda and the Taliban in Afghanistan.

In mid-October, cases of anthrax were recognised in Florida, New York and Washington, DC, and investigators immediately saw links to the 11 September Al-Qaeda terrorists (41, 42). President Bush stated on 24 October that he felt that Al-Qaeda was responsible for the anthrax attacks (12). Previous assessments (23) had concluded that terrorist groups such as Al-Qaeda might receive biological weapons from states which sponsored terrorism, and on 27 October a report was released linking Al-Qaeda with Iraq (83). A persistent assumption that Al-Qaeda, Iraq and biological weapons were linked was expressed in US government policy and became established in the popular consciousness of many in the USA.

Subsequent events showed this assumption to be wrong. The perpetrator appeared to be a scientifically trained American alarmist hoaxer who, while trying to implicate Islamic terrorists, had simultaneously attempted to minimise fatalities by identifying the material as anthrax and warning that immediate antibiotics were needed.

The lack of any subsequent anthrax attacks was consistent with the action of an alarmist hoaxer who had succeeded in raising the alarm about biological weapons, and had no interest in causing further American casualties. Scientific investigation revealed that the material was not related to the Iraqi weapon strain (10), but was a closely held US anthrax strain, which resembled anthrax preparations produced by the US weapons programme (9, 11).

Military successes in Afghanistan allowed the inspection of many core Al-Qaeda facilities and resulted in the capture of many Al-Qaeda documents. These revealed that, despite some interest expressed in biological weapons in training manuals, there was no sophisticated understanding of the topic. No evidence of imported BW pathogens or biological weapons was found, and there were no facilities capable of producing biological weapons (43).

The alarmist hoaxer of the 2001 postal attacks presumably wanted to force the USA to address the potential danger of biological attack by terrorists. This apparent hoax

succeeded. The attack demonstrated the practicality and disruptive effect of even a small biological attack using anthrax on an element of the infrastructure, such as the US Postal Service. However, the increased emphasis now placed on bioterrorism response means that it competes directly for funds and scientific expertise with existing requirements in orthodox public health and medical research. In addition, the great attention paid to biological weapons after the 2001 postal attacks can only increase the interest of terrorists in obtaining such weapons.

The misapprehension of an Iraqi biological warfare capability before the 2003 invasion by the Coalition

The USA justified the invasion of Iraq in 2003 by the 'Coalition of the Willing' principally with the assertion that pre-emptive military action was needed to neutralise illegal Iraqi 'weapons of mass destruction'. However, inspections by the International Atomic Energy Agency had already led the agency to conclude that Iraq had no nuclear weapons programme (24). Thus, the US justification for military action relied heavily upon the alleged possession of a biological weapons capability (93). Subsequent investigations by the USA after the invasion failed to reveal any biological weapons or production facilities (39, 40).

Iraq certainly met the criteria of a suspect regime. Iraq had invaded Iran in 1980 and Kuwait in 1990. Iraq had initiated chemical warfare in the Iran-Iraq War and against Kurdish separatists. The UN inspections in the aftermath of the 1991 Gulf War discovered an offensive BW programme that had not been disclosed and had remained hidden for several years (85).

Although known Iraqi BW facilities were destroyed under UN supervision following the 1991 Gulf War, UN inspections ceased after 1998. From 2000, US intelligence received reports from a small number of Iraqi defectors that the BW programme had been reconstituted. These sources were considered valid by US policy-makers, despite failures to confirm their descriptions of the supposed Iraqi programme.

A well-publicised early source was Adnan Ihsan Saeed al-Haideri, a civil engineer who defected in 2001 and stated he had worked on or visited over 20 underground BW production facilities, and produced construction contracts for them (60). His accounts continued to be cited by US policy-makers (61, 100), even after UN inspectors returned to Iraq in November 2002 and could not locate the supposed underground facilities, even using ground-penetrating radar (33). Another major source was an informant called 'Curveball', a chemical engineer, who described mobile BW production facilities (22). Like al-Haideri, his information continued to be accepted as valid, despite evidence from satellite surveillance that his description of fixed facilities was incorrect and the mobile units could not have been serviced as he reported.

Moreover, his description of the operation of the mobile facilities failed on a fundamental microbiological fact. 'Curveball' claimed that Iraq operated the mobile units only during the Moslem Sabbath, to avoid UN inspections, and US Secretary of State Colin Powell used this 'Sabbath production' scenario at the UN in his justification for military intervention, on 5 February 2003. However, the production of anthrax spores requires more than the allotted 24 hours. This was pointed out by a recognised biological expert immediately after the UN presentation (98).

Ultimately, the reports of Iraqi BW production proved to be fabrications generated by an Iraqi exile group anxious to provide evidence that would motivate the USA to invade Iraq, overthrow Saddam Hussein, and thus provide political opportunities for these exiles in a subsequent Iraqi regime (22).

The mistaken contention that Iraq possessed biological weapons in 2003 called into question US ability to detect illegal biological activities. This reduction in US credibility, in turn, prejudiced efforts to institute pre-emptive defence measures against biological attack.

Misappraisals when evaluating events: erroneous allegations of biological warfare use

Misappraisals can occur when a *bona fide* threat of BW use exists but suspicious events are interpreted as BW attacks when in fact they are not. As with global misapprehensions of BW risk, such allegations do not appear unreasonable. These misappraisals typically occur in circumstances:

a) where an adversary has a well-established, credible BW capacity

b) when there is continuing military or secret sabotage, in which biological attacks might reasonably be considered

c) when anomalous outbreaks of disease are reported.

The urgent need to implement defensive measures may result in action being taken on the basis of a preliminary scientific assessment, before a more complete investigation can be conducted. History indicates that investigating scientists may be presented with fabricated data. Even extensive scientific investigation may not be definitive, and the final appraisal may depend upon political assumptions rather than scientific determination.

Once a public allegation of a biological attack is made, the political and propaganda aspects often overwhelm the scientific evaluation of the event.

Misappraisals of biological attack are not benign. The allegation that successful biological attacks have been made erodes the international consensus against BW use. A country that believes it has been the victim of a BW attack may feel justified in developing its own offensive BW capability so that it can retaliate in kind. Hence, mistaken conclusions of BW use, even in good faith, only make future biological attacks more likely.

Korean War allegations that the United States of America used biological warfare

In 1952 and 1953, the governments of North Korea and the People's Republic of China accused the USA of waging biological attacks against them during the Korean War. The USSR echoed these charges in an intense propaganda campaign. These allegations, and the US response, present a very complex political, military and scientific event, one where all participants indulged in deliberate exaggeration and fabrication, to some degree (28). A complete discussion of all these facets is beyond the scope of this paper. Instead, this survey focuses on the difficulties faced by those Chinese biological scientists who were asked, in early 1952, to evaluate a possible biological attack, in the midst of a complicating political and military crisis.

The underlying threat of a biological attack by the USA was considered high by the Chinese in the early months of 1952. The fighting in Korea had reached a stalemate, and there had been repeated threats by the USA to introduce 'new weapons' to break the impasse (73). The USA made no secret it was pursuing a biological weapons programme. The People's Republic of China was aware that the USA had protected Japanese war criminals in exchange for information from the World War II Japanese BW programme. 'Dual use' activities by the USA in 1951 further alarmed the Chinese. For instance, the USA renewed contact with Japanese BW experts and sent a laboratory ship to investigate an epidemic in North Korea and to monitor an epidemic in a US-controlled prisoner-of-war camp. The USA began immunising troops against yellow fever (89) (which is not endemic in Korea), and intensified insect-control activities along the front lines.

These actions suggested US preparations for a Japanese-style BW attack using insect vectors. Although historical records reveal that these activities were not related to plans for a BW attack in Korea (28), the Chinese concern was prudent. By January 1952, the Chinese Government increased its level of surveillance for BW attack by sending bacteriologists to military medical laboratories in North Korea, and by alerting field commanders to be vigilant for evidence of a Japanese-type BW attack, especially insects or other odd objects falling from overflying aircraft (25).

The orders to be alert for unexplained groups of insects produced responses from Chinese field units in Korea, despite the fact that January in Korea is frigid, and insects are normally extremely rare. The insects sent to military laboratories for analysis consisted of an odd combination of human fleas, domestic spiders, domestic and garden flies, and an obligate bat parasite. These appear to have been overwintering in sheltered areas, and may have been exposed by war damage to buildings or gardens, or perhaps collected by field units wishing to appear zealous in conducting their surveillance mission.

In mid-February 1952, a North Korean military laboratory reported isolating plague bacilli from the human fleas, and cholera bacilli from flies (19). These initial reports triggered allegations of a BW attack, and resulted in the implementation of extensive military and civilian defence programmes (25).

It is now clear that at least the laboratory report of plague from North Korea was fabricated. In mid-1952, a sympathetic international commission (the International Scientific Commission for the Investigation of the Facts Concerning Bacterial Warfare in Korea and China) investigated the allegations. Correlation of its published (38) and unpublished records (63), combined with original documents from the Republic of China from the 1940s (18, 46), reveals that the Soviet member of the commission and a Chinese bacteriologist attached to a North Korean laboratory conspired to misrepresent technical elements of Japanese BW attacks (34, 66), to cover a scientific inconsistency in the original report.

Exactly who instigated the original fabrications is unclear. Soviet documents admit that local Soviet agents participated in some subsequent fabrications of BW incidents in North Korea, but do not mention the crucial initial reports (54, 55, 56, 99). The Politburo later claimed (perhaps ingenuously) that it was unaware the allegations were based on fabrications until 1953. The Soviet propaganda 'machine' reacted only slowly to the allegations, supporting the view that it was reacting to rather than creating them. The actions of the Chinese Government also suggest that it was unaware the initial reports were fabricated, because it took extensive defence measures and began an independent investigation of the attacks: unlikely responses if it knew the reports were fallacious. It is possible that the initial laboratory report fabrications may have been the independent action of an alarmist hoaxer. The prime candidate would be the Chinese bacteriologist who wrote the initial plague report and who later helped to deceive the international commission. He was familiar with the Japanese BW attacks of the 1940s, and had been seconded to the North Korean

military bacteriology laboratory during the period of high alert for BW attacks.

Increased surveillance for BW attacks in both Korea and the People's Republic of China quickly produced more reports of suspicious events (36, 37). These were investigated by Chinese scientists with remarkable scientific rigour (20, 21, 38). Their investigations encountered significant problems. An unseasonable outbreak of encephalitis occurred, and an unidentified virus was isolated from swarms of 'mosquitoes' seen unseasonably in the area. Similarly, a rickettsia bacterium was isolated from unseasonable swarms of insects.

These two isolates were used to justify allegations that the US had widened its BW attacks to include Chinese territory. Embarrassingly, the 'mosquitoes' were later identified as non-vector crane flies, and the virus proved unrelated to the encephalitis outbreak when tested serologically. The rickettsia sample was lost after the initial animal isolation and could not be characterised. Much to the credit of the Chinese investigation, these critical preliminary findings were retracted publicly.

A significant problem mentioned by the Chinese field investigators was the extra vigilance of citizens asked to report suspicious activity which could be linked to BW attacks. Field reports indicate that natural occurrences were frequently misinterpreted as BW attacks. There was suspicion that the desire to appear politically conscientious may have influenced these reports, either because their makers exaggerated or 'embroidered' facts, or because the reports were invented outright. Many such reports were examined and dismissed by the Chinese field investigators (25).

The few field reports that seemed to describe possible BW attacks generally relied upon the assumption that BW attacks were likely. Most reported otherwise unexplained swarms of insects or other suspicious objects, discovered after US aircraft had flown overhead. Pathogens were isolated from these insects in only a small minority of cases and, in most of these, the pathogens could have been present naturally, such as enteric diseases in flies (36). Human disease was only very rarely associated with these events.

After May 1952, public reports of suspected BW attacks ceased, and the allegations entered an overtly political Cold War propaganda phase. Internal Chinese government summaries of the BW situation in May 1952 identified only four outbreaks of disease ascribed to BW attacks. Although considered significant, they were modest in their overall scale. The largest was the encephalitis outbreak, with 42 confirmed cases in total and 20 deaths. An additional 40 cases, including eight deaths, were suspected to be encephalitis. An outbreak of plague in the Chinese forces in Korea accounted for 18 confirmed cases with eight deaths, and eight suspected cases with three deaths. Four fatal cases of inhalation anthrax were identified in the north-east of the People's Republic of China. An additional four fatal cases of paratyphoid were also ascribed to BW attacks (25). Although the propaganda phase of the allegations continued until after the Korean armistice, the Chinese identified no significant increase in infectious diseases, and few new scientific data appeared for analysis.

Shortly after the death of Stalin in March 1953, the Soviet Government abruptly discontinued its propaganda campaign, and requested the Chinese to cease its campaign as well, citing the belated discovery of the North Korean fabrications. The Soviets never again mentioned the Korean War BW allegations, even in their own military histories of BW. The Chinese interrupted their campaign briefly, while they re-investigated the scientific findings, but ultimately continued it. They incorporated the BW allegations into their histories of the Korean War as fact, and adopted the technical findings of their scientists into their military and civil defence doctrines (17, 25, 67, 73, 102).

Not until the late 1990s would important scientific data resolve the most troubling of the unresolved allegations (27). Modern genomic analysis of multiple Chinese anthrax isolates from 1952, from the area of the suspected BW attacks, indicated they were indigenous to Asia, and did not correspond to US weapons strains in use at the time (28).

Allegations by Cuba

Cuba has accused the USA of attacking it with biological agents on several occasions. These allegations accord with the typical circumstances: the USA had a known BW capability before 1969, and Cuba, like the USSR, might well have doubted that the USA had really ended this capability. The USA supported a vigorous paramilitary and clandestine sabotage programme against Cuba, and a series of disease outbreaks occurred which the Cubans considered suspicious. Clearly, elements of propaganda could have played a role. Blaming the USA for disease outbreaks not only unified the Cuban people against the USA, it shifted the focus from failures in Cuban public health and animal disease control programmes.

The Cuban Government has released too little scientific and historical information for a definitive, disinterested analysis. However, an analysis of the 1962 Newcastle disease outbreak has been described in some detail by Wheelis (25). This outbreak was alleged by Cuba to be the result of BW sabotage of an avian influenza vaccine with the live Newcastle disease virus, causing a widespread Newcastle disease outbreak. However, it would be

impossible to determine the precise spread or aetiology of the outbreak or to state that contaminated vaccine was the cause, without detailed information on the following:

– the pattern of the outbreak

– the movements of vaccinators in the avian influenza programme

– specific analyses of suspected lots of contaminated vaccine

– an account of activities at the vaccine production facilities.

Newcastle disease was endemic in Cuba in 1962 and, since it is highly transmissible, Wheelis concluded that an equally possible aetiology of the outbreak would be inadvertent transmission by vaccinators and vaccinating equipment during the avian influenza immunisation programme. Newcastle disease could have been widely spread through carelessness during the veterinary vaccination programme without the need for deliberate sabotage.

Wheelis provides an important insight into this outbreak. He was able to access extensive CIA documents on sabotage programmes against Cuba from that period, which had been declassified under the Kennedy Assassination Investigation. Wheelis concludes that Cuban concern that the USA might have been responsible for this outbreak in 1962 was valid, because the USA was openly pursuing an offensive BW programme at the time, and the CIA was engaged in an active sabotage programme against Cuban industry and agriculture. This sabotage programme was well known to the Cubans from its results, as well as from interrogating captured CIA agents.

Moreover, Wheelis found that the CIA did explore the possibility of using clandestine BW releases in its sabotage programme. However, the specific proposal was to use incapacitating biological agents spread by insects to target field workers, disrupting the Cuban sugar and tobacco harvests. The goal was to 'cripple' Cuban exports to discredit the Castro Government with the Cuban people. The US sabotage policy specifically avoided damage that would alienate ordinary Cubans, such as attacks on domestic food production. In fact, the US BW programme could not provide a suitable BW agent in 1962, and the proposal was not acted upon. There is no documentary evidence that the 1962 Newcastle disease outbreak was the result of a CIA sabotage programme.

Allegations of 'yellow rain'

In 1981, the USA alleged that Soviet client regimes in Laos and Vietnam had used biotoxin weapons against the Hmong minority people and Kampuchean insurgents, and that the USSR itself had used similar weapons against mujahidin rebels in Afghanistan. Although a wide variety of attacks and resulting symptoms were reported, the most characteristic attack was described in the allegations as 'yellow rain'. These occurrences collectively came to be known as 'yellow rain attacks' (69).

The allegations accorded with the pattern already demonstrated. The USSR had a BW programme before the signing of the Biological Weapons Treaty, and the USA was clearly suspicious that the USSR was in violation of that Treaty, a conviction strengthened by an outbreak of anthrax near a suspected BW facility in the city of Sverdlovsk in 1979. (The US suspicions of a continuing Soviet BW program ultimately proved valid.)

The releases occurred in military actions sponsored or made directly by the USSR. The reports of illnesses associated with military attacks were clearly suspicious.

As early as 1978, the USA made initial investigations into yellow rain, collecting both physical evidence and extensive testimony from survivors. The initial laboratory findings identified no classical chemical or biological agents, but a university laboratory reported trace amounts of trichothecene mycotoxins in some specimens. In 1982, the US Government issued allegations in which the symptoms were described as typical of trichothecene mycotoxin poisoning and mycotoxins were reported as being identified in multiple specimens from the attack sites.

However, the persuasiveness of the initial data suffered in 1983 and 1984, when 'follow-up' investigators from a US Army/State Department team re-interviewed many of the original 'victims' and they admitted they had fabricated their stories or passed on hearsay as personal experience to gain political asylum. The symptom complex reported by victims corresponded to mycotoxin toxicity in only five of the 217 alleged victims interviewed. The first laboratory analysis of trichothecene mycotoxins in the original specimens could not be confirmed by more specific assay in the chemical warfare laboratory of the US Army. Nor could mycotoxins be identified by French, Swedish or Canadian government BW laboratories in the original or subsequent specimens of yellow rain. The credibility of the allegations was dealt a severe blow when it was demonstrated that samples of the 'yellow rain' material recovered from leaves were in fact honey bee faeces, and the yellow rain phenomenon was due to collective defecation of honey bee swarms (75).

Despite the apparent discrediting of the 'yellow rain' claims and the negative scientific data from its own laboratories, the USA has never retracted the allegations. In fact, the conviction that important elements of the yellow rain allegations are true persists in US military thinking. United

States military manuals on chemical and biological warfare cited mycotoxin attacks in Vietnam in the 1970s and 1980s as proof of the military effectiveness of biotoxin weapons until 2003 (86), and still list 'chemical weapon attacks' as having occurred in Laos and Cambodia in the 1970s, and Afghanistan in the 1980s (90). Katz (44) has recently presented newly declassified data from the yellow rain investigation, and her analysis supports this aspect of US military editorial policy. Katz admits that the official yellow rain investigation failed to convince academics, the United Nations or the general public, but she weights the early 'positive' data more heavily than the later 'discrediting' data because she believes that publicity contaminated the later information. Katz concludes that, while incomplete, the available information supports a 'confident assessment' that biochemical weapons attacks of some sort did occur, though she finds little evidence to support the original charges that trichothecene mycotoxins were used in large amounts as a primary biotoxin agent directed against personnel.

Misadventures in pre-emptive interventions

When the risk of biological attack is considered high, biological scientists may be asked to advise on appropriate pre-emptive defence measures. Such decisions differ from similar risk/benefit evaluations undertaken in orthodox public health or veterinary situations because the actual risk of an outbreak is hypothetical, depending on the actions of an adversary. Moreover, the risks and benefits of a pre-emptive intervention and its public acceptance may be poorly predictable in the context of a BW threat.

Even prudent pre-emptive interventions have had unintended negative results. Some salient examples follow. While these examples use human immunisation programmes, the principles should be applicable to veterinary circumstances.

For instance, in case of a BW threat, advisers may propose pre-emptive vaccination in areas where a disease has been eradicated. However, vaccine shortages can be expected because, in contrast to containment immunisation programmes for focal outbreaks, pre-emptive vaccination campaigns must protect against multiple releases in vulnerable areas, and therefore require universal coverage. The political sensitivities of allies or economic partners may influence the timing of pre-emptive immunisation programmes, particularly if such vaccination will cause prolonged quarantine and disruption of normal trade. Using experimental or developmental 'indicator' vaccines to differentiate infected from non-infected (but vaccinated) herds may lessen these problems but guaranteeing the safety of any developmental vaccine is difficult, particularly in a crisis. Popular distrust may significantly disrupt an immunisation programme recommended by veterinary professionals. Sceptical farmers may refuse to co-operate with a voluntary programme, or take legal action against the imposition of a mandatory policy. Consumers may refuse to buy meat from vaccinated herds.

Misadventures in pre-emptive immunisation have not been benign. Some have had direct adverse effects on the health of the recipients, and others have failed to offer the desired protection. Moreover, these misadventures have had the indirect effect of eroding the credibility of such interventions. This can only complicate future efforts to provide pre-emptive protection against possible BW attacks.

The Japanese biological warfare capability and the 1942 yellow fever vaccination programme

The Japanese began a secret BW programme in the early 1930s (32). In 1939, a Japanese virologist attempted to obtain virulent and vaccine strains of yellow fever virus from the Rockefeller Institute. There was no legitimate reason for the Japanese to work with yellow fever, since it did not occur in Asia or the Pacific region. Shortly after the official request was refused, because international agreements forbade the transfer of yellow fever virus to Asia, a Rockefeller Institute employee was approached and offered a large bribe to provide the virus preparations illegally. The Federal Bureau of Investigation initially investigated this event, but the US Army was not informed until January 1941 (59).

General James Simmons, Chief of Preventive Medicine in the US Army, had long considered biological attacks to be a real threat. He proceeded to implement defensive measures against Japanese BW, aided by a US decision to explore the potential of BW and reports of Japanese BW attacks in the Republic of China (59). Simmons realised that the artificial introduction of yellow fever into Panama and Hawaii would disrupt critical 'chokepoints' or passageways of military and industrial transport. Moreover, the yellow fever mosquito was widely distributed in North America, Europe, Asia and the Pacific, and introducing the yellow fever virus might cause massive outbreaks in crucial European and Pacific theatres of war. In mid-1941, Simmons arranged with the Rockefeller Institute for large amounts of yellow fever vaccine to be manufactured and held in reserve.

In January 1942, immediately after the Japanese attack on Pearl Harbor, Simmons succeeded in instituting a programme to immunise all US military personnel against yellow fever. The programme was justified as a defensive measure against biological attack, although this aim was

not made public. The Rockefeller Institute chick embryo vaccine was used, which required the inclusion of human serum in the original inoculum. Unfortunately, this source of human plasma was contaminated by the hepatitis B virus, and a massive epidemic of 'homologous serum jaundice' (hepatitis B) occurred in recipients of certain lots of the vaccine, beginning in March 1942. The source was quickly traced to the yellow fever vaccine, and the immunisation programme was halted on 15 April 1942. Ultimately, 50,000 US servicemen and servicewomen were hospitalised with post-yellow-fever-vaccine hepatitis B, and an estimated 330,000 cases occurred (74). This was the largest single-source outbreak of hepatitis B ever recorded. A military disaster was avoided only because few US troops were in combat so early in the war.

The debacle of the 1942 yellow fever vaccination programme interrupted, but did not end, efforts to pre-emptively vaccinate against yellow fever and other potential Japanese biological attacks. Importantly, and in contrast with the putative German BW programme, multiple mutually supporting data had been received to confirm that the Japanese had an advanced BW programme. Many Western-trained scientists 'on the ground' in the Republic of China confirmed that Japanese BW attacks had been made on Chinese cities, using plague (59). Military intelligence reported that Japanese troops had been trained to make BW attacks and, as the war progressed, captured Japanese documents confirmed this training and indicated that Japan had developed BW munitions (87). Captured Japanese medical officers eventually reported the location and named the commander of the Japanese BW facility in Manchuria (88). A report in March 1942, from Brazil, of another Japanese attempt to obtain yellow fever re-emphasised the yellow fever risk (59). A more focused yellow fever immunisation campaign was begun in Hawaii and Panama between 1943 and 1945, after a serum-free vaccine had been developed. Since Japanese attacks using plague had been identified in the Republic of China, immunisation against the plague was instituted for soldiers in the Pacific, even in areas where no plague had ever been reported naturally, notably for the invasions of Iwo Jima and Okinawa (91).

No Japanese BW attacks were experienced by US troops, but the pre-emptive immunisations were justified. Although Japan did not acquire yellow fever virus in its 1939 and 1942 attempts, its interest remained high. The Japanese Government apparently also requested yellow fever virus from Germany (30). Germany and Japan did exchange strategic materials by long-distance submarine voyage, but no record exists of any yellow fever virus being received by Japan. At a critical point in the war, Japan decided to use biological weapons against the USA. The Japanese dispatched a BW team with biological agents, including plague from the Republic of China, to the Mariana Islands in 1944, but the ship was sunk en route (31).

Pre-empting Nazi biological warfare: the botulism toxoid controversy before the Normandy invasion

As discussed previously, Allied intelligence believed that Germany was pursuing an active BW programme, and émigré sources had reported that botulism toxin was being developed as a biological agent. This, and the fact that a major British BW researcher was interested in botulism, resulted in the development of an experimental toxoid against botulism toxin. Sufficient toxoid was produced by the BW programme to allow immunisation of the entire force for the Normandy landings.

The lack of solid corroboration for the émigré reports of German BW efforts was an important factor when BW scientists urged that the invasion force be pre-emptively immunised against botulism toxin. The US Theater Surgeon, directly responsible for the health of the combat troops, was sceptical of the safety of an untried vaccine, pointedly recalling the disastrous yellow fever vaccination programme of 1942 (82). More importantly, perhaps, the Allies had broken the German military codes and Eisenhower knew that the Germans had made no preparation for a BW attack. Much to the displeasure of the BW scientists (47), Eisenhower refused to order pre-emptive immunisation.

Pre-emptive immunisation against anthrax and botulism in the 1991 Gulf War

Iraq had acquired virulent strains of BW pathogens from the USA during the Iran-Iraq War of the 1980s. Before Iraq invaded Kuwait on 2 August 1990, US intelligence services had concluded that Iraq possessed a biological weapons capability. Anthrax and botulism toxin were reported as agents. The USA alerted its forces in the Gulf region to the possibility of Iraqi biological attacks on 9 August (62, 76).

Although, on 30 August, an expert advisory board recommended that troops be immunised against anthrax and botulism toxin as soon as possible, only 150,000 doses of anthrax vaccine and 34,000 doses of botulism toxoid were available to the USA. Since primary immunisation protocols called for three doses for each recipient, these stocks were clearly insufficient to immunise all of the 700,000 USA forces expected to be deployed in the Persian Gulf area during the anticipated hostilities with Iraq (77). Morale problems were feared if only some units were vaccinated. Moreover, grave political complications were foreseen if vaccines could not be offered to the military personnel of coalition partners and civilians in host Persian Gulf countries (76).

By 21 September, the Joint Chiefs of Staff decided that the decision was no longer 'medical' but rather 'political, social

and military/operational' (76). Any public discussion of BW or defensive immunisation was delayed while troops and materials were moved into the war theatre. The political and military authorities deliberated BW defensive options, but shared their concern with few allies. France learned of the US concern when the USA immunisation campaign was announced in late December 1990 (94). Not until 5 January 1991 was a targeted vaccination programme begun for US troops. The 1991 Gulf War began on 17 January and ended on 28 February 1991.

As a result of the shortages of vaccine and time, immunisation could only be partially implemented. The US military plan truncated a six-dose, 18-month anthrax protocol to a two-dose, two-week schedule. Only 150,000 of the 700,000 US military personnel in the region received anthrax vaccine, and only a fraction of those received two doses. The botulism toxoid had not been licensed, and was treated as an investigational drug, administered voluntarily with informed consent. No more than 8,000 personnel received even one dose of botulism toxoid. An evaluation of the US pre-emptive immunisation against anthrax during the 1991 Gulf War is problematic. Although Iraq used no BW weapons in the 1991 Gulf War, the threat assessment that Iraq possessed delivery systems and military quantities of anthrax and botulism proved accurate (85). Both the agent preparations and munitions later proved to be primitive; nevertheless, some agent/delivery scenarios could have caused mass casualties. A pre-emptive effort to counter this threat was prudent.

However, there is considerable doubt that the US immunisation campaign would have been effective in preserving military efficiency or protecting individual soldiers from a BW attack. Only about 20% of US military personnel received any anthrax vaccination at all, and it is not known how many received two doses. Anthrax vaccine was known to produce immunity only slowly and after multiple inoculations, hence the six-dose, 18-month protocol. Primate studies found that protective immunity could be demonstrated six weeks after a second dose (78). Since initial immunisations did not begin until the week of 5 to 12 January, this immunity would not have been reliably present in the first cohort immunised until the week of 2 to 9 March. The Gulf War ended on 28 February. The botulism programme was even less effective: no more than 1% of US troops were immunised, and botulism toxoid produced immunity even more slowly: a state of 'minimal immunity' did not occur until late April, well after the war was over.

Pre-emptive measures against anthrax, botulism and plague in the 1991 Gulf War

The United Kingdom (UK) had also come to the conclusion, before the Iraqi invasion of Kuwait, that Iraq possessed a military BW capability, with anthrax and botulism toxin. The UK had sufficient anthrax vaccine for a complete course for all of its 53,500 troops deployed in the Gulf. The UK had no botulism toxoid but did have 20,000 doses of botulism antitoxin, suitable for treatment after an attack. Since a unilateral decision to vaccinate against anthrax would have been politically sensitive, the UK delayed implementing its anthrax immunisation programme, in deference to US government indecision. However, by early December, time had run out if the UK wanted to complete its seven-week, three-dose immunisation schedule before the 15 January 1991 UN deadline for military action. The UK expressed a desire to begin vaccinations, regardless of US plans. This may have stimulated the USA to begin its programme. In any case, the UK co-ordinated its anthrax vaccination programme with that of the USA, and began immunising on 2 January 1991. The UK administration, aware that the vaccine produced immunity only slowly, administered pertussis (whooping cough) vaccine as an adjuvant, hoping to speed the development of immunity. In November 1990, the UK had assessed that Iraq might also have the ability to use plague as a weapon. Thus, it instituted a programme of plague immunisation on 21 January 1991, after the war had begun (84).

Despite the UK beginning the war with sufficient time and vaccine stocks to complete the full primary immunisation schedule, the delay in implementation caused the UK anthrax vaccination campaign to be incomplete. Although 75% of UK forces received the first anthrax inoculation, fewer received the second because hostilities had already begun, and very few received the third because the war ended before the final dose was due. Post-war research in animals did not confirm that the pertussis vaccine adjuvant speeded the development of anthrax antibodies after anthrax vaccination.

Subsequent pre-emptive campaigns of anthrax immunisation by the United States of America, from 1998 to 2005

Following the 1991 Gulf War, unexplained chronic illnesses appeared in Gulf War veterans. Exposure to many substances, including experimental and investigational drugs and vaccines, was hypothesised as the cause (52). Legislation was passed, prohibiting the compulsory administration of investigational drugs or vaccines to military personnel without a Presidential finding of military necessity (92). This popular distrust extended to the anthrax vaccine, particularly when the licence of the vaccine manufacturer was revoked for multiple safety and potency violations (26). The reputation of the vaccine was further tarnished when the manufacturer was unable to regain the licence for two more years (65).

When compulsory universal military anthrax immunisation began again in 1998, significant resistance to the programme developed among forces on active duty and reserve. This resulted in, as follows:

– several hundred personnel being court-martialled for refusing immunisation

– many reserve personnel leaving the armed services (95)

– a protracted legal battle that did not end until December 2005.

The existing programme, at present, remains voluntary, focused narrowly on those personnel who are deployed in high-risk areas (101).

Popular distrust of the anthrax vaccine was highlighted in late 2001, when the US Government offered anthrax vaccine to any worker potentially exposed to anthrax in the 2001 postal attacks (97). The experts at the Centers for Disease Control refused to recommend vaccination (70, 71), and demanded a liability waiver from the participants, who would have received unlicensed lots of vaccine from the still uncertified manufacturer. Given the already tarnished reputation of the vaccine, it is not surprising that only 138 of the 10,000 postal workers and congressional staff who had been potentially exposed to the postal anthrax releases chose to participate in the vaccine trial (81).

A pre-emptive campaign of smallpox vaccination by the United States of America, 2003

As early as the late 1990s, there had been calls for pre-emptive vaccination of some health-care workers against smallpox (2), but before the terrorist attacks of 11 September 2001, official sanction was withheld (72). During 2002, preliminary recommendations for limited pre-emptive vaccination were debated (3). In late 2002, in anticipation of the 2003 US invasion of Iraq, President Bush ordered a pre-emptive smallpox immunisation programme for US military and civilian health-care workers and emergency response personnel, targeting 500,000 troops and 10.5 million civilians (80). While the compulsory military programme was completed, the voluntary civilian programme was never met with enthusiasm. Only 25,645 (6%) of the targeted 439,000 health-care workers were immunised before the war began (14). Moreover, this programme revealed increased cardiac complications post-vaccination (14). After no biological weapons were found in Iraq, the programme virtually ceased: fewer than 1,000 workers volunteered between 9 August and 31 December (15, 16). In total, only 39,213 (< 9%) of the targeted 439,000 health-care workers participated (16), and plans to immunise an additional ten million emergency response personnel were cancelled.

Conclusion

Although it may appear that policy-makers should 'err on the side of safety' when evaluating and responding to threats of biological attack, it is an ironic finding of this study that such errors tend to degrade rather than augment the safety they seek to obtain. Repeated misapprehensions that an adversary possessed biological weapons have only encouraged the development of these weapons. Misappraisals of biological weapon use have increased the risk that such weapons might actually be used, and flawed and unnecessary pre-emptive interventions have discredited such efforts and prejudiced future programmes. It would seem prudent to demand considerable rigour in any such evaluations of BW in times to come.

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Erreurs d'interprétation en préparation à une attaque biologique : une étude rétrospective

M. Furmanski

Résumé
Se préparer à une attaque biologique implique d'analyser et de coordonner les informations et les événements relevant des domaines scientifique, politique et social. Or, les informations qui doivent être évaluées sont, par définition, incomplètes. Il n'est donc pas surprenant que ces interactions aient régulièrement abouti à des conclusions erronées et à des interventions imparfaites. Cette étude rétrospective examine les cas dans lesquels des erreurs majeures ont été commises. L'auteur décrit plusieurs exemples pris dans chacune des trois grandes catégories : méprises concernant les risques d'attaque biologique ; évaluation erronée d'un événement isolé perçu comme étant une attaque biologique ; suites accidentelles nuisibles d'une action préventive visant à se protéger contre une attaque biologique. L'étude identifie des éléments communs à chacune de ces erreurs qui peuvent servir à éviter d'en commettre à l'avenir. L'étude conclut, en évaluant les conséquences de ces erreurs, qu'elles accroissent souvent les dangers que l'on cherche à éviter.

Mots-clés
Arme biologique – Déformation de l'information – Désinformation – Fièvre charbonneuse – Fièvre jaune – Guerre bactériologique – Histoire – Médecine militaire – Perception erronée – Pluie jaune – Propagande – Toxine botulinique – Vaccin – Vaccination – Variole.

Errores de juicio en la preparación para ataques biológicos: análisis histórico

M. Furmanski

Resumen
Prepararse ante un eventual ataque biológico supone analizar y coordinar información y acontecimientos en los terrenos científico, político y social. La información que debe evaluarse es, por definición, incompleta. No resulta sorprendente que las interacciones de ese tipo hayan llevado con frecuencia a conclusiones erróneas e intervenciones defectuosas. En este repaso histórico, el autor examina una serie de casos en los que se han producido errores de envergadura. En primer lugar describe varios ejemplos de tres clases distintas: apreciación errónea del riesgo de ataque biológico; definición errónea de un episodio anómalo como ataque biológico; y percances a la hora de actuar preventivamente contra un ataque biológico. Después señala una serie de

elementos importantes en cada una de esas actuaciones erróneas que pueden ser de utilidad para evitar futuros tropiezos. Tras evaluar sus consecuencias, el autor concluye que esos errores de juicio sirven a menudo para alimentar el peligro que pretenden evitar.

Palabras clave
Ántrax – Arma biológica – Desinformación – Error de juicio – Fiebre amarilla – Guerra microbiana – Historia – Información errónea – Inmunización – Lluvia amarilla – Medicina militar – Propaganda – Toxoide botulínico – Vacuna – Viruela.

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Public perception and risk communication in regard to bioterrorism against animals and plants

G.S. Pearson

Department of Peace Studies, University of Bradford, Bradford, West Yorkshire BD7 1DP, United Kingdom

Summary

This paper examines the total international prohibition on the use of disease to attack humans, animals and plants, noting that in the past several countries had developed programmes for attacks on animals and plants as well as humans. Current activities undertaken by intergovernmental organisations – the World Health Organization (WHO), Food and Agricultural Organization (FAO) and World Organisation for Animal Health (OIE) – to counter the threat of attacks on humans, animals and plants are examined. Effective countermeasures to deliberate attacks need to be developed in harmony with existing measures to control natural or accidental outbreaks of disease. Finally the paper assesses the risk and the public perception of it, and considers what risk communication is needed and to whom. Clear mandates are needed for the FAO and OIE to be prepared to deal with outbreaks of disease, and with contamination of the food supply chain, whether accidental or intentional.

Keywords

Animal – Bioterrorism – Contamination – Deliberate outbreak – Disease outbreak – Food supply chain – Plant – Public perception – Risk – Risk communication.

Introduction

While much attention has been given internationally and nationally to the dangers of bioterrorism against humans, especially since the anthrax letters in the United States of America (USA) in October 2001, much less consideration has been given to the dangers of bioterrorism against animals and plants. This paper examines the total international prohibition on the use of disease to attack humans, animals or plants, and notes that prior to this total prohibition a number of countries had developed programmes for attacks on animals and plants as well as humans. The paper goes on to examine the current activities being undertaken by the intergovernmental organisations – the World Health Organization (WHO), Food and Agricultural Organization (FAO) and World Organisation for Animal Health (OIE) – to counter the threat of attacks on humans, animals and plants, and concludes that effective measures to counter deliberate attacks need to be developed alongside existing measures to control natural or accidental outbreaks of disease. Finally, the paper will assess the risk and the public perception of it, and consider what risk communication is needed and to whom. One conclusion is that clear mandates are needed for both the FAO and OIE to be prepared to deal with outbreaks of disease and with contamination of the food supply chain, whether these are accidental or intentional.

Deliberate releases of disease to attack humans, animals and plants are totally prohibited by the Biological and Toxin Weapons Convention (BTWC) (12), which opened for signature in 1972 and entered into force in 1975. Currently, this has 155 States Parties and 16 Signatory States (14) who are bound by the obligations set out in Article I of the Convention:

'Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

(1) microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;

(2) weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict'.

Successive review conferences of the BTWC have reaffirmed the comprehensiveness of this prohibition and have made it explicitly clear that it applies to humans, animals and plants. For example, the Final Declaration (13) of the Fourth Review Conference in 1996 stated that:

'The Conference reaffirms that the Convention prohibits the development, production, stockpiling, other acquisition or retention of microbial or other biological agents or toxins *harmful to plants and animals, as well as humans*, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes' (emphasis added).

In addition to the prohibition, Article IV of the Convention requires each State Party to take any necessary measures within its territory or anywhere under its control to prohibit and prevent the activities proscribed by the Convention:

'Each State Party to this Convention shall, in accordance with its constitutional processes, take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition, or retention of the agents, toxins, weapons, equipment and means of delivery specified in Article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere'.

In the United Kingdom (UK) such national measures were taken by the Biological Weapons Act 1974 (9) which used language very similar to that in Article I by stating that:

'(1)no person shall develop, produce, stockpile, acquire or retain –

(a) any biological agent or toxin of a type and in a quantity that has no justification for prophylactic, protective or other peaceful purposes; or

(b) any weapon, equipment or means of delivery designed to use biological agents or toxins for hostile purposes or in armed conflict.

(2) In this section –

'biological agent' means any microbial or other biological agent; and

– 'toxin' means any toxin, whatever its origin or method of production.

(3) any person contravening this section shall be guilty of an offence and shall, on conviction on indictment, be liable to imprisonment for life'.

The Final Declaration of the Fourth Review Conference in 1996 stressed the importance of adopting national measures to prevent the use of biological or toxin weapons in terrorist or criminal activity:

'The States Parties recognize the need to ensure, through the review and/or adoption of national measures, the effective fulfilment of their obligations under the Convention in order, inter alia, to exclude use of biological and toxin weapons in terrorist or criminal activity'.

Prior to the agreement of the BTWC in 1972, there were national biological weapons programmes that were based on anti-animal and anti-plant agents as well as anti-personnel agents (3, 8). However, national biological weapons programmes have been principally focused on the development of anti-personnel agents, with secondary attention given to anti-crop agents and even less to anti-animal agents. Anti-animal agents were considered in some of the earliest programmes, including biological sabotage in the First World War when it was argued by Germany that while anti-personnel use of such agents was prohibited, anti-animal use was probably not (14). Following the signature of the 1925 Geneva Protocol, to which many States Parties entered a reservation that they would no longer be bound by the Protocol should they be attacked with chemical or biological agents, the focus was on the means of retaliation in kind if chemical or biological agents were used against a State. It was such considerations that led the UK to develop its anthrax cattle-cakes, which would have been used against German cattle if Germany had used biological weapons against the UK. During and after the Second World War, the British biological weapons programme focused on developing anthrax as an anti-personnel weapon, although no stockpile of such weapons was ever produced and the stockpile of anthrax cattle-cakes was destroyed after the war (2). In the post-war years, the weapons programme in the USA focused on anti-personnel agents, as well as stockpiling but not weaponising three anti-crop agents: stem rust of wheat and rice blast. Although some attention was given to anti-animal agents, the USA does not appear to have selected or stockpiled any such agents (15). The Soviet Union programme is said to have studied anti-livestock agents including African swine fever, foot and mouth disease and rinderpest (1).

The biological warfare programmes in the UK and USA – of whatever type: anti-personnel, anti-plant or anti-animal – terminated in the mid-1950s and the late 1960s respectively, paving the way for the agreement of the BTWC, which entered into force in 1975. Although the Soviet Union continued its biological warfare programme for some decades, in 1992 President Yeltsin issued a decree terminating such activities. Consequently, by the 1990s, with the opening for signature in 1993 of the Chemical Weapons Convention (CWC) and its entry into force in 1997, there was total prohibition of both chemical and biological weapons.

The threats posed by chemical and biological weapons can usefully be considered as a spectrum (10) (Fig. 1).

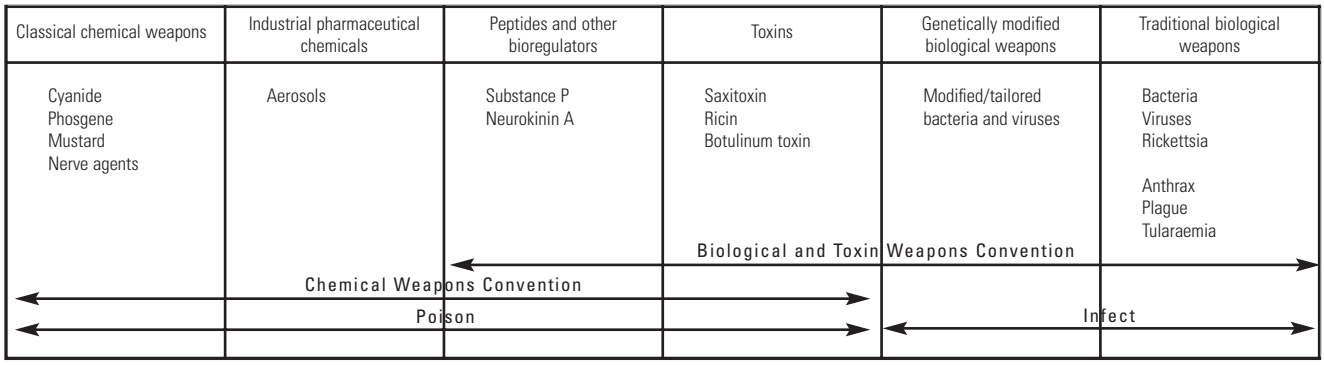

Fig. 1
The comprehensive prohibition of the Chemical Weapons Convention and the Biological and Toxin Weapons Convention

Figure 1 shows clearly the overlap between the two Conventions in the mid-spectrum region. The CWC in its Article II stipulates that its prohibition of toxic chemicals includes 'any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans *or animals*' (emphasis added). The CWC also, in Article VII on National Implementation Measures, requires that each State Party shall adopt the necessary measures to implement its obligations under the Convention. In particular, each State shall:

'Prohibit natural and legal persons anywhere on its territory or in any other place under its jurisdiction as recognised by international law from undertaking any activity prohibited to a State Party under this Convention, including enacting penal legislation with respect to such activity'.

Consequently, although the BTWC and the CWC primarily address States Parties, the requirements for national implementation in both Conventions should ensure that all persons are prohibited and prevented from carrying out activities prohibited by the Convention – and thus provide a legal framework that prohibits acts by sub-State actors such as criminals or terrorists.

Bioterrorism concerns

Although the deliberate releases of biological agents is acknowledged as possibly tempting for terrorists, it is clear that chemical or biological attacks are not necessarily the weapons of choice. Chemical and biological weapons attack human beings or animals primarily through the dissemination of the agent into the atmosphere and its carriage downwind to the target population. In the case of chemicals, sufficient quantities have to be delivered to cause harm to the victims, and for an effective attack significant amounts – several tons – need to be available and spread at the right time and in the right way. In the case of biological agents, the amount required is just enough to infect an individual who inhales the agent, and the quantities involved are correspondingly less – typically kilograms. However, there are significant technical problems with biological attacks: the agent has first to be obtained, and then adequate quantities have to be grown. The agent must then be disseminated, and for effective infection the particles need to be neither so large that they fall harmlessly to the ground nor so small that they are inhaled and exhaled without being retained in the lungs. Furthermore, as biological agents are living micro-organisms, they are fragile and may be killed through the forces needed to disseminate them or the ensuing exposure to sunlight and the open air. Finally, local micrometeorology – local wind eddies, updrafts, temperatures and the like – determines whether a turbulent atmosphere results in so much dispersion and dilution that the target population does not receive enough of the agent to be infected.

In comparison with terrorist devices using explosives, chemical and biological weapons offer few attractions and much uncertainty. With explosive devices, the effects are immediate and can be accurately predicted. In chemical and biological attacks, there is much uncertainty: has enough agent been disseminated, is the particle size optimum for retention in the lung, are the meteorological conditions right to spread the agent to the target? A further disadvantage is the delay before effects are experienced – possibly hours for chemical agents, and days or weeks for biological attacks.

Assessing the threat of possible terrorist activities using biological agents has always been a question of striking the right balance – being prepared but not exaggerating the dangers. A policy of over-reaction, in which every suspicious event is assumed to be an act of bioterrorism, is not in the best interests of security. Indeed, it can suggest to the terrorists that they should resort to bioterrorism to attract

public attention, because that is what appears to gain most publicity. There is a real danger that a bioterrorism hoax could result in such an over-reaction that terrorists might be tempted into trying to mount an actual attack. A far more prudent approach is one in which there is an awareness of the possible dangers should there be a deliberate release of biological agents, and in which the existing measures to contain natural outbreaks of disease are strengthened so as to be able to cope with both natural and deliberate outbreaks.

One of the most comprehensive and considered recent assessments of chemical and biological weapons was issued by the WHO in 2004 – *Public Health Response to Biological and Chemical Weapons*: *WHO Guidance* (19). This recognises the uncertainties associated with the delivery of chemical or biological agents, and then makes the point that these difficulties are not the only, or even the most demanding, technical problems. In the case of biological agents, the guidance points out that there are difficulties in selecting the appropriate strain in the first place, testing it, and then maintaining its virulence throughout culturing, harvesting, processing, storage, weapon-filling, release and aerosol travel. The study concludes that although the probability of a large-scale, high-technology biological/chemical attack may be low, if such an attack nevertheless happened – if, improbably, all the many imponderables and uncertainties favoured the attacker – the consequences could be very severe. In considering strategies for national preparedness against such attacks, it would certainly be irresponsible to disregard the possible effects of deliberately released biological or chemical agents, but a prudent government would not overestimate them. Given the emotional shock of even an alleged threat of a biological or chemical release, countries need at least to consider how to address such dangers should they occur, as an integral part of the national response to other threats to public health and well-being.

The WHO study goes on to note that, whether in relation to natural disasters such as earthquakes or to large-scale accidents in industrial production, storage or transportation facilities, many countries will already have formulated a general response strategy and plan, which they will maintain and modify in the light of changing circumstances and experience. The principles of risk management for dealing with chemical or biological attacks will overlap with those for dealing with natural or man-made disasters or emergencies. The WHO goes on to say that where deliberate biological or chemical releases pose additional risk-management problems, biological or chemical amendments to an existing disaster/emergency strategy and plan will, in most circumstances, be adequate for civil preparedness.

The executive summary to the WHO study sets out a number of recommendations, of which the following are particularly pertinent in the context of this paper:

'(1) Public health authorities, in close cooperation with other government bodies, should draw up consistency plans for dealing with a deliberate release of biological and chemical agents intended to harm civilian populations. These plans should be consistent or integral with existing plans for outbreaks of disease, natural disasters, large-scale industrial or transportation accidents, and terrorist incidents.

(2) Preparedness for deliberate releases of biological and chemical agents should be based on standard risk-analysis principles, starting with risk and threat assessment in order to determine the relative priority that should be accorded to such releases in comparison with other dangers to public health in the country concerned. Considerations for deliberate releases should be incorporated into existing public health infrastructures, rather than developing separate infrastructures.

(3) Preparedness for deliberate releases of biological or chemical agents can be markedly increased in most countries by strengthening the public health infrastructures, and particularly public health surveillance and response, and measures should be taken to this end'.

The World Health Assembly (WHA) in May 2002 adopted Resolution WHA 55.16, which should also be noted here (17). The Assembly stated that it was:

'Underlining that the focus of the WHO is on the possible public health consequences of an incident involving biological and chemical agents and radionuclear material, regardless of whether it is characterised as a natural occurrence, accidental release or a deliberate act; [and]

Seriously concerned about threats against civilian populations, including those caused by natural occurrence or accidental release of biological or chemical agents or radionuclear material as well as their deliberate use to cause illness and death in target populations'.

It requested the Director General:

'(1) to continue, in consultation with relevant intergovernmental agencies and other international organisations, to strengthen global surveillance of infectious diseases, water quality, and food safety, and related activities such as revision of the International Health Regulations and development of WHO's food-safety strategy, by coordinating information gathering on potential health risks and disease outbreaks, data verification, analysis and dissemination, by providing support to laboratory networks, and by making a strong contribution to any international humanitarian response, as required;

(2) to provide tools and support to Member States, particularly developing countries, for strengthening their national health systems, notably with regard to emergency

preparedness and response plans, including disease surveillance and toxicology, risk communication, and psychosocial consequences of emergencies'.

Thus the WHA has clearly mandated the WHO to carry out various activities related to countering the deliberate release of biological, chemical or radionuclear material.

What is the risk to animals and plants

Although there are differences in precisely how deliberate releases to attack animals or plants might be carried out, the overall risk perception and the relevant countermeasures that should be taken are very similar to those described in the WHO study of risks to human populations. In short, it would be prudent to consider the possibility of deliberate releases to attack plants and animals, but this should be done in the context of the threats to animals and plants from natural outbreaks of disease. Strategies to counter such natural outbreaks should be reviewed and updated so as to cater also for deliberate releases to attack animals and plants. The WHO recommendations – if amended to replace 'public health' by 'animal health' and/or 'plant health' – are equally valid in considering deliberate releases to attack animals.

The WHO guidance (19), in its sections (6.5 and 6.6) relating to the FAO and to the OIE, makes the following observations. In regard to the former, the guidance notes that the FAO has not formally been involved in the control of biological or chemical weapons, but is nevertheless prepared to play an active part within its broad mandate in providing technical and humanitarian assistance. The guidance points out that in recent years the FAO has contributed significantly to emergency relief and rehabilitation when droughts, floods, earthquakes, hurricanes, locust swarms, livestock plagues, war, civil strife and natural and man-made disasters have caused immense suffering to the populations affected.

Furthermore, with regard to the OIE, the WHO notes that although the OIE has no programmes or activities specifically designed to prevent or react to biological warfare, the ongoing sharing of information on the occurrence, prevention and control of animal diseases, including zoonoses, is relevant to this objective.

The extent to which intergovernmental organisations such as the WHO, FAO and OIE are addressing the possibilities of deliberate releases to attack animals and plants must therefore be examined. Such a study will provide insight into the current situation in regard to risk communication and public perception.

Terminology

Anyone considering the risks to animals and plants needs to recognise that there is a great deal of variation in the terminology used in the different fora that consider the threats posed to humans, animals and plants by biological weapons and by terrorist attacks. For example, the term 'agroterrorism' is rarely used in any of the international fora. In the meetings of the States Parties to the BTWC, there is mention of 'biological weapons' and 'biological terrorism'; the term 'biosafety' is generally used to refer to the safety of the facilities in which biological and toxin agents are held, while 'biosecurity' relates to the physical security of such biological agents and toxins. Other terms are rarely used. The WHO uses terms such as 'deliberate release' and 'deliberate outbreaks' of disease and, in relation to food, the term 'food safety', which relates to ensuring that food is free from contamination and safe to eat. The FAO uses the term 'food security' in relation to access to sufficient, safe and nutritious food, and uses the term 'food safety' in the same sense as the WHO. 'Intentional contamination' is used in the context of terrorist attacks against food. These different terms need to be borne in mind when activities in different fora are considered.

World Health Organization food safety

The WHA's Resolution 55.16 adopted in May 2002, as noted above, specifically included a requirement for the Director General to continue to strengthen food safety and to develop the WHO's food-safety strategy. It is evident that the WHO is working closely with the FAO to address food safety issues along the entire food production chain – from production to consumption – using new methods of risk analysis which provide efficient, science-based tools to improve food safety, thereby benefiting both public security and economic development. As part of this effort on food safety, the WHO in 2002 issued 'Terrorist threats to food' (18), with guidance for establishing and strengthening prevention and response systems. This guidance stems from the requirements of WHA Resolution 55.16 and points out that:

'Outbreaks of both unintentional and deliberate food-borne diseases can be managed by the same mechanisms. Sensible precautions, coupled with strong surveillance and response capacity, constitute the most efficient and effective way of countering all such emergencies, including food terrorism. This document provides guidance to Member States for integrating consideration of deliberate acts of food sabotage into existing programmes for controlling the production of safe food'.

It goes on to state that:

'Prevention, although never completely effective, is the first line of defence. The key to preventing food terrorism is establishment and enhancement of existing food safety management programmes and implementation of reasonable security measures. Prevention is best achieved through a cooperative effort between government and industry, given that the primary means for minimising food risks lie with the food industry. This document provides guidance for working with industry, and specific measures for consideration by the industry are provided.

Member States require alert, preparedness and response systems that are capable of minimising any risks to public health from real or threatened food terrorism. This document provides policy advice on strengthening existing emergency alert and response systems by improving links with all the relevant agencies and with the food industry. This multi-stakeholder approach will strengthen disease outbreak surveillance, investigation capacity, preparedness planning, effective communication and response'.

This WHO guidance provides a balanced consideration of the risk of food being used as a vehicle for terrorist acts, and compares the risks of attacks on food to those of attacks on water or air as vehicles for terrorist activities. It points out that:

'Deliberate contamination of food might, in some regards, be easier to control than attack through air or water. The safety of food is closely controlled in many developed countries, both by the government and the private sector. Food safety infrastructures offer a means for preventing and mitigating sabotage of the food supply. The dietary diversity available in many developed countries also reduces the likelihood that the entire food supply would be contaminated and would tend to dilute potential health effects. In addition, international food safety initiatives and enhanced disease surveillance and response activities can be developed for preventing and responding quickly to food terrorism. On the other hand, food is also the most vulnerable to intentional contamination by debilitating or lethal agents. The diversity of sources of foods, including the global market, makes prevention difficult, if not impossible. At the same time, many developing countries lack basic food safety infrastructures and are vulnerable to deliberate acts of sabotage'.

In regard to the role of other international organisations relevant to food safety, the WHO guidance notes that while the WHO has the mandate to address aspects of human health as they pertain to food, the FAO addresses agricultural production and food security, including food quality and safety issues. The WHO has many links with the food safety aspects of FAO programmes which are implemented in the context of food security – to ensure the access of all to sufficient, safe and nutritious food. In meeting this mandate, the FAO provides advice to member governments (and to food producers, the food industry and consumers) on the application of food safety management systems and effective national controls to prevent food contamination. More broadly, the FAO provides support to agriculture and fishing communities to increase production and improve the living conditions of rural populations. This combination of assuring a safe and nutritious food supply for all while supporting the agriculture and fisheries sectors makes a suitable starting point for responsible action along the food chain. In addition to food safety, the FAO Plant Protection Service addresses plant health and quarantine matters, while animal health matters are the concern of the FAO Animal Production and Health Division.

In contrast to the links between the WHO and FAO, the links between the WHO and OIE do not appear to be as close. The WHO guidance notes that the OIE is concerned primarily with animal health and quarantine issues. Due to the increasing demand of consumers for improved food safety worldwide, the OIE has identified the need to expand its normative and scientific activities into 'animal production food safety' and to work with other relevant organisations in addressing and preventing the 'production to consumption' food-borne hazards of animal products (meat, milk, eggs, honey etc.).

Food and Agriculture Organization food safety

At the 32nd FAO Conference in December 2003, there was a Ministerial Round Table (5) which addressed the dimension of food safety in food security. The Round Table pointed out that the 1996 World Food Summit Plan of Action defines food security in the following way: 'Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'. The Plan then states that food safety refers to those hazards associated with food that can cause ill-health in humans. A number of the hazards occur naturally; others are the results of contamination. Some, such as microbial pathogens, may cause acute illnesses; others may increase the risk of chronic diseases such as cancer. There is a universal agreement that food should be safe.

The report of the December 2003 conference includes no specific mention of terrorism or of intentional contamination. Indeed, searches of the FAO website using the word 'terror' register no hits, although searching under 'contamination' does reveal a document (4) entitled

'Terrorist threats to foods' submitted by the WHO to the FAO/WHO Global Forum of Food Safety Regulators held in Marrakech, Morocco on 28 to 30 January 2002. This paper gives a reasoned overview of the potential for deliberate contamination of foodstuffs, and notes that the WHO and FAO are widening their disease surveillance and response operations to include food sabotage and to provide guidance to Member States in developing programmes for the prevention and detection of terrorist threats to food, and for responding to any attacks.

The 2nd FAO/WHO Global Forum of Food Safety Regulators, held in Bangkok, Thailand, on 12 to 14 October 2004, addressed the prevention of and response to intentional contamination on the basis of a paper (7) prepared by the FAO/WHO secretariat. During this forum, the WHO announced (6) the inauguration of the International Food Safety Authorities Network (INFOSAN), which had been developed in cooperation with the FAO to promote the exchange of food safety information and to improve collaboration among food safety authorities at national and international levels. It is clear that INFOSAN recognises that the rapid globalisation of food production and trade has increased the likelihood of international incidents involving contaminated food, and that INFOSAN has a role to play as one of the basic preparedness measures that need to be taken in regard to terrorist threats to food.

World Organisation for Animal Health food safety

At the 32nd Conference of the FAO, note was taken of the long-standing cooperation between the FAO and the OIE, which dates back to 1947, when an informal arrangement was concluded between the two organisations. Subsequent to that, in 1953, an interim Agreement had been concluded and confirmed by the Conference. The Conference further noted that over the years cooperation had expanded and now covered a wide range of areas in animal health involving, in particular, exchange of information, consultation and exchange of experience on studies and projects. As a result, there was a need to better coordinate the efforts of the two organisations in control of animal diseases and food safety within the framework of their respective mandates, through a new Agreement which was affirmed by the Conference. This sets out the responsibilities of the OIE and the FAO, and lists a number of areas in which joint action will be taken.

At the 2003 OIE International Committee meeting, the Codex Alimentarius Commission, which is responsible for the development of scientific standards for the protection of consumer health and good commercial practices, noted that the Codex has to meet new challenges, and that collaboration with the OIE is a priority for its future strategy. As a result of global developments, the Codex has to take into account the growth in international trade, food-borne diseases, new technologies, new food production systems and food bioterrorism.

A year later, at the 2004 OIE International Committee meeting, bioterrorism was mentioned as one of the reasons why animal identification and traceability were of increasing importance. The Working Group on Wildlife Diseases had studied in detail the risk of wildlife disease crossing borders – and underlined the specific risk of such diseases being introduced as a result of a terrorist act – and measures to be taken to reduce the ecological and health consequences should this occur. The Group had consequently agreed to prepare a generic draft emergency preparedness plan.

The 2005 OIE International Committee meeting noted that New Zealand had been faced with an act of bioterrorism and that such acts could happen anywhere in the world. The meeting observed that the OIE continues to work within the framework of the Biological and Toxin Weapons Convention; noting that representatives of the approximately 150 States Parties to the Convention currently meet annually in Geneva, Switzerland. The OIE, with the support of the FAO and the WHO, has indicated to the States Parties to the Convention that the most effective way of preventing bioterrorism using animal pathogens was to strengthen national Veterinary Services by improving their early-warning and surveillance systems for animal diseases, and for all Member Countries to comply strictly with OIE standards.

Analysis

Thus, all three of the relevant intergovernmental organisations – the WHO, FAO and OIE – are evidently engaged in considering how to strengthen food safety measures and preparedness for outbreaks of disease in animals and plants; such preparations include to a greater or lesser extent consideration of both natural and intentional outbreaks. There is, however, considerable variation in the extent to which these measures explicitly address bioterrorism, and the term 'agroterrorism' is rarely used. This variation in terminology also occurs in national websites: thus the Department of Agriculture in the USA highlights agroterrorism (www.usda.gov/homeland security), whereas in the UK there is no mention of this on the Department of the Environment, Food and Rural Affairs website (although there is mention of food safety and biosecurity, which is defined as taking steps to make sure that good hygiene practices are in place to help prevent the spread of animal disease; see

www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm). The European Union also addresses food safety and biological safety, but although it has a website page (http://europa.eu.int/comm/food/international/trade/bioterror_en.htm) on bioterrorism, this is entirely concerned with the implementation of the US Bioterrorism Act 2002. The article notes that, 'While fully supporting the aim of protecting the food supply chain, the European Community is concerned about the effectiveness, and potential for trade distortion, of the measures proposed'. In Canada, the Canadian Food Inspection Agency has in place well-planned emergency response procedures (www.inspection.gc.ca/english/liaison/secur/secure.shtml) aimed at protecting food, plants and animals from accidental or intentional events, and is ready to act rapidly and effectively in response to emergencies affecting food safety and the agricultural sector.

There would be benefits from the adoption of a more consistent approach in which the three intergovernmental organisations and various national authorities adopted similar terminology. This would make it easier to reassure those concerned that measures have indeed been taken to counter the dangers posed by both natural and intentional outbreaks of disease or contamination of food supplies.

Three key questions, which this paper will address in turn, are:

– what is the risk?

– what is the public perception of the risk?

– what risk communication is needed – and to whom?

What is the risk?

There is undoubtedly a risk that there may be deliberate attempts to cause outbreaks of disease in animals or plants, or intentional contamination of food. There is much to be said for addressing this risk as part of international and national preparedness for dealing with outbreaks of disease and with contamination of the food supply chain, as the measures that need to be taken are the same whether an outbreak is natural or deliberate and whether contamination is accidental or intentional. All countries have a common interest in ensuring that their animals and plants are healthy and free from disease, and that the food supply chain provides safe food.

There is no advantage in putting too much emphasis on the possibility of deliberate outbreaks of disease or of intentional contamination, nor from highlighting vulnerabilities. It is far more prudent to work on enhancing measures to ensure the health of animals and plants and the safety of the food chain, while making it clear that these measures will address both natural and deliberate outbreaks and accidental and intentional contamination. Such an approach will deter would-be terrorists and criminals and provide reassurance to the public that the national and international authorities and agencies are prepared.

What is the public perception of the risk?

Public perceptions are influenced by reports in the press and television, which tend to seek controversy and to increase public concern and alarm – 'Good news is not news!' is all too true in the age we live in. Reports of terrorist incidents and the emphasis on 'breaking news' tend to focus on the alarm and disruption caused, rather than on the preparedness and professionalism of the emergency services and national ministries. There is a need to ensure that the press and television are provided with accurate, proactive information, and for a sense of responsibility to be engendered among press and television reporters of the importance of balance and of providing reassurance to the public.

The public is generally unaware that biological weapons, whether against humans, animals or plants, are totally prohibited. There is a need for countries to do much more to educate the public through programmes in schools and in universities that make everyone aware that biological agents and toxins are totally prohibited under the BTWC and national implementing legislation. Such national legislation should make it illegal for any individual to carry out an attack using biological agents or toxins, and thus make it illegal for terrorists or criminals to perform such acts.

Public concerns in regard to animals and plants are closely related to confidence that the food people eat is safe and will not cause them short or long-term harm. The public around the world is increasingly looking to national governments to provide such assurance and to demonstrate that food is indeed safe.

What risk communication is needed – and to whom?

As a deliberate attack or intentional contamination in one country can have serious consequences in another, there is a need for the WHO, FAO and OIE to recognise this in their advice to their Member States in regard to disease surveillance and product safety measures. They should

ensure that all Member States have effective, well-rehearsed preparedness plans in place to deal with outbreaks of disease, whether natural or deliberate, and with contamination, whether accidental or intentional, of the food supply chain.

While the Word Health Assembly has clearly recognised the dangers and taken appropriate action, it is not evident that the FAO Conference or the OIE International Committee have provided as clear a mandate to the FAO and the OIE to be prepared to deal with outbreaks of disease or with contamination of the food supply chain, whether accidental or intentional. The Member States of the FAO and the OIE should take steps to ensure that the FAO and OIE have comparable mandates to that given to the WHO by the WHA. All three intergovernmental organisations need to work together to harmonise their preparations and thereby encourage all Member States to take appropriate national measures.

At the public level, the Member States need to reassure their citizens that their governments – and the governments of neighbouring countries – have effective, well-rehearsed plans in place to deal with outbreaks of disease and with contamination of the food supply chain, whether accidental or intentional, as described earlier. Governments need to recognise their responsibility for ensuring that the national and international press and television are provided with accurate and timely information. While much can be done to educate the press and television about the total prohibition on deliberate outbreaks, and the measures in place to counter them prior to any such incident, it is essential during any attack that the press and television – and through them the public – are kept informed in real time of what is being done. Governments have to recognise that if they do not provide accurate and timely information, the media will seek 'talking heads' to speculate and, if these people are ill-informed or untrained to deal with the media, the frenzy for 'stories' will aggravate the situation. There are also direct international benefits if the government is providing accurate and timely information, as neighbouring countries will be reassured that all possible steps are being taken to control and contain any outbreak. The more transparent the activities of the government of the country in which an attack has occurred, the greater and faster will be the international support and assistance. Furthermore, the imposition of trade restrictions by neighbouring countries will be less likely if the government can clearly demonstrate that it has taken all necessary steps to prevent the further spread of disease or contamination. In addition, governments should remind the public that any actions intended to cause an outbreak or contamination are totally prohibited, and any instigators will be prosecuted with the full force of the national laws. Effective public communication of preparedness and of the illegality of any such action will also help to deter terrorists or criminals from undertaking such attacks. Clear statements of these facts would form part of the web of assurance and deterrence that has long been advocated (11) as the counter to the threat of biological weapons.

There continues to be a vital need in every country for all the elements of the 'web of assurance', to assure the public that all reasonable steps have been taken both nationally and internationally. The web of assurance is made up of the following elements:

a) international and national regimes that totally prohibit chemical and biological weapons:

– the universality of the BTWC and CWC and the 1925 Geneva Protocol

– the withdrawal of all reservations to the Geneva Protocol

– a legally binding instrument to strengthen the effectiveness of the BTWC

– national implementing legislation for the BTWC and CWC in all countries

b) controls on dangerous pathogens and chemicals:

– addressing handling, use, storage and transfer both nationally and internationally

c) wide-ranging protective measures:

– preparedness, detection, diagnosis and medical countermeasures

– preparedness before and after release

d) determined national and international response to use or threat of use of chemical or biological weapons:

– diplomatic actions, sanctions, military intervention

– a recognition of their responsibilities by the five permanent members of the United Nations Security Council

– national prosecution of instigators.

A strong, publicly declared commitment to such a web of assurance both nationally and internationally provides two immense benefits: first it could deter the would-be user, and second it would reassure the public both nationally and internationally that all reasonable steps are being taken to ensure their safety and security.

Communication sur le risque de bioterrorisme contre les animaux et les végétaux et perception de ce risque par le public

G.S. Pearson

Résumé
Cet article se penche sur l'interdiction internationale totale d'utiliser la maladie pour porter atteinte à l'homme, aux animaux et aux végétaux, en faisant remarquer que plusieurs pays ont par le passé élaboré des programmes axés sur des attaques contre ceux-ci. Les activités menées par des organisations intergouvernementales – l'Organisation mondiale de la santé (OMS), l'Organisation des Nations unies pour l'alimentation et l'agriculture (FAO) et l'Organisation mondiale de la santé animale (OIE) – pour faire face à la menace d'attaques contre l'homme, les animaux et les végétaux sont examinées. Des parades efficaces contre des attaques délibérées doivent être élaborées en harmonie avec les mesures existantes visant à maîtriser les foyers naturels ou accidentels de maladie. Enfin, l'article évalue le risque et la perception qu'en a le public, et examine le type de communication des risques requis et ses destinataires. La FAO et l'OIE doivent être investies de mandats clairs pour qu'elles soient préparées à faire face à des foyers de maladie et à une contamination, tant accidentelle qu'à des fins malveillantes, de la chaîne d'approvisionnement alimentaire.

Mots-clés
Animal – Bioterrorisme – Chaîne d'approvisionnement alimentaire – Communication sur les risques – Contamination – Foyer de maladie – Foyer d'origine intentionnelle – Perception du public – Risque – Végétal.

La opinión pública y la comunicación del riesgo en relación con actos de bioterrorismo contra animales y plantas

G.S. Pearson

Resumen
El autor examina la prohibición internacional absoluta de utilizar enfermedades para atacar a seres humanos, animales o plantas, y señala a este respecto que varios países pusieron en marcha en el pasado programas destinados a tales fines. También pasa revista a las actividades que llevan a cabo actualmente organizaciones intergubernamentales como la Organización Mundial de la Salud (OMS), la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO) o la Organización Mundial de Sanidad Animal (OIE) para desactivar la amenaza de ataques contra seres humanos, animales o plantas. Para contrarrestar ataques intencionados hay que preparar medidas que estén en consonancia con las que se aplican actualmente a la lucha contra brotes infecciosos naturales o accidentales. Por último, el autor evalúa el riesgo y la forma en que éste es percibido por el gran público, y se plantea qué tipo de comunicación al respecto se necesita y a quién debe ir dirigida. Es preciso

asignar un claro mandato a la FAO y la OIE para que, llegado el momento, sean capaces de hacer frente a brotes de enfermedad o a la contaminación, ya sea accidental o intencionada, de la cadena de abastecimiento alimentario.

Palabras clave
Animal – Bioterrorismo – Brote de enfermedad – Brote de origen intencionado – Cadena de abastecimiento alimentario – Contaminación – Opinión pública – Planta – Proceso de comunicación del riesgo – Riesgo.

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A history of biological disasters of animal origin in North America

G.A. Ackerman & J. Giroux

Weapons of Mass Destruction Terrorism Research Program, Center for Nonproliferation Studies, Monterey Institute of International Studies, 460 Pierce St., Monterey, California, 93940, United States of America

Summary

This paper examines past occurrences in North America relevant to the possibility of biological disasters with animal origins. With respect to naturally occurring animal disease outbreaks, North America, while not as adversely affected by epizootics as other regions, has had its fair share of such outbreaks of both 'traditional' and emerging animal diseases. The traditional category includes such diseases as anthrax, classical swine fever, bluetongue, brucellosis, foot and mouth disease, and the family of equine encephalomyelitis viruses. The emerging diseases include relatively more recent culprits such as postweaning multisystemic wasting syndrome, poultry enteritis mortality syndrome, and newly discovered examples of the transmissible spongiform encephalopathies. Additionally, several serious diseases of human beings that involve animal vectors or reservoirs occur naturally in North America or have emerged in recent decades; these include plague, hantavirus, monkeypox, West Nile virus and avian-derived influenza. At the same time, there have been very few intentional attacks on livestock using biological agents and no recorded cases in North America of animals intentionally being used to transmit disease to humans. According to the historical record, therefore, naturally occurring emerging zoonoses probably constitute the greatest threat in terms of biological disasters with animal origins. However, some of the general trends in terrorist activity, such as the intensification of activities by animal rights extremists against facilities undertaking animal research, mean that the possibility of intentional animal-related biological disasters should not be discounted.

Keywords

Biological disaster/attack – Bioterrorism – Epidemic – Epizootic – Livestock – Outbreak – North America – Terrorism – Zoonosis.

Introduction

During the past decade, and especially since the terrorist attacks of 11 September 2001, there has been a surge of speculation and angst about the possibilities of a bioterrorist attack on the territories of the United States of America (USA). This has included increasing public awareness of the possibility that such an attack may target or utilise North America's indigenous or imported fauna. There is also, of course, the perennial danger of naturally occurring epizootics wreaking havoc on the livestock industry and thus inflicting significant harm on the regional economy. While the historical record is hardly an infallible predictor of what, if any, hazards lie ahead in terms of biological disasters with animal origins, we should not ignore Confucius' admonition to study the past if we would define the future. This paper will therefore examine past occurrences in North America that are relevant to the possibility of biological disasters with animal origins.

The authors will describe four different types of events that are pertinent to the topic. The paper begins with a survey of some of the more important outbreaks that have occurred naturally among animals in North America. This

will be followed by a brief discussion of human epidemics in North America in which animals are known or suspected to have acted as either vectors or the source of the epidemic. These first two event types will not be dealt with comprehensively; only some of what the authors believe to be the more salient cases will be mentioned. This is partly owing to limitations of space, but a more significant reason is that despite repeated attempts to produce a comprehensive listing of such incidents from 1900 to the present, including queries to relevant government agencies, the authors were unable to confirm the existence of any systematic record of such events. If indeed there are no broad chronologies of these types of events, this suggests a need to develop a historical database that could be mined for analytical insights into the origin and course of biological disasters involving animals.

The last two sets of data to be discussed concern intentional biological attacks, beginning with biological attacks against animals in North America and concluding with biological attacks against humans that utilised animal life as vectors or zoonotic reservoirs. These latter sets of data are drawn from databases maintained by the Weapons of Mass Destruction Terrorism Research Program at the Monterey Institute of International Studies, which records information on all intentional incidents involving non-state actors and chemical, biological, radiological and nuclear weapons. The paper will conclude with some remarks concerning the extent to which the historical record can be used to forecast possible future threats.

Naturally occurring epizootics among animals in North America

North America, while not as adversely affected by epizootics as regions such as South-East Asia or parts of Africa, has had its fair share of naturally occurring outbreaks and near-disasters. The sources of these events can be broadly divided into two main categories: well-known, 'traditional' animal diseases, and those that in the North American context are emerging diseases of animals. While these categories are not clearly defined (an emerging disease of today could be regarded as endemic within a few decades), the former category includes such diseases as anthrax, classical swine fever (CSF) – also known as hog cholera – bluetongue, brucellosis, foot and mouth disease (FMD), and the family of equine encephalomyelitis viruses. The emerging category includes relatively more recent disease culprits such as postweaning multisystemic wasting syndrome (PMWS), poultry enteritis mortality syndrome (PEMS), and newly discovered examples of the transmissible spongiform encephalopathies. The etiologic agents of some of these more recently recorded diseases are still not fully understood. Furthermore, there are also certain zoonotic pathogens that have sub-clinical effects on animals but pose an emerging health hazard to human beings, including *Escherichia coli* O157:H7, hantavirus, newly discovered species of *Ehrlichia* that cause human granulocytic and monocytic ehrlichiosis, and the monkeypox virus. Although the authors' list of naturally occurring animal disease outbreaks is far from comprehensive, certain significant diseases and outbreaks will be discussed below in order to illustrate past experience and mitigating efforts undertaken in North America.

When looking at animal pathogens historically present in North America, anthrax (as well as being a highly feared biological weapon) has long been regarded as a serious disease of livestock (and humans), and there have been periodic outbreaks in North America. For example, Canada experienced eight sporadic outbreaks of anthrax among bison herds between 1962 and 1991, which collectively led to the deaths of over a thousand animals (18). In the past five years, anthrax outbreaks in the USA have led to several hundred livestock deaths, primarily in North and South Dakota, Texas and Minnesota. In May 2000, anthrax was detected on a North Dakota farm, which led to the quarantining and vaccination of 132 farms and resulted in 157 livestock fatalities on 31 farms by September that year. In 2001, an outbreak erupted in south-west Texas that affected 63 farms, infecting 1,638 animals of 11 different species (3).

While anthrax outbreaks can be largely controlled by a prompt disposal of infected carcasses, the highly contagious FMD can involve quarantine and mass destruction of exposed livestock. In addition, FMD has been identified as a serious bioterrorist threat because animal infection is easily accomplished and such an attack would cripple a crucial part of the agriculture sector in North America (8). During the 1920s, FMD outbreaks in the USA resulted in the loss of more than 120,000 livestock and deer. Fortunately, there has been no outbreak in the USA since 1929, when Southern California was affected (9), and the last major outbreaks of FMD in Mexico and Canada occurred in the 1950s. Nevertheless, the possible reappearance of FMD in North America poses a constant threat to the livestock sector, especially in the USA where vaccines are not routinely used and farms operate in a highly concentrated manner, which would make the raw economic loss potentially devastating.

Various species of brucella bacteria, including *B. suis*, *B. abortus* and *B. melitensis* have been endemic causes of brucellosis among livestock in the USA, although the rates of both human and animal occurrences have decreased to relatively negligible levels in the past half-century. The recent discovery of brucellosis in bison herds in

Yellowstone and Grand Teton National Parks has, however, raised fears of a potential rise in the incidence of the disease among livestock in surrounding states (17).

A disease of wild ruminants that has been responsible for several deer epizootics in the USA and southern Canada is epizootic haemorrhagic disease (21). In the pig industry, one of the most economically devastating diseases has traditionally been CSF. By 1978, CSF was eradicated in the USA as well as Canada, but still exists in parts of Mexico (15). Another set of pathogens endemic in the Americas is the equine encephalomyelitis family of viruses, which are spread by mosquito vectors and cause three significant diseases: eastern, western and Venezualan equine encephalomyelitis. Although a relatively rare cause of disease in the human population, these viruses have triggered several epizootics in North America in the past century. For example, during 1937 and 1938, more than 300,000 equines in the USA and Canada were infected with western equine encephalomyelitis, and a series of epizootics of Venezuelan equine encephalomyelitis occurred in Central America, Mexico and Texas between 1969 and 1971 (6). Eastern equine encephalomyelitis continues to be a constant threat in many states, especially in the south.

Recently, several emerging diseases of animals have appeared in North America in almost every sector of animal agriculture. Fortunately, none have yet resulted in large losses to the agricultural sector. With certain pathogens, however, their very appearance has been a cause for concern. Two poorly understood syndromes affecting swine herds have been observed in the USA within the last decade: several small outbreaks of PMWS have been reported, and the first two documented cases of porcine dermatitis and nephropathy syndrome occurred in Michigan in 1997 (30). The commercial poultry industry has had to contend with PEMS since 1991. Exotic Newcastle disease, a serious disease of birds, has also struck the USA several times in the past few decades. An outbreak in southern California from 1971 to 1973 caused severe disruption and resulted in the extermination of 12 million commercial poultry birds, and the loss of US$ 56 million in direct costs to the industry and increased poultry prices (29). More recently, an outbreak in southern California and Nevada from 2002 to 2003 led to the elimination of over 2 million birds (28).

The reappearance in Yellowstone National Park, Michigan and Texas, of *Mycobacterium bovis*, a less common cause of tuberculosis, has raised concern that the disease might spread to commercial cattle herds (16).

One class of diseases that has drawn extensive attention in recent years is the transmissible spongiform encephalopathies, which are caused by proteinacious particles known as prions. Although scrapie has been observed in sheep for a long time, the appearance of similar diseases in other animals (including bovine spongiform encephalopathy [BSE] in cattle and chronic wasting disease [CWD] in deer) became front-page news around the world when it was shown that these diseases are zoonotic and transmissible to humans through ingested animal material, resulting in a fatal disease labelled variant Creutzfeldt-Jakob disease. There have only been two positive BSE cases in the USA and three in Canada, while CWD has been recorded in the Canadian province of Saskatchewan and in the western USA. Despite the small number of cases, the discovery of BSE in cattle in the USA has the potential to cause severe disruption to the industry due to export bans, productivity losses in small farming communities and decreases in domestic and foreign consumer confidence. And if there were found to be a transmissible spongiform encephalopathy specific to North America, this would not be unexpected; the discoverer of transmissible mink encephalopathy, the late Richard Marsh, claimed that the farmer whose mink were affected had fed the animals only on fallen cattle (20).

Naturally occurring zoonoses in North America

Several serious diseases of human beings that involve animal vectors or reservoirs occur naturally in North America. Among the most virulent of these is plague. Plague is a bacterial infection caused by *Yersinia pestis*, which is transmitted by the rodent flea and has the capacity to develop into three forms: bubonic, septicaemic and pneumonic. The disease is endemic in the rodent population in many parts of North America and sporadically crosses over to the human population. At present most cases of human plague are mild and endemic in the western and south-western regions of the USA, where 10 to 15 human cases of plague are reported each year (13). From 1924 to 1925, Los Angeles experienced a rat-borne epidemic, and in 1965 seven cases were reported from the Navajo Reservation in McKinley County, New Mexico. Thereafter, the average annual number of human plague cases has increased (5), with approximately 400 human cases of plague reported to the Centers for Disease Control and Prevention (CDC). In addition, a few cases have emerged from south-western Canada and parts of Mexico. In Canada, south-eastern Alberta and south-west Saskatchewan display ongoing plague activity in animals, but no human cases have been reported.

One of the zoonotic diseases most feared by infectious disease specialists is influenza. Influenza pandemics can emerge rapidly and the virus manifests an ability to produce strains to which the human population has no immunity, on occasion causing widespread upheaval due

to the virus's high contagion and virulence factors. The 1918 Spanish flu, H1N1, continues to hold the title for the most devastating flu pandemic to date. Infecting more than 200 million people worldwide, H1N1 spread to the USA and within 18 months caused more than 500,000 deaths (14). Subsequent pandemics, which were not nearly as devastating, include: the 1957 Asian flu, H2N2 (probably caused by the interaction of an animal with human H1N1 and avian H2N2 strains), which caused 70,000 USA fatalities, and the 1968 Hong Kong flu, H3N2, which led to 34,000 USA fatalities (14).

The recent appearance of a highly pathogenic avian influenza (AI) virus (H5N1), the so-called 'bird flu', has led many scientists to express concern that this might signal another major flu pandemic. Before 1997 this virus was known to infect only birds, yet it subsequently made a leap to infecting humans, suggesting that mutation could result in a strain capable of human-to-human transmission (34). While domestic flocks, and more recently pigs, are the most common vectors, cats are also thought to be possible infection vectors for H5N1, which spreads in the air, manure and, more recently, through contaminated feed, water, equipment and clothing (1).

No cases of human or animal infection with the current strain have been reported in North America, but the continent has had several brushes with similar organisms in the past. In 1924 and 1929, a low-pathogenic AI was recognised in the USA and quickly eradicated. Scientists soon discovered, however, that H5N2 and H7N1 could mutate while circulating within infected pig or poultry populations and develop a high pathogenicity if not treated immediately. Tentative reactions by farm owners and agricultural producers who fail to respond aggressively to such outbreaks can have devastating consequences. This was the case in 1983, when H5N2 infected Pennsylvania poultry farms with a low-pathogenic influenza that within six to nine months evolved into a highly pathogenic form. The outbreak devastated flocks and caused the extermination of 17 million birds in an eradication effort that took more than two years, causing the loss of US$ 65 million in direct costs and US$ 200 million in indirect costs (33). In 1992, a similar outbreak occurred in poultry flocks in Mexico, where a low-pathogenic H5N2 influenza quickly evolved into a lethal form. A poor response and failure to institute proper containment measures meant that the disease was not controlled until 1995, when the virus reverted to a low-pathogenic form (33). The government administered more than 2 billion doses of vaccines. More recently, a H7N2 outbreak in Virginia's Shenandoah Valley infected one person, affected 197 poultry farms and caused the killing of nearly 5 million birds (23). Following this was an outbreak in 2004 of H7N3 influenza in poultry farms in the Fraser Valley region of British Columbia. In March 2004, two laboratory-cases of human infection were confirmed, alongside ten other cases involving infected Fraser Valley poultry workers (10). All infected persons were treated, the area was quarantined, and by August the Canadian Food Inspection Agency had destroyed 17 million birds in the Fraser Valley and thus eliminated the virus (10).

There are also several zoonoses that have emerged in North America that, while not necessarily affecting animal agriculture in any significant fashion, might pose a public health threat. Stephen Ostroff of the CDC declared that 'There's no way that West Nile is going to go away', following the startling discovery in 1999 of the mosquito-borne West Nile virus (WNV) in a dead crow at the New York City Bronx Zoo (4). The discovery of WNV signalled the introduction of a completely new virus to North American public health officials, and led to the hospitalisation of 59 New York residents who developed symptoms including flaccid paralysis (4). Known as 'NY99', this outbreak caused seven fatalities.

While most people infected with WNV show few if any symptoms, the remaining 20% of patients can experience flu-like symptoms and inflammation of brain tissue that leads to partial paralysis (encephalitis) and/or serious swelling of the tissue that encloses the brain and spinal cord (meningitis). By 2002, reports from both Texas and Mexico revealed that WNV had infected nearly 700 horses and 30 birds in Coahuila, Tamaulipas, Chihuahua and other areas. There were no reports of human infection in Mexico, leading public health officials to wonder whether the Mexican population maintains some type of immunity due to prior exposure to four strains of dengue virus, a member of the same family of flaviviruses (24). By 2003, seven Canadian provinces (Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan and Alberta) had also been affected (26). While rates of human infection have continued to decrease, 60 mosquito species have been identified as potential vectors for a virus that in the course of its North American tour has affected 200 species of birds, reptiles, and mammals (32), leaving public health officials shocked by the uncharacteristic mobility of the virus, for which they were unprepared. At the time of writing, there is no vaccine available for humans.

Monkeypox, a relative of smallpox, camelpox and cowpox, is a virus endemic to the African rainforest that made its surprising North American debut in several states of the USA's Midwest in 2003. Public health officials believe animal-to-human transmission occurred through prairie dogs that made contact with infected rodents that had been imported from West Africa. Over 70 cases of human infection were reported to the CDC, all characteristically involving human contact with infected prairie dogs (11). The smallpox vaccine was used to contain the outbreak and dispel public fear, while multiple bans were placed on the importation of African rodents and the distribution, sale and transport of prairie dogs, tree squirrels, rope

squirrels, dormice, Gambian giant rats, brushed-tailed porcupines and striped mice. Although they have not yet reached North America, the nipah and hendra viruses are further examples of two diseases found in fruit bats that are potentially lethal and possess the ability to move across borders in the same way that monkeypox did.

Escherichia coli O157:H7 and *Salmonella* Typhimurium DT104 are two organisms that have caused serious illness in North American human populations in the past decade. The primary sources are infected cattle and their faeces, despite the fact that *E. coli* O157:H7 rarely results in overt symptoms in cattle. In 1999 nearly 1,000 illnesses and two deaths attributed to *E. coli* were reported in upstate New York, after attendees of a county fair consumed water that was contaminated with manure runoff from infected cattle (7). Ontario, Canada, has experienced two major *E. coli* O157 outbreaks in the last five years. The first, and more severe of these, occurred in May 2000 when 2,500 people were infected with *E. coli* O157 after water supplies became contaminated, causing seven fatalities. In the second outbreak, in 2005, four people were infected after a vendor distributed milk infected with the H7 strain (22, Case # 1833).

Since the first appearance of hantavirus pulmonary syndrome (HPS) in May 1993 in the south-western USA, 396 cases have been reported, with 36% resulting in death (12). The syndrome is caused by the hantavirus and transmitted through rodents. In Canada from 1989 to 1999, 32 confirmed cases of HPS, with a fatality rate of 38%, were reported (25). There have been no reports of human-to-human transmission, but the CDC in the USA has classified hantavirus as a Category C agent, an emerging pathogen that could be engineered for mass dissemination in the future because of its availability and ease of production.

Intentional biological attacks on livestock in North America

According to the historical record, there have been very few intentional attacks on livestock using biological agents. The most prominent case occurred during the First World War, when Germany developed a covert programme of bioagricultural warfare with the help of American-born Anton Dilger. Dilger obtained cultures of anthrax and glanders in Berlin and smuggled them into the USA, where he grew them in a laboratory in Baltimore. He used the pathogens to contaminate needles and infect horses and mules in the USA that had been drafted for the armies of European allies of the USA. Following initial contamination the virus reportedly spread naturally and led to an estimated 3,000 infected horses and significant costs (2). Such claims, however, must be treated with caution. Given the state of veterinary medicine at the time, it is possible that at least some of the infections attributed to human sabotage might merely have been the result of natural disease outbreaks among stressed animals kept in crowded conditions.

The only other relevant case occurred in 1997 in Berlin, Wisconsin, where Brian W. 'Skip' Lea dumped pesticides onto deadstock (rendered-down animal products) of the National By-Products (NBP) company, which had been sold as animal feed to other businesses. An anonymous letter informed NBP that its supply had been contaminated, forcing the company to shut down its Wisconsin plant and engage in a massive recall at a cost of US$ 2.5 million (27, 31). Granting that pesticides are chemical agents, the use of biological materials (deadstock) to disseminate the pesticides arguably places this incident in the biological category as well. Lea was indicted and charged as the saboteur in September 1999.

Intentional attacks on humans by means of zoonotic diseases using animals as vectors in North America

There have been no recorded cases in North America of animals intentionally being used to transmit disease to humans. There are however two instances of this activity forming part of the thinking of perpetrators. Between 1975 and 1977, Artis O'Dell and Leon Horton sent several threatening letters containing ticks allegedly infected with deadly diseases as part of an extortion campaign. Most of the time, the ticks did not survive passage through mail-cancelling machines. O'Dell and Horton were arrested in May 1981 and later convicted of conspiracy to obstruct commerce by means of extortion (22, Case # 407). The second instance occurred in September 1978, when Mayor Lewis Murphy of Tucson, Arizona, received an undisclosed number of letters threatening that unless a US$ 500,000 ransom was paid, the poor were given food, and the Kino Community Hospital resumed performing abortions, the perpetrator would contaminate the city with bubonic plague-carrying fleas. The perpetrator did not arrive to collect the money when police delivered it (22, Case # 401).

General trends in chemical and biological attacks

According to the CDC, four of the six deadliest biological agents are zoonoses: *B. anthracis, Y. pestis, Francisella tularensis*, and filoviruses/arenaviruses (1). However, the record of intentional biological attacks involving animals is exceedingly sparse, with the vast majority of agriculturally related attacks involving chemical agents or crops as a target. For example, it is alleged that in 1970 the Ku Klux Klan used cyanide to poison the water supply of a 1,000-acre farm owned and operated by a group of Black Muslims, killing 30 cows (22, Case # 447). In fact, the overall record of intentional chemical attacks is much greater than that of biological attacks. There have only ever been 41 confirmed uses of biological agents as weapons by non-state actors, while the figure for chemical agents is 225. The corresponding casualty figures are even more telling – with 6,659 non-fatal injuries and 1,652 fatalities within the last century from the non-state use of chemical agents, compared with 1,079 non-fatal injuries and only 21 fatalities from corresponding biological attacks (22). These figures may give some indication of what to expect if those using chemical and biological weapons were to change their tactics and target animals.

Animal rights and environmental extremism

The past decade has seen a rapid increase in both the number and scale of attacks by animal rights and environmental extremists. The Federal Bureau of Investigation in the USA estimates that one group alone, the Animal Liberation Front (ALF), has committed over 700 criminal acts and caused US$ 112 million in damage in the past decade (19). The ALF and another group opposed to animal experimentation and vivisection, Stop Huntingdon Animal Cruelty, have launched many of their attacks on facilities that work with both animals and animal and human pathogens. While the primary purpose of these so-called 'direct actions' is usually to release experimental animals, disrupt research and/or intimidate scientists, there is the possibility that such an attack could result in the accidental release of an animal or zoonotic pathogen into the environment.

Conclusion

The above description of North America's colourful history of epizootics and zoonoses reveals a wide variety of pathogens that have found their way through or to animals on the North American landmass. North American agriculture has had to contend with many of the maladies that afflict livestock throughout the world, in addition to several diseases found only in this region. Moreover, transnational flows of goods, people and other vectors mean that this region is increasingly being exposed to emerging natural diseases of animals, some of which may have dire consequences for the region's livestock industries.

Conventional ideas regarding bioterrorism regard humans as the primary target. At present, fortunately, the main threat to livestock does indeed seem to be naturally occurring outbreaks, especially those involving emerging (foreign) animal diseases, rather than intentional biological attacks. Yet circumstances may change. The agricultural industry is vulnerable both economically and politically. These weaknesses, coupled with the relative ease of procuring and disseminating animal pathogens, present an attractive option for intentional attacks on livestock in North America. Natural outbreaks of diseases can, however, serve an illustrative function in highlighting the mass disruption and devastation that could arise from a well-planned intentional release.

Naturally occurring emerging zoonoses probably constitute the greatest threat related to biological disasters with animal origins. The human immunodeficiency virus, severe acute respiratory syndrome, monkeypox, Nipah virus, AI and WNV are all examples of emerging infectious diseases that have jumped from animal reservoirs into the human population while exercising their ability to spread rapidly. Urbanised centres are expanding and encroaching on natural animal habitats, international travel is increasing, and trade in exotic animals and agriculture is becoming globalised; consequently containment is difficult, the rate of infection is rapid, and hosts outside the regional locus of infection are all but immune. If the history of animal disease in North America teaches us anything, therefore, it is that we must maintain constant vigilance towards emerging biological threats, not only for the sake of the economic health of our livestock industries, but also for public health in general. ■

Aperçu historique des catastrophes biologiques d'origine animale en Amérique du Nord

G.A. Ackerman & J. Giroux

Résumé
Le présent article passe en revue l'historique des événements en Amérique du Nord en rapport avec la possibilité de catastrophes biologiques d'origine animale. En ce qui concerne les foyers de maladie animale naturelle, ce continent, bien que moins touché par les effets négatifs des épizooties que d'autres régions, a enregistré bon nombre de foyers épizootiques de maladies animales tant « classiques » qu'émergentes. Parmi les maladies traditionnelles figurent la fièvre charbonneuse, la peste porcine classique, la fièvre catarrhale du mouton, la fièvre aphteuse et la famille des encéphalomyélites équines. Les maladies émergentes regroupent des pathologies relativement plus récentes telles que le syndrome cachectique multisystémique du post-sevrage et certaines encéphalopathies spongiformes transmissibles découvertes récemment. En outre, plusieurs maladies humaines graves dans lesquelles interviennent des vecteurs ou des réservoirs animaux se déclarent naturellement en Amérique du Nord, ou sont apparues ces dernières décennies ; il s'agit notamment de la peste, des infections à hantavirus, de la variole du singe, de la fièvre West Nile et de la grippe d'origine aviaire. En revanche, on a constaté très peu d'utilisations à des fins malveillantes d'agents biologiques contre le bétail et on n'a signalé aucun cas, en Amérique du Nord, d'animaux utilisés dans l'intention de transmettre une maladie aux humains. Ainsi, selon les archives, les zoonoses émergentes survenant naturellement constituent probablement la menace la plus grave de catastrophe biologique d'origine animale. Cela étant, compte tenu de certaines tendances générales en matière d'activités terroristes, telles que l'intensification des actions des extrémistes défenseurs des droits des animaux dirigées contre les centres de recherche pratiquant des expériences sur les animaux, la possibilité d'une catastrophe biologique d'origine intentionnelle en rapport avec les animaux ne doit pas être écartée.

Mots clés
Amérique du Nord – Attaque/catastrophe biologique – Bétail – Bioterrorisme – Épidémie – Épizootie – Foyer – Terrorisme – Zoonose.

Historia de los desastres biológicos de origen animal en Norteamérica

G.A. Ackerman & J. Giroux

Resumen
Los autores examinan diversos episodios que han tenido lugar en Norteamérica relacionados con la posibilidad de desastres biológicos de origen animal. Por lo que respecta a brotes zoosanitarios por causas naturales, esa región, aunque menos afectada que otras por las epizootias, no ha dejado de sufrir un buen

número de brotes de enfermedades animales, tanto "tradicionales" como emergentes. Entre las primeras figuran por ejemplo el carbunco bacteridiano, la peste porcina clásica, la lengua azul, la brucelosis, la fiebre aftosa o las virosis de la familia de la encefalomielitis equina. Entre las enfermedades emergentes hay dolencias relativamente nuevas como el síndrome multisistémico de desmedro post-destete o el de mortalidad de pavipollos por enteritis, o ejemplos recientemente descubiertos de encefalopatías espongiformes transmisibles. En Norteamérica, además, se dan de forma natural o han aparecido en los últimos decenios una serie de graves enfermedades humanas en las que intervienen vectores o reservorios animales: peste, hantavirosis, viruela símica, fiebre West Nile o gripes derivadas de la influenza aviar. Al mismo tiempo, en Norteamérica ha habido muy pocos ataques intencionados contra el ganado con agentes biológicos, y no se ha registrado ningún caso de utilización deliberada de animales para transmitir enfermedades a las personas. A juzgar por la historia, en consecuencia, la mayor amenaza por lo que respecta a los desastres biológicos de origen animal radica probablemente en las zoonosis emergentes inducidas por causas naturales. Sin embargo, dentro de las características generales de la actividad terrorista se observan ciertas tendencias, como la intensificación de los actos contra instalaciones de investigación animal por parte de extremistas que enarbolan los derechos de los animales, que impiden descartar la posibilidad de que se produzcan desastres biológicos de origen intencionado vinculados al mundo animal.

Palabras clave
Bioterrorismo – Bovino – Brote – Desastre/ataque biológico – Epidemia – Epizootia – Norteamérica – Terrorismo – Zoonosis.

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La erradicación de la peste porcina africana en el Brasil, 1978-1984

T.M.P. Lyra

Doctora en Ciencia Animal, ex-Secretaria de Defensa Agropecuaria del Ministerio de Agricultura, Producción Pecuaria y Abastecimiento del Brasil, SQN 304, Bl. D, Apto. 311, 70736-040 Brasilia, DF, Brasil

Resumen

El episodio de peste porcina africana en el Brasil se produjo como consecuencia del aumento de focos en Europa y de los intercambios comerciales y turísticos entre España, Portugal y Brasil durante ese período. La erradicación de la enfermedad, las medidas de sacrificio de cerdos, la eliminación de los cadáveres y el aislamiento de las granjas afectadas tuvieron una fuerte resonancia en los medios de comunicación, generando un importante impacto socioeconómico. Se prohibió criar cerdos en depósitos de basura y alimentarlos con ceba considerada de riesgo sanitario. Tanto los análisis realizados en el Brasil como las consultorías nacionales e internacionales de investigadores de laboratorios de referencia concluyeron que la enfermedad se propagó desde Río de Janeiro hacia otros estados, como consta en los informes oficiales. A continuación de las acciones de emergencia, se implantó un programa de control sanitario que permitió mejorar la calidad del sector de producción de cerdos. La autora describe la vigilancia epidemiológica de la peste porcina africana, la peste porcina clásica y enfermedades parecidas, la bioseguridad en la producción de cerdos, y el plan de actuación de emergencia con capacitación en sanidad animal para los médicos veterinarios y agentes sociales. Los resultados del programa de erradicación fueron excelentes, a pesar de la discusión en torno al empleo del rifle sanitario en un país con graves problemas sociales. En 2004, Brasil era el cuarto país productor y exportador de carne porcina en el mundo, con una producción de 2.679.000 toneladas y un volumen de exportación de 508.000 toneladas destinado a mercados internacionales con alto nivel de exigencia.

Palabras clave

Acción de emergencia – Brasil – Peste porcina africana – Planificación – Sanidad animal.

Introducción

La peste porcina africana (PPA) fue descrita por Montgomery, con el relato de focos en Kenia en 1910 después de la introducción de razas europeas por los colonizadores. La enfermedad, de forma aguda y fatal, apareció en cerdos importados.

En la población de cerdos autóctonos la enfermedad no presentó manifestaciones clínicas. Ese aspecto llamó la atención sobre la capacidad de adaptación del virus al sistema ecológico, puesto que estaba presente en insectos (garrapatas) y en los cerdos nativos de África, sin que éstos últimos, sin embargo, manifestaran ningún cuadro clínico de enfermedad. En 1957, la PPA fue identificada en Portugal y poco tiempo después en España, en Francia y en Italia. En 1964, apareció un foco en Francia, en la frontera con España. En junio de 1971, el primer caso en América fue detectado en Cuba, pero no hubo notificación oficial a la Organización Mundial de Sanidad Animal (OIE) antes de 1980. Debido a la situación epidemiológica de la PPA en algunos países de Europa y de África, el Brasil prohibió la importación de cerdos domésticos o salvajes, así como de semen, carnes, vísceras y productos derivados

provenientes de España, de Portugal, de Cuba y del continente africano, extendiendo dicha prohibición a los cerdos que habían hecho escala en los puertos de esos países o de África (3).

La condición privilegiada de América del Sur, alejada de los otros continentes, con el océano como barrera natural de protección contra las enfermedades provenientes del África y de Europa, ya no tenía validez. Con la introducción de la PPA en Cuba (en 1971), y en la República Dominicana, Haití y Brasil (en 1978), se pudo comprobar la vulnerabilidad de esta barrera natural (6).

En el Brasil, el primer foco de PPA fue identificado en Río de Janeiro, en el municipio de Paracambi. El primer cerdo murió el 30 de abril de 1978 y trece días después ya habían muerto unos 200 cerdos de un total de 1.000 que contaba la granja afectada. El foco fue considerado como "emergencia sanitaria" y se adoptaron las recomendaciones de la OIE: sacrificio sanitario de los animales enfermos y contactos, cremación de los animales muertos, desinfección, desinsectación y destrucción de las instalaciones no conformes. Estas medidas fueron reguladas por el Decreto Presidencial n° 81.798/78, que autorizó a movilizar todos los órganos del gobierno, bajo la coordinación del Ministerio de Agricultura, para la lucha contra la PPA (8, 22).

Los sacrificios en los focos con rifle sanitario y la destrucción de los cadáveres, tuvieron una importante repercusión en la prensa. La falta de un programa educativo que preparara el público a entender las medidas de erradicación se tradujo por un impacto sin precedentes, con noticias diarias en los medios de comunicación. Varios informes destacaron el hecho que la enfermedad ocurría sólo en pequeñas granjas, dando origen a la opinión polémica de que se trataba de una represalia contra los pequeños productores. En realidad, la forma de transmisión del virus a través de los restos de comida que se utilizaban para alimentar a los cerdos fue un factor de propagación de la enfermedad en granjas con bajo nivel zootécnico. Este acontecimiento, junto con la reacción de no aceptar el diagnóstico, tuvo como consecuencia una idea equivocada que llevó incluso a que se negase la existencia de la enfermedad.

El impacto social y económico del diagnóstico de la PPA en el Brasil, fue sin precedentes. Con la posterior implantación de un programa de control sanitario el sector se organizó, pasando a contar con una industria de calidad, cortes especiales y asistencia veterinaria para los productores. El programa, implantado en 1981, después de la disminución de los focos, fue planeado desde la base hasta la total erradicación, manteniendo una vigilancia activa de la peste porcina clásica (PPC) y de la PPA, y realizando análisis serológicos y virológicos.

Actualmente los indicadores de calidad de la producción porcina brasileña demuestran la eficacia del sector, con 26 cerdos terminados/hembra/año, que a los 160 días de edad pesan 110 kilos. En 2004, el Brasil fue el cuarto mayor productor y exportador mundial de carne de cerdo, con una producción de 2.679.000 toneladas y un volumen de exportación de 508.000 toneladas con un valor de 774 millones de dólares americanos, lo que representa un aumento de 40,5% con relación al año anterior (1). El riesgo de introducción de animales y productos derivados infectados aumentó en el mundo entero, debido a los frecuentes intercambios internacionales. Esto significa que el sistema de vigilancia interna debe tener la prioridad para poder detectar con rapidez cualquier enfermedad exótica y ser capaz de erradicarla de inmediato (16).

El objetivo del presente trabajo es describir las acciones de emergencia para evaluar el impacto y la importancia de mantener el programa sanitario dentro de la producción porcina.

Resultados

Los determinantes epidemiológicos de la ocurrencia de la PPA en el Brasil fueron los siguientes: el aumento del número de focos en Europa y la intensificación de los intercambios comerciales y turísticos entre el Brasil y los países afectados, España y Portugal; el deficiente control de la PPC en el país, que ocasionó un desconocimiento de la situación sanitaria del sector de la producción porcina brasileña.

En 1978, aumentó el número de focos en Europa, totalizando 2.384 casos en España, 864 en Portugal y 24 en Italia. Este acontecimiento, junto con la intensificación del tránsito internacional, puede explicar la aparición de los focos detectados en la Isla de Malta, en la República Dominicana, en Haití y en el Brasil. En 1980, apareció un caso en Cuba (que fue notificado a la OIE), en 1984 en Francia y en 1985 en Bélgica. En el Brasil las investigaciones epidemiológicas demostraron que en el primer foco, el propietario había recibido ilegalmente restos de comida provenientes de vuelos internacionales del aeropuerto cercano de Río de Janeiro, recién inaugurado, que todavía no disponía de horno crematorio. La Figura 1 muestra el depósito de restos de comida encontrados en el lugar.

Los focos secundarios se detectaron en granjas donde se alimentaba a los cerdos, como en el primer caso, con restos de comida. La granja se encontraba cerca de una estación de gasolina en la carretera Río de Janeiro-São Paulo, en donde se reabastecían los camiones que salían de Río de Janeiro con destino a São Paulo y al sur de Minas Gerais.

Cuando empezó la mortalidad, el propietario vendió algunos cerdos a camioneros de estados vecinos, lo que dio la falsa impresión de que el origen de la enfermedad estaba en esos estados receptores. En el primer foco, como medida de emergencia se sacrificaron todas las especies de animales que existían, con destrucción de las instalaciones, desinfección, desinsectación y cuarentena. El diagnóstico se realizó en el laboratorio de Referencia para América, localizado en Plum Island, Estados Unidos de América. El día 31 de mayo de 1978, Mebus y col., confirmaron el diagnóstico de PPA en el Brasil (15). Posteriormente los diagnósticos fueron realizados en el laboratorio equipado para este fin, con el apoyo de la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO) (equipos y consultoría) en el Instituto de Microbiología de la Universidad Federal de Río de Janeiro (8). Los trabajos de diagnóstico recibieron consultoría internacional desde que se inauguró el laboratorio.

Durante la fase febril, se observó que los cerdos se amontonaban en las esquinas de las instalaciones (Fig. 2). Se comprobó que enfermaban animales de edades diferentes, observándose lesiones hemorrágicas en los animales de piel clara, más frecuentes en las orejas y en el hocico. En los caseríos pobres (favelas), los cerdos eran criados entre depósitos de basura. El sacrificio fue seguido por la comunidad y por la prensa, denotando el carácter social de la enfermedad (Fig. 3).

Las lesiones observadas, en especial en el primer foco eran características de la forma aguda de la enfermedad. El bazo presentaba hemorragias, aumentaba de tamaño y tomaba un color oscuro. En la Figura 4, se observa el bazo de un animal afectado comparado con otros de cerdos que no presentaban síntomas de la enfermedad.

Fig. 1
Depósito de restos de comida utilizados en la alimentación de cerdos – foco de peste porcina africana – Paracambi, Río de Janeiro
Foto: archivo personal

Fig. 2
Amontonamiento de lechones, en la etapa inicial (febril) de peste porcina africana

Fig. 3
Sacrificio de cerdos acompañado por la población y por la prensa

Fig. 4
Bazo, aumentado de volumen, hemorrágico, de aspecto oscuro
Foto: archivo personal

Acciones de emergencia contra la peste porcina africana

En el período 1978-1979 se adoptaron medidas de emergencia sanitaria con establecimiento de un grupo de trabajo a nivel federal a través de la Comisión Central de Erradicación, con sub-comisiones en todos los estados. Las estrategias de lucha comprendían los siguientes tipos de actuaciones:

– operación de destrucción de depósitos clandestinos de restos de alimentos en las ciudades, con la retirada y destrucción de restos de comida de bares, restaurantes, hoteles y otros establecimientos, y la prohibición de su venta;

– operación de control de agrupamiento y de tránsito de cerdos, prohibiendo las ferias, las exposiciones y entornos con agrupamiento de cerdos, e instalando puestos de control de tránsito en las carreteras para controlar los movimientos de cerdos y confiscar y eliminar a los cerdos encontrados;

– operación de censo con realización del censo de la población porcina en las áreas de focos;

– operación de foco, a través del rastreamiento de focos, captura, verificación y sacrificio de animales enfermos, sospechosos y contactos para su posterior cremación;

– operación de repoblación; seis meses después de haber eliminado los cerdos enfermos y muertos así como los residuos, y de haber realizado por lo menos dos desinfecciones de los locales afectados, se autoriza la repoblación, colocando cerdos sentinelas comprobados negativos para la PPA y vacunados contra la PPC;

– operación de educación sanitaria y de comunicación social, con la participación de los actores sociales mediante aclaraciones en reuniones y visitas. Se elaboraron folletos que fueron distribuidos en los aeropuertos y puertos para explicar las precauciones a seguir para la revisión de equipajes, así como folletos de orientación para los productores sobre las medidas generales de prevención de la enfermedad, y otros materiales didácticos utilizados en reuniones con productores;

– operación de recursos financieros, con identificación de las necesidades y liberación de recursos por parte del gobierno federal, estatal, empresas, asociaciones y fundaciones;

– operación de estudio del impacto económico, con análisis del costo de la erradicación y cálculos sobre las pérdidas resultantes de la prohibición de venta de carne y productos derivados de cerdos para los mercados internacionales, así como de las barreras para la exportación de otros productos como soja, café y pimienta del reino;

– operación de apoyo internacional, con ampliación de la cooperación técnica y económica por parte de organismos internacionales como la Organización Panamericana de la Salud, el Instituto Interamericano de Cooperación para la Agricultura (IICA), la FAO, la Organización Mundial de la Salud y la OIE, y de gobiernos extranjeros y órganos del propio gobierno brasileño.

La fase de emergencia fue eficaz. Los primeros análisis demostraron que la enfermedad se circunscribió a Río de Janeiro. Considerando este aspecto, se propuso el sacrificio de la población porcina del estado para proteger la producción porcina tecnificada del país. Antes de que empezaran las operaciones de sacrificio, se detectó un foco en el estado de São Paulo, lo cual obligó a modificar la estrategia (14). La fase de emergencia duró de 1978 a 1979; en ese período, 224 focos fueron identificados, 66.966 cerdos fueron sacrificados y la indemnización fue de US$ 2.118.257. El Cuadro I muestra los diagnósticos virológicos realizados en ese período.

Cuadro I
Número de muestras enviadas al laboratorio y de resultados positivos entre 1978 y 1979

Año	Número de muestras	Resultados positivos de peste porcina africana
1978	511	207 (41%)
1979	202	17 (8%)
Total	713	224 (31%)

Programa de erradicación de la peste porcina africana y de control de la peste porcina clásica en el Brasil

En 1976 no existía control de la PPC. El diagnóstico se efectuaba basándose en las observaciones clínicas y anatomopatológicas. Se declararon 640 focos y se produjeron cuatro millones de dosis de vacuna, para un rebaño que contaba 34 millones de cerdos. Estos datos indican que el rebanõ no estaba protegido (8).

La institucionalización del programa específico de control de la PPC y de erradicación de la PPA tuvo lugar en 1981, después de declararse siete nuevos focos de PPA. En los focos se mantuvieron las acciones de emergencia, con vigilancia sanitaria activa en busca de casos residuales. El país fue dividido en regiones, con estrategias diferentes para obtener áreas libres y su ampliación progresiva hasta alcanzar la

condición de país libre. La región Sur fue prioritaria, debido a que en ella se concentraba 44% de la población porcina de la nación y que era el principal centro productor de cerdos para consumo y reproducción (3). El programa defendió ante la OIE la estrategia de regionalización, invocando la extensión territorial del Brasil, y esta política fue aprobada por la OIE. Este fue el primer programa de aplicación regional. A continuación se describen las actividades realizadas.

Vacunación contra la peste porcina clásica

La vacuna utilizada era la cristal violeta – con virus inactivado. En 1979 la vacuna con virus vivo fue controlada en el Brasil mediante un estudio comparativo de sus efectos en relación con los de la vacuna con virus inactivado cristal violeta, en trabajos de campo y de laboratorio. Se comprobó la eficacia de la vacuna con virus vivo en lechones que quedaron protegidos a los 12 días post-vacunación. La protección era de 100% a los 21 y 70 días post-vacunación, mientras que los animales vacunados con la vacuna atenuada (cristal violeta) sólo quedaban protegidos a los 21 días post-vacunación. La inocuidad de la vacuna con virus vivo fue controlada en fetos y en recién nacidos de cerdas vacunadas durante la gestación, lo cual demostraba que la vacuna no presentaba patogenicidad residual (10). Después de estos resultados, se utilizó la vacuna con virus vivo para el control efectivo de la PPC en el Brasil. La estrategia de control de la enfermedad era de dejar de vacunar después de que desapareciera el último caso clínico. Se organizó la certificación de las granjas de reproducción libres de PPA y controladas para PPC, enfermedad de Aujeszky, brucelosis y tuberculosis, con el objetivo de obtener unidades de cría libres y luego progresivamente, estados y regiones libres. Se realizaron análisis serológicos con el objetivo de identificar y controlar las enfermedades de la esfera reproductiva y vigilar las formas subclínicas de la PPC y de la PPA presentes en madres portadoras (*carrier sows*).

Vigilancia serológica y epidemiológica

En el período 1980-1984, se realizó en el Brasil un estudio serológico en la población porcina de la región Sur del país. Los sueros que habían dado resultados positivos a la prueba de inmunoelectro-osmoforesis (IEOF) fueron sometidos a la prueba de inmunofluorescencia indirecta (IFI). El estudio dio los resultados siguientes: 434 sueros resultaron positivos a la prueba de IEOF, de los cuales 80 (18,4%) también resultaron positivos a la prueba de IFI, considerada definitiva, o sea un total de 0,04% resultados positivos. La pequeña proporción de resultados positivos muestra que la enfermedad se encontraba en la fase final de erradicación. Los autores observan sin embargo que no es recomendable usar en la población una prueba de la que no se haya aclarado previamente el grado de sensibilidad y de especificidad (13). Se utilizó como prueba serológica la IEOF, como recomendado por expertos internacionales (18). La prueba había sido realizada anteriormente en España (19). Las granjas de origen de los cerdos positivos fueron despobladas. Actualmente la prueba de IEOF es recomendada por la OIE solo como clasificación.

Tanto la PPC como la PPA son imposibles de distinguir en sus manifestaciones clínicas y en las lesiones que ocasionan. Los informes de enfermedades parecidas a la peste porcina deben ser analizados en el campo y confirmados en el laboratorio. El laboratorio de referencia para el diagnóstico fue instalado en el LANARA en Pedro Leopoldo, Minas Gerais; también fueron homologados, en el estado de Rio Grande do Sul, el Laboratorio de Pesquisas Desiderio Finamor (IPVDF), en el Paraná el Laboratorio Marcos Enriette y en São Paulo, el Instituto Biológico de São Paulo.

Control del tránsito interno e internacional

Se ampliaron los controles de tránsito e internacional, con fiscalización en los puertos, aeropuertos y puestos de frontera para equipajes y para el destino de los alimentos que son servidos a bordo.

Sistema de información

Se estableció un sistema de información como parte del sistema internacional coordinado por el IICA. Se puso a disposición un número de teléfono de llamada directa y gratuita para la declaración de focos. Se desprende del análisis del sistema de información una serie de indicadores para el estado de Paraná (Cuadro II). Los focos presentaban un cuadro epidemiológico comparable al de la PPA. La comparación con la población porcina total del estado puso de manifiesto que la enfermedad estaba circunscrita.

Cuadro II
Indicadores observados en los focos de peste porcina africana, en relación con la población total del estado de Paraná en 1978 (4)

Indicadores	Cantidades
Población en los focos (animales expuestos)	4.396
Enfermos	679
Muertes	558
Porcentaje de ataque	15,45%
Porcentaje de muertes	12,69%
Porcentaje de letalidad	82,18%
Población porcina del estado	4.500.000
Índice de morbilidad del estado	1,51/10.000
Índice de mortalidad del estado	1,24/10.000

Por el estudio de los formularios de PPA, se verificó que en los focos, el tipo predominante de animales era el cerdo de quintal y el mestizo, destinados a la venta para el consumo; la cría era de tipo casero, con utilización de restos de comida para la alimentación o asociación de restos de comida con raciones de fabricación propia; los propietarios no solían trabajar con cooperativas ni tenían asistencia veterinaria. La fiebre y las alteraciones de la piel eran los síntomas observados con mayor frecuencia (4).

Impacto de la peste porcina africana en el Brasil

Impacto de las medidas de emergencia

A pesar del resultado positivo de las medidas de emergencia, el sacrificio de los animales en los focos con martillos y rifles tuvo un fuerte impacto en la prensa. Esta estrategia era desconocida por la población y la falta de preparación para comprender y aceptar las medidas de erradicación se tradujo por la publicación diaria de informes en los medios de comunicación. Todo esto fue motivo de artículos que sugerían que la enfermedad sólo afectaba a las pequeñas unidades de producción y que presentaban el sacrificio de los cerdos como una acción en contra de los pequeños productores. En realidad, la forma de propagación de la enfermedad a través de los restos de comida era lo que favorecía que la enfermedad se diera en granjas con bajo nivel zootécnico y productivo.

Impacto relacionado con la forma de manifestación de la enfermedad

En 1960, profesionales brasileños visitaron Portugal y observaron la enfermedad en su forma aguda y fatal. De regreso al Brasil describieron esta forma como característica de la PPA, y así ocurrió efectivamente en el primer foco en Paracambi. Como en los demás focos la enfermedad se presentó en forma subaguda, no se acertó el diagnóstico, por falta de conocimientos sobre esa forma de presentación de la enfermedad. Para aclarar esta situación el autor publicó un artículo (11) dedicado a la forma de presentación de la enfermedad con baja mortalidad, tal como la habían descrito varios autores cuando apareció en Francia (7), y también en España, en donde fueron relatados focos que ocasionaron pérdidas exclusivamente entre animales lactantes (5). La cepa del virus de la PPA que circuló en el Brasil era de baja patogenicidad (15). La gran mortalidad observada en el primer foco se explica por el control sanitario deficiente y por la presencia simultánea de otros agentes patógenos.

La OIE describe una forma subaguda con tasas de mortalidad comprendidas entre 30% y 70%, así como una forma crónica con mortalidad reducida (17).

Hace poco un estudio explicó que persisten dudas sobre los focos de PPA en el Brasil. Los autores de este estudio pusieron en duda el diagnóstico realizado, considerando que los resultados obtenidos fueron "falsos positivos", y concluyeron que el foco de Paracambi había sido la única ocurrencia de la enfermedad en el Brasil (23). Sin embargo, esta afirmación no se justifica, sobre todo si consideramos que el virus fue aislado a partir de muestras recibidas de los distintos focos. Además, debido a los posibles efectos de la enfermedad en el negocio agropecuario, se tomaron medidas de erradicación rápidas y con el máximo rigor. En un programa de erradicación suelen aparecer resultados falsos positivos, pero la mayor preocupación del Servicio Veterinario es de encontrarse con un resultado falso negativo. Es unánimemente reconocido que en un proceso de erradicación lo más importante es disponer de pruebas con alto nivel de sensibilidad, que limiten al mínimo el riesgo de resultados falsos negativos. En Río de Janeiro se detectaron muestras positivas provenientes de barrios pobres (*favelas*) y de depósitos de basura en lugares alejados del foco inicial (Teresópolis). El estudio serológico realizado en el estado de Paraná en 1983 demostró la persistencia del agente. Los últimos focos, ocurridos después de 1979, fueron erradicados mediante la eliminación sanitaria de los cerdos (final de muerte en el frigorífico) para evitar escándalos en la prensa. La decisión de no alertar a la prensa y de eliminar a los cerdos de esa forma fue tomada con los agentes sociales que participaban en las comisiones del programa de erradicación, junto con el sector público y privado.

Posición de los productores y de los industriales

La mayoría de los focos se presentaron en contextos de cría caracterizados por condiciones sanitarias deplorables, lo que indica el aspecto social como determinante epidemiológico de la enfermedad.

La industria y los grandes productores brasileños dejaron de exportar y desconfiaron del diagnóstico. El sector contrató como consultante al Doctor Carnero, investigador de Maisons-Alfort, Francia, que en su informe dirigido a las autoridades brasileñas concluyó: "de las conversaciones que tuvimos a todo nivel, se desprende un sentimiento de desconfianza respecto a la existencia real de la PPA en el país. Los hechos epidemiológicos, síntomas y resultados de necropsias son perfectamente compatibles con la evolución de una PPA de carácter subagudo, pudiendo concluirse sin reservas que el virus de esta enfermedad está presente en el país. Aceptar tesis distintas no tiene fundamento y será muy perjudicial para el objetivo deseado, es decir la eliminación del virus del país" (8, 9).

El mismo consultante volvió al Brasil en misión oficial el 12 de octubre de 1979, y afirmó que la campaña conducida durante un año contra la PPA había tenido un resultado positivo para la erradicación de la enfermedad. Durante los diez meses anteriores, el virus sólo se había aislado tres veces en el laboratorio, demostrando que la enfermedad había dejado de propagarse y estaba desapareciendo, y que había llegado el momento de iniciar la etapa de sanidad final. El uso de la vacuna viva tipo china producida en conejos contra la peste porcina clásica, con rigurosos controles de inocuidad y potencia, solucionaría más de la mitad de los problemas clínicos y disminuiría la carga de trabajo del laboratorio (8, 9).

Repercusión en los medios de comunicación e impacto político y económico

El tratamiento por la prensa de las medidas de erradicación fue muy exagerado. Hubo problemas sociales debidos a la cuarentena de seis meses impuesta a las granjas y al hecho que los productores no recibieron indemnización por las pérdidas sufridas. Como la enfermedad prácticamente no afectó la producción porcina tecnificada, también hubo un impacto político (12).

Los costos directos e indirectos de las acciones de emergencia, sumaron 13 millones de dólares incluyendo las indemnizaciones de 66.902 cerdos muertos, con pérdidas asociadas a los cerdos eliminados de US$ 14.576.320,43. Además de las pérdidas directas, hubo una baja en el consumo de hasta 40% como consecuencia de la disminución de la oferta. El sector fue decayendo, pequeños productores fueron a la quiebra y unas dos mil familias que dependían de la producción porcina quedaron desempleadas. Las exportaciones de carne de cerdo se paralizaron. Hubo además restricciones de exportaciones brasileñas para productos de origen vegetal, como soja, café y pimienta del reino.

Investigaciones realizadas en el Brasil

La muestra de virus de PPA aislada del primer foco fue inoculada a tres ejemplares de cerdo mestizo. Los animales enfermaron presentando lesiones típicas del curso agudo de la enfermedad. Los fragmentos de varios órganos con lesiones y las muestras de sangre, tomados durante la etapa virémica, al ser examinados por las técnicas de hemadsorción e inmunofluorescencia directa confirmaron los resultados (20).

La posibilidad de transmisión del virus de la PPA por la vacuna contra la PPC tipo cristal violeta fabricada con la sangre de cerdos fue estudiada por Rodriguez y col. (21). El fenómeno de adsorción de los hematíes fue estudiado también, revelando la presencia del virus en la superficie de los hematíes, adherido a esas células; en algunos casos la partícula viral fue encontrada en el interior de los eritrocitos. La muestra de Paracambi se mantuvo en estado viable a un pH de 2,0 a 12,0 (20).

En un estudio de campo y de laboratorio se compararon los análisis serológicos realizados para el diagnóstico de la PPA (13).

Aspectos positivos

Une serie de hechos permitió detectar y notificar rápidamente la enfermedad, y luego actuar con eficiencia.

Rápida identificación de la enfermedad

El foco ocurrió en una granja situada cerca de la Universidad Federal de Río de Janeiro y de la Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). El propietario de los cerdos había cambiado de pienso y atribuyó la mortalidad al nuevo pienso. Solicitó entonces indemnización. El veterinario de la industria de piensos realizó un diagnóstico para buscar el origen del problema, con el Profesor Tokarnia, el 10 de mayo de 1978. Al ver las lesiones, el Profesor Tokarnia consideró la sospecha de PPA, debido a que los animales habían sido vacunados contra la PPC. Al visitar la granja ese mismo día, pudo constatar que en ella se utilizaban para alimentar a los cerdos restos de alimentos servidos en vuelos internacionales llegados a Río de Janeiro. El Profesor Neitz, de Sudáfrica, en visita a Brasil, confirmó el diagnóstico clínico y anatomopatológico de PPA.

Rápida notificación

El Profesor Neitz incitó a sus colegas brasileños a que hicieran una rápida notificación de la PPA a los Servicios Veterinarios oficiales (23). El 12 de mayo de 1978 se notificó oficialmente la enfermedad.

Rápida actuación

El Director del Servicio de Defensa Zoosanitaria, Dr. Ubiratan Mendes Serrão, envió varios veterinarios oficiales a la granja afectada en la noche de 12 de mayo. La eliminación del foco fue rápidamente iniciada por el jefe de la Defensa Sanitaria de Río de Janeiro.

Apoyo gubernamental

El gobierno inmediatamente tomó conciencia de la necesidad de erradicar esta enfermedad exótica. Hubo una extensa colaboración por parte de los demás ministerios. Tanto el ejército como la policía militar prestaron una ayuda eficiente en la eliminación de los focos.

El diagnóstico de la muestra enviada al Centro de Referencia para las Américas, en Plum Island, Estados Unidos de América fue conocido el 31 de mayo de 1978, pero las medidas de erradicación fueron introducidas el día mismo de la notificación.

Se prohibió criar cerdos en depósitos de basura. Los productores empezaron a observar y a tomar medidas de bioseguridad. Los pequeños productores se asociaron a industrias con asistencia veterinaria total o a cooperativas. Se estableció una estructura sanitaria para el sector de producción porcina, que pasó a contar con una industria de calidad, cortes especiales y asistencia veterinaria.

Se estableció una estructura para el diagnóstico de la PPC y de la PPA en el país, en el Laboratorio de Referencia LANARA, en Pedro Leopoldo. Los métodos de identificación empleados fueron los de referencia internacional: diagnóstico viral, hemoadsorción en cultivos de leucocitos e inmunofluorescencia directa, y en el diagnóstico serológico, IFI e inmunoelectroforesis (2).

La PPC fue erradicada de la región de producción porcina adelantada, apareciendo episodios limitados en las regiones Norte y Noreste del país. La erradicación de la PPC es de suma importancia para la vigilancia de la PPA, ya que las dos enfermedades tienen manifestaciones clínicas y anatomopatológicas parecidas.

Discusiones y conclusiones

La aparición de la PPA hubiese tenido un impacto menor, si la población y los veterinarios hubieran estado preparados para las acciones de emergencia. Es conveniente realizar periódicamente simulaciones de las acciones de "emergencia zoosanitaria". El impacto y los costos de la política de erradicación son altos, pero son más bajos que los que conlleva un programa de control, que siempre dura más tiempo. Las medidas adoptadas disminuyeron el número de focos y permitieron el éxito del programa de erradicación.

Es necesario ser prudente con los informes que se dan a la prensa sobre los procedimientos de erradicación de enfermedades. Deben evitarse las entrevistas polémicas por los problemas que causan entre los agentes sociales. Si no hubiese bajado tanto el precio de la carne de cerdo, el problema social hubiera sido menor, lo cual indica la necesidad de una mejor comunicación entre los productores y los industriales.

El determinante epidemiológico para que se mantenga la PPA en el ecosistema es la presencia de la garrapata del género *Ornithodorus*, reservorio del virus. Según los estudios e informes de especialistas, esta garrapata no se encuentra en el Brasil. El virus no encontró condiciones ecológicas para su adaptación, por la ausencia del reservorio, lo cual interrumpió el ciclo de transmisión y contribuyó a eliminar la enfermedad.

La FAO tuvo una participación importante y ofreció su apoyo a las acciones, por medio de asesorías, instalación del laboratorio de diagnóstico y organización de seminarios nacionales e internacionales de gran importancia en los que se habló de las situaciones de distintos países, presentando las experiencias realizadas y las estrategias comunes de erradicación adoptadas.

La OIE envió a especialistas y reconoció al Brasil como país libre de PPA en 1985. Los informes de la OIE con relación a las Américas indican que la enfermedad ocurrió en cuatro países de América Latina (República Dominicana, Haití, Cuba y Brasil) y que fue erradicada en los mismos. Los Estados Unidos de América no han reconocido el estatus sanitario del Brasil respecto de la PPA. Hoy en día, dentro de los acuerdos de la Organización Mundial del Comercio, la referencia máxima para asuntos de sanidad animal es la OIE, y sus decisiones deben ser aceptadas.

La PPC fue erradicada del sector de producción de cerdos gracias a la aplicación de un programa de inmunización con vacuna viva, seguido de su retirada y certificación de las unidades de producción y estados libres. En 2001, ocurrieron solamente 12 focos en la región noreste del Brasil, actualmente en fase de erradicación. De las estrategias de planificación y de actuación en sanidad animal del programa de erradicación de la PPA y de control de la PPC, destacamos como pioneras a las siguientes:

a) la certificación de unidades de producción libres de determinadas enfermedades, tales como la PPA, la enfermedad de Aujeszky, la brucelosis y la tuberculosis, controladas para leptospirosis, PPC (en la etapa inicial), y posteriormente libres de PPC;

b) la participación de los agentes sociales en 1981, con la formación de un fondo de indemnización integrado y administrado por los productores e industriales, o sea por el sector privado;

c) la adopción de criterios de regionalización previos a la institucionalización de los mismos por la OIE, buscando la obtención de áreas libres por regiones en el Brasil y justificando internacionalmente estas medidas por la extensión territorial del país. España apoyó la estrategia brasileña y después la implantó en su propio programa.

Es fundamental consolidar el programa mediante la vigilancia epidemiológica, capacitando al personal para actuar en estas emergencias. El entrenamiento en sanidad animal es importante para que los médicos veterinarios perciban el foco de la enfermedad en su relación con el sistema de producción y la región del país dentro de su

análisis epidemiológico, sin esperar que todos los focos presenten la misma característica que el foco inicial. Lamentablemente, en aquella época, no existía un acercamiento de la investigación con la defensa sanitaria, lo que hubiera permitido evitar las dudas respecto a las acciones de erradicación y la demora en la información.

El foco de PPA pudo detectarse gracias a la orientación del investigador internacional que se encontraba en Río de Janeiro. Los focos de ampliación de la PPA en las *favelas* y en otros municipios del estado de Río de Janeiro fueron secundarios. Los investigadores de EMBRAPA realizaron las pruebas biológicas con inoculación de cerdos vacunados contra la PPC, o sea, utilizaron la prueba biológica descrita en el postulado de Koch. Esa decisión llevó al sacrificio de todos los cerdos de la EMBRAPA por la Defensa Sanitaria (22), debido al riesgo que representaba para toda la región la falta de bioseguridad, incluso de aislamiento. Las pruebas recomendadas por la OIE deben ser mantenidas en los laboratorios de diagnóstico con una formación continua del personal, y los profesionales deben recibir instrucciones para notificar de inmediato a los Servicios Veterinarios cualquier sospecha, para que éstos realicen la colecta del material para el diagnóstico y tomen las medidas de erradicación necesarias.

The eradication of African swine fever in Brazil, 1978-1984

T.M.P. Lyra

Summary

The African swine fever episode in Brazil was due to trade and tourism between Spain, Portugal and Brazil, at a time when outbreaks were on the rise in Europe. The eradication of the disease, the slaughter of pigs, the elimination of the carcasses and the isolation of affected farms were given wide media coverage, and had a major socio-economic impact. It was forbidden to raise pigs in garbage dumps or to give them feed considered hazardous. Analyses performed in Brazil as well as national and international investigations by researchers from reference laboratories concluded that the disease had spread from Rio de Janeiro to other states, as is stated in official reports. Following emergency measures, a control programme was implemented, leading to enhanced quality in the pig farming sector. The authors describe epidemiological surveillance of African swine fever, classical swine fever and related diseases, biosafety in swine farming, and the emergency action plan comprising animal health training for veterinarians and social workers. The results of the eradication programme were excellent, despite the controversy over compulsory sacrifice in a country with serious social problems. In 2004, Brazil was the fourth largest pork producer and exporter, with an output of 2.679 million tons and exports of 508,000 tons to international markets with very high standards.

Keywords

African swine fever – Animal health – Brazil – Emergency measure – Planning.

L'éradication de la peste porcine africaine au Brésil, 1978-1984

T.M.P. Lyra

Résumé

L'épisode de peste porcine africaine est survenu au Brésil suite à l'augmentation des foyers en Europe et à l'intensification des échanges commerciaux et touristiques entre l'Espagne, le Portugal et le Brésil à cette époque. L'éradication de la maladie, et plus particulièrement les méthodes d'abattage des porcs, l'élimination des carcasses et la mise sous quarantaine des fermes affectées ont eu une forte répercussion dans les médias, avec des conséquences sociales et économiques considérables. Il fut interdit d'élever des porcs dans des décharges publiques et de les nourrir avec des aliments considérés à risque. Les études réalisées au Brésil ainsi que les travaux des consultants de laboratoires de référence nationaux et internationaux ont conclu que la maladie s'est propagée à partir de l'état de Rio de Janeiro vers les états voisins, comme cela est indiqué dans les rapports officiels. Une fois prises les mesures d'urgence, un programme de prophylaxie sanitaire a été mis en place, qui a permis d'améliorer la qualité de la production porcine du pays. L'auteur décrit la surveillance épidémiologique de la peste porcine africaine, de la peste porcine classique et de maladies animales apparentées, ainsi que la biosécurité dans les élevages de porcs et le programme d'action sanitaire d'urgence, avec une formation complémentaire en santé animale pour les vétérinaires et les travailleurs sociaux. Le programme d'éradication a eu d'excellents résultats malgré les débats soulevés par l'abattage sanitaire systématique dans un pays secoué par de graves problèmes sociaux. En 2004, le Brésil était le quatrième producteur mondial de viande de porc, avec une production de 2 679 000 tonnes et un volume d'exportation de 508 000 tonnes vers des marchés internationaux à forte exigence de qualité.

Mots-clés

Brésil – Mesure d'urgence – Peste porcine africaine – Planification – Santé animale.

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Quantitative risk assessment case study: smuggled meats as disease vectors

M. Wooldridge [1], E. Hartnett [1], A. Cox [2] & M. Seaman [2]

(1) Centre for Epidemiology and Risk Analysis, Veterinary Laboratories Agency, New Haw, Addlestone, Surrey KT15 3NB, United Kingdom
(2) SafetyCraft Ltd, 20 Pollard Road, Morden, Surrey, SM4 6EG, United Kingdom

Summary
Outbreaks of foot and mouth disease (FMD), African swine fever (ASF), classical swine fever (CSF) and swine vesicular disease (SVD) can cause significant economic and social costs and severe trade limitations. A number of commodities may be contaminated with these hazards, including meat and meat products derived from infected animals. Great Britain (GB) enforces a number of regulations to prevent the importation of such pathogens. However, the illegal importation of meat provides a route by which controls may be circumvented and pathogens imported. This paper discusses a series of risk assessments examining the disease risk to the GB livestock population of FMD, CSF, ASF and SVD from the illegal importation of any meat product from any region in the world. This paper describes the development of a quantitative risk assessment model designed to identify the major contributors to this risk, and discusses the challenges posed when undertaking such complex risk assessments.

Keywords
African swine fever – Classical swine fever – Disease control – Foot and mouth disease – Import – Meat smuggling – Quantitative risk assessment – Swine vesicular disease.

Introduction

The project described here was initiated, in early 2002, at the highest level of government when the Secretary of State for Environment, Food and Rural Affairs chaired a meeting of all the major stakeholders and the risk assessment team. This expressed a commitment to incorporating risk assessment into decision making involving all interested parties. The aim of this paper is to describe the process and discuss some lessons learned.

In 2001 Great Britain (GB) suffered an outbreak of foot and mouth disease (FMD), suspected of being initiated by the smuggling of meat or meat products contaminated with FMD virus (FMDV) which subsequently found their way into incompletely treated pig swill. This led to strong political pressure for action to control meat imports. In response to the recommendations of the Royal Society Inquiry into Infectious Diseases in Livestock (16), and political pressure to provide evidence of the risk, in 2002 and 2003 the Department for Environment, Food and Rural Affairs (Defra) commissioned a series of quantitative risk assessments. These were to assess the risk of infection of GB livestock by FMDV, classical swine fever virus (CSFV), African swine fever virus (ASFV) and swine vesicular disease virus (SVDV) due to smuggled meat and meat products. Their findings were to assist in deciding what future disease prevention and control policies would best suit the specific circumstances of GB. The country has a considerable global trade, and vast numbers of people pass through key airports and ports. Thus, not only disease control issues but also wider practical and business issues must be considered when determining disease control policies.

The risk assessments were undertaken using the guidelines given in the World Organisation for Animal Health (OIE) *Terrestrial Animal Health Code* (22), and are described in

detail in two risk assessment reports produced by the Veterinary Laboratories Agency (VLA) and published by Defra (19, 20). It was clear from the outset that the methodology had to reflect the many origins of meat contaminated by the specified hazards, and the diverse routes by which it is imported illegally into GB, and then distributed such that livestock can be exposed and infected.

Methods

In estimating the risk associated with the importation of illegal meat, a common model structure was used to develop the risk assessment for each virus. The model parameters were specified for each of the viral hazards as appropriate, reflecting the differences in the microbiological characteristics of each of the four hazards. The risk assessment model consists of three separate components:

a) estimating the flow of illegally imported meat into GB

b) estimating the probability that meat is contaminated with a virus, specifically FMDV, ASFV, CSFV, and SVDV

c) identifying exposure pathways and estimating the probability and frequency of infection in GB livestock caused by contaminated meat.

Together these components, which are summarised in Figure 1, represent the various pathways by which the virus is transferred from its country of origin to livestock in GB.

To give maximum information to policy makers, a modelling approach was required which would allow for traceability of all significant parameters at each stage of the process. The model was therefore constructed using an object-oriented code, which also permitted examination of the behaviour of the model at each step. The modelling structure also reflects the various possible routes taken by contaminated meat. Hence, the model is complex in terms of the level of detail given by the model results, the mathematical formulation, and the volume of information and data that was collated to populate the model. The following presents a summary overview of some of the key components of the model. Full technical details are published elsewhere (9, 20).

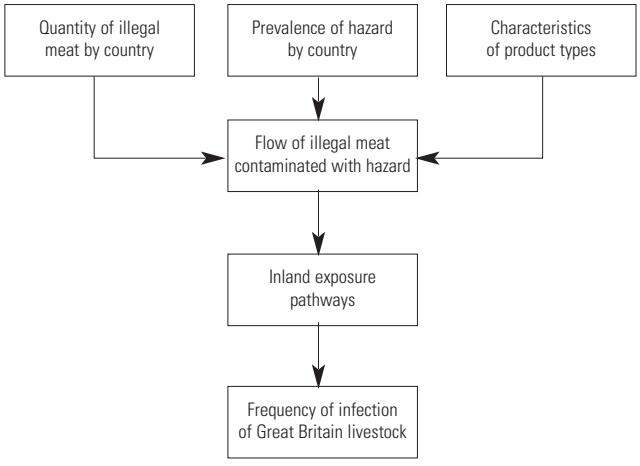

Fig. 1
Summary of the components of the risk assessment to estimate the frequency of infection of livestock following exposure to illegally imported meat

Estimating the quantity of meat imported illegally into Great Britain

The primary source of data used to derive the flow of illegal meat for this assessment was the illegal animal product seizures (ILAPS) database. This database was set up at the Ministry of Agriculture, Fisheries and Food (now a part of Defra) in April 2001. Until April 2003, it recorded seizure information provided both by enforcement agencies and by other supporting agencies. These agencies included the Association of Port Health Authorities, Local Authorities Co-ordinators and Regulatory Services, the State Veterinary Service and the Food Standards Agency (FSA). Until April 2003 Her Majesty's Customs and Excise (now part of Her Majesty's Revenue and Customs [HMRC]) supported the work of these agencies in various ways, including making seizures in the public interest, but was not itself a legal enforcement agency. However from that date, when it obtained legal enforcement powers, seizure data was entered directly into a database set up by HMRC, and data for April to September 2003 was taken from that database. The seizures reported included those from all countries which were, at the time, outside the European Union (EU), and thus included those which became Member States in 2004.

The ILAPS database holds data on seizures of products of animal origin (POAO) where the importers sought to evade correct importation procedures. Information was gathered on smuggled products in freight (both air and sea), mail, and passenger baggage. Data were also collected where smuggled products were seized inland from trading premises. Data for entry onto ILAPS were collected on meat (including poultry meat), fish, dairy products and other goods, for example honey.

Once a seizure was made, the seizure data were submitted by the agency concerned to the Illegal Imports Team within the International Animal Health Division of Defra, for entry to the ILAPS system. Ideally, these data should have comprised:

– weight of the products seized
– point of origin

– mode of transport
– point of entry to the UK
– the enforcement agency which made the seizure
– details of the importer and the exporter.

However, the database had a number of limitations. There were problems in obtaining a unified approach to the data submitted due to the multitude of reporting authorities. Some agencies provided more details than others. In addition, as the process of reporting became more embedded, the frequency of reports increased. Thus the data collected in the later months are more likely to give an accurate picture of meat flows by type, origin, etc. Both the risk assessment team and Defra were aware of these limitations. However, even though ILAPS did not contain complete details of 100% of the seizures made, it represented the best dataset available at the time on the level of seizures of illegal meat and meat products.

The data recorded on ILAPS made possible the categorisation of the types of meat flows from the different regions in terms of the meat species and product type. Although seizure data can be taken as indicative of the properties of the flow of illegal products from each region, assessment of the quantity is more complex. The data in ILAPS only recorded information about seizures. At that time the system did not hold information about the frequency of searches where no seizures occurred. In addition, searches were not conducted on a random basis but ad hoc, and targeted towards those routes (primarily air passenger traffic from certain regions) where it was known that there was a significant flow of POAO. It was therefore necessary to develop 'scale factors' which related the total quantity of illegal meat seized to the probable total flow of successfully smuggled illegal meat.

To obtain scale factors for each mode of entry of illegal meat (that is: sea freight containers, passenger baggage, post plus courier, and air freight), data collected in another exercise commissioned by Defra were analysed. In this exercise, a number of additional checks were carried out at major air and seaports, in an attempt to identify the proportion of smuggled meat missed in existing routine enforcement checks. It focused on the two modes of entry considered to be of most significance: passenger baggage and containerised sea freight. Data from this exercise supplemented the routine data available in the ILAPS database. This information provided a basis for deriving scale factors for passenger baggage and sea freight, updated to decrease bias as improved ILAPS data became available, and formatted as distributions to take into account the uncertainty inherent in the data source. This additional study significantly enhanced capacities to use information in the database to estimate the flow of illegal meat, and highlights the importance of continuing communication between the risk assessment team and the risk managers. Communicating difficulties about key data gaps enabled the initiation of further work to help address those data gaps.

In summary, the stages in generating a representative flow of meat for the model are:

a) the assumption was made that the seized consignments from a given region, as reported in the ILAPS database, are representative of the number and type of illegal meat imports from that region (but not necessarily the weight). (It was recognised that this assumption may not always be true, but no additional information was in existence.) The difference between the total estimated number of illegal imports and the number seized at ports was calculated by using the scale factors;

b) each of the product type descriptions in the ILAPS database (approximately 1,725 different words or phrases because the information was collected in free format) was translated into generic descriptions of meat species and processes, using categorisations such as cattle, pig, sheep, and cooked, dried, bone-in and de-boned to describe the meat species and product types respectively;

c) the four main transport modes for meat into GB (that is sea freight, air passenger baggage, air freight and post) were used to characterise the mode of arrival into GB from each region;

d) the estimated proportion of the meat flow seized from each region, by mode of entry, was derived from the scale factors. This was expressed as a matrix, allowing the numbers of importations for each region and transport mode to be assessed separately, thus maintaining a high degree of detail in the model and therefore in the final estimates of risk;

e) the weight of meat imported in each consignment was derived by sampling from a weight distribution obtained by statistical analysis of the ILAPS data; these weight distributions are a function of the mode of arrival.

The resulting estimates of the amount of illegal meat imported were on average 11,875 tonnes of meat per year, with a 90% certainty interval ranging from 4,398 to 28,626 tonnes per year. This estimate is based on seizure data available at the time of risk assessment development: specifically, the 29 months up to 30 September 2003.

Prevalence of hazard

For each region of the world the prevalence of each of the hazards was required to enable an estimate of the proportion of the flow that would be contaminated. A major problem highlighted through the development of these risk assessments was the shortage of data about the

disease status of many of the individual territories considered. Due to the way that trade can spread diseases when pathogens are present, the global disease situation is monitored, and data collected, by a number of organisations. The main source of such information is the OIE. Each year the OIE collates information on the disease status of member countries for a number of diseases, recording the number of establishments affected by each disease that have been reported throughout the year. However, the OIE members comprise only 73% of the countries considered in this study. There is no centralised source of disease-occurrence data for non-member countries. As each member country initiates its own reporting of disease occurrence, some countries may fail to, or be unable to, report complete data. Some countries do not report at all. Reports of disease occurrence are likely to be underestimates, as some establishments that are affected may go unnoticed or not be reported to the appropriate authority within the country.

Other bodies are also involved in collating data on outbreaks, though none are as extensive as the OIE database. The World Reference Laboratories and United States Department of Agriculture Animal Health Manual, and the Food and Agricultural Organization's (FAO) Emergency Prevention System (EMPRES) bulletins and alerts provide relatively independent data (1, 4, 18). However, these data are qualitative and not available for all years. The European Commission for the Control of FMD provides yearly updates on disease situation and control measures for FMD but is limited to selected countries (5). For some minor trading nations, particularly island communities, there are no available data on previous outbreaks, although import and export partners can be identified. To address this key data deficiency, all available data were aggregated to provide estimates of prevalence, as summarised in Figure 2. The evidence base(s) for each component of Figure 2 is given in Table I. Initially this system was intended to model illegal meat flows by country of origin. However the data available were unable to support this level of differentiation. Therefore, to reduce the reliance on country-level data with their associated high degrees of uncertainty, estimates were aggregated on a regional basis. The final estimates of risk were therefore less dependent on poor-quality, country-specific data.

Product characteristics

To estimate the levels of viral contamination, viral loads in the tissues of infected animals were estimated from published data; for example for FMD the following references were used: pigs (2, 12, 13), sheep (17), cattle (3, 8). Survival data on the persistence of each of the hazards were then incorporated into the model to determine how well, and for how long, the virus will persist in the product during processing and subsequently. Incorporation of this

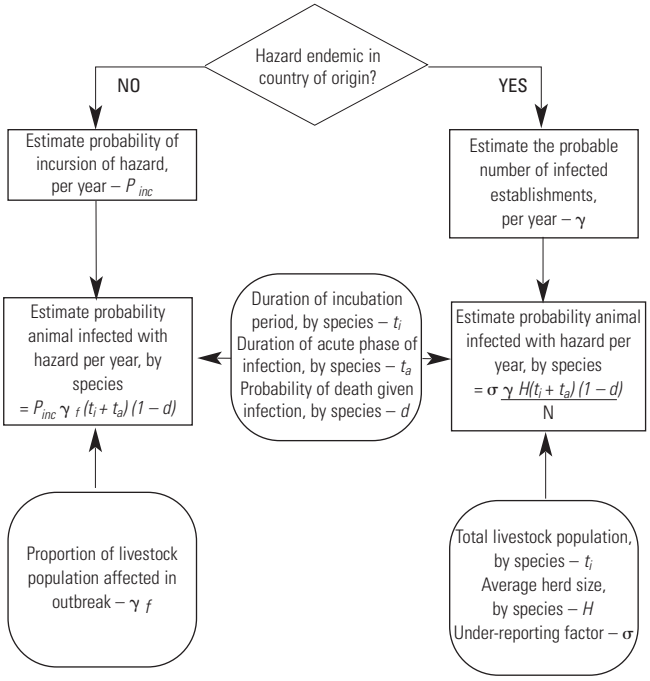

Fig. 2
Summary of the stages to estimate the prevalence of each hazard in the 223 populated territories considered in the risk assessment

information provides an additional level of distinction between product types; for example CSFV has been reported to survive in smoked meat for up to 90 days (15), while in salted meat there is evidence of survival for up to 313 days (11). Accumulating these data with processing times and transportation times from the region of origin to GB made it possible to estimate the degree of degradation in the viral contamination level which occurs during production and transit. This allows an estimation of the contamination level of the product at the point of import into GB. The expected flows of meat into GB contaminated with each of the hazards is summarised in Table II.

Inland exposure pathways

The final component of the model describes the mechanisms by which the imported meat reaches livestock, plus an estimate of the dose of pathogen (the hazard) to which animals would be exposed. This was achieved through the development of a module which describes all the pathways by which each hazard may reach livestock. These pathways include swill feeding, landfill of meat waste from restaurants, and other methods of disposal such as littering. The module includes the pathways that appear on scientific grounds to be the most significant, taking into account the microbiological characteristics of each of the hazards and the impact of each of the mechanisms and processes upon the virus. The pathways modelled for FMD are shown in Figure 3. Full

Table I
Evidence used to estimate the prevalence of each hazard in the territories considered in the risk assessment

Parameter description		Value	Source of data (reference)
Probability meat is contaminated			
Number of affected establishments		–	OIE (21), AVIS (1), USDA (18), EMPRES (4), EUFMD (5), expert opinion (19, 20)
Level of underreporting		40%	Expert opinion (19, 20)
Livestock population size		–	FAOSTAT (6)
Period of viable virus in tissues			
Total duration of infection	ASF	230 days	(10, 14)
	CSF	19 days	(10, 14)
	SVD	12-21 days	(10, 14)
Latent period	FMD-cattle	1-7 days	(10, 14)
	FMD-swine	2-8 days	(10, 14)
	FMD-sheep	3-12 days	(10, 14)
Acute period	FMD-cattle, sheep	4-11 days	(10, 14)
	FMD-swine	6-7 days	(10, 14)
Probability of death	ASF	0.05-1	(10, 14)
	CSF	0.95-1	(10, 14)
	SVD	0	(10, 14)
	FMD-cattle, swine, sheep	0.02-0.2	(10, 14)
Probability of selecting an infected non-farmed species		10% lower than farmed	Expert opinion (19, 20)
Proportion of population affected in an outbreak	ASF	Triangular (0, 0.0022, 0.022)	OIE (21)
	CSF	Triangular (0, 0.0005, 0.005)	OIE (21)
	SVD	Triangular (0, 0.0004, 0.004)	OIE (21)
	FMD	Triangular (0, 0.002, 0.02)	OIE (21)

ASF : African swine fever
AVIS : Advanced Veterinary Information System
CSF : classical swine fever
EMPRES : Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases of the FAO
EUFMD : European Commission for the Control of Foot-and-mouth Disease
FAOSTAT: Food and Agriculture Organization statistical databases
FMD : foot and mouth disease
OIE : World Organisation for Animal Health
SVD : swine vesicular disease
USDA : United States Department of Agriculture

details of the pathways for each hazard and evidence upon which the pathways were selected are provided in the VLA risk assessment (20). The absence of earlier studies meant that many of the parameters relied on expert opinion. Given the level of exposure (dose) for livestock, the probability of infection was estimated using published dose–response information; for example for FMD the model of French *et al*. (7) was adopted. Aggregating these probabilities over the entire flow of illegal imports provided an estimate of the frequency of infection per year for each hazard.

Frequency of infection of Great Britain livestock

Table II
Estimated flows of the quantity of illegally imported meat that is contaminated with each of the hazards per year into Great Britain

Hazard	Contaminated flow per year (kg)		
	5th percentile	Mean	95th percentile
African swine fever	0.007	0.046	0.138
Classical swine fever	7.5	263	794
Swine vesicular disease	0.002	0.007	0.021
Foot and mouth disease	64.6	214.2	565

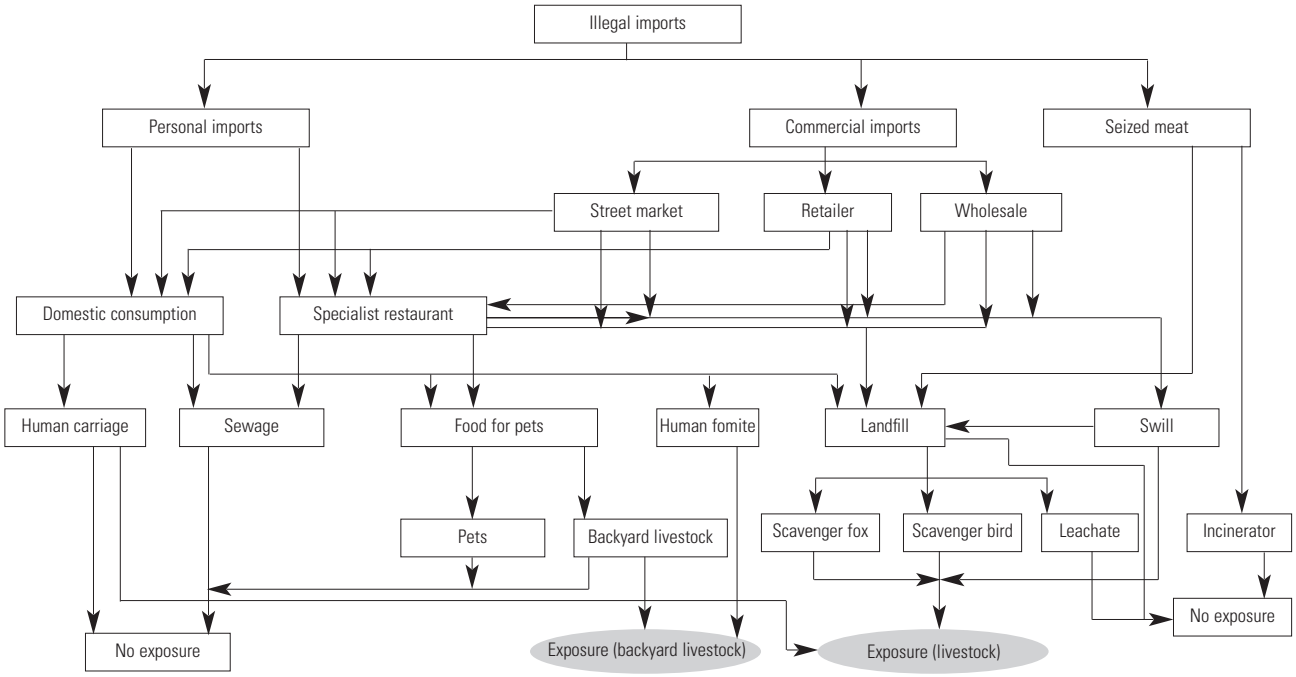

Fig. 3
The inland exposure pathways for foot and mouth disease (FMD) describing the plausible routes by which FMD virus might reach livestock from illegally imported meat

The frequency of infection is a result of the flow of contaminated meat through the inland exposure pathways which results in the exposure of livestock to each viral hazard considered. The risk assessment provides a numerical estimate of the risk posed by each region of the world for each disease considered. The frequency of infection per year for each hazard is summarised in Table III.

Table III
The frequency of infection per year for infection with each of the hazards as a result of the illegal importation of meat and meat products into Great Britain

Hazard	Frequency of infection per year		
	5th percentile	Mean	95th percentile
African swine fever	2.9×10^{-5}	6.1×10^{-4}	2.3×10^{-3}
Classical swine fever	0.006	0.3	0.8
Swine vesicular disease	3.4×10^{-10}	6.9×10^{-10}	2.2×10^{-8}
Foot and mouth disease	0.0017	0.015	0.053

Model validation

Validation of risk assessment models cannot generally be undertaken by comparing outputs with known values. The known values (by definition) do not exist at the time, and many years – possibly hundreds or more – may be needed to verify the model for low probability estimates, even though these may be of high impact and thus of crucial importance to the risk manager. Thus risk assessment best practice requires that such models are validated by peer review, using appropriate biological and – for quantitative models – mathematical experts. This process is designed to ensure that the data used are the best currently available, all assumptions are reasonable, and the mathematical computations are correct. This peer review process was undertaken for the model used in this assessment. Biological and other relevant experts were consulted on input data and risk pathways throughout the process. Preliminary results were also subject to inspection by relevant experts, which was followed by model review and adjustment where appropriate. An independent peer review of the overall mathematical model was undertaken when development of the model was complete.

Factors contributing to the risk of infection

Investigation of the factors that contribute to the risk of infection will further inform our understanding of the risk to livestock from the importation of illegal meat, aiding decision makers when considering control policy. The risk of infection can be considered in a number of informative ways: for example, by region, by product type or by exposure pathway. Some of the key insights gained from

this work are summarised.

Risk of infection by region based upon mean estimates

For full definitions of the regions, and the uncertainty distributions surrounding the mean estimates, see VLA, 2004 (20).

– Imports from the Near and Middle East were the most likely to cause infection with FMD, with imports from this region accounting for approximately 47% of the frequency of infection;

– imports from Eastern Africa represent the greatest proportion of the risk of infection with ASF, with imports from this region accounting for approximately 96% of the frequency of infection;

– imports from Western Africa represent the greatest proportion of the risk of infection with CSF, with these imports accounting for approximately 79% of the frequency of infection;

– imports from Eastern Europe represent the greatest proportion of the risk of infection with SVD, with imports from this region accounting for approximately 70% of the frequency of infection. Some of the countries in this region are now within the EU, and thus no longer have individual import controls.

Product type based upon mean estimates

For full definitions of the uncertainty distributions surrounding the mean estimates, see VLA, 2004 (20).

– Imports of cattle and pig meat represent the greatest proportion of the risk of infection with FMD, accounting for approximately 88% of the total frequency of infection. Cattle were the dominant species, accounting for approximately 64% of the total risk of infection. A large proportion of the risk was attributed to exposure to FMDV-contaminated bone-in and dried de-boned meat, with imports of such products accounting for approximately 69% of the total frequency of infection;

– imports of de-boned meat are the most likely to cause infection with ASF. Imports of such products account for approximately 77% of the total frequency of infection;

– imports of dried de-boned meat are the most likely to cause infection with CSF. Imports of such products account for approximately 70% of the total frequency of infection;

– imports of ground meat (in matrix) represent the greatest proportion of the risk of infection with SVD. Imports of such products account for approximately 52% of the total frequency of infection. De-boned meat is the next largest contributor with 22% of the total frequency of infection.

Import and inland routes

– The model considers the importation of meat by various routes of entry. These are passenger baggage, air freight, sea freight and post, plus couriers. The model results indicated that passenger baggage was the biggest contributor to the risk for each of the disease hazards. However, the large quantities involved often suggested a commercial incentive, rather than importation for private use;

– of all the possible pathways considered by which livestock could be exposed to contaminated meat, meat that follows the human carriage route contributes the most to the risk of infection. Here individuals may inappropriately dispose of leftover meat, for example by littering, direct feeding or 'fly-tipping' (illegal dumping of rubbish, often on the verges or in ditches along country lanes). Illegal swill feeding was the second largest contributor to the risk (all swill feeding to pigs is now illegal in GB), and scavengers at landfill sites the third. However, based on mean estimates, these last two routes account for a very small proportion of the total risk. The feeding of backyard livestock and wild boar make minor contributions to the estimate of risk;

– once the meat has passed through all the stages considered by the model and results in livestock exposure, for FMD it was found most likely that infection would occur in pigs. Of the predicted risk of FMD infection per year, on average 96% of the risk was associated with commercially reared pigs, 3% with cattle, 1% with sheep and goats, and a low risk in backyard pigs and wild boar.

Discussion

The development of the risk assessments posed a number of challenges to both the risk managers and the risk assessment team, including:

a) managing the complexity of the required information about seizures. This was collected by a number of organisations, making collaboration between organisations essential;

b) appropriately involving stakeholders in the risk assessment process, thus ensuring they are informed and have the opportunity to contribute as the process develops, and that they have realistic expectations of the insights that risk assessments can and cannot provide;

c) handling the development of risk assessments which are fit for purpose – in this instance with a very large scope and many intermediary results – while under pressure for a quick completion due to the urgency of the issue;

d) communicating the use of the results and the

importance of outputs from the risk assessment, in addition to the estimates of risk.

Below we discuss these key issues further.

The importance of cross-organisational collaboration and partnership

This risk assessment utilised many types of data from many different sources. Some of the data – for example those used to estimate the prevalence of FMD in each region of the world, or to estimate the level of virus present in different meat products, or for dose–response modelling – relied heavily upon routinely reported outbreak data, literature searches and individual biological experts. However for other data, for example those needed to estimate the probable quantity of illegally imported meat, or to identify probable post-import exposure pathways, there was no 'routine' source of information. New approaches were necessary involving extensive collaboration across different interest groups.

Taking the quantity of illegal imports as an example, there were two major sources of data. The first was the ILAPS database, a cross-organisational information-gathering exercise set up in 2001 and run by Defra to record the seizures of illegally imported meat, as identified primarily by local and port health authorities (PHA). This required the active involvement and support of several organisations. The ILAPS database contained the hard data which provided the starting point on which the estimates of quantities of illegal imports were based. Despite the imperfections of the database, it played an essential role as an underpinning basis for estimates of illegal imports and without it, it is hard to see how such an estimate could have been made. The second major source of information for this model input was HMRC and PHA officers themselves. They were willing to set aside time to discuss with the risk assessment team the methods, problems, successes and failures in the checking procedures at points of entry to GB. These discussions helped put the ILAPS data into context and allowed the quantified estimation of illegal imports. Without this essential cross-organisational cooperation, primarily between Defra and HMRC but including other organisations, it is very difficult to see how this quantification could have been attempted.

The value of stakeholder involvement

Throughout the process, there was close stakeholder involvement in the form of a steering group set up and chaired by Defra. The steering group had representatives from a wide range of organisations, including the National Farmers' Union (NFU), FSA, HMRC, local authorities, commercial transport providers, restaurant organisations and others, and met regularly throughout the risk assessment process. The meetings provided a very useful forum for the exchange of information and ideas; questions, disagreements and points of view were all aired and technical explanations given. The format for involving stakeholders developed as experience was gained, and in such a way as to maximise efficiency and reduce time diverted from the risk assessment itself. The most effective format was found to be a brief presentation of progress, with handouts supplied and time for debate, at meetings held only whenever there was truly something new to discuss. One particular issue which caused concern was that of the presentation of intermediate results. Some of the audience were unaware that risk model development is an iterative process, and for this reason intermediate outputs are no guide to the final result. However, we were asked by Defra to provide these intermediate outputs, and this caused temporary difficulties for some participants.

The steering group forum enabled the risk assessment process and results to gain public support from a wide range of stakeholders, which is vital in such a high profile undertaking. Nevertheless this process is time consuming, and for urgent projects it must be recognised that it does delay the output.

Interpretation, uncertainty and the value of results

Quantitative risk assessments, by definition, produce a result in numerical terms. Developments in stochastic methodology and the utilisation of expert opinion have resulted in numerical outputs which incorporate and describe the uncertainty in the system. This raises a number of issues with regard to the interpretation, meaning and use of those outputs.

When risks have to be managed and decisions made, it is understandable that the more certain the facts, the easier it is to make decisions and plan policy. Thus, in general, risk managers would like uncertainty minimised. A single number output from a quantitative risk assessment is therefore easier to deal with and understand. One typical initial response, when the 5th to 95th percentile range of a distribution is very large (as in this case), is that 'it doesn't really help'. However, this totally understandable reaction ignores the most important feature of the result: namely that there are very large uncertainties, and they do need to be taken into account when making decisions. A deterministic model which gave as a result a single number might have been easier to understand, but it would almost certainly have been wrong – and where the uncertainties are very great, it could be very badly wrong. Using mathematics does not make uncertainty go away. The risk manager who wants to make best use of a risk distribution needs to understand exactly what that distribution is

telling them, which is much more than a single number ever could.

But the final result from a risk assessment, and in particular a complex quantitative assessment such as this, is unlikely to be the most important feature of that assessment. The basis of any good risk assessment is the identification of the 'risk pathway', the chain(s) of events necessary for the unwanted outcome to occur. The delineation of this risk pathway itself will almost always provide insights, which will assist the risk manager in managing the final risk.

In this risk assessment, for example, identifying all the possible inland exposure pathways, and considering which were plausible and which were not, was of great value, and could be used again for assessments of other exotic pathogens with similar characteristics. The specific methodology used here also allowed for the estimation of a vast number of intermediate outputs, for example the quantity of illegally imported meat by region of origin, the quantity of contaminated meat by type of product, and many others. Again this provides insights into the problem and indications of where risk reduction measures might most successfully be employed. These are all outputs which would have been impossible without the formal methodology of a risk assessment, and for the intermediate estimates, a quantitative risk assessment of the type employed. Such insights are, in the authors' opinion, at least as valuable as the final numerical result, and probably more so.

The risk manager is not the only person interested in the results, however. The FMD epidemic, for example, was a particularly sensitive and politically charged issue, and in its aftermath there were many interested parties. The difficulty of presenting uncertainty to an audience not used to dealing with probabilities meant that the clarity of presentation of the results was crucial if they were to be understood. Although a 'single number' output would have been simpler to present, it would have been particularly misleading given the uncertainties in the data. Of course, even when the uncertainties are explained, it is very easy for those with other agendas to quote only, for example, the mean values, thus distorting the results and allowing misinterpretation.

Fit for purpose: how complex must a model be?

Risk assessments may range from something very brief, rapid and simple, which would usually be qualitative, to something very complex which takes considerable time and resources, and which may be qualitative or quantitative. The choice between simple or complex will depend upon various factors, but one will be the speed with which an initial answer is required. Where an output is required within a day, there is little choice in the approach. However, in a situation such as the one described in this paper, the initial request for a risk assessment derived from an outbreak which had already occurred. Although speed of response was identified as a factor, a quantitative risk assessment was specified by the risk managers concerned. Thus, the need for a trade-off between speed and precision was present from the start. The question therefore arises, would a simpler, speedier model have been preferable? And if so, how could that have been achieved?

The advantages of the complex methodology actually used were that it was able to provide a great range of answers, and multiple insights into the pathways involved. In addition, simplification may have made model adaptation to other diseases much more complicated. In this model, so many factors were explicitly considered that the adjustments to the model necessary for use with other pathogens were very clear, specific, and data based – and thus relatively simple. A simpler model (for example using some kind of black-boxing to replace explicit parts of the risk pathway) would only have been able to deliver a final 'result' with few variant arguments or scenarios.

It is difficult in any event to see how a useful but much simpler quantitative model could have been developed which covered all the risk pathways. The model used grew out of a consideration of the risk under investigation – which included potentially contaminated animal products of a huge variety of types, with different properties and from all regions of the world, reaching GB through a number of routes, then passing through a wide variety of inland exposure pathways to all susceptible livestock species. Indeed, because of this, the assessment broke new ground in microbial and animal health risk assessment with respect to the scope (whole world, any product, any route…) and mathematical structure of the model.

One apparent possibility for simplification might have been to select a specific product from a specific country, and look at the probability of that causing infection in GB. But – unless this procedure were repeated for all products from all countries individually, and gave some assessment of comparable quantities by each route – this would not have answered the questions about which were the riskiest regions, or products or exposure pathways. And so we arrive full circle back at the need for a model of the type and complexity used, if we wish to answer the questions posed. Such a model takes time to build, and resources to provide the data inputs – but once built can be re-used and adapted as new data becomes available, or for other pathogens. Of course, incorporation of newly available data or model adaptation for other pathogens require model validation of equivalent rigour to that described for initial use.

Was this large and complex project worth the resources used?

The intention of the risk assessment was to provide information to help guide strategies for reducing the specified risks in the future. To this end, insights were provided which can be summarised as follows:

– illegal importation of meat contaminated with the hazards specified is a plausible contributor to the risk of an outbreak occurring in GB

– the types of meat products, and the regions from which they originate, which make the largest contribution to the risk were identified

– a number of preconceptions about the possible origins and pathways of infection were examined and discounted

– the main modes by which contaminated meat arrives in GB were identified

– potential exposure pathways were elucidated

– the major data gaps which prevent the reduction of uncertainty in the results were identified.

These insights have been useful in a number of ways. Information on the patterns of flow of illegal meat into GB has subsequently been incorporated into policy and practice to help inform enforcement activity by HMRC, for example in targeting checks on passenger baggage.

The risk assessment highlighted the problems inherent in having a number of authorities responsible for border security, in terms both of enforcement and of data gathering. There has been a huge increase in enforcement at the border since HMRC took over responsibility for anti-smuggling activity against illegal imports in April 2003, reflected by a massive increase in seizures of POAO since that time, as shown in Table IV.

As with any quantitative model, the specific results reflect the data inputs. Changing conditions will lead to changes in the data, and once available this can be incorporated into the model. For example, new data on seizures or on the current global disease situation could be incorporated relatively easily to give an updated assessment if required. In fact, following on from the identification of the key data gaps, and to put the risk from illegal imports into the overall GB risk context, a further related project is now being undertaken: a qualitative risk assessment looking at legal and illegal imports of animals and animal products, from both within and outside the EU. New data identified in this may in due course be appropriate for updating the quantitative model. As has been stressed, due to the high level of uncertainty, the results obtained must be interpreted with caution. More complete quantitative data would begin to reduce this uncertainty, and targeted studies are the only way to obtain this and thus get maximum benefit from the model.

Table IV
Number of seizures of products of animal origin by year from 1 April 2001 to 31 March 2005

Period	Number of seizures
1 April 2001 – 31 March 2002	2,053
1 April 2002 – 31 March 2003	7,819
1 April 2003 – 31 March 2004	15,838
1 April 2004 – 31 March 2005	25,610

In summary, a number of demonstrated benefits have resulted from this work, but to maximise use of the modelling method developed requires data not yet available. Perhaps the model is a methodological development which is ahead of its time.

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Étude de cas sur l'évaluation quantitative des risques : les viandes importées illégalement en tant que vecteurs de maladies

M. Wooldridge, E. Hartnett, A. Cox & M. Seaman

Résumé

Les foyers de fièvre aphteuse, de peste porcine africaine, de peste porcine classique et de maladie vésiculeuse du porc peuvent engendrer d'importants coûts économiques et sociaux et de graves limitations aux échanges. Un certain nombre de marchandises sont susceptibles d'être contaminées par les agents de ces maladies, notamment les viandes et les produits carnés tirés d'animaux infectés. La Grande-Bretagne a mis en œuvre diverses réglementations visant à empêcher l'importation de ces agents pathogènes. Néanmoins, l'importation illégale de viandes représente un moyen de se soustraire aux contrôles et par là même un risque que des agents pathogènes soient importés. Le présent article examine une série d'évaluations du risque de fièvre aphteuse, de peste porcine classique, de peste porcine africaine et de maladie vésiculeuse du porc auquel est exposé le cheptel britannique par suite de l'importation illégale de tout type de produit carné en provenance de n'importe quelle région du monde. L'article décrit l'élaboration d'un modèle d'évaluation quantitative du risque visant à identifier les principaux facteurs de ce risque et passe en revue les problèmes posés par la réalisation de ces évaluations complexes.

Mots-clés

Contrôle des maladies – Évaluation quantitative du risque – Fièvre aphteuse – Importation – Importation illégale de viandes – Maladie vésiculeuse du porc – Peste porcine africaine – Peste porcine classique.

Ejemplo de evaluación cuantitativa del riesgo: la carne de contrabando como vector de enfermedades

M. Wooldridge, E. Hartnett, A. Cox & M. Seaman

Resumen

Los brotes de fiebre aftosa, peste porcina africana, peste porcina clásica y enfermedad vesicular porcina pueden inducir importantes pérdidas económicas y problemas sociales y acarrear estrictas limitaciones al comercio. Muchos artículos pueden resultar contaminados, en particular la carne y los derivados cárnicos procedentes de animales infectados. En Gran Bretaña están en vigor una serie de reglamentos para impedir que esos patógenos penetren en el país. Sin embargo, la importación ilegal de carne es una práctica inasequible a los controles, y por ello una posible vía de importación de patógenos. Los autores describen una serie de procesos para determinar el riesgo de que la población de ganado británico contraiga una de las cuatro enfermedades citadas a resultas de la importación ilegal de cualquier producto cárnico de cualquier región del mundo. También exponen la elaboración de un modelo de

determinación cuantitativa del riesgo, concebido para identificar los principales factores que contribuyen a ese riesgo, y examinan las dificultades que se plantean al llevar a cabo evaluaciones de semejante complejidad.

Palabras clave
Contrabando de carne – Control de enfermedades – Determinación cuantitativa del riesgo – Enfermedad vesicular porcina – Fiebre aftosa – Importación – Peste porcina africana – Peste porcina clásica.

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The illegal introduction of rabbit haemorrhagic disease virus in New Zealand

Peter O'Hara

Formerly Deputy Director General of the Ministry of Agriculture and Forestry of New Zealand, 219 Plateau Road, Te Marua, Upper Hutt, New Zealand

Summary

In 1997, a group of pastoral farmers, frustrated by governmental and official responses to their problems of rabbit control, introduced and spread the rabbit haemorrhagic disease virus in a clandestine operation that succeeded in distributing infection over a large area of the South Island before the disease was detected by government officials. The government concluded that eradication was not technically or economically feasible and the disease was accepted as being endemic.

The episode highlighted the inadequate decision-making environment that existed at the time, now improved by the passage of the Hazardous Substances and New Organisms Act.

It also highlights the importance of having a comprehensive biosecurity detection and response capability, including the ability to conduct prompt risk assessments, since preventing entry of biological agents may be difficult to achieve in the face of a determined adversary.

Keywords

Biocontrol – Illegal release – Rabbit haemorrhagic disease.

Introduction

In late August 1997, dead rabbits were found on a farm in the South Island of New Zealand. Post-mortem and laboratory studies confirmed that death was due to infection with the rabbit haemorrhagic disease (RHD) virus. An emergency disease-control response was initiated by the Ministry of Agriculture and Forestry (MAF). The farm was placed under quarantine and an area movement restriction implemented in an effort to contain infection in that area. However, in the course of investigations during the following week, it became apparent that the disease was already widely distributed over a large area of the South Island.

The RHD virus had been deliberately introduced from Australia and multiplied by the inoculation of captured wild rabbits whose tissues (mainly liver and spleen) were harvested at death and homogenised; the homogenate was then applied to grain, carrot and parsnip baits to distribute over farms infested with rabbits. The carcasses of infected rabbits were also distributed to create infection foci. Although the principal objective was to spread infection as widely as possible, it became clear that both biocontrol (control of the rabbit population through the propagation of an epidemic from infection foci) and biocide (use of infected baits to kill individual rabbits) objectives were being pursued. Infectious material was passed covertly from farmer to farmer to ensure wide distribution.

It became clear that the introduction and spread of the virus had been managed in a highly effective clandestine operation involving a significant number of farmers who farmed land prone to infestation by rabbits. The operation had been in effect for several weeks before the outbreak was first officially recognised. Anecdotal evidence suggests that the virus was in New Zealand before the official decision not to permit the release was announced.

The MAF was forced to announce that no prosecutions for possession of the virus (possession and deliberate spread were illegal at that time) would be taken, in order to encourage farmers to provide the information needed to gauge the extent of the infected area. The extensive distribution led to the conclusion that eradication was probably not technically feasible and could not be justified economically. The political and legal ramifications of this decision are discussed below.

Why did it happen?

The European rabbit (*Oryctolagus cuniculus*) was introduced to New Zealand in the 19th Century and rapidly established itself over most of New Zealand. By the late 19th Century, rabbit numbers had reached pest proportions in many areas of pastoral land, particularly in the drier areas (rainfall 300 mm to 600 mm per year), and were having a severe impact both on pastoral farming and on the environment.

Between 1887 and 1995, the New Zealand government subsidised the costs of control, and control measures were implemented by regional committees. In 1990 the government decided to withdraw its financial support and a five-year phase-out programme was implemented. At the end of this programme, farmers became responsible for meeting the costs of rabbit control undertaken on their own account and/or imposed on them by regional government. For many who farmed pastoral land that favoured the development of high-density rabbit populations, these costs became a severe impost on the farming budget which precluded expenditure on other essential inputs. In some cases, the costs were financially crippling.

An attempt to introduce the myxoma virus as a biocontrol agent in the 1950s was unsuccessful because of the lack of suitable vectors. A new application to introduce the myxoma virus and a rabbit flea vector in 1991 was rejected in 1993, the government opting to invest in Australian research on the RHD virus as potential biocontrol agent because it was seen as a more publicly acceptable option.

The escape of the RHD virus from the field trial site on Wardang Island, South Australia in September 1995 and its rapid dissemination over most of southern Australia caused New Zealand to step up its consideration of the use of the virus as a biocontrol agent. However, the risk of an uncontrolled release of the virus in New Zealand was seen as something to be avoided. The immediate response to this risk was to declare the virus an 'unwanted organism' under the Biosecurity Act 1993 and to increase vigilance at the borders. The declaration made the possession and deliberate spreading of the virus illegal.

A group of interested parties filed an application to import the virus as a biocontrol agent in June 1996 but, after a protracted and often acrimonious period of public consultation and debate, the Deputy Director General of MAF, acting under delegated authority, decided to reject the application (4). A quirk of New Zealand law at the time gave responsibility in this matter to a bureaucrat rather than having the decision taken at a political level. The grounds for declining the application to import the virus were that, although the identified risks were not sufficient to preclude introduction of the virus at some future time, too little was known of the likely epidemiological performance of the virus in the New Zealand environment to justify those risks at that time. However, the decision-maker drew attention to some consequences of the decision: the inability of farmers to meet the costs of rabbit control with the available technologies would have serious impacts on the environment as well as on productivity. This warning was largely ignored.

A feature of the public consultation process leading up to the decision on the application was the high degree of polarisation of opinion and the widely divergent perceptions of the risks in the community. An analysis of the risk-communication process (6) concluded that although considerable effort was made to ensure that the public were well informed, they did not become engaged with the issues until a very late stage, and that the debate was fuelled by public disagreement among scientists on the interpretation of data and risk assessment. In such circumstances the decision inevitably created winners and losers.

Rejection of the application was angrily received in political and farming circles. The decision was publicly criticised by the Prime Minister, Minister of Agriculture and farming leaders. The anger was sufficient to encourage some farmers to take matters into their own hands. Anecdotal evidence suggests that a negative decision had been anticipated and that plans for the illegal release were already in place if not already implemented.

Political and legal consequences

When it was concluded that eradication was not feasible, the government opted for a pragmatic (some say expedient) approach. Changes to the law were necessary to legitimise the possession and spread of virus-infected material, give legal effect to the MAF's decision not to proceed with prosecutions for the previously illegal possession and spreading, and to alter the status of the virus from the 'unwanted organism' classification.

The way in which the application to import the virus as a biocontrol agent had been considered, through bureaucratic rather than political channels, highlighted a deficiency in the national law at the time. This has been corrected by the passage of the Hazardous Substances and New Organisms (HSNO) Act, which defines the decision-making process, the decision-making body, and the ability for decisions to be made at a political level in appropriate circumstances. It is likely that the decision on the RHD virus application would have been made at the political level had the law been in force at that time.

However, it is by no means clear that, if a future decision made under the HSNO Act was unpopular with a particular group, this would be less likely to lead to an illegal act. In the event that such an illegal act led to the introduction and establishment of an organism, the same considerations would apply as in the case of the RHD virus. The decision would still be based upon the feasibility of and justification for selection of the available options: eradication or control of the organism, or alternatively acceptance or exploitation of its presence. The reasons for a decision to keep an organism out of a country are not the same as the reasons that govern what to do once that organism is established. Establishment of an organism may fundamentally alter the status and decision-making environment of a country in which the establishment occurs.

Biological consequences

Rabbit haemorrhagic disease is now endemic to New Zealand. The initial epidemic significantly reduced the abundance of rabbits in most parts of the country, but the extent of reduction in numbers varied in time and in space (5) for reasons that are not entirely clear. One explanation is the persistence of rabbits immunised by surviving infection or being exposed to non-viable virus by virtue of the methods used to spread the tissue homogenates.

Since the initial epidemic, periodic localised epidemics, occurring usually in the late summer and autumn, reduce local populations. Long-term survival of virus nucleotides in wild rabbits has been demonstrated, with genomic length sequences found in two samples that suggest these rabbits retain the potential to be infectious (2).

In most parts of New Zealand, rabbit numbers fluctuate around a low mean number as the result of the impacts of unfavourable weather and predation on the survival of young rabbits. In this situation, RHD has a minimal impact. In the drier parts of New Zealand, survival of young rabbits is higher in spite of predation, and here RHD continues to have a beneficial effect on numbers. While the use of other forms of control (poisons, shooting) has not been eliminated, the overall costs of rabbit control are much more acceptable to farmers than in pre-RHD days.

Domestic rabbits can be protected by maintaining isolation and vaccination.

Conclusions

There have been a number of reviews of the legal, political and social consequences of the release of RHD virus in New Zealand (1, 3, 7). The following are the author's conclusions. They draw on the findings of the reviews but should be regarded as personal views rather than a summary of those findings.

The introduction of RHD virus

The illegal introduction and spread of RHD virus was probably an inevitable consequence of the official decision not to permit the legal introduction of the virus as a biocontrol agent. How the introduction was achieved has not been determined, but much is now known about the concerted campaign to spread the virus, once introduced. The farmers responsible considered their livelihoods were threatened, felt betrayed by successive refusals to allow biocontrol agents to be imported, and let down by their government's perceived failure to recognise their plight. Many show no remorse for their actions.

Vulnerability of borders

It is difficult to conceive of border control measures that would have prevented the introduction of the virus in the face of a determined effort by a person or persons with sufficient understanding of how to get viable virus into the country.

Policy-making

The policy consequences of a negative decision on the application to import the virus were not thought through, and the warnings of the decision-maker were ignored.

The Hazardous Substances and New Organisms Act

New Zealand now has a much better legal framework for making such decisions (the HSNO Act) but this provides no guarantee that disaffected persons will not take the law into their own hands in the future. However it is likely that the consequences of a particular decision will be more fully explored as part of the decision-making process in future.

The threat

The actions of the farmers have been likened to bioterrorism. While their motives may not have been the same as those of a terrorist, they demonstrated how efficient organisation can frustrate official efforts to prevent the introduction and establishment of a disease agent.

The need for response capability

New Zealand's biosecurity capability has earned respect over many years, and with the establishment of Biosecurity

New Zealand has had its scope and capability further extended. Bioterrorism is a recognised threat and contingency planning for it is in place. However, recent world events have demonstrated that all too often the official response has to deal with the aftermath of a terrorist act rather than prior prevention. This emphasises the critical importance of having a carefully planned comprehensive response capability with the capacity to make rapid operational decisions and obtain political endorsement of them.

■

L'introduction illégale du virus de la maladie hémorragique du lapin en Nouvelle-Zélande

Peter O'Hara

Résumé
En 1997, un groupe d'éleveurs pastoraux, déçus par les réponses gouvernementales et officielles aux problèmes que leur posait le contrôle des populations de lapins, ont introduit et disséminé le virus de la maladie hémorragique du lapin dans le cadre d'une opération clandestine qui a eu pour résultat de répandre l'infection dans une grande partie de l'île du Sud avant que la maladie soit détectée par des responsables gouvernementaux. Le gouvernement a conclu que l'éradication de la maladie n'était pas réalisable d'un point de vue technique ou économique et le caractère endémique de la maladie a été accepté.
L'épisode a mis en lumière l'inadéquation du cadre décisionnel qui existait à l'époque, désormais amélioré par l'adoption de la loi sur les subtances dangereuses et les nouveaux organismes.
L'épisode montre également combien il est important de disposer de capacités globales de détection des problèmes de biosécurité et de réaction à ceux-ci, y compris en matière d'évaluation rapide des risques, puisqu'il peut être difficile d'empêcher l'introduction d'agents biologiques face à un adversaire déterminé.

Mots-clés
Contrôle biologique– Dissémination illégale – Maladie hémorragique du lapin.

■

La introducción ilegal del virus de la enfermedad hemorrágica del conejo en Nueva Zelanda

Peter O'Hara

Resumen
En 1997, un grupo de ganaderos, frustrado por la respuesta de la administración a sus problemas para controlar las poblaciones de conejos, introdujo y propagó el virus de la enfermedad hemorrágica del conejo en una operación clandestina, con la que consiguió extender la infección por una vasta zona de la Isla Sur antes de que las autoridades la detectaran. El Gobierno llegó a la conclusión de que la erradicación no era técnica y económicamente viable y se resignó a considerar endémica la enfermedad.

Aquel hecho puso de manifiesto la inoperancia de los mecanismos decisorios existentes por entonces, mejorados ahora con la aprobación de la "Ley sobre sustancias peligrosas y nuevos organismos".
Esa experiencia también deja patente la importancia de disponer de un sistema global de detección y respuesta de seguridad biológica, lo que incluye la capacidad de determinar riesgos con rapidez, puesto que, ante determinados adversarios, puede ser difícil impedir la penetración de agentes biológicos.

Palabras clave
Control biológico – Diseminación ilegal – Enfermedad hemorrágica del conejo.

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A review of recent unexpected animal disease events in Japan and Korea and the follow-up action taken

Y. Ozawa [1], S. Makino [2], J.Y. Park [3], J.H. Chang [3], J.H. Kim [3] & S.H. An [3]

(1) OIE Honorary Adviser, 2-30-3 Utsukushigaoka, Aoba-ku, Yokohama 225-0002, Japan
(2) Obihiro University of Agriculture and Veterinary Medicine, Research Center for Animal Hygiene and Food Safety, Inada-cho, Obihiro, Hokkaido 0808555, Japan
(3) National Veterinary Research and Quarantine Service, 480, Anyang City, Gyeonggi Province, 430-824, Republic of Korea

Summary

In Japan, the need to improve countermeasures against biological weapons was recognised after the Aum Shinrikyo cult attempted to use biological weapons in 1995. This paper describes how the two relevant ministries in Japan worked together to cope with recent disease outbreaks, including cases of classical swine fever (CSF) and avian influenza, which evidence suggests might have been the result of the deliberate misuse of unauthorised vaccines that had been illegally imported. By implementing successful control measures the two ministries were able to eradicate all the diseases within very short periods.

In the past few years, the Republic of Korea has also experienced outbreaks of foot and mouth disease, highly pathogenic avian influenza, and CSF, all of which had previously been absent (or had been eradicated) in Korea. A review of the historical background, major events of the outbreaks and the control measures which were implemented are presented here.

Keywords

Anthrax – Classical swine fever – Foot and mouth disease – Highly pathogenic avian influenza – Japan – Republic of Korea – Severe acute respiratory syndrome – Smallpox – Zoonosis.

Japan

Bioterrorism countermeasures in Japan

Prior to their famous 1995 sarin gas attack in Tokyo's subways, the Aum Shinrikyo religious cult had disseminated *Bacillus anthracis* and had also attempted to release botulinum toxin on multiple occasions. It was these attacks that prompted Japan's Defence Agency to examine their countermeasures against biological weapons. However, their basic knowledge of biological weapons was limited at that time, and specific requirements for the detection and protection of biological agents were not included in their discussions.

In 2000, a committee of experts on anti-bioterrorism was formed in order to study the countermeasures against biological weapons required by the Defence Agency and the armed forces in Japan – the 'Japan Self-Defence Forces'. The committee members first studied the anti-terrorism policy of the United States of America (USA), then, in April 2001, they debated the essential countermeasures to bioterrorism that should exist in Japan and published concrete recommendations for the Defence Agency. These recommendations highlighted the need for a better understanding of biological weapons, the international challenges they present, and the current capacity for eliminating the risks they pose, and focused on fundamental approaches to bioterrorism and countermeasures to biological weapons by the Self-Defence Forces. Although these recommendations were designed for the Defence Agency, it was extremely important that they included advice for the Self-Defence Forces as they have been and will be on front-line duty during major national disasters.

Shortly after 9/11 in 2001, a meeting was held at the Cabinet Office to review countermeasures against biological weapons. In the meeting, Government Ministers discussed the coordination of policies among different ministries, and it was decided, at the Prime Minister's initiative, to establish a crisis-management task force. At present, Japanese public health law already incorporates procedures for crisis management. The official bio-defence policy in Japan includes programmes for the enhancement of healthcare systems, co-operation among healthcare facilities, strict control over biological and biochemical agents, the provision of accurate and timely information, and the strengthening of skills to cope with terrorism. However, some people consider that it does not include concrete and substantial proposals that would enable Japan to defend itself if biological weapons were ever actually used. To strengthen existing laws the Government decided that the Ministry of Education, Culture, Science and Technology, the Ministry of Health, Labour and Welfare (MHLW) and the Ministry of Agriculture, Forestry and Fisheries (MAFF) should strictly control the storage and distribution of hazardous pathogens, such as *B. anthracis*, haemorrhagic fever virus, and foot and mouth disease (FMD) virus.

In recent years, several unexpected outbreaks of zoonoses and diseases of farm animals have occurred in Japan. The diseases that primarily involved public health were dealt with by the MHLW, and those primarily affecting agriculture by the MAFF. Zoonotic diseases such as anthrax, bovine spongiform encephalopathy (BSE) and rabies are managed by both MHLW and MAFF.

Ministry of Health, Labour and Welfare

The organisational structure of the departments and divisions within the MHLW has been described elsewhere (11). All infectious diseases of public health concern, including some zoonoses, are dealt with by the Tuberculosis and Infectious Diseases Control Division, which forms part of the Health Service Bureau of MHLW. The MHLW has held a series of committee meetings related to bioterrorism, and since October 2001 it has published a total of 27 guidelines and regulations on its home-page (http://www.mhlw.go.jp/kinkyu/j-terr.html).

These guidelines cover anthrax (*B. anthracis*), botulism (*Clostridium botulinum* toxin), plague (*Yersinia pestis*), smallpox (variola major), tularaemia (*Francisella tularensis*) and viral haemorrhagic fevers (filoviruses [e.g. Ebola, Marburg] and arenaviruses [e.g. Lassa, Machupo]). Among them, anthrax and smallpox are thought to be the most dangerous and powerful candidates for biological weapons; all these diseases, except smallpox and plague, are zoonoses.

Smallpox and anthrax

In Japan, official bioterrorism countermeasures have focused on anthrax and smallpox. But information on other infectious diseases, including how to respond in emergency situations, has been published through the home-pages of the MHLW.

In accordance with government smallpox guidelines (7), a stockpile of smallpox vaccine has been prepared as an urgent matter because the younger age group has not been vaccinated. Simulation exercises for smallpox outbreaks that may occur as a result of a bio-terrorist attack have also been proposed. At present, the smallpox vaccine is fully stockpiled in Japan and priority would be given to medical doctors, fire-fighters, policemen, and other first responders.

The control of anthrax is easier than smallpox, because person-to-person anthrax infection rarely occurs. The most effective countermeasure for the prevention and treatment of anthrax is to have a sufficient stockpile of antibiotics. As *B. anthracis* is sensitive to various kinds of antibiotics Japan has a stockpile of antibiotics sufficient to deal with initial attacks. Just after 9/11, new quinolone antibiotics, such as ciprofloxacin, were approved as drugs which would be covered by the national health insurance scheme. In addition, a stockpile of disinfectant is essential for combating environmental contamination by bacterial biological weapons such as *B. anthracis*.

It was emphasised in the White Paper on defence published in 2000 that advanced knowledge of biological weapons should be urgently acquired, but the budgetary provisions for the development of new techniques to detect, inspect, diagnose, prevent and treat anthrax were not provided, as the ministries concerned generally give low priority to rare infectious diseases. Just after 9/11, the financial resources were made available to some extent, but it has not been sufficient.

Severe acute respiratory syndrome

In March 2003, shortly after the occurrence of severe acute respiratory syndrome (SARS) in Hanoi and Hong Kong, the MHLW issued the World Health Organization (WHO) case definitions for reporting SARS, and started surveillance in Japan. The SARS Surveillance Committee was established to verify all the cases reported to the MHLW and to announce the results.

For the Japanese administration the SARS outbreak was the first outbreak of an emerging infectious disease since the enactment of the revised Infectious Disease Control Law in April 1999. In early April 2003, the Infectious Disease Control Law was revised again and it was decided that SARS would be newly classified as a Category I infectious disease.

In June 2003, a physician from Taipei China visited Japan as a tourist, and became symptomatic. He was hospitalised shortly after his return home, and was diagnosed with SARS. Immediately, traceback investigations in Japan were conducted by the local governments and the MHLW, and they later confirmed that there was no secondary case among any of the people who had been in contact with the physician in Japan (1).

As a result of the SARS surveillance programme the medical infrastructures of Japan were reviewed and further improved, the guidelines for the management of SARS patients in hospital were also improved, and the quarantine systems for Category I diseases were reinforced. Also, the emergence of SARS raised some issues related to the control of bioterrorism, such as the medical infrastructure required when international air travel is involved, the quick establishment of diagnostic capacity for a new disease, and the management of disease information to avoid public panic. The importation of wildlife such as Himalayan palm civets and raccoon-dogs coming from the People's Republic of China was prohibited.

Systematic countermeasures are considered necessary in view of an ever increasing threat of bioterrorism. A series of meetings have been and will be held by the MHLW in order to strengthen the measures to cope with all infectious diseases that might be artificially introduced.

Ministry of Agriculture, Forestry and Fisheries

The organisational structures of the MAFF have been described in a previous report and will not be discussed here (11). In 2001, shortly after 9/11, MAFF formed the Head Office for anti-bioterrorism under the leadership of the Minister of Agriculture, Forestry and Fisheries. This office collaborated closely with Cabinet Headquarters in collecting and disseminating information about market prices and the movements of agricultural products, evaluating economic losses of agricultural industries, and ensuring the safety of the staff members engaged in counter-bioterrorism activities. The first countermeasure taken by the MAFF was to tighten the storage systems of pathogens of socio-economic importance.

In recent years, a series of unexpected disease emergencies have surfaced in Japan, and the Animal Health Division of MAFF has been engaged in the control of FMD, highly pathogenic avian influenza (HPAI) and classical swine fever (CSF).

Foot and mouth disease

Japan had been free from FMD since 1908, but in March 2000 an unusual disease in cattle in Miyazaki Prefecture, south western Japan, was reported by a veterinarian. Within a few days the disease was confirmed as FMD by the National Institute of Animal Health. A 50 km restricted zone was put in place, but the disease spread to two other farms within this zone, and all cattle in those three farms were destroyed and buried. The virus isolated was an unusually mild strain of type O FMD virus. A total of 47,177 serum samples were tested, but no seropositive cases were found other than on the three farms previously mentioned.

Sero-surveillance for type O virus was expanded to investigate the cattle on farms where imported straw or hay were used, and another positive case was detected in April 2000 in a farm in Hokkaido (northern Japan); 705 cattle on the farm were killed and buried. No other seropositive cases were found.

The type O virus isolated in Japan was very mild, and did not spread as easily as the type O viruses found in Taipei China or the Republic of Korea in 2000. It was experimentally proved that the strain isolated in Japan could grow and produce typical lesions in pigs, but could not produce any signs of infection in Holstein cattle. Those observations indicated that the strains of type O virus in Japan's neighbouring countries were not of the same origin; the strain in Japan was most similar to isolates from South Africa (2000) and the United Kingdom (UK) (2001) (3, 10, 12). The type O virus isolated in Japan was most probably introduced from a neighbouring country via imported straw. In view of the fact that the virus was exceptionally mild it was concluded that the FMD virus had been introduced into Japan unintentionally.

Highly pathogenic avian influenza

Highly pathogenic avian influenza had been absent from Japan since 1925, but in January 2004, an outbreak of HPAI on a poultry farm in Yamaguchi Prefecture (western Japan) was confirmed, and 35,000 layers were slaughtered and buried. On 16 February 2004, HPAI appeared in Ohita Prefecture, at a very small pet farm of 13 bantams and one duck, and all birds were killed and buried. On 28 February 2004, a third HPAI outbreak occurred at a layer farm in Kyoto Prefecture, and 198,000 chickens were slaughtered. Prohibited zones were established around the three farms and all eggs originating from the farms within these zones were destroyed. The owner of the farm in Kyoto prefecture was punished due to an intentional delay in reporting the disease. A fourth and last outbreak was reported on 3 March from a broiler farm near Kyoto, 5 km away from the third farm. Approximately 275,000 birds died or were slaughtered and over one million eggs were destroyed due to the above four outbreaks of HPAI in Japan. However, the farms in Kyoto were distant from the other farms where outbreaks occurred and there was no epidemiological evidence to prove that the infection was spread by the movement of humans or poultry products (6).

All virus isolates in Japan were H5N1 virus; they were closely related to the strain isolated in the Republic of Korea (similarity more than 99%), but different from those isolated in Vietnam and Thailand in 2004 (similarity 93%). The same H5N1 virus was also isolated from nine dead crows in the Kyoto area, indicating that wild birds could spread the disease in Japan. For these reasons, it is considered that the HPAI epizootics in Japan in 2004 were caused by the movement of wild birds and not by human movement (21).

More recent surveillance for avian influenza (AI) started in June 2005. Subsequently, the presence of a low pathogenic avian influenza (LPAI) virus, subtype H5N2, has been found in Ibaraki and Saitama Prefectures. The virus isolated showed 94% to 97% similarity with the virus strains isolated in Guatemala between 2000 and 2002. A MAFF expert committee indicated that the outbreaks of AI might be the result of using an unauthorised defective vaccine that had been illegally imported.

Classical swine fever

There were no outbreaks of CSF in Japan between 1993 and 2003. In 2000, vaccination was suspended in 32 prefectures when the Government decided to prohibit the use of the vaccine without the authorisation of local government. By October 2004, the number of farms authorised to vaccinate had been reduced to 4% of all farms in Japan. It was under these circumstances that the spread of CSF virus (CSFV) was confirmed on five farms between March and September 2004 in Kagoshima Prefecture (south-western Japan). Four of the five farms were located within a 1 km radius; one was about 100 km away from the other four farms. The virus isolated from those five farms was confirmed as CSFV, but the virus was not the same as the vaccine strain (GPE^-) authorised for use in Japan. The strains isolated in those five farms were identical, but were different from the field virus previously isolated in Japan and were different from the vaccine strains widely used abroad (16).

Investigations of the origin of the virus on those farms revealed that the owner of the first farm injected a medicine into the pigs that had been sick for a few months even after antibiotic treatment. The manager of the farm bought the medicine from an unidentified person. The medicine, which did not have a proper label and which could have contained an unauthorised virus strain, was injected into the farm's 1,144 pigs. The outbreaks on the neighbouring farms were due to the spread of virus from the first farm via the movement of vehicles, humans, pets and wildlife. The origin of the virus isolated from a farm 100 km away was not identified, but the characteristics of the virus were identical to those from the other four farms. In total, 3,669 pigs on five farms were slaughtered (World Organisation for Animal Health [OIE] weekly report dated 3 December, 2004).

It was concluded that the disease was caused by a virus which was contained in the medicine introduced by an unidentified person from a neighbouring country. After the outbreaks in Kagoshima Prefecture, the vaccination against CSF was increased temporarily, but it is the intention of the government to introduce a total ban on the use of CSF vaccine, while strengthening the surveillance programme for CSF.

Recent changes in the structure of national Veterinary Services

Following the occurrence of BSE in Japan in 2001, MAFF undertook a thorough review of the Veterinary Services, focusing particularly on food safety. As a result, an independent Food Safety Commission (FSC) was created within the Cabinet Office in July 2003, which has since undertaken risk analysis related to foods. Based on the results of these risk assessments, risk management procedures have been implemented either by the MAFF or by the MHLW or by both ministries. Moreover, in August 2003, the Division of Veterinary Services was moved from the Department of Livestock Industries of the MAFF to the Department of Food Safety of the same ministry. Although the activities of the Veterinary Services remained basically the same, cooperation between the MAFF and MHLW has been strengthened.

In view of the new outbreaks of diseases of an emergency nature, such as FMD, HPAI and CSF, the Food Safety and Consumer Affairs Bureau of the MAFF was reorganised on 1 October 2005, and the Animal Health Division was divided into the following two Divisions:

a) the Animal Health Division, which deals mainly with the prevention/control of animal diseases within the country and at quarantine stations (this Division is responsible for managing trade negotiations, risk analysis and matters relating to the OIE)

b) the Animal Products Safety Division, which deals with the safety of animal and fish products for human and animal consumption (this Division is responsible for the control of veterinary drugs, biologics, antibiotics, feeds, small animal practices, and the traceability of cattle).

Now both Divisions are better prepared for unusual events, including the intentional introduction of animal disease agents and harmful substances.

The Republic of Korea

Unexpected events in recent years in the Republic of Korea

Highly pathogenic avian influenza

Up until 2003 the Republic of Korea (Korea) had remained free from HPAI, although sporadic cases of LPAI had been

reported. Low pathogenic avian influenza (H9N2) was first reported in 1996, when five farms in three provinces were affected (6). All chickens in the infected farms were slaughtered and buried. After a two-year absence, LPAI was again reported in 1999 and 2000. In 2001, H5N1 HPAI virus was isolated from frozen duck meat that had been imported from the People's Republic of China, but no HPAI outbreaks were reported at that time (17).

The first case of HPAI in Korea was reported on 10 December 2003 in a broiler breeder flock that was exhibiting high mortality, decreased feed consumption, a drop in egg production and mild respiratory signs (4). The chicken farm was immediately placed under movement restrictions and on 15 December 2003 the National Veterinary Research and Quarantine Service (NVRQS) confirmed the presence of H5N1. This was the first official report for this outbreak of H5N1 in Asia (2), but epidemiological analysis suggested that the primary outbreak actually began in Southeast Asia around August 2003 (R. Morris, personal communication). When the last case was reported on 20 March 2004, a total of 19 farms, consisting of ten chicken farms and nine duck farms, had confirmed reports of HPAI. No clinical signs were observed in ducks except on one commercial farm where birds had respiratory symptoms with a moderate mortality.

In response to the outbreaks, an emergency headquarters and control centre was set up by the Ministry of Agriculture and Forestry (MAF) and the NVRQS to deal with the situation quickly. Control measures were implemented, including stamping-out of susceptible animals in infected and neighbouring farms within a 3 km radius, movement controls within a 10 km radius, and disinfection. Epidemiologically linked high-risk livestock were also depopulated as a precautionary measure. A total of 5,607,635 animals from 381 farms were destroyed, as were all animal by-products on these farms. The use of vaccination was not considered as it would have delayed the eradication of HPAI in Korea. Subsequent evaluation of the stamping-out measures using disease modelling concluded that these measures were critical in reducing virus production and subsequent spread (5).

Active surveillance was initially focused on ducks, as their lack of clinical signs may have resulted in undetected widespread spread of the disease. Over 10,000 ducks were tested and two HPAI positive breeder farms were detected as a result. Also, a total of 5,460 faecal samples from wintering wetlands of migratory wild birds were tested, resulting in the detection of 26 AI viruses, but none were found to be H5N1. In addition, a total of 371 wild birds of 14 species were tested and H5N1 was isolated from two magpies captured around the infected farms. However, it is likely that the magpies were secondarily infected from chickens as they are non-migratory birds commonly found in Korea and they eat carrion (4).

Due to major concerns regarding the possibility of transmission to humans, people living around the infected farms and personnel involved in disease control were extensively tested. Fortunately, no human cases were detected.

Genetic sequence analysis of the HA and NA genes showed that the Korean isolates were all of the same origin, being almost identical to each other with over 99% homology. This is in contrast to the heterogeneity shown in other countries and maybe due to the low prevalence of the HPAI virus before initial detection and the rapidity of the control measures (5). The H5N1 isolate was also sent to one of the OIE reference laboratories for HPAI (National Veterinary Service Laboratories, Ames, Iowa, USA) and to the WHO Collaborating Centre for Influenza (Center for Disease Control, Atlanta, Georgia, USA) for further characterisation and evaluation of the potential risk of human infection. These studies showed that there were genetic differences in the HA and NA genes when the Korean isolate was compared to those isolated in Vietnam and Thailand in 2004. Also, unlike the isolates from Vietnam and Thailand, which have caused human infections, the Korean isolate showed an absence of mutation in the M2 protein genes, which are related to the resistance to amantadine and rimantadine (2, 8). A comparison of the HA and NA genes showed that the Korean isolates were closely related to those isolated in China in 1997 and 2001. In addition, a full gene comparison of the Korean isolates and of the HPAI isolate from Japan showed greater than 99% homology, indicating that these viruses may have been from a common source (2). Epidemiological investigations concluded that the most likely source of the outbreak was migratory birds moving through the East Asian-Australasian flyway route from the end of October to early November. Introduction via foreign travellers or the illegal entry of meat was considered to be less likely, but it could not be ruled out. Most of the inter-farm transmission was determined to be through mechanical spread by people and vehicles (5).

Foot and mouth disease

The first recorded case of FMD in Korea was in 1911, which was followed by sporadic outbreaks concentrated in the Northern provinces sharing borders with the People's Republic of China and Russia. The number of affected animals peaked in 1918, when 36,397 animals were infected. Before the most recent outbreak in 2000 the last reported outbreak in the Korean peninsula had been in 1934 in Hamkyoung province, now a part of North Korea.

A suspect case of foot and mouth disease was reported on 24 March 2000 and laboratory diagnosis conducted by the NVRQS officially confirmed the case on 2 April 2000. This was the first case of FMD in Korea after an absence of 66 years. In accordance with OIE guidelines, the samples were

also sent to the OIE World Reference Laboratory (Pirbright, UK), which confirmed the diagnosis. A total of 15 FMD cases were reported between 24 March and 15 April 2000 in three provinces: Gyeonggi, Chungbuk and Chungnam. Only cattle farms were affected. Clinical symptoms included depression, excessive salivation, lameness, and vesicles and ulcers on the mouth, tongue, hooves and teats.

Control measures, including stamping-out, movement restrictions, and emergency vaccinations were implemented. A total of 2,216 animals from 182 farms were culled as a part of the stamping-out policy. Movement restrictions were applied to two types of zone, protection zones (areas within a 10 km radius of the infected farms) and surveillance zones (areas within a 10 km to 20 km radius of the infected farms). The decision to conduct emergency vaccinations was made because the circumstances at that time favoured wind-borne spread. Some 860,700 and 661,770 animals within the protection and surveillance zones were vaccinated during the first and second round of booster vaccinations, respectively. All vaccinations were completed by August 2000 and there have been no further vaccinations. One of the major features of the emergency vaccinations was the decision not to slaughter all vaccinated animals. At that time, the OIE *Terrestrial Code* did not specify a required waiting period for a previously FMD-free country not practicing vaccination to regain its previous status if all vaccinated animals were not slaughtered. The 2005 OIE *Terrestrial Code* now specifies a waiting period of six months (20). Although this resulted in having to wait over a year after the last reported case before the country could recover its FMD-free status, the use of vaccination was regarded as being successful in quickly bringing the outbreak under control (13). After the outbreak, a national FMD surveillance programme, which consisted of the passive surveillance already in place and the newly initiated active surveillance of testing statistically selected and targeted samples, was implemented to maintain an effective system of detecting FMD and to provide sufficient evidence that the country continues to be free from FMD. From 2000 to 2001, a total of 63,589 animals from 14,692 farms were tested as part of the sero-surveillance and 88,624,673 animals were clinically examined. The results of the surveillance activities showed no evidence of FMD in Korea.

The FMD virus isolate was the same Pan-Asia O type that was also responsible for the outbreaks in many East Asian countries such as Mongolia and Russia in 2000. Epidemiological investigations concluded that the most likely source was imported hay and/or international travellers, and genetic analysis of the field isolates showed that multiple introductions into the country could have been possible (3, 14). In May 2001, Cheju Island, situated to the south-west of the Korean peninsula, received recognition from the OIE as 'FMD-free without vaccination' and the whole country regained this same status on 19 September 2001. The 2000 FMD outbreak initiated changes in control policy, increased training, education and public awareness, and heightened quarantine measures at the border to prevent another outbreak.

Despite these efforts, a new outbreak was reported in 2002. Between 2 May and 23 June a total of 16 farms (15 pig farms and one cattle farm) located in the two provinces of Gyeonggi and Chungbuk were confirmed with FMD. In contrast to the situation in 2000, pig farms were most affected and symptoms included vesicles on the nose, tongue, hoof and teat, loss of hooves and high mortality in piglets.

An emergency headquarters and control centre was quickly put in place within MAF and the NVRQS to coordinate the control measures. A total of 160,155 animals from 162 farms were culled as a part of the stamping-out policy that included the pre-emptive culling of pigs within a 3 km radius. Movement restrictions were applied in two types of zones, protection zones (areas within a 3 km radius of the infected farms) and surveillance zones (area within a 3 km to 10 km radius of the infected farms). No emergency vaccinations were conducted based on the fact that infections were restricted to pigs and local spread was mostly by people and vehicles and not via airborne infection. An evaluation of the control measures in 2002 concluded that three factors were especially important in improving the effectiveness of the control measures: heightened awareness of the disease, thus reducing the delay in notification; improvement in field diagnosis, such as the use of pen-side antigen tests, thereby reducing the delay in diagnosis; and quicker culling operations, such as the support of military personnel, thus reducing the delay in culling (19). Disease modelling concluded that rapid notification by the farmers was the most significant variable that could have affected the course of the outbreak in 2002, and thus demonstrated the importance of the awareness and co-operation of farmers in disease control. In 2002, a total of 18,482 animals from 3,673 farms were tested as part of the sero-surveillance and over 96,086,463 animals were clinically examined. The surveillance activities indicate that there have been no further cases of FMD in Korea since the 2002 outbreak.

The virus isolated in 2002 (AY114146) was also a Pan-Asia O type, but it was found to be closer to the viruses responsible for the 2001 outbreaks in the People's Republic of China and Mongolia than to the 2000 Korean isolates (9). This supported the view that the 2002 outbreak was likely to be a reintroduction from overseas. Epidemiological investigations concluded that the most likely sources were foreign workers or international

travellers. The country regained its previous status as 'FMD-free without vaccination' on 29 November 2002.

Classical swine fever

The first reported case of CSF in Korea was in 1908, with subsequent outbreaks being restricted to the Jeonbuk and Hamnam provinces. However, by 1948, CSF had spread across the country and had become an endemic disease. With the introduction in 1967 of a tissue culture attenuated live vaccine, LOM-850 vaccine, the number of cases dropped dramatically, but sporadic cases were still being reported into the 1990s.

In 1996 a three-stage nationwide CSF eradication campaign was initiated. The first stage was to encourage the use of vaccines to reduce the number of outbreaks and the second stage was to introduce mandatory vaccination and vigorous compliance testing throughout mainland Korea, except in Jeju province. The third stage was the cessation of all CSF vaccination and confirmation of CSF-free status. Stage 1 began in 1997 followed by Stage 2 in 1999. As an apparent result of the campaign no outbreaks were reported in 2000 and 2001 and after conducting a risk assessment the decision was made to ban all vaccination against CSFV on 1 December 2001. It seemed the country had successfully eradicated CSF and was on its way to becoming recognised as a CSF-free country.

This changed, however, when in April 2002, two cases were confirmed in Gangwon Province, and later that year, between October and December, eleven more cases were reported in Gyeonggi Province. Emergency vaccination was implemented in the surrounding areas, as was a stamping-out policy for all infected and neighbouring farms. At that time, these outbreaks were assumed to be isolated cases and the country was still considered to be at Stage 3 of the CSF eradication programme. However, the situation changed in 2003 when between March and May a total of 65 pig farms were confirmed as infected across the country. As a result, the Government made the decision to resume nationwide vaccinations, resulting in a major setback for the CSF eradication campaign. An interesting feature of the 2003 outbreak was that most of the CSF infections could be traced to the purchasing of pigs from one breeding farm (18). In hindsight, it is clear that more attention should have been directed towards breeding farms, which generally follow strict biosecurity measures but have the potential to be the source of widespread transmission should they become infected.

The CSFV isolates belonged to genetic group 2, which differed from the previous Korean isolates that were all classified as group 3 (8, 15). The genetic analysis data (AY168611, AF521712) supported the view that this was a new introduction from outside the country, most likely from north-eastern Asia (18).

Follow-up actions

In 2001, the NVRQS, which is the MAF agency responsible for the prevention and control of animal diseases, quarantine inspection at the border, livestock product safety and veterinary research in Korea, was restructured and expanded into three departments: the Livestock Products Safety and Inspection Department, the Animal Disease Research Department, and the Animal Disease Control Department. This resulted in the addition of two new divisions, the Animal Disease Diagnosis Division and the Veterinary Epidemiology Division, and three additional district offices. In 2002, the Animal Health Division, a part of the Livestock Bureau under the MAF, was expanded into two divisions, the Animal Health Division, which would focus their attention on livestock diseases, and the Livestock Products Sanitation Division, which would manage issues related to livestock products. The number of government officers involved in animal health was increased, both in the central government and in the provincial governments.

Amendments were made to the Act for the Prevention of Livestock Epidemics, and to its ordinances. For example, requirements for imported straw and forage were included, which were based on the conclusions of a 2000 FMD epidemiological report. Also, control guidelines for FMD, HPAI and CSF were established and subsequently revised based on the experiences and lessons learned from dealing with the outbreaks.

To improve quarantine measures at the border, additional disinfection facilities were installed at ports to disinfect ship cargoes. Beagle detector dog units were introduced in 2001 to prevent the entry of illegal livestock products and they are considered to have been successful, not only in terms of the number of seizures but also by the way in which they have captured the public's interest and educated them in the importance of quarantine work. The recently installed electronic billboards at major ports and airports, and public announcement services on planes are being used along with traditional posters and leaflets to bring public attention to the risks of bringing illegal livestock products into the country.

It should be noted that, with the increase in international trade and the movement of people, even the most strict quarantine measures at the border may not be enough to prevent new introductions. Farmers need to practice good biosecurity measures to prevent disease introduction into their farms. Disease awareness and reporting by farmers and field veterinarians are also crucial because most cases are first reported by farmers and early detection and reporting were found to be the most significant factor in reducing the size of the 2002 FMD outbreak in Korea (19). Continued education of farmers through meetings, leaflets and farm visits is being conducted to maintain heightened

awareness. Also, a system of awards and higher compensation for early reporting and fines for delays has been implemented to encourage early reporting.

The NVRQS conducts epidemiological analysis and research into the development of diagnostic tests, vaccines, therapeutic agents, and surveillance methods. In 2002, pen-side tests for FMD were developed and used successfully to reduce the time required for diagnosis. Recently, pen-side tests for HPAI were also developed. In 2004, the construction of the Emerging Disease Research Facility was completed at the NVRQS, which contains BL3+ laboratories to facilitate research into emerging and re-emerging diseases such as BSE, HPAI, SARS. Epidemiological studies into the outbreaks that have occurred continue to provide a clearer understanding of their source, their method of transmission and the effectiveness of the control measures used, so as to be better prepared for future emergencies. One of the major issues that is currently being addressed is what can be done to prevent the introduction of exotic diseases by wild birds.

The HPAI outbreaks demonstrated that there was a need for increased co-operation between veterinary and human health organisations to better maintain the preparedness of these services in Korea. It was for this reason that the Zoonosis Committee was formed in 2004. The members of the committee – experts from the NVRQS, specialists from the Korea Centre for Disease Prevention (part of the Ministry of Health and Welfare) and university professors – meet regularly to discuss and make recommendations. There are five subcommittees dealing with various bacterial, viral and prion diseases, such as anthrax, brucellosis, rabies, HPAI, Japanese encephalitis and BSE.

Furthermore, outbreaks of livestock diseases such as HPAI and FMD are now considered to be national disasters of major importance and are handled by the Office for Government Policy Co-ordination, which is in charge of managing each administrative and affiliated department under the command of the Prime Minister. This allows for better communication and co-ordination between the various ministries that would take a role during such emergencies, i.e. the Ministry of Agriculture, the Ministry of Health and Welfare, the Ministry of National Defence, the Ministry of Planning and Budget, and other ministries that deal with matters such as disease control, public health, the possibility of bioterrorism and the allocation of emergency F.

The need for the Veterinary Services to improve communication with the media and the public was evident during the HPAI and FMD outbreaks. The coverage by the media was often sensationalised, resulting in a drastic drop in consumption and exasperating government and industry efforts to deal with the crisis. Since then, a campaign has been implemented by the government to provide information to the public that can be accessed more quickly and easily, such as through its website. It is hoped that by being more transparent the public will gain confidence in the Government and be able to make informed judgments based on facts.

Livestock identification and tracking systems are currently being tested and evaluated for future implementation. They are expected to have an impact not only on food safety but also in disease control, facilitating rapid investigations through improved traceback systems.

Conclusion

The outbreaks of HPAI, FMD and CSF were devastating blows to the livestock industry and stakeholders in Korea. They initiated changes that included the reorganisation and expansion of the government organisations responsible for livestock and livestock products; the revision of legislation and emergency control guidelines; and the implementation of various measures and programmes to improve disease prevention, quarantine at the border, surveillance activities, the education of farmers, and public awareness. However, as the threat of animal and human disease emergencies is growing in the region, it will continue to test the Veterinary and Public Health Services and their readiness.

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Examen d'épisodes récents et inattendus de maladies animales survenus au Japon et en Corée et mesures de suivi prises

Y. Ozawa, S. Makino, J.Y. Park, J.H. Chang, J.H. Kim & S.H. An

Résumé

Au Japon, la nécessité d'améliorer la parade contre les armes biologiques a été reconnue à la suite de l'attentat à l'arme biologique perpétré en 1995 par la secte Aum Shinrikyo. Le présent article décrit comment le ministère de la Santé, du travail et de la protection sociale et le ministère de l'Agriculture, des forêts et de la pêche ont coopéré pour faire face aux récents foyers de maladies, notamment aux cas de peste porcine classique et d'influenza aviaire, qui, selon les indications disponibles, pourraient bien être consécutifs à l'utilisation impropre et délibérée de vaccins non autorisés qui avaient été importés illégalement. En mettant en œuvre des mesures de contrôle efficaces, les deux ministères ont pu éradiquer avec succès toutes les maladies en un laps de temps très court.

Ces dernières années, la République de Corée a également enregistré des foyers de fièvre aphteuse, d'influenza aviaire hautement pathogène et de peste porcine classique, alors qu'auparavant le pays n'avait connu aucune de ces maladies (ou les avait éradiquées). L' article présente le contexte historique, les principaux événéments survenus pendant les épidémies et les mesures de contrôle mises en place.

Mots-clés

Fièvre aphteuse – Fièvre charbonneuse – Influenza aviaire hautement pathogène – Japon – Peste porcine classique – République de Corée – Syndrome respiratoire aigu sévère – Variole – Zoonose.

Casos recientes de enfermedades animales inesperadas en Japón y Corea y medidas adoptadas al respecto

Y. Ozawa, S. Makino, J.Y. Park, J.H. Chang, J.H. Kim & S.H. An

Resumen

En el Japón, la tentativa de atentado con armas biológicas que la secta Aum Shinrikyo llevó a cabo en 1995 sirvió para que se admitiera la necesidad de mejorar las medidas destinadas a contrarrestar ese tipo de armas. Los autores describen la labor conjunta de los ministerios de Salud, Trabajo y Bienestar y de Agricultura, Bosques y Pesca para afrontar recientes brotes infecciosos, en particular de influenza aviar y peste porcina clásica, que a tenor de las pruebas existentes podrían ser fruto del uso intencionado de vacunas no autorizadas, obtenidas por importación ilegal. Aplicando medidas de control, los dos ministerios lograron erradicar ambas enfermedades en poco tiempo.

En los últimos años, la República de Corea también ha sufrido brotes de fiebre aftosa, influenza aviar altamente patógena y peste porcina clásica, enfermedades hasta entonces ausentes (o ya erradicadas) del país. Los autores repasan los antecedentes históricos, los brotes más importantes y las medidas de control adoptadas.

Palabras clave
Carbunco bacteridiano – Fiebre aftosa – Influenza aviar altamente patógena – Japón – Peste porcina clásica – República de Corea – Síndrome respiratorio agudo severo – Viruela – Zoonosis.

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Risk of a Rift Valley fever epidemic at the haj in Mecca, Saudi Arabia

F.G. Davies

The Whittery, Chirbury, Powys SY15 6DA, United Kingdom

Summary
Rift Valley fever (RVF) is a zoonotic disease that affects both humans and domestic animals. In humans, it can cause a fatal haemorrhagic fever disease. When domestic animals such as sheep, goats, camels and cattle are infected, the infection may or may not be accompanied by clinical signs of disease. Both sub-clinical and clinically affected animals present a hazard as a source of infection for humans. The risk of infection is greatest at the time of killing, when aerosols of infected blood may be generated, particularly by traditional sacrificial slaughtering practices. Every year some 10 million to 15 million small ruminants may be slaughtered during the religious festivals at Mecca. Some of these animals come from the Arabian Peninsula itself, but most are imported across the Red Sea, from countries in East Africa and the Horn of Africa, where RVF is known to be enzootic and can be greatly amplified during periods of epizootic virus activity. These animals may be transported to and arrive in Mecca within the incubation period for the disease. Rift Valley fever is also known to occur in the tihama zones of both Saudi Arabia and Yemen.

Keywords
Mecca – Ramadan – Religious festival – Rift Valley fever – Ritual sacrifice – Saudi Arabia – Small ruminant – Trade from Africa – Zoonosis.

Introduction

The problem

Two major religious festivals are held at Mecca during Ramadan: id al Fitr and id al Adha/Arafa. Pilgrims visit Mecca during Ramadan and to make the haj, and many millions are present for the two principal festivals, particularly id al Adha. The number of people present at these festivals varies from year to year, but estimates suggest that it may be of the order of 12 million to 15 million. People travel from all over the world to the festivals, which usually take place between late November and April, although the actual dates vary from year to year.

One of the principal practices of the haj, particularly at id al Adha, which each pilgrim or family wishes to perform, is the ritual sacrifice of a ram by 'halal'. The exact number of pilgrims and families who actually carry out such a sacrifice is not known, but a figure of 1 million to 2 million animals a day during the short period of a few days at each festival has been suggested. Much of the halal takes place among the huge crowds that are present on such occasions. Slaughter by proxy also takes place at well-appointed slaughtering facilities, where pilgrims arrange for an animal to be slaughtered on their behalf. Halal has been shown to be a means for infection of humans with Rift Valley fever (RVF) virus, if the animal is viraemic at the time of killing.

To supply this annual demand for small ruminants, particularly sheep, for the haj festivals, there is a huge trade from all the pastoralist areas in east and north-east Africa and the Horn of Africa to Saudi Arabia. The animals have traditionally originated largely from the semi-arid pastoral zones of north-east Kenya, Somalia, south-east Ethiopia, western Sudan and Yemen. These zones generally have low moisture indices of –30 to –50 and consist of bushed and wooded grasslands with *Acacia* or *Commiphora* trees. They do however include riverine systems with floodplains that

emerge from the plateau and mountain regions of Africa and Arabia, which seasonally have a higher water table and may provide excellent grazing at certain times of the year. Traditionally, animals are moved to these areas prior to the period of sale as they fatten more readily on the better pastures.

The Somali black-head or fat-tailed sheep, which originates in these ecosystems, is the animal most desired for sacrifice and has the highest value at the haj. Only entire male animals are involved in the trade, and these must be without any blemish or defect, otherwise their value is diminished.

A traditional marketing and trading system has developed over many years to supply this commodity. A well-structured transport system takes animals directly from the grazing areas in Africa to the ports on the Red Sea, and from these to Jeddah by sea. The value of the animals varies according to their condition; large, well-grown animals in excellent condition fetch the highest price in the market place. For this reason, there is premium on transporting the animals directly from the point of origin to Mecca in the shortest possible time. An animal in transit may lose up to a kilo a day from stress and lack of adequate fodder and water, so it is clearly in the interests of the traders to ensure that the animals arrive in Mecca as swiftly as possible. All these factors create a situation in which animals infected at the point of origin or in transit at watering points may arrive at Mecca within the incubation period for RVF infections.

An additional component of this trade to Mecca is the importation of animals from Africa to Yemen, mostly via the port of Mokkah, to be fed and fattened in the plateau and tihama zones. These animals then enter a northward traditional trade route within Yemen to be marketed in Saudi Arabia and in Mecca during the haj period. Since many human and animal cases of RVF were recognised in the tihama zones of Yemen and Saudi Arabia in 2000/2001, it is now becoming clear that these areas are also enzootic for RVF virus.

The risk presented by halal

The very close proximity of such high densities of people and the large numbers of animals being slaughtered by halal present a hazard. Should the blood be infected with zoonotic pathogens, these may be disseminated to the population during the halal ceremonies by droplets or aerosols, or via the skin by wound contamination. Some hazards are more easily detectable than other hazards. Anthrax is a potential hazard which is usually associated with some clinical signs, and can thus be identified. Screening has been routinely carried out for brucellosis for many years at the ports of exit. There are other disease agents, which may be asymptomatic in sheep and other domestic animals, and these have greater potential to cause serious problems because they are zoonotic pathogens; examples include RVF and Crimean-Congo haemorrhagic fever (CCHF). These present a serious public health problem to the Saudi Arabian health and livestock ministries involved.

Rift Valley fever

Route of infection

Experience in many parts of Africa has shown that a proportion of human cases of RVF result from the killing of RVF-infected animals or post mortem examination of carcasses. Many recorded instances have shown the association of halal with human RVF infections in Egypt. On occasion, several people present at a single halal slaughtering have subsequently become infected with RVF. The infection is thought to result from the contamination of skin cuts or abrasions and/or from inhalation of the blood aerosol/droplet formation following the cutting of the arteries during the halal. This is likely to be the major route, for many people have been infected while holding the animals although they did not actually come into contact with infected tissue or blood.

The situation at Mecca, where hundreds of thousands of people are concentrated at the haj and millions of animals are killed over a period of a few days, greatly amplifies the likelihood of RVF infection of humans should a proportion of those sheep be viraemic or infected with the virus.

Rift Valley fever infection in humans

Rift Valley fever in humans is one of the highly fatal haemorrhagic fevers, and this syndrome frequently signals the onset of an epizootic/epidemic of RVF. Investigations of such cases have resulted in the identification of RVF epidemics in Egypt, Somalia, Yemen and Saudi Arabia (6, 7, 8, 9, 10, 20). However, the great majority of human RVF virus infections do not manifest in this dramatic manner.

In humans RVF occurs most frequently among those working with or looking after animals, such as shepherds, farmers, milkers, slaughterhouse staff and veterinarians.

The human disease syndromes (1, 21, 29) present as: fever, mylagia, hepatitis and gastro-enteric signs. These clinical signs, either separately or together, comprise by far the greatest proportion of human infections with RVF virus. Many may be so mild as to be unremarkable. The fever is diphasic with a one-day to two-day interval, and is usually accompanied by one or more of the other clinical signs.

However, these signs are highly non-specific and of limited value in identifying index cases of RVF by clinical means. Clearly, it is not justifiable to consider RVF a possible diagnosis on routine presentation of such signs. The course of the disease is usually three to nine days, with jaundice and possibly some haemorrhagic diarrhoea.

Haemorrhagic fever

This occurs only in 1% to 2% of cases and is the most dramatic form of the disease. It is very often fatal. There may be syndromes with different levels of severity, from mild bloody diarrhoea to profuse haemorrhagic vomiting and diarrhoea. There may be more generalised signs of haemorrhagic fever, such as nasal and subcutaneous bleeding, which are also associated with a high fatality rate. The occurrence of such a syndrome should invariably trigger investigations at a higher laboratory level to test for the haemorrhagic fevers such as Ebola, Marburg and CCHF. Such a clinical syndrome can generate a level of panic among inadequately supported medical staff, who often lack the special facilities and equipment that are required for barrier nursing and are critical for the safe nursing of such cases. However, nosocomial infection does not occur with RVF as it does with many of the other haemorrhagic fevers.

Encephalitis

This syndrome develops after an apparent recovery from the fever/mylagia syndrome described above and is thought to affect only about 1% of cases, although this may be too low an estimate.

Ocular disease

This syndrome also develops some days after an apparent recovery from the febrile disease and presents as a retinal vasculitis. It may not be recognised at all, or, if severe, only several weeks later. The condition may resolve itself as the inflammation subsides without severe residual retinal damage. In some cases, infarctions may develop which result in a scarring of the retina and permanent loss in visual acuity. The lesions appear to develop more commonly in the peripheral areas of the retina away from the central macular zone, which is visually more important. The occurrence of this syndrome is thus less readily identified and may have a much greater incidence in RVF epizootics than has hitherto been thought.

Mortality

The mortality rates experienced in most RVF epizootics have been less than 1% to 2%. This has been found in situations where most of the mild clinical cases would not have been included in the case study. On occasion, a much higher fatality rate has been found; an example was Arabia during the 2000/2001 epizootics in the tihama of Yemen and the Kingdom of Saudi Arabia where a fatality rate of 17% was recorded. The outcome in these situations may have been due to intercurrent infections with chronic parasitic disease such as malaria, which may have made the patients more susceptible. Certainly, more severe clinical RVF is seen in areas where malaria is hyper-endemic.

Rift Valley fever infected countries

The whole of sub-Saharan Africa, across the wide range of ecological zones found in the continent, may be considered to be enzootic for RVF, as demonstrated by many animal and human disease data with serological findings, such as those contained in reports produced by the OIE and the FAO. Most RVF viral activity is cryptic, at a low level, and not associated with any disease syndromes in humans and animals. Some cryptic low-level RVF virus activity may be occurring each year in many of the sub-Saharan countries. Most countries do not detect such RVF virus activity. This reflects a lack of systematic surveillance activities for RVF and of the capacity or justification for doing any such testing.

Information is available on the natural history of the virus in many African countries, which share common ecological characteristics across the whole of the African continent. The results show a consistent pattern of virus activity related to particular ecosystems and climatic conditions. While Egypt has experienced epizootic RVF, there is no evidence that any of the Mahgreb countries in north Africa have been infected with RVF virus. Arabia recognised clinical RVF in humans and animals for the first time in 2000/2001.The tihama regions of Saudi Arabia and Yemen were principally involved, and their ecological characteristics are identical with those across the Red Sea in Africa. The Red Sea constitutes the floor of the Great Rift Valley before its separation from the African continent. Today, in Arabia, the eastern floor and the mountain range to the east, represent the edge of the Rift Valley. It is thus not surprising to find evidence of RVF virus activity in such a habitat.

Rift Valley fever in Africa

As with some of the other African virus diseases of livestock, RVF is remarkable in that most of the indigenous livestock breeds of cattle, hair sheep and goats, show relatively high levels of resistance to the disease compared to those breeds/strains imported to the continent (2; Davies, unpublished observations). This resistance is considered to be genetic. Rift Valley fever is only evident clinically in exotic livestock or in animals in the more arid and semi-arid zones in the Sahelian and semi-desert zones to the north and south. Camels are also susceptible in these areas. Throughout much of Africa, RVF produces no clinical signs in livestock other than some abortions, which

may be and often are overlooked. Many African countries have found 15% to 35% of sheep, goats and cattle seropositive for RVF virus throughout most agro-climatic zones in their country, yet no clinical disease has ever been reported in humans or in animals. This is critical information, for it shows that there could be considerable RVF virus activity in a country with no clinical signs of disease. Such a situation has now been confirmed by unpublished epidemiological studies in many African countries. They are infected, but there are no visible signs of the disease.

Historical evidence suggests that epizootics of RVF are extremely rare in the semi-arid zones within the Horn of Africa. Most of the trade sheep that are exported to Saudi Arabia for the haj originate in these zones. There was a period of greatly increased RVF virus activity in north-east Kenya between 1961 and 1963, which was associated with extensive flooding of the major river basins (22, 23, 24). The next obvious outbreak of RVF there was in 1997/1998, after an interval of 34 years. The disease was also confirmed as present at the same period in neighbouring ecotopes, following the identification of disease in humans in the contiguous riverine flood plain systems of the Genale, Wabi Shabelle, and Juba rivers in Somalia and Ethiopia (6, 7, 8, 9, 10, 11). Some evidence of cryptic low-level RVF virus activity had been detected by serology in Kenya, Ethiopia and Somalia during the inter-epizootic periods of the 1980s and 1990s, but no clinical disease had been reported in animals in the latter two countries. More baseline data is required on cryptic virus activity in these areas. There is a lack of transparency in publishing RVF results due to their negative impact upon a trade that is said to be worth at least US$ 0.6 billion per year.

Risk assessment

Risk during inter-epizootic periods

Many tens of millions of sheep and goats have been exported during inter-epizootic periods from Somalia (and from the Ogaden region of Ethiopia and north-east Kenya) to Saudi Arabia and other countries in the Arabian Peninsula. This large-scale movement of animals has not been associated with any disease outbreaks that might be attributed to RVF. The available evidence suggests that such inter-epizootic periods prevail for at least 95% of the time in the semi-arid lands of the Horn of Africa.

The current changes associated with global warming and the periodic increased amplitude of the southern ocean oscillation temperature indices may alter this historic climatic pattern. One consequence is likely to follow the greater amplitude in the oscillation of the southern ocean temperatures: the frequency, magnitude and extent of flooding in the region may become much greater and more severe. The historical pattern of RVF virus activity in the region may change radically as a result.

Rift Valley fever risk in epizootic periods

A ban on imports of sheep and goats to the haj at Mecca from the semi-arid zones of the Horn of Africa is justified when there is good evidence for the onset of greatly increased RVF virus activity in the regions from which the animals are being transported. This information can be derived (probably with more than 95% accuracy in parts of East Africa) by climatic predictions, which can be made from satellite-derived information systems. The ground truth data is not currently available to extend this principle to the whole of the region, but efforts are being made to validate a model to do this. It must be emphasised that by the time the virus has been detected at the point of origin of the animals, it is too late and infected animals may already have been exported.

The journey by road and sea to Jeddah from such zones may be completed within the incubation period for the disease. Thus the importing of sheep entails a risk of transporting RVF virus. The possibility that large numbers of viraemic sheep (or goats) may arrive in Mecca and be slaughtered is real. A 1.5% to 3% infection rate, which might prevail if the animals were shipped from an area with high RVF virus activity at or near peak virus activity, could result in some 15,000 to 30,000 infected sheep being slaughtered on the peak day of id al Adha. The risk of RVF infection to pilgrims would thus be significant. It is possible that 5% to 10% or more of sheep from any one epizootic area might be infected.

Awareness of this problem increased in Saudi Arabia, after the identification of epizootic RVF in the country in 2000/2001. This has highlighted the need to establish some guidelines for the control of animal movements at national and international levels. It is especially important to Saudi Arabia due to the very large numbers of sheep and goats which travel through or arrive in the country for the great religious feasts at Mecca every year. This trade has two components.

The first component is the movement of animals from the Horn of Africa and Sudan directly to the ports of Jizan or Jeddah, which is near Mecca. This involves transport by road from regional markets in Somalia, Region 5 of Ethiopia or north Kenya, mainly to the ports of Berbera, Bossasso and Port Sudan, and from these by boat to Saudi Arabia. The speed of the system allows them to arrive in Jeddah within five to ten days of leaving the regional markets. This issue is discussed in some detail in Food and Agriculture Organization (FAO) reports (5, 15).

The second component of animal imports encompasses the 'trickle trade', which involves the movement of animals in a northerly direction in the tihama of Arabia from Yemen into Saudi Arabia. Many of the sheep and goats traded in this way originate in the Horn of Africa and have been transported to the Arabian Peninsula by way of the Yemeni ports of Aden, Al Mukha and Al Hodeidah. However, a significant number are from within Yemen itself; they are grazed and traded in a northerly direction to the big markets on the border with Saudi Arabia. This trade has probably continued unaltered for centuries. These animals could be exposed to RVF during passage through the tihama of Yemen and Saudi Arabia if the climatic conditions are favourable for RVF virus activity.

The incubation period for Rift Valley fever

Observations of laboratory infections indicate that the incubation period for RVF is 18 h to 7 days, and the viraemia may persist for one to seven days (16, 17). The actual period of viraemia varies with the genotype of the animal and its relative susceptibility to the virus. Distinct differences occur (2; Davies, unpublished data). Wool sheep exotic to Africa are in general, highly susceptible, with viraemias persisting for four to seven days. The indigenous hair sheep breeds in East Africa are relatively insusceptible, with generally brief periods of viraemia lasting from a few hours to one to two days, with neither malaise nor clinical signs of disease.

The incubation period and duration of viraemia are critical in attempting to assess the levels of risk posed by RVF virus in sheep to the pilgrims at Mecca. There have not been adequate experiments to determine these characteristics in the strains or breeds of sheep principally involved in the trade.

Strategies for control in the exporting countries

Some institutional involvement in regulating the trade is necessary. A good basic knowledge of animal health matters and clinical signs is a starting point. Such information can be systematically gathered and reported in a network with good information flow. Specific disease information, based upon laboratory investigations, is a valuable aid. A systematic strategy should be established to gather real time evidence by monitoring the weather patterns using satellite predictive tools, and to monitor the presence or absence of RVF virus activity by sentinel herd studies or IgM searches in high-risk zones. The latter can be driven by climatic data, which can identify pre-epizootic conditions.

Evidence for the presence or absence of RVF virus activity in one biotope in Kenya, East Africa, was monitored and has provided invaluable baseline ground truth data (3, 14, 26). The evidence was collected over more than 25 years and the results were correlated with rainfall data and later with remote sensing satellite data (RSSD). The correlation of periods of virus activity with rainfall, cold cloud density (CCD) and normalised differential vegetation indices (NDVI) allowed predictions to be made of the periods when RVF virus activity was likely to occur. The predictive capacity was improved by the inclusion of the southern ocean temperature oscillation index. The system has also been shown to correlate with periods of RVF virus activity in Zambia (12). These information systems require more ground truth data to validate their extension and application to both similar and other, drier ecotopes in Africa and elsewhere. The system may be used to drive monitoring activities on RVF in these countries, where some baseline data of RVF virus activity is available or where identical ecosystems exist.

Retrospective studies (14) made following the 1997/1998 RVF epidemic show that these predictive tools might have been helpful in Region V of Ethiopia and north-east Kenya and Somalia. There is one caveat however: the rainfall measurements must be made in the catchment areas for the river systems and not in the floodplains, where the virus activity occurs. The catchment areas may be far distant from the actual disease sites in the floodplains. However, it is possible to measure rainfall in the mountain catchment areas for the rivers using a satellite data model of basin excess rainfall monitoring systems (BERMS), which can predict the amplitude of the expected river flow (26). In the wetter ecozones of the highlands and coastal plains in Africa the measurements are relevant at the disease sites. This is the case in ecological zones II, III and IV (14). The danger is that the tools may be applied elsewhere in the absence of any ground truth information, which is hazardous.

The major concern is to avoid the importation of animals from Africa to Mecca for slaughter at a time when there is known to be RVF virus activity at the point of origin of the animals involved. This can only be achieved by establishing collaborative monitoring and networking systems for RVF throughout the sub-region. Efforts are being made to establish a forum where all the modelling and predictive data can be discussed by the interested parties (exporters and importers). The involvement of international organisations such as the FAO and World Organisation for Animal Health (OIE) is important to assist in decision-making at this level.

Such networking activity could be facilitated by the establishment of regional forums on exporting and on laboratory information such as the Regional Animal Disease Surveillance and Control Network (RADISCON) and the Pan African Information System (PANINFO),

coordinated and validated by international organisations such as the FAO, World Health Organization and OIE. Saudi Arabia, as the end user in the livestock marketing chain, has the greatest interest in the establishment and operation of such information networks for RVF and other diseases.

The validity and practicalities of acquiring the above information are discussed briefly below. To generate the information relevant to the problem the following methods can be used:

a) surveillance by:

– clinical inspection of the animals

– serological surveys

– sentinel herd monitoring

– reporting networks for abortion

b) laboratory studies by:

– virus isolation

– enzyme-linked immunosorbent assay testing for IgM or IgG

– other serological methods

c) predictive epidemiology by:

– rainfall monitoring

– met-sat climate monitoring

– RSSD monitoring of CCD and NDVI, southern oscillation index (SOI) and BERMS, fed into a predictive model (when available)

– establishing geographic information systems databases on densities and movement patterns of livestock population

– establishing a database on RVF vector distribution, density and breeding biology

– developing a regional approach to RVF epidemiology.

Determination of the actual risks involved

Clinical inspections of flocks of sheep and goats of breeds indigenous to the region are unlikely to detect RVF virus activity, for the disease is mostly cryptic in these genotypes. Abortion is the principal sign of infection, but the trade is exclusively in male animals and these are unlikely to show any clinical signs of the disease.

To achieve hard data would require the sampling and serological testing of the livestock populations in transit in an attempt to obtain information on the existence of ongoing RVF activity. However, a meaningful sample to give confidence at the 1% level would require sample sizes of 10,000 or more animals. The logistics and practicalities of doing this make it an impossible task. No laboratory in the region has the capacity to cope in a very short period with the number of tests which would be required to give meaningful results.

The trade depends upon rapid movement of animals from source to avoid the loss of weight which occurs in transit (around 1 kg per day). Delays resulting from sampling and testing are not acceptable to the traders, nor is any weight loss from the stress of sampling. Any permanent marking or ear tagging of animals would also have a negative effect upon the trade. The alternative is to make some assessment of the 'relative risk' presented by RVF in the area from which the animals originate. It has been mentioned that animals may originate from areas that have no institutional capacity in animal health. The pastoralists in these semi-arid zones of Africa are totally dependent upon this trade for their survival. They constitute a highly vulnerable population group. A trade ban would have a dramatic negative impact upon their economy.

Assessment of relative risk

The climatic determinants of the onset of RVF virus activity are those which allow the emergence of large numbers of the primary *Aedes* mosquito vectors. The necessary climatic conditions must persist for long enough to allow the generation of large populations of the secondary mosquito vectors – *Culex, Anopheles, Mansonia* and other genera. These preconditions are: the occurrence of prolonged and persistent rainfall over several months, leading to a rise in the water table in the higher potential agro-ecological zones, which leads ultimately to some local or extensive flooding. This has been seen in East Africa and parts of South Africa in geomorphic formations called 'dambos', which are depressions found in grasslands prone to flooding. Coincident with the rainfall, the inter-tropical convergence zone (ITCZ) in Africa needs to be much broader and deeper, for longer periods of time than is usual. Rainfall of two to ten times the mean annual values has been associated with periods of epizootic RVF. Flooding in the semi-arid and arid zones is likely to occur in floodplains downstream from the actual rainfall zones, often long distances from the rainfall which occurs in plateaus or mountain forest zones. Examples are the watersheds of the Wabi Shabelle and Genale rivers in the Ethiopian plateau, the Tana River flowing from Mount Kenya, the Nile, and the Senegal and Niger rivers in West Africa. Regional epizootic/epidemic periods may be associated with 10 times to 50 times the mean rainfall in the semi-arid zones, and are clearly driven by the El Niño phenomenon.

The analysis of these climatic factors is the most valuable and cost effective means presently available to make a

relative risk assessment for RVF. To utilise these, recommendations are proposed below as a template for monitoring RVF in the region.

The World Trade Agreement

The trade in small ruminants, mainly sheep, to Saudi Arabia for the religious festivals at Mecca has been estimated to be worth US$ 0.6 billion to US$ 0.9 billion dollars each year. Traditionally this had been an unregulated trade, until the awareness of the danger presented by RVF infection was perceived by the Saudi Arabian Health Ministry. The World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures has stressed the need for internationally accepted monitoring and surveillance systems for diseases such as RVF.

Historically, there has often been a considerable trade advantage to be gained by (sometimes deliberate) ignorance of a particular disease problem. This is no longer the case, and importing countries such as Saudi Arabia are in a position to demand verifiable internationally accredited data regarding the status of any disease problem in a country of origin. This is highly relevant to the huge trade in sheep to Mecca for Ramadan and the haj. The situation in one traditional major source of the animals, Somalia, is complicated by the lack of any institutional capacity to generate the critical data. A similar observation may apply to the Ogaden region of Ethiopia, for the animals from this region are traded largely through Bossaso and Berbera in Somalia/Somaliland.

Current and potential monitoring activities for Rift Valley fever

Ethiopia

There is little or no information available to show the distribution of RVF virus in the country. No disease problem which might be RVF has ever been recorded other than in the south-east of the country in 1997/1998. Given the ecological characteristics of RVF enzootic areas common to East Africa and the Horn of Africa, other areas of the country have the potentially to harbour RVF.

Activities should focus on the riverine floodplains of the wabi Shabelle river and its many tributaries in the Ogaden in the south-east of the country. Baseline data for a 10-year to 20-year period should be obtained, and the differences detected in CCD and NDVI levels for the region in the year 1997 compared with the average values. Clear differences may become evident and serve as the basis for early warning in this region.

Sudan

Rift Valley fever virus activity has been shown to occur upstream of the Gezira irrigation scheme on the Nile, in the large area of the Nile basin with its many tributaries in the south-west of the country, in the riverine irrigated areas near Khartoum, and in Equatoria Province (4, 18, 19).

There are no longitudinal data on the virus activity in the country on which to base any assessment of the level of risk of RVF epizootic virus activity.

An analysis of the conditions which prevailed in 1997 compared with the 20-year means for CCD and NDVI may give some indication of the predisposing conditions. The regional determinants such as SOI indices and the characteristics of the ITCZ and BERMS data for the Nile would be highly relevant.

North-east Kenya

North-east Kenya contributes to the trade in sheep and goats in this region.

Rift Valley fever occurred in epizootic form in the north-east of the country in the years 1961/1962 and 1997/1998. The rainfall and RSSD during these years gave a clear indication of the pre-epizootic conditions (14).

Reasonably accurate predictions can be made for the likelihood of epizootic RVF occurring. The flooding which occurred in those years covered hundreds of square miles in the floodplains of the Uasa Nyiro and Tana River basins. Such a level of flooding is extremely rare.

Between these epizootics, RVF virus activity is extremely difficult to detect in these semi-arid zones, but occasional sero-conversions in camels or cattle (13) show that it does occur.

Somalia

Serological studies carried out many years ago showed the presence of RVF antibody in sheep, goats, cattle and camels in the country. However, no clinical disease syndrome had ever been observed in humans or animals until the epizootic year of 1997/1998.

In 1997/1998 deaths among humans and abortions in camels, sheep, and goats were reported and confirmed to have been caused by RVF in the floodplain areas of the Wabi Shabelle and Juba river systems in the south of the country. No RVF was confirmed in the drier northern parts of the north-east of Somalia (6). Remote sensing satellite data are analysed on a monthly basis by FAO monitoring

systems (MetArt, the Africa Real Time Environmental Monitoring Information System [ARTEMIS]/the Famine Early Warning Systems) to assess the potential for food production. These data can also be used to monitor potential RVF virus activity.

Arabian Peninsula

An analysis of the pre-epizootic conditions in Jizan may reveal the nature of the predisposing factors for RVF in the country in the year 2000. Current observation shows that rainfall was at least two or three times higher than normal from May through to October 2000.

Sentinel herd systems have been established in the high-risk areas in the tihama of both Saudi Arabia and Yemen.

Risk management

Predictive inputs

Any indication that major pre-epizootic/epidemic conditions have been identified in exporting countries should be followed by a total ban on livestock trade to Mecca from the affected countries/regions. Clearly the importing country, i.e. Saudi Arabia, should be the decision-maker in implementing this ban. Transparent monitoring and reporting of the climatic conditions related to the risk of RVF virus activity should be the responsibility of the exporting countries, in collaboration with the importing countries. A regional trade commission would be an excellent forum within which such decision-making can be made and coordinated. Efforts are being made to establish a Red Sea Livestock Trade Commission to facilitate this.

It is strongly recommended that any regional predictive modelling system for RVF should be operated by an agency such as the FAO, which is already active in projections of the relative risks presented by army worm, locusts and quelea in this region. Close collaboration with the disease regulatory body, the OIE, is essential. This would generate the necessary confidence among the countries involved and ensure validation of any and all predictions.

Vaccination

Vaccinated animals would present no risk from RVF at Mecca.

Killed vaccines are expensive and do not always protect against abortion or death, even after repeated vaccinations. In many parts of Africa and in Egypt, the Smithburn vaccine strain (SNS) of a modified live virus has been extensively used. It is valuable as a means of protecting livestock in high-input/high-output systems in the known epizootic areas where valuable, highly susceptible stock are kept. The Smithburn vaccine strain is a cheap and effective vaccine. It is immunogenic, conferring a lifelong immunity, but suffers the disadvantage that it can produce foetal abnormalities early in pregnancy and abortions later in at least 5% to 15% of pregnant animals in the susceptible breeds of sheep and goats. A good protective immunity can also be induced in cattle by this vaccine. Management standards in such situations are high, and owners follow the strict instructions to vaccinate only when the animals are not pregnant. However, in the face of an epidemic many farmers will take a risk and vaccinate regardless of the problems, which are significantly less than those of the disease itself.

The breeds of sheep and goats involved in the trade outlined above are not highly susceptible to RVF. The trade is in male animals and these can be successfully immunised against RVF by using the SNS vaccine. The mortality induced by the disease has not been greater than 1% to 3% in outbreaks in the Horn of Africa and the Arabian Peninsula, and while abortion rates can reach 10% to 30% in the most severely affected areas, they are less than 10% overall. Vaccination is not a cost-effective, economically justifiable intervention in these low-input/low-production systems against a disease, which may appear at 5-year to 35-year intervals (although the periodicity may change with global warming). The herd structure is predominantly female as males are sold off early and owners do not follow a strict breeding pattern. Many females are liable to be pregnant at any time and problems may follow the use of live vaccine in such herds. In practice, however, few or no abortions have followed its use in these relatively RVF-resistant breeds.

The vaccination of animal populations in semi-arid zones to minimise the amplification of RVF virus and reduce the risk of human infections is another issue. Such an intervention may be justified by the need to limit the impact of a zoonotic disease, and the recognition of pre-epizootic conditions may be the signal for this. However, vaccination on an annual basis cannot be justified, other than in highly focused programmes during periods when RVF virus activity is anticipated in areas that are recognised as being at high risk.

Certification

Problems are likely to arise with any attempts to certify vaccination, for most animals originate in areas where there is no institutional capacity to either administer or validate the status of the trade animals with regard to their origin, vaccination history or immunity to RVF virus. Previous attempts at validation have not proved encouraging. It is hoped that this situation will change.

Conclusions

The evidence, which has accrued over the past 50 years, suggests that whatever risk exists from RVF is normally at a low level. No major RVF disease incident has been reported at Mecca during this time despite the importation of millions of sheep and goats from RVF enzootic and epizootic areas in the Horn of Africa. The last major epizootics of RVF in the semi-arid zones of the Horn of Africa occurred in 1961/1962 and 1997/1998. The export trade was uninterrupted in 1961/1962 and illegal trade was thought to have occurred during 1997/1998. No disease episodes which may have been attributable to RVF were recorded in Saudi Arabia in 1997/1998. They may well have occurred, however. The potential certainly exists.

The author strongly recommends that the movement of sheep and goats to Mecca for the religious festivals should be strictly prohibited from any area in which epizootic RVF virus has occurred in the previous three to six months. This principle should be applied both to the animals originating in the Horn of Africa and in Arabia itself.

Predictive epidemiological inputs can drive prophylactic vaccination campaigns in the high-risk areas, wherever this can be justified economically and where the necessary institutional capacity exists. The predictive models which are available give at least three months lead time (25, 26, 27, 28). The areas where prophylactic vaccination might be used are, for example, where there are high-input/high-production livestock systems, as in the highland areas of East Africa, or where a relatively limited area is involved, such as the tihama of Arabia. This measure is much less feasible in the semi-arid zones where the pastoralists are moving all the time.

High-risk areas can be defined on the basis of the virus activity detected or disease problems experienced in previous RVF epizootics or by post-epizootic serological surveys. There can be little justification for routine annual RVF vaccination in the semi-arid zones, where the livestock are relatively insusceptible and the losses caused by the disease are low or negligible. Rift Valley fever is not a disease problem for the livestock producers; however, it is perhaps the most important factor which affects trade in the region. Vaccination may be driven by the realities of the market place but vaccinated animals present no hazards per se at the haj. Importing countries may decide that they wish all animals to be vaccinated against the disease.

■

Risque d'épidémie de fièvre de la Vallée du Rift lors du hadj, le pèlerinage à La Mecque, Arabie saoudite

F.G. Davies

Résumé

La fièvre de la Vallée du Rift est une zoonose qui touche à la fois l'homme et les animaux domestiques. Chez l'homme, la maladie peut se traduire par une fièvre hémorragique mortelle. L'infection des animaux domestiques tels que ovins, caprins, camélidés et bovins peut entraîner ou non l'apparition des signes cliniques de la maladie. Les animaux atteints d'infection clinique comme infraclinique représentent un danger pour l'homme en tant que source d'infection. Le risque d'infection est maximal au moment de l'abattage, où peuvent être produits des aérosols de sang infecté, en particulier dans le cadre des pratiques d'abattage rituel. Chaque année, quelque 10 à 15 millions d'animaux peuvent être sacrifiés à l'occasion des fêtes religieuses de La Mecque. Certains de ces animaux proviennent de la péninsule arabique elle-même, mais la plupart sont importés, en passant par la Mer Rouge, de pays d'Afrique orientale et de la Corne de l'Afrique, où la fièvre de la Vallée du Rift est

enzootique et peut être considérablement amplifiée en période d'activité épizootique du virus. Ces animaux sont susceptibles d'être transportés vers La Mecque et d'atteindre ce lieu alors qu'ils sont en période d'incubation de la maladie. On sait que la fièvre de la Vallée du Rift se déclare également dans les zones de la Tihama de l'Arabie saoudite et du Yémen.

Mots-clés
Arabie saoudite – Exportation de l'Afrique – Fête religieuse – Fièvre de la Vallée du Rift – La Mecque – Petit ruminant – Ramadan – Sacrifice rituel – Zoonose.

Riesgo de epidemia de fiebre del Valle del Rift durante el 'haj' de La Meca (Arabia Saudí)

F.G. Davies

Resumen
La fiebre del Valle del Rift (FVR) es una enfermedad zoonótica que ataca a los animales domésticos y al hombre, en el que puede causar una fiebre hemorrágica mortal. Cuando afecta a animales domésticos como la oveja, la cabra, el camello o la vaca, la infección puede acompañarse o no de signos clínicos. Los animales enfermos, ya sea en forma subclínica o clínica, suponen un peligro para el ser humano como fuente de infección. El riesgo de infección es máximo en el momento de la matanza, pues pueden generarse aerosoles de sangre infectada, sobre todo cuando se emplean métodos tradicionales de sacrificio. Cada año, en el curso de distintas celebraciones religiosas, se sacrifican hasta 10 a 15 millones de animales en La Meca. Aunque algunos de ellos provienen de la propia Península Arábiga, la mayoría llegan a través del Mar Rojo de países esteafricanos o del Cuerno de África, donde se sabe que la FVR es enzoótica y puede verse muy amplificada en los periodos de actividad del virus epizoótico. Esos animales pueden ser transportados a La Meca y llegar a su destino durante la fase de incubación de la enfermedad. Se sabe que la FVR también está presente en las zonas de "tihama" (llanura desértica) de Arabia Saudí y el Yemen.

Palabras clave
Arabia Saudí – Celebración religiosa – Comercio desde África – Fiebre del Valle del Rift – La Meca – Pequeño rumiante – Ramadán – Sacrificio ritual – Zoonosis.

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Kenya, Mau Mau and bioterrorism

F.G. Davies

The Whittery, Chirbury, Powys SY15 6DA, United Kingdom

Summary
The Mau Mau uprising in Kenya was to some extent directed against the European settlement of the traditional African livestock and farming areas in what became known as the 'White Highlands'. The original population groups were displaced and the seasonal grazing ranges for their cattle greatly restricted. When these herders grazed their cattle alongside roads in settled areas, there was a strong response by the administration and many of the animals were impounded and sold. Reprisals for such seizures included the 'hamstringing' of settler cattle, which involved cutting the Achilles tendon of a hind limb. This effectively resulted in the animals being slaughtered on humane grounds.

Keywords
Bioterrorism – Cattle – Hamstringing – Kenya – Mau Mau – Settlers.

History

The response of the European administration to the Mau Mau uprising in Kenya in 1951 involved punitive actions against African stock-owning communities. This was especially the case in the 'White Highland' areas of Nanyuki and Naivasha Districts, which were particularly attractive to new settler communities. The settlers developed large tracts of land for intensive agriculture and livestock farming. This process had been occurring since the Europeans first came to Kenya but it was more intensively pursued in the period 1945 to 1951 as more and more European ex-service personnel settled in Kenya after the war.

The African population had hitherto used these lands for the seasonal grazing of their cattle, sheep and goats. Often 'agreements' were made with their tribal chiefs/elders to vacate the land. The result was that many herders were displaced from their grazing land, and were left without adequate grazing for their livestock. Many became 'squatters' in the eyes of the administration, and lived in communities close to the areas from which they had been displaced.

Causes

The squatters grazed their cattle at the margins of the settled white farming areas and at the forest edge. They moved along the roads, grazing as they went, to wherever they could find any grass. Their presence constituted a nuisance as well as a potential disease hazard. The movement of herds of indigenous cattle in such a haphazard manner was likely to create a potential disease hazard to the settled farming areas of the 'White Highlands'.

Many settler farms kept livestock breeds that had been imported into Kenya from Europe and elsewhere. These imported breeds had much greater production potential than the Kenyan cattle, but were far less resistant to the endemic diseases prevalent among the indigenous cattle and small ruminant herds. Many of the latter had developed high levels of resistance, which was both genetic and acquired. Disease control activities at that time involved movement restrictions, which were primarily designed to protect and exploit the higher production potential of the improved livestock breeds held in the White Highland farming areas and did not consider the indigenous cattle breeds to a similar extent.

Animal diseases such as rinderpest, bovine pleuropneumonia and possibly also some tick-borne diseases might be carried by the indigenous cattle groups, and pox virus disease of sheep and goats was also a potential threat. They presented significant hazards to the improved stock on many of the settler farms, and animal movement restrictions were a major component of the disease control activities at that time. These measures were primarily designed to protect and exploit the higher production potential of the improved livestock breeds held

in the White Highland farming areas and did not consider the indigenous cattle breeds to a similar extent.

The response of the government to this problem was thus to attempt to remove the hazards presented by these marginal cattle – belonging to people they described as 'squatters' – to the high-potential cattle breeds owned by the settler farmers. The authorities involved in implementing this policy were the European District Councils. Policing of the 'squatter' cattle became more rigorous. As a collective punishment, the cattle were often impounded and their owners could be forced to sell them (Throup, personal communication), often at prices that were below their actual market value. Furthermore, the purchasers were often the settlers themselves, which increased the resentment.

Impact of the policies

The responses of the squatter populations – first removed from their traditional seasonal grazing areas, and then displaced from their home areas – were driven by a deep-seated resentment at the treatment they were receiving from the government. The activities were believed by the administration to be carried out by Mau Mau 'terrorists' who were known to be hiding out in the Aberdare and Mount Kenya Forests. It is just as likely that the displaced squatters themselves were responsible. They were incensed by the injustices which they believed that they had experienced at the hands of the administration.

The response

The herders practised two types of activities against the administration and the settler farming communities. First, large areas of pastureland were set alight to destroy the seasonal grazing potential of the farmland. This was especially the case in the Nyeri and Nanyuki Districts. Second, cattle were attacked with *pangas*, the simple, sharp-bladed, hand-axe-like tool used by many Kenyan African communities in their daily life. The *panga* is used in agriculture as a cultivating and cleaning tool, and in the cutting and collection of wood for household purposes. It was used to cut the large tendon at the point of the hock (the Achilles tendon). This comprises the tendons of the gastrocnemius, superficial and deep digital flexor muscles. If both hind-limb tendons on an animal are cut, the animal is totally unable to stand on its hind legs. If only one tendon, then that leg becomes totally useless. There is no treatment for these injuries and affected animals must be slaughtered on humane grounds.

This activity occurred mainly in the Nanyuki and Nyeri Districts, and to some extent in the Naivasha District. The number of cattle maimed in this way has not been accurately determined, but is thought to be of the order of several thousand. Figures of between 1,000 and 10,000 have been quoted, but contemporary opinion would suggest that the figures were very much of the lower order and that only 1,500 to 3,000 were so affected. Hard data on this point are difficult to obtain.

Hamstringing cattle was an economic strategy, and it was suspected that those small-scale African farmers who had been displaced from the White Highlands were behind it. They had been paid extremely low prices for their land, and many were living in squatter communities in the adjacent villages or forest edges. The government at the time had also, on occasion, confiscated the livestock of these communities as a form of collective punishment. Confiscations were often followed, particularly in the Nyeri District, by the reprisal of hamstringing cattle belonging to the white farmers (Anderson, personal communication).

Impact of attacks on cattle

The impact of this activity in economic terms was probably not very significant. It served however to drive more vigorous Government responses against the Mau Mau uprising and to increase security activities against those perceived to be responsible.

Conclusions

This sad chapter of events reveals the potential for bioterrorism that targets animal populations as a means to aggravate and draw attention to real and perceived injustices. The impact was particularly distressing to those involved in livestock farming and management. The economic impact in this instance was probably not great. A conclusion might be drawn that this was a totally understandable response by a population, which had experienced real injustice (in their view) by a less than equitable administration.

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Kenya, Mau-Mau et bioterrorisme

F.G. Davies

Résumé
L'insurrection Mau-Mau au Kenya était dans une certaine mesure dirigée contre l'installation de colons européens dans les zones africaines traditionnelles d'agriculture et d'élevage que l'on a appelées par la suite « White Highlands » (hautes terres occupées par les Blancs). Les groupes de population d'origine ont été déplacés et les aires de pacage saisonnier de leur bétail ont été très réduites. Quand ces éleveurs faisaient paître leurs bovins le long des routes dans les zones d'installation, l'administration réagissait avec vigueur et un grand nombre d'animaux étaient capturés et vendus. En représailles à ces saisies, les éleveurs pratiquaient le « *hamstringing* » qui consistait à couper le tendon d'Achille d'un membre postérieur des bovins des colons. Cette pratique aboutissait à l'abattage des animaux mutilés pour des raisons de compassion.

Mots-clés
Bioterrorisme – Bovins – Colons – Hamstringing – Kenya – Mau Mau.

Kenia, Mau Mau y bioterrorismo

F.G. Davies

Resumen
El levantamiento Mau Mau en Kenia iba dirigido en cierta medida contra la colonización europea de áreas ganaderas y agrícolas tradicionales africanas, en lo que vino a denominarse 'White Highlands' (meseta blanca). La población autóctona fue desplazada y las zonas de pasto estacional para su ganado se vieron muy reducidas. Cuando los pastores llevaban su ganado a pastar junto a caminos en zonas de colonización, la administración reaccionaba con dureza, incautándose de muchos animales y después vendiéndolos. Estas acciones desencadenaban a su vez represalias tales como la sección de un tendón de Aquiles de los bovinos de los colonos. En la práctica, ello se tradujo en el sacrificio de los animales mutilados por motivos estrictamente humanos.

Palabras clave
Bioterrorismo – Colonos – Ganado bovino – Kenia – Mau Mau – Sección del tendón de Aquiles.

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Achievements of the Soviet biological weapons programme and implications for the future

I.V. Domaradskij [1] & W. Orent [2]

(1) Moscow Gabrichevsky G. N. Research Institute of Epidemiology and Microbiology, Admiral Makarov Road, 10, Moscow 125212, Federation of Russia
(2) 4562 Club Circle, Atlanta, Georgia 30319, United States of America

Summary

The military–biological complex of the former Union of Soviet Socialist Republics was a true Frankenstein's Monster, with a powerful scientific potential – for good and for ill. This article examines both the direct scientific results of the twin biological weapons (BWs) programmes run by the 'civilian' Biopreparat and by the Ministry of Defence (MoD) and the public health benefits that sprang, despite the original intent, out of those programmes. The authors will also explore the potential for both crop and livestock destruction and for enhanced agricultural methods growing out of the parallel Soviet programme under the management of the Special Directorate of the Ministry of Agriculture.

In the last section of the article the authors discuss the situation in the military–biological complex that arose after former President Boris Yeltsin's 1992 decree abolishing all research and development on offensive BWs. The possibility is considered that expertise, technologies and materials from the former Soviet BWs programme have leaked out of Russia, because the living standards in Russia remain low and the overwhelming majority of scientists have a miserable existence.

Keywords

15th Directorate – Antiplague System – Biopreparat – Military–biological complex – Ministry of Agriculture – Ministry of Defence – State Scientific Centre of Applied Microbiology – Vector.

Introduction

The development of biological weapons (BWs) in the Union of Soviet Socialist Republics (USSR) began in the 1920s and proceeded through the next few decades until the beginning of the Second World War; by then, stocks of relatively primitive BWs were available to the Soviet military. At this point, Soviet BWs research employed only natural strains of microorganisms. But after more than 40 years of research it became clear that using only natural strains made it very difficult to achieve what the military viewed as desirable results. Some of the leading biologists of the USSR, many of them fully *au courant* with scientific developments in the West, realised that they needed an entirely new approach to the problem of making effective weapons. This new approach would incorporate the latest achievements in molecular biology and genetics. Because of the closed nature of Soviet science and society, however, Russian biological sciences lagged behind those of the West. There were few experts who were on a par with Western molecular biologists and geneticists, and there was no modern equipment.

How was Soviet biological science, crippled by decades of Lysenkoism, to overcome the advantage held by the West? In the early 1970s, the Soviet Government created a new 'civilian' branch of the BWs programme, called 'Biopreparat'. Biopreparat, established under the Main Directorate of Microbiological Industry under the USSR Council of Ministers, was designed to do whatever was necessary to modernise Soviet science and construct a suitable scientific and industrial base for the design and production of modern BWs. A specific directive from the highest levels of the Soviet Government also established the ultra-secret Interagency Scientific and Technical Council (ISTC) for molecular biology and genetics, to inspire, direct and oversee all the work performed by

Biopreparat. At the same time, the ISTC also controlled the development of a parallel line of BWs research conducted by the Ministry of Defence (MoD) (before the creation of the supposedly civilian Biopreparat the MoD had handled all BWs research). Also closely connected to the ISTC was another programme, managed by the Ministry of Agriculture. This programme directed all research on the creation and development of biological agents designed to destroy crops and livestock.

All of these organisations were, quite naturally, designated 'top secret'. At the same time, the Soviet government created another council for the study of molecular biology and genetics, this time at the Academy of Sciences of the USSR. Though this council was open, it had a dual purpose:

a) to promote the legitimate investigation of the fundamental aspects of evolutionary and molecular biology and genetics in which the USSR lagged seriously behind the West

b) to serve as a 'cover story' for the secret ISTC and the fledgling Biopreparat.

In fact almost all civilian microbiological programmes were used as 'cover stories' to hide the top-secret BWs programmes of the MoD and Biopreparat. Of these, the programme called 'Problem Number Five' was particularly important. This odd-sounding name refers to a defensive programme designed to protect the Soviet people from BWs and infectious disease. Within the Problem Number Five programme, the Antiplague System, a vast network of institutes and stations that spanned much of the territory of the USSR, played an especially significant role. Though the Antiplague System was originally devised to fight plague and other diseases native to the region, its institutes, including the famous 'Mikrob' Institute at Saratov, came, through Problem Number Five, to serve as suppliers of strains and expertise to the Biopreparat and the MoD BWs programmes. The Mikrob Institute, for example, supplied the military programme with the most virulent available strains of *Yersinia pestis*, the plague agent. Another large antiplague institute, created in Volgograd in 1971, performed vital services for both the military and Biopreparat. At first scientists at the Volgograd antiplague institute studied pathogens that produce a deep mycosis affecting nearly all organs; later this work was extended to studies of the genetics of *Burkholderia pseudomallei* and *Bacillus anthracis* and to developing technology for the rapid diagnosis of the agents of especially dangerous infections.

After the signing (in 1972) and ratification (in 1975) of the international Biological Weapons and Toxins Convention, which prohibited the development, manufacture and accumulation of stocks of BWs and toxins, the USSR used the cover of the convention to accelerate their offensive weapons programme, though now in even deeper secrecy.

Even now, the military are doing all they can to deny or conceal the existence of the Soviet offensive programme, as evidenced by lectures delivered by the chief of the former 15th Directorate of the MoD, V.I. Yevstigneev, at the Moscow Institute of Physics and Technology in 2003 (15). His words were echoed by the retired general A. Vorob'ev (14), vice-chief of Biopreparat from 1979 until 1987. Interestingly, who or what forces them to obfuscate the issue – over 10 years after Presidential Decree No. 390 of 11 April 1992 abolished the entire offensive BWs system – is unknown.

According to all reports, the development of offensive BWs in Russia has stopped, though research using the agents of especially dangerous infections proceeds in institutions of the MoD and in facilities that were formerly under the jurisdiction of Biopreparat. Officially, all this research now falls under the rubric of biodefence.

Unfortunately, even now, little is known or understood by the wider public about the large-scale research and development carried out in the USSR as part of 'Problem Number Five'. Even data that would be helpful to scientific programmes are still classified.

The military–biological complex and socially useful activities

During the Soviet regime, the military–biological complex was created for offensive purposes and not for the common good. Still, public health benefits, in spite of the military's intent, did accrue from this work – as inadvertent by-products of research into the design and creation of BWs. Research into vaccination and treatment regimes was intended, more often than not, as a smoke-screen to reinforce the existing cover story surrounding the secret work of the military–biological complex.

The Ministry of Defence biological weapons research and development facilities under the jurisdiction of the 15th Directorate

The first important example of a public health benefit deriving from the activities of the military–biological complex is an anthrax vaccine, which was developed for human use by Nikolai Ginzburg at the Sanitary-Technology Institute (STI) of the MoD; in the late 1940s this institute became known as the Scientific Research Institute of Epidemiology and Hygiene (also known as the Kirov Institute). In 1940, Ginzburg isolated a mutant of a

highly virulent strain of *B. anthracis*, the agent that causes anthrax (5). The mutant strain had low virulence for both white mice and guinea-pigs and did not cause disease in rabbits or sheep, but it still retained its immunogenicity. Using this mutant, Ginzburg and his associates rapidly created a live vaccine known as STI (from the abbreviation of the original name of the institute where it originated). The STI vaccine was successfully used to protect the staff of the Red Army during the 1944 offensive of the Second Ukrainian Front in Romania, where anthrax was considered a threat. The STI live vaccine is still in use in Russia; it has an epidemiological efficacy of about 70%.

The immunoprophylaxis of plague is a second example of the considerable, if inadvertent, contribution that the Soviet military–biological complex made to public health. As in the case of anthrax, military considerations before and during the Second World War necessitated the development of plague vaccines. In the late 1930s and early 1940s, the Red Army fought the Japanese in Mongolia and Manchuria, where there were natural foci of particularly dangerous strains of the causative agent of plague; i.e. the strains found among the large native burrowing rodents known as 'tarabagan' (*Marmota sibirica*). A strain known as EV (the initials of a young girl who had died of plague in Madagascar), held at the Pasteur Institute in Paris, was sent to the USSR in the late 1930s. A highly immunogenic clone of this strain, isolated in the Sanitary-Technical Institute in 1941, formed the basis of a dry live vaccine. The creation of this vaccine was of the utmost importance, as no liquid preparations of the EV strain survived for more than ten hours at room temperature, making it impossible to use them under field conditions in wartime. The dry live vaccine proved invaluable: by the beginning of the Manchurian offensive in August 1945, millions of soldiers had been inoculated with this vaccine. Not a single case of plague was recorded among Soviet troops, whereas among inhabitants in the same period at least 500 cases were reported (10). Instructions for producing the dry live plague vaccine were transmitted in 1946 to the Ministry of Health. The technology used in the Kirov institute to develop dry live vaccines was later employed in the fight against tularaemia, brucellosis and tuberculosis.

Two other institutes, one in Sverdlovsk, now known as Ekaterinburg, and one at Zagorsk, now Sergiyev Posad, were also involved in research and development that had public health implications. The technologies required to produce anatoxins for immunoprotection from botulism, tetanus and gas gangrene, oral vaccines against smallpox and encephalomyelitis, diagnostic methods for several infectious diseases and equipment for cultivating anaerobic bacteria were all created in these two institutes.

The development of ways to protect army personnel from infectious agents, including those that might be deployed as BWs, was of major importance to the military. Military scientists investigated aerogenic methods of immunisation using dry vaccines. These novel preparations, unlike any used in the West, were administered via aerosol. The results of this research were summarised by N.I. Aleksandrov and N. Gefen (1) and then by V.A. Lebedinsky (6). As one of the advantages of this approach, Aleksandrov and Gefen emphasised the possibility of administering the vaccine to soldiers under field conditions – in tents and even in the open air. The other advantage of this dry aerosol preparation was its ability to confer a degree of pulmonary immunity that could not be achieved with traditional means of immunisation. These dry preparations protected monkeys, sheep and other animals from infection through the respiratory tract. Furthermore, aerogenic vaccination is much less reactogenic than other forms of administration and causes very few side-effects – the principal author of the present article was exposed to the aerogenic vaccination against plague without any complications.

These studies by Aleksandrov and Gefen and by Lebedinsky are of interest even today, not only from the scientific point of view but also because they provide substantial evidence that aerogenic methods of infecting people and animals have been part of the Soviet military doctrine for at least the past fifty years. Further information about certain aspects of the military's work on aerosol infections can be found in the monograph by V.I. Ogarkov and K.G. Gapochko (11), which by pure accident became available for open sale.

Though this list is by no means exhaustive, it gives a general idea of the technologies and prophylactics developed by the military that were then transferred to the Ministry of Health.

Biopreparat

As the authors related in an earlier publication (4), the designers of the modern (post-1973) Soviet BWs system established Biopreparat in order to raise the design and production of BWs to a qualitatively new level by using the latest advances in molecular biology and genetics. At first, military scientists focused on developing strains of bacteria that would be both resistant to antibiotics and have altered antigenic structures. Scientists believed that such approaches would complicate the treatment of infected people or even render treatment impossible and reduce the efficiency of vaccination. Viruses, too, were to be modified: military virologists worked to create viruses with altered antigenic structures as well as recombinant viruses that would possess other unusual properties.

At first, Biopreparat scientists had to organise the manufacture of materials that were unavailable in the

USSR: reagents, enzymes and components of media for bacterial and viral cultivation. They also needed to create banks of cellular cultures and bacteria. The Institute of Enzymology in Vilnius, Lithuania, and special directorates in the Institute for Ultra-pure Preparations in Leningrad (now St Petersburg), the State Scientific Centre of Applied Microbiology (SSCAM) at Obolensk, two hours from Moscow, and the State Research Centre of Virology and Biotechnology ('Vector'), near Novosibirsk, Siberia, were created for these purposes. As a result, in the late 1970s many scarce reagents and a number of important enzymes became easily accessible to open scientific institutes in the country.

Similarly, although the development and manufacture of devices and instruments used in biomedical research was spurred on by the needs of the BWs facilities of Biopreparat and of the MoD, autoclaves, instruments for lyophilisation, reactors, chromatographs, samplers and so forth were also delivered to the open research institutes. All of this design and manufacture – for both BWs facilities and open institutes – was carried out by the research and design institutes in Moscow and by factories in Yoshkar Ola, Kirishi, Berdsk and Penza.

During the construction phase of Biopreparat's own scientific centres, Biopreparat carried out joint research projects in different areas of biology with open scientific research institutes and universities. Biopreparat provided financial assistance and supplied the institutes with imported equipment and reagents. Furthermore, Biopreparat trained research fellows at the Antiplague System in microbiology. In three of the antiplague institutes Biopreparat also created departments of molecular genetics, which worked under the cover of Problem Number Five. The results of some research from that period were published in the open press and reported at conferences on the Plasmid Programme, which was also financed by Biopreparat. The Plasmid Programme served as yet another cover story: officially, the Plasmid Programme was created by the open Council for Molecular Biology and Genetics at the Academy of Science. The programme existed for 14 years and helped to introduce modern biology to the young employees of many institutes. Besides this programme, the principal author of the present article organised the Laboratory of Extrachromosomal Heredity of Microbes, the first in the USSR. The laboratory, which was well equipped, closely connected to scientists in the outside world and located at the Moscow Research Institute for Protein Synthesis (an open institute), was completely financed by Biopreparat. These international connections allowed the development and organisation of a bacterial culture collection, which was necessary for genetic research. Furthermore, the laboratory carried out, on a contract basis, joint research projects with open institutes in Krasnodar, Saratov, and Tartu in Estonia.

The discovery that the plague microbe had plasmids, or rings of extrachromosomal DNA, was particularly significant both for the military and for the wider scientific world. This discovery was made at the Laboratory of Extrachromosomal Heredity of Microbes, during research carried out jointly with the military. This laboratory dealt only with vaccine strains – work with highly pathogenic microbes was forbidden in Moscow and other major cities – while parallel research was carried out with virulent strains in the Kirov Institute. The same open Moscow laboratory also developed methods of transferring foreign genetic information into *Y. pestis*. This discovery allowed the subsequent creation, at the Kirov Institute, of a virulent *Y. pestis* strain with the particular characteristics, including antibiotic resistance, necessary for the development of a new, more refined, kind of BW.

The discovery of plague plasmids, which enabled the study of the plague germ's pathogenicity and the development of a more effective plague weapon, was made several years before the publication of the same discovery in the West.

Collaboration between military and open laboratories also produced work with public health benefits, even at the heart of the secret BWs system. At the Biopreparat facility SSCAM, researchers explored the creation of biological means of protecting plants against plant pests as well as against the insect vectors of human and animal diseases. The basis for these explorations was the microbe *Bacillus thuringiensis*, whose cells contain a toxin ('delta endotoxin'). Commonly known as 'Bt', *B. thuringiensis* is an insecticidal bacterium marketed worldwide for the control of many important plant pests, principally Colorado beetle and Lepidoptera (butterflies and moths) caterpillars but also mosquito larvae. *Bacillus thuringiensis* products represent about 1% of the total agrochemical market – fungicides, herbicides and insecticides – across the world. Commercial Bt products consist of powders containing a mixture of dried spores and toxin crystals.

Factories in Berdsk (near Novosibirsk) and Stepnogorsk (in Kazakhstan) manufactured Bt preparations. The Stepnogorsk facility had been built to produce BWs, particularly the anthrax agent, *B. anthracis*. Nevertheless, the manufacture of Bt products also served the interests of Biopreparat. First, it provided a cover story for the large-scale cultivation of *B. anthracis*. Second, it enabled technology to be modernised and new equipment to be tested using an agent that would not subject factory personnel to the risk of infection, because Bt products are harmless to humans. The second factor was extremely important. Despite stringent safety precautions, the risk of infection and possible epidemic outbreaks from working with the causative agents of dangerous infections remains. In addition to the sensational and tragic events in Sverdlovsk in 1979, when an accidental release of *B. anthracis* spores killed at least 68 people (8), there were

other less well-known incidents, illustrating the lethal dangers of working with highly pathogenic agents. Manufacturing failures resulted in several laboratory workers becoming infected with *Brucella abortus* in one of the open Moscow institutes in the 1970s, and a number of laboratory researchers at Vector died from haemorrhagic fevers – Marburg in 1988 and Ebola in 2004. Experimental work with *Burkholderia mallei* killed a researcher at SSCAM in 2004.

Some, although not all, of the molecular biology and genetic research by Biopreparat scientists became public knowledge – and therefore available to open scientific research laboratories – after the break-up of the USSR. Attention was focused on studies of *Francisella tularensis*, a bacterium whose genetics were little known in open academic circles at that time. As a result of Biopreparat research into tularaemia, a means of transferring heterologous genetic information into *F. tularensis* had been developed. Adding novel and alien genetic material to *F. tularensis* was necessary to create altered strains and, less ominously, to elucidate its pathogenicity. Also of singular importance is the extensive research conducted at Obolensk on *B. anthracis*. Some years ago Andrei Pomerantsev, one of the principal anthrax researchers at SSCAM, developed a method for introducing haemolytic genes from *Bacillus cereus* into *B. anthracis* (12) – this experiment had real significance for BWs research because, theoretically, the addition of heterologous genes to *B. anthracis* could make its strains more virulent. Furthermore, such a trait in a pathogenic *B. anthracis* strain would prevent its ready identification: virtually all diagnostic laboratories look for non-haemolytic *B. anthracis* and would discard a haemolytic colony as just another bacillus, thus delaying the strain's identification. While it is hard to see a public benefit from this research, it is worth noting that the research at Obolensk on anthrax has facilitated the development of a new vaccine to replace the STI live vaccine currently used in Russia. Andrei Pomerantsev now works in the United States of America at the National Institute of Allergy and Infectious Diseases.

As far back as the 1980s, the former Soviet BWs programme created a demand for recombinant organisms, specifically *Y. pestis* and species of *Francisella* and *Brucella*, that were engineered to express mammalian beta-endorphin, a form of neuropeptide. Three of Biopreparat's institutes took part in this work. Beta-endorphin was synthesised at the Leningrad Institute for Ultra-Pure Preparations; the chemical synthesis of the gene that produces beta-endorphin was carried out at Vector, and the actual introduction of the gene into the bacteria, followed by experiments on live animals using those recombinant bacteria, was performed at SSCAM. This chain of research and experiments proved that mammalian genes can be expressed even in highly pathogenic bacteria (3).

This research was critically important for the so-called 'Problem Factor', a programme first proposed to Biopreparat by Major General Igor Ashmarin in the late 1970s. He had the idea that germs expressing neuropeptides might be used to disable people, rather like biochemical agents such as tear gas, 'intoxicant' or other 'inoffensive' gases are supposed to do, without causing death. It was a highly original idea, whose realisation – at least in Ashmarin's original conception – could have produced a more 'humane' weapon than one using deadly disease agents by themselves. Furthermore, this research opened the way for the inexpensive production of neuropeptides in large quantities, using bacteria as 'biochemical pumps'.

If we attempt to estimate the contribution of Biopreparat to the Russian national economy, we must especially note that it created a modern scientific and technological infrastructure for continued research in the life sciences, which simply did not exist before Biopreparat was established. Despite drastic changes in the Russian economy, a drain in manpower, particularly at the highest levels of scientific expertise, and the general decline of governmental support for advanced molecular and genetic research, this scientific and technological base has survived and continues to function. The most salient example of this survival is the transformation of Vector, which still includes seven scientific research institutes, four affiliated enterprises and a number of other separate structural divisions, and which figures prominently in joint public health research projects with American scientists.

The Special Directorate of the Ministry of Agriculture of the Union of Soviet Socialist Republics

The Special Directorate of the Ministry of Agriculture of the USSR had a fine scientific and industrial base. It included at least three veterinary institutes (Vladimir City, Pokrov in Vladimir Oblast and Otar in Kazakhstan) as well as the Institute of Phytopathology, based in Galitsino near Moscow with branches in Uzbekistan and the Far East.

At Pokrov researchers studied African swine fever and rinderpest, which is caused by a virus belonging to the *Morbillivirus* genus; at Vladimir City scientists investigated foot and mouth disease (FMD), and researchers at Otar worked on African horse sickness. In the area of phytopathology, the Special Directorate studied, for example, plant diseases caused by fungi, including rice blast (which is caused by *Pyricularia oryzae*), yellow rust, leaf rust and potato late blight (which are caused by various *Phytophthora* species).

The principal efforts of the Directorate were devoted to developing genetically enhanced bioagents and BWs

technology directed against crops and domestic animals. But, so far as we know, Directorate scientists never achieved much in this arena. It is doubtful whether this Special Directorate contributed much to the national economy at the time. But the Special Directorate left a legacy of sound scientific and technical research, much as Biopreparat has done. Science-based agriculture – far removed from the disastrous agricultural policies of Trofim Lysenko – was vital for the rise of sophisticated animal husbandry and agriculture in Russia.

The Antiplague System

The venerable Antiplague System, which dates from before the Russian Revolution, cannot truly be considered as a branch of the Military–biological complex. Nevertheless, for many years their research institutes were involved tangentially in the activities of the military–biological complex, mainly through Problem Number Five – a code-name for biodefence activities focusing on the prevention, treatment and urgent prophylaxis of dangerous infections. Antiplague researchers also worked to develop rapid diagnostic methods and new approaches to the development of vaccines, including 'chemical vaccines' – using only isolated antigens – as well as new live vaccine strains for plague and other diseases. The disease treatment protocols were approved by the Ministry of Health and then employed by the MoD and Biopreparat, which also obtained various diagnostic tests from the Antiplague institutes. These institutes also manufactured large quantities of the live plague vaccine EV, which was stored mainly for civil defence.

One of the significant achievements of the Antiplague System researchers in the field of immunology was the creation of a novel 'chemical' plague vaccine. This new 'chemical' vaccine consisted of two antigens, one isolated from *Y. pestis* and one from the related but less virulent *Y. pseudotuberculosis*. This new vaccine is especially effective for revaccination after an initial injection of the live EV vaccine. The chemical vaccine represents an advance over the original live strain because it is less reactogenic and thus less potentially dangerous.

Antiplague System researchers also developed techniques for introducing resistance to the most widely employed antibiotics into the live EV strain. This altered strain was used to develop a dry vaccine to be administered simultaneously with the antibiotics; in this way, someone being treated for plague exposure could be vaccinated with a live strain at the same time as receiving antibiotics to treat an incubating infection. Though these techniques have clear public health significance, they also held great interest for the MoD and Biopreparat: adding antibiotic resistance to a vaccine strain proved that resistance could be added to virulent strains – one of the goals of the Soviet BWs programme.

The Antiplague System also played a major role in the professional training of personnel for the MoD and Biopreparat.

What now?

The enormous scale of BW-related activities in the USSR raises an important question: what happened to the military–biological complex after the country's disintegration and President Boris Yeltsin's decree of 11 April 1992?

The MoD lost its testing area on Vozrozhdenie Island in the Aral Sea and was radically restructured. According to General Yevstigneev, the 15th Directorate (in 1992 it became known as the MoD Biological Defence Department) focused on 'ensuring the country's biological security', which he interpreted as 'protection of people, farm animals and plants, and the environment from dangers that were or are caused by a source of a biological–social emergency' (15). However, P.I. Melnichenko (7), the MoD's Chief Epidemiologist, stressed that 'at present neither the public nor the government is fully prepared to adequately respond to the threat of bioterrorism in Russia or to take timely and effective steps to mitigate its consequences'. Coming from such a source, this statement can be taken at face value despite the implicit irony: according to the government's official pronouncements, the military have always concentrated on developing defences against BWs, and prevention has always been at the heart of all public health measures.

Today's Biopreparat is officially a public corporation. It has been deprived of its major research and production base in Stepnogorsk (now in Kazakhstan) and the institutes directly involved in the development of BWs (SSCAM and Vector are now under the Ministry of Health).

It is important to note that retired General Yevstigneev has become the first deputy of Biopreparat's current Director General, perhaps because Biopreparat is on the list of institutions allowed 'to carry out independent expert examination of goods and technologies for the purposes of export control'; this includes binary (or dual-use) products – in other words, those suited for both military and peaceful purposes (13). The authors are unable to explain why Biopreparat is allowed to do this, since the research centres formerly owned by Biopreparat are now directly controlled by the State Health Inspectorate (one of the departments of the Russian Ministry of Health). A strange situation!

The alliance of the Antiplague System and the MoD is also worthy of note. It may have been caused by the need to pool their efforts in the fight against terrorism. Be that as it

may, the Antiplague System is much more closed, in particular to foreigners, than in the past.

As far as the authors are aware, the Special Directorate of the Ministry of Agriculture of the USSR was liquidated and its facilities are now used for civilian purposes. For example, the Federal Centre of Animal Health Protection – descended from the Institute for FMD at Vladimir – pursues multi-faceted research and is also engaged in the manufacture of many biological products for the prophylaxis and treatment of diseases in animals. The Centre also produces medical products for the treatment of human diseases.

In conclusion, it should be noted that living standards in Russia remain low, and the overwhelming majority of scientists have a miserable existence. In general, this is also true of scientists who work for military facilities and those who receive direct grant support from ISTC, the USA or other funding body for research at former Biopreparat institutes. This contributes to a Russian brain drain, to the possible export of BWs from Russia (if any remain in storage) and to the concern over the potential leaking of expertise, technologies and materials from the former Soviet BWs programme. It is therefore appropriate to mention the 1998 accounts of a very small group of researchers, mainly from academic institutes, but not from Biopreparat, who went to Iran to teach genetics and molecular biology (9). The authors also remind the reader of a public suggestion by N. Kislichkin, formerly of Obolensk, to sell the Soviet 'weaponised' strains of *F. tularensis* (2).

■

Résultats du programme soviétique en matière d'armes biologiques et conséquences pour l'avenir

I.V. Domaradskij & W. Orent

Résumé

Le complexe militaro-biologique de l'ex-Union des Républiques socialistes soviétiques était un véritable monstre de Frankenstein, doté d'un puissant potentiel scientifique – au service du bien et du mal. Le présent article examine d'une part les résultats scientifiques directs des programmes jumelés en matière d'armes biologiques gérés par le Biopreparat « civil » et par le ministère de la Défense et, d'autre part, les bienfaits pour la santé publique qui ont découlé de ces programmes, en dépit de leur visée originale. Les auteurs explorent également les possibilités de destruction des cultures et des élevages et d'amélioration des méthodes agricoles qui résultent du programme soviétique parallèle exécuté sous la conduite de la Direction spéciale du ministère de l'Agriculture.

Dans la dernière section de l'article, les auteurs examinent la situation au sein du complexe militaro-biologique à la suite du décret de 1992 de l'ex-Président Boris Yeltsin abolissant la recherche et le développement en matière d'armes biologiques offensives. Ils envisagent la possibilité d'une fuite hors de Russie de l'expertise, des technologies et du matériel issus de l'ancien programme soviétique relatif aux armes biologiques, fuite qui s'expliquerait par le niveau de vie qui reste faible en Russie et par l'existence misérable de l'écrasante majorité des chercheurs.

Mots-clés

15e Direction – Biopreparat – Centre scientifique d'État de microbiologie appliquée – Complexe militaro-biologique – Ministère de l'Agriculture – Ministère de la Défense – Système de lutte contre les fléaux – Vecteur.

■

Éxitos del programa soviético de armas biológicas y consecuencias de cara al futuro

I.V. Domaradskij & W. Orent

Resumen

El complejo militar-biológico de la ex Unión de Repúblicas Socialistas Soviéticas era un verdadero monstruo de Frankenstein, dotado de un enorme potencial científico, para bien y para mal. Los autores examinan los resultados científicos directos de los programas gemelos de armas biológicas, dirigidos por la entidad 'civil' Biopreparat y por el Ministerio de Defensa, así como los beneficios que de ellos se siguieron para la salud pública pese a sus objetivos originales. También estudian las posibilidades de destrucción de cultivos y ganado y de mejora de los métodos agrícolas que podían derivarse del programa soviético paralelo que estaba a cargo de una dirección especial del Ministerio de Agricultura.

En el último capítulo los autores exponen la situación en que quedó el complejo militar-biológico después del decreto promulgado en 1992 por el Presidente Boris Yeltsin por el que se abolían todas las actividades de investigación y desarrollo de armas biológicas ofensivas. Después consideran la posibilidad de que los expertos, la tecnología o determinado material del programa soviético de armas biológicas hayan salido de Rusia, dado el bajo nivel de vida que sigue imperando en el país y la misérrima existencia a la que se ven abocados los científicos.

Palabras clave

15ª Dirección – Biopreparat – Centro Científico Estatal de Microbiología Aplicada – Complejo militar-biológico – Ministerio de Agricultura – Ministerio de Defensa – Sistema antiplagas – Vector.

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International organisations and their role in helping to protect the worldwide community against natural and intentional biological disasters

B. Vallat, J. Pinto & A. Schudel

World Organisation for Animal Health (OIE), 12 rue de Prony, 75017 Paris

Summary

Preventing the spread of disease through international movements is one of the key objectives of the World Organisation for Animal Health (OIE). One of the ways it seeks to achieve this is by publishing international standards and guidelines aimed at, *inter alia*, preventing the importation of pathogens that are dangerous for animals and humans and strengthening Veterinary Services so that they can improve their surveillance and response systems. The OIE works in close partnership with the Food and Agriculture Organization of the United Nations (FAO), and together the two organisations have developed a joint initiative – the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs). Member Countries of these organisations could increase their capacity to manage the risks of disease occurrences, whether natural or deliberately introduced, if they would all strictly implement existing OIE international standards. Compliance with these standards greatly depends on the political willingness of national policy-makers and on a successful transfer of resources to developing countries in support of good governance and appropriate policy implementation. A United Nations Resolution obliging its Member Countries to implement OIE standards could prove invaluable in this respect.

Keywords

Agreement on the Application of Sanitary and Phytosanitary Measures – Food and Agriculture Organization of the United Nations – Global Framework for the Progressive Control of Transboundary Animal Diseases – International standard – Surveillance – Transparency – Veterinary Services – World Organisation for Animal Health.

Introduction

Preventing the spread of animal diseases and zoonoses through international movements is one of the key objectives of both the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO). The OIE seeks to accomplish this by establishing international standards and guidelines aimed at preventing the importation of pathogens that are dangerous for animals and humans (while avoiding unjustified sanitary barriers) and through the surveillance, notification and control of diseases.

The OIE was founded in 1924, well before the creation of the United Nations. Initially, 28 countries united with a mandate to share information on animal disease outbreaks to allow Member Countries to take the appropriate control measures to protect themselves and to prevent further spread of the disease. There are now 167 OIE Member Countries. Providing a mechanism for prompt reporting of

disease outbreaks/occurrences is still one of the primary roles of the OIE, but the organisation is also recognised as the international standard-setting agency in the area of animal health. OIE standards include:

– procedures for surveillance and prompt reporting of outbreaks of animal diseases and zoonoses

– requirements to be met by Veterinary Services for surveillance, notification, early warning and response, and the chain of command

– requirements that should be met for a country or zone to be defined as free from certain infectious animal diseases and zoonoses

– recommendations for the safe importation of animals, animal products, semen, and embryos

– procedures for the inactivation of infectious agents

– the general provisions that countries should meet to reduce the risk of the spread of infectious animal diseases and zoonoses, including standards on the quality of national Veterinary Services.

These standards are included in various OIE publications, such as the *Terrestrial Animal Health Code (Terrestrial Code)*, the *Aquatic Animal Health Code (Aquatic Code)*, the *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals (Terrestrial Manual* [3]) and the *Manual of Diagnostic Tests for Aquatic Animals* (the *Aquatic Manual* [2]), the contents of which will be described in more detail later.

The FAO is one of the largest of the specialised United Nations Agencies, the mission of which is to develop agriculture, animal production, fisheries and forestry. In the field of animal production, the FAO Animal Health Service focuses its activities on assisting developing country members to control infectious and parasitic diseases, and to prevent their spread to other countries or regions. Livestock are important in supporting the livelihoods of poor livestock keepers, consumers, traders, and labourers throughout the developing world. Diseases affecting livestock can have a significant impact on animal productivity and production, on trade in live animals, meat and other animal products, on human health (through diseases transmissible from animals to humans), and, consequently, on the overall process of economic development. The activities of the FAO Animal Health Service include the provision of relevant and up-to-date information on:

– selected animal and zoonotic diseases

– the means of, and basic requirements for, the control and management of major animal diseases

– the increasingly important area of safeguarding humans from diseases originating from livestock and/or transmitted through the consumption of animal products.

More recently, the OIE and FAO have been strongly committed to convincing national policy-makers and international donors that the cost of strengthening Veterinary Services so that they can provide better surveillance, early warning systems and management of epizootics, including zoonoses, is negligible compared with the economic losses resulting from the accidental or intentional introduction of infectious animal diseases and zoonoses.

This paper briefly describes the shared objectives of the two organisations before discussing the systems they have in place to achieve these aims and providing details of the standard-setting work of the OIE.

Common objectives of the OIE and the FAO

The OIE and FAO have certain key objectives in their work for the prevention and control of infectious animal diseases and zoonoses; these main areas of activity are discussed below.

Transparency in the animal disease situation worldwide

Each OIE Member Country is committed to providing reports to the OIE Animal Health Information Department on its health status regarding significant animal diseases and diseases transmissible to humans; the OIE then disseminates the information to all Member Countries to enable them to take appropriate action and to protect themselves. The FAO stipulates that notification to the OIE is obligatory and provides tools for data capture and reporting. Non-member countries are encouraged to report.

Collection, analysis and dissemination of veterinary scientific information

Using the FAO network and its own network of internationally recognised scientists, Collaborating Centres and Reference Laboratories, the OIE collects, analyses and publishes the latest scientific information on the control and prevention of important animal diseases, including those transmissible to humans. The FAO serves as a source of expert advice to OIE groups and committees.

Strengthening of international coordination and cooperation in the control of animal diseases

The FAO implements and/or contributes to the implementation of country or regional projects and

programmes to prevent and control animal diseases by strengthening capacities and emergency preparedness for disease detection, analysis, and reaction. With OIE support, the FAO provides technical expertise to Member Countries (particularly developing countries) requesting assistance with animal disease control and eradication programmes. These activities are performed in coordination with other regional and international organisations, donor countries, and agencies responsible for supporting and funding the control of infectious animal diseases and zoonoses.

World trade in animals and animal products: protecting animal and human health while avoiding unjustified sanitary barriers

The OIE develops standards for use by its Member Countries to enable them to protect themselves against disease incursions as a result of trade in animals and animal products, while avoiding unjustified sanitary barriers. These standards are developed by experts from the Member Countries and from the OIE network of 170 Collaborating Centres and Reference Laboratories and in collaboration with FAO and FAO/IAEA (International Atomic Energy Agency) Joint Division experts.

In 1995 the standards developed by the OIE were recognised by the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) of the World Trade Organization (WTO). In order to harmonise SPS measures and remove unjustifiable sanitary restrictions to international trade, the Agreement states that Governments should use these international standards, guidelines and recommendations. Its goal is to minimise the risk of importing pathogens and to remove unjustified restrictions to international trade. The Agreement states that while it is the sovereign right of a country to provide an appropriate level of animal and public health protection at its borders, this right is not to be misused for protectionist purposes. An importing country can only apply sanitary measures to imports if a similar level of protection is applied internally and to all imports. Members Countries may introduce standards providing a higher level of protection than that provided by the OIE standards if there is a scientific justification, but these standards must be based on science-based risk analysis.

The FAO is in charge of assisting its Member Countries, particularly the developing countries, to implement international animal health standards. It has undertaken several studies on the cost of complying with the standards established by world bodies and has developed mid- and long-term policy options that countries can use to implement such standards. Moreover, the FAO is committed to developing a systems approach, through national capacity building and performance indicators, to assist countries to attain compliance and improve trade opportunities.

Towards greater transparency in the animal health situation worldwide

The OIE is the worldwide observatory for animal health. It is supported in this mandate by the FAO. Its key mission is to keep national Veterinary Services and international organisations informed of the appearance and course of epizootics in any country in the world that represent a threat to animal or public health (zoonoses). The system is based on official animal disease information reports that the Veterinary Services of Member Countries have an obligation to submit to the OIE. The use of standard reporting forms ensures that the system is fed with the required data in a standardised format. The strength of the OIE Animal Disease Information System is its 'legal' basis as defined in Chapters 1.1.2 and 1.1.3 of the OIE *Terrestrial Code* and in Chapters 1.1.3 and 1.2.1 of the OIE *Aquatic Code* (6, 7).

The OIE Animal Health Information System has procedures for gathering weekly, annual and biannual animal health data from around the world (the International Monitoring System) and procedures for collecting more urgent information (the International Early Warning System). The International Early Warning System consists of an alert procedure to warn of exceptional epidemiological events (natural or intentional) occurring in Member Countries. Information is aimed at decision-makers and other stakeholders to enable them to take necessary preventive measures. Under this system, the occurrence of a disease, including zoonoses, or any exceptional epidemiological event must be reported as soon as possible (within 24 hours) to the OIE Central Bureau, which then quickly redistributes the information through a variety of channels. Follow-up reports are provided weekly to allow end-users to follow the epidemiological situation as it develops.

To improve the transparency of animal health information, the OIE is also working with the FAO to develop a verification procedure for non-official information from various sources on the existence of disease outbreaks that have not yet been officially notified to the OIE. These processes use different sources of information such as diagnostic results from OIE or FAO Reference Laboratories, scientific papers, field projects, newspapers, the internet, Global Public Health Intelligence (GPHIN), and ProMed.

In addition, in order to improve the control of highly contagious diseases, the FAO and OIE have recently developed a new initiative: the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs), which is based on a regional approach to animal disease control. The GF-TADs will improve both the quality and quantity of disease information and epidemiological intelligence. An integral aspect of the GF-TADs programme is the Global Early Warning System (GLEWS), which is due to be developed jointly by the FAO, the OIE and the World Health Organization (WHO) as an instrument to assist stakeholders and the international community to predict and prevent livestock animal disease threats through epidemiological analysis and the integration of additional factors that may have an impact on the occurrence and spread of such diseases (e.g. economic factors, civil unrest, climatic changes). The success of this initiative will rely heavily on the sharing of information on animal health and zoonoses in humans among the three organisations. Results of disease information tracking systems will be shared and compared for verification purposes. Through its own Animal Disease Information System the OIE will verify information with the Government representatives of the various Member Countries, thus significantly improving the quality of official information. Similarly, the FAO, through projects and activities in its Member Countries, will also verify the reliability of information and work towards improving transparency. The WHO will also share information gathered by its Global Alert and Response Team and other parties working in the area of zoonotic diseases and veterinary public health.

The expected activities of the GLEWS can be summarised as follows:

– use of designated OIE/FAO Collaborating Centres/Reference Laboratories for specific analysis and modelling trends;

– dissemination of information that complements the OIE Information System;

– dissemination of early warning messages that concentrate on predicting livestock animal disease threats through epidemiological analysis and the integration of additional factors that may have an impact on the occurrence and spread of such diseases;

– design of control strategies;

– development of coordinated responses to animal health and zoonotic emergencies. If consultation among the OIE and FAO shows that an onsite assessment of the situation would be valuable, an urgent field mission may be considered, in consultation with the WHO when relevant. This joint mission would engage the country authorities, especially those of the Ministries of Health and of Agriculture, to obtain a better appreciation of the situation and offer assistance in the formulation of urgent intervention strategies. The joint mission experts would be responsible for briefing supervisors and suggesting a course of action.

While every effort is being made to improve the OIE Animal Health Information System, the major difficulty encountered, as with any international activity, is the quality of the information received, especially information from countries where the Veterinary Services do not comply with OIE standards and do not have adequate resources (e.g. lack of trained veterinarians and epidemiologists, poor equipment and laboratory facilities, inadequate involvement of farmers and other stakeholders in national surveillance systems, and absence of disease control programmes and emergency preparedness plans). In such countries, potentially dangerous situations might go unnoticed or not be dealt with promptly, thereby increasing the risk of disease spreading to other countries.

The OIE has a limited source of emergency funds for use in rapidly assisting Member Countries faced with exceptional epidemiological situations. Typically, these funds are used to immediately send experts from OIE Reference Laboratories or Collaborating Centres to assess the epidemiological situation in the field, and advise national authorities and other international organisations.

The FAO has a well-defined mandate to provide assistance to countries in the field of animal health. One of the key tools it uses to achieve this is its Emergency Prevention System-Livestock (EMPRES-Livestock) programme, which became fully operational in 1994. This system promotes the containment and control of the most serious epizootic diseases of livestock (transboundary animal diseases – TADs), and their progressive elimination on a regional and ultimately a global basis, through international cooperation, involving early warning, early reaction, research, and coordination. EMPRES capitalises on the information provided by the Global Livestock Production and Health Atlas (GLiPHA: www.fao.org/ag/againfo/resources/en/glipha/default.html), which depicts animal population densities, production systems, soil use, and other quantitative information that aids in disease intelligence, ecological understanding, and the development of intervention measures. The EMPRES-Livestock programme focuses on the major epizootic diseases – rinderpest, avian influenza, contagious bovine pleuropneumonia, foot and mouth disease, peste des petits ruminants, Rift Valley fever, Newcastle disease, lumpy skin disease, classical swine fever, and African swine fever. Early warning messages with trend analyses and the potential implications of the disease are posted on the web and distributed via the EMPRES-Livestock mailing list. EMPRES provides training assistance to national epidemiologists and advises on the development of surveillance programmes in the least developed countries.

In the event of a disease emergency and at the request of an FAO Member Country EMPRES can intervene to assist in combating diseases through the FAO's Technical Cooperation Division. Currently, technical cooperation projects (TCPs) are ongoing in over 40 countries, some with regional approaches to disease surveillance and control. While efforts are being made to build capacities in some least-advanced countries, what has been achieved so far has to be further strengthened to better respond to the real needs of many countries, e.g. the need for assistance in improving their national surveillance and monitoring systems and in bringing their contingency plans up to an acceptable level. Furthermore, the available resources must be dramatically increased for tackling emergency situations and to avoid the spread of TADs to other countries.

The warning system operated by the OIE Central Bureau allows Member Countries to react rapidly if the need arises. Member Countries must report any of the following incidents to the OIE Central Bureau within 24 hours:

– the first outbreak of an OIE listed disease

– the re-occurrence of a listed disease following a report declaring that the outbreak has ended

– the first occurrence of a new strain of a pathogen

– the sudden and unexpected increase in the distribution, incidence, morbidity or mortality of a disease prevalent within the country

– an emerging disease with significant morbidity and mortality or zoonotic potential

– evidence of change in the epidemiology of a listed disease (including host range, pathogenicity, strain).

This information is immediately relayed to the other Member Countries as follows:

– by fax or e-mail to countries directly threatened

– through the weekly publication *Disease Information*, available on the OIE website or by mail using the OIE distribution list.

Subsequent to any of the above notifications, Member Countries should send weekly reports by fax or e-mail to provide further information on the evolution of the incident that justified urgent notification.

The FAO obtains additional information from its networks: extensive field activities, Reference Laboratories, rumour-tracking (e.g. GPHIN, ProMed). This information and the resulting analyses are communicated to Member Countries and the OIE either directly or through various channels (FAO-AGA website, EMPRES Bulletin, etc.). As previously mentioned in the above discussion of the GLEWS, a cooperative approach to the information systems is currently being developed between the OIE, FAO and WHO.

These warning systems will provide an improved worldwide surveillance network for the early detection and rapid reporting of any suspicious disease occurrence that is natural or could have its origin in an act of agroterrorism/bioterrorism, i.e. an intentional introduction of pathogens.

Through the International Early Warning System all OIE Member Countries receive alert messages on disease outbreaks, or suspicion thereof, via fax or e-mail. In addition, the OIE annual publication entitled *World Animal Health* provides a wide variety of information on the animal health situation worldwide and reports on the disease control methods Member Countries apply. A selection of all this information is integrated into the World Animal Health Information Database (WAHID) – a regularly updated computerised database available on the OIE website (www.oie.int).

Scientific information is disseminated through other publications, including the OIE *Scientific and Technical Review* (and similar FAO publications), which contains research articles and guidelines of the very highest standard for animal disease control. The FAO also publishes manuals on specific disease recognition, guides on contingency planning, participatory approaches to epidemiology, and booklets on sample collection and submission.

By collecting, processing and disseminating data on animal diseases throughout the world, the OIE and FAO endeavour to ensure transparency in the animal health situation worldwide for the benefit of its Member Countries. The information thus generated is essential for the success of national and regional disease control programmes, for reducing the health risks arising from international movements, and for the early detection of disease attributable to the escape or deliberate introduction of pathogens from acts of bioterrorism.

Towards improved health safeguards in international trade

The smooth flow of animals and animal products requires:

– the development and adoption by the international community of animal health standards aimed at avoiding the risk of importing and spreading diseases and pathogens transmissible to animals and humans

– the harmonisation, strict implementation, and greater transparency of national animal health regulations applicable to trade in animals and their products so as to avoid unjustified sanitary barriers.

OIE Standards

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures advocates the use of standards developed under the auspices of the OIE. Various normative works, approved by the OIE International Committee (the OIE's highest authority; every Member Country is represented), are designed to promote the harmonisation of regulations applicable to trade and animal disease control, these are:

– the *Terrestrial Code*

– the *Aquatic Code*

– the *Terrestrial Manual*

– the *Aquatic Manual*.

The *Terrestrial Code* for mammals, birds and bees is developed by the Terrestrial Animal Health Standards Commission, and the *Aquatic Code* is developed by the Aquatic Animal Health Standards Commission (see section entitled Specialist Commissions). The *Codes* contain the requirements for the international movement of animals and animal products and also provide guidelines for disease reporting (see chapters 1.1.2 and 1.1.3 of the *Terrestrial Code* and chapters 1.1.3 and 1.2.1 of the *Aquatic Code* [6, 7]). Both these publications are updated annually and are available in paper and electronic versions (www.oie.int).

The *Terrestrial Manual*, developed by the Biological Standards Commission, and the *Aquatic Manual*, developed by the Aquatic Animal Health Standards Commission, presents standard methods for diagnostic tests and vaccine production to be applied notably in the context of international trade and national animal disease control programmes. Both texts constitute the reference standards for the international harmonisation of the diagnosis of animal diseases and vaccine control; they also contain specific chapters on the following topics:

– sampling methods

– the packaging and transport of samples

– quality management and the biosecurity of veterinary laboratories

– tests for sterility and freedom from contaminants

– human safety in the veterinary microbiology laboratory

– veterinary vaccine production

– disinfection and inactivation procedures

– laboratory methodologies for bacterial antimicrobial susceptibility testing.

In addition to the standards that appear in the *Manuals* the OIE publication *Quality Standard and Guidelines for Veterinary Laboratories: Infectious Diseases* (1) describes standards for the management and biosecurity of laboratories conducting tests for infectious diseases. It contains technical requirements for these laboratories and includes specific details with respect to test method validation, reference reagents, and laboratory proficiency testing.

The FAO plays a prominent role in providing expertise to the OIE and assisting countries to meet OIE standards through various activities such as national expert capacity building, field projects, and the transfer of technologies and expertise.

OIE activities

As well as publishing standards and disseminating disease information reported by Member Countries, the OIE now takes a proactive approach to disease reporting and will also report information on confirmed positive results provided by OIE Reference Laboratories (4) or from unofficial sources, such as scientific publications, ProMed and lay publications, after the information has been verified by the Member Country.

In addition to reporting disease occurrence the OIE, through the work of the Scientific Commission for Animal Diseases, develops and updates lists of countries recognised as being free from some serious diseases, most notably foot and mouth disease, bovine spongiform encephalopathy, rinderpest and contagious bovine pleuropneumonia. These lists make a substantial contribution to the health security of international movements.

Towards objective and impartial expertise in animal health

The International Agreement of 25 January 1924 establishing the OIE made it responsible for promoting and co-ordinating research on the surveillance and control of animal diseases throughout the world. This objective has been attained by the creation of a worldwide animal health network, involving the establishment of Specialist Commissions and Working Groups, the designation of Collaborating Centres and Reference Laboratories, the

organisation of meetings of experts and the continuing publication of scientific articles.

Specialist Commissions

The four Specialist Commissions study problems of animal disease surveillance and control and questions relating to the harmonisation of international regulations. Members are elected by the representatives of all OIE Member Countries (the International Committee).

The Terrestrial Animal Health Standards Commission contributes to the development, in collaboration with other Specialist Commissions, of the generic and specific chapters in the *Terrestrial Code*. In addition, it promotes the adoption by the International Committee of standards on animal health (including zoonoses), animal welfare, and animal production food safety. It also promotes harmonised surveillance methods and disease control regulations and proposes guidelines and recommendations concerning the trade or international movement of mammals, birds and bees and their products.

The Scientific Commission for Animal Diseases contributes to the development of better strategies and methods for animal disease surveillance and control. The Commission convenes groups of specialists of the highest standard, particularly in the event of an animal health emergency, to verify or evaluate the status of Member Countries in terms of specific animal diseases.

The Biological Standards Commission harmonises methods for the diagnosis of animal diseases and the control of biological products, especially vaccines used for veterinary purposes. The Commission coordinates a programme to develop standard reagents aimed at standardising diagnosis.

The Aquatic Animal Health Standards Commission collects all available information on disease control methods for fish, molluscs and crustaceans. The Commission harmonises rules governing trade in aquaculture products and recommends the optimum diagnostic methods. It also organises scientific meetings on these topics.

All the standards proposed by the various specialist Commissions must be approved by the International Committee before publication. All the standards, recommendations and guidelines of the OIE relating to animal health, zoonoses and international trade in animals and animal products are recognised by the WTO.

OIE Reference Laboratories and Collaborating Centres

These OIE Reference Laboratories and Collaborating Centres, of which there are 170, covering 92 diseases and topics and located in 31 different countries, provide OIE Member Countries with support and scientific advice on all matters relating to the surveillance and control of animal diseases. This support can take many forms, such as the provision of experts (over 150 world-renowned scientists), the preparation and supply of diagnostic kits or standard reagents, and the organisation of seminars, courses, and scientific meetings.

Working Groups

Three OIE Working Groups are currently active:

– wildlife diseases

– animal welfare

– animal production food safety.

These Working Groups meet to review progress made in their field and to ensure that the information is made available rapidly to all OIE Member Countries. They also contribute to the organisation of scientific meetings, seminars, workshops and training courses.

The OIE Working Group most concerned with biosafety and biosecurity is the Working Group on Wildlife Diseases (WGWD). This Group collects information on wildlife diseases from Member Countries and urges Member Countries to recognise the importance of wild animals as potential reservoirs (and even as possible targets of deliberately introduced biological agents) when planning responses to outbreaks of disease, exotic or otherwise.

The WGWD has determined that relatively few countries have developed plans for responding to any disease incursions that may affect wild animals. In order to assist OIE Member Countries that may wish to undertake such planning, the WGWD will, in the course of the next 3 years, review preparedness and response plans that already may have been prepared. From these plans the Group will identify the essential major components and information requirements for this planning.

National preparedness for the possible incursion of exotic diseases must include both the preparedness of all the relevant public authorities and stakeholders to intervene and the assembly of up-to-date information on the population size, demography and susceptibility of indigenous wild animal species. It should also include the development of feasible procedures for the early recognition and diagnosis of a disease outbreak, the subsequent prevention of disease transmission between wildlife and domestic livestock and the spread of disease within wild animal populations. Effective planning for responses to an exotic disease incursion must accord to wildlife the same degree of attention that is now given

solely to domestic livestock. A national consultative network of wildlife expertise needs to be created and deployed in order to develop a range of techniques that can be used to reduce the risk of transmission of disease from livestock to wildlife (and *vice versa*) in the event of an exotic disease outbreak. These actions will establish the necessary databases, lines of communication and science-based plans to achieve a high level of preparedness to deal with an exotic disease incursion into a national wildlife population.

The OIE Working Group on Animal Production Food Safety, established between the OIE and high level representatives of the Codex Alimentarius Commission, is responsible for hazards to consumers that are likely to occur during animal production (on the farm). This Working Group also covers intentional actions likely to occur on a farm, e.g. the introduction of zoonotic agents.

During the 72nd General Session of the OIE International Committee in 2004, Member Countries recognised that zoonotic diseases are emerging and re-emerging with great frequency. They indicated their overwhelming support for a greater OIE role in confronting the challenges of such zoonoses. They also recognised the need to co-ordinate activities horizontally, among animal and public health officials and organisations, and vertically, through national, State, and local groups. For this purpose a Resolution (Resolution No. XXIX) was adopted during the 72nd General Session which encouraged further consideration of the OIE's thinking and commitment regarding emerging and re-emerging zoonoses; more specifically, it advocated the following:

– active consideration of this issue as part of the development of the fourth OIE strategic plan (2005-2010)

– the creation of an Ad hoc Group on Emerging Diseases which would work closely with members of the Working Group on Wildlife Diseases, the Working Group on Animal Production Food Safety, the Ad hoc Group on Epidemiology, OIE Reference Laboratories and other relevant bodies or experts (5).

There appears to be little possibility of preventing bioterrorist attacks on domestic animals and the subsequent spill-over into wildlife populations. There is also the risk that wildlife could be the initial target of covert bio-attacks and that infection could then spread into contiguous domestic livestock. Consequently, interdisciplinary and international efforts to increase surveillance and identification of disease pathogens and improved mechanisms for interagency and intergovernmental co-operation and collaboration will be necessary to combat the threat of disease agents likely to be used as a bioweapon.

Conclusions

If they are correctly implemented the tools currently available through the OIE and FAO can do a lot to increase the ability of Member Countries and of the International Community to protect themselves against the threat of a bioterrorist incident. However, such protection depends on the diligence with which Member Countries follow the existing guidelines and recommendations. The livestock development programmes of the FAO Animal Production and Health Division include recommendations on animal production, health and policy, all of which are invaluable in preparing an effective response to a biological disaster. If these recommendations are implemented alongside OIE guidelines the better prepared a country can be. The OIE guidelines and the benefits they bring can be summarised as follows:

– the OIE standards designed to control disease and to prevent the accidental or intentional introduction of pathogens provide a basis for the harmonisation of national legislation

– the OIE guidelines relating to the biosecurity of laboratories (based on expertise provided from researchers in human and animal health), provide advice on the safe management of biological agents used in those laboratories

– the OIE guidelines, standards and recommendations (and EMPRES principles) relating to surveillance and prompt notification of diseases of domestic livestock and wild animals (including zoonoses) encourage transparency of disease information

– the OIE standards on the quality and evaluation of Veterinary Services can be used to improve the quality and efficiency of Member Countries Veterinary Services, thereby guaranteeing increased vigilance in disease monitoring and surveillance. Compliance with these standards leads to improved early warning and early detection systems, thus ensuring a timely and rapid response to any emergency.

It is plain therefore that effective global biosecurity can only be achieved if all OIE and FAO Member Countries conscientiously comply with the standards and guidelines of the OIE, effectively train stakeholders and ensure the availability of adequate human and material veterinary resources.

Many countries share a common concern about the natural occurrence or deliberate misuse of biological pathogens that can affect public health, food and animal production. Existing methods of disease prevention and containment, regulations, international guidelines and standards are being extended at both national and international levels to improve the ability of countries to prevent, manage and recover from natural, accidental or deliberate introduction

of animal diseases. In this regard there are, at present, substantial differences among countries in the perception of national threat from the deliberate use of pathogenic biological agents. However, significant progress would be made if all Member Countries would strictly implement existing OIE international standards. This is dependent on the political willingness of all national policy-makers and the transfer of resources from developed countries to developing countries in order to support good governance and appropriate policies based on the implementation of existing standards. A Resolution on this voted by the United Nations would provide great support in this respect.

Les organisations internationales et leur contribution à la protection de la communauté mondiale contre les catastrophes biologiques naturelles et d'origine intentionnelle

B. Vallat, J. Pinto & A. Schudel

Résumé

L'un des objectifs fondamentaux de l'Organisation mondiale de la santé animale (OIE) consiste à prévenir la propagation des maladies animales via les mouvements internationaux. L'OIE cherche à atteindre cet objectif notamment en publiant des normes internationales et des lignes directrices visant, entre autres, à prévenir l'importation d'agents pathogènes dangereux pour les animaux et pour l'homme et à renforcer les Services vétérinaires pour qu'ils puissent améliorer leurs systèmes de surveillance et d'interventions. L'OIE travaille en partenariat étroit avec l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO), et ensemble, les deux organisations ont élaboré un programme commun – le Cadre global pour le contrôle progressif des maladies animales transfrontalières (GF-TADs). Les Pays membres de ces organisations pourraient accroître leur capacité à gérer les risques d'apparition de maladies, tant naturelles qu'introduites délibérément, si tous appliquaient rigoureusement les normes internationales de l'OIE existantes. Le respect de ces normes dépend en grande partie de la volonté politique des décideurs nationaux et du transfert probant des ressources en faveur des pays en développement à l'appui de la bonne gouvernance et de la mise en œuvre des politiques appropriées. Une résolution des Nations Unies obligeant ses Pays membres à appliquer les normes de l'OIE serait extrêmement utile à cet égard.

Mots-clés

Accord sur l'application des mesures sanitaires et phytosanitaires – Cadre mondial pour le contrôle progressif des maladies animales transfrontalières – Norme internationale – Organisation mondiale de la santé animale – Organisation des Nations Unies pour l'alimentation et l'agriculture – Service vétérinaire – Surveillance – Transparence.

Las organizaciones internacionales y su influencia en la protección de la comunidad internacional contra desastres biológicos de origen natural o intencionado

B. Vallat, J. Pinto & A. Schudel

Resumen

Uno de los objetivos básicos de la OIE (Organización Mundial de Sanidad Animal) se cifra en impedir la propagación de enfermedades a consecuencia del movimiento internacional de animales y productos de origen animal. Uno de los métodos que utiliza para ello es la publicación de normas y directrices internacionales destinadas, entre otras cosas, a prevenir la importación de patógenos peligrosos para el hombre y los animales y a fortalecer los Servicios Veterinarios ayudándolos a mejorar sus sistemas de vigilancia y respuesta. La OIE colabora estrechamente con la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), y ambos organismos han puesto en marcha una iniciativa conjunta denominada Programa Global para el Control Progresivo de las Enfermedades Transfronterizas de los Animales (GF-TADs). Si todos los países miembros de ambas organizaciones aplicaran estrictamente las normas internacionales vigentes de la OIE, mejorarían su capacidad para manejar el riesgo de enfermedades, debidas a causas naturales o a actos intencionados. El cumplimiento de esas normas depende en gran medida de la voluntad de los responsables políticos nacionales y de la eficaz transferencia de recursos a los países en desarrollo para apoyar la buena gobernanza y la correcta aplicación de las políticas. En este sentido, una resolución de las Naciones Unidas por la que se obligara a los Estados Miembros a aplicar las normas de la OIE podría resultar de gran ayuda.

Palabras clave

Acuerdo sobre las Medidas Sanitarias y Fitosanitarias – Norma internacional – Organización Mundial de Sanidad Animal – Organización de las Naciones Unidas para la Agricultura y la Alimentación – Programa Global para el Control Progresivo de las Enfermedades Transfronterizas de los Animales – Servicio Veterinario – Transparencia – Vigilancia.

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Distinguishing between natural and unnatural outbreaks of animal diseases

M. Hugh-Jones

Department of Environmental Studies, School of Coast and Environment, Energy, Coast and Environment Building, Louisiana State University, Baton Rouge, LA 70803-5705, United States of America

Summary

An intentional outbreak of disease among livestock, or agricultural crops, will share a number of characteristics with those aimed at humans – unexpected pattern of disease in season or place, possible explosive incidence, unusual pathogen either in itself or of its genetic structure, difficult diagnosis – but there will also be notable differences: human cases, if they occur, will be coincidental and the major impacts will be delayed and of severe economic consequence. An investigative and analytical protocol is proposed for identifying such an event. Unless the nature of the event is self-declaring, such investigations necessitate a very thorough and careful investigation by a dedicated and experienced epidemiologic team. At the same time a country should take steps in advance of such an event to be prepared and to save time later, such as determining possible targets, identifying early warning indicators, establishing molecular biologic expertise and reference collections of possible pathogens, and preparing a tactical and forensic response.

Keywords

Agent weaponisation – Diagnosis – Economic cost – Molecular strain – Publicity – Target.

Introduction

This title may be better reworded as 'What is a suspicious (agricultural) incident?' Such a question by itself indicates that the cause of most such events is expected to be not immediately obvious.

Firstly, such agricultural incidents will differ significantly from intentional events that primarily target human beings, as follows:

– any human deaths will at worst be coincidental, even where zoonoses are concerned

– any agricultural impact may be delayed significantly and only become obvious after weeks or even months

– the major losses follow from the disease and are not directly of the disease itself, which in comparison may be relatively trivial.

An effective 'attack' does not necessitate massive death and destruction, quite the reverse. It is the necessary responses to agricultural disease, to contain and clean up, to prevent further spread, and then to reclaim the previous level of disease control or freedom, lost exports, and international recognition that eat up effort and funding. There is a very different time scale and series of available tools for attacks involving animals than there are for those involving public health and human bioterrorism/biological weapons (BT/BW). The desired results from an agricultural BT/BW attack are much more complicated than the simple widespread terror induced in a human target population.

A unique and necessary characteristic of a purposeful unnatural event is that it must follow strategic objectives. By definition they cannot happen by accident – the only accident that can happen is an 'own-goal' or an unplanned release from a covert facility, and even these latter 'accidents' reflect an intended later purpose, as yet maybe unknown to the investigators. Without a strategy, without a purpose, there is no reason to have mounted such an attack.

A normal livestock disease outbreak is not without alarm and major concerns – local, national, and international –

and these fears can be manipulated if blame for such an event, real or imagined, is stage-managed to be laid at another's door. Disinformation on a perfectly normal outbreak – much less one that has been contrived – could be so structured as to be persuasive and withstand nominal investigation. The reality is surely that there will be more disinformation disseminated than actual agricultural BT/BW attacks mounted.

However, a suspicious agricultural BT/BW incident may have many of the characteristics listed below, though some may take some time to become apparent.

Characteristics of a suspicious incident

Characteristics that would be indicative of a suspicious event are as follows:

a) unusual time and/or place, i.e. at extremes of a normal geographical or seasonal distribution for the disease, and/or

b) in an unusual population subset, age group, or unexpected location(s), and/or

c) explosive start, and/or

d) atypical clinical presentation, and/or

e) 'missed' cases and difficult diagnostics, and/or

f) marked reversal of an otherwise steady progress in disease control or freedom, and/or

g) epidemiologically 'weird' event; it in no way matches normal experience or knowledge, and/or

h) unexpected strain of agent or multiple strains, or features indicating deliberate genetic manipulation, and/or

i) location in the vicinity of a military or suspect facility.

Characteristics that would be conclusive proof of a deliberate attack would be:

a) exotic disease agent without prior epidemiological trail, and/or

b) evidence of weaponisation, identification as a biological warfare agent, and/or

c) proof of release by a biological weapon.

Characteristic consequences of a deliberate attack

A deliberate attack would be likely to have the following consequences:

a) marked economic or political costs with benefits, possibly singular, to a competitor, and/or

b) removal of target country/industry from international trade, and/or

c) target country must continue imports from competitor, and/or

d) marked social unrest, maybe with the movement of a significant part of the population as a result of losing their livestock or crops.

Additional factors

A suspicious agricultural BT/BW event would probably be characterised by most of the above factors, but there are additional factors that would add further weight to the theory that an event had been caused deliberately, for example:

a) diagnosis in unusual circumstances

b) publicity that is premature or from obscure source(s)

c) coded claim(s) of authorship

d) echoes of previous or subsequent events.

These factors will be discussed in greater detail later in this paper. It should be kept in mind that it is hard to envisage any circumstances in which a country or commercial company would publicly claim or admit to having been involved in active BT against another. The public and global opprobrium would be damning.

Intentional attacks, whether on humans or agriculture, have the potential to raise public alarm. In the case of an agricultural attack this alarm (which plays to terrorist intentions) stems from the threat to food safety and exports. There is always the concern that the perpetrator(s) may not have thought an attack through and just tried something because of the hype and the potential for making a 'big' statement. But public widespread alarm and government over-reaction are potential results from both normal and intentional events.

Monitoring suspicious activity and preparing response plans

There is a need to have done one's 'homework' well before any incident occurs, both to give a frame of reference and provide a body of updatable knowledge, but also to save time when it happens. If and when such a suspicious incident should occur there is certain to be some institutional panic and reactive demands that 'something must be done'. Maybe not. But when a decision is made to follow up such an incident the response should move with deliberate speed.

Target pre-identification

The first step in preparing for a possible attack is to identify possible targets, by:

a) defining the hypothetical 'goals' of potential attackers

b) identifying their probable objectives and ranking them

c) prioritising critical target-countries and industries

d) following up with preparatory collection of data and confirmation of the existence of a minimal administrative/organisational infrastructure within each target-country or industry; identifying liaison persons/local guides in case of need

e) ensuring that reference databases of strain characteristics already exist and are readily accessible – there is no point in having to do these comparison analyses on top of the urgent field samples.

Early warning indicators

In addition to normal intelligence awareness activities it is important to develop warning systems that can detect the signs that an attack may be about to happen, signs such as:

– 'own-goals': telltale accidents within a notional 'attacker' country or commercial company (maybe in relation to known institutes) or outside the country and well away from target crops or livestock

– unexpected minor events among sentinel or 'canary' animals/flocks; unsuccessful attacks with only a few cases; discovery of deployed pathogens but without clinical cases ('hang-fires')

– 'practice' events: while these 'events' may be normal outbreaks and probably are, they are not necessarily subject to detailed investigation and so their cause may be in doubt. A pattern of events might – not may – indicate that someone is getting the kinks out of a system

– travellers at airports found with pathogenic cultures, with or without adequate explanations.

National Veterinary Services should go on stand-by-alert if any of the above events are reported.

Prepared response

An appropriate game plan(s) should be agreed and ready before it is needed. The plan should be designed to:

– limit response to investigating initial events and the identification of first isolates, so that the investigators do not get in the way of the normal Veterinary Service response teams

– get people into the field quickly to collect and archive information and samples, with initial processing of samples in the field

– ensure that field workers can maintain a strict, fully documented audit trail on all materials collected, whether or not analysed, in case of the need for later recommendations or forensic investigations.

Investigating suspicious outbreaks

One must always be aware that BT/BW events will be rare and therefore any suspicious incident is most likely to have a normal if not prosaic explanation whatever the initial impression or belief. Similarly, the implications of a proven attack are so far reaching that any investigation resulting in such a conclusion must be so thorough as to survive the most rigorous of examinations. Therefore, unless the circumstances are blatantly those of an obvious BT/BW event – the biological equivalent of the recent twin-towers air crash, for example, ten widely separated cases of rinderpest across the United States of America (USA) within one week – the primary investigative position is that the situation was normal and, if unexpected, merely unusual. Thus 'rule one': look for a normal explanation. And 'rule two': try harder to find a normal explanation. Only if that fails does 'rule three' apply: 'round up the usual suspects'.

Clinical presentation

One of the very first steps in every epidemiological investigation is to confirm the diagnosis. Though most natural and possibly unnatural events will involve the same pathogens or near relatives that are well documented and that present in an almost textbook manner, some initial cases may be different. This may be clinically demonstrated by various indicators, as follows:

– a shorter than expected incubation period of many cases, not just the first of a normal Gaussian distribution

– an unexpected disease presentation, e.g. pneumonic plague in the absence of bubonic cases

– a confused symptomatology, e.g. though one agent is recovered or presumed there are lesions indicative of another pathogen

– the appearance of an increased virulence and a poor response to normally successful treatments, e.g. an increased case fatality rate

– significant numbers of cases in a population, whether human or livestock, which should have a high level of immunity

– a difficulty in getting confirmed laboratory diagnoses in cases patently and intimately co-associated with the initial outbreak or outbreaks. At the same time, inexperience in the proper collection and shipping of diagnostic samples can reduce even the best laboratory to uselessness and initiate loud agency-saving claims that everything was done correctly but nothing was found, with variations on which end is pointing the finger at the other, and therefore any failures are due to the agent. Subsequent tests will reveal the truth.

Epidemiological investigation

Based on informed epidemiological experience, literature, and databases, 99 out of 100 such outbreaks will be normal events and fully explicable from existing knowledge. Events at the extremes of normal probabilities are by their nature infrequent but not *ipso facto* abnormal. An event having a low probability of being a deliberate attack will only be regarded as such when matched or unmatched with other events. 'Experience' may indicate that certain infrequent events are commonly associated with a specific set of circumstances and these may be missing in a contrived and not-normal outbreak. Therefore, the events leading up to the 'incident' must be carefully analysed by experienced investigators. This should include examining evidence for prior outbreaks or infections indicative of an unrealised endemic or sporadic situation. This must be differentiated from the sudden appearance of a highly virulent agent and/or an abnormal reduction in the incubation period, possibly in a population with a normally protective level of herd-immunity.

Investigations should also cover commercial, legal and illegal importations of likely fomites (e.g. machinery, used sacks, harnesses), vaccines, vectors, fruits, seed, birds and poultry, eggs, livestock and livestock feed and feed components. It is a distinct advantage to know beforehand the genomic 'fingerprint' of all livestock and poultry authorised and unauthorised vaccines in circulation, overtly or covertly, alive or dead. Improper production of a 'dead' vaccine can result, and has resulted, in subsequent disease outbreaks.

Another important aspect is to investigate who or what were not apparently affected. The absence of disease can be as informative as the presence. Why was this group spared whilst another was not? The more factors the two groups have in common, the more extraordinary is absence/presence.

With true zoonotic infections it is usual for animals to be affected before humans, either because of reservoirs, vector exposure, or just being cumulatively exposed to higher ID50s/LD50s. For example, Eastern equine encephalitis equine cases will normally appear some 14 days before any symptomatic human cases are reported. When humans are affected as the apparent primary host, it is worth searching for affected animals to determine whether in fact it is they that are the primary hosts. This can fill cartographic gaps for places where humans are not, e.g. dairy cows and sheep in the countryside and humans in villages, and gaps in time, as animals may be found dead before human cases are reported and are sometimes diagnosed faster in veterinary laboratories. Human botulism normally follows the consumption of contaminated home-made or commercial food products without animal cases, other than household companion animals. Similarly, botulism outbreaks in poultry or livestock come from feeds or forage and will not affect humans. Thus, if there are human cases associated with the latter animals it must be from a common source. Also, the spatial persistence of a biological threat in the soil, water or air will be demonstrated by sporadic illnesses in animals and grazing livestock.

Existing control programmes

When a livestock disease control programme suddenly becomes ineffective, it can raise suspicions of an external cause. One must then carefully and objectively investigate the situation and the existing programme's surveillance system. The set-back to the programme is probably 100% expectable in hindsight, especially if the outbreak has revealed imbedded defects in the programme design, implementation, reporting cycle and response time, funding, training, or tactical control. Many national disease control programmes work well until they are challenged by a real epidemic; e.g. Taiwan and the recent foot and mouth disease (FMD) epidemic, which appears to have originated in some smuggled viraemic pigs from mainland China and then was probably exacerbated by the new owners selling ill pigs into the market system. Similarly, the present anti-rinderpest campaign in Africa could have a set-back either because of local inefficiencies or because of purposeful interference.

However, a new case in an area well cleared of disease for a number of years and with farmers experienced and knowledgeable of the costs to be incurred if the condition were to be reintroduced should give cause for concern. But farmers greed is not unknown, just as is their ability to be seduced by cheap animals with forged or absent papers. Local knowledge is a significant help in sorting out such scenarios as well as in interviewing the affected farmers.

One should never lose sight of the possibility of unexpected outbreaks following upon the illegal importation of fruit and livestock, which by definition lack the appropriate certificates and health guarantees. These will generally follow a pattern of expectations of those

knowledgeable in fighting these risks – medfly in fruit from Central America, tuberculosis in cattle crossing the Texas-Mexico border, Newcastle disease in smuggled parrots, or other pathogens contained in food being used to hide smuggle drugs. A variation on this is the present flood of bushmeat into Europe from Africa and the potential for it to contain exotic pathogens that pose a risk to humans and might also find their way to garbage-fed pigs. A similar risk is posed by any illegal smuggling of meats. What characterises these events is that there are no external beneficiaries other than those individuals directly involved in the illegal activities.

It is not impossible to conceive of a covert attack by a national Government on a sub-national group within its borders. A giveaway for this would be the intensity, or lack thereof, of the investigation as to the cause or causes. Similarly, a country might oppose such an investigation under international arrangements. Failure to cooperate would probably constitute a violation of the protocol and could be taken as confirming guilt. Therefore, even if the Government was reluctant because of internal problems of sovereignty or of revealing politically sensitive information on internal matters there would be an incentive to at least give the appearance of cooperation (8). This could involve an apparently cooperative Government steering the investigation towards certain information and away from other information; for example, the investigating group being taken unknowingly to wrong locations, different from the location where the attack was initially described as having taken place.

Inexplicable events

These are 'weird' events that go far beyond expectations, such as Venezuelan equine encephalitis in northern latitudes; vector-borne diseases in areas without appropriate vectors; normally feed-borne diseases in grazing stock not receiving supplemental feed; outbreaks on isolated farms or ranches, from which for a number of years animals had only been sold, not bought in. Was the spread of outbreaks in line with existing knowledge and/or was it independent of normal commercial/industrial activities, marketing, weather, and/or livestock/crop densities? For example, if the infection is normally wind-borne (e.g. with certain FMD viruses) was the initial disease spread downwind or across the prevailing wind direction; if it is a density-dependent infection, such as bovine brucellosis, was it first noted in one or more small herds with less than ten cows? Was the outbreak in the dry season while the local vectors are all wet-season breeders? Was it associated with a novel vector, even if a pre-existing vector had been well established for many decades?

One of the most fruitful epidemiological investigations is to look at outliers, i.e. cases that occur by themselves well away from the rest. Why? Because in the body of the epidemic there are many potential modes of spread, but at the margins there can only be very few reasons as to how it got there. Thus, one can identify whether the causative agent has higher survival times or resistance, is transmitted by an uncommon or unusual route, or is the usual epidemiological opportunist.

Similarly, one may be investigating whether clusters of a similar illness in non-contiguous areas or places have a natural explanation. Usually they will. An experienced epidemiologist knows that there are always a few mysteries whose explanation comes, if at all, almost by chance at a later date.

In brief, an inexplicable event is one which does not make epidemiological sense. It is totally outside normal experience or knowledge. Obviously, this might still be a natural outbreak, amply providing a new and unappreciated insight into the disease, and must be investigated in case this is so. Even the ten rinderpest cases, mentioned earlier, might be explainable if it were found to be related to a recent importation of wildebeest from Africa that somehow were cleared from quarantine early and shipped to widely dispersed 'wildlife' parks with resident beef cattle or nearby dairy farms.

Genetic evidence

Strain identification

Isolates from the initial outbreaks should be compared rapidly with known isolates in the pathogen archives. The molecular and polymerase chain reaction structure based on standardised techniques should be compared with the library of known markers and sequences. This comparison could produce any number of results on the origin of the isolate, for example:

– with luck and a comprehensive collection, it may exactly match a known strain with a documented origin, e.g. from outbreaks in a distant country or from prior outbreaks in the affected country or a neighbouring country;

– it may be 'new', but it might lie within a group of strains whose regional or national origin is known;

– with a measurable variation it may be possible to place it both in a general area and within a geographical radius of one strain or within radii of other known strains;

– the genomic markers may be associated with a specific ecology and/or host species, further defining its natural origin;

– the same unstable genome in two geographically distant isolates or from outbreaks years apart would indicate stable storage and release in several areas simultaneously or on separate occasions;

– if multiple strains are identified, are they logical? Do they have any other characteristics, such as resistance to a number of antibiotics, a documented collective availability to one institute, or an unusual common ability such as to successfully withstand freeze-drying while others commonly do not? If they are very diverse, their likelihood of naturally occurring together must be regarded as remote, at least until other evidence is available. However, in some cases there may be an epidemiological explanation for the presence of diverse strains, e.g. many different strains are recovered when anthrax outbreaks occur on several farms as a result of the common use of contaminated food: there can be different strains on different farms, different strains from individual animals in the same herd, and even varied strains in individual animals. It derives from the multiple sources of contaminated bones in the same batch of bone meal.

There is always the possibility that Country '*A*' in 'attacking' Country 'B' may use strains or vectors from Country '*C*'. Therefore, just because the identified strain is associated with one origin does not mean with certainty that it came directly from there. Nonetheless, once the strain has been identified it can provide useful clues as to who the attackers, or their contractees, may be, i.e. people/organisations who have documented ownership or access to the strains, who have the technical and scientific capacity to mount such an attack, and who have travelled in the area from where the strain originates.

The results of any successful strain identification must be promptly transmitted to the investigation team as it may open up a series of new questions and probabilities.

Purposeful genetic modifications affecting virulence

The virulence of a pathogen could be affected by genetic modification (1). The following characteristics would suggest a genetically modified pathogen:

a) resistance to antimicrobial agents, especially to multiple antibiotics

b) increased pathogenicity through

– expression of new pathogenic factors, producing a novel clinical mix of lesions

– enhanced effect of established pathogenic factors

– altered innate immune responses to the microbe

c) expression of biologic-response modifiers

d) expression of immune-response modifiers

e) altered antigenic characteristics, e.g.

– decreased recognition by diagnostic reagents

– avoidance of vaccine-induced immune recognition.

Vaccines depend on a suitable adaptive immune response to identified vaccine-preventable infections or intoxications. Pathogens may avoid immune protection if the genes encoding or regulating the expression of the immune targets are altered or if immune regulating genes are expressed by recombinant microbes. While several recombinant organisms capable of avoiding vaccine-induced immune responses have been reported (3, 7) the existence of naturally occurring genetic variants able to escape immune recognition (5) should not be forgotten.

Purposeful genetic modifications affecting diagnosability

If diagnosis by the normal laboratory procedures can be made less efficient or neutralised, it will immediately put a major stumbling block into any responding control activity (1). And the need to mobilise new or novel procedures will increase the cost and negatively impact the laboratory surge capacity. Thus the following diagnostic tests may give false-negative results in detecting genetically altered pathogens:

a) immunity-based diagnostic tests – this type of test will give false-negative results if the pathogen was altered to express antigens that do not bind the specific antibodies used in the assays or stimulate antibodies that do not bind standard detection targets. Examples of immunity-based diagnostic tests are:

– antigen detection assays (immunohistochemical analyses, direct immunofluorescence assays, antigen-capture enzyme-linked immunosorbent assays [ELISAs], bacterial agglutination assays)

– antibody-response detection assays (ELISAs, complement fixation assays, passive haemagglutination assays, indirect immunofluorescence assays, haemagglutination inhibition assays, and plaque-reduction neutralisation tests);

b) biochemistry-based bacterial identification tests – if the test depends on bacterial enzymes or specific viral encoded proteins it may be nullified if these products are genetically altered so that the products are either not expressed or are altered in structure or function;

c) nucleic acid-based diagnostic tests – these tests may fail because they are designed to detect specific gene regions dependent on reagents that hybridise to specific nucleotides. Similarly, digestion products of assays based on restriction fragment-length polymorphisms may not be of the expected size or may not hybridise to organism-specific probes.

Evidence of weaponisation

In spite of the events of 2001 and the intelligence fears of fall out from offensive research the probability

of weaponisation should not be presumed. Much can be achieved with pathogens off the shelf, out of the ordinary laboratory refrigerator or deep freeze; however, if a pathogen has been 'weaponised' there may be markers. The internal organisation of the genome may exhibit areas of discontinuity or heterogeneity reflecting purposeful manipulation. The discontinuities should be examined for obviously artificial junction sequences or rare restriction sites. Detailed genomic analysis may reveal whether the recovered isolates are 'normal' or whether they contain genes which are unusual and/or add virulence beyond the normal range, or have evidence of sequence insertions, deletions, or inversions, or contain episomes that are preferred vectors for genetic engineering. Similarly, finding an unstable genome in two distant sites or from outbreaks years apart would indicate stable storage and release in several areas simultaneously or on different occasions. Finally, dependent on how the micro-organism is grown, the genome may adapt and reflect the means of production. This would be demonstrated by subtle genomic changes between the primary outbreak(s) at the epicentre and subsequent spread. If the original inoculum can be found, say in feedstuffs or even in a suspect 'device', it may demonstrate the methods of storage and/or delivery. For example, additives to render the agent resistant to freeze-drying and aerosolisation such as microencapsulating reagents (poly DL-lactil-co-glycolic acid, sorbitol, trehalose) would be evidence of weaponisation, as would any genetic manipulation intended to increase the survival time of the pathogen in adverse environmental conditions.

Another factor to consider when looking for signs of weaponisation would be the physical form of the pathogen. An excellent example of this are the spores of *Bacillus anthracis* involved in the USA 2001 events. This was a highly aerosolisable product apparently consisting mainly of individual spores and few, but small, clumps; not something that one normally associates with occupational exposures, e.g. in mills and tanneries. The spores also arrived by mail.

Economic and trade analysis

Under normal circumstances all countries will try to take advantage of another country's problems whatever their cause. So judgement here has a large measure of subjectivity unless taken in regard to the previous 'event characteristics'.

There must be a concordance between the goals and objectives of a suspect organisation and the suspicious BW event; e.g. an international fruit consortium might well want to bankrupt the banana export industry in a competing region, but this would not be achieved through an outbreak of FMD in pigs in one of the latter's member countries.

A careful analysis must be made of whether the event has resulted in any of the consequences that are indicative of a deliberate attack (as described earlier in the Introduction) – to what degree did which countries benefit? For example, if Country 'B' suffers an outbreak, which countries increased – or against expectations did not decrease – their trade in the same period? By how much did they benefit from 'B's problems? Or on the other hand, in a notional prospective analysis, how much would they benefit? Nationally, the loss of exports will reverberate back reducing national demand and thereby producing excesses which can be very expensive to absorb. The suspect organisation may not be the most obvious beneficiary if, for example, it had set up others to (also) benefit at the expense of the target, i.e. as in billiards, with a bank-shot off the cushion.

Imaginary 'bank-shot' scenarios:

a) country 'N' improves its infrastructure and will soon be self-sufficient in wheat. Country 'G' uses country 'A's rust spores against 'N'. 'N' accuses 'A' and cuts off imports of 'A's grain, and probably other products as well. 'G' increases its grain exports to 'N', along with other benefiting countries;

b) country 'J' releases rust spores in country 'K', thereby reducing the latter's harvest and capability of exporting grain to its neighbour, country 'L'. 'J' increases its exports to 'L'. 'K' now cannot cover energy requirements and becomes politically unstable, thereby deflecting 'L's attention to its border with 'K', and away from 'J'.

On the other hand, a group just wanting to inflict severe economic damage but unable to financially benefit could still mount a biological attack, successful or otherwise.

People movements

Social unrest will aid terrorism and the terrorist's desire for political anarchy, opportunity, power, and change. At sporadic levels agricultural BW events will produce uncertainty and increased tension. At its most extreme in an agricultural economy when one kills the livestock and markedly reduces harvests the people must move if they are to survive. Thus it may also provide a land vacuum attracting third parties. The latter situation played a significant part in the civil wars in the former Yugoslavia.

In the Ethiopian war with Somalia, the livestock of Somalis living in the Ogaden region of Ethiopia were attacked with Napalm, with the result that the people had to take refuge with their relatives in Somalia. The influx of refugees, with some of their livestock, especially small ruminants, overloaded the governing capacity of the Somali government as well as accelerating over-grazing and the desertification of various family and clan seasonal grazing areas.

If an animal disease outbreak results in social unrest it could well be a deliberate attack, particularly if it occurs repeatedly. This is especially true in developing countries, where this type of attack can be very effective in forcing people to leave their lands. Such an event is less likely in developed areas of the world, because an attack on the high-security farms in the concentrated farming systems of these countries would require much more sophisticated planning than an attack on village livestock in low-security farms in non-intensive systems.

Diagnosis

Most agricultural costs from outbreaks are self-inflicted by the host country as they respond to the need for a rapid resolution. This response is usually out of all proportion to the number of index or primary cases. Therefore the 'initial' hit can be singular, even numerically trivial (e.g. Botswana with one FMD case; Israel and mercuric chloride [$HgCl_2$] in an orange; Chile and half a box of grapes). Under these circumstances the 'attacker' must aid the diagnostic process to ensure that the instance is (*a*) recognised and (*b*) reported. Therefore, what were the circumstances leading up to the initial recognition of the incident and its subsequent diagnosis and laboratory confirmation?

If a disease is not well known by professionals in the target country it may be missed. Therefore, one must keep in mind the concept of 'number needed for diagnosis'. How many cases are needed until the condition is recognised correctly? Experts in a disease always forget that their less-informed colleagues may have no idea what the disease is or even recognise the signs.

Similarly, have the surveillance and diagnostic capacities been recently improved? Therefore, could it have been a normal case that would otherwise have been missed? For example, the diagnosis of endemic cholera via naturally contaminated blue crabs in southern Louisiana is a function of physician awareness and laboratory enthusiasm. Outbreaks of human cholera follow upon hot, drier than usual summers, and the Cajun preference for not over-cooking their seafood. One successful diagnosis will beget others and soon there is an unexpected 'epidemic' and all it was was a hot, dry summer.

Therefore, one should always be aware of personnel competence, training, and technical laboratory improvements in surveillance efficiency.

Publicity

Most conditions have to be reported to national authorities and to international bodies such as the World Organisation for Animal Health (OIE), the Food and Agriculture Organization and the World Health Organization. International reporting is frequently a monthly or annual requirement; only a limited number must be reported immediately. Any unusual departure from the conventional pattern of reporting should raise questions, e.g. was it reported 'too quickly' and what were the circumstances? If so, the appropriate investigative action can then be taken.

Latterly, there have been instances where cases of human Creutzfeldt-Jakob disease have been reported in the local USA newspapers as 'mad cow disease', sometimes with immediate effect on the price of beef futures. This is just journalistic ignorance and stupidity, but it could equally well be purposeful in the appropriate circumstances. With the internet, CNN, ProMED-mail, and modern information systems the opportunities for rapid, global dissemination of news is almost unlimited. Within ProMED-mail we have already begun to see instances of 'stirring' by certain individuals regularly referring to local news reports in distant cities that reflect very specific personal viewpoints. It would be naive to think that this was in any way new, but the growth of the global internet means that the capacity to disseminate 'news' is now available to a far greater number of people. Similarly, there have been attempts to spread disinformation via ProMed-mail, but fortunately they have been unsuccessful thanks to the experience and watchfulness of those in charge of processing incoming communications.

Keeping the reporting of disease outbreaks to the routine, usual procedure means that 'premature' reports can be detected and investigated, thus preventing the spread of disinformation and ensuring that suspicious events are identified.

Coded claims of authorship

The only groups that would admit to initiating a BW attack on agriculture, when not in wartime, would be terrorists. No country or commercial company would wish to. Such terrorist claims would reflect a grab for power, or a desire to create social unrest or to increase market share in mercenary activities.

There will be frequent false claims. However, increasingly, specific terrorist events are going unclaimed or with the perpetrators being presumed.

Echoes of previous or subsequent events

Bioterrorism and biological weapon events do not occur in isolation. A successful 'attack' follows successful research,

training and field trials. Similarly, it is unlikely that a successfully completed 'attack' will not be repeated, i.e. be a 'one-off', if the perpetrator has maintained technical competence. Any technology has a parenthood and genealogy attached to it; for example, similar research will be reported in different institutes by students of the originators; scientists are surprisingly unoriginal sometimes, such that trials get repeated and mimicked by other groups. Therefore, any event has the capacity to cast a 'shadow' forward and backwards in time. Thus a BW-suspect event without such echoes or shadows may well not be BW-related or may be merely opportunistic, which appears to be the case with the 2001 anthrax letters. 'Terrorists are tactically conservative, preferring weapons with which they are familiar. Rather than adapting entirely new techniques, most terrorists appear to prefer to adapt and improve their existing ones' (2). However, 'experience has nonetheless demonstrated repeatedly that, when confronted by new security measures, terrorists will seek to identify and exploit new vulnerabilities, adjusting their means of attack accordingly and often carrying on despite the obstacles placed in their path'. This may be facilitated by internet sources, which might cut out the need for personal contact and instruction from experts (2).

Investigating the 1973 outbreak of Newcastle disease in Northern Ireland

In November 1973, Newcastle disease (ND) suddenly appeared in Northern Ireland, where the viscerotropic disease had not been seen in three and a half years and Ireland had been regarded as essentially free for 30 years. It was successfully controlled with only 36 confirmed affected layer flocks. Contemporary investigations failed to reveal the source. The event itself was certainly unexpected as Northern Ireland did not, and does not, import animal proteins or by-products, such as bone meals or poultry offal meals. The possibility therefore existed that it might not have been a normal outbreak and it was so investigated retrospectively, using more advanced technology than that available at the time (6).

Source investigations

At the time of the outbreak, several possible sources of infection were investigated, the results of which are outlined below.

Direct infection via quarantined viraemic birds

No quarantine records supported the theory that the disease had been introduced via quarantined birds.

Legal imports of exotic birds into semi-intensive quarantine

Enquiries did not yield any support for this route of entry.

Illegal or unrecorded exotic bird importations

By its very nature this is difficult to investigate, but the investigations carried out at the time failed to reveal that anybody associated with the affected farms had been involved in this type of activity.

Imported parrots

In the early 1970s there were a series of ND outbreaks in North America and Western Europe that were associated with a sudden fad for parrots from South America and Africa. For example, in 1971 Paraguayan parrots escaped from an importer's premises and infected nearby commercial egg-laying flocks in southern California. By the time the outbreak had finished in 1973 it had cost US$ 56 million.

Elsewhere, Switzerland had widely dispersed outbreaks, all associated with one shipment from South America; the Netherlands, in 1970, isolated Newcastle disease virus (NDV) from ten shipments of birds coming from Colombia and Paraguay, plus some of these birds were sick and infected when they later arrived in South Africa; Germany 'frequently' isolated NDV from newly imported psittacines mainly from Paraguay, but also from Colombia.

While the Antrim '73 epidemic in Northern Ireland could not be traced directly to imported parrots, it was suspected that the outbreak might in some way have been connected, but it was not known how.

Movements of people or vehicles

Extensive enquiries concentrated on 'hard-to-explain' outbreaks but failed to yield any positive information.

Feed stuffs

No feed stuffs were thought to be at the origin of the outbreak at the time. All protein meals were derived from poultry products that originated in Northern Ireland, as did meat and bone meals. Only grains were imported.

Vaccines

No vaccines were used at the index farm. Newcastle disease vaccines were not used in the province.

Human (kitchen) wastefood

No outbreak was found to be associated with the feeding of kitchen waste, nor with such materials from the nearby Aldergrove Airport.

Imported eggs

There was no commercial incentive to import eggs. Boxes with the names of Scottish or English retailers contained domestic eggs, diverted for local trade and still in their export packs.

Wind-borne virus

While winds with high humidity and adequate force were blowing in the right direction to carry the virus from infected flocks in England, the distance was considered too great.

Wild birds

While there were historical precedents of ND being introduced via wild birds, no detailed investigations were carried out.

Sabotage

Sabotage was considered at the time both within and without the Northern Ireland Department of Agriculture. Enquiries at each infected premise covered this possibility despite that fact that disease prevention procedures on many farms were poor and it was possible that the virus could have been introduced via dirty poultry crates, muddy Wellington boots, etc. The targeted farms were largely protestant, so the involvement of the Irish Republican Army (IRA) or other nationalist paramilitary group could not be ruled out at the time, but there was no evidence to support such a hypothesis beyond mere suspicion and speculation. The attacks were a claimable success, but there were no claims of responsibility from any political association or paramilitary group.

Retrospective investigations

The initial outbreaks were all in layers that had mash, pelleted, complex rations with many components, while broilers with simple rations were not affected. This had suggested that certain feed stuffs may have been contaminated, but the affected farms bought their feed from a variety of retailers, so there did not appear to be a link. However, later investigations discovered that all feed coming into Ireland was imported via Rotterdam docks, where it may have been contaminated by infected pigeons. The Netherlands had an active vaccination programme, but it prevented disease, not infection, so there was a possibility that all feed mills in Ireland could have distributed contaminated feed.

Genomic analysis of Newcastle disease virus Antrim '73

The virus isolates from this epidemic were very similar to those of the Essex '70 epidemic in the United Kingdom (UK), which were identical to the previous American NDV isolates. This demonstrates an epidemic commonality (Group A – Fig. 1), which is to be expected if the UK and the immediate related European outbreaks followed the movement of American parrots to Europe. Group B is a group of Hungarian isolates that were isolated some years later as the Newcastle panzootic spread eastwards across Europe. Unfortunately no intermediate virus isolates have survived.

Of course, an alternative viewpoint might suggest that varied NDV strains were characteristic of an aggressive group with tight security and three separate teams, each with their own infected eggs to be placed broken in the targeted flocks so that they would be eaten by the chickens; or however else delivery was to be achieved – a Roswellian interpretation in the opinion of the writer in the absence of any strategic or economic advantage.

Economic assessment

The costs of the outbreak in Northern Ireland were severe, but the economic assessment revealed that deliberately introducing NDV into the country would have brought little financial benefit to anyone, thus making the sabotage theory highly unlikely. The market for table eggs in the UK was declining rapidly and most countries in Europe had Newcastle disease problems of their own at that time, so there was little motivation for anyone to try to gain a larger share of the market by destroying the industry in Northern Ireland.

The final bill was £668,994 (or £4.7 million to £5.1 million in 1997 terms) (4) but efficient control meant that the uninfected flocks within the country were able to keep the domestic market afloat and Antrim quickly returned to full production. The economic costs had no obvious social or political impacts inside the country; in fact, the outbreak brought all those involved closer together. The eradication campaign left Northern Ireland free of Newcastle disease and with no need to vaccinate, and the outbreak had no other benefit to anyone outside Northern Ireland.

Conclusion

There was nothing in the investigation which provided firm evidence to support the theory that the appearance of ND in Northern Ireland had been the result of a bioterrorist attack. Moreover, the outbreak had none of the additional characteristics of suspicious attacks, e.g. no premature publicity, no coded claims of authorship, and nothing about it was reminiscent of a previous or subsequent attack. The conclusion, therefore, was that this was a natural series of outbreaks resulting from a

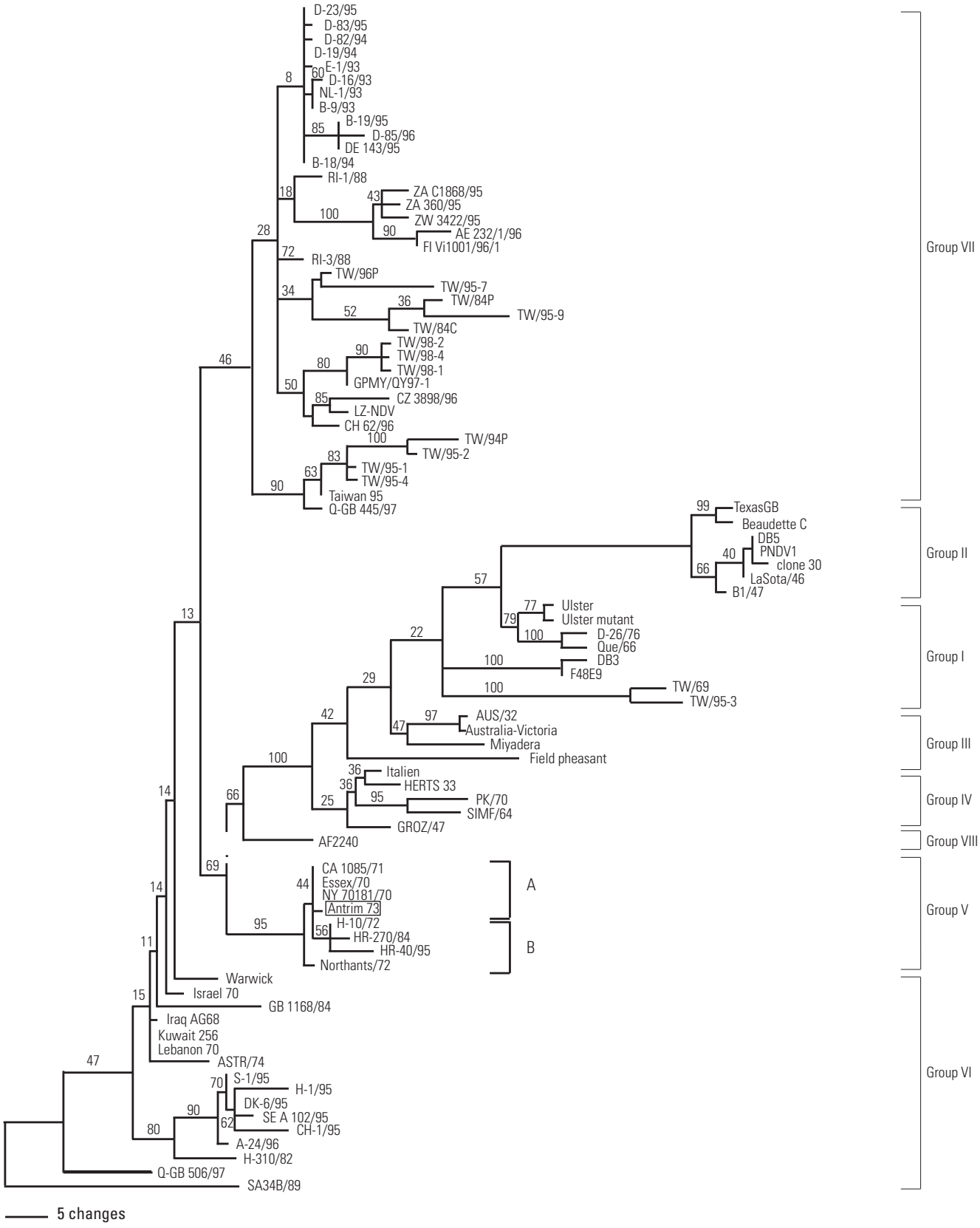

Fig. 1
Phylogenetic analysis of Newcastle disease virus (6)

conjectural source outside Antrim involving imported contaminated poultry feed.

Final remarks

While there is at present heightened awareness of the risks of BT/BW-related disease outbreaks, the reality is that we will, unfortunately, still have outbreaks, small and large, that are normal in all respects. These must be handled efficiently, cost-effectively, and quickly. But as long as the potential for unnatural/intentional outbreaks exists, we must be prepared. Part of this preparation is to be proactive in their recognition. It is not sufficient to have a John Snow produce evidence after it has happened and explain why. It is vitally important to be realistically sensitive to possible prior signature events. And any and every prediction must be validated. On the other hand one must guard against hypersensitivity, which by definition is unnecessarily expensive and not cost effective. But be aware. Be alert. And when in doubt as to the normality of any given event investigate promptly, appropriately, and quietly.

Distinction entre les foyers de maladies animales d'origine naturelle et non naturelle

M. Hugh-Jones

Résumé

Un foyer de maladie d'origine intentionnelle apparu dans un élevage ou dans des cultures présentera des caractéristiques communes avec un foyer visant l'homme – saison ou lieu inattendus pour la maladie, caractère explosif possible en termes de fréquence, nature ou structure génétique inhabituelles de l'agent pathogène, diagnostic difficile – mais aussi des différences notables : les cas humains, s'il en existe, seront fortuits et leurs principaux effets seront différés et auront une portée économique importante. L'auteur propose un protocole d'investigation et d'analyse pour l'identification d'un tel événement. À moins que la nature de l'événement soit évidente, ces investigations nécessiteront un examen très approfondi et rigoureux mené par une équipe épidémiologique spécialisée et expérimentée. En même temps, les pays doivent anticiper ce type d'événement en prenant des mesures préventives qui leur permettront d'être prêts et de gagner du temps, par exemple en identifiant les cibles possibles, en définissant les indicateurs d'avertissement précoce, en réalisant une expertise biologique moléculaire et une collection de référence des agents pathogènes éventuels, enfin en préparant une réponse tactique et médico-légale.

Mots-clés

Cible – Coût économique – Diagnostic – Identification moléculaire de la souche – Publicité – Utilisation des agents pathogènes comme armes.

Discriminación entre brotes zoosanitarios de origen natural y no natural

M. Hugh-Jones

Resumen

Un brote infeccioso de origen intencionado que afectara al ganado o los cultivos agrícolas tendría una serie de rasgos en común con los brotes dirigidos contra seres humanos (comportamiento insólito de la enfermedad por el lugar o la estación, eventual incidencia explosiva, patógeno inusual, ya sea por sí mismo o por su estructura genética, diagnóstico difícil, etc.), pero también presentaría diferencias notables, puesto que los casos de infección humana, si llegara a haberlos, serían fortuitos, y las principales consecuencias surgirían con más retraso y constituirían sobre todo un grave percance económico. El autor propone un protocolo de investigación y análisis para detectar este tipo de episodios. A menos que ello resulte obvio por la propia naturaleza del caso, las investigaciones requieren un trabajo de análisis realmente exhaustivo y cuidadoso por parte de un equipo de epidemiólogos expertos. Paralelamente, a fin de estar preparado y ganar tiempo llegado el momento, un país debería adoptar medidas para adelantarse a los acontecimientos, por ejemplo determinando posibles objetivos, definiendo indicadores de alerta rápida, consolidando sus conocimientos técnicos en biología molecular, elaborando colecciones de referencia de posibles patógenos y preparando una respuesta táctica y forense.

Palabras clave

Costo económico – Diagnóstico – Objetivo – Publicidad – Uso armamentístico de agentes biológicos – Variedad molecular.

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Élaboration et mise en place de systèmes de surveillance épidémiologique des maladies à haut risque dans les pays développés

B. Dufour [1], P. Hendrikx [2] & B. Toma [1]

(1) Unité Maladies contagieuses, École nationale vétérinaire d'Alfort, 7, av. du Général-de-Gaulle, 94700 Maisons-Alfort, France
(2) Service de coopération et d'action culturelle, Ambassade de France, B.P. 780, Saint-Domingue, République Dominicaine

Résumé

En pathologie animale, au cours des deux dernières décennies, en raison de l'évolution favorable des maladies animales majeures, la surveillance épidémiologique est progressivement passée au premier rang des priorités dans les pays développés.

La gestion de réseaux d'épidémiosurveillance efficaces des maladies animales à haut risque dans les pays développés découle des règles générales de fonctionnement des réseaux d'épidémiosurveillance et comporte quelques particularités. Cet article rappelle dans un premier temps quelles sont les modalités du fonctionnement optimal des réseaux de surveillance épidémiologique. Il décrit et analyse ensuite les qualités attendues des réseaux de surveillance des maladies à haut risque : sensibilité et spécificité de la détection, simplicité et adaptabilité du système, ainsi que rapport coût/efficacité. Enfin, il illustre ces notions générales en présentant quatre exemples de surveillance épidémiologique de maladies animales en pays développés : la fièvre aphteuse en Europe, la peste porcine en Europe, l'infection à virus West Nile aux États-Unis d'Amérique et en France, et la fièvre catarrhale ovine en France.

Mots-clés

Épidémiovigilance – Menace biologique – Surveillance épidémiologique.

Introduction

La surveillance épidémiologique est « une méthode d'observation fondée sur des enregistrements en continu permettant de suivre l'état de santé ou les facteurs de risque d'une population définie, en particulier de déceler l'apparition de processus pathologiques et d'en étudier le développement dans le temps et dans l'espace, en vue de l'adoption de mesures appropriées de lutte » (23).

Cette définition illustre clairement que la surveillance épidémiologique a pour finalité, entre autres, de détecter l'apparition de maladies animales exotiques introduites à partir d'un autre pays, ou de nouvelles maladies, inconnues jusqu'alors.

Cet objectif de vigilance, que nous nommerons « épidémiovigilance », doit permettre la détection précoce, puis le suivi de leur évolution en vue d'actions de prévention ou de contrôle, de maladies considérées à haut risque et capables de provoquer des désastres :

– parce qu'elles sont hautement diffusibles et conduisent à des épizooties ayant des conséquences économiques majeures pour un pays ; la fièvre aphteuse est, en Europe, un exemple de ce type de maladie ;

– parce qu'elles peuvent avoir un impact important en termes de santé publique. Il s'agit alors de maladies zoonotiques graves comme, par exemple, la rage ou, dans certains cas, l'infection à virus West Nile chez l'homme ;

– parce qu'elles sont de bonnes candidates à d'éventuelles actions bioterroristes, par exemple la fièvre charbonneuse.

Les systèmes de surveillance épidémiologique sont des outils d'aide à la décision dans le domaine de la prévention et du contrôle de ces maladies. Ils reposent le plus souvent sur un ensemble de personnes et/ou d'institutions organisées entre elles en réseaux (réseaux de surveillance épidémiologique) pour effectuer la surveillance d'une ou de plusieurs de ces maladies.

La rapidité et la pertinence des décisions sanitaires prises dépendent de la fiabilité du système de surveillance. Assurer efficacement la détection et le suivi des menaces sanitaires constitue donc un préalable à toute lutte efficace.

Après avoir présenté les modalités de fonctionnement générales des réseaux de surveillance, nous analyserons les qualités attendues pour que les réseaux de surveillance des maladies à haut risque puissent jouer efficacement leur rôle d'alerte et d'aide à la décision, puis nous présenterons quelques exemples de fonctionnement de ce type de réseaux dans les pays développés.

Fonctionnement des réseaux de surveillance épidémiologique

Tous les réseaux de surveillance épidémiologique fonctionnent suivant quatre étapes (12) (Fig. 1) :

– la collecte des données,

– la transmission des données,

– le traitement des données,

– la diffusion des résultats.

Un réseau fonctionne de manière optimale si divers points critiques sont bien contrôlés ; ces points critiques sont :

a) La définition précise du champ d'observation et des objectifs : le choix des maladies à surveiller dépend de leur gravité, de leur potentiel de diffusion, de la mortalité, de la morbidité, de leur impact économique, des possibilités d'interventions préventives et curatives ainsi que de la réglementation et notamment des obligations nationales et internationales. Il n'est donc ni possible, ni d'ailleurs nécessaire, de surveiller toutes les maladies. Les objectifs doivent être très précis, car ce sont eux qui conditionnent l'organisation générale du fonctionnement du réseau, ainsi que la nature et la fréquence des données à recueillir et à traiter. La définition des objectifs doit se réaliser en collaboration avec les différents acteurs du réseau.

b) Le choix et la définition des modalités de la surveillance doivent être réalisés avec précision et consignés dans un protocole de surveillance. Ces modalités peuvent être fondées sur les principes de la surveillance passive, c'est-à-dire l'organisation d'une déclaration des cas suspects par les intervenants de terrain, ou active, par l'organisation de la collecte des données sur la totalité de la population ciblée ou un échantillon. Elles devraient être conditionnées par les résultats d'une analyse de risque permettant d'orienter les lieux de la surveillance et la manière de réaliser cette surveillance.

c) La standardisation permet d'assurer que toutes les données collectées sont comparables. Elle s'effectue à tous les niveaux, de la définition du cas jusqu'aux techniques d'analyse et d'interprétation des résultats.

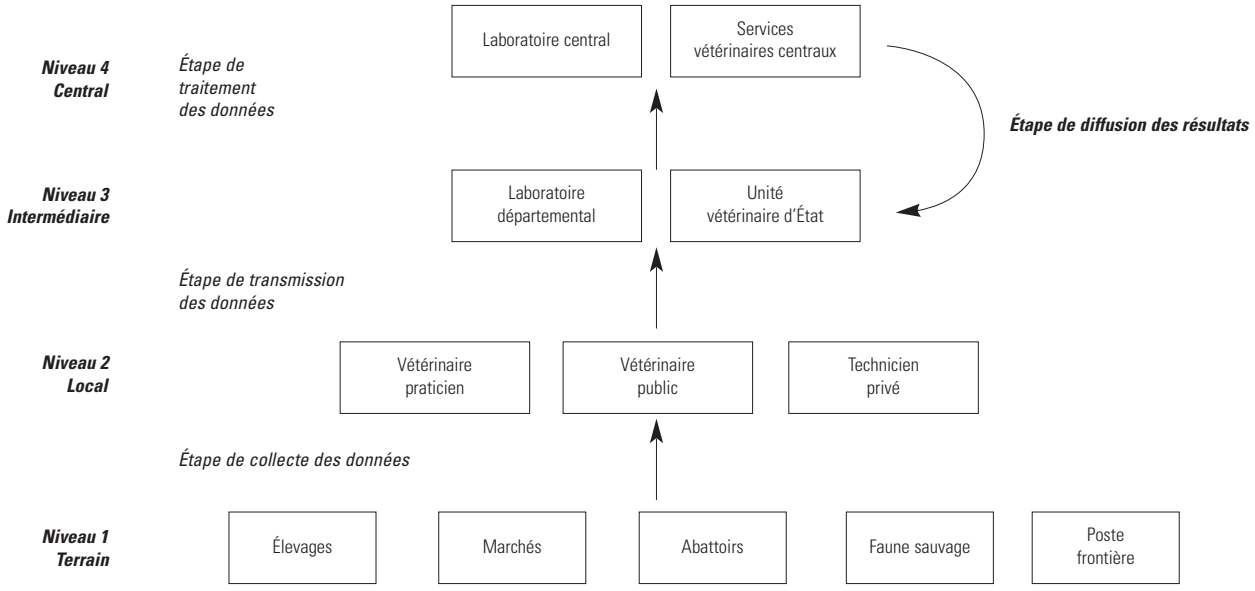

Fig. 1
Acteurs et étapes du fonctionnement d'un réseau de surveillance épidémiologique

d) La gestion et le traitement des données sont des tâches importantes pour un réseau. Elles doivent être organisées au préalable pour éviter la perte de données et assurer que leur exploitation sera réalisée en conformité avec la fréquence et la qualité déterminées à l'avance. L'interprétation des données traitées est un travail résultant de la confrontation de compétences d'épidémiologistes et d'experts techniques sur les maladies concernées.

e) La diffusion des informations conditionne la pérennité du réseau ; elle peut s'effectuer de plusieurs manières : des méthodes traditionnelles, telles que des bulletins périodiques, des courriers, ou des supports plus modernes, informatiques ou télématiques. Deux types de diffusion doivent être distingués : la diffusion interne, à destination des membres du réseau, est une condition essentielle de son fonctionnement en assurant le maintien de la motivation de tous les acteurs ; la diffusion externe à destination de partenaires ne participant pas directement au réseau.

f) L'organisation institutionnelle correspond à tout ce qui contribue à structurer et formaliser l'intervention des organismes et acteurs du réseau de surveillance épidémiologique. Elle permet de définir la répartition des rôles dans le réseau ainsi que les responsabilités et organes de décision. Cette organisation repose classiquement sur un comité de pilotage, un ou plusieurs comités techniques, une unité centrale, un ou plusieurs laboratoires de diagnostic, des unités régionales, des postes de surveillance et des sources de données. La formation de l'ensemble des acteurs du réseau est un enjeu majeur de la réussite de la mise en place et de la pérennisation des activités de surveillance.

g) Le suivi et l'évaluation des réseaux de surveillance épidémiologique fournissent des éléments concrets permettant d'identifier les points faibles de leur fonctionnement pour proposer les mesures les mieux adaptées à leur amélioration. En fonction des objectifs et des utilisateurs de l'évaluation, plusieurs méthodes peuvent être proposées (21) et notamment deux modalités d'évaluation complémentaires : l'évaluation interne reposant sur des indicateurs de performance et de diagnostic (14, 15), et l'évaluation externe reposant sur un audit technique et économique ponctuel du fonctionnement du réseau (10).

L'efficacité des réseaux d'épidémiovigilance repose sur trois conditions supplémentaires :

a) une sensibilisation importante est essentielle pour renforcer l'implication de tous les éleveurs et vétérinaires dans la vigilance et améliorer l'exhaustivité de cette vigilance. Ce sont en effet eux qui entretiennent le contact le plus étroit avec les animaux et qui peuvent par conséquent donner l'alerte la plus précoce ;

b) des laboratoires de référence doivent être en mesure d'assurer la qualité et la rapidité du diagnostic. En effet, les maladies ciblées ne font pas souvent l'objet d'un diagnostic de routine et l'absence de ces laboratoires peut ainsi entraîner des retards importants dans la gestion d'une suspicion ;

c) la rareté des phénomènes ciblés nécessite le maintien d'une équipe d'experts en mesure d'apporter un appui scientifique et technique aux acteurs de terrain pour renforcer notamment la spécificité des suspicions.

Qualités attendues des réseaux de surveillance des maladies à haut risque

L'efficacité de la surveillance d'une maladie capable de provoquer un désastre est conditionnée par le niveau de qualité de certaines caractéristiques du réseau : la sensibilité et la spécificité de la détection, la simplicité du système et son adaptabilité (18) ainsi que son rapport coût/efficacité.

Sensibilité de la détection

Définition

Pour une maladie donnée, la sensibilité de la détection correspond à la capacité du réseau de surveillance à détecter tous les cas (11). La sensibilité conditionne la précocité de la détection ce qui, pour les maladies à haut risque, est essentiel afin de pouvoir agir le plus rapidement possible.

Actions nécessaires pour obtenir une bonne sensibilité

L'obtention d'un bon niveau de sensibilité de la détection repose sur plusieurs actions :

La définition du cas surveillé

La définition du cas surveillé, c'est-à-dire de « l'individu présentant les caractéristiques du phénomène étudié » (23), est essentielle pour garantir la sensibilité du réseau ; ainsi, pour un réseau de surveillance clinique d'une maladie, le nombre de suspicions sera plus ou moins grand selon la précision et l'exigence du descriptif clinique de la définition du cas. Par exemple, si l'on définit une suspicion de fièvre aphteuse comme « tout ruminant ou porcin présentant des lésions buccales », le nombre de suspicions sera logiquement plus élevé que si l'on indique par exemple que ces « lésions buccales doivent être constatées sur plusieurs animaux apparaissant de manière groupée ».

La sensibilisation et la formation des acteurs du réseau

Les acteurs d'un réseau d'épidémiovigilance de maladie à haut risque sont essentiellement les éleveurs, les vétérinaires et les laboratoires. Il convient que chacun de ces acteurs ait une conscience aiguë de l'importance du rôle qu'il a à jouer dans la détection des maladies à haut risque.

Les éleveurs ont un rôle déterminant, si le système est fondé sur la surveillance de suspicions cliniques. En effet, tout le système repose alors sur leur capacité à identifier les signes cliniques susceptibles d'être rattachés à la suspicion et à accepter de les déclarer aux autorités compétentes. L'attention des éleveurs doit être mobilisée par des campagnes de sensibilisation régulières. L'exemple des campagnes d'information sur la fièvre aphteuse en France est intéressant dans la mesure où il illustre clairement l'importance de l'investissement financier et humain à réaliser pour aboutir à une sensibilisation correcte.

Le rôle des vétérinaires est également fondamental pour le diagnostic différentiel et la prise des premières mesures en cas de suspicion légitime (en particulier, effectuer et expédier les prélèvements nécessaires, indiquer à l'éleveur les mesures à prendre pour éviter la dispersion de la maladie). La formation continue de ces acteurs est alors une action primordiale pour leur permettre de jouer pleinement leur rôle. Les animateurs des réseaux doivent s'impliquer dans cette formation en définissant les objectifs des réseaux et en fournissant des supports pédagogiques adaptés (cassettes vidéo, jeux de transparents…).

Les laboratoires jouent également un rôle important dans le dispositif de détection précoce des maladies à haut risque ; il convient qu'ils aient à la fois la compétence et la disponibilité nécessaires. Leur compétence est en principe assurée par leur mise sous assurance qualité et par leur participation régulière à des essais inter-laboratoires organisés par des laboratoires de référence nationaux ou internationaux. Leur disponibilité doit faire l'objet d'un contrat les liant à l'État pour le diagnostic de ces maladies.

L'entraînement aux alertes

Pour les maladies à haut risque dont la surveillance est fondée essentiellement sur des réseaux de collecte passive des données, par exemple dans le cas du suivi des suspicions cliniques, la stimulation de la vigilance peut être effectuée par des exercices périodiques de simulation d'alertes sur le terrain. Les acteurs s'entraînent alors à réagir lors de l'apparition de la maladie et, à cette occasion, la sensibilisation est réactivée.

La synergie des actions

Pour les maladies à haut risque le permettant, en particulier celles qui présentent des cycles épidémiologiques complexes avec différents réservoirs sauvages, l'efficacité globale de la détection est améliorée si le système de surveillance comprend plusieurs branches ou plusieurs réseaux de surveillance. Ainsi, à une surveillance passive des suspicions cliniques, il est possible, dans certains cas, d'adjoindre une surveillance active (sérologique par exemple) de la même espèce ou d'espèces sauvages réceptives (exemples : l'infection à virus West Nile ou la peste porcine classique). Malgré les limites de chacune de ces surveillances, leur association augmente de manière importante la sensibilité globale du système.

Par ailleurs, l'existence de réseaux de surveillance globale, par espèce animale ou groupe d'espèces, des maladies présentes sur le territoire, est également un élément favorable à la surveillance des maladies exotiques à haut risque. En effet, les échanges dans ces réseaux et le fait que les espèces animales concernées fassent l'objet d'une surveillance permettent la remontée assez rapide d'éventuels éléments alarmants nouveaux, à la condition que ces réseaux soient préparés à identifier et à investiguer ces événements. Ces réseaux permettent donc d'améliorer la sensibilité globale de la détection de certaines maladies à haut risque.

Valoriser les résultats de l'analyse et de la prévision du risque

La satisfaction de tous les critères qui viennent d'être énoncés nécessite des systèmes complexes et souvent coûteux à mettre en place et surtout à maintenir dans la durée. L'utilisation des données issues de l'analyse du risque et de la modélisation de l'évolution des risques majeurs permet de concentrer les efforts de surveillance sur les zones ou pendant les périodes qui auraient été identifiées pour présenter un risque plus important d'apparition de la maladie surveillée. Cette méthode permet à la fois une économie de moyens et un renforcement de la sensibilité de détection dans les zones de plus fort risque comme peut l'illustrer la surveillance de la fièvre catarrhale ovine dans le Sud de la France. En effet, les résultats de la surveillance épidémiologique et entomologique de la fièvre catarrhale ovine dans l'ensemble du bassin méditerranéen ont permis d'élaborer une cartographie des zones à risque d'apparition des vecteurs et de la maladie (20). Dans le Sud de la France, cette modélisation spatiale du risque est utilisée par le ministère chargé de l'agriculture pour orienter la pose des pièges entomologiques et pour réaliser la surveillance sérologique active des cheptels (6).

En retour, les données issues de la surveillance épidémiologique vont alimenter les analyses et les modèles et permettre d'en accroître la précision. L'étroite association de la surveillance, de l'analyse du risque et de la modélisation agit ainsi comme un processus itératif aux bénéfices réciproques.

Spécificité de la détection

Définition

Pour une maladie donnée, la spécificité de la surveillance consiste à ne détecter que les cas (11), afin de limiter au maximum les fausses alertes.

Actions nécessaires pour obtenir une bonne spécificité

La définition du cas surveillé

Elle joue également un rôle sur la spécificité du système d'épidémiovigilance. En effet, plus la définition sera précise et étroite et plus cela limitera le nombre de suspicions enregistrées. Cependant, sensibilité et spécificité sont liées et opposées, et donc, si la définition du cas surveillé est extrêmement précise, cela risque de diminuer la sensibilité du dispositif.

La compétence des laboratoires

Dans le cas de la surveillance de suspicions cliniques (qui, par nature, ne sont pas très spécifiques d'une maladie donnée), il faut que les tests de laboratoire pratiqués assurent une bonne spécificité de la détection afin d'éviter les fausses alertes. Ceci dépend du niveau de performance des laboratoires qui doit être garanti par des procédures d'assurance qualité et des essais inter-laboratoires. Par ailleurs, les laboratoires sauront d'autant mieux assurer la spécificité de la surveillance qu'ils sont capables d'effectuer le diagnostic des principales maladies pouvant être confondues cliniquement avec la maladie surveillée.

Simplicité du système

Définition

Un système de surveillance simple est un système dont les circuits de collecte, de centralisation des données et de diffusion de l'information sont les plus courts et directs possibles. Ceci doit permettre de limiter au maximum les déperditions de données et de rendre le système compréhensible et acceptable par tous les acteurs.

Actions nécessaires pour obtenir une bonne simplicité

Un moyen pour assurer la simplicité du système de surveillance est de faire participer des acteurs de terrain à son élaboration ce qui a, de plus, l'avantage d'augmenter leur motivation et leur sensibilisation par leur implication dans l'organisation du réseau. Par ailleurs, lors de la création du réseau il convient de veiller à n'avoir qu'un nombre restreint de niveaux et de circuits (Fig. 1).

Adaptabilité du système

Définition de l'adaptabilité du système

L'adaptabilité d'un système correspond à sa capacité à continuer d'être efficace dans une situation qui ne correspond pas exactement à ce qui a été prévu et organisé. Or, dans le cas des risques accidentels ou provoqués, cette qualité est très importante car, par définition, ces risques peuvent être particulièrement inattendus, que ce soit par leur nature (maladie nouvelle ou émergence surprenante d'une maladie existante), la zone géographique atteinte (en 2001, le Royaume-Uni n'était pas considéré comme le pays d'Europe le plus à risque pour la réapparition de la fièvre aphteuse) ou les modalités de leur survenue (l'intervention du bioterrorisme peut faire que les modalités d'introduction de la maladie échappent aux critères épidémiologiques connus).

Actions nécessaires pour obtenir une bonne adaptabilité

S'il est par définition impossible de prévoir l'imprévu, il est nécessaire de donner aux réseaux de surveillance épidémiologique les moyens de réagir efficacement à une modification des données de base de la surveillance. Des réponses sont à trouver dans les domaines de l'organisation et des outils de surveillance.

On augmentera l'adaptabilité d'un réseau de surveillance en développant un niveau suffisant de décentralisation de la prise de décision. Lorsque les réseaux sont conçus comme des systèmes hiérarchisés et formalisés, l'excès de centralisation et de formalisme peut conduire à une déresponsabilisation des acteurs de terrain. Celle-ci non seulement entraîne une démotivation des acteurs dans le cadre du fonctionnement normal du réseau, mais les empêche de réagir efficacement en adaptant leur comportement aux événements imprévus, notamment s'ils se sentent prisonniers de procédures trop restrictives ou complexes. Il convient donc de développer des réseaux avec une organisation institutionnelle ouverte permettant une décentralisation de la prise de décision et donnant aux acteurs de terrain le pouvoir d'influer sur l'organisation du réseau et une part de responsabilité dans l'orientation des investigations.

Si la formalisation est une réponse adéquate à la gestion d'un risque prévu, la gestion de l'imprévu bénéficiera, entre autres, de l'exploitation des systèmes informels. Il convient en effet d'exploiter les données non formalisées afin de les mettre en cohérence et de les transformer en indicateurs précoces porteurs de signification. Pour cela, il faut mettre en place les outils de communication qui permettent une réelle mise en réseau des intervenants de terrain (et pas seulement des systèmes de communication verticaux et hiérarchisés) tels que le permettent les nouvelles technologies de l'information (saisie et échange de données depuis le terrain à l'aide d'assistants personnels numériques par exemple) (11).

En second lieu, il est intéressant de développer les outils permettant l'exploitation des données informelles qui

circulent au sein des réseaux d'intervenants de la surveillance ainsi qu'au sein des grands réseaux mondiaux de l'information, comme le réalisent l'Organisation mondiale de la santé animale (OIE) ou l'Organisation mondiale de la santé. En parallèle, il est important de mettre en place des groupes d'experts pluridisciplinaires qui seront à même d'interpréter ces données et de proposer des investigations complémentaires.

Rapport coût/efficacité

Définition

On peut considérer que pour les maladies à haut risque, l'efficacité d'un système de surveillance est caractérisée essentiellement par sa capacité à détecter précocement tous les cas. Le rapport coût/efficacité du système de surveillance correspond donc à la relation entre la sensibilité du réseau et son coût. Par ailleurs, la durabilité d'un système de surveillance est conditionnée, entre autres, par un coût raisonnable permettant d'assurer la pérennité du financement.

Actions nécessaires pour obtenir un bon rapport coût/efficacité

Si l'on souhaite un bon rapport coût/efficacité, il ne faut pas prétendre à une détection exhaustive, et il est nécessaire de définir un niveau de sensibilité optimal. Ainsi, la sensibilité de la surveillance active de la peste porcine classique par sérologie à l'abattoir ne pourrait être de 1 que si tous les porcs abattus faisaient l'objet d'une recherche sérologique, ce qui, sur le plan financier, n'est pas acceptable. On se contente donc de définir un taux de prévalence limite que l'échantillonnage réalisé permet de détecter. Ceci est possible car ce type de surveillance est complété par une surveillance passive des suspicions cliniques.

On peut envisager de privilégier un échantillonnage ciblé (vers une sous-population à haut risque, par exemple, celle des animaux importés de pays à risque) par rapport à un échantillonnage aléatoire. Par ailleurs, la réduction des coûts peut être obtenue, lorsque cela est possible, par l'emploi de tests de dépistage de troupeau plutôt que de tests individuels.

La pérennité du financement est souvent conditionnée par une bonne communication des résultats du réseau vers les décideurs et donc les financeurs. Des évaluations régulières du réseau grâce à des indicateurs de performance (14) ou par des audits externes (10) sont également des atouts majeurs auprès de décideurs pour assurer la pérennité du financement.

Quelques exemples de réseaux de surveillance épidémiologique de maladies animales vont permettre d'illustrer ces notions générales.

Exemples

La surveillance de la fièvre aphteuse en Europe

Caractéristiques de la maladie

Maladie animale hautement diffusible, la fièvre aphteuse représente un risque sanitaire majeur pour l'Europe. L'épizootie britannique de 2001 (7) a clairement mis en lumière les conséquences dramatiques d'une détection tardive et, par suite, l'importance d'une détection précoce grâce à un système sensible. Les bovins et les porcins étant très sensibles à la maladie et l'incubation étant très courte, il serait illusoire de vouloir détecter l'apparition de la fièvre aphteuse dans ces espèces par une surveillance sérologique. Les systèmes de surveillance en Europe correspondent donc à une surveillance passive des suspicions cliniques.

Description du système de surveillance

Le schéma général de la surveillance de la fièvre aphteuse en Europe présenté dans la Figure 2 est défini par des textes réglementaires au plan européen (3). Chaque État membre doit faire la preuve de la mise en place d'une telle surveillance sur son territoire.

À partir d'une alerte clinique (la suspicion légitime est fondée sur l'apparition de lésions buccales ou podales de ruminants ou de porcins) signalée par un vétérinaire sollicité par un éleveur, des prélèvements sont réalisés sous la responsabilité de l'autorité vétérinaire locale et adressés au laboratoire agréé pour ce diagnostic. Pendant l'attente de la réponse, l'exploitation placée sous surveillance est bloquée (13).

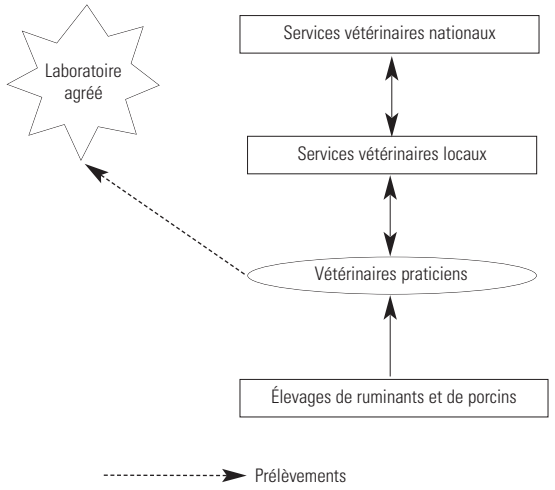

Fig. 2
Schéma du fonctionnement du réseau fièvre aphteuse en Europe

Degré d'efficacité

Il est difficile d'évaluer le fonctionnement global du système en Europe car il est très dépendant des réseaux nationaux ainsi que l'a montré l'épizootie de 2001. Chaque État membre est responsable de la sensibilisation de ses acteurs du réseau de vigilance. À travers le seul nombre de suspicions recensées chaque année par chaque État, il n'est pas aisé de se faire une idée précise de l'efficacité globale du dispositif. L'épizootie européenne de 2001 a dramatiquement mis en évidence des carences de la détection précoce en Grande-Bretagne. La France et les Pays-Bas, déjà alertés par la situation britannique, ont réagi plus rapidement.

En 1997, le réseau français a fait l'objet d'un audit (17) qui a conclu que son fonctionnement était globalement satisfaisant. Néanmoins, par rapport aux critères d'efficacité définis précédemment, il apparaît tout de même d'une sensibilité assez limitée : le nombre de suspicions enregistrées annuellement est faible, rapporté au nombre d'animaux des espèces sensibles ; par contre, ce nombre a été multiplié par six l'année de l'épizootie britannique. Par ailleurs, le réseau est assez simple et bien adapté. Le rapport coût/efficacité de ce système n'a jamais été établi, mais le coût du réseau est tout à fait modique comparé au coût du plan d'urgence fièvre aphteuse français.

La surveillance de la peste porcine classique en Europe

Caractéristiques de la maladie

La peste porcine classique est une maladie infectieuse, très contagieuse, spécifique des suidés. Cette maladie est très redoutée car elle provoque des pertes importantes en élevage et, en conséquence, fait l'objet d'une politique d'éradication au plan européen (2). La durée d'incubation est assez variable (de 4 à 30 jours) et il existe une grande diversité des formes cliniques. La peste porcine classique dans les élevages porcins est en voie d'éradication en Europe (19) ; par contre, cette maladie est présente chez les sangliers d'un certain nombre de régions européennes dont les Pays-Bas, l'Allemagne, le Luxembourg, la Belgique et le nord-est de la France (16).

Description du système de surveillance

La surveillance de la peste porcine en Europe repose sur trois réseaux parallèles : une surveillance passive de toutes les suspicions cliniques, dont le fonctionnement est voisin du réseau d'épidémiovigilance de la fièvre aphteuse ; une surveillance active sérologique d'un certain nombre de porcs à l'abattoir chaque année et une surveillance active de la faune sauvage par des prélèvements de sang sur des sangliers abattus à la chasse dans les zones infectées. La Figure 3 récapitule la description du système de surveillance pour la France (8, 9).

Degré d'efficacité

Comme pour la fièvre aphteuse, il est difficile de faire une évaluation globale de l'efficacité du réseau en Europe. Par ailleurs, l'efficacité de chaque type de surveillance est différente. Ainsi, le niveau de sensibilité de la surveillance passive des suspicions cliniques dépend du niveau de sensibilisation des acteurs de terrain (en particulier de celui des éleveurs). Le nombre de suspicions déclarées est un indicateur à suivre. La simplicité et l'adaptabilité de ce type de surveillance sont bonnes. Quant au coût, il est relativement modique.

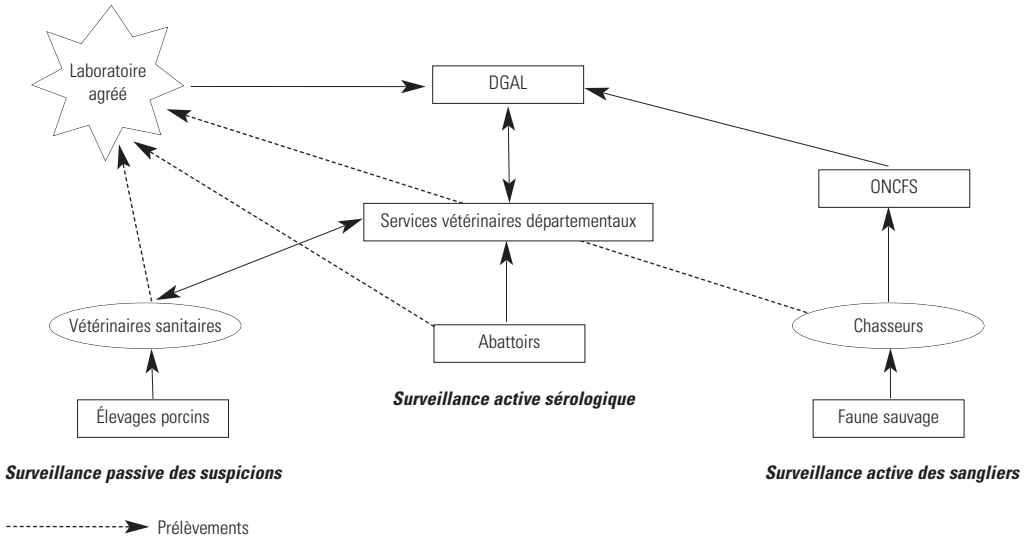

Fig. 3
Schéma du fonctionnement du système de surveillance de la peste porcine en France

DGAL: Direction générale de l'alimentation : direction française des Services vétérinaires
ONCFS: Office national de la chasse et de la faune sauvage

En ce qui concerne la surveillance sérologique active à l'abattoir, la spécificité du système de surveillance est liée à la spécificité des réactifs utilisés et peut être qualifiée de bonne. Par contre, la sensibilité de ce type de surveillance est directement liée à l'échantillonnage réalisé. En France, par exemple, chaque année 10 000 sérums de porcs reproducteurs font l'objet d'un échantillonnage aléatoire.

Le rapport coût/efficacité du système est, dans ce cas, un facteur déterminant ; en effet, la maladie étant *a priori* absente des territoires surveillés, une bonne sensibilité de la surveillance implique de prendre un effectif à contrôler trop élevé pour être économiquement acceptable. L'effectif actuel ne permet que de détecter un « taux de prévalence limite » déjà élevé. Dans ce cas, afin d'améliorer la détectabilité, il convient de cibler l'échantillonnage sur les élevages les plus à risque (élevages ayant un fort taux d'introduction, par exemple).

La surveillance active de la faune sauvage, à partir du moment où elle se déroule aussi autour des zones infectées, permet de suivre, à moindre coût, l'éventuelle progression géographique de l'infection et de prendre d'éventuelles mesures de surveillance, renforcées en particulier pour les porcs élevés en plein air qui constituent une cible majeure de contamination par les sangliers infectés.

La surveillance de l'infection à virus West Nile aux États-Unis d'Amérique et en France

Caractéristiques de la maladie

L'infection à virus West Nile est une arbovirose. Le cycle épidémiologique de la maladie fait intervenir des moustiques ornithophiles, principalement du genre *Culex*, qui assurent la transmission chez les oiseaux hôtes amplificateurs du virus West Nile, à la fois réservoirs et victimes de l'infection selon les espèces. Certains mammifères peuvent également être affectés par la maladie, mais constituent le plus souvent des impasses épidémiologiques. Le virus est en particulier responsable de l'apparition d'encéphalites graves chez l'homme et le cheval. Touchés pour la première fois en 1999, les États-Unis d'Amérique ont été le théâtre de la plus grande épidémie/épizootie d'infection à virus West Nile jamais décrite, avec la totalité des États touchés en trois ans de développement de l'infection. En France, dans le Sud (région camarguaise principalement), on identifie épisodiquement des foyers.

Description du système de surveillance

La complexité du cycle épidémiologique de la maladie conditionne les modalités de surveillance qui associent des techniques passives et actives dont l'objectif est la détection précoce de toute circulation virale, dans le but de diffuser des messages de prévention à l'attention des populations humaines et des propriétaires des populations animales à risque. Tous les éléments du cycle épidémiologique sont ainsi pris en compte :

a) surveillance passive :

– mortalité aviaire : détection de mortalité sur les espèces d'oiseaux sensibles à la maladie (notamment les corvidés aux États-Unis d'Amérique) ;

– maladie clinique des équidés : déclaration par les vétérinaires des manifestations cliniques pouvant être rapprochées d'une infection par le virus West Nile ;

– maladie clinique chez l'homme : déclaration des cas d'encéphalite par les hôpitaux ;

b) surveillance active :

– surveillance sérologique de l'avifaune : détection de conversions sérologiques sur des populations sentinelles (volailles aux États-Unis d'Amérique et canards en France) ;

– surveillance virologique des vecteurs potentiels : détection du virus dans des pools de vecteurs triés par espèce ;

– surveillance virologique des produits sanguins humains destinés à la transfusion.

Degré d'efficacité

Il est également difficile d'effectuer une analyse fine de l'efficacité des différentes activités de surveillance de l'infection par le virus West Nile aux États-Unis d'Amérique et en France. On constate cependant que, depuis 1999, ces systèmes ont permis de mettre en évidence un grand nombre de cas de la maladie tant chez l'homme que chez l'animal (Tableau I) et, avec la croissance de la sensibilisation à cette maladie, il semble que la sensibilité de la surveillance se soit améliorée au cours du temps (5).

L'analyse comparée des différentes modalités de surveillance a permis aux Centers for Disease Control and Prevention (États-Unis d'Amérique) de proposer un gradient de précocité et donc de sensibilité de détection de la circulation virale comme l'indique la Figure 4. Cette analyse place ainsi la surveillance passive de la mortalité aviaire (particulièrement importante aux États-Unis d'Amérique) parmi les outils à privilégier. Cette comparaison n'est cependant pas entièrement transposable à la situation française où la circulation du virus en 2000, 2003 et 2004 ne s'est jamais accompagnée d'une mortalité significative d'oiseaux. Ce constat illustre l'importance de l'adaptation des procédures de surveillance aux formes épidémiologiques de la maladie dans les zones ciblées par la surveillance. C'est ainsi que la surveillance sérologique de l'avifaune est utilisée en France comme outil d'alerte précoce malgré le coût et les difficultés pratiques de mise en œuvre de cette surveillance sur le terrain, notamment

Tableau I
Comparaison de l'incidence annuelle de l'encéphalite à virus West Nile aux États-Unis d'Amérique et en France, chez l'homme et chez le cheval, pour la période 1999-2003 (1)

Année	Cas humains				Cas équins			
	États-Unis d'Amérique		France		États-Unis d'Amérique		France	
	Cas [a]	Décès	Cas	Décès	Cas	Décès	Cas	Décès
1999	62 (0,27) [b]	7	0	0	25 (5)	9		
2000	21 (0,009)	2	0	0	60 (11)	22	76 (220)	21
2001	56 (0,24)	7	0	0	732 (138)		0	0
2002	4 156 (18)	284	0	0	15 257 (2 879)	4 500	0	0
2003	9 858 (43)	264	7 (0,11)	0	5 181 (978)		7 (20)	1

a) cas cliniques
b) les chiffres indiqués entre parenthèses correspondent à des taux d'incidences annuels en cas par million, les tailles de populations humaines et équines utilisées pour calculer ces taux étant issues de la base de données FAOStat (disponible en ligne à : http://faostat.fao.org/)

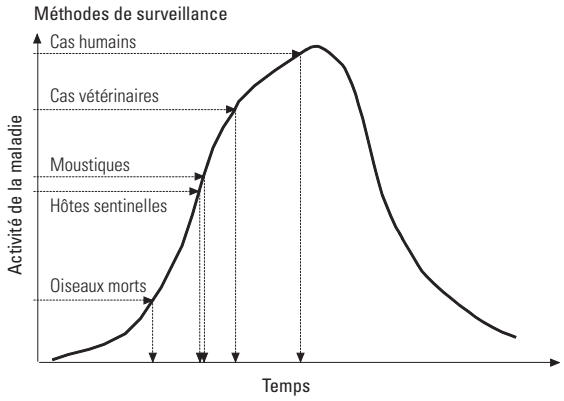

Fig. 4
Sensibilité estimée des modalités de surveillance de l'infection à virus West Nile aux États-Unis d'Amérique (Centers for Disease Control)

pour permettre de détecter de faibles niveaux de circulation virale sur le terrain.

Enfin, par l'importance de la maladie humaine et animale, la surveillance de la circulation du virus West Nile illustre également l'intérêt d'une organisation institutionnelle solide qui permette d'intégrer harmonieusement les surveillances animales et humaines (4).

La surveillance de la fièvre catarrhale ovine en France

Caractéristiques de la maladie

La fièvre catarrhale ovine (ou *bluetongue*), est une arbovirose non contagieuse, transmissible aux ruminants, qui affecte particulièrement les ovins. L'agent infectieux est un virus à acide ribonucléique de la famille des *Reoviridae*, genre *Orbivirus*, pour lequel 24 sérotypes ont été identifiés. Il n'y a pas de protection croisée entre les types viraux. Le virus de la fièvre catarrhale ovine est transmis par la piqûre d'un insecte diptère de la famille des Cératopogonidés : *Culicoides* spp. En Afrique et en Europe du Sud, c'est essentiellement *C. imicola* qui est responsable de la transmission de la maladie.

Depuis 2000, la maladie a fortement progressé dans l'ensemble du bassin méditerranéen en touchant un nombre croissant de pays (l'ensemble des pays du Maghreb, l'Espagne, la France, l'Italie, la Grèce et la Croatie). Cinq types du virus sont impliqués dans cette progression (1, 2, 4, 6, 16). Dans plusieurs pays méditerranéens, cette progression est à mettre en parallèle avec celle de la distribution de *C. imicola*.

Utilisation de l'analyse de risque et de la modélisation pour la surveillance

Les premiers signes de l'intérêt de l'utilisation des modèles pour la surveillance de la fièvre catarrhale ovine en France ont été manifestes lors de la première apparition de la maladie en Corse (France) en octobre 2000 (24), confirmant ainsi le premier modèle de distribution de *C. imicola* mis au point par Sellers et Mellor (22), qui montrait que la Corse présentait des conditions climatiques favorables à l'installation du vecteur. Ces modèles ont ensuite été affinés (20) et ont permis la mise au point de véritables cartes des risques d'installation du vecteur. C'est ainsi que la réalisation des piégeages entomologiques chargés de surveiller l'apparition de *C. imicola* en France continentale sont prioritairement orientés selon ces cartes des risques. Par ailleurs, elles mettent en évidence des zones d'exclusion du risque, ce qui permet d'économiser des moyens de piégeage et de renforcer la sensibilité de détection dans les zones à plus haut risque. Il a ainsi été possible d'avoir une sensibilité suffisante pour mettre en évidence l'installation du vecteur dans le département du Var en 2004. C'est sur cette même base que sont orientées les surveillances sérologiques et

cliniques, la carte des risques devenant ainsi un véritable outil de communication et de sensibilisation de l'ensemble des acteurs de la surveillance.

Conclusion

La détection précoce des maladies à haut risque repose le plus souvent, totalement ou en partie, sur une surveillance passive des suspicions cliniques. Ce type de surveillance doit être activé régulièrement par des actions de formation et de sensibilisation des acteurs de terrain sur qui l'efficacité du dispositif repose. Cependant, malgré les efforts, ce type de système reste fragile et quand la maladie le permet il convient de le croiser avec d'autres méthodes actives (sérologie dans les élevages ou sur la faune sauvage quand il y a lieu). Les méthodes de surveillance pour ces maladies doivent faire preuve d'adaptabilité et de réalisme. De ce point de vue, la comparaison des systèmes de surveillance de l'infection à virus West Nile entre les États-Unis d'Amérique et l'Europe est intéressante car il apparaît clairement que le comportement d'un même agent pathogène peut être différent sur deux continents et nécessite donc des modalité de surveillance différentes.

La sensibilité des réseaux de surveillance peut être notablement améliorée lorsque des travaux d'analyse et de modélisation du risque permettent d'orienter les activités et de concentrer les moyens de surveillance.

Enfin, il faut insister sur l'utilité des réseaux de surveillance globale de syndromes, ou de la mortalité par espèce animale ou par groupe d'espèces, qui permettent de détecter rapidement des incidents sanitaires pouvant être les premiers signes d'alerte pour des maladies à haut risque.

The design and establishment of epidemiological surveillance systems for high-risk diseases in developed countries

B. Dufour, P. Hendrikx & B. Toma

Summary
In animal pathology, epidemiological surveillance has, over the last two decades, gradually become a top priority in developed countries, due to progress made in fighting major animal diseases.
The management of effective epidemiological surveillance networks for high-risk animal diseases in developed countries is based on general rules governing epidemiological surveillance networks, but involves certain specificities. This article first of all sets out the requirements for the optimal functioning of epidemiological surveillance networks. It then describes and analyses the qualities expected of high-risk animal disease surveillance networks: detection sensitivity and specificity, simplicity and adaptability, and good cost efficiency. Finally, it illustrates these general concepts via four examples of animal disease epidemiological surveillance in developed countries: foot and mouth disease in Europe, West Nile virus in the United States of America and France, and bluetongue in France.

Keywords
Biological threat – Early detection – Epidemiological surveillance.

Creación y aplicación de sistemas de vigilancia epidemiológica de enfermedades de alto riesgo en los países desarrollados

B. Dufour, P. Hendrikx & B. Toma

Resumen

En materia de patología animal, y dada la positiva evolución de las principales enfermedades animales en los dos últimos decenios, la vigilancia epidemiológica ha pasado progresivamente a encabezar la lista de prioridades de los países desarrollados.

La gestión de redes eficaces de vigilancia epidemiológica de enfermedades animales de alto riesgo en los países desarrollados responde a las reglas generales de funcionamiento de este tipo de redes, aunque también conlleva ciertas peculiaridades. Los autores recuerdan en primer lugar cuáles son las modalidades de funcionamiento idóneo de una red de vigilancia epidemiológica, y después describen y analizan las cualidades que en principio deben presentar las redes de vigilancia de enfermedades de alto riesgo: sensibilidad y especificidad de la detección, simplicidad y adaptabilidad del sistema y buena relación entre costo y eficacia. Por último, ilustran esas nociones generales con cuatro ejemplos de vigilancia epidemiológica zoosanitaria en países desarrollados: la fiebre aftosa en Europa; la peste porcina en Europa; la infección por virus West Nile en los Estados Unidos de América y Francia; y por último la fiebre catarral ovina en Francia.

Palabras clave

Amenaza biológica – Detección temprana – Epidemiovigilancia.

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La conception et la mise en œuvre de programmes d'épidémiosurveillance efficaces dans les pays d'Afrique subsaharienne

F. Bendali

Vétérinaire épidémiologiste, Coordination régionale pour l'Afrique de l'Ouest et du Centre, Programme panafricain pour le contrôle des épizooties, B.P. 2954, Bamako, Mali

Résumé

L'élevage représente l'une des principales richesses des pays en développement. L'amélioration du cheptel national et de sa productivité par un contrôle des principales maladies et la prévention des épizooties est un objectif majeur des pays. L'organisation des systèmes de surveillance des maladies est désormais incontournable pour une bonne gestion de la santé animale tant au plan national qu'international. Ainsi, les pays en développement ont progressivement mis en place des réseaux d'épidémiosurveillance (RES) malgré des contextes défavorables (pauvreté, manque de ressources ou d'infrastructures…) et grâce à des aides extérieures. À ce jour, de nombreux réseaux fonctionnent de manière satisfaisante et produisent des résultats tangibles. Néanmoins, des efforts demeurent indispensables pour améliorer la qualité des informations sanitaires produites, leur performance, et leur pérennisation. Cet article passe en revue le contexte et les motivations de la mise en place des RES dans les pays en développement, particulièrement en Afrique, en décrivant quelques-unes de leurs particularités de fonctionnement, et quelques résultats. Enfin, il présente l'exemple du réseau mauritanien d'épidémiosurveillance des maladies animales dans la gestion d'une crise sanitaire.

Mots-clés

Afrique subsaharienne – Épidémiosurveillance – Épizootie – Pays en développement.

Introduction

Dans les pays en développement, l'élevage représente l'un des principaux piliers de l'économie nationale. Son importance tient à ses aspects économiques (commerce, capital, épargne, outil de travail), sociaux (statut, hiérarchie, culture…) et alimentaires (consommation de lait, viande, œufs…).

La forte croissance démographique des pays pauvres, le changement socio-économique (exode rurale, urbanisation, changements environnementaux), la faible performance du sous-secteur de l'élevage traditionnel (par opposition à l'élevage intensif périurbain) et l'amplification des échanges commerciaux sont à même de favoriser, à terme, le risque d'une catastrophe sanitaire (grandes épizooties, zoonoses, etc.) (1, 15).

Des maladies animales spécifiques jadis éradiquées de certaines régions (Europe) telles que la péripneumonie contagieuse bovine, la fièvre aphteuse, la rage ou la tuberculose restent enzootiques dans de nombreux pays en développement selon les informations sanitaires déclarées (14). De même, la résurgence de certaines maladies ou d'anciens fléaux comme la peste bovine (en voie d'être éradiquée du continent africain) ou certaines zoonoses (fièvre de la Vallée du Rift, rage…) peuvent avoir des conséquences dramatiques. Ces risques sont réels non seulement dans les pays pauvres, mais également dans les pays développés en raison de l'accroissement du commerce et des échanges internationaux (1).

Pour prévenir les catastrophes sanitaires et préserver le cheptel, et en dépit de leurs contextes, les pays en développement s'attèlent à l'amélioration de leur Service

public vétérinaire, notamment dans la surveillance et la prévention des maladies animales. De plus, afin de respecter les engagements internationaux en termes d'échanges d'animaux (et de produits d'origine animale), les pays en développement doivent satisfaire certaines exigences vis-à-vis de la qualité des services vétérinaires (3, 12).

Pour toutes ces raisons, de nombreux pays ont mis en place des systèmes ou réseaux d'épidémiosurveillance (RES) durant ces dernières années.

À l'instar des pays développés, la surveillance des maladies animales dans les pays en développement est menée en suivant les mêmes méthodes, basées sur le principe de recueil d'observations et de données zoosanitaires enregistrées de façon continue puis analysées afin de servir à adopter des mesures de lutte efficaces.

Le fonctionnement global et les principes de surveillance des maladies étant abordés en détail dans d'autres articles (3, 10), y compris dans ce numéro spécial de la *Revue* (9), nous nous concentrerons dans cet article sur les propriétés des RES dans les pays en développement, plus particulièrement dans les pays de l'Afrique subsaharienne, en abordant : le contexte de leur mise en place, et certains aspects parmi les plus importants de leur organisation et de leur fonctionnement.

La surveillance épidémiologique en Afrique subsaharienne

Après avoir passé en revue l'intérêt, l'importance et la nécessité de la gestion de la santé animale, notamment par la surveillance et le contrôle efficaces des maladies, nous en présenterons les aspects les plus significatifs.

Contexte de lancement des réseaux d'épidémiosurveillance

De manière générale, la maîtrise de la situation sanitaire dans un pays est motivée par plusieurs enjeux :

a) le risque d'apparition d'une maladie hautement contagieuse et économiquement grave dans un troupeau qui provoquerait des pertes pour l'éleveur,

b) la crainte d'introduction ou de résurgence d'une épizootie dans une zone ou totalité du territoire qui décimerait le cheptel,

c) les pertes économiques consécutives à la suspension ou l'interdiction des exportations à des pays tiers,

d) le respect des engagements internationaux en matière d'échanges (conventions bilatérales, Accord sur l'application des mesures sanitaires et phytosanitaires de l'Organisation mondiale du commerce, Organisation mondiale de la santé animale [OIE], Organisation mondiale de la santé, etc.).

Dans le contexte particulier des pays en développement, la connaissance de la situation sanitaire peut manquer de précisions et de formalisation. En outre, les énormes efforts accomplis dans l'éradication ou la maîtrise de certaines maladies graves ayant provoqué des épidémies dévastatrices par le passé (peste bovine, peste porcine africaine, péripneumonie contagieuse bovine, fièvre aphteuse) justifient une veille permanente et efficace afin d'en prévenir toute résurgence et de pouvoir réagir promptement face à la première suspicion.

C'est ainsi que ces pays ont été accompagnés et amenés progressivement à organiser et améliorer le fonctionnement de leurs services vétérinaires afin de les rendre plus performants, notamment par la création de réseaux de surveillance efficaces tout au long de cette dernière décennie.

Nous nous inspirerons fortement dans cet article de l'expérience de terrain et d'exemples concrets de la trentaine de pays africains ayant participé au Programme panafricain pour le contrôle des épizooties (PACE) (6, 7).

Organisation structurelle

Les réseaux de surveillance des maladies dans les pays en développement sont dans leur quasi-totalité, des réseaux nationaux couvrant l'ensemble du territoire, à l'exception de quelques rares situations où le réseau repose sur une structure régionale autonome (ou fédérale) ou quelquefois sur des zones spécifiques, par exemple s'agissant de la surveillance de la fièvre de la Vallée du Rift dans certaines région spécifiques au Sénégal et dans le delta intérieur du Niger au Mali (6, 7).

Du point de vue structurel, la plupart des pays ayant mis en place des RES, notamment les pays francophones, se sont généralement inspirés d'un modèle classique – qui se superpose à la structure existante des Services vétérinaires – avec une organisation pyramidale comprenant : un organe décisionnel et stratégique, le « Comité de pilotage », qui regroupe les personnes ou institutions en charge des orientations globales, de la politique de la santé animale, de la validation et de l'évaluation (ministères, directions générales…) ; un organe scientifique et technique, le « Comité technique » composé de personnalités ou institutions scientifiques en charge de l'élaboration des protocoles de surveillance, de l'analyse des données et de la formation ; une instance centrale

de coordination, « Unité centrale », responsable du suivi quotidien et de l'animation ; le tout reposant sur des acteurs régionaux et des agents de terrain qui récoltent et transmettent les données (Fig. 1) (8). L'officialisation des RES est souvent traduite par des textes réglementaires (décrets, arrêtés), même si parfois ces structures manquent de régularité (réunions irrégulières des instances) (6, 7). Quand ils sont élaborés et utilisés, les termes de référence ainsi qu'un guide (ou charte) de fonctionnement sont des outils appréciables et utiles aux intervenants à chaque niveau hiérarchique. Ils permettent une standardisation des activités et une certaine garantie de la qualité du travail accompli.

Politique et stratégie nationales

Parce qu'il est nécessaire de prendre des décisions en connaissance de cause et de réagir promptement, il est indispensable que les données collectées sur le terrain soient précises, complètes et pertinentes. La capacité de collecter des données en permanence, ainsi que la vitesse de transmission pour les analyser en vue d'une réaction immédiate, constituent un indicateur de la performance des Services vétérinaires (8, 11). À cet effet, la politique globale de l'élevage et la stratégie nationale de contrôle des maladies sont fondamentales (15). Nous constatons une similitude dans la politique globale des pays à contextes

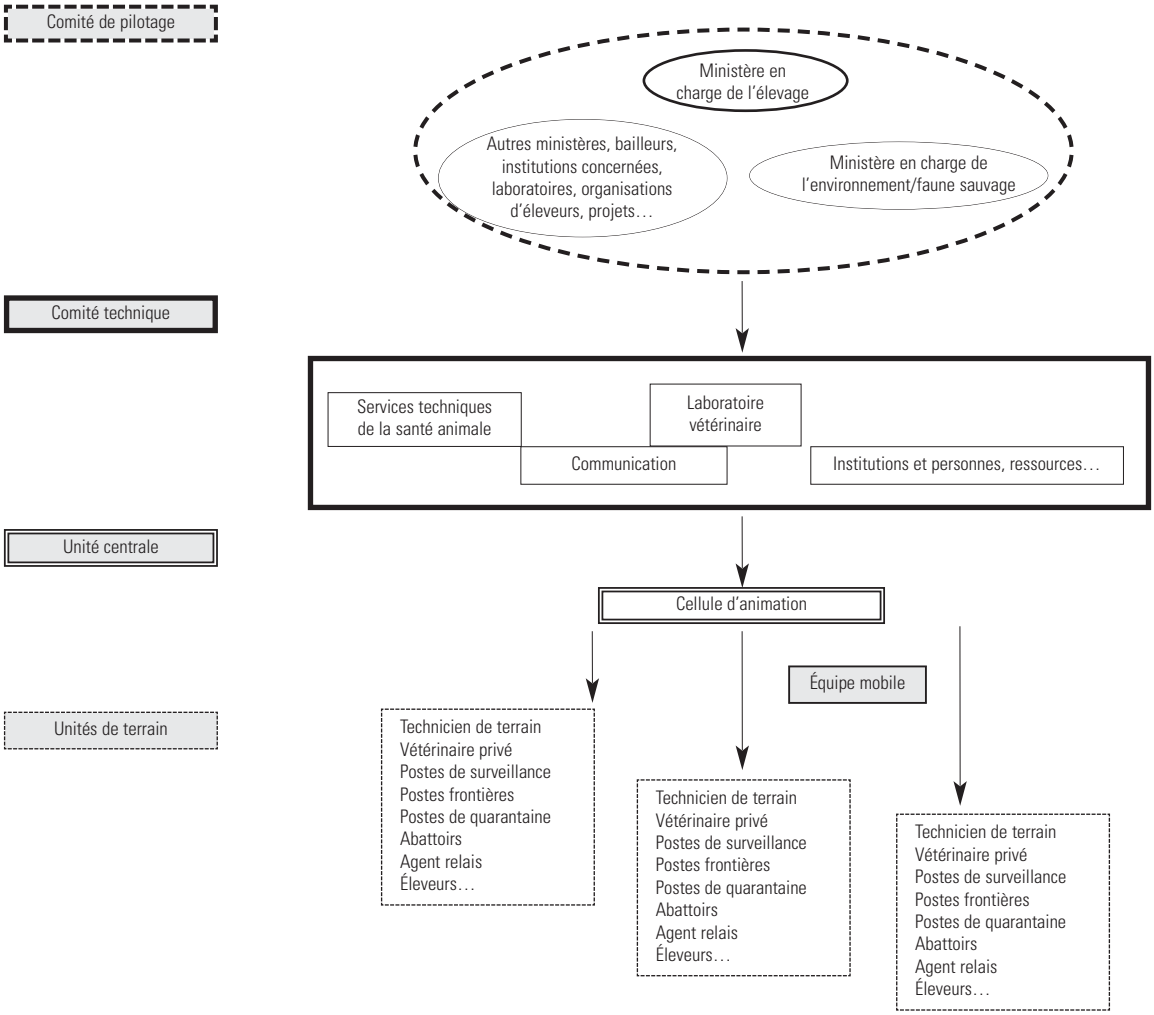

Fig. 1
Organisation structurelle d'un réseau d'épidémiosurveillance dans les pays subsahariens
La figure illustre le schéma usuel des réseaux d'épidémiosurveillance avec son instance décisionnelle, le « Comité de pilotage » (en traits discontinus). L'autre instance du réseau est le « Comité technique » (en encadré gras), la troisième instance est la « Cellule d'animation » (en double encadré) composée d'une équipe ou « Unité centrale » réduite chargée de la coordination et de l'animation quotidienne du réseau. En fin, les « Unités de terrain » (en pointillés) représentées par tous les acteurs

régionaux semblables et qui connaissent les mêmes maladies prioritaires… En revanche, les aspects techniques (plans de lutte, protocoles, gestion des crises, police sanitaire…) ne sont pas systématiquement et clairement détaillés ou suffisamment définis (6, 7, 16). Dans le même sens, certainement par manque de moyens, le fonds d'urgence ou de calamités est budgétisé et inscrit dans le budget des états sans pour autant en garantir la diligence et les modalités de son déblocage en cas de besoin. C'est ainsi qu'on peut parfois observer des retards dans la mise en place des mesures de lutte pour stopper une épizootie et donc le risque de sa propagation (ce fut le cas de la peste porcine africaine entre 2000 et 2003 dans certains pays côtiers du Golfe de Guinée : Ghana, Togo et Bénin) (1).

Afin de pallier ces contraintes de mobilisation des fonds d'urgence, notamment lorsqu'il s'agit de grave épizootie dans un contexte régional, une coordination supranationale peut être envisagée sous l'égide d'institutions internationales (OIE, Organisation des Nations Unies pour l'alimentation et l'agriculture [FAO], Union africaine-Bureau interafricain des ressources animales [UA-IBAR], etc.). Nous citerons l'exemple de la peste bovine pour laquelle un fonds d'urgence commun aux pays du PACE a été confié à l'OIE pour pouvoir être rapidement mobilisé et déployé en cas de réapparition de cette épizootie.

Financement

La lutte contre les maladies repose évidemment sur des actions onéreuses. Ce coût est principalement attribué aux activités de surveillance en continu (moyens matériels, suivi, communication, etc.), d'une part, et à la gestion des crises éventuelles, d'autre part (indemnisation des éleveurs, abattage, campagnes de vaccination, mobilisation humaine et matérielle, etc.).

Bien que la politique nationale de l'élevage, le contrôle des maladies prioritaires et les activités de surveillance relèvent de l'activité régalienne des Services publics vétérinaires nationaux, les pays en développement ne disposent pas des moyens humains et matériels suffisants pour en assurer la bonne exécution (6, 15). Néanmoins, la mise en place et le démarrage des activités ont pu se réaliser dans la majorité des pays. Les uns saisissant l'opportunité de programmes régionaux financés par des aides publiques internationales (Union européenne [UE], FAO, etc.) pour démarrer des programmes de grande envergure comme le Programme africain d'éradication de la peste bovine ou le PACE, les autres bénéficiant de programmes d'assistance nationaux (programme de coopération technique de la FAO, Banque africaine de développement) ou bilatéraux (coopération de pays divers, etc.).

L'exemple le plus récent et le plus significatif est le programme régional PACE – financé principalement par l'UE et exécuté par l'UA-IBAR – qui visait particulièrement l'appui aux Services publics vétérinaires notamment à travers l'installation et l'amélioration de la surveillance des maladies dans les pays africains subsahariens.

La période de mise en place et de lancement des RES s'est étalée sur quelques années ; saisissant la disponibilité des fonds, elle concernait essentiellement la réalisation des gros investissements, la logistique, l'acquisition du matériel de diagnostic et les formations des acteurs (6).

Une fois passée cette période de démarrage, exigeante et très budgétivore, les pays prévoient de contribuer progressivement au financement de leurs RES pour se substituer – au moins partiellement – à l'aide étrangère. Le but ultime étant d'atteindre à moyen terme, un niveau d'autofinancement pour un fonctionnement pérenne et acceptable. L'expérience a malheureusement montré par endroits, qu'on assistait à un fléchissement, voire à un arrêt ou à une suspension des activités de surveillance épidémiologique dès la fin de la subvention ou la clôture du projet de développement (6).

En effet, on peut également comprendre que le contexte politico-économique des pays (stabilité, pauvreté) conditionne les moyens alloués à l'élevage et à la santé animale en particulier. Ce point critique de carence de financement demeure donc très préjudiciable à une bonne surveillance des maladies et à fortiori à leur contrôle. Néanmoins, conscients de cela, certains pays tels que le Mali, le Sénégal ou le Tchad se sont attelés tout récemment à inciter davantage l'implication financière de l'État dans la surveillance épidémiologique. Le gouvernement du Burkina Faso assure pour sa part, près de la moitié (43 %) du fonctionnement des activités. D'autre part, des pays comme la Guinée Bissau ou la République du Congo montrent des faiblesses à ce niveau pour diverses raisons (faibles enjeux de l'élevage et manque de structuration ou de moyens, respectivement) (7).

Les activités de surveillance

Les activités de surveillance peuvent se synthétiser en deux grandes parties :

a) l'une, sur le terrain, en charge de la surveillance, de la détection des cas et de la transmission des données,

b) l'autre, centrale, en charge de la coordination, de l'analyse et de la synthèse des données pour en produire une informations sanitaire pertinente.

Au niveau central, l'animation est souvent confiée à une unité (de trois personnes au Tchad, à neuf cadres en Mauritanie, par exemple). Les compétences techniques – notamment en épidémiologie, gestion des données et

épidémiosurveillance – et la disponibilité de ce personnel varient d'un pays à l'autre.

Sur le terrain, les activités de suivi sont assurées principalement par des techniciens. Sous le label « techniciens vétérinaires de terrain » nous entendons l'ensemble de personnes ayant suivi une formation technique minimale. Leur cursus est certes, très hétéroclite, allant d'une formation de quelques jours ou quelques semaines pour les « auxiliaires », les « vaccinateurs » ou les « agents communautaires », à quelques années pour les « techniciens » ou « ingénieurs » d'élevage. Les compétences minimales attendues de ces techniciens sont la reconnaissance des signes cliniques des maladies surveillées, la connaissance des modalités de déclaration et l'application des premières mesures d'urgence éventuelles (6, 7).

Les vétérinaires qualifiés au sens universel sont très peu nombreux dans beaucoup de pays en développement et sont, pour la plupart, employés par les services publics au niveau de l'administration centrale notamment ou en tant que responsable régionaux.

Le maillage géographique et la couverture du territoire par ces techniciens – critère important de précision et d'efficacité – varient considérablement d'un pays à l'autre. Au Ghana par exemple, le gouvernement emploie près de 600 agents dans son système de surveillance épidémiologique, plus de la moitié d'entre eux étant impliqués dans la surveillance active et répartis sur les 329 postes d'observation ce qui représente une densité significative, comparativement à d'autres pays plus vastes avec beaucoup moins d'agents en poste (7). Au Mali, pays d'environ 1,2 million de kilomètres carrés, on dénombre 42 postes de surveillance et une centaine de vétérinaires mandataires pour un cheptel de 7 millions de bovins et 16 millions d'ovins et caprins, alors qu'en Guinée, pays d'une superficie six fois moindre et comptant 2,3 millions de bovins et 1,5 million de petits ruminants, il existe 31 postes de surveillance dédiés à la peste bovine et plus de 300 postes de surveillance.

Les vétérinaires privés, dont l'installation est en constante progression en raison des ajustements structurels et des limites de la fonction publique mais aussi d'une volonté politique, s'impliquent timidement dans les systèmes de surveillance nationaux. En effet, dans certains pays, leur adhésion reste très faible voire inexistante (Tchad) ; à l'inverse, ils sont activement mêlés aux RES (en Guinée, en Côte d'Ivoire, au Burkina Faso et au Sénégal). En Côte d'Ivoire, les praticiens privés couvrent près des deux tiers des postes de surveillance.

Les activités de surveillance de la faune sont relativement faibles en raison de leur complexité : elles exigent une sensibilisation particulière, requièrent une technicité élevée et nécessitent une coordination entre différentes institutions. Néanmoins, elles ont connu dernièrement une véritable impulsion dans quelques pays, du fait de la procédure de certification pour la peste bovine de l'OIE qui impose une surveillance dans toutes les espèces sensibles (6).

Les laboratoires vétérinaires

Concernant le laboratoire de diagnostic, les pays en développement disposent bien souvent d'un seul laboratoire national pouvant fournir les analyses de base (Centre national d'études et de recherches vétérinaires [CNERV] à Nouakchott en Mauritanie ; Laboratoire de recherches vétérinaires et zootechniques de Farcha, N'Djaména au Tchad ; Laboratoire national vétérinaire de Garoua au Cameroun, à titre d'exemples).

Pour illustrer leur préparation à faire face aux catastrophes sanitaires, nous mentionnerons le cas de la peste bovine. La majorité des 30 pays du PACE ont un laboratoire vétérinaire fonctionnel et équipé pour son diagnostic (à l'exception de six pays : Burundi, République démocratique du Congo, Gabon, République centrafricaine, Rwanda et Somalie). Les méthodes employées sont variées :

a) immuno-diffusion en gélose et ELISA d'immuno-capture pour la détection de l'antigène,

b) ELISA de compétition (c-ELISA) et dosage ELISA indirect (i-ELISA) pour la détection des anticorps,

c) sondes froides et d'amplification en chaîne par polymérase-transcriptase inverse (RT-PCR) pour la détection du génome nucléique (au Cameroun, en Éthiopie et au Mali).

En outre, trois laboratoires : le National Veterinary Research Centre de Muguga (Kenya), le Laboratoire central de pathologie animale de Bingerville (Côte d'Ivoire) et le Laboratoire national d'élevage et de recherches vétérinaires (LNERV) de Dakar (Sénégal) sont considérés comme laboratoires régionaux de référence de l'UA-IBAR. Ils emploient, en plus, des tests validés par l'OIE pour l'isolement et l'identification du virus : détection de l'antigène (immuno-diffusion en gélose, et ELISA d'immuno-capture), détection des anticorps (c-ELISA, i-ELISA, test de neutralisation virale [VNT]), détection de l'acide nucléique (sondes froides, RT-PCR) et séquençage (à Bingerville) (7).

Concernant les laboratoires provinciaux, en raison du manque de moyens, ils sont, soit inexistants, soit très peu fréquents ou encore non fonctionnels. Le Bénin se distingue par ses quatre laboratoires régionaux opérationnels où chacun est dédié à une maladie prioritaire (sorte de laboratoire de référence national).

Les autres partenaires de la santé animale

En dehors des professionnels de la santé animale au sens strict (vétérinaires, techniciens, Services publics vétérinaires), l'implication d'autres acteurs et institutions dans le contrôle des maladies est différemment appréhendée dans les pays. Certains ont privilégié et encouragé l'implication effective des éleveurs de manière directe, comme en Guinée, particulièrement dans le cadre de la lutte contre la péripneumonie contagieuse bovine et le rôle actif des comités de défense sanitaire sur le terrain. D'autres, de manière indirecte, à travers leurs associations et représentants, comme au Bénin où la participation des groupements et associations d'éleveurs aux instances est remarquable (6, 7). La coopération avec les services de santé publique est aussi observée dans certains pays où sévissent des zoonoses majeures ; c'est l'exemple de la fièvre de la Vallée du Rift au Sénégal (implication de l'Institut Pasteur) ou en Mauritanie (Comité interministériel) (5, 6).

Maladies concernées

L'autre particularité de ces réseaux est liée au fait qu'ils couvrent un certain nombre de maladies jugées prioritaires par les responsables nationaux (Tableau I). Il s'agit le plus souvent de maladies présentes dans le pays, et que les autorités tentent de contrôler, voire d'éradiquer. Il peut également s'agir de maladies désormais inexistantes dont l'exemple le plus courant en Afrique est la peste bovine, quasiment éradiquée.

Tableau I
Hiérarchisation des maladies majeures notifiables à l'Organisation mondiale de la santé animale (OIE) dans 17 pays africains en développement (5)

Maladie	Bénin	Burkina Faso	Cameroun	Congo	Côte d'Ivoire	Gabon	Guinée	G. Bissau	G. équatoriale	Mali	Mauritanie	Niger	RCA	RDC	Sénégal	Tchad	Togo	Priorité générale
Peste bovine	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Peste des petits ruminants	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Péripneumonie contagieuse bovine	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trypanosomose	1	1	2	2	1	2	3	3	3	2	3	3	1	2	3	1	1	1
Rage	1	1	2	3	1	3	3	3	3	3	1	2	2	2	3	3	1	1
Tuberculose bovine	1	1	2	2	1	3	3	3	3	2	3	2	3	3	3	1	1	1
Fièvre aphteuse	1	1	3	3	1	3	2	2	1	1	1	1	2	1	1	1	1	2
Maladie de Newcastle	1	2	1	1	1	1	3	1	1	2	3	2	2	2	1	2	1	2
Peste porcine africaine	1	1	1	1	1	1	2	1	1	3	3	3	3	1	1	3	1	2
Brucellose	1	1	3	2	2	3	2	3	3	3	3	3	2	3	3	1	2	2
Fièvre charbonneuse	3	1	2	3	2	3	3	3	3	2	3	2	3	3	3	3	1	2
Septicémie hémorragique	1	2	2	3	3	3	3	3	3	3	3	2	3	3	3	1	3	2
Dermatose nodulaire contagieuse	2	2	3	3	1	3	2	2	3	2	3	3	3	2	1	3	2	3
Fièvre de la Vallée du Rift	3	3	3	3	2	3	3	3	3	1	1	3	1	3	1	2	3	3
Clavelée et variole caprine	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	1	3	3
Maladie vésiculeuse du porc	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Stomatite vésiculeuse	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Influenza aviaire hautement pathogène	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Babésiose bovine	3	3	3	2	3	3	3	3	3	3	3	3	1	3	3	1	3	3
Cowdriose	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Echinococcose	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	1	3
Pleuropneumonie contagieuse caprine	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	3
Salmonellose (*S. abortusovis*)	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3
Épididymite ovine	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3
Théiléiose	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3

1 : haute priorité 2 : priorité moyenne 3 : faible priorité

RCA : République centrafricaine
RDC : République démocratique du Congo

Sur un échantillon de 17 pays africains, et à partir d'une liste de maladies relativement importantes ou répandues notifiables à l'OIE (celles de l'ancienne Liste A et quelques-unes de la Liste B), les épidémiologistes responsables des RES de ces pays ont hiérarchisé 25 maladies. La classification s'est déroulée principalement selon l'incidence ou la prévalence de la maladie, ses répercussions économiques, le contexte local de l'élevage et les objectifs de surveillance respectifs… (5). Si l'on examine les résultats de cette analyse (Tableau I), on peut constater que six d'entre elles, à savoir la peste bovine, la péripneumonie contagieuse bovine, la peste des petits ruminants, la trypanosomose, la rage et la tuberculose bovine, étaient quasi unanimement considérées comme majeures et de haute priorité. À un second niveau figurent la fièvre aphteuse, la maladie de Newcastle, la peste porcine africaine, la brucellose bovine, la fièvre charbonneuse et la septicémie hémorragique, dont le niveau de priorité était médian. Puis, en troisième niveau d'importance, les autres maladies telle que la dermatose nodulaire contagieuse et la fièvre de la Vallée du Rift…(5).

Communication

La communication est le résultat et le fruit des activités de surveillance consistant en la collecte puis la diffusion des informations sanitaires. Il s'agit d'un aspect déterminant, notamment lors des gestions des crises sanitaires ou d'épizooties. Les actions de communication à l'échelon national peuvent se distinguer selon deux voies, exposées ci-dessous.

Le volet ascendant ou centripète

Le volet ascendant ou centripète, provenant du terrain vers l'unité centrale, est essentiellement composé des messages d'alertes, de suspicions, de rapports mensuels, de diagnostics, de prélèvements, etc.

Cet aspect est capital pour déclencher l'alerte lors d'une suspicion légitime. Or dans les pays en développement, il est souvent difficile à mettre en œuvre pour plusieurs raisons, dont l'étendue du territoire, la faible densité des techniciens, ainsi que le manque de logistique de communication et de déplacement. Ceci est d'autant plus vrai dans les vastes pays sahéliens où l'élevage est majoritairement transhumant (Mali, Niger, Tchad…).

Le volet descendant ou centrifuge

Le volet descendant ou centrifuge, est analysé puis diffusé par l'unité centrale à destination des agents de terrains, des autorités, des institutions partenaires nationales ou internationales et des médias…

Ce dernier volet est aussi primordial que le précédent car de lui dépendent plusieurs paramètres tels que la remontée et le retour d'information sur le terrain, la prise de décision par les autorités, la transmission de l'information sanitaire aux instances régionales et internationales.

Occulter ou négliger ce volet conduirait inéluctablement à démotiver et discréditer des agents de terrain qui ne reçoivent pas de suivi de leurs investigations (soutien, résultats d'analyse…), à l'absence ou à l'inefficacité de réaction face à une suspicion ou foyer primaire d'une éventuelle épizootie (retard de prise de décision, propagation de la maladie…), et cela entacherait la crédibilité des autorités vis-à-vis de l'opinion internationale.

Dans les pays en développement, l'information sanitaire est véhiculée essentiellement à travers des rapports de situations ou des bulletins périodiques. Les rapports techniques réguliers sont souvent mensuels (à l'exception des messages d'alerte ou d'urgence type SR-1) et sont également expédiés à une fréquence plus ou moins variable à l'UA-IBAR et à l'OIE. À ce sujet, nous mentionnerons une nette progression des activités de rapports durant ces dernières années. En 2003, le pourcentage des rapports envoyés à l'OIE par les pays africains a atteint 91 % contre 69 % l'année précédente. Avec le même élan, le pourcentage des rapports expédiés à l'UA-IBAR a progressé de 12 % à 65 % entre 2001 et 2003. Bien que la détection des maladies se soit améliorée, il ne s'agirait pas pour autant d'une augmentation d'incidence : ce franc progrès est essentiellement attribué à la sensibilisation continue des autorités vétérinaires des pays et à leur engagement pour une régularité et une transparence de l'information (2).

Nonobstant l'augmentation de la soumission des rapports sur les maladies au niveau international au cours des dernières années, il reste encore à relever certains défis en matière de réactivité face à l'urgence, de standardisation des données, et d'amélioration de la qualité des rapports. Pour remédier à ces lacunes et assurer une standardisation et une codification suffisantes, l'UA-IBAR a par exemple, mis en place une base de données continentale appelée Base de données intégrée du PACE/Système d'information des ressources animales en Afrique (PID/ARIS) et accessible en plusieurs langues (français, anglais et portugais). S'agissant de la qualité des rapports, une attention particulière devrait être portée sur l'harmonisation du recueil des données, la cohérence des données, l'unité épidémiologique utilisée, les données sur les espèces sensibles potentielles, le manque de données géographiques et l'utilisation d'un système d'information géographique (SIG).

Concernant les revues ou bulletins sanitaires, ils connaissent une bonne dynamique de progression dans de nombreux pays africains sur le plan de la régularité et de la qualité. C'est l'exemple d'*EPIVET-Info* au Mali, du

SISAC-Info en Centrafrique ou du *Bulletin du Réseau d'épidémiologie des maladies animales du Tchad* (REPIMAT). Leur fréquence est souvent trimestrielle, ils sont destinés en premier lieu aux professionnels de la santé animale, même si parfois leur diffusion est plus large (6). Ces publications paraissent parfois en plusieurs langues dans certains pays, soit en langues officielles, soit en langues locales ou dialectes (wolof au Sénégal, arabe/français en Mauritanie). Quand à leur contenu, ces supports résument généralement, en quatre à huit pages, la situation sanitaire de la période écoulée, les foyers ou incidences des maladies surveillées, leur évolution, et développent des thèmes techniques choisis selon les circonstances.

Exemple du Réseau mauritanien d'épidémiosurveillance des maladies animales

Afin d'illustrer les observations mentionnées précédemment, il nous a semblé intéressant de citer un exemple de RES, celui de Mauritanie, le réseau mauritanien d'épidémiosurveillance des maladies animales (REMEMA). Ce choix est motivé par la récente suspicion de peste bovine et la gestion du risque d'éclatement d'une épizootie dans la sous-région en 2003 (4).

Depuis sa mise en place en 1999, le REMEMA a fait l'objet de quelques missions d'évaluation qui ont conclu à un système doté d'une bonne organisation, dynamique et fonctionnel. Le réseau produisait des résultats pertinents et son activité était en constante progression. Depuis son éradication (dernier foyer en 1983 et arrêt des vaccinations en 1998) et l'obtention du statut de pays indemne de la maladie auprès de l'OIE en 2003, la peste bovine fait l'objet d'une rigoureuse épidémiovigilence. Aussi, le REMEMA s'est attelé à la surveillance clinique et sérologique édictée selon les procédures internationales (OIE) tant sur le bétail que sur les espèces de la faune sauvage réceptives. Pour ce faire, il repose sur : 47 agents des postes de surveillance ; des éleveurs informateurs sensibilisés ; des fiches d'enquête épidémiologique de terrain (recherche de signes évocateurs) ; des rapports mensuels et des recherches cliniques et sérologiques aléatoires dans les troupeaux tirés au sort. Pour la faune sauvage, la surveillance est basée sur : des fiches spécifiques de surveillance ; un suivi par les agents du ministère du Développement rural ; une surveillance dans le Parc national du Diawling ; la collecte de sérums par l'Association des chasseurs et le campement de chasse de Keur Macène (4).

Au cours de la campagne de sérosurveillance 2002-2003, deux sérums positifs (parmi 28) pour la peste bovine ont été révélés chez des phacochères abattus dans le sud du pays. Ce résultat du CNERV a été confirmé dans un premier temps par le laboratoire régional de référence (LNERV, Dakar) puis par le Laboratoire mondial de référence (Institute of Animal Health, Pirbright), ce qui a eu pour conséquence immédiate la suspension du statut en septembre 2003. La Mauritanie s'est aussitôt engagée dans un vaste programme d'investigations et de surveillance du bétail et de la faune dans la même zone. Une stratégie a été adoptée et exécutée, consistant en une mobilisation générale (professionnels, éleveurs, autorités…), la détermination des zones à risque, l'élaboration d'un protocole d'échantillonnage, des recherches ciblées et aléatoires (symptômes et sérologie), etc., afin d'infirmer ou de confirmer la circulation virale. Les investigations ont concerné prioritairement la zone considérée à risque dans le Sud-Ouest (région de Trarza), où se concentre la quasi-totalité de l'élevage laitier du pays, comportant environ 140 000 têtes en élevage semi-sédentaire. C'est également la zone qui connaît une densité de faune sensible élevée. Le reste du cheptel national (environ 1,5 million de bovins) est transhumant et réparti sur le Sud et Sud-Est du territoire.

Ainsi, entre octobre 2003 et janvier 2004, 1 889 échantillons de sérums bovins et 6 échantillons de phacochères ont été récoltés et analysés. À l'exception de deux sérums bovins positifs (mais écartés car l'estimation de l'âge prêtait à confusion), aucun autre cas positif n'a été rencontré. Par conséquent, la Mauritanie a recouvré son statut de pays indemne de la maladie par l'OIE dès mai 2004 (13).

En conclusion, au-delà des aspects relatifs à la validité des tests pour les sérums de phacochères (spécificité et sensibilité du test ELISA de compétition, spécificité d'espèce, estimation de l'age des animaux…), ce cas illustre la bonne gestion d'une crise à travers tous ses stades : d'une recherche et surveillance efficaces d'une maladie éradiquée à l'aide d'un réseau fonctionnel, en passant par une bonne implication des partenaires (chasseurs en l'occurrence), l'analyse des données, l'interprétation des résultats de laboratoire, la transparence et la communication des résultats à chaque étape, la réactivité des décideurs et les mesures entreprises, jusqu'à la sortie de crise et la maîtrise de la situation (4, 13).

Conclusion

À l'issue de la mise en place et du démarrage des RES dans la majorité des pays en développement, nous constatons un progrès significatif dans la connaissance des situations sanitaires et une nette amélioration dans la gestion des épizooties et la transmission des informations sanitaires.

Toutefois, cet élan devra se maintenir pour consolider les acquis et améliorer les performances des RES. Les pouvoirs publics nationaux gagneraient à promouvoir la surveillance et la prévention des épizooties majeures en s'engageant à actualiser leur législation et polices sanitaires et en assurant la pérennisation des activités, notamment en accordant une priorité à son financement.

Sur le plan technique, quelques faiblesses et insuffisances subsistent. Ceci est en partie lié au faible recul dans le fonctionnement et l'expérience des RES, mais aussi – et surtout – aux insuffisances en ressources humaines, avec des cadres qualifiés peu nombreux et souvent mal mis à profit. Par ailleurs, la pauvreté de ces pays explique à la fois le manque de moyens logistiques nécessaires au fonctionnement des RES, mais également l'absence de motivation des éleveurs concernés à déclarer un foyer lorsqu'ils ne sont pas indemnisés pour les animaux abattus ni pour les contraintes que leur imposent les mesures de surveillance (manque à gagner) (6, 7).

L'instauration des indicateurs de performance comme outil de suivi et d'évaluation permettrait aux réseaux d'améliorer la qualité des informations sanitaires fournies (exactitude, pertinence, validité) (11) et par conséquent leur crédibilité. Enfin, l'aide financière et l'assistance technique des bailleurs et des fonds publics internationaux devraient se poursuivre, tout en incitant les gouvernements à prendre progressivement le relais, car il en va d'une meilleure maîtrise collective de la santé animale mondiale et des échanges à moindres risques sanitaires. ■

The design and implementation of effective epidemiological surveillance programmes in Sub-Saharan Africa

F. Bendali

Summary
Livestock is one of the main sources of wealth in developing countries. The improvement of national herds and of their productivity through controlling the main diseases and preventing epizootics is a major objective in these countries. The organisation of surveillance systems is indispensable to proper animal health management, both nationally and internationally. Therefore, thanks to foreign assistance, developing countries have gradually established epidemiological surveillance networks, despite unfavourable contexts (poverty, lack of resources or infrastructure…). To date, many networks are operating in satisfactory manner and produce tangible results. However, further efforts must be made to improve the quality of sanitary information produced, its performance and sustainability. This article discusses the context and motivations for the establishment of epidemiological surveillance networks in developing countries, especially in Africa, by describing some of their operational specificities and some results. Finally, it presents the example of a Mauritanian animal disease epidemiological surveillance network and its role in managing a health crisis.

Keywords
Developing country – Epidemiological surveillance – Epizootic – Sub-Saharan Africa.
■

Concepción y aplicación de programas eficaces de vigilancia epidemiológica en los países del África subsahariana

F. Bendali

Resumen
La ganadería representa una de las principales riquezas de los países en desarrollo, y en este sentido la mejora de la cabaña ganadera y su productividad mediante el control de las principales enfermedades y la prevención de epizootias constituye un objetivo básico para dichos países. La organización de los sistemas de vigilancia sanitaria es ahora un elemento ineludible para gestionar correctamente la sanidad animal a escala tanto nacional como internacional. De ahí que, pese a un contexto desfavorable (pobreza, falta de recursos e infraestructuras...), y gracias a la ayuda exterior, los países en desarrollo hayan ido instaurando progresivamente redes de vigilancia epidemiológica (RVE). En la actualidad hay numerosas redes que funcionan satisfactoriamente y ofrecen resultados tangibles. Sigue siendo indispensable, sin embargo, un gran esfuerzo para mejorar la calidad de la información sanitaria obtenida, así como el funcionamiento y la continuidad a largo plazo de las redes. El autor examina el contexto y las razones de la creación de las RVE en los países en desarrollo, especialmente en África, describe algunos de los aspectos singulares de su funcionamiento y expone parte de los resultados que con ellas se han obtenido. Por último, presenta el ejemplo de la red mauritana de vigilancia epidemiológica zoosanitaria a la hora de gestionar una crisis.

Palabras clave
África subsahariana – Epizootia – País en desarrollo – Vigilancia epidemiológica.

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Animal disease outbreak control: the use of crisis management tools

K. Kroschewski [(1)], M. Kramer [(1)], A. Micklich [(1)], C. Staubach [(1)], R. Carmanns [(2)] & F.J. Conraths [(1)]

(1) Friedrich-Loeffler-Institute, Federal Research Institute for Animal Health, Institute of Epidemiology, Seestrasse 55, 16868 Wusterhausen/Dosse, Germany
(2) State Ministry of Agriculture and Forestry, Ludwigstrasse 2, 80539 Munich, Federal State Bavaria, Germany

Summary
In this era of globalisation the effective control of animal disease outbreaks requires powerful crisis management tools. In the 1990s software packages for different sectors of the government and agricultural industry began to be developed. In 2004, as a special application for tracking the movement of animals and animal products, the European Union developed the Trade Control and Expert System (TRACES) on the basis of its predecessor, the ANImal MOvement (ANIMO) project. The nationwide use of the ANIMO system by the veterinary authorities in Germany marked the beginning of the development in 1993 of a computerised national animal disease reporting system – the *TierSeuchen-Nachrichten* (TSN) – using the ANIMO hardware and software components. In addition to TRACES and TSN the third pillar for the management of animal disease outbreaks and crises in Germany is the national cattle and swine database – called *Herkunftssicherungs- und Informationssystem für Tiere*. A high degree of standardisation is necessary when integrating the different solutions at all levels of government and with the private sector. In this paper, the authors describe the use of these tools on the basis of their experience and in relation to what we can do now and what we should opt for in the future.

Keywords
Animal disease – Crisis management – Database – European Union – Germany – Outbreak control – Software tool.

Introduction

In a global market that includes the international trade of animals and animal products, animal disease outbreak control, response, and crisis management require powerful software tools. Multiple outbreaks of classical swine fever (CSF), foot and mouth disease (FMD) and highly pathogenic avian influenza (HPAI) highlight the necessity of the prompt availability of information on a number of different issues, such as:

a) contact between farms: this is of the utmost importance from an epidemiological point of view, as contact between animals from different herds is the main route of infection. Knowledge about national and international animal trade and/or movement is essential if contact with contagious herds is to be avoided

b) the 'curriculum vitae' of animals: for instance, in the case of bovine spongiform encephalopathy (BSE), knowledge about the origin of the animals is crucial in identifying the specific cohort that must be considered exposed to the BSE agent

c) data relating to farms in the affected regions, more specifically:

– the number of farms in the region at the different administrative levels, including detailed information about the registered farms at the national and regional levels

– the number of susceptible animals by species in the region

– farm locations: the classification at municipality level is usually not precise enough for regional crisis management; ideally, the geographic coordinates of each premise where herds are kept should be registered so that they can be entered into a geographical information system (GIS)

– the number and composition of mixed farms for the analysis of multiple species diseases

– the numbers and kinds of infected farms, and of those farms free of disease

– the number of animals that are kept on infected farms and on disease-free farms

d) up-to-date epidemiological status reports: early warning systems are needed and must be electronically supported with the latest information on the epidemiological situation nationally and worldwide

e) agreed responses: availability of central databases (CDB) with an official handbook on disease control and crisis management.

Requirements for the national organisation of crisis management

In Germany the organisation of crisis management is divided between the National Animal Disease Crisis Centre and the Task Force of Animal Disease Eradication. The tasks of both divisions are precisely defined. A couple of these tasks require the prompt availability of information, in the majority of cases in summarised form, e.g. disease statistics, validated epidemiological reports and information on animal movements and populations at risk. Of paramount importance is the maintenance and updating of the animal disease handbooks in connection with the preparation for and enactment of disease outbreak exercises. The evaluation of these exercises has demonstrated the usefulness of powerful software tools. Software applications are more likely to be successful if their development, testing, implementation, support, training, and strategic development are organised and well prepared in a continuous dialogue with the users. The experience of constructing a national agricultural database in Germany has shown that the format for the farm registration of livestock numbers should be standardised so as to facilitate their analysis, the comparability of results, and the exchange of data. Collaboration between competent ministry and federal (regional as well as local) authorities and institutions is vital in such an undertaking.

Epidemiological instruments required for animal disease monitoring and for outbreak investigations

Ideally, the following databases should be available to the Veterinary Services:

a) a complete inventory of all farms and other animal holdings

b) diagnostic results from all tested animals (infected and uninfected)

c) case/outbreak data.

In Germany, these databases exist but they cannot all be accessed at all levels. Inventories of farms and animal holdings are maintained at the district or town level. Due to data protection regulations, only the local veterinary authorities have full access to these data, which include addresses, telephone numbers, etc. Diagnostic data recorded by the veterinary investigation centres (VIC) are also maintained in electronic databases but access is restricted to the VIC staff. An online database of animal disease outbreaks with detailed information on the affected animals and the locations of the outbreaks is maintained at the national level; access is restricted to the veterinary authorities at national, state and local level.

To analyse data as part of regular animal disease monitoring and surveillance activities and in the course of outbreak investigations, animal and disease data must be electronically available at all times, preferably online and in a geo-referenced format. These data can then be used when analysing the temporal and spatial behaviour of disease, to predict its kinetics, and to study transmission pathways as part of the required tracing-back and tracing-forward.

Incoming data and information on suspected outbreaks can also be used as an early-warning system.

On the basis of the outbreak data, and the numbers of affected animals, farms or holdings, and products (e.g. milk, eggs, slaughter pigs), the personnel and logistical resources that are required to control the outbreak can be planned.

Veterinary officers and veterinary epidemiologists must be trained so that they can enter data, preferably in the field, and utilise the available databases without delay to contain any outbreak as quickly as possible. Appropriate software must be provided that supports outbreak management. This can be better achieved by implementing a GIS that

spatially locates diseased farms, can establish restriction zones, can calculate the numbers of animals that will be affected by the measures to be taken, and helps to notify farmers individually and regionally.

Geographical information systems – indispensable for modern crisis management

Geographical information systems are computer-based tools that can store, analyse and display both spatial and non-spatial data (3); GIS software can be split into three functional groups:

a) GIS, in a more narrow sense, with the ability to generate, modify, transform and analyse geographically referenced data

b) mapping software to visualise the spatial data without the possibility of manipulating the geometric feature database

c) database management systems (DBMS) as general-purpose software products which can store but also analyse small to extremely large geographical datasets without visualisation.

The traditional distinctions between these are vanishing through the hardware and software revolutions of the past decade; desktop GIS software, geographically-enabled programming languages, embedding of GIS functionality in application software, and mapping on the Internet have allowed the application of a broad spectrum of analyses and visualisation techniques of spatial epidemiological data. Nevertheless, it is necessary to define the purpose of the analysis to determine the appropriate GIS tool.

Geographical information systems and spatial epidemiology are playing an increasingly important role in animal disease control. For some time, district veterinary authorities and laboratories in Germany and other European Union (EU) member states (e.g. the Netherlands, the United Kingdom, Denmark) have been using GIS in applied disease control. This has been mainly in outbreaks of notifiable diseases by supporting district veterinary officers in the definition of restriction areas, and in planning control measures and eradication strategies. With the help of GIS and new spatial statistical methods, the spatial and temporal spread of diseases can be analysed and the risks defined.

Existing tools for animal disease outbreak control and crisis management in Germany

TRACES: Trade Control and Expert System

With the introduction of the common market within the EU on the 1 January 1993, the border veterinary inspection posts between member states were closed. To keep the transport of animals and products of animal origin within the EU under control, the European Commission (EC) developed an automated network between the various EU veterinary authorities called ANImal MOvement (ANIMO) on the basis of Council Directive 90/425/EEC of 26 June 1990 (11). With this system the responsibility for checking animals and animal products was shifted to the veterinary offices at the place from which the animals/products originated and at the final destination. To that end the responsible veterinary office at the point of origin entered the health certificate into the computer and transferred it to the central EU ANIMO server in Dublin. The responsible veterinary office at the destination could then download the health certificate from the server and then, if necessary, take samples when the consignment arrived. The same procedure was applied to imports from, or exports to, third countries: the responsible border inspection post from where the consignment left the EU would create an ANIMO message for the veterinary office at the destination (importing country) or, the border inspection post from where the consignment entered the EU would receive an ANIMO message from the veterinary office at the point of origin (exporting country), respectively.

To make the communications with the EU ANIMO server more effective, and to give the senior veterinary authorities the opportunity to access their national animal data traffic, a national ANIMO server was installed at the Institute of Epidemiology at the Federal Research Centre for Virus Diseases of Animals (now the Friedrich-Loeffler-Institute). Instead of each directly communicating with the central EU ANIMO Server, the German ANIMO units (veterinary authorities and the border inspection posts at the EU border with third countries) communicated exclusively over this national ANIMO server with the EU ANIMO server in Dublin. The ANIMO system was introduced in Germany on 1 September 1993. Regular operation (data communication with the EU ANIMO Server) started on 1 June 1994. Despite the initial shortcomings of this system (see below) and the extra work the veterinary officials had to do in 'times of peace' (i.e. in disease-free periods), ANIMO proved to be a success in Germany in the following 'times of crisis':

– 1996: outbreaks of CSF in the Netherlands

– 2001: outbreaks of FMD in Great Britain, France and the Netherlands

– 2003: outbreaks of HPAI in the Netherlands.

During these outbreaks it was possible to locate consignments of animals coming from these countries into Germany and to initiate appropriate measures which helped to prevent these diseases from spreading into the country.

Although ANIMO represented progress regarding the documentation relating to the transport of animals and animal products between member states of the EU, it still had several shortcomings:

– no data transfer in real time, so it could take several days until the receiver got the ANIMO message

– no facility to respond to the sender if the consignment did not correspond to what was described in the documentation or if the competent authority of the place of destination was legally required to inform the competent authority of the place of origin that the consignment had arrived (Council Decision 1774/2002 of 3 October 2002 [6])

– misdirected messages because of wrong addresses

– extra data-entry work for the sending veterinary authority

– no possibility of using this system for animal welfare.

At approximately the same time as the ANIMO system came on line, a similar system was beginning to be developed for use at veterinary inspection posts (road, railway, airport, port) at EU borders with third countries. This System to assist with the Health controls of Imports of items of veterinary concern at Frontier inspection posts from Third countries (SHIFT system) was due to be developed on the basis of the Council Decisions 92/438/EEC of 13 July 1992 (12) and 92/563/EEC of 19 November 1992 (13), but it did not get beyond the development of several prototypes. For this reason, the EC launched the Trade Control and Expert System (TRACES) (regulation 2003/24/EC of 30 December 2002 [7]). The system has the following goals:

– integration of the existing ANIMO system with the SHIFT system

– development of an integrated database

– improved control and tracing of consignments of animals and animal products

– decision support in regard to imports of animals and animal products from third countries

– introduction of a central alert system

– risk assessment

– reduction in the administrative workload.

As a web-application (one central web server with a CDB and online access from clients with a browser), TRACES provides fast and up-to-date information for the responsible veterinary authorities and it enables electronic certification (Fig. 1).

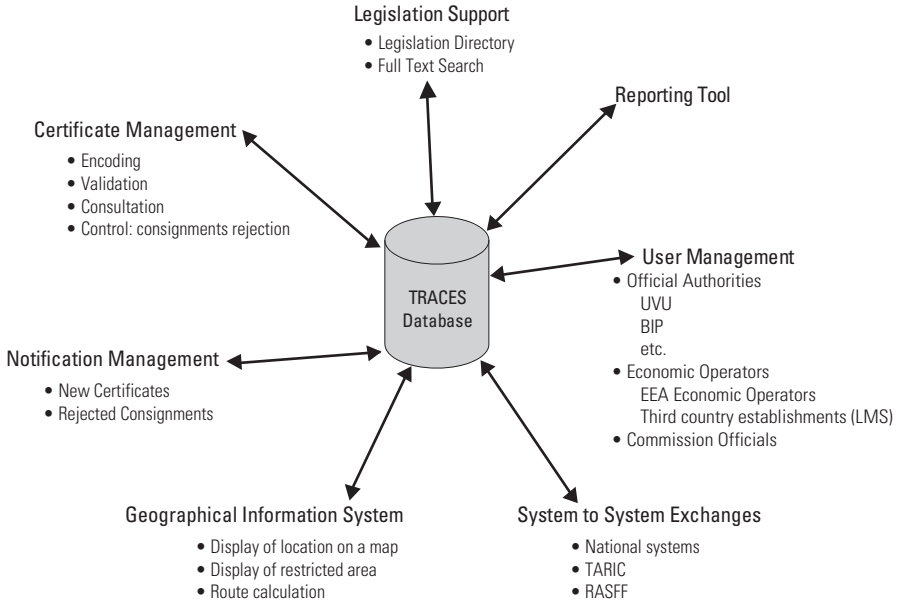
TRACES is multilingual, so all member states can use it in their own languages and all of the current 32 different health certificates can be displayed and printed out in all of the different languages. Commercial operators can now use TRACES by entering their consignment data themselves, with the result that the relevant veterinary office only needs to certify the consignment. This allows a reduction in the administrative workload of the veterinary authorities. The integration of private veterinarians and/or veterinarians approved by the veterinary authorities is also possible, but this has not been implemented in Germany. It is envisaged that veterinary authorities and organisations in third countries will be able to connect to TRACES and thus reduce the administrative workload at the border inspection posts, because these organisations will have entered their consignment data in advance.

When a health certificate has been entered, the users responsible (e.g. the veterinary officers [or commercial operators that use TRACES] in importing countries) are notified by e-mail, indicating that there is a certificate to be processed. Then the responsible authority can initiate controls or other measures concerning the consignment and enter the results into TRACES (Fig. 2).

The system was gradually introduced in 2004 and the use of TRACES has been obligatory for all EU member states since 1 January 2005 (Decision 2004/292/EC of 30 March 2004 [9] and regulation 599/2004 of 30 March 2004 [8]). Further information regarding TRACES can be found at http://www.traces-cbt.net.

The national animal disease reporting system in Germany

Since the introduction of ANIMO in 1993 every district veterinary office in Germany has been equipped with a personal computer, modem and communication software as a prerequisite for computer-aided communication within the government Veterinary Services. This equipment was also needed for the development of the computer-supported national animal disease information system – or *TierSeuchen-Nachrichten* (TSN) – at the Institute of Epidemiology attached to the former Federal Research Centre for Virus Diseases of Animals (now the



BIP: Border Inspection Post
EEA: European Economic Area
LMS: List Management System
LVU: Local Veterinary Unit
RASFF: Rapid Alert System for Food and Feed
TARIC: Integrated Tariff of the European Community

Fig. 1
Architecture of the European Union (EU) Trade Control and Expert System (TRACES)
The database is designed to facilitate trade in animals and animal products and track consignments moving within the EU and leaving/entering the EU for/from third countries (4)

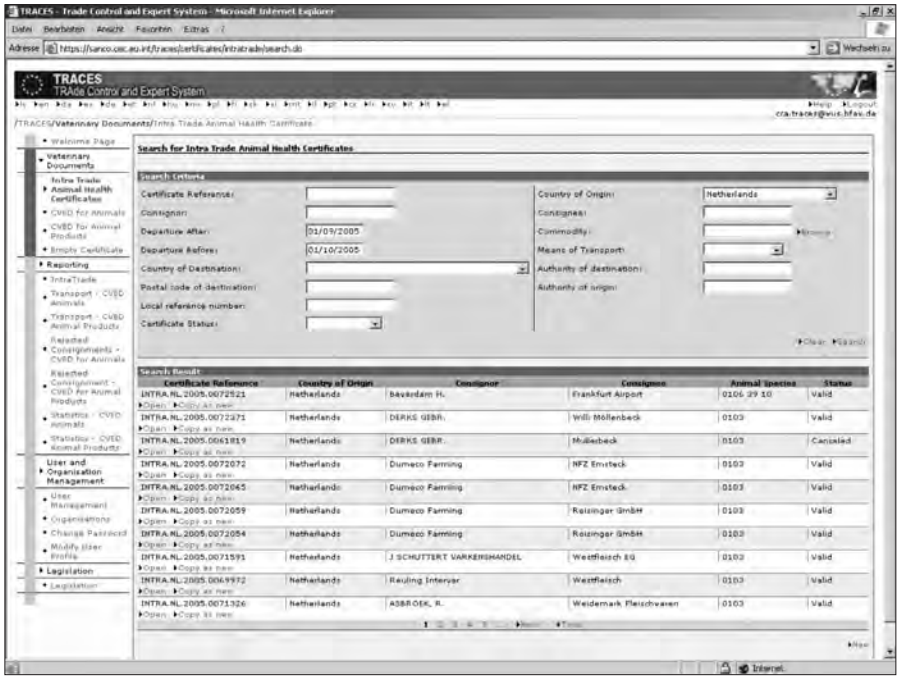


Fig. 2
Example query using the European Union Trade Control and Expert System (TRACES): query of all incoming animal consignments from the Netherlands with departure dates between 1 September 2005 and 1 October 2005

Friedrich-Loeffler-Institute, Federal Research Institute for Animal Health [15, 16]). The official nationwide start of TSN was 1 January 1995, as stipulated by national legislation. The first Windows© version was implemented in December 2000. This also marked the beginning of its transformation into a crisis management system.

The TSN system has two components. The client component in the local veterinary office is used for offline data acquisition. Disease outbreak information is then transmitted to the centralised animal disease database (CADDB) on the server (second component) at the Friedrich-Loeffler-Institute in Wusterhausen. In Wusterhausen, information is stored in a structured query language database. Only authorised users have access. The data flow is shown in Figure 3 (14, 17).

The TSN can be used in local area and wide area networks. As many districts and towns as required, with separate local veterinary authorities, can be installed in one place. Therefore, data acquisition and query are possible from different computers and various localities. This is especially necessary during epidemics that affect more than one district or town.

During an epidemic extensive information needs to be collected for each outbreak. These data can then be managed and edited in the outbreak explorer or editor. Data acquisition is based on default values, which allow maximum plausibility control. Entry fields are compulsory or voluntary depending on the information value for disease control. Changes in animal disease notification and/or data record definitions can and should be taken into account immediately via the automated synchronisation of master data by communication with the CADDB; the dynamic data are synchronised in the same manner. Master data are available for different entry fields, e.g. for diseases, pathogens, species, diagnostic methods, and sources of infection. These master data are regularly updated in compliance with national and international laws and regulations (10, 19).

Crisis management demands complex farm and livestock management in connection with geo-referenced positions of the animal disease outbreaks and of all affected farms and associated agricultural business, such as abattoirs, dairies, and rendering plants. The TSN system offers diverse farm management and GIS functions concerning animal disease outbreak control, response, and crisis management (17, 18). Animal disease cases and farms can be localised precisely by using digital topographical maps accessible via mouse click (geo-referencing). The spatial distribution of animal disease cases can be shown at different resolutions and/or administrative levels. The geo-referencing of all farms will be completed in all districts and federal states of Germany in the near future. Districts with geo-referenced farm databases can manage and analyse spatial data as follows:

– automated presentation of the spatial distribution of farms on digital topographical maps; e.g. for inspection visits by field task forces

– automated creation of farm lists and addresses

– livestock composition analysis

– transmission and exchange of data files, e.g. between task forces, by standardised visualisation of the zones via TSN

– fast and precise creation of restriction and surveillance zones. These zones can be visualised in the form of radii or polygons that can be defined without any restrictions. A flexible presentation of the livestock of these areas can also be produced by the software, as illustrated in Figure 4. For publication purposes this display example is much simplified. The actual display can have a wealth of detail, including houses, woods, roads, streams and rivers.

An important point with both suspected and confirmed outbreaks is to be up-to-date on diagnostic methods and to have task force guidelines, such as for the duties of each member of the task force and for coordination in space and time. An HTML-based collection of diagnostic methods is integrated into TSN. The national reference laboratories for notifiable diseases are responsible for updating this information. A search function and a glossary are included. A standardised handbook for animal disease eradication is currently under development. The CADDB can also be used for communication between the involved authorities at the federal state level and the Federal Ministry of Consumer Protection, Food and Agriculture.

Furthermore, when queried, CADDB can provide information in different formats, e.g. it can supply official certificates, tables and maps (Figure 5 – national situation of transmissible spongiform encephalopathy cases in 2004) and provide access to official statistics and to an address list of veterinary authorities. Each veterinary office can update its own address. The CADDB address link can be used as an early warning system based on email notification. Responsible official veterinarians can activate this optional function.

The TSN software will be upgraded in the near future. A so-called crisis module will be implemented that allows the management of bigger restriction and surveillance zones, for example, several overlapping districts and/or federal states. The improved system will be able to process data about epidemiological surveys, livestock estimates, clinical examinations and culling (14).

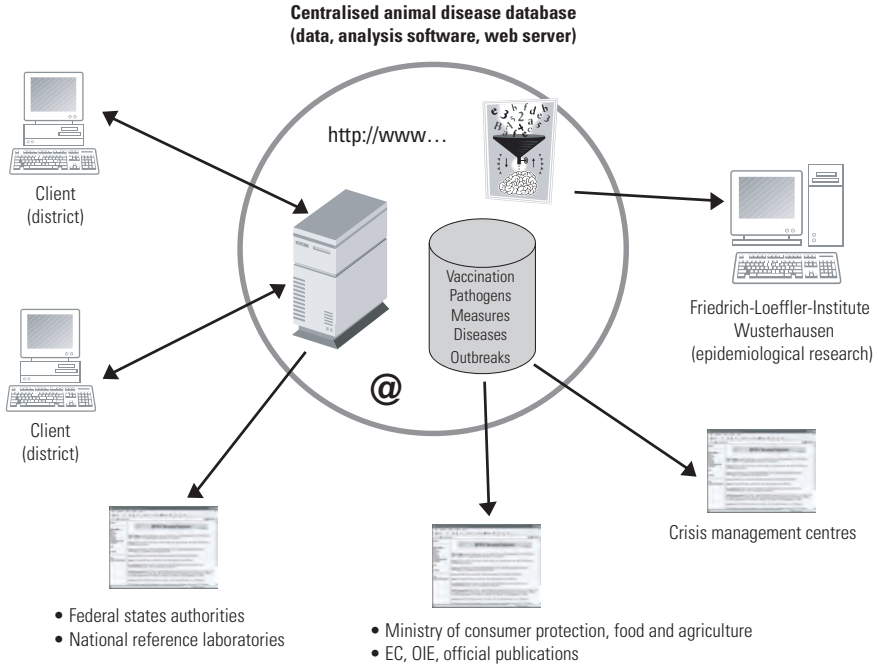


Fig. 3
The flow of data in the national animal disease reporting system in Germany

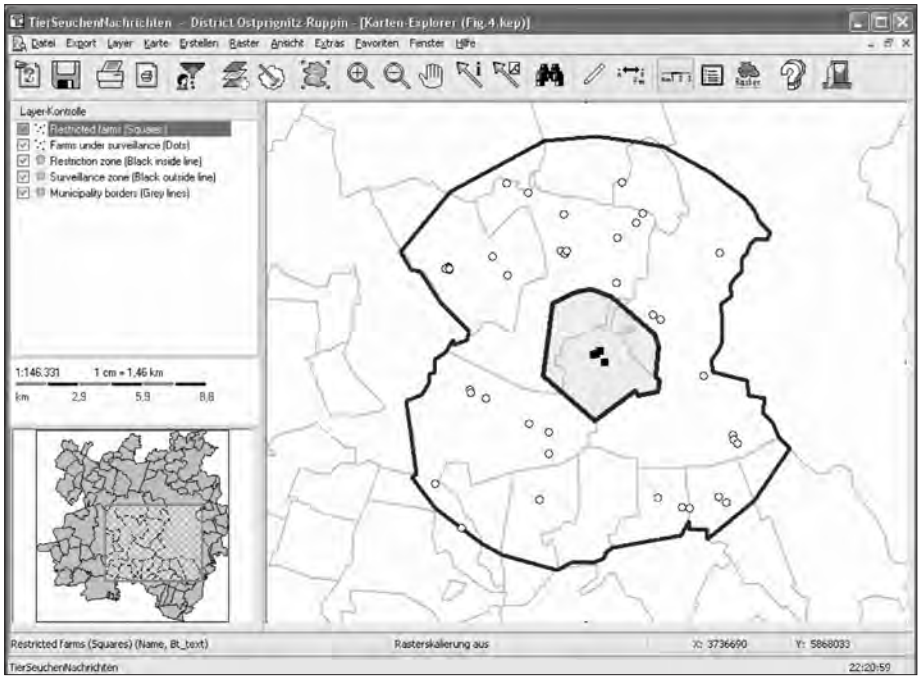


Fig. 4
An example of the way in which restriction and surveillance zones can be depicted using the German animal disease reporting system: solid black squares (restricted farms), open circles (farms under surveillance)

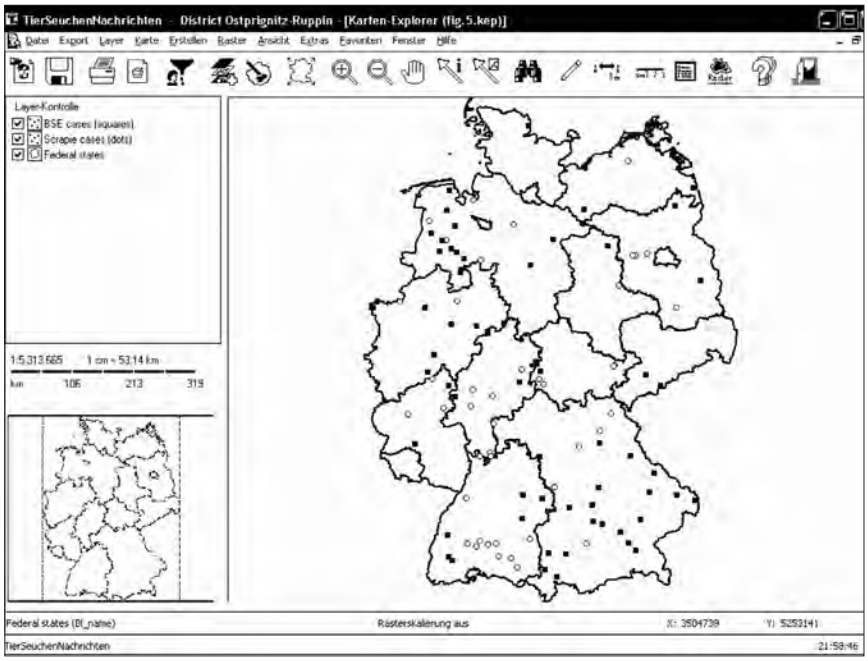


Fig. 5
Example of data presentation using the German animal disease reporting system: geographical distribution of transmissible spongiform encephalopathy cases in 2004 with differentiation between bovine spongiform encephalopathy (black squares) and scrapie (open circles)

Herkunftssicherungs- und Informationssystem für Tiere – the national cattle and swine database

The *Herkunftssicherungs- und Informationssystem für Tiere* (HI-Tier) is the computerised, Internet-based herd and animal identification and registration (I&R) system that was established in Germany in 1999 on the basis of Regulation (EU) No. 820/97 (5) and the corresponding national regulation (www.hi-tier.de). According to these regulations all holdings and holders of cattle, including traders and slaughterhouses, have to be registered and have to report all changes in their stock (births, on and off movements, imports, exports, deaths or slaughter) to a national CDB. The reporting can be done either via Internet, phone code system or by postcards (1, 2).

In addition to the veterinary regulations, EU-premium payments for cattle in Germany are allocated on the basis of the information in the CDB. This puts enormous pressure on all sectors of the livestock industry, including farmers, traders, exporters and slaughterhouses, to report all changes correctly and promptly to the CDB.

To ensure the best possible data quality in the HI-Tier, a strict two-step quality assurance programme was established. In the first step each report is checked before storage for completeness and correctness. Only correct and complete reports are stored. In a second step after storage all reports on individual animals (identified by ear tag number) are checked against all other reports about this same animal. In the event of discrepancies or contradictions the report holders are informed via Internet or letter and asked to confirm or correct their report.

The HI-Tier CDB receives about 40 million reports from cattle holders every year; the average per day is about 110,000, and more than 85% of all reports arrive via the Internet.

Since 2002, in addition to the I&R functions of the system, the veterinary laboratories and the Veterinary Services store certain individual disease data in the CDB, e.g. test results for BSE, bovine herpesvirus type 1, and bovine viral diarrhoea. Furthermore, information about the vaccination of individual animals can also be stored and retrieved. Contrary to most other veterinary databases for cattle, HI-Tier is based on detailed information about individual animals (obtained through ear tag numbers) and not on summarised information about herds.

This specific information in the CDB from various sources allows the Veterinary Services in combination with web access via Internet to make a wide range of epidemiological enquiries at any time and in any place.

To trace an individual animal, the specific ear tag number merely has to be entered into the query 'Einzeltierverfolgung'. This will provide all reports on one animal including the date of birth, movements, slaughter (including the holding where this took place), as well as the test results for specific diseases. In a second step, all possible contacts of an animal can immediately be retrieved by using the hyperlink on the herd registration number ('Betrieb'). For female animals, all calves of the dam can be retrieved via the link 'Kalbungen'.

Under the query 'Bestandsregister' (farm registry) the herd registration number allows an investigator to retrieve the farm registry, identifying all animals individually, for any specific herd in Germany for a defined day or period since 1999.

Information about the number of herds in a specific area as well as the number of cattle within these herds, including information on their specific disease status can be retrieved with a query called 'Allgemeine Betriebs-Tier-Übersicht'. This query offers more than 20 different selection criteria according to the different categories of information in the CDB. For example, it is possible to analyse how many cattle in a specific county were born after a certain date and are female.

In case of animal disease outbreaks in cattle and pig holdings, connections with the animal disease reporting system or EU expert systems can be established, epidemiological tracing investigations can be carried out immediately, and the necessary staff and equipment for disease control measures in restriction or vaccination zones can be planned precisely.

Conclusions

Since the 1990s European countries have been confronted with several epidemics of diseases such as BSE, CSF, FMD and HPAI. Because of the high densities of livestock and farms in certain areas in Europe, including some German regions, controlling these epidemics has required superior crisis management. Superior crisis management comprises well coordinated use of the available, but maybe limited, material capacities and a number of specialists in task forces in combination with support services. Other vital components of effective crisis management are the aggregated mapping of livestock in affected regions and the rapid identification, by ear-tag number, of individual animals on named and geo-referenced recorded farms and of contacts between animals and specified farms.

Considering the enormous volumes of data in multiple fields, powerful software packages are required. In Germany such packages are available and utilised. The nationwide use of the EU project TRACES and the German projects TSN and HI-Tier allow the country to take proper measures for animal disease outbreak control, response and crisis management according to modern standards.

■

Le contrôle des foyers de maladies animales : utilisation des outils de gestion de crise

K. Kroschewski, M. Kramer, A. Micklich, C. Staubach, R. Carmanns & F.J. Conraths

Résumé

À notre époque de mondialisation, le contrôle efficace des foyers de maladies animales nécessite des outils puissants de gestion des crises. Pendant les années 90 des progiciels pour divers secteurs de l'administration et de l'agriculture ont commencé à être mis a point. En 2004 l'Union européenne a mis en œuvre une application spéciale pour suivre les déplacements des animaux et des produits d'origine animale, le Trade Control and Expert System (TRACES : Système de contrôle du commerce et d'expertise), sur la base de son prédécesseur, le projet ANImal MOvement (ANIMO). L'utilisation dans toute l'Allemagne du système ANIMO par les autorités vétérinaires de ce pays

a marqué le début de la mise en œuvre en 1993 d'un système informatisé national de notification des maladies animales – le *TierSeuchen-Nachrichten* (TSN) – qui utilise les composantes et les logiciels d'ANIMO. En plus du TRACES et du TSN, le troisième pilier de la gestion des foyers et des crises de maladies animales en Allemagne est la base de données nationales sur les bovins et les porcins – appelée *Herkunftssicherungs- und Informationssystem für Tiere*. Un niveau élevé de standardisation est nécessaire pour intégrer les diverses solutions à tous les niveaux du gouvernement et avec le concours du secteur privé. Dans ce document, les auteurs décrivent l'utilisation de ces outils à partir de leur expérience et dans la perspective des mesures que nous pouvons prendre aujourd'hui et des solutions que nous devrions choisir dans l'avenir.

Mots-clés
Allemagne – Base de données – Contrôle des foyers – Gestion de crise – Maladie animale – Outil logiciel – Union européenne.

Utilización de herramientas de gestión de crisis para luchar contra brotes zoosanitarios

K. Kroschewski, M. Kramer, A. Micklich, C. Staubach, R. Carmanns & F.J. Conraths

Resumen
Para combatir eficazmente un brote zoosanitario en la actual era de la mundialización se necesitan potentes herramientas de gestión de crisis. En los años noventa se empezaron a crear módulos informáticos para distintos sectores de los poderes públicos y la industria agropecuaria. En 2004 la Unión Europea elaboró una aplicación especial para seguir los movimientos de animales y productos de origen animal, el sistema TRACES (sistema experto de control del comercio), basándose para ello en un proyecto anterior que respondía al nombre de ANIMO (ANImal MOvement). La aplicación del sistema ANIMO en todo el territorio alemán por parte de las autoridades veterinarias del país marcó el inicio de la elaboración, en 1993, de un sistema nacional informatizado de notificación de enfermedades animales, el *TierSeuchen-Nachrichten* (TSN), que utilizaba componentes de hardware y software del ANIMO. Junto con el TRACES y el TSN, el tercer pilar de la gestión de crisis y brotes zoosanitarios en Alemania es la base de datos nacional de bovinos y porcinos, denominada *Herkunftssicherungs- und Informationssystem für Tiere*. Para integrar las distintas soluciones en todos los niveles de gobierno, concertadamente con el sector privado, se requiere un alto grado de estandarización. Los autores describen el uso de estas herramientas basándose en su experiencia y pensando en lo que es factible hoy en día y conveniente de cara al futuro.

Palabras clave
Alemania – Base de datos – Control de brotes – Enfermedad animal – Gestión de crisis – Herramienta informática – Unión Europea.

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The National Incident Management System: a multi-agency approach to emergency response in the United States of America

J.F. Annelli

Interagency Coordination, Emergency Management and Diagnostics, United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, 4700 River Road, Unit 41, Riverdale, MD 20737, United States of America

Summary

This paper outlines the development of a universal incident management system across all of government in the United States of America called the National Incident Management System. The system has been incorporated into the National Response Plan and the procedures of United States Department of Agriculture (USDA) agencies, using the United States Forest Service's National Interagency Incident Management System as a model. This model has enhanced USDA's effectiveness in a wide range of emergencies that might affect American agriculture, including natural disasters (e.g. earthquakes, floods, hurricanes, pest and disease outbreaks, and wilderness and other types of fires), nuclear and conventional events, or the accidental or deliberate introduction of a biological, chemical or radiological agent threatening the United States food supply, critical infrastructure or economy.

Keywords

All-hazard – Incident command system – National Incident Management System – National Interagency Incident Management System – National Response Plan.

Introduction

As the 17th Century English author John Donne once said, 'no man is an island', and the same is true of a country's animal health officials. This axiom is brought home to us time and time again when emergency animal disease eradication efforts affect not just agriculture, but the environment, public health, trade, tourism, and even confidence in the government itself. In the United States of America (USA), the events of 11 September 2001, the subsequent deliberate dissemination of anthrax, and the United Kingdom's foot and mouth disease epidemic in the same year dramatically highlighted the importance of governmental preparedness and response capabilities in a large-scale national or regional emergency as well as in smaller-scale incidents (6). In an emergency situation, governments must act quickly to:

a) determine the nature of the event

b) initiate an appropriate response

c) cope with the event

d) facilitate recovery.

The tragic events of 200l demonstrate the need for the United States Department of Agriculture (USDA) and other governmental departments to 'think big' as they plan for the mobilisation of large-scale resources to address potentially large-scale disasters. In addition to natural catastrophes, USDA must plan for worst-case scenarios such as deliberate attempts to interrupt or undermine

confidence in the food supply of the USA or to disrupt critical infrastructures (e.g. rural utilities). Although each USDA agency's existing cadre of agricultural professionals is sufficient to cope with 'ordinary' emergencies, the agricultural community could easily be overwhelmed by the logistical, operational and administrative demands of a sizable regional or national crisis. To cope with such events, the agricultural community must expand its ties with the emergency management community and other organisations so as to be prepared for a major agricultural emergency. In recognition of this the National Incident Management System (NIMS) was established (3), adopting many of the features of the United States Forest Service's National Interagency Incident Management System (NIIMS).

The National Interagency Incident Management System model

The NIIMS is a successful incident response management strategy that is widely used in the emergency management community. This model provides a structure for making a coordinated response in an emergency situation and for gaining access to the resources necessary for successful recovery. The approach is used widely in events or conditions that pose a potential or actual threat to the public and the environment, such as potential violence at the Olympic Games, natural disasters, domestic terrorism, major hunts for people, airplane crashes, and law enforcement activities – including border incidents involving drugs.

Organisationally speaking, the NIIMS model and similar universal incident management approaches have been used by most governmental emergency management organisations in the USA, including those in areas such as the military, law enforcement, health care and public works. It is the model that the armed forces use in combat situations and that the US Coast Guard uses for emergency response and management on location during and after a major disaster. The US Department of Energy is adopting the model for use in responding to nuclear emergencies.

The NIIMS model is also used by all Federal agencies involved in wildland fires and by state and county wildland fire agencies in the continental United States.

The incident command system (ICS) – the cornerstone of the NIIMS model – was developed as a result of the devastating 1970 forest fires in California. This incident demonstrated a need to develop a common system for use by all fire service organisations.

The NIIMS model features the ICS as the process by which best to manage emergencies through objectives and direction provided by executives and line officers. The NIIMS also features components such as training programmes, individual qualification criteria and publications management. The model and its various adaptations have proven to be the best emergency management systems available. The major components of NIIMS include the following:

– National Multi-Agency Coordination (MAC) Group
– emergency operations centre(s)
– geographical MAC groups
– area commands
– incident management team (IMT).

The NIIMS, adopted by several federal, state and local agencies in 1982, served as the basis for today's NIMS. On 28 February 2003, the President of the USA issued Homeland Security Presidential Directive (HSPD)-5 (8), which directs the Secretary of Homeland Security to develop and administer a NIMS. According to HSPD-5:

'This system will provide a consistent nationwide approach for Federal State, and local governments to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity. To provide for interoperability and compatibility among Federal, State, and local capabilities, the NIMS will include a core set of concepts, principles, terminology, and technologies covering the incident command system; multi-agency coordination systems; unified command; training; identification and management of resources (including systems for classifying types of resources); qualifications and certification; and the collection, tracking, and reporting of incident information and incident resources.'

Many similarities exist between the NIIMS and the NIMS; however the latter incorporates new, additional components. The NIIMS was designed to meet the challenges of wildland fire, whereas the NIMS aims to address the challenges of all hazards or terrorist events. In addition, NIMS puts greater emphasis on prevention and preparedness measures. With the exception of the way the intelligence function is handled, the principles and concepts of the NIMS ICS are the same as the NIIMS ICS. Under the NIMS ICS, the incident commander has flexibility about where to assign the intelligence and information function, e.g. command staff or operations. Table I gives an outline of the five components of the NIIMS and the six components of NIMS (5).

Table I
Components of the National Interagency Incident Management System (NIIMS) and the National Incident Management System (NIMS) in the United States of America

NIIMS	NIMS
1) Incident command system (ICS)	1) Command and management, including ICS
2) Training	2) Preparedness
3) Qualification and certification	3) Resource management
4) Publication management	4) Communications and information management
5) Supporting technologies	5) Supporting technologies
	6) NIMS management and maintenance

The National Incident Management System

To provide this framework for interoperability and compatibility, the NIMS is based on an appropriate balance of flexibility and standardisation. The NIMS provides a consistent, flexible, and adjustable national framework within which government and private entities at all levels can work together to manage domestic incidents, regardless of their cause, size, location or complexity. This flexibility applies across all phases of incident management: prevention, preparedness, response, recovery and mitigation. The NIMS provides a set of standardised organisational structures – such as the ICS, MAC and public information systems – as well as requirements for processes, procedures and systems designed to improve interoperability among jurisdictions and disciplines in various areas, including: training, resource management, personnel qualification and certification, equipment certification, communications and information management, technology support and continuous system improvement.

The NIMS integrates existing best practices into a consistent, nationwide approach to domestic incident management that is applicable at all jurisdictional levels and across functional disciplines in an all-hazards context. Six major components make up this systems approach. Each is addressed in a separate chapter of the NIMS document (3). Of these components, the concepts and practices for command and management (Chapter II) and preparedness (Chapter III) are the most fully developed, reflecting their regular use by many jurisdictional levels and agencies responsible for incident management across the USA. Chapters IV to VII, which cover resource management, communications and information management, supporting technologies, and ongoing management and maintenance, introduce many concepts and requirements that are also integral to the NIMS but that will require further collaborative development and refinement over time.

National Incident Management System components

The following discussion is taken from the NIMS document and provides a synopsis of each major component of the model, as well as how these components work together as a system to provide the national framework for preparing for, preventing, responding to and recovering from domestic incidents, regardless of cause, size or complexity. A more detailed discussion of each component is included in the relevant chapters of the NIMS document.

Command and management

The NIMS standard incident command structures are based on three key organisational systems.

The incident command system

The ICS defines the operating characteristics, interactive management components and structure of incident management and emergency response organisations engaged throughout the life cycle of an incident (Fig. 1).

Multi-agency coordination systems

These define the operating characteristics, interactive management components and organisational structures of entities that support incident management, operating at the Federal, State, local, tribal, and regional levels through mutual-aid agreements and other assistance arrangements.

Public information systems

These refer to processes, procedures and systems for communicating timely and accurate information to the public during crisis or emergency situations.

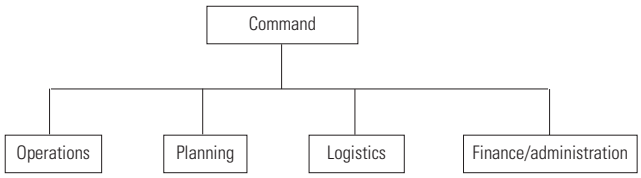


Fig. 1
Incident command system: one of the organisational structures of the National Incident Management System (NIMS) in the United States of America (command staff and general staff)

Preparedness

Effective incident management begins with a host of preparedness activities conducted on a 'steady-state' basis, well in advance of any potential incident.

Preparedness involves an integrated combination of planning, training, exercises, personnel qualification and certification standards, equipment acquisition and certification standards, and publication management processes and activities.

Most countries have some form of planning process in which 'response plans' are prepared. Training and exercises must be given a high priority; it is all too easy to allow 'regular' work to take precedence over the preparedness phase. One way to overcome this is to have an ongoing training plan for responders. Something unique to NIMS is the emphasis on personnel qualification and certification standards. This provides that ongoing training plan. Most countries focus on what needs to be done but not who needs to do it. In the USA we are developing an extensive credentialing system so that when a plan calls for a specific task to be performed we have a pre-trained cadre of people to choose from who can perform that function.

Planning

It has been said that it is the planning, not the plan, that matters. Developing outstanding response plans without the input and commitment of the people who will implement those plans is a waste of time. Response plans describe how personnel, equipment and other resources will be used to support incident management and emergency response activities. Plans provide mechanisms and systems for setting priorities, integrating multiple entities and functions, and ensuring that communications and other systems are available and integrated in support of a full spectrum of incident management requirements. The USA has developed a 'suite' of plans called the National Animal Health Emergency Management System (NAHEMS) guidelines (7), the key to which is the response to highly contagious disease, rather than disease specific plans. Since we may not know the name of the next disease outbreak (as was the case with Nipha virus), a general response plan that can be applied to any large contagious disease outbreak or epidemic seems more appropriate. The NAHEMS guidelines include:

a) field investigations of animal health emergencies

b) disease control and eradication strategies and policies

c) operational procedures for disease control and eradication

d) site-specific emergency management strategies for various types of facilities

e) administrative and resource management

f) educational resources.

Training

Training includes standard courses on multi-agency incident command and management, organisational structure and operational procedures, discipline-specific and agency-specific incident management courses, and courses on the integration and use of supporting technologies. Currently these courses are focusing on the administrative aspects of the response such as the roles of the finance section chief or documentation specialist. Courses based on the sections of the NAHEMS guidelines are also being developed for such positions as disposal team leader.

Exercises

Incident management organisations and personnel must participate in realistic exercises – including multidisciplinary, multijurisdictional and multisector interaction – to improve integration and interoperability and optimise resource utilisation during incident operations. An exercise plan should be designed to ensure that each area of the response plan is practised. A well-thought out and planned scheme should include orientation and a table-top exercise before ever attempting a functional exercise.

Qualification and certification

Qualification and certification activities are undertaken to identify and publish national-level standards, and to measure performance against these standards in order to ensure that incident management and emergency response personnel are officially certified as appropriately qualified to perform NIMS-related functions.

Equipment acquisition and certification

Incident management organisations and emergency responders at all levels rely on various types of equipment to perform tasks essential to their missions. A critical component of operational preparedness is the acquisition of equipment that will perform to certain standards, including the capability to be interoperable with similar equipment used by other jurisdictions.

Publications management

Publications management refers to forms and form standardisation, developing publication materials, administering publications and revising publications when necessary. Administrative tasks will include establishing conventions for naming and numbering, managing the publication and promulgation of documents, and exercising control over sensitive documents.

Resource management

The NIMS defines standardised mechanisms and establishes requirements for processes to describe, inventory, mobilise, dispatch, track and recover resources over the life cycle of an incident. In the exotic Newcastle disease outbreak in 1993 in the USA, 60% of the federal veterinary workforce were deployed to the outbreak. An additional 2,000 people were also deployed at five locations in three different states. The logistics of ordering the right people and having them arrive at the right time required an extensive system to mobilise, dispatch and track these resources.

Communications and information management

The NIMS identifies the requirement for a standardised framework for communications, information management (collection, analysis and dissemination) and information sharing at all levels of incident management. Such standardisation increases in importance as the complexity of the incident increases. Many of our recent incident responses, including those to bovine spongiform encephalopathy, exotic ND and Hurricanes Katrina and Rita, have involved multi-agency cooperation, and communication is of the utmost importance.

The two main elements are briefly described below.

Incident management communications

Incident management organisations must ensure that effective, interoperable communication processes, procedures and systems exist to support a wide variety of incident management activities across agencies and jurisdictions. As major outbreaks require more resources than the regular day-to-day activities a national veterinary service will have to use available resources from other agencies. This is the case for both a disease outbreak and a natural disaster. In a major natural disaster, such as inflicted in the USA by Hurricane Katrina, hundreds of agencies, jurisdictions and volunteer organisations came together to provide a single response organisation, sometimes successfully, sometimes not.

Information management

Information management processes, procedures and systems help ensure that information, including communications and data, flows efficiently through a commonly accepted architecture that will support:

– the numerous agencies and jurisdictions responsible for managing or directing domestic incidents

– those affected by the incident

– those contributing resources to the incident management effort.

Effective information management enhances incident management and response and helps ensure that crisis decision-making is better informed. An effective organisational structure is also important to enhance communication and decrease duplication of effort.

Supporting technologies

Technology and technological systems provide supporting capabilities essential for implementing and continuously refining the NIMS. These include voice and data communications systems, information management systems (i.e. record keeping and resource tracking) and data display systems. Also included are specialised technologies that facilitate ongoing operations and incident management activities in situations that call for unique technology-based capabilities.

Ongoing management and maintenance

This component establishes an activity to provide strategic direction for and oversight of the NIMS, supporting both routine review and the continuous refinement of the system and its components over the long term.

As stated previously, this paper is a summary of the overall NIMS document. The NIMS training courses are available at: http://training.fema.gov/EMIWeb/IS/is700.asp.

Additional training and information is also available at the Federal Emergency Management Agency's Emergency Management Institute, which offers a broad range of on-line independent study courses as well as residential training that addresses key elements of NIMS (1).

Conclusion

The NIMS is part of a comprehensive National Response Plan (NRP) (4). This is summed up in the first five paragraphs of the Preface to the NRP:

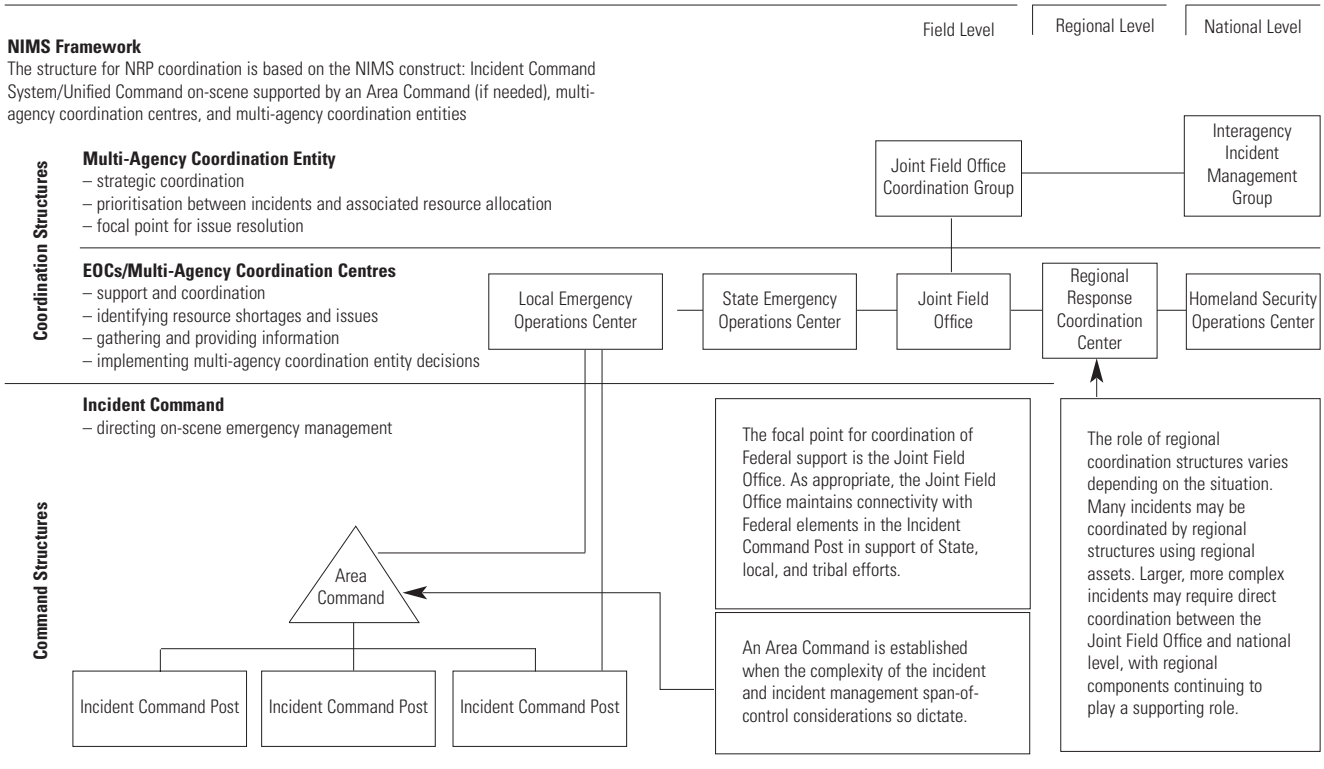
'In Homeland Security Presidential Directive (HSPD)-5, the President directed the development of a new NRP to align Federal coordination structures, capabilities, and resources into a unified, all-discipline, and all-hazards approach to domestic incident management. This approach is unique and far reaching in that it, for the first time, eliminates critical seams and ties together a complete spectrum of incident management activities to include the prevention of, preparedness for, response to, and recovery from terrorism, major natural disasters, and other major emergencies. The end result is vastly improved coordination among federal, state, local, and tribal organisations to help save lives and protect America's communities by increasing the speed, effectiveness, and efficiency of incident management.

The NRP represents a true "national" framework in terms of both product and process. The NRP development process included extensive vetting and coordination with Federal, State, local, and tribal agencies, nongovernmental organisations (NGOs), private-sector entities, and the first-responder and emergency management communities across the country. The NRP incorporates best practices from a wide variety of incident management disciplines to include fire, rescue, emergency management, law enforcement, public works, and emergency medical services. The collective input we received from our public- and private-sector partners has been, and will continue to be, absolutely critical to the implementation and continued refinement of the core concepts included in this groundbreaking national plan.

The NRP is built on the template of the NIMS, which provides a consistent doctrinal framework for incident management at all jurisdictional levels, regardless of the cause, size, or complexity of the incident. The activation of the NRP and its coordinating structures and protocols – either partially or fully – for specific Incidents of National Significance provides mechanisms for the coordination and implementation of a wide variety of incident management and emergency assistance activities. Included in these activities are Federal support to State, local, and tribal authorities; interaction with NGOs, private donor, and private-sector organisations; and the coordinated, direct exercise of Federal authorities, when appropriate.

The NRP is also an essential element of the broader policy coordination and reconciliation mechanisms of the Federal Government. The operational and resource coordinating structures described in the NRP are designed to support existing White House policy mechanisms and decision-making entities during the response to a specific threat or incident. Also, while the NRP itself creates no new authorities, it serves to unify and enhance the incident management capabilities and resources of individual agencies and organisations acting under their own authorities in response to a wide array of potential threats and hazards.'

It will not be simple to change the linkages and tried-and-true individual organisation approach that have served small-scale incidents so well. Change is not without cost in both time and money. Adapting the approach of the USA to a more integrated and coordinated NRP based on the principles of the NIMS (Fig. 2) will require:



EOCs: Emergency Operation Centers
NIMS: National Incident Management System

Fig. 2
Structure for National Response Plan (NRP) coordination in the United States of America (2)

– supporting NRP concepts, processes and structures so that they can fulfil their assigned functional responsibilities and ensure effective and efficient incident management. Such development will include designating representatives to staff interagency coordinating structures, as required;

– agreeing to the terms and conditions in the 'Memorandum of Agreement: Mutual Aid for Incidents of National Significance (non-Stafford Act)', set forth in the Financial Management Support Annex, Attachment 3, December 2004, in the NRP (4). This provision is applicable only to Federal departments and agencies;

– providing cooperation, resources, and support to the Secretary of Homeland Security in the implementation of the NRP, as appropriate and consistent with the authorities and responsibilities of those agencies that are providing support;

– cooperating with appropriate Federal incident management leadership, including the Principal Federal Official, Federal Coordinating Officer, and Federal Resource Coordinator, as appropriate and consistent with the agencies' own authorities and responsibilities, in order to enable effective and efficient incident management;

– modifying existing interagency and agency incident management and emergency response plans to facilitate compliance with the NRP;

– forming and maintaining incident management partnerships with state, local, tribal and regional entities, the private sector, and NGOs;

– utilising departmental and agency-specific authorities, resources, and programmes to facilitate incident management activities in accordance with the NRP;

– developing, exercising, and refining headquarters and regional capabilities to ensure sustained operational readiness in support of the NRP.

The NRP and the NIMS are continual works in progress and will be undergoing continual improvements based on lessons learned. In this first year of operating under the NRP and NIMS there have been a variety of opportunities to learn what worked and what did not work, what was implemented and what had not yet transitioned to the new plans. This past 2005 hurricane season alone will provide a wealth of learning opportunities to revise and improve these plans. Phase 3 of the NRP implementations calls for a review and assessment at the end of the year that began in December 2005. This will be followed by a four-year review cycle to ensure continual improvement.

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Le Système national de gestion des incidents : une approche pluri-organisationnelle aux situations d'urgence

J.F. Annelli

Résumé
Le présent article décrit l'élaboration d'un système universel de gestion des incidents à tous les niveaux de gouvernement aux États-Unis d'Amérique, nommé National Incident Management System (Système national de gestion des incidents). Ce système a été intégré dans le Plan national d'intervention et dans les procédures des organismes qui relèvent du Département de l'agriculture des États-Unis (USDA), en prenant comme modèle le Système national inter-organisationnel de gestion des incidents du Service des forêts. Ce modèle a augmenté l'efficacité de l'USDA pour réagir à toute une série de situations d'urgence qui pourraient toucher l'agriculture américaine, y compris les catastrophes naturelles (séismes, inondations, ouragans, invasions de ravageurs et foyers de maladie, incendies dans des réserves naturelles ou autres type de feux), accidents nucléaires ou conventionnels, introduction accidentelle ou délibérée d'agents biologiques, chimiques ou radiologiques, menaçant l'approvisionnement alimentaire, les infrastructures essentielles ou l'économie des États-Unis d'Amérique.

Mots-clés
Plan national d'intervention – Système de commandement en cas d'incident – Système national de gestion des incidents – Système national inter-organisationnel de gestion des incidents – Tous-risques.

El Sistema Nacional de Gestión de Incidentes como mecanismo interinstitucional de respuesta de emergencia

J.F. Annelli

Resumen
El autor describe sucintamente la creación de un sistema universal de gestión de incidentes común a todos los órganos gubernamentales de los Estados Unidos de América, denominado Sistema Nacional de Gestión de Incidentes. El sistema ha sido incorporado al Plan Nacional de Respuesta y a los protocolos de los organismos del Departamento de Agricultura de los Estados Unidos (USDA), utilizando como modelo el Sistema Nacional de Gestión Interinstitucional de Incidentes del Servicio Forestal del país. Este modelo ha colocado al USDA en disposición de intervenir con mayor eficacia en muy diversas emergencias susceptibles de afectar a la agricultura estadounidense, entre ellas catástrofes naturales (terremotos, inundaciones, huracanes, plagas o brotes de enfermedad e incendios forestales o de otro tipo), accidentes nucleares o convencionales e introducción accidental o deliberada de un agente biológico, químico

o radiológico que amenace el abastecimiento alimentario, la economía o alguna infraestructura básica del país.

Palabras clave
Peligro – Plan Nacional de Respuesta – Sistema de mando en caso de incidentes – Sistema Nacional de Gestión de Incidentes – Sistema Nacional de Gestión Interinstitucional de Incidentes.

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Making better use of technological advances to meet stakeholder needs

M.J. Marshall [1], P.A. Roger [2] & J.B. Bashiruddin [3]

(1) Animal Health Resources Ltd., Registered Office: 5 South Parade, Oxford OX2 7JL, United Kingdom
(2) Veterinary Consultancy Services, Reeth, Richmond, North Yorkshire DL11 6SZ, United Kingdom
(3) Institute for Animal Health – Pirbright, Ash Road, Pirbright, Woking, Surrey GU24 0NF, United Kingdom

Summary

Controlling transboundary diseases requires an inclusive and collaborative international approach. Decisions should be taken (and seen to be taken) on advice from multidisciplinary teams of scientists and representatives from all groups significantly affected by the disease (the 'stakeholders'). Changes in trade and travel mean that, unless a new model is developed for disease prevention, there is a real possibility that transboundary animal diseases will become increasingly difficult to control. The traditional government approach of dealing almost exclusively with the commercial sector of the livestock industry is no longer sufficient, and new ways must be found to include all sectors, including 'grey' husbandry (fragmented, disparate groups whose involvement with animals may range from the legal and responsible to the unsanctioned and/or illegal).

The increasing convergence of human and animal health issues makes it imperative to make the best possible use of new tools. The particular challenges confronting veterinary science are: preventing the introduction of disease, rapidly identifying disease and controlling epidemics. This paper focuses on the United Kingdom to investigate the inadequacies of current approaches, identify needs, offer recommendations and propose a new approach to disease control, which emphasises global considerations. The objectives are: better participation across the entire sector, better communication, better science and better decision-making, all of which should lead to better security from disease.

Keywords

Disease alert – Disease control – Grey husbandry – Inadequacy – Livestock management – Livestock-keepers – Partnership – Policy – Registration – Shared responsibilities – Stakeholder – Surveillance – Technological advances – Traditional farming.

Introduction

All livestock-keepers are on the 'front line' of animal disease identification and biosecurity measures. Risks of livestock diseases, including zoonotic diseases, have become a global problem. Disease control must include all national stakeholders and involve regional and international cooperation. Legislation must be based on sound science but also appreciate the wide variety of animal husbandry. In a time of rapid change, old methods may not be sufficient or appropriate. New technologies and innovative approaches should be discussed openly with stakeholders, and more widely explored (32).

Technological advances, when applied to human and animal health, are subject to peer review, intellectual property rights legislation, and budgetary priorities, which generally support national industries. There is seldom a clear priority to control disease for the protection of human and animal welfare and to safeguard a secure food supply. The adoption or 'uptake' of new technologies is further complicated by the multidisciplinary aspects of disease control and the socio-economic-political interactions involved in controlling foreign and endemic disease while trying to maintain a disease-free status. Examples from the United Kingdom (UK) include limitations on the use of vaccination for foot and mouth disease (FMD) due to trade

constraints and limitations on the control of bovine tuberculosis (TB) due to extraneous support for another wild population (the badger). Decision-making processes at local, national, regional and international levels are often further hampered by a poor understanding of the available technologies and the exclusion of many important sectors.

The term 'stakeholder' is of American/English origin and even in English is subject to interpretations from the legal to the looser more modern usage. The term is not easy to translate into other languages, where often the term 'shareholder' is used. However, 'the whole point of stakeholders is that they are not shareholders; that is, they have no ownership in the enterprise but they nonetheless have an interest in its performance' (22).

Those regarded by government as the 'key' stakeholders normally participate in decision-making. However, the 'grey' husbandry sector is often excluded from consultation and discussion, either deliberately or simply because grey management systems are fragmented with no will or means to be represented. This sector includes important but disparate groups that can range from responsible small family farms to organisations conducting practices, such as ritual slaughter and cock fighting, which are acceptable in some countries and illegal in others. This disparate sector may share only the characteristic of having little or no representation with decision-makers but, as they all potentially have a major impact on disease prevention and spread, it is essential to include these groups in all aspects of disease control. Ignoring this sector means risking losing control of disease spread (32).

The importance of these grey areas is demonstrated by the increasing circulation of reports from unofficial sources (as a supplement to official reports from national governments), by international organisations such as the World Health Organization, Food and Agriculture Organization (FAO), World Organisation for Animal Health (OIE), and on-line disease reporting services, such as ProMED-mail (46). Unofficial reports are increasingly the first alert of emerging disease situations to reach the international community.

The risk of the spread of livestock diseases, including zoonotic diseases, is a worldwide problem that needs to be appreciated and tackled globally. An article by scientists from the Italian Public Health Ministry stated that, 'Changes in the livestock industry, such as the rapid transportation of animals over long distances, and the concentration of livestock in large intensive units, are conducive to outbreaks of exotic diseases which can occur unexpectedly' (31).

There is increasing recognition of the need to apply a common approach to the control of animal and human diseases, and to establish strong links between human and animal health clinicians, researchers and public health officials (27). A thorough discussion of the needs and weaknesses of the United States of America (USA) and recommendations to improve preparedness can be found in the Office of Science and Technology Policy (OSTP) Blue Ribbon Panel publication (26). The Royal Society provides a similar analysis and recommendations for the UK (43).

This paper highlights some shortcomings in responses to recent disease situations and suggests possible beneficial changes, focusing on the needs of stakeholders. Examples are taken from epidemics of FMD, classical swine fever (CSF), bovine spongiform encephalopathy, exotic Newcastle disease (END), severe acute respiratory syndrome (SARS), and both high and low pathogenic avian influenza (HPAI and LPAI), as well as the continuing problem of bovine TB (bTB). These events are used to illustrate current inadequacies, while the authors propose recommendations that take better advantage of recent and proposed technological advances. New initiatives, such as the Animal Health Foresight Project, that address these shortcomings and deserve serious consideration by the international community are highlighted.

References in this paper come from unofficial as well as official sources. Since the concerns of stakeholders are presented in unofficial communications, and rarely appear in official peer-reviewed scientific publications (33), the use of both sources is neither accidental nor coincidental.

Animal husbandry

In the context of the control of animal diseases, stakeholders are defined as all those who have a direct or indirect interest in animal disease, due to the potential impact on their lives or the lives of their animals. These stakeholders include:

– national and international competent bodies

– industry

– the rural sector, including farmers, processors and retailers

– keepers of companion animals

– the tourist industry

– the scientific and professional sector, including veterinarians, scientists and economists.

To be effective, animal disease control must involve a true and inclusive cross-section of livestock-keepers from the farming sector. This obviously includes commercial producers, who are often regarded by national governments as the 'key' stakeholders and therefore

routinely included in consultations and decision-making, and have the power to create and implement policy. However, the 'grey' areas of animal husbandry must also be included.

'Grey' husbandry is defined as all livestock management systems whose practitioners are not officially represented and thus rarely have a voice in decision-making. It is a diverse sector, including:

a) those with small family farms

b) those who pursue:

– non-intensive production

– backyard production (often with mixed and unconventional species)

– hill farming

– pastoralism

– nomadic herding or hunting

c) those who keep animals:

– as companions

– for sporting and leisure activities

– as draught animals.

There are some management systems which do not fit easily into the classification of either 'key' or 'grey'. Animals owned as an investment (e.g. racehorses) could be kept under a variety of management systems; zoos and wildlife parks are often represented at national and international levels; and farm animal parks, or animals in laboratories or centres for scientific purposes, are usually represented under special measures.

The term 'grey' refers only to the lack of representation and makes no judgements about the management systems within this sector. Their inclusion in disease control is important because their actions, no less than those in the key industries, affect the entire livestock community and public health. Among all sectors involved in animal husbandry, there will be a range – from those who comply with high standards of biosecurity and animal welfare to others who undertake illegal or dangerous practices, whether deliberately or from lack of funds or knowledge. Both endemic and, especially, transboundary diseases can spread rapidly unless those responsible for disease control take active and effective measures that are acceptable to all involved in animal husbandry.

Current disease control policy is complex, owing to:

– increasing opportunities for the translocation of disease agents

– changing husbandry practices

– environmental changes

– the apparent widening of species specificities of some agents.

The policies of today try to take these facts into consideration and recognise that, for effective surveillance and control, many systems, such as structures of livestock management, veterinary coverage and resource mobilisation, must be linked to highly efficient information and decision-making systems. However, there have been inadequacies in the current policies and practices, many of which stem from a biased understanding of the livestock sector. This has been highlighted recently in the wake of outbreaks of:

– SARS

– CSF

– FMD

– END

– HPAI

– LPAI

– bTB.

Historical perspective

European Community Directive 85/511 excluded the practice of routine vaccination for FMD, ensuring that, in 1990, Member States of the European Union (EU) adopted the policy of stamping out (i.e. slaughtering infected/affected animals and true dangerous contacts) to control disease epidemics through Council Directive 90/423 (19, 20). The intention is to achieve the international trading status of a disease-free region without vaccination. However, stamping out had already been the favoured policy in the UK for over a century. Although this procedure may be considered 'ruthless' when conducted these days – particularly when pre-emptive slaughter is involved – it was, until recently, the only disease control available. In addition, it was effective for diseases that are, unlike FMD in adult animals, fatal with high morbidity, such as contagious bovine pleuropneumonia, rinderpest and African swine fever and CSF.

Woods (51) explained the elevation of FMD 'from a private nuisance to a state-fought plague'. The UK realised the significance of import controls but, when UK livestock was subject to such controls because of spasmodic FMD infection, influential pedigree breeders pressed for the slaughter of infected animals. This eventually became the universal and compulsory policy. New measures were taken to make significant diseases notifiable and to implement passive and active surveillance followed by

eradication and compensation – the critical disease control factors that are currently still in force.

Within the farming community, there is often no consensus on the best control strategies (with the exception of illegal import controls). This was illustrated by the views in 2001 of the National Farmers' Union (NFU), regarded as the 'key' agricultural stakeholder in the UK. Rossides (42) asserts that it is apparent that the UK Government and Veterinary Authorities did not fully appreciate the nature, pattern and scale of livestock movements in the UK. Thus, they did not fully foresee the likely impact of these movements on disease control. Rossides lists sensible recommendations, including the proposal that the Government should work in cooperation with key stakeholders. But if the Government continues to consult only the 'key' sector and ignores the grey, it increases the risk of failing to appreciate the actual nature and pattern of livestock-keeping. This could result in an inability to prepare for and control another disease outbreak.

The anatomy of a disease epidemic

Some of the lack of consensus in the farming community may stem from a scarcity of accurate information about the various disease control options available. There must be open discussion of all such options, particularly when scientific disagreements occur. In all cases, risk analysis must be seen to be open, transparent and inclusive, to give all stakeholders confidence in the decisions taken on their behalf. It is imperative that basic strategies are explained and agreed upon in advance, so that decisions can be taken quickly in the event of an outbreak.

Consultations

Both grey husbandry and large industry have a common duty to submit to the regulations of control policy (e.g. duties of notification, carcass disposal), but the difference is that the latter are consulted. For example, smallholders who requested to be allowed to vaccinate their animals in the 2001 FMD epidemic were refused, without consultation on the issue. Such an oversight can be counter-productive if it fosters feelings of injustice, and results in apathy and loss of trust.

Control policies need to be inclusive in their development and transparent in their application. Consultation processes must also be broad and inclusive, in that all stakeholders should have the opportunity to participate. Government consultations often seem biased towards the well-funded and more powerful sectors of the industry.

The UK process of consultations with stakeholders on disease preparedness and contingency planning illustrates some of these shortcomings. In particular, there has been a lack of open reporting of meetings, which are often held separately, without coordination, involving different groups of stakeholders organised by different groups within the Department for Environment, Food and Rural Affairs (Defra) (33).

Lack of information is a common problem. This is exacerbated by the wide use of temporary emails, which are frequently used to communicate with stakeholders. Moreover, they often replace permanent paper files in government departments. Stakeholders who have responded to various consultations are often critical that the time and energy they have devoted to this process seems useless when their responses have been lost in the electronic ether.

Communication channels must be enhanced to ensure that accurate, up-to-date and unbiased information is readily available and widely distributed to all stakeholder groups. The ProMED-mail system of archiving provides an excellent model (http://www.promedmail.org/). For example, a search on 'PRO/AH> Avian influenza – poultry vs. migratory birds' gives instant access to both historical and up-to-the-minute reports and moderators' comments on this topic.

Alerts and awareness

Livestock-keepers need targeted alerts and specific advice when faced with an increased risk of infection. Blanket recommendations to livestock-keepers and their veterinarians, without accompanying details, are not helpful. General and regional alerts should be posted on government websites, and specific red alerts should be sent to organisations and registered, individual livestock-keepers, using an automated system of direct, personal communication, for example, by email or messages to mobile phones.

Educating livestock-keepers through effective targeted communications on disease risk would enable them to judge the risks relevant to their holdings, and prepare and implement appropriate biosecurity measures. It would help to ensure that they inspect their animals, not only for endemic diseases but also for unusual clinical signs. Rapid identification of disease is essential, both at the endemic source and in preventive surveillance. This requires the cooperation of animal-keepers, who are in the front line. For a wide variety of reasons, there may be a serious lack of ability and/or willingness on their part to recognise and report suspicious clinical signs. Fundamental in encouraging the cooperation of livestock-keepers is to give them choice and control.

From the perspective of the keepers, the first stage in a potential outbreak is to routinely examine their animals.

What do they do when faced with an animal showing a suspicious clinical symptom or sign? If the animal concerned is of low value or medical advice (proportionately) is too costly, the possible disease is unlikely to be reported, and the animal will probably be consumed, sold, thrown in the rubbish bin or buried on-farm.

Reporting

The willingness of livestock-keepers to report suspicious signs depends on a variety of factors, in addition to the direct veterinary costs:

– education
– awareness (including alerts)
– incentives
– compensation
– safe, rapid and affordable disposal of carcasses
– trust.

Relationships with neighbouring holdings may also play a role: while it is in the interest of neighbouring holdings to have an outbreak quickly identified and controlled, the resulting imposition of prolonged movement restrictions discourages reporting.

Livestock-keepers are sometimes reluctant to report a suspected disease and have samples sent for testing because of the effect on their own and neighbouring holdings. Rapid on-farm diagnostics can clarify suspicions and alleviate unnecessary hardships. Such diagnostics could be used to screen for notifiable diseases. Adverse results would then justifiably initiate or 'trigger' quarantine and movement restrictions, while samples are sent to reference laboratories.

Suspicious signs may be noticed first when animals are taken to market or agricultural shows, where there may be routine veterinary inspections. Reporting in these cases can vary. Consideration should be given to active surveillance at these locations.

Failure to report will lead to failure to identify an early index case and thus a catastrophic delay in finding the primary case(s). This can lead and has led to epidemics. To encourage reporting, various authorities (5) have proposed that incentives should be offered, in the form of increased compensation, to all those reporting early signs of disease. Early identification and recognition is essential to containing disease spread. Compensation is important for all livestock-keepers, and for all aspects of disease control, as discussed above.

Reporting by the veterinary practitioner as a basis for surveillance

Some larger enterprises will have their own veterinary support, sometimes permanently on-site. Many from the grey sector will lack that support, so their first decision is whether or not to seek veterinary advice. In some circumstances, veterinary support is simply not available, for example, as reported in a suspected outbreak of FMD in Punjab (6). Numerous examples can be found from sources such as ProMED-mail and the University of California, Davis, FMD Surveillance and Modeling Laboratory.

In most countries, state-run disease surveillance still has a bias towards accurately reporting only exceptional diseases, so that common diseases seen on farms (e.g. contagious ecthyma in sheep in the UK) are reported as low incidence (under-reported), whereas it is well recognised that the opposite is true. The same surveillance systems implemented for exotic diseases should also monitor endemic diseases, so that adjustments can be made when grading the disease according to impact. Early control actions may reduce the impact of these common diseases.

Efficient sampling of suspicious cases, as a basis for movement restrictions, vaccination and slaughter

When a notifiable disease is suspected, samples should be taken and tested from all potential cases, especially in the early stages. Portable, rapid on-site or near-site tests should be used to ensure appropriate movement restrictions can be imposed promptly, for a positive test, and to prevent lengthy restrictions if there is no disease (4, 14). Depending on circumstances, these samples should also be sent to a diagnostic laboratory for confirmation, and, if appropriate, to identify the serotype for vaccine use. Wider movement restrictions may be implemented as soon as laboratory confirmation occurs. Care should be taken to preserve a record of all test results and ensure that they are available for epidemiological analysis.

To ensure the efficiency of disease control strategies, a review of the way(s) in which field samples are delivered to the reference laboratories (as a support or 'back-up' to rapid on-site testing, to act as the model or 'gold standard' for identifying an index case, as well as to determine the identity of the serotype for vaccine production) is essential. Delivery must be rapid, direct and traceable and may need to involve other agencies, such as the armed forces or police. Written protocols and standard operating procedures (SOPs) must be integral to any plan to ensure forensic standards are maintained during collection, preparation, transportation and delivery. Problems that can

arise, such as carriers refusing to transport samples or delays until a pilot will accept such a cargo, as well as customs delays, reinforce already powerful arguments for the use of on-site diagnostic testing.

Surveillance and biosecurity

The essential components of a surveillance system are:

a) the reporting of unusual symptoms, rapid diagnostics and identification of patterns;

b) an enhanced role for a geographical information system (GIS) linked to an information technology (IT) system, which would avoid some of the mistakes made in identifying the locations of holdings or of groups of animals as occurred in the UK in 2001. It would also enhance, for example, risk analysis by incorporating a local application of relevant meteorological and other information;

c) the collection, storage and sharing of disease information (32).

All three of these components depend on an acceptable and effective system of individual animal identification and registration of livestock holdings.

It is important that these components mesh together. Rapid identification of disease is essential, both at the endemic source and in preventive surveillance, requiring the full cooperation of animal-keepers. It is also essential, and a government responsibility, that surveillance has a direct effect on what policies are drafted and what actions are taken.

Information databases

Rapid analysis and detection of animal-related risks (RADAR) (13) is a new government information management system being developed in the UK, which collects veterinary surveillance data from many different sources in a common format, so that the information can be combined. The objective of RADAR is to make it possible to analyse this information and then publish reports, highlighting:

– the threats to public health and animal health and welfare

– the risks they pose

– the geographical areas at risk.

The database should be inclusive and avoid the present bias or 'skew' that is currently inherent in veterinary surveillance systems. This skew is an effect of the samples submitted not being representative of the common problems seen on farm (they are predominantly submitted from animals suffering from problematical or unusual symptoms), and thus have an inbuilt bias against reflecting the true incidence of problems seen on farm. However, good surveillance cannot be effective without the political will to tackle particular disease problems.

One development in the UK is the Farm Health Planning Initiative, in which farm health plans are developed by the livestock owner, in conjunction with their veterinary surgeon (9). This should improve the rapid recognition and reporting of unusual symptoms or signs at the site of an index case. Ideally, the farm health plan is based on:

– local husbandry practice

– knowledge of the local disease risks

– close knowledge of the specific holding involved.

This helps the industry to identify and treat existing problems, so as to eradicate them or at least minimise their effects. Proper quarantine and isolation facilities will be established for any new animals and a detailed written protocol put in place to ensure that no visitor, visiting vehicle or equipment can exacerbate problems. The plan should provide a written record of how the livestock industry plays an active role in the partnership against emerging disease.

While it is essential that this type of data is available in a meaningful and useful format to all those concerned with animal health, rather than only to official outlets, confidentiality must also be considered. If the confidentiality of livestock-owners is not protected, they will be less willing to report any suspected disease.

Another way to enhance disease surveillance and control is to allow private sponsored surveillance, such as that provided by Hachaklait, a Mutual Society for Clinical Veterinary Services and Livestock Insurance in Israel (http://www.icba-israel.com/icba-haklait.html), and the National Animal Disease Information Service (NADIS) (http://www.nadis.org.uk), a network of 40 sentinel veterinary practices and six veterinary colleges which monitor animal diseases in the UK. Due to a wide distribution of practices, with over 100 more having expressed an interest in joining the network, NADIS provides a regional representation of information across the whole spectrum of endemic diseases of interest to farmers, veterinary surgeons and the government. Together with other disease surveillance systems, NADIS could provide a basis for syndromic surveillance, with data to help highlight the presence of any new emerging disease. At present, the funding for this excellent system is through limited sponsorship, and collecting the data involves considerable effort from the sentinel veterinary practices. There is a time lag in retrieving the information, which is

recorded, transcribed and distributed monthly. A more rapid turnaround would be possible, using newer tools, if core funding were provided.

Registration of livestock

Registration systems for livestock should be developed, which are both acceptable and beneficial to government and the livestock sector.

For the government, effective control strategies require accurate information on the numbers, locations and management systems of animals, and the contact details of the owners.

For the livestock sector, benefits should include receiving targeted alerts and:

a) information on risks, so that livestock-owners can take appropriate, on-farm biosecurity measures

b) advice, so that they are aware of the tools and control options available, particularly during an outbreak

c) assistance, so that they have access to the necessary diagnostic and vaccination tools and/or safe slaughter and disposal.

Currently, there is a perception amongst many livestock keepers that registration with the government will be a fast track to slaughter in the event of a disease outbreak. In fairness and to attract livestock keepers to register, real benefits such as those outlined in the points below need to be offered. During a disease threat, those who register with management systems which would justify specific derogations such as from slaughter or trade restrictions or exemptions such as from keeping animals indoors (e.g. premises that are closed holdings or have approved/inspected biosecurity or testing regimes) must receive a benefit as recognition for their registration. This would be a reasonable basis on which to allow quarantine and vaccination, rather than slaughter, and therefore eliminate the cumbersome UK proposal (discussed below) which depends on numbers of animals of specific species, rather than on the real risks associated with management systems and/or species' susceptibility.

The authors therefore suggest a mutually beneficial system of livestock registration, in which owners could choose to register with the government or a private veterinary scheme. Those who register their livestock with the government would:

– have access to rapid diagnostic testing as soon as suspicious clinical signs are reported. If their animals test negative for the presence of antibodies against the disease, they would have the option of vaccination or quarantine, subject to further testing;

– be able to have their livestock vaccinated if vaccination is authorised (eliminating complicated schemes of rare breeds requiring a specific number of breeding males and females to be eligible for vaccination);

– be able to have their livestock slaughtered at a pre-agreed rate of compensation.

Those who register with a private veterinary practice or group would have the option of quarantine and testing in an outbreak, but at their own expense, possibly through an annual insurance agreement, or with the assistance of a non-governmental organisation. Under the private option, the government would benefit from access to a channel of communication that would not otherwise be available.

Anyone outside either option could then be considered outside official livestock-keeping, with a justifiable suspicion of illegal practices or lack of knowledge (providing that adequate information on registration was available and that the above schemes were well run and not prohibitively expensive).

Geographical information systems

Accurate predictive 'real-time' models of disease behaviour have been made possible by GIS, used in conjunction with satellite information. However, those in control of modelling must be veterinarians familiar with animal disease behaviour, or serious misconceptions may arise (23, 24, 25, 28, 30, 47, 48). M.E. Hugh-Jones (personal communication, 2004) notes GIS systems in which global positioning system (GPS) chips: 'are incorporated into handheld data loggers, these sites can be recorded automatically without the risk of error. Too many farms in 2001 were identified by map reference numbers and slaughter initiated, or attempted, in spite of owner claims that the stock were not affected; in each case the slaughter team had the right map reference but the wrong map, or vice versa. Nobody needs such lethal and expensive mistakes.' It is logical to build GIS into the registration process.

Animal identification

To have a regulated and safe livestock industry, it is necessary to be able to:

– trace the movement of individual animals along the production chain

– correlate the product with the site of production

– identify animals in an emergency.

For this, it is important to have an identification and tracking system that is simple to use, easy to administer,

avoids duplication, is difficult to circumvent and which links easily with GIS systems to pinpoint exact locations. Electronic implants, such as the National Livestock Identification System used in Australia, are sufficiently advanced to accomplish this, but their recovery at the abattoir is not yet perfect and food safety issues must be considered (3). Manual tagging and paper records entered on to a central computerised database seem quite a clumsy system compared with new technologies and, even with this slower and more labour-intensive manual method, mistakes occur. The EU has a target of adopting electronic identification of all major farmed species by 2008. Various methods are in place at present, including microchips, boluses, ear tags, and photographic and description identification of specific features.

Non-invasive technologies for individual animal identification would be welcomed by the livestock community, and research into their development should be encouraged. These include biometrics and deoxyribonucleic acid (DNA) identification, from, for example, fibre samples for mitochondrial DNA.

Active surveillance

The cooperation of the livestock sector and the effective use of a continuous, real-time active national surveillance programme are essential in the rapid identification of disease. A formal, active FMD surveillance methodology, described by Bates *et al.* (2), includes the following:

– using new technologies (e.g. portable, rapid diagnostic devices) in cost-effective mass screening and environmental testing

– integrating transboundary disease surveillance into existing mass-screening systems for endemic diseases

– strategic targeting of high-risk animals, times and locations (e.g. at milk collection, in livestock markets)

– strategic use of specimens submitted for routine diagnostic testing.

It is essential that, during collection, the data are not skewed or artificially unbalanced, especially if these data will be used to determine current and future control measures.

Improvements in surveillance and control are needed at all levels: local, national, regional and international. There are a number of prerequisites for the classical approach to establishing and maintaining a national disease control programme, as identified by Shimshony and Economides (46). These are:

– controls on the importation of animals and animal products

– efficient disease monitoring in the field

– rapid and reliable laboratory diagnosis

– epidemiosurveillance, with appropriate communication networks both within and outside the country

– an effective veterinary infrastructure in the field to apply the necessary disease control measures, either directly or with accredited professionals

– appropriate rules and legislation, and tools to enforce them effectively.

This is indeed an ideal and a target. Few, if any, countries completely satisfy these prerequisites at present.

Assessing which new diseases should be regarded as notifiable

The example of low pathogenic avian influenza

The outbreak of END in the south of England in 2005 raised concerns over migrating waterfowl and the risk of introductions of avian influenza (AI). The Chief Veterinary Officer considered the risk to be low because the waterfowl carried LPAI. However, the Panel on Animal Health and Welfare of the European Food Safety Authority assessed the risks of mutagenesis of LPAI to HPAI as being significant enough to recommend the inclusion of H5 and H7 LPAI, together with HPAI, as notifiable diseases (18). The Panel recommended such measures as:

– limiting contacts between wild migratory birds and poultry

– limiting movements and contacts of animals and people between farms

– updating education for farmers

– promoting cooperation between epidemiologists and ornithologists who map bird migration routes.

The Panel also recommended including LPAI in the legislation banning imports of live birds and products from countries with recent outbreaks of HPAI, in addition to tightening import controls on the trade in feathers, down and manure. Moreover, they highlighted the need for:

– development of an early warning system to monitor LPAI

– identification of high-risk areas (those in proximity to migratory bird pathways or wintering sites)

– maintenance of safe distances between farms

– regional contingency planning for mass culling

– vaccination.

Previously unknown diseases

Shimshony (45) identified the need for active syndromic surveillance, especially to identify newly emerging diseases. Syndromic surveillance refers to methods relying on detection of individual and population health indicators that are discernible before confirmed diagnoses are made (29, 38). In other words, this involves the collection and description of developing symptoms rather than reporting the identification of a particular disease. As an example, he discussed the epidemic of Rift Valley fever (RVF) in Egypt, which led to the OIE categorising RVF as a List A disease in 1980. There were problems at all levels, with the most serious being the absence of early detection and reliable reporting systems. Shimshony commented that, 'the initial diagnosis of RVF, when it has penetrated a previously unaffected territory for the first time, is notoriously difficult, index cases usually being misdiagnosed'. He noted that, when the disease spread into South Africa for the first time, in 1950, it took six months, with some 20,000 clinical cases in humans; and 100,000 mortalities (as well as many abortions) in sheep and cattle, before a definite diagnosis was made. Murray and McCutcheon (35) observed that even the strongest preventive management systems cannot guarantee that outbreaks of animal diseases will not occur. They cite outbreaks of previously unknown diseases, such as equine morbillivirus, which was discovered in Australia in 1994, and had significant animal and public health implications, which no system could have prevented. The emergence of SARS, linked by recent evidence to bats, also demonstrates that it may be difficult to survey the movements of unknown agents especially when the syndrome closely mimics a known disease.

A previously unknown vector can also present difficulties, along with research opportunities. The recent evidence that links bats to SARS, Nipah and Hendra viruses presents an opportunity for scientists to break the transmission chain (1), but illustrates the need to be careful not to lay the blame too quickly on certain animals, practices or management systems.

For effective surveillance, stakeholders, especially in the grey sector, must be involved.

Biosecurity on the farm

Consideration should be given to biosecurity issues, such as whether other animals and people visit the farm. Closed herds, where new animals do not enter, reduce the risk of disease introduction.

To control bTB and other diseases, the creation of different herd categories has been proposed, with varying levels of biosecurity, according to the particular management system and the purpose for which the herd is kept. A closed herd with good fencing, which is not in contact with any other farmed livestock, in an area with no recognised incidence of bTB, would be a very low-risk herd (especially to a species of low susceptibility). However, a herd with active movement of breeding stock and visiting males, kept on a farm near to other cattle, in an area with a recognised incidence of TB, would be a high-risk herd. These categories could be widened to include other disease prevention strategies and should be part of a written health plan devised with the local veterinary surgeon (41). Competent farm biosecurity needs to be formally and positively recognised as part of outbreak control. Where regulations are perceived as disproportionate, unscientific, unreasonable or inadequate, rules are more likely to be broken. Stakeholder collaboration and support is vital in achieving farm biosecurity.

Legal imports of live animals

The movement of live animals is a controversial topic among stakeholders, due to animal welfare concerns and disease risks. It is helpful to distinguish between animals imported as companion animals or for genetic diversity, and animals imported for food. The disease risks from all live animal imports can be controlled through diagnostic tools. Most live animals that are intended to remain alive are subject to quarantine and further testing, unless they originate from a region that only requires certificates (e.g. between EU Member States). As there are risks of introducing animals with preclinical, subclinical and asymptomatic infections, further measures should be taken by the importing country. Rather than relying only on export certificates, all imported live animals, or an agreed sample, should be appropriately re-tested with negative results before being released to the new owners. The costs for this testing should be met by the owners. The community of stakeholders is therefore involved and when informed would, it is hoped, support the additional costs.

With regard to genetic diversity, new and inexpensive embryo transfer technology can reduce the need to transport live animals for breeding, although this may not be suitable for all species. International guidelines are available on diseases that can be avoided using artificial breeding techniques (54).

The arguments for and against the import/export of live animals for food are complicated by considerations of traditional practices (as opposed to a more general consensus to have animals slaughtered at the nearest point to production), which are not within the scope of this paper. However, strict measures can also be taken here to reduce the risks of disease spread, by programmes of active and targeted surveillance.

Targeted use of diagnostic tools, accompanied by enhanced biosecurity measures and proper controls, provides protection for meetings where animals and humans mingle, such as livestock markets, agricultural shows and companion animal fairs.

There are constant risks from the exotic companion animal or 'pet' trade, from illegal imports of live animals, meat products and 'bushmeat'. This is discussed elsewhere by Wooldridge *et al.* (52).

Partnership: shared responsibility and mutual benefit

Towards a genuine partnership between government and industry

On the EU FMD and CSF Coordination Action (CA) website, views have been sought from stakeholders on how to improve the relationship between the livestock sector and government. Breeze (5) suggests disease control cost-sharing in a partnership between government and industry, implying responsibilities for both. Industry can expect 'performance benchmarks' to be set for components such as an inducement scheme for early reporting, rapid verification and rapid communications: '... the government should ... be prepared to demonstrate that it is meeting its Performance promises...'. Breeze advocates rewarding vigilance instead of threatening negligence. For example, extra compensation would be given to the first owner reporting a suspicious case that proved to be an infection of concern. This bonus would also be paid to those subsequently reporting suspicious cases that prove positive within the first two weeks after a definitive diagnosis.

At the Netherlands Presidency of the European Commission Conference on the 'Material and Immaterial Costs of Animal Disease Control' in 2004, Rudman (36), as Chair of the Committee of Professional Agricultural Organisations (COPA) and the General Confederation of Agricultural Co-operatives in the EU (COGECA), reported that, while there are many endemic or on-farm infections or conditions that livestock farmers can deal with, given appropriate advice, there are also diseases that are not within their power to prevent. Disease prevention on a national scale is the province of government. Rudman pointed out the responsibility of government not only to ensure food safety, but also to control disease whilst avoiding regulations and responses that could unbalance economic competition. He argued that these measures cannot be borne as a primary cost by food producers.

Where national biosecurity measures fail to protect the national herd or flock from epizootic disease, Rudman argues for adequate compensation for direct loss (personal communication, 2005; 36). He explains that the EU Veterinary Fund provides compensation of up to 60% of the market value of the animals destroyed and is fully supported by the European Agricultural Guidance and Guarantee Fund. Rudman also emphasises the deleterious effect that the withdrawal of central funding from these bodies would have on control programmes across the EU. It is his opinion that the threat of withdrawal of compensation for disease outbreaks or epidemics caused by transboundary exotic infection is unacceptable and must remain the responsibility of government.

Pappi and Henning (37) record the importance of organisations such as COPA/COGECA in informing and influencing policy decisions within the EU. This type of representation is an important way of giving EU stakeholders a chance to participate in policy decisions.

Unnecessarily complicated interpretation of the European Union foot and mouth disease directive

The European Union foot and mouth disease directive (7, 21) allows special provision to protect genetic diversity during future outbreaks by establishing a list of farms or holdings where a 'breeding nucleus' of rare or special breeds is held.

The way in which Defra has chosen to interpret this is unclear in the latest Defra contingency plan, version 1.1 (11), where Defra has removed the detailed requirements that were specified in the previous version, 1 (10), implying that these important details have not yet been finalised and are therefore still open to revision (12). However, these details continue to appear on other Defra (7, 8) and livestock association (39) websites. The suggested UK system of classifying holdings by numbers of males and females (the 'breeding nucleus') of certain species, recognised by the Rare Breeds Survival Trust, is an extremely limiting approach, is unnecessarily complicated and restrictive, and would be virtually impossible to enforce. That such uncertainty in interpretation, which could cause considerable confusion and delays in the event of an outbreak, persists more than 5 years since the 2001 epidemic is a matter of serious concern to stakeholders (17).

The complex criteria are described by the Rare Breeds Survival Trust as follows (39):

'Any special provisions would only apply to those premises that hold breeding nuclei of FMD susceptible animals. The

established definition of a breeding nucleus for each breed is as follows:

Cattle: minimum of 8 females plus minimum of 1 male (or AI [artificial insemination])

Sheep: minimum of 16 females plus minimum of 1 male (or AI)

Pigs: minimum of 3 females plus minimum of 1 male (or AI)

Goats: minimum of 6 females plus minimum of 1 male (or AI)

Eligibility criteria:

– the breed must be listed as rare in the UK's Report to FAO on Farm Animal Genetic Resources

– the breed must be native to the UK

– the animals must be registered with a recognised breed society

– the premises must have a breeding nucleus equal to or exceeding the minimum numbers/population above.'

'Based on these criteria we [Defra] will be able to compile a register of holdings which contain breeding nuclei of genetically valuable stock which may qualify for special measures in the event of an outbreak' (10).

It should be noted that factors other than genetic diversity may be relevant in deciding which animals should qualify for special measures in an outbreak. These may include behaviour characteristics and training (e.g. llamas trained for trekking).

The registration system is a welcome development and should be open to any livestock-keeper who wishes to register and will comply with the requirements. In return, the livestock-keeper should have increased options available, subject to veterinary approval, such as quarantine and vaccination, without regard to the numbers of animals in the holding. This would avoid any temptation to move animals simply (and, in the event of an outbreak, illegally) to achieve the required number to protect against slaughter. The registration database could include other relevant information, such as the management system and species in the holding, as well as listed rare breeds and genetically valuable animals. While accurate knowledge of numbers and species is an important component to preventive vaccination, specifying minimum numbers of animals as a pre-requisite to derogations adds unnecessary complications, especially in an emergency. Uncertainty and unclear regulations could be even more problematic.

Enforcement

Regulations should be based on the best scientific advice on the most effective, proportionate and acceptable disease prevention measures, not on whether the regulations are difficult to enforce. (See the Defra reports on meetings with stakeholders on the CA website: fmd-and-csf-action.org.) In what other areas is legislation against activities avoided simply because of the potential difficulties of enforcement? Such considerations have not prevented the UK Government from legislating against hunting with dogs, even though police forces acknowledge that this legislation is difficult to enforce, and despite protests from many stakeholders that this legislation will lead to considerable problems, e.g. disposal of fallen stock and the spread of mange in foxes and dogs. The enforcement of illegal import legislation can be enhanced by increasing surveillance, including forensic testing.

When regulations are perceived as disproportionate, unscientific, unreasonable or inadequate, rules are more likely to be broken. Use of appropriate, including new, technologies would reassure stakeholders that regulations are being adequately enforced. The use of inappropriate or unvalidated decisions 'casts long shadows', affecting not only the final financial and economic costs of an epidemic but the health of communities and individual farmers.

The psychosocial effects of the 2001 UK FMD epidemic in a rural population were investigated in a qualitative, diary-based study by Mort *et al.* (34). They found: '…profound psychosocial effects of the disaster among a wide range of rural workers and residents that would not be revealed by more traditional biomedical or health research methods…'. The study reveals that, 'continuing feelings of bereavement, fear of a new disaster, concern about the undermining of the value of local knowledge', long after the end of the epidemic, still cause distress. The 'loss of trust in authority and systems of control' expressed by the respondents is perhaps one of the most worrying aspects of the study.

Individual animal identification and traceability

There has been some resistance to animal identification systems on the grounds of confidentiality and practicality, by both the commercial sector and small-scale producers. In the USA, producers worry that they will lose control of information about their animals and operations with a government-run trace-back system that, according to livestock industry sources, suffers from a lack of funding and ever-changing ideas about system features and which equipment to use. The National Cattlemen's Beef Association believes that the livestock industry could assemble a less expensive and more flexible system faster than the government and is spearheading a private-sector

database (40). While their proposed system is not as complex as everybody would like, it could be used by producers to store data such as feed records, breed lineage and health care, and this 'value-added' information could help to defray its costs.

While some producers doubt the government could keep their records confidential, others express scepticism about trusting a private database with the information. Another suggestion is for the government to remain in charge but to contract out some of the work (40). Breeze also addresses these concerns on the Internet (4).

There may also be resistance to government identification of animals in other cultures, where the benefit of gaining knowledge for disease control may be regarded as secondary to concerns about the disclosure of details on personal wealth.

One proposal for research into alternative data collection strategies is discussed in the OSTP report (26). A suggestion is the development of technology platforms (electronic or internet based systems for data collection), with the real-time capacity to develop large databases from private databases very quickly in an emergency.

The uptake of new technologies

Tools that are becoming increasingly sophisticated and powerful should be used appropriately and effectively. However, they should also be applied with common sense, and respect for the traditional and often simple practices that have been effective in the past. Changes in agricultural and trade practices which lead to the rapid spread of disease require the use of new technologies, especially as part of an active surveillance programme. Quick and effective surveillance by non-invasive diagnostic technologies and support with rapid on-site tests that can be used in conjunction with the tracing of animal movements would be a way in which new technologies could be incorporated.

These technologies should be made available where needed, with international assistance to ensure they can be adopted by communities that cannot afford the associated costs.

Stakeholders sometimes express concern that new technologies may not be fairly evaluated or used because of conflicts of interest, the protection of local jobs and research grants and a preference for supporting technologies developed by national governments. An example in the UK is a perceived reluctance by government laboratories to accept on-farm, rapid diagnostic tests. When new technologies are introduced, there may be a shift in some fields of employment, but national and private diagnostic laboratories will always be required. Ideally, new technologies should be evaluated and first used in non-crisis periods, rather than during an epidemic, to avoid misinterpretations arising from unfamiliarity.

The selection of a particular diagnostic device (53) should be based on fitness for the purpose, even if it was developed in another country. The costs of prevention and effective control must certainly outweigh the benefits of supporting a local device if it is not ready and/or not as fit for the purpose. There will almost always be a need for a wide variety of devices which are useful in different situations. For example, some real-time, reverse transcription polymerase chain reaction devices are very heavy, and only suitable for use in a mobile laboratory, while others may be lightweight and highly portable but require considerable training to use. Thus, the latter should only be employed by qualified members of a Veterinary Service or taskforce. Some will be multiplex (i.e. designed to detect and differentiate several infectious agents in a single assay), especially useful in screening imports and at places where livestock gather. Rapid pen-side tests, e.g. lateral flow devices, which could easily be used without training by livestock-keepers, may be helpful as a guide for movement decisions, especially in the aftermath of an epidemic, or as a quick guide to protect veterinary practitioners who are examining animals with uncertain symptoms.

Stakeholders need assurance that such partisan concerns will not determine the acceptability of new technologies. Research into innovative tools should also not be impeded by the approach that, 'what we have now already works well, so why change?' International advice must be considered to ensure that the most appropriate tools for the purpose are used. The costs of an epidemic must always be set against the costs of prevention, early detection and effective control.

Rudman, who is veterinary and public health adviser to the National Farmers' Union (NFU), has pointed out that livestock-keepers need to have confidence in the authority of a test, i.e. know that the technology is effective, consistent and will not lead to more uncertainties (P. Rudman, personal communication). 'For all farmers' impatience with Government, they want official sanction of the methodology if their businesses are at risk.'

One example of investment in new technology is that food retailers are willing to introduce radio frequency identification (RFID) technology, which will mean costly changes in their supply chains. However, to add perspective, 'the high level of investment allows only the biggest retailers to implement the technology' (16).

In the field of animal disease control, researchers cannot afford to let these expensive technologies be available only to the commercial sector. Governments should invest in technologies which protect their national animal and public health.

When trust is lost, how can it be regained?

While stakeholder involvement should be more inclusive, it is not possible for all stakeholders to have a direct voice in policy-making. New approaches that would help stakeholders from the livestock, veterinary and government sectors to work in partnership should be investigated.

An example of a practical measure is the proposal for registering livestock (outlined below), either directly with the government or through appropriate representative bodies.

An Animal Health Association, where all sectors can meet, discuss their concerns and propose and vote on resolutions, would be a welcome development. An example is the United States Animal Health Association (www.usaha.org), whose stakeholders include livestock-keepers and representatives, scientists and government regulators. This Association provides an independent forum where differing views can be expressed and explained, disagreements can be discussed and conflicts potentially resolved.

The goal is for stakeholders to have trust in those who make decisions, and in the decisions that are taken. A properly constituted, permanently operational and balanced Expert Group, as specified in the EU FMD Directive 2003 Article 78 (1) (21), would reassure stakeholders and give them confidence that any decisions are based on the best advice, as analysed by the Royal Society in their Annex A the technical input into the decision-making process (43).

A welcome step in this direction has been taken by the European Commission through their support of the Coordination Action on FMD and CSF (fmd-and-csf-action.org), which brings together researchers and stakeholders. The partners, from European reference laboratories, the FAO, OIE and the European Commission, work together to eliminate gaps and duplications in research. Stakeholders, especially those from the livestock and veterinary sectors, will have access to accurate, unbiased information and the opportunity to discuss issues on line. The intention is to establish a permanent platform for communication. Another complementary EU initiative is the European Technology Platform for Global Animal Health which also began in early 2005.

An Animal Health Foresight Project conducted in 2005 by Canada and the USA, with international participation including Chief Veterinary Officers (CVOs), sought disease control alternatives to mass animal destruction and the accompanying problems of mass carcass disposal. 'Based on the opinions and observations expressed by the participants, 10 conclusions were derived leading to the development of a new paradigm for animal health – all based on animal-health optimization rather than destruction' (50). The critical change elements that were analysed as part of a new paradigm for animal health are science and technology research and development, education, engagement, information management and communications. Together, these will help the drive towards the optimum resolution which will provide incentives to share data and report disease and to help create a pre-emptive plan for the next crisis, as well as increasing the proper use of tracking and diagnostic technology, improving public trust, empowering consumers to make informed decisions and enhancing the risk management approach to disease control. The need for international standards to be changed to match a risk management approach was considered an important component (49).

The SSAFE initiative is a global alliance launched in 2006 by the OIE and hosted by the University of Minnesota (USA) which intends to provide input from the entire food supply chain, to facilitate and enable progress in strengthening the global food safety system as well as animal disease prevention and control worldwide, and to leverage resources through public-private partnerships for collective action (55).

It must be recognised, however, that decisions on disease control are never simple and never without controversy.

Recommendations

These recommendations for improvements are broad and flexible, in recognition of the wide range of:

– differing livestock management situations

– access to funding for appropriate and effective tools

– relations between governments and veterinary agencies

– decision-making processes throughout the world.

Disease control measures should be taken in partnership with all sectors, and allow livestock-keepers some degree of choice and control.

a) Animal disease control must involve a true and inclusive cross-section of livestock-keepers, including 'grey' husbandry, which may be represented by a variety of organisations, as well as the 'key' stakeholders.

b) Small-scale and traditional farming deserve support, as they rarely have access to expensive technologies, but provide a range of benefits, including food security and environment enhancement. They also act as sentinels for disease outbreaks, especially in relation to covert or illegal activities, such as livestock smuggling and 'bushmeat'.

c) Effective communication channels are crucial to provide:

– accurate and unbiased information, including alerts (using modern communications technologies)

– explanations of the available technologies (e.g. diagnostics and vaccination)

– a forum for discussion

– a way of contributing to national, regional and international decision-making.

d) The degree of stakeholder involvement in policy-making should be assessed to promote a true partnership. Mechanisms to assist this process should be considered, such as the creation of national and regional Animal Health Associations. Such associations would work in partnership with government, that is, independently but with government participation. They would have the power to propose resolutions and to vote, as a check and balance on the powers and responsibilities of the Chief Veterinary Officer, particularly if there is evidence that national consultations are not adequate.

e) Decisions about control measures must be based on expert, unbiased and balanced advice, from a permanently operational group. Bodies that have a mandate to 'challenge' this advice must be adequately informed and should only exercise their challenges in non-crisis periods, not during an emergency, which can lead to confusion and delays.

f) Control measures must be applied flexibly and with sensitivity to local needs and traditions but remain effective… sometimes a difficult balance.

g) Livestock registration should be encouraged, and organised with an important component of incentives and choice. Registration can occur as a partnership between government and livestock-keepers or a representative organisation. Benefits to the government would include accurate information about livestock populations and management systems to assist effective control measures. Benefits to livestock-keepers would include receiving targeted communications to aid in effective planning and on-farm biosecurity measures, and the possibility of implementing appropriate and proportionate controls throughout the production chain according to individual circumstances, e.g. an on-site pathogen testing system could support quarantine, rather than slaughter, as an option and allow certification of disease-free status. Reactions to the threat of notifiable diseases are generally government-led, with varying degrees of producer control. Access to laboratory and on-site testing is controlled through different mechanisms in different countries. This inconsistent restriction adds a further complication to international policies on disease control, allowing producers in some countries, but not in others, the ability to use surveillance data for the security of their own industries (15). Herd/flock registration could be indicated on a retail label to assure consumers of enhanced testing of the product. However, confidentiality issues must also be addressed.

h) Innovative approaches (including incentives and compensation) to educate and encourage livestock-keepers to recognise and report unusual signs and symptoms should be explored and encouraged.

i) The role of clinical inspection should be reassessed, as a result of the advances in portable, rapid pathogen-detection devices, although clinical diagnosis will still be the basis of suspicion of disease in the first instance.

j) The role of portable, rapid diagnostic technology should be reassessed, to aid in disease control and management and reduce the burden on reference laboratories during an epidemic.

k) Control decisions, such as movement restrictions and vaccination strategies, should be rapid, supported by the use of on-site or portable diagnostic devices linked to GIS and accurate databases of livestock populations, meteorological conditions, etc. They should also be capable of identifying and responding to previously 'unknown' emerging diseases.

l) Efficient sampling of suspicious cases must be the basis for:

– declaration of an index case

– imposing movement restrictions

– using slaughter as a control measure.

Field samples should be delivered to reference laboratories to support rapid on-site or near-site testing, and supply accurate data (thus acting as the benchmark) in a rapid, direct and traceable manner. This process may involve other agencies (such as the armed forces or police). To ensure forensic standards are maintained during sample collection, preparation, transportation and delivery, appropriate written protocols and SOPs must be integrated into any plan. This plan should be established during non-crisis periods and available to all laboratories.

The establishment of the Animal Health Foresight Project (49, 50), which was discussed at the USAHA meeting in 2005 and which encapsulates the ideas in this paper, appears to have been subject to a very quiet approach. The responsibility for informing stakeholders rests with the CVOs and national governments of each participating country, providing an exciting opportunity to demonstrate

responsiveness to national accountability and international cooperation.

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Faire un meilleur usage du progrès technologique pour répondre aux besoins des parties prenantes

M.J. Marshall, P.A. Roger & J.B. Bashiruddin

Résumé

Le contrôle des maladies transfrontalières nécessite une démarche internationale de grande ampleur et fondée sur la coopération. Il faut prendre les décisions (et le faire savoir) sur la base d'avis émanant d'équipes pluridisciplinaires de scientifiques et de représentants de tous les groupes qui sont fortement affectés par la maladie (les « parties prenantes »). L'évolution du commerce et des voyages signifie que, si l'on n'élabore pas un nouveau modèle pour la prévention des maladies, il est très possible que les maladies animales transfrontalières deviennent de plus en plus difficiles à contrôler. La démarche habituelle des gouvernements, qui consiste à s'occuper presque exclusivement du secteur commercial de l'élevage, ne suffit plus et il faut trouver de nouveaux moyens pour prendre en compte tous les secteurs, y compris l'élevage « gris » (les groupes fragmentés et disparates dont l'attitude envers les animaux peut être au mieux respectueuse de la loi et responsable, et au pire incontrôlée, voire illégale).

La convergence de plus en plus forte entre les questions de santé humaine et de santé animale oblige à faire le meilleur usage possible des nouveaux outils. Les défis particuliers auxquels est confrontée la science vétérinaire sont les suivants : prévenir l'introduction de maladies, identifier celles-ci rapidement et contrôler les épidémies. L'article se concentre sur le cas du Royaume-Uni pour rechercher les insuffisances des méthodes actuelles, identifier les besoins, offrir des recommandations et proposer une nouvelle approche de la lutte contre les maladies, qui met l'accent sur les considérations de portée mondiale. Ses objectifs sont une meilleure participation de tout le secteur, une meilleure communication, une meilleure connaissance scientifique et un meilleur processus de decision, améliorations qui devraient apporter plus de sécurité face aux maladies.

Mots-clés

Alerte sanitaire – Besoin – Élevage gris – Élevage traditionnel – Gestion du cheptel – Inadéquation – Lutte contre la maladie – Partenariat – Partie prenante – Politique – Progrès technologique – Surveillance.

Mejor uso de los avances tecnológicos para satisfacer las necesidades de las partes interesadas

M.J. Marshall, P.A. Roger & J.B. Bashiruddin

Resumen

La lucha contra las enfermedades transfronterizas requiere soluciones que aúnen colaboración internacional y carácter integrador. Para tomar decisiones conviene basarse (y dejar claro que así se hace) en los dictámenes de equipos multidisciplinares compuestos por científicos y representantes de todas las partes que sufran las consecuencias de la enfermedad (las "partes interesadas"). La reciente evolución de los modos de comercio y viaje supone que, a menos que se elabore un nuevo modelo de prevención de enfermedades, existe la posibilidad real de que cada vez sea más difícil controlar las enfermedades animales transfronterizas. La solución que tradicionalmente adoptaban los gobiernos (ocuparse exclusivamente de la vertiente comercial de la industria ganadera) ya no basta, y en este sentido es necesario encontrar nuevas fórmulas que engloben a todos los sectores, entre ellos la ganadería "gris" (colectivos heterogéneos y fragmentarios cuyo trabajo con los animales puede ir desde lo lícito y responsable hasta lo tolerado y/o lo claramente ilegal). La creciente convergencia entre los problemas de salud humana y los de sanidad animal obliga a hacer el mejor uso posible de las nuevas herramientas. Entre las dificultades que afronta específicamente la ciencia veterinaria están las de prevenir la introducción de enfermedades, detectarlas con rapidez y controlar las epidemias. Los autores se centran específicamente en el Reino Unido para reflexionar sobre la inadaptación de los planteamientos actuales, determinar las necesidades existentes, formular recomendaciones y proponer nuevas formas de controlar las enfermedades, poniendo el acento en el trabajo a escala mundial, todo ello con vistas a cumplir los siguientes objetivos: una participación más amplia de todo el sector; una mejor comunicación; más profundos conocimientos científicos; y decisiones más acertadas, todo lo cual debería traducirse en una más sólida protección contra las enfermedades.

Palabras clave

Alerta sanitaria – Alianza – Avance tecnológico – Control de enfermedades – Ganadería tradicional – Gestión ganadera – Inadaptación – Necesidad – Parte interesada – Política – Vigilancia.

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Disease prevention and preparedness for animal health emergencies in the Middle East

A. Shimshony [1] & P. Economides [2]

(1) Koret School of Veterinary Medicine, Hebrew University, P.O. Box 12, Rehovot 76100, Israel
(2) Veterinary Public Health Consultant, Aesop 35, Aglandjia, Nicosia 2113, Cyprus

Summary
The animal health situation in the Middle East is particularly unfavourable, as this area is exposed to many serious animal diseases. The Middle East is ill-prepared to institute disease prevention and control measures, due to deficiencies at both national and regional levels. Early detection, diagnosis and reporting of diseases must become a priority within these countries and effective communication should be maintained among them. Regional animal health programmes and the support of international institutions are essential to improve preparedness for natural or human-caused emergency situations, which can seriously affect animal health. Such emergencies can also have significant impacts on related public health issues.

Keywords
Animal health – Control – Emerging disease – Epidemiology – Epizootic – Middle East – Preparedness – Prevention – Regional co-operation – Zoonose.

Introduction

The Middle East region encompasses countries around the eastern Mediterranean. This area is largely defined by its political and economic situation, while the countries of the Middle East share several common ecological characteristics, from an epidemiological point of view. Infectious animal diseases move easily within the region, causing great economic losses. Animal health authorities are confronted by many challenges, due to the following main factors:

– geographical position. This area is at the crossroads of international transportation between three continents: Europe, Asia and Africa;

– an unstable political situation. This instability is reflected in inadequate regional co-operation and little or no exchange of epidemiological information;

– the need to restructure and consolidate national Veterinary Services. These Services have both peripheral (field activities, extension) and central (diagnosis and research) deficiencies;

– the climatic conditions common to the various ecological sub-regions;

– the diversity of livestock production systems, including predominantly extensive, traditional animal husbandry, characterised by communal grazing, as well as uncontrolled animal movements and nomadism;

– the fact that most countries in the region are consistent importers of livestock and animal products;

– the fact that the major routes of migratory birds, between Europe and Africa, cross this region;

– different market trends in animals and animal products. These may affect decision-making and could also result in the introduction of exotic animal diseases;

– demographic changes, characterised by a growing human population, desertification and increasingly limited water resources;

– obvious disparities in economic wealth among these countries, influencing decision-making on animal health issues.

Several authors have recently described this complex regional situation (2, 8, 16, 34, 36).

In climatic terms, the entire region has a strongly marked pattern of summer drought and winter rain. Aridity (with rainfall often below 100 mm per year) and very hot summers characterise vast areas of land. Rainfall is extremely erratic in regard to both season and geographical location. However, there are two large river delta areas in the region, the Nile and the Mesopotamia, where large numbers of ruminants are concentrated, together with a dense and heterogeneous arthropod population. This situation represents an abundant source of wind-borne disease agents.

The land resources of the Middle East are small and fragile. Pastoralism is practised over large areas of steppes (grassy plains), which are widespread in almost every country in the region. Nomadic herding, involving mainly small ruminants, and seasonal transhumance are widely practised. Humans and animals tend to share common premises, making the former prone to zoonotic diseases. Productivity is low, due to:

– the small-scale, family-type farming structure

– natural hazards, pests and diseases

– the limited availability of feed resources

– limited capital and credit.

Special festivals or occasions, such as the Bairam feast at the end of Ramadan, may involve the ritual slaughter of millions of animals. There is also a deep-rooted, traditional preference for home slaughter in the region. Together, these factors result in deficient meat inspection and poor disease monitoring. The Middle East has also become the largest importer of food and animal feed in the developing world, due to a rapidly growing population. Imports, principally of live sheep (an annual figure of more than 12 million, almost 64% of the global trade in live sheep) and animal products, now account for more than 25% of the total import bill for the region (34).

This situation, when combined with serious political instability (which causes a lack of co-operation among various countries in the region and undermines regular and proper disease reporting), has created significantly unfavourable epizootiological conditions in the Middle East. These conditions also endanger neighbouring regions.

Animal health

Information obtained from official sources

Although some countries of the region have adequately functioning mechanisms for reporting animal diseases, zoonoses and food-borne disease, most do not have efficient surveillance and reporting systems in place. Under-reporting is common because:

– there are no adequate laboratory diagnostic facilities

– there is insufficient professional and public awareness

– reporting of some diseases, including zoonoses and food-borne disease, is not obligatory.

The poor animal health situation in the Middle East has been repeatedly demonstrated by the presence of major epizootic livestock diseases in the region. Some of these have been regarded as endemic for many decades, while others penetrated the Middle East for the first time during the last years of the 20th Century, and have since become established. Examples include Rift Valley fever (RVF) (14), lumpy skin disease (LSD) (30, 33) and peste des petits ruminants (PPR) (38).

Information on the disease situation in the Middle East is derived principally from the statistics of the World Organisation for Animal Health (OIE). All OIE Member Countries are expected to officially report to the main office any occurrence of a listed disease within their respective boundaries, in line with a procedure outlined in the *Terrestrial Animal Health Code* (41).

A recent decision by the Member Countries of the OIE in committee meant that, from mid-2005, all notifiable diseases were amalgamated into a single list. In addition, requirements for initial and subsequent periodic disease reports have been substantially revised. However, in this paper, the authors will refer to the procedures which existed until mid-2005.

According to these earlier provisions, all notifiable diseases were divided into two lists, as follows:

– List A included transmissible animal diseases characterised by their potential for very serious and rapid spread, irrespective of national borders

– List B included animal diseases which presented significant socio-economic and/or public health consequences within countries.

The principal obligations of Member Countries when notifying listed diseases were as follows:

a) List A diseases must be reported immediately, followed by weekly 'follow-up' reports

b) List B diseases, if occurring in the country for the first time, or if a significant change in epidemiology has occurred, must be reported immediately, followed by weekly follow-up reports.

In addition, Member Countries were required to provide annual reports on their animal health status, encompassing the incidence of all List A and B diseases and the measures applied to prevent and control them. The collected monthly and annual data are available on 'Handistatus', the OIE website database (http://www.oie.int/hs2/ report.asp?lang=en). This database has provided the main source of information for this paper (Table I).

Table I includes raw data for the following nine List A diseases in mammals:

– foot and mouth disease (FMD)
– rinderpest (RP)
– PPR
– contagious bovine pleuropneumonia
– LSD
– bluetongue (BT)
– RVF
– sheep pox/goat pox (SP/GP)
– African horse sickness (AHS).

Table I
Occurrence of selected epizootics in the Middle East until 2004
(as reported by Middle-Eastern countries to the World Organisation for Animal Health until the end of 2004)

Country	Foot and mouth disease serotypes							RP	PPR	CBPP	LSD	RVF	BT	SP/GP	AHS
	O	A	C	Asia 1	SAT 1	SAT 2	SAT 3								
Bahrain	2003	1965	…	…	1962	…	…	1985	0000	0000	2003	0000	0000	2000	0000
Cyprus	1964	1964	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	+?	1989	1960
Egypt	2000	1972	–	–	–	1950	–	1987	1989	1971	1990	1993	1974	1999	1959
Iran	2004	2004	0000	2004	1964	0000	0000	1994	2004	0000	0000	0000	2004	2004	1963
Iraq*	2002	1978	…	1975	1962	…	…	1985	2001	…	…	…	…	2001	…
Israel	2004	1981	0000	1989	1962	0000	0000	1983	1993	1941	1989	0000	2004	2004	1944
Jordan	1999	1978	1969	1961	1962	0000	0000	1972	2000	0000	0000	0000	1999	2002	1962
Kuwait	2004	1977	0000	1981	1970	2001	…	1985	1991	1991	1991	0000	0000	2004	0000
Lebanon	2003	1992	1992	1984	1962	…	…	1993	1997	1992	1993	–	1992	2003	1960
Libya	1994	1979	…	…	…	2003	…	1966	0000	0000	0000	0000	0000	2004	1964
Oman	2004	…	…	1982	…	…	…	1995	2004	0000	1984	0000	2001	2004	0000
Palestinian Authority	2004							1983	2004	…	…	0000	–	2004	0000
Qatar	2001	…	…	…	…	…	…	1987	–	1997	–	–	–	1999	–
Saudi Arabia	2004	1994	1987	1994	1970	2000	–	1997	2004	–	0000	2004	2004	2004	…
Syria	2002	2002	1969	1988	1962	0000	0000	1983	1988	–	–	–	–	…	1961
Turkey	2004	2004	0000	2002	1965	0000	0000	1996	…	0000	0000	0000	1979	2004	1961
United Arab Emirates	2003	1990	…	…	…	…	…	1995	2004	1990	2000	0000	…	2004	0000
Yemen	2004	1998	–	1980	…	1990	…	1995	2004	…	1995	2004	…	2004	–

*Iraq: Last available year for foot and mouth disease statistics was 2002; for peste des petits ruminants and sheep pox/goat pox, 2001
0000: disease never reported
–: disease not reported (date of last outbreak not known)
(year): year of the last reported occurrence of the disease
+?: serological evidence and/or isolation of the causal agent, but no clinical signs of disease
…: no information available
SAT: Southern African Territories
RP: rinderpest
PPR: peste des petits ruminants
CBPP: contagious bovine pleuropneumonia
LSD: lumpy skin disease
RVF: Rift Valley fever
BT: bluetongue
SP/GP: sheep pox/goat pox
AHS: African horse sickness

Some missing data have been added from other sources (34).

Foot and mouth disease is prevalent in the Middle East. It has been recorded more than once in 17 countries in the region during the last ten years. In fact, the only country which has been free of FMD throughout the period is Cyprus. In most of these countries, serotype O is regarded as endemic.

The FMD serotype Asia 1 has caused large epizootics in the Middle East in the past, and has recently been reported from Iran (2004), Turkey (2002) and Saudi Arabia (1994). Serotype A_{22} is present (2004) in Iran and Turkey, and has recently been reported from Syria (2002) and Yemen (1998). No reports have been received from Iraq in recent years, but the situation is presumably similar to that in Iran and Turkey.

In the past, exotic strains of FMD virus (FMDV) were involved in panzootics, covering large areas in the region, extending as far as the frontiers of Europe. Such panzootics included outbreaks of FMDV types Asia 1 (1957-1964, 2000); Southern African Territories 1 (SAT 1) (1962-1964), and A_{22} (1964-1965, 1996) (Fig. 1).

The recurrence of such situations is not a remote possibility, due mainly to the continuous influx of live sheep for slaughter, principally into the Arabian Peninsula. Animals from Africa and Asia can readily introduce strains of FMDV which then spread among the local ruminants, particularly nomadic sheep and goats. These animals may then further disseminate the virus into large-scale, commercial dairy farms. Serotype SAT 2 was introduced into Saudi Arabia as recently as 2000, later appearing in Kuwait (2001) and Libya (2003). Genetic profiling of FMDV strains by nucleotide sequencing is a powerful epidemiological tool to trace the virus spread. It appears that the recent spread tracks are similar to those described in the past; namely, that FMDV was probably introduced into the Arabian Peninsula from the Horn of Africa, and then spread from the Gulf States in a north-westerly direction (2, 15, 18, 19).

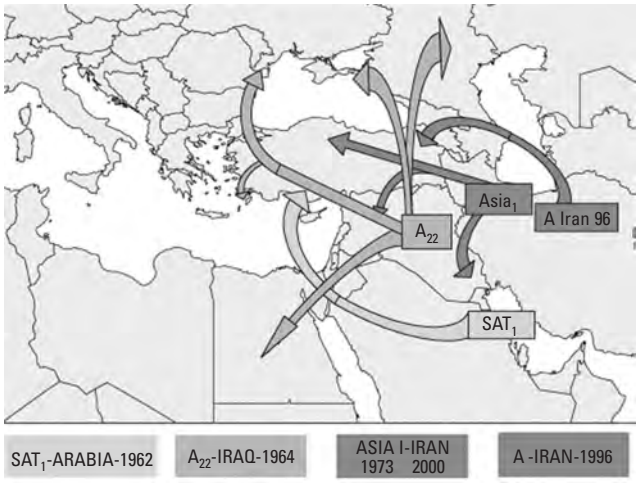

Fig. 1
Introductions of foot and mouth disease serotypes from the Middle East to the frontiers of Europe from 1962 to 2000 (25)

Rinderpest has been reported quite frequently in the Middle East. The last major spread was observed during the early 1980s, a period of significant political unrest. Later outbreaks of RP have been recorded in the following countries:

– Lebanon (1993)
– Iran (1994)
– Oman (1995)
– the United Arab Emirates (UAE) (1995)
– Yemen (1995)
– Turkey (1996)
– Saudi Arabia (1997) (22, 38).

Peste des petits ruminants, a disease initially regarded as restricted to West Africa, was unknown in the Middle East before 1988. Since then, it has spread into 14 of the 18 Middle-Eastern countries covered in this paper (Table I). A 1998 Food and Agriculture Organization (FAO) report (38) indicates that PPR was clinically suspected in Yemen as early as 1984, while, during a serological surveillance on the coastal belt between 1990 and 1994, applying competitive enzyme-linked immunosorbent assay, antibody prevalence rates were 1.5% in sheep and 1.8% in goats. In the mountainous areas, during the same period, prevalence rates were 3.1% in sheep and 10.3% in goats. In the drier north-eastern and eastern areas, rates were 7.0% in sheep and 7.5% in goats. The disease appears as 'present in Yemen since 2000' in the OIE database.

Turkey reported PPR to the OIE for the first time in 1999. The potential for spread was demonstrated in June 2000, when an outbreak was unofficially reported on the island of Cyprus by Turkish-Cypriot veterinarians (see 'Information obtained from other sources: Cyprus' below).

The FAO report concluded that the PPR virus appeared to have spread within the Middle East in the 1990s, probably through a combination of nomadic movements by small ruminants and trade, and has become endemic. The report also reiterated that PPR probably spread from the Horn of Africa to the southern Arabian Peninsula, as the recorded lineage of the virus appears to be common to the two regions. Trade in livestock has undoubtedly fostered this spread. A second lineage is present in Bangladesh, India, Pakistan, Iran, Israel and Turkey. It can safely be assumed that other countries in that region, such as Jordan and

Syria (where seropositive animals were initially detected as early as 1989 and 1991, respectively), as well as Lebanon, have been similarly infected.

Lumpy skin disease, initially known to be restricted to sub-Saharan Africa, has in recent years been recorded in Oman, Egypt, Kuwait, Lebanon, Bahrain and Yemen. A single outbreak in Israel (1989) was eradicated by the immediate application of the stamping-out policy (33).

Rift Valley fever, a serious arthropod-borne disease in ruminants which causes haemorrhagic fever in humans, was restricted to sub-Saharan Africa until its detection in Egypt in 1977 (23). Since then, there have been several recurrences in Egypt but apparently on a limited scale (24). The introduction of RVF into Yemen and Saudi Arabia in 2000, its first appearance outside the African continent, was of particular concern in view of its grave public health aspects (35, 43). Rift Valley fever can cause serious animal and human suffering and significant economic loss. This highlighted the need for improved preparedness and surveillance (9). In fact, RVF is now suspected to be endemic, as it was reported in Saudi Arabia in 2001, 2003 and 2004 (see 'Zoonoses', below).

Three Middle-Eastern countries, Bahrain, Kuwait and Libya, referred, in their annual reports to the OIE, to bluetongue as a disease which has never been reported within their respective territories. However, serological evidence and the knowledge available on its epidemiology and the distribution of the vector, *Culicoides imicola*, may indicate that BT is enzootic throughout the region, in spite of a lack of reports. The BT virus (BTV) serotypes recorded between 1963 and 2001 in eight Middle-Eastern countries (Israel, Egypt, Jordan, Syria, Turkey, Cyprus, Iraq and Lebanon), involved in clinical or subclinical (serology only) infections, have previously been summarised in table form (28). While BTV4 seems to be the predominant serotype involved in clinical disease, seven other serotypes have been identified in infected animals: 1, 2, 6, 9, 10, 12 and 16.

Sheep and goat pox are historically regarded as being endemic in all countries in the Middle East. However, some countries have observed only sheep pox.

African horse sickness last reached epizootic proportions in this region during the early 1960s. Later, during the 1980s, AHS occurred sporadically in the Arabian Peninsula, as reported to the OIE Regional Commission for the Middle East. If and when it is re-introduced from Africa, this disease may again spread, due to the presence of its known vector, *C. imicola*.

In fact, all List A ruminant diseases, except vesicular stomatitis, which is restricted to the Americas, have been reported in the Middle East during recent decades. This fact, combined with the lack of efficient controls on animal movement throughout the region, underlines the potential epizootiological hazards in the Middle East, the urgent need for improved preparedness and prevention in the region as a whole, as well as in each country, and the importance of co-operative, integrated activities within the entire area.

In terms of the avian diseases on List A, highly pathogenic avian influenza (HPAI) has never been reported from Bahrain, Cyprus, Iran, Jordan, Kuwait, Libya or the UAE. The only countries that have officially notified the OIE of outbreaks are Egypt (1965) and Israel (1988). However, an H9N2 avian influenza A virus is known to have been present in various Middle-Eastern countries in recent years. The continued presence of this subtype in the Middle East may mean that it is becoming an established endemic disease (4). Although H9N2 is not an HPAI virus strain, economic losses may at times be considerable. The main concern with this strain is its documented potential to infect humans, as reported in Hong Kong in 1999 and 2003. It has been postulated that shared gene constellations in avian influenza viruses H9N2 and H5N1 may confer the ability to cause infection and disease in humans.

Newcastle disease (ND) also seems to be prevalent in the region, though it is poorly reported. In their annual reports to the OIE, two countries, Qatar and Oman, referred to ND as a disease which had never been reported within their respective territories. Vaccination against ND is practised in all Middle-Eastern countries.

Information obtained from other sources

The OIE, like other international and national organisations, can disseminate only the information that is officially reported by Member Countries. Such reports, when available, vary in their quality since the availability, regularity, expediency and accuracy of official disease reporting may differ between countries. Various factors may affect the ability of the different national Veterinary Authorities to:

– obtain early, accurate and complete information about the animal diseases in their respective territories

– confirm clinical suspicions by reliable laboratory testing in a timely manner

– immediately forward or publish the gathered information.

Even in countries which have the infrastructure and expertise to obtain such information, economic and political constraints are known to affect the transparency needed to satisfactorily supply essential disease-related information, both to the OIE and the international animal-

health community at large. Independent, scientifically-based monitoring institutions may help in overcoming such constraints, enhancing the early availability of information on emerging diseases and supporting early-warning systems. Several internet-based epidemiological programmes have been initiated in recent years by private and academic non-governmental institutions.

One of the more comprehensive, non-official programmes for monitoring emerging diseases in humans and animals, is ProMED-mail (http://www.promedmail.org/). This online program, established in 1994, is currently operated by the International Society for Infectious Diseases, a non-profit-making, professional organisation. The principal intent of ProMED-mail is to assist local, national and international organisations by disseminating data on outbreaks of emerging infectious diseases, as rapidly as possible, wherever they occur. These data come from sources such as media reports, online summaries, local observers, official reports and various others. A team of expert human, animal and plant disease moderators screen, review and investigate such reports before posting them on the network. In contrast to official national and international organisations, which can only publish information which is officially reported to them, ProMED-mail has no such constraints. It can independently post preliminary and unofficial reports, as well as summaries, and operates seven days a week.

Between its inauguration in 1994 and July 2005, ProMED-mail has issued 23,116 postings, of which 12,773 concerned animal health and/or zoonotic issues. Of the eight regions covered (North America, Europe, Asia, Africa, South America, the Pacific, Eastern Europe and the Middle East), the last seems, on the whole, to gain less intensive coverage than other parts of the world, to varying degrees among the countries of the region. Perhaps unsurprisingly, North America and Europe lead the list with postings and members. The following data, derived from the ProMED-mail website in mid-August 2005, present the total numbers and selected animal health postings received from Middle-Eastern countries since 1995, their respective subjects and years of issue. Disease data that have not been covered by official sources, such as the OIE, the World Health Organization (WHO) and national reports, are marked with asterisks (*).

Bahrain

There were no postings from Bahrain.

Cyprus

There were 12 animal health-related postings from Cyprus, including:

– salmonellosis (1996)

– *Brucella melitensis* in bovines (1996*, 2002)

– PPR, reported by Turkish Cypriot veterinarians (2000*)

– unexplained deaths in flamingos (2003*)

– BT in sheep (2004)

– ND (2005).

Egypt

There were 14 animal health-related postings from Egypt, including:

– RVF (1995, 2003)

– streptococcal illness due to jerboas (1996*)

– phlebovirus infection (1997*)

– West Nile virus (1999*)

– avian influenza H10N7 (2004*).

Iran

There were 18 animal health-related postings from Iran, including:

– the bovine spongiform encephalopathy import ban (1998)

– FMD (1999, 2001)

– Crimean-Congo haemorrhagic fever (CCHF) (2000*, 2001*, 2002*, 2003*, 2004*, 2005*)

– white spot disease in shrimp (2005).

Iraq

There were 21 animal health-related postings from Iraq, including:

– anthrax (1995, 2004*)

– camelpox (1995*)

– Old World screwworm (1998)

– PPR (1998)

– FMD (1999)

– RVF (unconfirmed) (2001*)

– rabies (2004*)

– leishmaniosis (2001, 2003, 2004, 2005)

– Veterinary Services, restoration and reactivation of (2005*).

Israel

There were 88 animal health-related postings from Israel, including:

– rabies (1995, 1997, 2003, 2004, 2005)

– ND (1997, 2001, 2005)

– sheep pox (1997, 2003)

– FMD (1998, 1999, 2001, 2004)

– PPR (1998, 2004)

– *Pseudomonas mastitis* in dairy sheep (1998*)

– West Nile virus in:
i) domestic avians (1998, 1999*)
ii) humans (2000*, 2001, 2002, 2003, 2004, 2005)
iii) migratory birds (1998*, 2005*)
iv) mosquitoes (2002*)

– equine influenza (2002)

– scrapie (2002)

– botulism in cattle (2002)

– *Aedes albopictus* in Israel, first record of (2002*)

– undiagnosed ulcers in fish (2003*)

– anisakiasis, suspected (2003*)

– BT (2003)

– *Vibrio vulnificus*, fatal (2003*)

– leishmaniosis, cutaneous, in humans (2004)

– transmissible gastroenteritis in swine (2004)

– equine rhinopneumonitis (2005).

Jordan

There were two animal health-related postings from Jordan, as follows:

– anthrax in circus lions (1997)

– FMD (1999).

Kuwait

There were 15 animal health-related postings from Kuwait, including:

– *Escherichia coli* (1997*)

– ND (1997)

– Old World screwworm (1998)

– contagious caprine pleuropneumonia (1998)

– FMD (1998, 2000, 2002)

– leishmaniosis (2003).

Lebanon

There were two animal health-related postings from Lebanon, as follows:

– FMD (1999)

– brucellosis in humans and caprines (2004).

Libya

There were seven animal health-related postings from Libya, including FMD (2003).

Oman

There were two animal health-related postings from Oman, including West Nile virus in equines (2003*).

Palestinian Authority

There were no postings from the Palestinian Authority.

Qatar

There were no postings from Qatar.

Saudi Arabia

There were 75 animal health-related postings from Saudi Arabia, including:

– Tick-borne encephalitis, tick-borne flavivirus, Alkhurma virus (1997*, 2002*, 2004*)

– RVF in:
i) animals (2004)
ii) humans (2000, 2001, 2003, 2004)

– West Nile virus – import ban (2000*)

– FMD (2001, 2003)

– PPR (2002)

– avian influenza H9 virus (1998*)

– poultry die-off (2004*)

– new variant Creutzfeldt-Jakob disease – suspected, not confirmed (2004*)

– camelpox, suspected (2005*).

Syria

There were four animal health-related postings from Syria, including FMD (2002, 2003).

Turkey

There were 17 animal health-related postings from Turkey, including:

– RP, provisional freedom from (1998, 1999)

– BT (1999)

– food poisoning from fish (1999*)

– FMD (1999, 2000, 2001)

– ND (2001)

– trichinellosis (2004)

– cutaneous lesions in humans (anthrax or contagious ecthyma) (2004*)

– CCHF (2002*, 2003*, 2005*)

– PPR (2004)

– tularemia, water-borne (2005*)

– anthrax – human, ovine, caprine (2005).

United Arab Emirates

There were seven animal health-related postings from the UAE, including:

– camel death – undiagnosed (1999*)

– CCHF (2000*)

– sheep and goat die-off (2001*)

– FMD (2003)

– glanders, equine (2004).

Yemen

There were 20 animal health-related postings from Yemen, including:

– rabies (1997)

– RVF (2000, 2001)

– leishmaniosis (2005).

In addition to ProMED-mail, there are other sources of information about the disease situation in the Middle East. Reports are perhaps the main resource and they can be obtained from many groups, including the following:

a) regional and international organisations

b) research institutions

c) advisory enterprises

d) working groups and commissions, such as:

– the Emergency Prevention System (EMPRES)

– the United States Agency for International Development/Middle East Regional Co-operation Program (USAID/MERC)

– European Union-sponsored regional programmes

– the Mediterranean Zoonoses Control Programme (MZCP).

Important data can also be derived from papers and reviews published in scientific journals. To cite one example: the presence of PPR in Yemen was indicated in a Regional Animal Disease Surveillance and Control Network (RADISCON) report, published after the visit of an FAO expert to Yemen at the end of 1998. The disease may have entered Yemen several years earlier (38).

Bovine ephemeral fever has been reported to be re-emerging in several Middle-Eastern countries since the early 1990s. In Israel, the mortality rate in 1990 was 3% and in 1999 almost 4% in affected dairy herds (42). The average mortality or emergency slaughter rate in these herds was 0.4% for calves (up to one year old) and 4.4% for cows in lactation. In Saudi Arabia, the mortality rates varied between 0% and 2.6% (1).

Akabane virus has been reported as a cause of epizootics of congenital malformations in ruminants in Israel (32); the virus was also identified in Oman. Serological surveys have demonstrated antibodies to Akabane virus in domestic animals in Cyprus, Syria and Turkey (43).

However, so far, these sources have lacked the urgency required to handle emergency situations effectively.

Veterinary public health and food safety

In general, most countries in the Middle East have limited capacity and resources to plan and implement policies to control zoonoses and food-borne diseases which affect public health, animal health, production and trade.

The important notifiable zoonotic and food-borne diseases in the region are as follows:

– acute hepatitis A and B

– anthrax

– brucellosis

– cholera

– CCHF

– echinococcosis/hydatidosis

– leishmaniosis

– leptospirosis

– listeriosis

– paratyphoid

– rabies

– salmonellosis

– shigellosis

– typhoid.

In addition, RVF and West Nile fever (WNF) are emerging. Creutzfeldt-Jakob disease has recently been added to the list in most countries. The authors will briefly discuss selected bacterial and viral diseases, below.

Food-borne diseases with symptoms of fever and diarrhoea are common in daily life and generally accepted as mild and self-limiting. Medical help is sought only when the problem becomes serious, with life-threatening symptoms.

A few of the countries in the region maintain poor food safety and surveillance systems. The priorities of these countries are to reduce acute diarrhoea and improve water sanitation. Others have acceptable surveillance systems in which the common food-borne diseases are reported; the food safety infrastructure in these countries has been substantially improved in recent years. Jordan, for example, has finalised a study on the importance of food-borne diseases. However, a great deal remains to be achieved in the area of food safety, including establishing priorities when trying to reduce the incidence of important food pathogens.

Approximately one-third of Middle-Eastern countries possess adequate basic infrastructures for food-borne disease surveillance. Their priorities are chemical residues and hazard analysis, including bacteriological and viral analysis. Unfortunately, there is no established regional network for the collection and sharing of these data.

The WHO Eastern Mediterranean Regional Office has collected and analysed official information from several countries in the region.

For Jordan, it was estimated that, during one month in 2002, at least 271 cases of salmonellosis, 1,899 cases of shigellosis and 854 cases of brucellosis occurred. A significant reduction in the incidence of food-borne diseases was observed between 1998 and 2002 (bloody diarrhoea: 12.7 and 4.8, respectively; typhoid: 12.7 and 4.8; hepatitis A: 16.9 and 10.2). In Saudi Arabia, the incidence of hepatitis A decreased from 14.7 in 2001 to 9.5 in 2003. However, no similar decrease was observed for typhoid, paratyphoid or salmonellosis. The incidence of food poisoning outbreaks increased, from 11 in 2001 to 16 in 2003.

In a review of all reported food-borne disease cases in Saudi Arabia between 1997 and 2003, the results were as follows:

– 47.17% were cases of *Salmonella*

– 10.84% were cases of *Staphylococcus aureus*

– 4.78% were cases of *Staphylococcus aureus* enterotoxigenic

– 6.70% were cases of mixed bacteria

– 5.96% were cases of *Escherichia coli*

– 4.43% were cases of *Bacillus cereus*

– 3.35% were cases of *Shigella*

– 16.77% of samples from all cases investigated were sterile.

It was found that poultry and other types of meat accounted for 79% of food poisoning cases.

In Lebanon, *Salmonella* was the most common cause of food poisoning. In addition, trichinellosis, mostly from wild boar, was a serious public health concern.

Zoonoses

The following selected zoonotic diseases are of significance in the region:

– brucellosis

– rabies

– leishmaniosis

– RVF

– WNF

– CCHF.

Brucellosis

Brucellosis, caused by *Brucella melitensis*, is a zoonosis endemic in all Middle-Eastern Countries, significantly affecting public health and with serious economic implications. It causes abortion 'storms' in goats and sheep and infections in humans (principally affecting rural populations and consumers of unpasteurised dairy products). Cattle, buffalo and camels can also be infected. The disease has a seasonal pattern, with the highest incidence during spring and summer.

Biovar 3 of *B. melitensis* is the strain most commonly isolated from animals in Egypt, Jordan, Israel, Tunisia and Turkey. Biovars 2 and 1 have also been isolated. The countries with the highest incidence of human brucellosis are Saudi Arabia, Iran, the Palestinian Authority, Syria, Jordan and Oman. Bahrain is reported to have zero incidence. Most human cases are caused by *B. melitensis*, particularly biovar 3.

There is some controversy over the best policy for controlling brucellosis in animals. In some countries, the 'test and slaughter' policy has been adopted, together with the vaccination of young females. In others, mass vaccination has recently begun, particularly for sheep and goats. The most commonly used vaccine to control *B. melitensis* is Rev. 1 vaccine. *Brucella abortus* S19 is used in cattle. RB51 vaccine for cattle is used on a small scale in some countries. Vaccination is limited to cattle and small ruminants (29).

In Jordan, the human incidence of disease (cases per 100,000 head of population) reached record figures of 26.1 in 1991 and 22.6 in 1995. By 1999, the figure had been reduced to 8.8 (3).

Cyprus has a control programme based on the test and slaughter of seropositive animals, and vaccinations are not permitted. During the 1990s, Israel conducted a large-scale test and slaughter programme, significantly reducing the infection rate. At present, mass vaccination, using Rev. 1, by the intraocular route, is practised (6).

Rabies

Rabies is still an important public health threat in most Middle-Eastern countries. Reliable data on rabies are scarce for many geographical areas of the world and the Middle East is no exception. According to available information, the major form of the disease in the southern and eastern parts of the region is urban canine rabies. During the last 15 to 20 years, wildlife (sylvatic) rabies became a problem on the Arabian Peninsula, particularly in Oman, Saudi Arabia, the UAE and Yemen (39).

Cyprus, Kuwait and Qatar are reported as being free from rabies. Post-exposure vaccination of humans, control of stray dogs and vaccination of domestic dogs are the main approaches applied by Middle-Eastern countries to prevent the disease in humans. In Israel, where sylvatic rabies has been dominant since 1975, oral vaccination of wildlife has been applied since 1998, significantly reducing the infection rate in foxes and jackals. Domestic dogs are annually and compulsorily vaccinated, and identified by microchips (26).

Leishmaniosis

Leishmaniosis is caused in the Middle East by viscerotropic and dermatropic strains of *Leishmania infantum* and *L. tropica*. The dog is the domestic reservoir but other mammals may act as sylvatic or peri-domestic hosts. The parasites are transmitted by sandflies belonging to the sub-genus *Phlebotomus*, which bite a wide range of warm-blooded animals, including people.

The extension of irrigation areas in Deir-es-tor, in north-eastern Syria, near the Euphrates River, where crops were grown for feeding sheep and goats, encouraged the multiplication of gerbils, which are the main animal reservoirs for zoonotic leishmanioses, and an epidemic of the disease subsequently appeared in the population of the area. This is a good example of environmental changes which favour outbreaks of zoonoses.

Rift Valley fever

This disease has also caused explosive epidemics in the region, most notably in Egypt (1977-1978, 1986-1987) (23, 24), resulting in hundreds of human deaths and heavy losses in the animal industry. Mass vaccinations were conducted and are still annually performed in cattle, sheep and goats.

From 1999 to 2001, the disease spread from the Horn of Africa to Yemen and Saudi Arabia, causing human suffering and mortalities, severe losses in young animals and disruption in the regional trade of live animals. Sporadic cases have continued to appear in Saudi Arabia in subsequent years (35, 43).

The Ministry of Agriculture and Water of Saudi Arabia implemented stringent measures to control the outbreaks. The measures applied included the following:

– restriction of animal movements

– systematic control of mosquitoes

– vaccinations with a live, attenuated vaccine (Smithburn strain)

– surveillance.

Rift Valley fever continues to threaten the Middle East and, in some areas, may have become endemic. Direct and indirect economic losses in Saudi Arabia have been estimated to exceed US$ 75 million per year. Active surveillance and early warning systems must be designed and implemented throughout the Middle East and preventive measures taken, before outbreaks of the disease re-occur.

West Nile fever

West Nile fever, an arboviral zoonotic disease transmitted by mosquitoes, has been reported in humans in Egypt and Israel since the early 1950s. Epidemics among the human populations of many African, Middle Eastern and some Mediterranean countries have been recorded at approximately ten-year intervals (25).

During the early 1960s, West Nile virus (WNV) was isolated in Egypt from cases of encephalitis in horses. In Israel, cases of severe meningo-encephalitis associated with WNV infection were recorded in humans in 1957. An outbreak in geese was seen in Israel in 1998 (20), and later in horses (37); cases of the disease in humans have been reported during the late summer months of each year since 2000. The possible introduction of the virus into Israel in 1998 by migrating storks has been documented (21).

Crimean-Congo haemorrhagic fever

This disease, a tick-borne viral zoonosis, has been reported in a few countries of the Middle East. The number of potential hosts is high.

The virus has been isolated from numerous species and subspecies of hard ticks, while antibodies have been found in many domestic and wild animals, including hedgehogs, hares and rodents.

Most human cases of CCHF occur in rural areas among farmers or livestock handlers, or among medical personnel, as reported in Dubai in 1979.

Cases of CCHF have been reported from Egypt, Saudi Arabia, Iraq, Iran and the Gulf countries. Recently, clinical cases have been documented in humans in Turkey (17).

Other diseases

Echinococcosis-hydatidosis (7, 27, 31) and salmonellosis (5) also deserve to be mentioned. Other zoonoses prevalent in the region (40) are out of the scope of this review.

Provisions for managing animal health emergencies in the Middle East

The classical approach to establishing and maintaining a national programme for controlling animal diseases includes, as minimum prerequisites, the following measures:

– the controlled importation of animals and animal products

– efficient disease monitoring in the field

– rapid and reliable laboratory diagnosis

– epidemiosurveillance, with appropriate communication networks both within and outside the country

– an effective veterinary infrastructure in the field, to apply the necessary disease control measures, either directly or through accredited professionals

– appropriate rules and legislation and the tools for their effective enforcement.

As previously described, a proportion of countries in the Middle East lack some or all of these prerequisites. This has been demonstrated on several occasions in recent decades, for instance, the introduction and spread of RVF, LSD and PPR – diseases which have become entrenched in the region though previously unknown there. Other emerging disease agents may also become established or 'get a foothold' and cause devastating losses to animal and/or public health if these are not recognised and identified in time, before spread occurs. A current example is the threat of avian influenza.

As a result of the inadequate flow of information in the region, caused by the absence of diagnostic data, inadequate communication and political difficulties, preventive mass vaccination is the only effective method, at present, to minimise or prevent catastrophes. Thus, for many years, several Middle-Eastern countries have continuously applied a trivalent FMD vaccine, incorporating serotypes O1, A_{22} and Asia 1, even though, for several years, type O has been the only prevalent virus type in the region. Other widely used vaccines are as follows:

– PPR vaccine

– sheep/goat pox vaccine

– poultry vaccines

– RVF vaccine (in Egypt, Saudi Arabia and Yemen).

However, the effectiveness of such measures is hampered by a lack of regional co-operation. It is therefore of the utmost importance to invest effort into overcoming political obstacles and enhancing regional projects. To this end, the involvement of international organisations, such as the FAO, OIE, European Union, USAID, the International Fund for Agricultural Development (IFAD) and WHO, is vital. Some programmes are already operating in the region, with promising results.

The FAO has initiated various regional operations in the past (namely, the Middle and Near East Regional and Animal Production and Health Project and the West Asia Rinderpest Eradication Campaign) and is currently enhancing the RADISCON and EMPRES.

The RADISCON plan, involving mainly transboundary animal diseases, is a joint FAO/IFAD venture, targeted at 29 countries in North Africa, sub-Saharan Africa, the Horn of Africa, the Middle East and the Arabian Gulf. It aims to strengthen the Veterinary Services in each country, by improving their capacity to collect reliable and crucial information on the distribution of selected animal diseases and zoonoses. It also aims to assist in the establishment of a National Animal Diseases Surveillance System in each Member Country. Several workshops have been held and the project seems to be achieving promising results, bridging gulfs between countries which would otherwise be impassable.

During the 1990s, a regional oversight committee (ROC) was established by the Chief Veterinary Officers of Egypt, Israel, Jordan and the Palestinian Authority. This has resulted in much fruitful co-operation on research into animal health and the control of zoonoses, with the assistance of USAID and the EU. The most recent ROC meeting took place in November 2002, in Aqaba, Jordan. The regional ROC website can be seen at http://www.move-in.org/index.html.

Following two FAO-sponsored expert missions to some selected RADISCON countries during 1997 and 1998, including Yemen, Jordan, Syria, Turkey, Egypt and Saudi Arabia, a report was published (38). The following observations, included in its summary, are still valid:

'Passive disease reporting systems exist in all countries under study, being stronger and more carefully structured in Egypt and Turkey than in other countries. No one country appears to maintain databases in which data on past and current outbreak situations has been captured and could be easily examined.

'The countries studied need to develop active surveillance mechanisms for all List A diseases. For instance annual surveys must be instituted to demonstrate where and at what level the causes of these diseases are circulating. This should be done under partnership arrangements with veterinary investigation laboratories.

'The need for database creation/upgrading is strong to be able to follow the epidemiology of List A diseases within the region, RP and PPR being cases in point.'

Control of zoonoses and food-borne diseases in the countries of the Middle East

The control of zoonoses and food-borne diseases in most countries in the Middle East is delegated to different Public Services attached to the Ministries of Health, Agriculture, Commerce and Trade, and the Municipal and even the Port Authorities. Veterinary Public Health (VPH) Units, which should address zoonoses and public health hazards from foods of animal origin, are deficient in most countries, and in many cases do not exist within the national Veterinary Service. Although these Services are gradually being upgraded and strengthened, most of their resources are spent in controlling animal diseases. Many obstacles hamper the efficient reorganisation of VPH activities. These include:

– the inherited colonial system of assigning VPH activities to other authorities (such as health inspectors), rather than to Veterinary Services

– confusion as to which authority should actually be responsible in a given field

– a lack of epidemiological studies and knowledge of the real extent of VPH problems

– lack of training

– inadequately staffed and poorly equipped Veterinary Services

– lack of public awareness.

Nonetheless, a few countries have made excellent progress in reorganising VPH activities and eradicating serious zoonoses. International organisations, such as the OIE, FAO and WHO, can help greatly in establishing efficient VPH programmes (10, 11, 12, 13, 40). In 2003, the Government of Saudi Arabia established an independent body which is solely responsible for the enforcement of food and drug legislation in this country.

In most countries of the Gulf, Municipal Authorities play a central role in food control management. The development of legislation on food is divided between the Quarantine Service and various Ministries.

This 'multiple-agency model' prevails in the Middle East. There is a tendency to focus on the consultation and collaboration processes when developing legislation. This approach is intended to improve efficiency, minimise duplication and identify gaps in public and animal health protection.

The multidisciplinary nature of any approach to controlling zoonoses and food-borne diseases is self-evident. It requires the co-operation of many professionals to develop, agree on and effectively implement a carefully formulated common vision, which encompasses their objectives for surveillance, early warning and preparedness.

Successful prevention and control of zoonoses and food-borne diseases also require public education, since the public must be aware of the risks posed to their health. Above all, it requires efficient and effective co-operation between the Veterinary, Medical, Public Health and other Government Services and non-governmental organisations. This is proven by the excellent results gained in controlling transboundary animal diseases and important zoonoses in Cyprus (6).

Contingency planning and rapid response

Contingency plans for existing transboundary animal diseases or those which may be introduced to the region should be developed on a regional basis. At present, such plans are non-existent. These diseases, even if introduced into only one country, constitute a continuing threat to livestock, public health and trade, and may have serious socio-economic consequences for the whole region. Such an event is unpredictable and may occur on a scale that nobody can anticipate. To cope with such difficult situations, Veterinary Services and all other available resources would have to be mobilised and stretched to their limits. To have any chance of success in controlling and eliminating a major epizootic, Veterinary Services must make timely and efficient preparations.

Developing the capacity required to respond rapidly to an animal health emergency is known as 'contingency planning'.

Contingency plans should be prepared for all transboundary diseases that exist in the region or its vicinity. Detailed arrangements for the management of a crisis should be worked out in advance, i.e.:

– describing the various co-ordinating committees

– identifying national and international expertise and infrastructure (laboratories, research institutes, reference centres, etc.)

– identifying the logistical resources available in different localities and regions (communications, transportation vehicles, etc.).

The involvement of external bodies (e.g. the police, army, etc.) should be foreseen in case there is a need to control animal transportations/movements through roadblocks or check-points. Risk analysis and assessment must be used to identify and prioritise all those diseases for which contingency plans should be designed.

As part of the contingency plan, the professionals concerned should identify those areas (such as quarantine measures, border controls, active disease surveillance and laboratory diagnostic capabilities) in which capabilities need to be strengthened. The timetable for implementing control measures might differ for each disease. The types of vaccines to be used must be decided and sufficient stocks maintained for use in case of an emergency.

Effective contingency planning requires more than just the advance preparation of written instructions and operating procedures. It must include animal and farm identification systems. Managing the large-scale destruction of animals and disposal of carcasses and other contaminated material, with or without emergency mass vaccinations, within the shortest possible time poses a huge challenge to the competent authority. Pro-active public awareness programmes may prevent the expected criticisms and pressures from the public, livestock-owners and traders. Moreover, these systems should undergo constant review for continuous updating.

Simulation exercises should be regularly conducted to ensure that these contingency plans are fully understood by all public and private veterinarians, livestock-owners, traders, police, local authorities and other ancillary bodies, and will immediately be able to be implemented when needed.

Contingency plans should be concise and clear. They should provide legal backing and sufficient information to allow competent authorities to make the required decisions and implement all necessary measures. The format and contents of the contingency plan should be tailored to the specific requirements and circumstances of each country in the region.

The following model may serve as a guide for the general contents (i.e. chapter headings) of a contingency plan:

– description of the disease

– legal powers from existing legislation

– financial provisions for implementing the plan

– the National Disease Control Centre and chain of command

– international liaison

– expert groups

– local control centres

– sources of trained personnel for implementation of the plan

– equipment and supplies resources

– policy for the entire country

– disease control measures and procedures for each zone

– eradication or elimination of the disease

– criteria for defining infected areas and disease control

– measures applied in infected areas and other zones

– livestock destruction and disposal of carcasses

– cleaning and disinfection

– livestock valuation and compensation to farmers

– samples required for diagnosis

– diagnostic laboratories

– vaccines and vaccination schedules
– training personnel
– publicity.

Conclusion

The Middle East is extremely prone to the introduction of exotic epizootic disease and the spread of endemic infections and zoonotic diseases. Political instability adds to the graveness of the situation. The presence of dormant as well as active extremist elements, who may at some stage decide to use bioterror, increases the challenge confronting countries in the region. Early disease detection systems, the development and improvement of diagnostic capabilities and the strengthening of veterinary field services are all needed. But the most urgently needed requirement is a radical improvement in animal health communication and co-ordination systems, both within countries – namely, between national headquarters and peripheral units – and among them. Achieving this change is crucial to controlling animal and zoonotic diseases in the Middle East, as well as in individual countries. Regional projects that target improving animal health communication and co-ordination systems, with the assistance of international organisations, are of the utmost importance. Ultimate success may be achieved only if these efforts are combined with local initiatives.

Prévention des maladies et préparation aux crises zoosanitaires au Moyen-Orient

A. Shimshony & P. Economides

Résumé
La situation zoosanitaire au Moyen-Orient est particulièrement défavorable puisque cette région est exposée à de nombreuses maladies animales graves. Le Moyen-Orient est mal préparé à l'instauration de mesures de prophylaxie et de contrôle des maladies, en raison de lacunes à l'échelle nationale et régionale. La détection, le diagnostic et la notification précoces des maladies doivent devenir des actions prioritaires au sein de ces pays et une communication efficace doit être maintenue entre eux. Les programmes zoosanitaires régionaux et le soutien des institutions internationales sont essentiels à l'amélioration des plans d'intervention en cas de situation d'urgence d'origine naturelle ou suscitée par l'homme et susceptible de compromettre gravement la santé animale. Ces situations d'urgence peuvent aussi avoir un impact important sur des problèmes connexes de santé publique.

Mots-clés
Contrôle – Coopération régionale – Épidémiologie – Épizootie – Intervention d'urgence – Maladie émergente – Moyen-Orient – Prévention – Santé animale – Zoonose.

Prevención de enfermedades y preparación para emergencias zoosanitarias en Oriente Medio

A. Shimshony & P. Economides

Resumen
En Oriente Medio la situación zoosanitaria resulta especialmente delicada, pues la región está expuesta a muchas y graves enfermedades animales. Debido a las carencias de los países y de la zona en su conjunto, Oriente Medio está mal preparado para instituir medidas de prevención y control de enfermedades. Estos países deben dar prioridad a la detección, diagnóstico y notificación precoces de enfermedades e instaurar mecanismos eficaces de comunicación entre ellos. Los programas regionales de sanidad animal y el apoyo de las instituciones internacionales son dos elementos básicos para mejorar la preparación ante situaciones de emergencia de origen natural o antrópico, susceptibles de perjudicar gravemente la salud animal. Este tipo de emergencias, además, pueden tener importantes repercusiones en el terreno conexo de la salud pública.

Palabras clave
Control – Cooperación regional – Enfermedad emergente – Epidemiología – Epizootia – Oriente Medio – Preparación – Prevención – Sanidad animal – Zoonosis.

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Technology, public policy and control of transboundary livestock diseases in our lifetimes

R.G. Breeze

Centaur Science Group, 1513 28th St NW, Washington, DC 20007 United States of America

Summary

There are no technological barriers to eliminating major transboundary livestock diseases. 'Elimination' means that diseases no longer threaten livestock in the developed world nor the livelihoods of hundreds of millions of small farmers elsewhere. The problem is not lack of technology but failure of public policy. Developed country policy should actively combat accidental and intentional introductions; protect livestock against future advanced biological weapons; minimise the economic impacts after introduction by any means; abandon mass slaughter as a control tool; engage in disease removal in pursuit of a global economic, societal, and environmental agenda; and make appropriate national and cooperative investments. This is the moment for policy change because transboundary livestock disease elimination now involves powerful government ministries outside ministries of agriculture that are concerned about disease threats from many sources. Change can acquire support from the public and many organisations with shared interests. New policy is needed to change the belief that government is solely responsible for excluding disease, responding to introductions, and compensating farmers for losses during eradication. Effective border control and domestic preparedness programmes depend upon government and industry working together with costs falling upon those responsible in the form of 'user fees'. Compensation for stock slaughtered during outbreak control should be covered by private insurance. Government and industry should share the costs of an effective surveillance, diagnostic and response system. Surveillance must achieve or approach real-time understanding of the disease situation at all stages and in all places and be accessible over the Internet by diverse government agencies and stakeholders in-country and abroad. Traditional responses must be abandoned because they encourage terrorism. Regulatory approval processes must be modernized because they cannot keep up with new technology.

Keywords

Command, control and communication system – Electronic disease reporting system – Especially dangerous pathogen – New technology – Outbreak insurance – Polymerase chain reaction – Responsibility – Slaughter policy – Surveillance – Threat agent detection and response – Transboundary disease – Vaccination.

Introduction

There are no technological barriers to the elimination of the major transboundary livestock diseases in our lifetimes. Here, these diseases are defined as transmissible diseases that have the potential for very serious and rapid spread, irrespective of national borders; that are of serious socio-economic or public health consequence; and that are of major importance in the international trade of animals and animal products. It was this type of disease that was included among the former List A diseases of the World Organisation for Animal Health (OIE). 'Elimination' means a condition where diseases no longer threaten the flocks and herds of the developed world or the livelihoods of hundreds of millions of small farmers elsewhere. For some

diseases 'elimination' may not be the same as eradication because reservoirs of potential infection may persist, but if we commit to a new vision, eradication of many diseases will occur during the lifetime of our children. This is not incredible: in 1885 Louis Pasteur tested his rabies vaccine in man for the first time; in 1983 trials of a vaccine for foxes and other wild animals began in Germany and now many countries are rabies-free.

Technology always gets better over time and that of the future will certainly be better than that of today, but what we have now is good enough to remove the threat of transboundary diseases. The problem today is not lack of technology but failure of public policy. Developed countries, such as the United States of America (USA), Canada, Western European countries (including to some extent Russia), Japan, Australia and New Zealand, have strong veterinary infrastructures, financial resources and the technology but do not have the diseases. The rest of the world has the diseases but not the infrastructure, resources or technology. Public policy in our world frames the threat in agricultural terms and focuses almost entirely on the domestic consequences to agriculture of periodic disease introductions in the course of international travel and trade – and, most recently, deliberate introductions by terrorists. With this policy, the threat continues to exist and with the increasing complexity of agribusiness and globalisation, the potential consequences grow ever more severe.

The policy that the countries of the developed world should adopt is quite simple and is shaped entirely by the realisation that for these countries transboundary livestock diseases are not a mere domestic agricultural matter: they impact national security, and undermine international commitments to world trade, economic development, alleviation of poverty, environmental stewardship, international public health, animal welfare and wildlife conservation. Developed countries must commit to:

a) actively combat accidental disease/pathogen introduction and deliberate attack by terrorists

b) protect livestock against advanced biological weapons (BW) of the future

c) minimise the economic impacts after introduction by any means

d) abandon mass slaughter as a control tool

e) engage in disease removal in pursuit of a global economic, societal, and environmental agenda

f) make appropriate national and cooperative investments to effect this policy.

So why does such a policy not exist? The main reason is the mistaken belief among policymakers, agricultural and other stakeholders and the public that the current policy is based upon the limitations of the very best science available in the world today. Science generally does allow novel solutions for old and intractable problems and shapes new policy to exploit these to the maximum. But this is not true of the field of transboundary disease control.

Safe and effective foot and mouth disease (FMD) vaccine has been available for over 40 years, but its use in the developed world to respond to accidental or deliberate disease introductions is not policy because of the fact, despite the reality of successful vaccination programmes in Europe and South America, that a few vaccinated cattle that are also exposed to infection may persistently carry virus in their throats and are suspected to be a source of infection to others. Compounding this was the absence, until 1995, of any means to distinguish between vaccinated animals and those that had recovered from infection (including those that had been both vaccinated and infected). For these reasons, vaccine was not used to assist control of FMD infection in Great Britain in 1967 or in 2001 – and would still not be used in Great Britain (or the USA) in 2006.

Between 1966 and 2006, a conservative estimate puts government spending in Europe, Russia, North and South America, South Africa and Australia at over US$ 1 billion on the construction and operation of specialised laboratory facilities, and on the salaries, equipment, supplies and operations of those researching FMD. But this investment has had no impact whatsoever on disease control. This is not just a British problem or limited to FMD: in the USA in 2006 there is not a single transboundary disease for which the federal government is ready and able to vaccinate any relevant proportion of the livestock or poultry at risk. This would suggest an extraordinary and sustained failure of science – the absence of any return on public investment on six continents over 40 years through any discovery that might permit use of vaccine and drive new policy. In fact there were such discoveries – they were just not adopted by veterinary regulatory agencies. The failure was in policy.

Present: scientist-enabled policy

The established relationship between science and policy for transboundary livestock disease control is shown in Figure 1. This does not reflect all the scientific inputs that might be brought to bear but just those sufficient for policymakers. The pool of transboundary animal disease workers is small and most are employed in non-policy positions by the same government agencies charged with either research or diagnosis and with determining and implementing the control policy. This cadre is weakly placed bureaucratically and in the long shadow of a dominating historical dogma – that for almost 300 years slaughter has been the policy. It is virtually impossible for

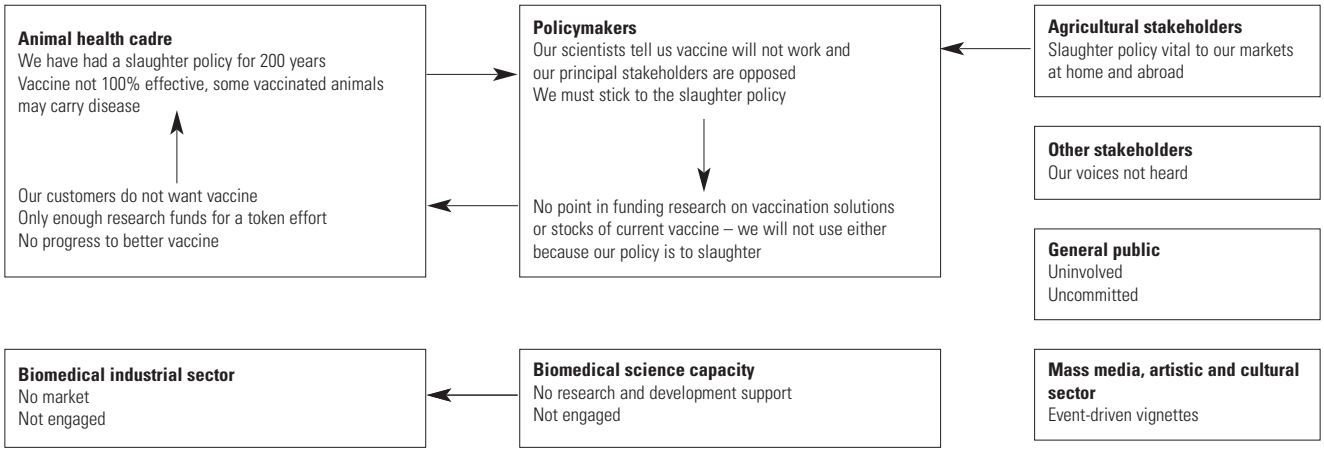

Fig. 1
The scientist-enabled policy cycle for transboundary livestock disease control

them to challenge the prevailing orthodoxy and completely so by making arcane comments and caveats about the technical properties of present or future vaccines and how these might influence some future event that is itself uncertain.

Policymakers lose no support from their strongest agricultural stakeholders by sticking with the status quo and what they hear is their scientific experts telling them there might be problems because of vaccine uncertainties. There is no gain for either policymakers or agricultural stakeholders in preparing for future uncertain events that have no political constituencies when there are plenty of current and certain problems that do. And agricultural stakeholders hold that a slaughter policy at home is vital to their markets domestically and overseas. So slaughter remains the policy.

Any broader discussion outside the Ministry of Agriculture does not occur, because the national biomedical sectors are not sufficiently knowledgeable of the issues and remain unengaged because there is no opportunity for reward. The general public is unaware, uninvolved and uncommitted. Even the sparks that the mass media and the artistic and cultural sector can ignite to sway public opinion and shift the most ossified bureaucracies are few, because they are generally struck by the rare events in their home countries that only happen every 30 years or so; the true calamity occurs in developing countries every day, but this is not widely reported by the media in developed countries.

The end result of all these factors is that policymakers believe there is no point in funding research on vaccination solutions or even in stockpiling enough of the current vaccine to make a difference when catastrophe strikes.

New: policy-driven science

What is needed is policy-driven science, where the policy is based upon a bold vision of the future, effective leadership across many countries and sectors, skilled advocacy and committed, zealous supporters, all of which will have to be sustained for a generation.

Time has conspired to move the issue of transboundary livestock disease elimination outside the confines of the world's Ministries of Agriculture and into a nexus with the more powerful realms of Defence, Foreign Affairs, Public Health, Homeland Security, Justice, Commerce, and Finance. Today, Ministries of Agriculture are not powerful within governments and the elimination of major livestock diseases will only be possible with the commitment of those ministries that are motivated by the following factors:

a) globalisation is not just an economic matter of shipping vast amounts of manufactured goods halfway round the world from where they can be produced most cheaply to places from which services, finance and high technology products can be sent in return. With this commercial torrent from far away lands comes crime, terrorism, and all the diseases that flourish in crowded places where there are no basic public health, veterinary or environmental services, and clean water, sewage treatment and the fundamentals of sanitation are unknown;

b) the crumbling residue of offensive BW research and production programmes across the former Soviet Union and in other countries poses a clear and present danger;

c) governments in many parts of the world are in a protracted struggle with resourceful and well-funded terrorist groups;

d) the scientist-enabled policy that has killed countless millions of healthy livestock is now killing millions of poultry as avian influenza (AI) H5N1 continues to spread westwards. Now there is a national and international crisis: billions of dollars have been pledged to domestic preparedness in public health agencies and the military, and billions more have been raised internationally to take the fight to the epicentre in Asia. If a small fraction of this money can establish effective veterinary infrastructure and safe animal agricultural practices in that region, this will be the basis for dramatic future improvements for all diseases.

The simple policy that is needed was stated earlier and is shown in Figure 2. The first step for its implementation is for policymakers to ask the entire scientific community and industry four key questions: what science can be applied to achieve these goals now; what science must be developed in the future; what is the estimated cost; and what are the constraints? The community will be eager to become informed and engaged because the potential individual rewards are obvious. The result should be a research and development agenda that covers the ground from basic research to veterinary and agricultural production practice and that identifies the critical path to product development and manufacturing through the government and private sectors. This is not difficult.

Informed public support

A key responsibility of government is to fund the research and development, and reduction to practice. But governments cannot do this in a vacuum – it is very much easier if the issue is perceived as important by the general public and supported and sustained over time by the many special interest groups who have the organisational power and advocacy skills to promote, or obstruct, key elements or all of the policy. Visible scientific outcomes that regularly demonstrate progress towards goals and reinforce both accomplishment and national commitment are also powerful motivators. Traditional agricultural stakeholders will find much that is attractive in a new approach to disease control: their fears will not be of the policy itself, only of who is to pay for it. Supporters will be found among those groups and individuals concerned about one or more of the following:

– the environment at home and abroad

– poverty reduction and improved public health in developing countries, especially Africa

– global economic development and its international health consequences

– animal welfare at home and abroad

– the conservation of wildlife and their habitats.

Support can also be obtained from the mass media and the artistic and cultural sectors – highly influential groups whose potential contributions have been almost totally overlooked in the past except at times of national crisis.

Many societies are growing more distant from the living sources of their food. Fifty years ago, most people were still in regular contact with those who grew, processed or delivered their food, and oftentimes with the livestock and poultry too. The growth of supermarkets in the developed world abolished these connections and for most people their first contact with their food is when they see cuts of meat, boxes of eggs or piles of fresh produce in the food aisles. Later came prepared foods ready to be cooked at home. Now the entire meal for a family may be in a box that just needs reheating. When the consequences of FMD control are shown on the television news as we eat these meals, the event could be taking place on another continent, even with the plumes of smoke outside and the

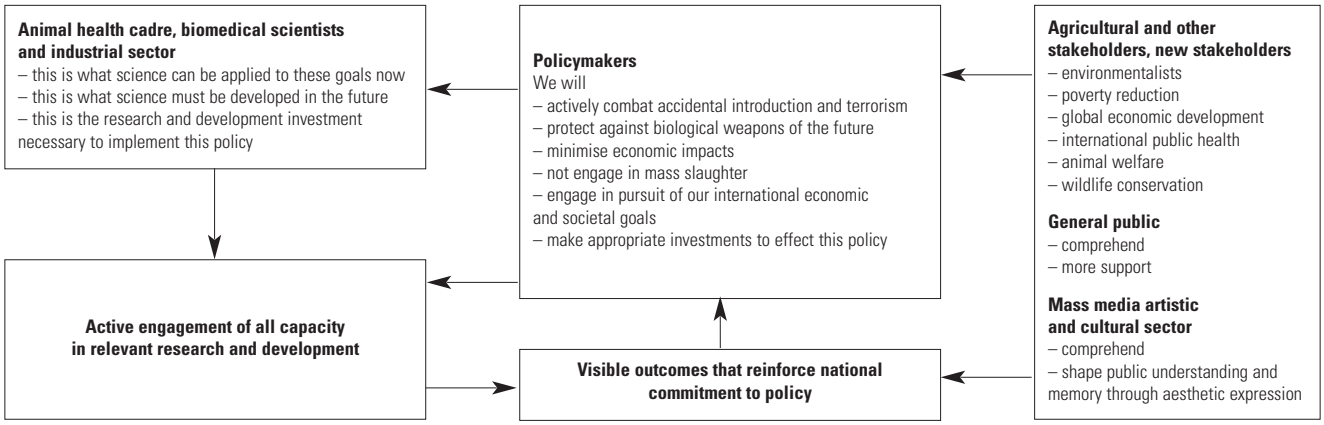

Fig. 2
The policy-driven science cycle for transboundary livestock disease control

fires on distant hillsides. A critical shift in public opinion will occur once the importance of transboundary livestock disease elimination can be effectively communicated.

The story of transboundary livestock diseases has not yet been told, but when it is this will generate the public support to solve the pressing problems that are now engaging government ministries in many countries. Peter Roeder, a Food and Agriculture Organization (FAO) Field Officer, summed it up well in a June 2001 letter to The Times of London published at the height of the British FMD epidemic, in which he described the effects of FMD in various parts of the world: 'the Cambodian subsistence farming family loses half its rice crop when the buffaloes are hit during paddy field preparation, and the fattening pigs and calves die or require expensive treatment. The progressive Bangladeshi dairy farmer with ten cows loses overnight most of the milk production and daily income from it. When the disease strikes just after lambing time, the northern Iraqi shepherd loses 400 of his 500 lambs from heart damage, together with much of the milk for consumption and sale. These real examples do not cover the full spectrum of impact, but they do illustrate the immediate, direct effects of FMD. The fight against epidemic diseases of humans and animals is far from over; indeed, for livestock diseases it has barely started in most of the world. A concerted fight against FMD and other epidemic diseases is needed, to start at their source where the reservoirs of infection persist. For the more developed nations to assist the developing nations in this fight must be regarded as enlightened self-interest, not benevolence'.

We cannot tell this story through government technical reports. To accomplish a policy change we must solicit the input of creative artists who can tell the story in ways that reach all the audiences that matter.

Challenging the dogmas

The prevailing wisdom is that it is the responsibility of government to keep transboundary livestock diseases out of our countries: when government fails in this task it is again government's responsibility to control the ensuing disease outbreak and compensate farmers whose livestock have been seized and killed in the process. Intermittent disease introductions are regarded as inevitable 'acts of God' that could not have been deflected by any reasonable human effort beforehand and for which no one can be held accountable. In this scenario, efforts to control disease outbreaks are framed in terms of a 'War against FMD' – in which FMD is the villain, farmers are innocent victims and the government seeks to be the hero (9). Livestock owners and agricultural industries are largely passive bystanders. The general public is not involved except as the intended audience for displays of government competence and as the source of tax revenues to support the whole enterprise, including compensation.

The author rejects this prevailing wisdom and sets out another view below. This is needed because the whole power of technology lies not in the invention itself but in how it is used. Success depends upon government and industry working together in a process that is comprehensive, adequately funded, and performing to measurable benchmarks, with costs falling upon those responsible in the form of 'user fees', not the general public through tax revenues. Specifically, there should be no government compensation of livestock owners for stock slaughtered during outbreak control: this should be covered by private insurance. Compensation for animals slaughtered during disease epidemics was a concept introduced over 100 years ago to encourage reporting by owners. While it may have some utility in this regard, and certainly still in developing countries, any benefit is greatly outweighed by the fact that it encourages and enables livestock owners and the industry to be disengaged from the entire issue of transboundary livestock disease control at the international, national and local levels, even down to the biosecurity of their own premises. This is a fatal weakness.

Roles and responsibilities

For the purposes of this paper, 'industry' means those concerned with the raising, processing and sale of livestock and poultry from farm to fork, including all zoo and commercial animals and birds from which commerce or profit is derived regardless of species. Other private sector industries will be identified later. The comments are directed at all transboundary livestock disease threats, with FMD as the example: one cannot detail all possibilities here.

Government and industry must agree on effective border control

Foot and mouth disease is not endemic in many countries, e.g. North America and Western Europe, so the only way FMD virus can become a livestock problem is if someone accidentally or deliberately brings in live infected animals, infected animal products, or the virus itself. The industry has no powers to prevent accidental or deliberate FMD introduction – this is an 'essentially governmental function' (although government employees do not necessarily have to perform the function). Governments can fulfil this responsibility by introducing legislation that covers the following elements:

a) the costs of preventing FMD and other transboundary livestock diseases from entering a country should primarily be borne by those passing across the country's borders or importing animals or goods of any kind that might carry

these infections. Globalisation has created a torrent of goods and people moving quickly across international borders and over vast distances and all involved in this torrent should contribute towards its effective policing;

b) plans should be developed for effective screening of people, conveyances (cars, trucks, boats, planes) and goods of all kinds arriving in a country to ensure that illegal imports of animals and animal products that might carry transboundary livestock diseases are detected;

c) systems to track and validate the movements of people, conveyances and goods should be employed to identify those arriving from countries where transboundary livestock diseases occur. Those identified conveyances and their contents and goods should be unalterable from the point of origin and they should be capable of being validated at the point of entry to counter criminal activity exploiting globalisation;

d) performance benchmarks should be established for issues such as how higher risk traffic will be identified and intercepted; what proportions of passengers, conveyances and goods will be examined; how they will be examined; and how results will be reported. So far as possible, robotic automated devices should be employed to screen the maximum numbers of potential targets. Industry must accept that it is not possible to examine all travellers, goods or conveyances and must agree with government what an acceptable fraction should be. Later, there might be redirection of inspection resources based upon risk assessment and experience;

e) a greater proportion of travellers, containers and goods coming from countries in which FMD and other diseases of concern are known to be present should be examined than from disease-free countries, thereby encouraging countries to eliminate disease within their borders. All travellers, conveyances and goods from countries not making acceptable progress in transboundary livestock disease control should be inspected, regardless of delays at the point of entry – thus elevating livestock disease from merely an agricultural problem at home to one that catches the attention of the whole economy;

f) a fee should be assessed on all travellers, conveyances, shipping containers and goods entering a country to pay for an agreed share of the increased costs of inspection and the costs of transboundary livestock disease elimination overseas. This fee would be greater for conveyances carrying live animals or animal products and for imports of live animals and animal products – but inspection should not be restricted only to these since the declared manifest might be incorrect. Reduced fees might apply to those meeting higher standards of validation as to the nature of the import and country of origin;

g) all sector components should contribute – the shipping companies as well as the shipper – to ensure that all are vested in the outcome. There should be real and significant penalties on the boat, truck or airline industry members found to be knowingly or unknowingly carrying illegal imports to discourage illegal imports at the point of loading in a foreign country;

h) on a non-disclosure basis, the government should make available to industry representatives up-to-date records on how well performance benchmarks are being met. The government should have the necessary resources to meet these benchmarks from tax revenues and user fees and be prepared to demonstrate that it is meeting its performance promises;

i) laws and regulations on penalties for failing to comply with importation requirements should be reviewed to ensure that penalties are commensurate with the likely degree of economic consequence;

j) through differential fees, the government should encourage adoption of importation practices that minimise fraud and maximise effective inspection, such as source validation, unalterable product seals, electronically verifiable certificates of origin, and lifetime tracking of the imported products in ways that can be validated in real time by customs inspectors at the point of importation. Specifically, there should be biological tests to validate the declared region or country of origin of meat that can be conducted at the point of importation.

Some of the steps above will deter terrorist attack using transboundary disease agents illegally brought into the country. Additional border control measures to deter terrorism benefit all society and are properly borne by general tax funds, not travellers and importers. The purpose of the above elements is to ensure that all those engaged in entering a country, with and without products or animals that might carry infection, contribute towards the costs of an effective programme that has a measurable impact on preventing illegal importations and ultimately on eliminating the sources of transboundary livestock diseases. The above comments do not address deliberate introduction (see below).

Government and industry must be accountable for performance

Governments have chosen to retain all powers to: diagnose FMD and other transboundary livestock diseases; respond to an introduction by vaccination and other health interventions; and to release vaccine to livestock owners. Industry should share the costs of an agreed and effective diagnostic and response system in which government meets agreed performance benchmarks that will limit industry losses should FMD occur. The elements of such a system are the same for both accidental and deliberate disease introductions. They are as follows (the term

'livestock' also includes all forms of zoo, game and other non-farm animals and birds):

a) early reporting of suspicious cases is critical to limiting any subsequent epidemic. Through education and training, government should ensure that livestock owners and those employed in the industry know what to look out for and how to report suspicious cases;

b) an inducement scheme might be adopted to encourage reporting. This component should have performance benchmarks;

c) within 6 h of the reporting of a suspicious case, government should have made a definitive detection of the transboundary livestock disease by transporting samples to a national or regional laboratory or by detection on the farm. This component should have performance benchmarks;

d) in cooperation with industry and the authority or authorities regulating the practice of veterinary medicine, government should have in place an emergency communications capability to inform directly all livestock owners and veterinarians, or a relevant defined subset of them, immediately (within 1 h) after a definitive diagnosis on a 24 h, seven days a week basis. This communication system may be by telephone, email, pager or other electronic means. This component should have performance benchmarks;

e) through education and training, government should ensure that all livestock owners and veterinarians know what preventative measures they should employ under their farming or business circumstances when disease is diagnosed. This component should have performance benchmarks. It is unrealistic to expect that all the industry will remain in a state of high alert on a permanent basis. But it is not unrealistic to expect that given a timely and specific alarm they should be able to respond immediately and appropriately based on their specific situation;

f) within 24 h of reporting, government should have made a definitive diagnosis, have determined the strain or subtype of the pathogen, and ordered the production and distribution of the most efficacious vaccine from stockpiled antigens. This component should have performance benchmarks;

g) the government should maintain a stockpile of vaccines (in the form of frozen antigen or other formulations of indefinite shelf life) to protect the country's livestock against all strains of the pathogen circulating in the world. The numbers of doses of each vaccine may not be the same as the total number of susceptible animals or birds but the government shall fully compensate, for all direct and indirect losses, all owners for whom vaccine is not available in the event of an outbreak;

h) the government should have a plan and capability to deliver sufficient vaccine for all susceptible livestock to their owners at pre-determined collection points (not at the farm) starting 72 h after definitive diagnosis and being complete within 144 h to 168 h so that the national herds and flocks have all been vaccinated within seven to ten days after detection. This component should have performance benchmarks;

i) owners should know where to collect their vaccine supplies, how to implement farm biosecurity measures and how to vaccinate their livestock or poultry. This will require significant advance emergency planning and regular exercising;

j) stockpiling vaccine precursors and the subsequent process of vaccine production and nationwide distribution under time deadlines are functions which would be best accomplished by the private sector using the principles already in place by which express mail companies provide integrated warehousing, distribution and delivery for other industrial sectors;

k) the government should ensure that sufficient laboratory capability and capacity exist to perform all diagnostic and differential diagnostic tests during and after an outbreak in a timely manner to meet performance benchmarks;

l) regional Agricultural Response Teams, such as the state response teams in the USA, should be established, trained and exercised (more information about the US model is available at http://www.flsart.org/). These teams should bring all the relevant national and regional government and private sector resources to bear in any form of agricultural emergency;

m) all components of the livestock production and animal product processing industry and the retail sector should pay a share of the above costs not borne by government because all components benefit from animal agriculture – this includes auctions, retail stores and slaughter plants. The consumers' portion is paid by government tax revenues. The purpose of such a cost-sharing scheme is to ensure that all those benefiting from the production, processing or sale of animals and animal products of national origin and those similarly benefiting from imported animals or animal products contribute towards the costs of an effective programme for the earliest possible detection and most rapid effective response to transboundary livestock disease threats and are actively engaged in their part of such a programme should disease occur;

n) when a transboundary livestock disease outbreak occurs during a period in which the government is not meeting its performance benchmarks for importation security, the industry should not have to pay its share of disease control costs stemming from failure on the government's part;

o) the same conditions will apply when there is a government failure in regard to diagnosis, vaccine deployment and preparedness;

p) the first owner to report a suspicious case that proves to be a transboundary livestock disease should be rewarded by government at four times the value of the stock; those subsequently reporting suspicious cases (that prove positive) within the first two weeks after the definitive diagnosis should be rewarded at twice the value of the stock. This is a reward for prompt notification, not a form of compensation for livestock killed in the course of control;

q) it is assumed that the national flocks and herds would be vaccinated within 14 days of first detection (13 days after definitive diagnosis). In the first 14 days, flocks and herds could be slaughtered as part of the control measures: thereafter, the numbers of infected premises should be small as vaccination and biosecurity measures take hold. Government would not pay compensation for any livestock killed during control measures: government should ensure that livestock owners can obtain insurance in advance against such an eventuality.

These elements are intended to promote industry-wide vigilance and immediate diligent attention and response after disease is diagnosed. With all performance benchmarks met, by government and industry, the goal is to halt an outbreak within two weeks of diagnosis by active commitment of all sections of the industry and related industries.

There are no acts of God

Once upon a time the only explanation for catastrophic disasters with extensive loss of human and animal life, e.g. hurricanes, floods, intense heat waves, droughts and other weather related events, was that these were acts of God beyond human control. The same explanation held for epidemics of infectious disease in humans and animals, such as the Black Death and the eruption of rinderpest into Europe. Now we know differently. While the natural event must necessarily run its course, advanced planning and preparedness can greatly mitigate the consequences. The same is true for incursions of transboundary diseases. Authorities must expect that exclusion procedures will sometimes fail and preparedness planning must assume this. When an accidental disease introduction results in a widespread livestock disease epidemic this represents two failures – in exclusion and in preparedness. It is not sufficient to point out that other countries have suffered through similar debacles. Either the government's Chief Veterinarian gave poor advice and must be held accountable or the government ignored good advice and is itself responsible.

The veterinary profession must make a stand on animal welfare

In a recent report to the European Food Safety Agency (5) an Expert Scientific Group stated: 'The eradication of FMD often involves killing of animals, sometimes in huge numbers and under less than ideal conditions...Poor welfare can result from inadequate stunning and might lead to pain from the injuries and from killing that is not instantaneous. There may also be other logistical problems, such as crowding resulting from pressure of time and space and restrictions on movements of stock, which can be causes of poor welfare'. The author would put the case less delicately. The mass killing in Great Britain in 2001 was the most shameful episode in the history of British Veterinary Medicine and today's images of thousands of bags of poultry being buried alive or hurled struggling onto the flames to control AI would be like a vision from Medieval Europe were it not for the fact that the bags are plastic and the perpetrators are wearing the latest personal protective equipment. How have we got to this place? In fact, we should not be engaged in mass killing at all: a non-slaughter alternative was available for FMD in 2001 and would be available for AI today if policymakers had acted in 1998. It is past time for the veterinary profession and its regulatory bodies to take a stand in regard to mass animal slaughter.

The potential for real-time disease surveillance

The pattern of events in the world, whether an infectious disease or criminal activity, commonly turns on three characteristics: complexity, venues and time. In the case of each transboundary livestock disease, the global pattern of events from places where the disease exists through the streams of travel and commerce that take it to our countries and what happens there when disease erupts can be described by these three characteristics, as follows:

a) Complexity – complexity of nonlinear systems is a way of understanding (8) the relationship among things that interact, such as the organisation of agriculture (including small and subsistence farmers) in the countries of disease origin and of global agribusiness in 2006

b) Venues – when discussing transboundary disease the venues to consider are:

– physical world: the farms and fixed assets of global animal agriculture and agribusiness and the flows between them, e.g. digital geographic information systems (GIS) data of many types, as well as climatic and meteorological data

– biological world: properties of the pathogen (ability to infect various species, potential for aerosol spread, survivability, etc.); locations, numbers and relationships of susceptible herds and flocks

– virtual world: everything connected to and available through the Internet, such as true and false information, disease reports

c) Time – this is the critical dimension. Time permits anticipation and response at home and abroad. If time is

gained, multiple alternate courses of action in space are possible. Generally, the more time there is the more options are available and the more likely it is that one or more of these options will be favourable. Conversely, the less time the fewer and less favourable the options.

Current transboundary disease surveillance strategies – and the responses disease outbreaks demand at home and abroad – ignore complexity, the virtual world, and, most importantly, the critical dimension of time. In most cases, our knowledge of the physical and biological worlds is also grossly deficient.

In almost all countries, suspicion of an outbreak of a transboundary disease begins when a farmer or veterinarian notices sick animals and calls a regional government official. The regional official travels to the site, examines the animals, and if a transboundary disease is still suspected takes samples for examination at a national reference laboratory. These samples are transported to the national reference laboratory where skilled technical staff attempt to identify the pathogen and thus to confirm the clinical disease diagnosis according to internationally accepted traditional methods. Non-traditional tests that test a region of the genetic material of the virus or bacterium that is a fingerprint (e.g. polymerase chain reaction [PCR]), may also be performed and have the advantages of being able to detect both live and dead pathogens at speed. But these tests are for the most part not yet recognised by the international community for formal diagnosis. If a transboundary disease is confirmed, or further more sophisticated tests are required, samples may be submitted to an international World Reference Laboratory. On confirmation, the country is required to notify the international community through the OIE. The entire process from first suspicion to formal notification typically takes many days and most countries are reluctant to disclose the existence of disease before formal confirmation.

The international and domestic surveillance system that is needed is not based on this historical precedent nor can it operate on the same languid timescale. What is needed is a system that achieves or approaches real-time understanding of the disease situation at all stages and in all places, i.e. a system that can be accessed over the Internet by diverse government agencies and stakeholders in the same country and in many countries through common software architecture and peer-to-peer networks so that each entity can keep its own data rather than have everything reside on one giant computer. Of course, this does not mean that all users have equal access to all data: tiered secured access is essential.

The current westward movement of AI H5N1 illustrates surveillance deficits at the international level. Spread has been through national and international poultry commerce and migratory birds. The latter's flyways are generally known, but this information by itself is of little use to government veterinarians seeking to implement active surveillance programmes (looking for disease in populations at risk) as opposed to passive surveillance (waiting for someone to discover and report dead birds). With limited financial resources, surveillance must be intelligently focused by knowledge of: the wild bird species infected at the point of origin in China; their migratory routes; specific sites along route where they congregate (and when); factors promoting congregation (to predict potential sites); and the presence of susceptible poultry. Public Health officials must also focus because infections are most likely in people in close contact with infected birds in high risk areas identified by veterinary authorities. Unfortunately, public health and animal health are two government departments that cooperate infrequently: wildlife disease surveillance often brings in a third department with poor communications. And critical knowledge of particular migratory birds is most likely found in private sector records of ornithologists or naturalists. The problem is in getting the right information to the right people in a timely manner so that optimal actions can be taken.

This example illustrates that the 2005-2006 AI outbreak is a complex system that involves at a minimum: global patterns of small farm agriculture (some 500 million enterprises) and international and national agribusiness; the patterns of human society in and between every country; the natural histories of hundreds of species of wild migratory birds; and, not least, the natural history of AI H5N1 itself. The physical and biological worlds associated with each of these have been hinted at above. For the first time, dwarfing that for FMD in 2001, we are witnessing the power of the Internet to begin to deliver information and shape public perception and understanding on a global scale. An international disease surveillance system that can capture all these data and more must be developed. Furthermore, it must be capable of delivering insight as well as information to the end user in a timely manner related to the contemplated action.

Previously (1) the author has described the intellectual and technological basis for a national animal disease surveillance system that would be part of a government 'command, control and communication' system (CCC system). This type of system would be the means to track events in real time, for command and control at all levels, and for communication between all parties involved, including the public, media and local community and business leadership of all kinds. The CCC system would allow responsible authorities to lead a coordinated cooperative campaign with many other partners beginning immediately the problem is recognised and focusing all available local resources where they are most needed in the first hours and days. The goal is 'information to insight in real time'.

The CCC system must have an organisation structure that will allow state and national action and regulatory agencies to undertake at least the following five actions:

a) observe, characterise and predict activities, both discrete events and patterns, across a minimum of the three venues (the physical, biological, and virtual) and the temporal world. Time is the critical dimension

b) relate information from all venues promptly and synthesise the results into a form that can be disseminated to those who need to know in order that informed action may be taken

c) catalogue historical events and also recognise emerging patterns of hazard, threat and opportunity in all the venues of human enterprise and natural phenomena to provide foresight and anticipation, the key ingredients of effective action

d) communicate and present knowledge derived from this information in ways that provide force-multiplying support to the action agency personnel at the centre of the system

e) provide timely, accurate, transparent, credible information to the public, media and local community leaders to promote understanding, allay unnecessary fears and prevent panic. Cable news channels must not be the sole source of current information for the public and local leadership.

In the example of FMD, the physical world would include wind, weather, and the location of personnel, disease detection equipment and other physical assets. The biological world would include demographic data on susceptible species and the aerosol characteristics of the exact type of FMD virus causing the problem. The virtual world means anything involving the Internet – including websites of advocacy groups with opinions relevant to the situation and the media. Public opinion in a crisis is not shaped by scientific results appearing after peer review in an academic publication. The Internet has unprecedented potential to drive public perception for good or bad and to shape action agency responses accordingly. The temporal world includes both chronological time and the relationships of events to each other in time. Here, examples would be the estimated times at which animals had been infected on the index farm and then became infectious for others, or the times when certain weather events occur or virus plumes are generated, and the relationship between these times and times of movements of people, animals and physical objects from farms in the data-defined quarantine zone.

To be a national seamless system for response to the full spectrum of disease threats, many historical and real-time data resources would also need to be available. Examples include: street maps; telephone numbers; topographic, ground cover and landscape maps; real-time satellite imagery; demographic data on population distribution; economic data by location; locations of specific businesses; water, sewer and other utility maps; medical resource maps; schools; law enforcement resources; locations of specialist auxiliary personnel and resources appropriate to a particular threat response, and so on. Each responsible agency would best identify the necessary resources in conjunction with all the anticipated partners at the national, state and local levels. Geographic information systems are now a vital component for optimum efficiency. All these would have to conform to set standards so that the whole is compatible.

Domestic preparedness for accidental and deliberate disease introduction

Animal agriculture in the USA (and Canada, Europe, South America, Australia and New Zealand) is perilously vulnerable to deliberate attack with foreign livestock viruses. Traditional government responses to such an event – sweeping quarantines, mass slaughter and burning or burial of millions of carcasses under the ceaseless eye of television – together with staggering financial losses triggered by international trade embargoes are exactly what terrorists want to see and what makes these viruses potential BW in the first place (1). The US policy to counter agroterrorism is fatally flawed because it mistakenly conflates the threats of inadvertent and purposeful disease introduction. Moreover, this policy was developed without understanding that it is only the ways in which the country has chosen to respond to foreign diseases in the past that allow terrorists to threaten it with them in the future.

As American and international agribusiness has industrialised, animal health officials have stubbornly clung to 18th Century ideas of epidemic disease control, despite abundant recent evidence from Taipei China, the Netherlands and Great Britain that in the context of modern agribusiness such actions guarantee catastrophe. If we try to counter deliberate assaults the same way, after a successful attack it will be national governments, not a terrorist gang, which is killing, burning, filling mass graves and wreaking economic havoc nationwide. In 2006 these are the wrong responses to either inadvertent or deliberate disease introduction and the consequences of this mistake cannot be limited to farmers: there will be lasting damage to the rural economy and public confidence in government and enormous costs for taxpayers. Should the foreign disease infect humans as well as livestock – as is now the potential with AI H5N1 – our families will also be at risk. All of which will greatly embolden and encourage terrorists.

Terrorist attacks on a nation's agriculture are not about imperilling food supplies: they are about terror, money, mass slaughter and funeral pyres all day every day on the international Cable News Network (CNN). National policy for inadvertent and deliberate foreign animal disease introductions should be simple: it should aim to minimise direct and indirect economic impacts and to not implement a policy of mass slaughter. Fortunately, most of the tools and technologies to permit such a policy already exist. There are now rapid, on-farm tests for these diseases; effective vaccination strategies; Internet-based command, control, and communication systems; and means to track animal products from farm to table in real time, even internationally. These allow for a more effective response than was possible 300 years ago and permit a new national policy. If countries in the developed world choose this way forward, there will be little point in deliberate attacks because the outcomes terrorists want to see will not be possible and inadvertent introductions will be eliminated with scarcely a footprint. But changing national policy will require input from a much broader group of policymakers than in the past: given the nature and magnitude of what is at stake this is not just a matter for agriculture any more.

The state of current preparedness is inadequate, everywhere. For at least 20 years it has been obvious that the modern agricultural industries of the developed world cannot use 18th Century methods to control naturally or intentionally occurring outbreaks like FMD in 21st Century agribusiness without catastrophic damage and enormous economic costs. To try to do so is a grave mistake and there are much better alternatives.

Government policymakers need to understand that:

a) control of inadvertent or deliberate FMD or other transboundary livestock diseases is not an animal health policy issue that can be left to agricultural authorities

b) traditional inadvertent outbreak controls are based on financial factors, not animal health – the 'best' response has been the one that triggered the lowest costs for agriculture, not the whole economy

c) terrorist attacks on animal agriculture are not aimed at denying the public food supplies, killing farm animals or making them sick; they are intended to produce terror, staggering financial losses, mass slaughter and funeral pyres – theatre that can be shown all day on television at home and abroad to demonstrate the capability of groups to strike at the heart of a country and to attract recruits and support

d) the damage from FMD, however introduced, comes from our response not the infection itself

e) the present response is conditioned by tradition

f) the current method of responding is what makes these transboundary livestock diseases terrorist weapons in the first place

g) most of the tools and technologies to allow new policy already exist; governments have just chosen not to use them.

With a policy that minimises direct and indirect economic impacts and does not require mass slaughter there is no theatre, nothing to show on television, no triggering of sweeping, costly trade embargoes, and little point in a deliberate attack. Governments can implement this new policy tomorrow and work with the OIE and World Trade Organization to modernise international regulations on animal health so that all countries that wish can follow the same path.

Fortunately, over the past decade the USA has developed the core technologies to implement this new policy and others will flow once the incentives are there. The principles of their operation and potential applications are described elsewhere (1). The key innovations were:

a) rapid, on-farm real-time PCR diagnostic tests that can be read by experts at a distance in real time over the Internet

b) a real-time, Internet-based CCC system to coordinate federal, state and local responses

c) a differential test that discriminates FMD vaccinated animals from those that have recovered from disease yet might still be infectious for others

d) tracking and identification systems to follow animals and products from farm to table through the entire production and processing chain, and even internationally.

Logically, similar systems can be developed for other transboundary diseases. Unfortunately, the USA, and other countries at risk, have chosen not to use these powerful tools, largely because there is enormous confusion at the policy level stemming from the proximity of the 2001 FMD outbreak in Great Britain – which caused even the most stubborn mass slaughter proponents to have second thoughts – and the terrorist attacks of September and October 2001, which are the events that first brought deliberate attack and BW into sharp focus for most people. As a result, there is conflicted thinking about: inadvertent introduction and catastrophes abroad, biological warfare, and agroterrorism.

To understand how the new policy would work, we need clarity about:

a) the nature of the threat

b) the nature of national vulnerability

c) the factors that make new policy a necessity

d) future technologies to prevent disease or cut financial losses

e) necessary changes in the relationship between government and industry that will enhance defences and minimise the impacts of disease.

The threat

Biological warfare has been planned or employed by many nation states over history as an adjunct to conventional weaponry. But it is not a current threat to any nation's agriculture. In World War II, there were plans (and even limited actions) to use BW that caused disease and death in animals and plants on a large scale as an act of war intended to cause hunger and deny food to the opponent's civilian population and armed forces. Most recently, the former Soviet Union clearly had the weapons, the delivery systems and the production capacity to threaten US food supplies in time of war. But such a threat does not exist today and it is highly improbable that a terrorist group has the capability and capacity (or intent) to provoke hunger in the USA by waging biological warfare against animal and plant industries. Specifically, one can discount the idea of kilograms of virus or fungus being dispersed by crop sprayer over vast populations of animals or acres of crops.

Thanks to current policy, terrorists, however, need only have capability – not capacity – to successfully attack agriculture in the USA and other developed countries. Terrorists want to see a dramatic public result that attracts media attention. Such results can only be triggered by attack on a big target – one or more of the dairy, beef, swine or poultry industries – with a transboundary livestock disease pathogen which leads to mass slaughter and costly international trade embargoes. Furthermore, to produce an epidemic, the pathogen must be easily spread by aerosol, direct contact or a flying insect vector beyond the initial site of attack. Only a handful of pathogens, all viruses, meet these criteria, as follows:

– FMD in cattle and swine

– rinderpest in cattle

– classical swine fever (CSF) and African swine fever in pigs

– AI and Newcastle disease viruses in poultry

– Rift Valley fever (RVF) virus.

The latter is a mosquito-borne virus of humans, cattle, sheep and goats; its significance as a terrorist weapon, like that of AI H5N1, depends less on its impact on agricultural economics and mostly on the ability of infected livestock and insects to serve as reservoirs for human infections.

The list of realistic terrorist livestock weapons threats is necessarily much smaller than the list of foreign viruses, bacteria, parasites and insects included on the OIE list of notifiable diseases that might be inadvertently introduced into a disease-free country like the USA in the course of normal international travel and trade. Such introductions would of course have consequences and would stimulate a government control response. But their nature is such that this response will be insignificant compared to FMD and the other six viruses listed above. The US Department of Homeland Security currently lists FMD, RVF, AI and *Brucella* as priority threats to agriculture in the USA. *Brucella* species cause disease in cattle, swine and sheep and also infect humans. Terrorists can threaten humans with *Brucella* (by aerosol release) but they could not threaten agriculture because such infections in livestock do not trigger mass slaughter or international trade embargoes. They are economically insignificant. Nor would terrorist infection of livestock with *Brucella* threaten human health – for decades the public has been protected by pasteurisation of milk and cheese. This was clearly shown in 1999 when *Brucella melitensis* was found in goats and cattle in Texas, probably after introduction from Mexico. The focus was eliminated without an economic ripple.

An advanced BW is one whose biological properties have been modified by genetic engineering or other means to defeat countermeasures. As an example, Soviet scientists added a novel toxin gene from another microorganism to *Bacillus anthracis* in an attempt to defeat the US military vaccine. There are thus two challenges in detecting BW:

a) to detect the known pathogen

b) to detect an advanced pathogen that has been modified genetically (and to understand the nature of the modification so as to develop countermeasures).

Governments thus seek to defend their countries against known disease agents and to anticipate and defend against technological surprise through advanced BW with unexpected properties (1, 6).

Eliminating or even totally eradicating FMD or any other transboundary livestock disease will not completely remove the threat of terrorism or future biological warfare employing this virus. Eliminating FMD would certainly make terrorist access to virus more difficult in the future; the purpose of the Biological Threat Reduction Program (BTRP) (see next section) is to make access very difficult under current conditions. But the world's most dangerous BW – once manufactured in large quantities by the former Soviet Union – is smallpox virus, the cause of a human disease eradicated globally almost 30 years ago. The end of smallpox as a public health problem also spelled the end of routine vaccination of the world's population and closure of vaccine production facilities. Today, the entire world

population is as vulnerable to smallpox as the peoples of the New World in 1492. Even if all world sources of FMD virus were to be destroyed – an improbable and immeasurable event – new virus could be made synthetically (FMD virus is a relative of polio virus, which has already been made in the test tube from scratch) and engineered to evade all known vaccines. We will thus need to maintain our defences against eradicated diseases to counter any future uses.

The nature of national vulnerability in the USA

The largest agricultural market in the world is the USA and this depends upon very large populations of domestic livestock and poultry. These flocks and herds are individually very large – just 2% of feedlots produce over 75% of the cattle – and for economic reasons the different industries have become clustered in a handful of states: 75% of swine are in the mid-West, 80% of broiler chickens are in the Southeast and over 80% of feedlot cattle are in the mid-West and Southwest states. As a result, very large populations of animals are at risk in small areas. These animals and birds have little or no innate resistance to foreign pathogens and, by policy, are not vaccinated against these diseases, which do not occur in the USA under normal circumstances. Similar situations pertain in other countries at risk.

The animal and poultry production, slaughter, processing and distribution system in the USA is highly integrated and characterised by rapid movement of vast amounts of product over broad geographies and through many hands from farm to fork. This system, which is highly efficient economically, could only develop over many decades because the USA was free of major animal diseases that might have hindered unrestricted inter-state trade. The system now embraces Canada and, to a lesser extent, Mexico and is becoming increasingly global. Of course, producers always realised that the possibility of inadvertent introduction of a foreign disease posed a constant threat but that seemed remote. As a result, US agribusiness never factored the consequences of introduction of a highly infectious, highly contagious disease into the production and processing system. And government did not do this either. Today, the USA is so vulnerable to inadvertent or deliberate introduction because it chose to build the system that way.

Factors that make new policy a necessity

The USA has been extraordinarily fortunate not to have experienced a major foreign disease epidemic in livestock or poultry over the past 20 years. Among the geopolitical changes that have greatly increased the potential for inadvertent disease introduction are: the fall of Communism; increased volume and globalisation of trade; expansion of the European Union; free trade agreements; containerised shipping; reduction of government investment in disease control, regulation and inspection of agricultural products; and liberalised international travel with direct flights to the USA from formerly distant parts of the world. These factors should have stimulated new policies to reduce vulnerability, but they did not.

Future technologies to prevent disease or cut financial losses

Almost to the end of the 20th Century, the only way American business could be threatened by a foreign virus was by accidental importation of FMD, rinderpest or some other threat. In 2006, however, American business is far more likely to be damaged by a computer virus delivered over the Internet from some foreign shore. The costs of such attacks can be considerable and even exceed those often quoted for FMD. Yet government has adopted quite a different approach to the business costs of foreign transboundary computer viruses as compared to animal and plant transboundary viruses. Government sponsors and encourages research on computer defences and supports law enforcement efforts to catch those responsible. But business is entirely responsible for the costs of staff, software and training to prevent or mitigate attack and for back-up systems to maintain key functions. If a company or individual chooses not to use these protections, they are free to go out of business when crippled by a computer virus attack.

In the 18th Century, farmers whose cattle had rinderpest did not receive compensation: those who did not report the disease were hung, drawn and quartered. But a century later the promise of compensation did increase reporting and helped end epidemics. In 2006 government compensation is one of the factors that promote industry complacency about inadvertent and deliberate threats. If all sectors of the industry had to insure against these losses instead of relying on government there would be immediate changes: private insurance companies would never accept the risky practices that have become engrained.

Government and agribusiness have built a tremendously vulnerable system that could be devastated by inadvertent or deliberate pathogen introduction. Yet some business sectors have opposed or blocked some of the very tools that are essential to mitigate losses if disease should strike: animal identification; country of origin labelling; bioterrorism prevention and preparedness steps; and identification and tracking of product. No licences or tests are required to farm animals, there are no rules or standards for farm or premise biosecurity and few employees are trained to prevent or detect disease. High-risk practices are common and the industry structure promotes them. For example, feeding garbage to swine is a very high risk practice by which FMD and other foreign

viruses can get a foothold to start an epidemic: the practice is only profitable if the risks are passed on to society in general. If the garbage is properly cooked the risks are minimal, but it is everyone's cooking that must be perfect, not just an individual's. It is not clear just why it is a societal responsibility to compensate the garbage feeder whose pigs get FMD: this is not different from a computer virus. And it seems unconscionable to compensate the garbage feeder but not the slaughterhouse worker and hotel owner who lose their jobs as a consequence of his actions. The answer is not to extend the scope of government compensation but to curtail it. If all farmers had to acquire insurance against the costs of FMD and other transboundary diseases, those that engaged in high risk practices would probably not be able to purchase insurance and would go out of business. This is not entirely a bad thing, even for other farmers: those that remained would adopt far more stringent practices for all inputs to their agricultural enterprise, as is commonplace for other industrial sectors.

Changing government–industry relations

But this is very definitely not to paint agribusiness as an adversary. The industry is the only player that can reduce national vulnerability through peer example and pressure. The industry is painfully vulnerable. This will not be solved by government rules and regulations. Industry itself has to take the initiative and government can best assist by using its penalties and inducements to encourage movement in the right direction. Of course there are already agricultural businesses with very high standards of biosecurity. These are the ones able to exert the necessary degree of process control throughout their operations. They are the benchmarks for others.

A new benchmark for veterinary surveillance and detection

The US Defense Department's Defense Threat Reduction Agency is engaged in a Biological Threat Reduction Program (BTRP) in some countries of the former Soviet Union: currently these are the Ukraine, Georgia, Azerbaijan, Kazakhstan and Uzbekistan, which together cover a broad swath of territory from the Polish border to the People's Republic of China. The overall purpose of the programme is to prevent proliferation of BW technology, pathogens and expertise at the source. This is accomplished through four interlocking activities designed to:

a) prevent the sale, theft, diversion or accidental release of BW materials, technology or expertise

b) consolidate especially dangerous pathogens (EDPs) into safe, secure central reference laboratories

c) improve national capabilities to detect and respond to EDP disease outbreaks

d) integrate government scientists into the international scientific community

e) eliminate any residual BW infrastructure and technologies.

Threat Agent Detection and Response System

The Threat Agent Detection and Response (TADR) system is the BTRP component charged with enhancing reporting, detection and response capability for human and veterinary EDPs, including wildlife reservoirs and vectors. The term 'EDP' has a specific legal definition in each country and the BTRP priority agents include some pathogens that are not classified as EDPs in all countries, yet are of mutual interest.

The TADR system is not intended to be yet another surveillance system but to be integrated into existing country surveillance and diagnostic systems operated by agencies of the Ministry of Health, the Ministry of Defence and the Ministry of Agriculture, so the following description of the general system architecture (see also Fig. 3) is modified according to individual country circumstances.

National level

At the national level, central reference virology and bacteriology laboratory capabilities are enhanced to provide biological safety level 2 and 3 laboratory and animal research space that complies with international standards for employee and environmental safety and for biological security. (There is a distinction between 'biological safety', which is intended to protect laboratory personnel and the environment from EDPs inside the laboratory and 'biological security', which is designed to prevent theft or unauthorised access to EDPs.) Laboratories are equipped to perform modern molecular tests, such as enzyme-linked immunosorbent assay (ELISA) and real-time PCR, as well as culture and traditional tests. Specialised transport is provided to allow rapid epidemiological investigation of suspicious cases and collection, safe packaging and secure transport of samples. The central reference laboratory serves four functions:

– a diagnostic laboratory for the city or region in which it is situated

– a national reference diagnostic capability

– a secure EDP repository (with electronic control of the pathogen inventory)

– the national locus for research with EDPs.

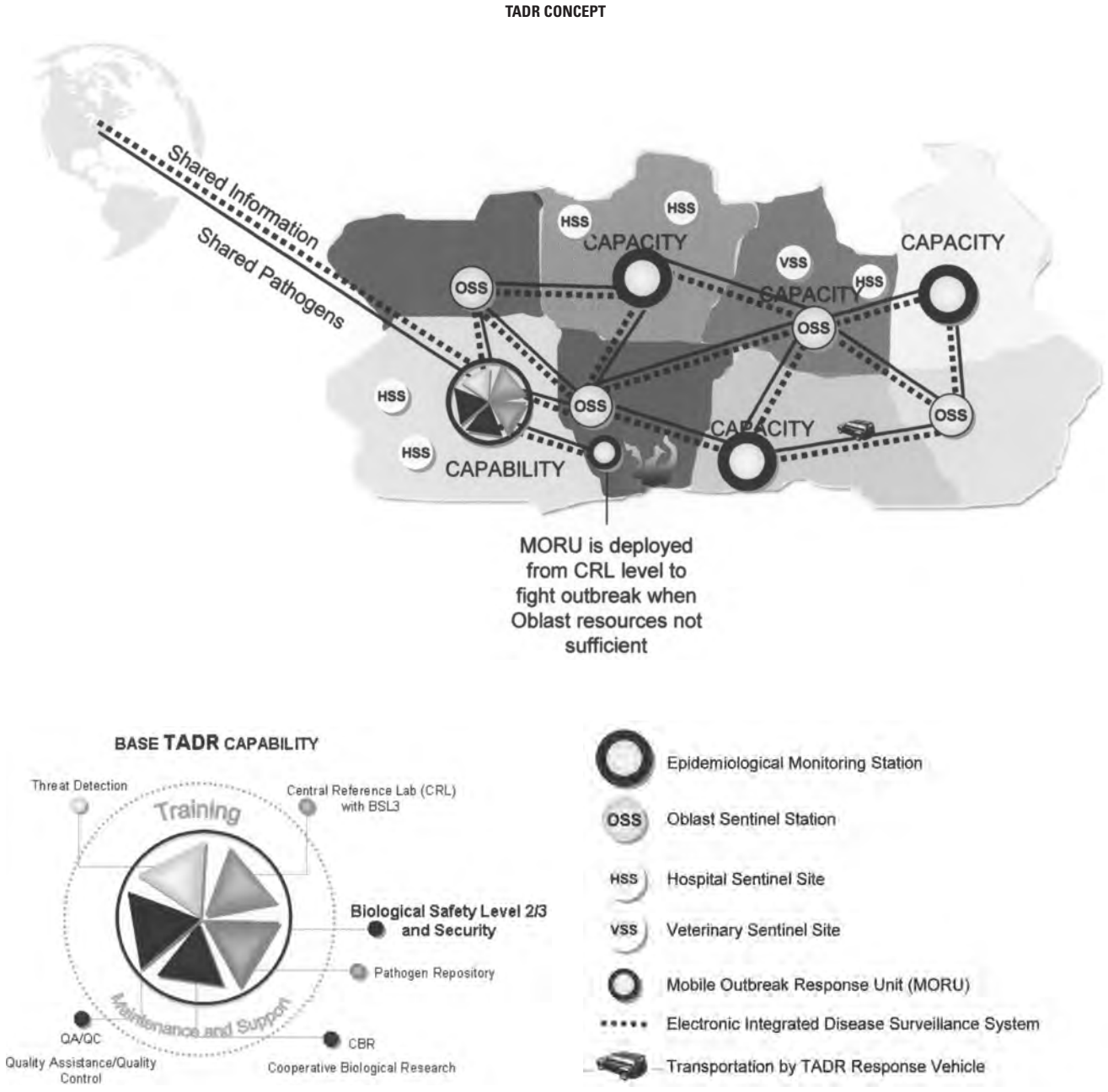

Fig. 3
Elements of the Defense Threat Reduction Agency's threat agent detection and response (TADR) system

Also managed at the national level are two rapid response teams, one for human health and one for veterinary health, each with appropriate cross-training to work together on zoonotic diseases. These are deployed by the Minister of Health or the Minister of Agriculture when resources at the regional level are not sufficient to contain the outbreak. The rapid response teams have portable PCR capability to provide additional disease detection capacity at the site of the outbreak and mobile access when deployed to an electronic infectious disease surveillance system (EIDSS) see below.

Regional level

At the regional level there are existing public health and veterinary epidemiological and diagnostic laboratories in every region (known as an oblast, which is larger than a county or canton but smaller than a state or province). These are the backbone of the existing system. All these laboratories are being upgraded by provision of an EIDSS; dedicated vehicles for case investigation, sample collection and transport; and biological safety equipment for collection, processing and packaging of samples. In addition to this

some laboratories are also being supplied with modern molecular tests, including ELISA and PCR. Laboratory detection activities will be at biological safety level 2. The EDPs will not be stored at these regional laboratories: after the detection test they will be destroyed or sent to the central reference laboratory for further analysis and characterisation as warranted.

Often it is not economically justifiable, or even physically possible, to renovate existing buildings to meet international biological safety and security standards, especially in regions of high seismic activity. Therefore, a new pre-engineered facility has become the standard model at the oblast level to provide the full range of surveillance, diagnostic and reporting capabilities. The numbers of oblast laboratories differ between countries, based in each country on geography, the distribution of susceptible human and livestock populations and knowledge of past and active foci of disease, such as tick reservoirs or porous borders across which small ruminants move without interruption. In Georgia there will be a total of three veterinary laboratories and in Uzbekistan six. For these regional veterinary laboratories, dedicated transport to investigate outbreaks on farms and to collect and transport samples under conditions optimal for subsequent laboratory diagnosis is critical.

District level

At the district level (known as a rayon) public health and veterinary officials will be trained in disease recognition and reporting mechanisms. This system is based on a three-tier case definition approach starting with a 'suspicious case' at the farm, hospital or rayon level, going to 'probable case' after a positive pathogen detection testing procedure at the oblast laboratory and ending as a 'confirmed case' after regulatory-approved tests at either the oblast or central reference levels. Certain infectious disease hospitals and slaughter plants that might be expected to encounter a significant number of cases will also receive biological safety equipment and training to ensure samples are collected and stored properly.

EIDSS: Electronic Infectious Disease Surveillance System

The EIDSS provides the means to report suspicious disease outbreaks in real time and to track the progress of case investigations, epidemiological investigations in the area and the results of sample testing. The EIDSS contains a GIS and will locate disease outbreaks by use of a geographical positioning device. This is vital when street addresses, premise identifiers, and unique animal and personal identifiers are not available. Historical records of disease distribution will also be incorporated. The system has the ability to track multiple samples from the same patient taken at different times and places. There are built-in links between human and veterinary health for cases of zoonotic disease. Although initially confined to the EDP list of diseases, the EIDSS is intended to encompass all public and animal disease surveillance information in the future. The EIDSS data is entered in the language of the country but can be searched in many languages. Combined with the rapid results obtained from real-time PCR detection, the EIDSS can report positive laboratory detections in close to real time, at most in a few hours depending on distance. The Rapid Response teams will be able to detect and report from the site of the outbreak should that be needed.

International standards, quality control, training programmes and regulatory changes

The TADR system uses the same equipment, test protocols and test reagents in all countries and the results are intended to be fully compatible with standards of international organisations like the World Health Organization (WHO) and of the US Centers for Disease Control and Prevention. There is a quality control and quality assurance programme and the laboratories will meet international performance standards. There is an extensive training programme in every aspect of this very new system: operation and maintenance of laboratory infrastructure; operation and maintenance of laboratory biological safety and analytical equipment; epidemiology and disease surveillance techniques; laboratory assays and their quality assurance. Extensive regulatory changes have to be made to existing country laws and regulations to accommodate unfamiliar concepts, equipment and procedures. This is an enormous task that could never be completed without earnest support from the countries themselves. Critical to success in matters that fall under many departments of government is an agreement at the Presidential or Cabinet level that the National Security Council and the Ministries of Health, Defence, Agriculture, Justice, Finance, Foreign Affairs and Customs and Excise will work together to identify and overcome barriers.

Technology is outpacing regulatory capability

The TADR system provides the architectural backbone for a more extensive nationwide detection and reporting system that will cover common diseases as well as EDPs and is a model that can be extended to other countries by other funding sources. With the TADR architecture in mind, the impacts of future technology can be anticipated.

The TADR system is using real-time PCR tests that identify pathogens one by one in a highly sensitive and specific manner. These tests are the state of the art for answering the question: is this a case of FMD or not? It would require three separate real-time PCR test procedures, which could proceed simultaneously in the same machine, to answer

the question: are FMD virus, CSF virus and African swine fever virus present in this sample? Many tests would be required to determine the cause of a fever of unknown origin, although specific causes could be ruled out one by one by single tests. The reason for this is that there are inherent limitations on the number of fluorescent dyes that can be used and discriminated in a PCR test procedure when testing for multiple pathogens at the same time (a multiplex test). The next generation is one of multiplex tests that can detect all transboundary pathogens in a single procedure. PCR technology using various combinations of 64 distinct molecular mass tags instead of dyes can identify many pathogens simultaneously. With this approach, 22 different viral, bacterial and Mycoplasma respiratory pathogens (2) and ten different causes of viral haemorrhagic fever (10) can be simultaneously and rapidly discriminated in human clinical samples. Mass tag PCR costs about the same as real-time PCR except for the one-time cost of the mass spectrometer, but it is a logical next step up diagnostically from single PCR tests: the technology also builds on experience with PCR and quality assured laboratory practices. The latest generation of microarray tests incorporates 30,000 viral, bacterial and parasite genetic sequences representing all vertebrate infectious agents on a single chip (W.I. Lipkin, personal communication and unpublished data, 2006). The technology for microarray chips that can detect all livestock (not just transboundary pathogens) infectious agents simultaneously is already upon us though their current production cost makes them too expensive for veterinary use at the moment.

The trend in technology is crystal clear. Technology has already allowed tests that could once only be conducted in sophisticated national reference laboratories to be conducted in less elaborate regional laboratories at lower levels of biological containment or on the farm. It has also allowed tests that even national reference laboratories could not do to become commonplace at the regional level. With time and money, and a firm basis of experience with current technologies, the TADR model will become increasingly sophisticated at the regional and lower levels, as well as centrally. This has significant implications for how transboundary disease diagnosis is regulated and approved at the national and OIE levels and for the future roles of the World Reference Laboratories, which are more likely to be handling viral and host genomic information transmitted electronically from the countries themselves rather than actual samples of virus from which information has historically gone in the opposite direction.

The research that defined real-time PCR tests for FMD, CSF and other transboundary diseases, was disclosed and demonstrated to veterinary regulatory agencies in the USA and Great Britain and to members of the US Animal Health Association in 2001; the scientific paper was published in 2002 (3). In 2006, a joint effort by British and US FMD diagnostic scientists essentially confirmed what was known in 2001 (7). But the test has still not been recognised by the OIE for international use for the diagnosis of FMD, even though the 2006 study (7) rediscovered that it would detect the presence of dead virus that could not be grown in cell culture and was, therefore, the new state of the art, as it had been since 2001. 'Validation' studies on the other tests are still in progress. In the meantime, there have been three highly significant technology advances: mass tag, FilmArray and the multi-pathogen chip. Our regulatory approval processes are completely broken when they cannot even keep up with generations of technology, far less specific applications. Transboundary disease diagnosis will never go back to being the province of a small club in select laboratories. We need to get these new generations of tests validated and out where they can be used within one year or less from discovery. The matter of pathogen detection has been trivial for some time and the tough question has become how to best use the new tests and the information they generate.

There are repeated calls for cheap, rapid pen-side tests that can detect FMD and other pathogens. This was identified as a critical need during the 2001 British FMD outbreak and in a recent European report (5). Such tests have existed for some years. The FMD real-time PCR test (and others for CSF, etc.) was always intended to be the trigger for regulatory action and response when used to detect and report infection, in close to real time, from the index farm over the Internet. But these tests have far greater potential. The challenge, immediately FMD is detected, is to discover where it is already present on other farms in the immediate area (tracebacks) and distantly. In the case of dairy farms, this could be done by positioning PCR machines at milk processing plants to test every truckload of milk delivered: detection in milk would immediately identify the farm(s) infected without regulatory officials stepping on the premises. More importantly, this also allows milk to continue to flow, thus turning a serious environmental disposal problem on the farm into a continuous active surveillance tool. The differential test that discriminates animals vaccinated against FMD from those that were previously infected should also not be limited to rare use in developed countries after vaccination programmes. In countries that do vaccinate, there is no easy way, short of having government employees administer the vaccine, to be sure that farmers are actually giving it to their stock (the expense of vaccination is in catching and injecting the animals, not in the vaccine purchase cost). The differential test might be more usefully used in producer managed regional FMD eradication programmes in which animals from herds in the region are tested as they passed through the slaughter plant to verify that producers had vaccinated their stock. Failure to do so would result in denial of

slaughter facilities in the region and intense peer pressure to vaccinate.

Recruiting others to the cause

The time is right to broaden the base of public support for transboundary disease elimination beyond the traditional animal health community. Those who are interested in public health, alleviating poverty, the environment, controlling the trade in exotic and endangered species, preservation of wildlife habitats, and animal welfare all have a stake.

Public health in Africa

Elimination of transboundary livestock diseases must advance hand in hand with the major investments now being committed to global public health programmes. The World Bank, the Bill and Melinda Gates Foundation, the US government and others have committed billions of dollars to develop and deliver vaccines and therapies for infectious diseases devastating the peoples of Africa and other parts of the developing world. Former US President Bill Clinton also emphasised the impact on African health and productivity of such common infections as malaria, sleeping sickness, human immunodeficiency virus, and tuberculosis and proposed that these be regarded as a national security issue for the USA. President Bush announced plans to double US foreign aid to improve global human health and has committed new funds to control AIDS internationally. The United Nations has launched a Global AIDS Fund to provide low cost medications for this disease. There is renewed interest from the international community in bringing new technologies to bear on solving these problems: there should be optimism about the chances of long-term success. But success in improving human health will not achieve its full potential unless a parallel effort is made to improve the health of domestic livestock in Africa and the developing world. When millions of new African and Asian lives have been saved, it is not well appreciated that their futures will still be very bleak without livestock and the many benefits they provide.

An international non-governmental initiative is required to envision, advocate, organise, catalyse and lead the effort to bring the same modern technologies that will solve the human health problems to bear on the major infectious livestock diseases of Africa and the developing world. Such a programme is likely to have immediate and significant successes that will reduce hunger and poverty and improve the economy at the micro- and macro-levels in many countries. At the same time, the threat of accidental or deliberate introduction of dangerous animal diseases into countries such as the USA, Europe, Australia and New Zealand will be greatly reduced or eliminated.

The global importance of livestock

Livestock are vital and irreplaceable in human societies and not just for food. They play critical yet often-overlooked roles in less-developed countries, where they have a very special place in the lives of the rural poor, particularly the poorest of all. In South America, Africa, the Middle East and Asia, livestock are relied upon as (4):

– a key source of human food and food security

– the sole form of nonhuman transportation and draft farm power to pull carts and ploughs

– the major asset bank and insurance source where no other financial markets exist

– an important source of cash income, especially for the very poor

– one of the few assets available to the poor, especially poor women and widows

– a means to provide manure and draft power to preserve sustainable soil fertility

– a way for the poor to exploit common property resources to earn income

– a source of diversified farm income

– the origin of inputs for other value-added industries, e.g. leather, shoes, clothing etc.

When diseases destroy herds and flocks, the consequences are far more profound than just loss of food – it is a simultaneous loss of one's job, tractor, car and life savings. People in North America, Europe and other regions where these diseases do not occur – where there are no longer pastoral societies dependent upon herds and flocks of cattle, camels, sheep and goats – have little concept of their impact elsewhere. Elimination of these diseases will gain support from those committed to removing poverty through its root causes.

Healthy livestock in a sustainable environment

Eliminating transboundary livestock diseases in developing countries will not result in larger flocks and herds, and greater environmental degradation – desertification, overgrazing and soil erosion. Healthy livestock herds and flocks can be managed for a sustainable environment. The means to achieve these goals are known and much attention has been paid to management systems that promote a sustainable environment. Critical issues of sustainable agriculture and livestock production in Africa have been

addressed by Delgado and others (4). In a comprehensive review of the subject, they gave particular attention to environmental, food safety and human health concerns. These are complex topics, but to summarise: there is every reason to expect that a new initiative in transboundary disease elimination can be part of a broader effort already under way with much international support to create a sustainable livestock industry that advances the poor and yet protects the environment. Rapidly increasing livestock numbers can cause serious environmental damage but can also be harmonious with, or even beneficial to, the environment when appropriate types and levels of production are in place. The International Trypanotolerance Center in the Gambia illustrated the possibilities by demonstrating that large numbers of *Trypanosoma*-tolerant cattle could be sustainably managed at the village level with native food resources.

Trade in exotic animals and endangered species

Tens of millions of wild animals and birds are shipped around the world each year, often illegally to evade international regulations that protect endangered species. These animals are used for food and medicines in Asian markets, in illegal and legal cockfights in the southern US states from California to the Gulf of Mexico, in the pet trade, and for other purposes. The range of species used for human food is far wider in Asia than in the West and this provides an increased opportunity for emerging pathogens to pass from these wild species to humans, especially under conditions where many species are held together in unsanitary high-density conditions in live animal markets where the animals may also be killed and prepared for human consumption. These wild animals may also carry transboundary diseases of livestock. This is an enormously difficult trade to regulate or to prohibit. The danger is that regulation will drive the trade underground where it may be more dangerous even though fewer animals may be involved. Eliminating transboundary disease will have no impact on the scale or ethics of the wild animal trade except to make it safer from the point of view of humans and domestic species that are also exposed. Strengthening border controls and establishing effective shipment inventory, tracking and origin records will deter smuggling.

Wildlife conservation

In Africa, especially Central Africa, the trade in 'bush meat' (hunted wild animals), especially endangered primates, is on a staggering scale. Bush meat is also smuggled abroad. The amounts are necessarily not known exactly but are believed to be very considerable. This meat poses very significant risks of disease transmission to humans (Ebola virus particularly) and to livestock. Eliminating transboundary livestock diseases will reduce the need for people to rely on bush meat when other meat is available.

The prospects for success are good: if we give them the tools they can finish the job

Developing countries do not have the research and technology base to invent by themselves the vaccines, diagnostic tests and other technologies necessary to control dangerous livestock diseases – but when these are made available countries can employ them successfully. If developed countries give them the tools they can finish the job. The evidence for this is the remarkable progress in global eradication of rinderpest over the past 20 years, organised by the FAO.

Rinderpest was once the world's most dangerous animal disease. But through international efforts, rinderpest has now been almost completely eradicated worldwide, except for small foci of infection in East Africa. Over the past few years eradication has proceeded in some very troubled parts of the world despite wars and political problems.

The other major infectious diseases may be more difficult to control technically because the microorganisms that cause them have evolved abilities to disable the immune and inflammatory defences of the animals they infect. While developed nations have created many new technologies intended for their own protection, they have not effectively transferred these technologies to the countries where the diseases are prevalent and where an ounce of prevention can help to prevent devastating epidemics both there and elsewhere. The next steps must be to ensure that the necessary vaccines, diagnostic tools and other technologies are developed into real products and made available to the national and international agencies that can use them. Much of what is needed is already available. The problem is the governmental and institutional barriers – many self-imposed – that need to be overcome to get these into the hands of those in the field. The missing link is a non-governmental organisation (NGO) that can ensure by advocacy and direct action that research and development deficits are filled, that regulatory hurdles are overcome, that new policies for deployment are developed and that efficacy is clearly shown by well-designed demonstration projects. Such an organisation should not be actively engaged in disease control and eradication programmes *per se*. There are established governmental organisations and NGOs that can accomplish this task if they have the necessary tools and technologies and a valid strategy.

The new organisation would tackle the world's most dangerous livestock diseases – diseases that are so significant economically for agricultural industries in developed countries that their study and control have

traditionally been under strict government control. Some might question the need for private enterprise in an endeavour that seems entirely in the realm of national governmental responsibility. But two of the main reasons the current global disease situation has become so dire are that study and control of these diseases have always been a government monopoly and that international cooperative initiatives have predominantly been government-to-government relationships. Governments have focused on their self-interests and international organisations have had too many other unrelated agendas for effective solutions. It is exactly because private initiatives have been so few and governmental monopoly so universal that the moment is ripe for an alternative agenda.

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Technologie, action publique et contrôle des maladies animales transfrontalières au cours des prochaines années

R.G. Breeze

Résumé

Il n'existe pas d'obstacles technologiques à l'élimination des principales maladies animales transfrontalières. L'« élimination » signifie que les maladies ne constituent plus une menace ni pour le bétail dans les pays développés, ni pour la subsistance de centaines de millions de petits éleveurs ailleurs. Le problème ne réside pas dans l'insuffisance des capacités technologiques, mais dans l'échec des politiques publiques. La politique des pays développés doit viser à lutter activement contre l'introduction accidentelle et intentionnelle d'agents pathogènes, à protéger les animaux d'élevage contre les prochaines armes biologiques de pointe, à réduire autant que possible et par tous les moyens l'impact économique d'une introduction éventuelle, à renoncer à recourir à l'abattage massif en tant qu'outil de lutte, à s'engager en faveur de l'élimination des maladies dans le cadre d'un programme mondial axé sur l'économie, la société et l'environnement, enfin, à faire les bons investissements nationaux et collectifs. Le temps est venu de changer de politiques puisque l'élimination des maladies animales transfrontalières concerne désormais de puissants ministères outre ceux de l'agriculture qui s'inquiètent des menaces sanitaires provenant de nombreuses sources. Le changement peut être appuyé par la population et par de nombreuses organisations qui partagent des intérêts communs. Il faut une nouvelle politique pour éliminer l'idée selon laquelle l'État est le seul responsable de l'éradication des maladies, de la réaction devant les introductions d'agents pathogènes et de l'indemnisation des éleveurs pour les pertes subies pendant l'éradication. L'efficacité des programmes de contrôle aux frontières et de préparation nationale aux situations d'urgence dépend de la collaboration des autorités et des entreprises dans une action dont les coûts incombent aux personnes responsables sous la forme de « redevances d'utilisation ». L'indemnisation pour les animaux abattus pendant la lutte contre une maladie devrait être couverte par une assurance privée. Le gouvernement et les entreprises devraient partager les coûts des systèmes de surveillance, de diagnostic et d'intervention. La surveillance doit arriver à saisir, en temps réel ou

presque, la situation sanitaire à toutes les étapes de la maladie et dans tous les lieux où elle sévit ; elle doit être accessible par internet aux divers organismes publics et parties prenantes dans le pays et à l'étranger. Les réactions traditionnelles doivent être abandonnées parce qu'elles encouragent le terrorisme. Il faut moderniser les processus réglementaires d'autorisation car ils ne peuvent plus suivre les progrès de la technologie.

Mots-clés
Agent pathogène particulièrement dangereux – Amplification en chaîne par polymérase – Assurance couvrant les pertes dues à l'apparition de foyers – Détection des agents qui constituent une menace et mesures prises contre ceux-ci – Maladie transfrontalière – Nouvelle technologie – Politique d'abattage – Responsabilité – Surveillance – Système électronique de déclaration des maladies – Système de maîtrise, de contrôle et de communication – Vaccination.

Tecnología, políticas públicas y control de las enfermedades transfronterizas del ganado en unos pocos decenios

R.G. Breeze

Resumen
No hay factores tecnológicos que impidan eliminar las principales enfermedades transfronterizas del ganado. "Eliminar" significa acabar con la amenaza que las enfermedades suponen para el ganado en los países desarrollados y para el sustento de cientos de millones de pequeños ganaderos en el resto del mundo. El problema no reside en la falta de medios técnicos sino en el fracaso de las políticas públicas. Un país desarrollado debe aplicar políticas que sirvan para: combatir activamente la introducción deliberada o accidental de patógenos; proteger al ganado de las armas biológicas avanzadas que puedan surgir en el futuro; reducir al mínimo las consecuencias económicas de la penetración de un patógeno por cualquier medio; renunciar al sacrificio masivo como método de lucha; participar en la liquidación de enfermedades como parte de un designio económico, social y ambiental de carácter planetario; y realizar las adecuadas inversiones dentro del país y en régimen de cooperación. Ahora es el momento de imprimir un nuevo rumbo a las políticas, toda vez que el objetivo de eliminar las enfermedades transfronterizas del ganado federa a una serie de ministerios poderosos que, junto a los de agricultura, están preocupados por amenazas sanitarias de muchos orígenes distintos. Esta nueva orientación puede gozar del apoyo del gran público y de muchas organizaciones que tienen intereses en común. Se necesita una nueva política para cambiar la arraigada mentalidad según la cual el gobierno es responsable único de erradicar enfermedades, responder a la penetración de patógenos e indemnizar a los ganaderos por sus pérdidas debidas a programas de erradicación. El control eficaz de las fronteras y los programas nacionales de preparación dependen de que el gobierno y la industria trabajen conjuntamente en un proceso cuyos costos deben sufragar los responsables a través de "cuotas de usuarios". Las indemnizaciones que perciban los ganaderos por los animales sacrificados durante un brote deben ser cubiertas por aseguradoras privadas. El gobierno y la industria deben compartir el costo de la aplicación de un sistema eficaz de vigilancia, diagnóstico y respuesta. Dicho sistema debe

servir para conocer en tiempo real o casi real la situación sanitaria en todo momento y lugar, y los diversos organismos y colectivos afectados, tanto del país como del extranjero, deben tener acceso a él por Internet. Es preciso renunciar a las tradicionales medidas de respuesta porque alientan el terrorismo, y también modernizar los procesos reglamentarios de aprobación porque en su estado actual quedan rápidamente obsoletos por la evolución de la tecnología.

Palabras clave
Detección y respuesta ante un agente peligroso – Enfermedad transfronteriza – Nueva tecnología – Patógeno especialmente peligroso – Política de sacrificios – Reacción en cadena de la polimerasa – Responsabilidad – Seguro contra brotes – Sistema electrónico de notificación de enfermedades – Sistema de mando, control y comunicación – Vacunación – Vigilancia.

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Use and abuse of mathematical models: an illustration from the 2001 foot and mouth disease epidemic in the United Kingdom

R.P. Kitching [(1)], M.V. Thrusfield [(2)] & N.M. Taylor [(3)]

(1) National Centre for Foreign Animal Disease, 1015 Arlington St, Winnipeg, Manitoba R3E 3M4, Canada
(2) Department of Veterinary Clinical Sciences, Royal School of Veterinary Studies, University of Edinburgh, Easter Bush Veterinary Centre, Roslin Midlothian EH25 9RG, United Kingdom
(3) Veterinary Epidemiology and Economics Research Unit, University of Reading, P.O. Box 237, Reading RG6 7AR, United Kingdom

Summary

Foot and mouth disease (FMD) is a major threat, not only to countries whose economies rely on agricultural exports, but also to industrialised countries that maintain a healthy domestic livestock industry by eliminating major infectious diseases from their livestock populations. Traditional methods of controlling diseases such as FMD require the rapid detection and slaughter of infected animals, and any susceptible animals with which they may have been in contact, either directly or indirectly. During the 2001 epidemic of FMD in the United Kingdom (UK), this approach was supplemented by a culling policy driven by unvalidated predictive models. The epidemic and its control resulted in the death of approximately ten million animals, public disgust with the magnitude of the slaughter, and political resolve to adopt alternative options, notably including vaccination, to control any future epidemics. The UK experience provides a salutary warning of how models can be abused in the interests of scientific opportunism.

Keywords

Culling – Epidemiology – Foot and mouth disease – Infectivity – Mathematical model – Modelling – Slaughter – Stamping out – Transmission – United Kingdom – Virus spread.

Introduction

The epidemic of foot and mouth disease (FMD) in Europe in 2001 had a profound effect on the public perception of the consequences of a highly infectious disease spreading within an intensive livestock industry. Although there had been epidemics of classical swine fever in the Netherlands in 1997 (in which over ten million pigs were slaughtered) and in England in 2000 (in which 80,000 pigs were slaughtered), the nightly appearance on television of apparently healthy cattle and sheep being sacrificed to bring FMD under control horrified both rural and urban communities, and involved government at the highest level. In Britain, four million FMD-susceptible animals on 10,157 premises were slaughtered: 2,026 premises were declared infected, 4,762 premises were considered dangerous contacts of infected premises and 3,369 premises were located near to infected premises (2). A further 2.5 million animals were slaughtered for reasons of welfare, such as overcrowding and compromised nutrition. The official figure for the number of animals slaughtered was approximately 6.5 million, but when the total number of still-suckling lambs, calves and pigs that were slaughtered is included, the total could be as high as ten million (33). The financial cost of the FMD epidemic in

the United Kingdom (UK), that is, including Northern Ireland where four premises were infected, was over US$ 12 billion, including US$ 4.5 billion in losses sustained by the leisure and tourist industry (95). However, the social cost – evidenced by the many newspaper reports and submissions to the various inquiries conducted after the epidemic – could not be quantified. Significantly, the excessive slaughter ignored Coase's principle of welfare economics (108), which states that the actual costs of state intervention must be considered, rather than costs deriving from a theoretically coherent policy.

These costs, both financial and social, initiated political pressure to change national, European Union (EU) and international legislation and guidelines on controlling future epidemics of FMD to make vaccination more acceptable. The amount of slaughter that took place, particularly in the UK and the Netherlands, is no longer likely to be tolerated by the public. Following the epidemic, British, Dutch and EU politicians made it clear that alternative methods of control, although still allowing slaughter of clinically affected animals and their immediate contacts, must be adopted, without prolonged trade penalties (27).

The total number of animals slaughtered during the epidemic cannot be altered, and the public memory of the mounds of dead animals, funeral pyres and burial pits cannot be erased. Inevitably, the impression remains that a mass slaughter strategy for the control of FMD was inappropriate. But, if a large proportion of the slaughter was, in fact, unnecessary, driven by a policy based on poor science, would there be sufficient justification to replace the traditional approach (which accounted for only part of the slaughter) with one relying more heavily on vaccination? Moreover, should these traditional methods be superseded if the perception that they failed (4, 44) was false?

A major contributor to the slaughter was the novel, automatic pre-emptive culling of all susceptible animals on farms adjacent to infected premises, whether or not there was reasonable suspicion that the virus was present. The perceived merit of this action came from mathematical predictive models, which indicated that it was crucial to bring the epidemic under control. This paper reviews the characteristics, and therefore appropriateness, of the models used as guides to control the 2001 epidemic in the UK, and explores some alternative control methods, including the traditional ones that were applied.

Transmission and infectivity

To control an epidemic of FMD, it is essential to understand the mechanisms by which the FMD virus is being spread because, by breaking viral transmission, the virus is starved of susceptible animals and, after the removal of any persistently infected animals (formally referred to as 'carriers') (80), will soon disappear. While such a concept seems self-evident, and applies to infectious diseases in general, it was not applied during the UK epidemic in 2001. Instead, the tactic recommended by predictive models was to pre-emptively cull susceptible animals that the models themselves predicted to have a higher probability of becoming infected than others, though still not particularly high (e.g. ≤ 26%) (31). There was no requirement to assess the mechanisms and likelihood of transmission in real, individual, cases.

Animals infected with FMD virus produce virus in all their secretions and excretions, particularly in their breath (as aerosols) and in the secretions associated with ruptured vesicles on their feet and in their mouths. The most common route of infection of susceptible animals in an unrestrained epidemic is by contact with animals showing clinical signs, and transmission can occur by the respiratory or oral routes, or through skin abrasions. Transmission of FMD virus can also occur by the movement, and usually subsequent ingestion, of infected animal products, such as milk from an infected cow, or meat from an animal that is slaughtered while still infected with FMD virus (22). This is most probably how infection entered the UK: through illegally imported meat products, some of which were fed, uncooked, to pigs (2). Once in the UK, spread of the virus occurred by the movement of infected animals. The virus also spread mechanically, on the hands, clothes, equipment and vehicles of people who had contact with infected animals, and then, without adequate disinfection, had further contact with susceptible animals. After movement controls were imposed on livestock, this spread by fomites became the major source of transmission, with airborne spread being of minor importance (98).

Infected pigs produce up to 3,000 times more aerosol virus than cattle or sheep (22), but are considerably less susceptible to infection by the aerosol route (23). Apart from the seven characterised antigenically distinct serotypes of FMD virus, which also have their own serotype-specific epidemiological characteristics (58), strains within each serotype vary in their virulence, host specificity and their ability to spread as an aerosol – so much so, that each strain can be considered to be unique (12). There have been examples of long-distance spread of FMD virus as an aerosol. For instance, the outbreak on the Isle of Wight in the UK in 1981 was caused by virus spreading as a plume from an outbreak in pigs in Brittany, France, over a distance of 250 km (25). The atmospheric and topographical conditions required for this degree of spread have been well defined, and spread over land rarely exceeds 10 km (22). An additional important component in calculating the extent of aerosol transmission is the

strain of FMD virus involved, because the quantity of virus particles produced by infected animals varies considerably between strains (23). For example, distances over which the C Noville strain is infectious are likely to be up to 50 times greater than for a strain of the Pan-Asia topotype (a topotype is a group of genomically closely related strains of FMD virus; the Pan-Asia topotype is within the serotype O), for similar donor and recipient species (24, 91). Thus, it is impossible to generalise or predict the behaviour of an epidemic strain without first studying its epidemiology in associated epidemics – if this information is available – and conducting controlled experiments – if time permits.

The FMD virus strain that caused the epidemic in the UK in 2001, and later spread to France, the Netherlands, Northern Ireland and the Republic of Ireland, was one of a group called the Pan-Asia topotype (60). Strains of FMD virus can be individually identified by the nucleotide sequence of the gene that encodes the major structural protein, viral protein 1. The high mutation rate of the virus (20, 21) allows discrimination between strains separated by space or time, and the association of strains with sequences within 5% homology into epidemiologically meaningful clusters. The Pan-Asia topotype was first characterised in India in 1990, and has spread through most of Asia, including those Asian countries previously free of FMD, such as Japan (free since 1908), twice into South Korea (free since 1934), eastern Russia, Mongolia and Taipei China (Taipei China had been infected only two years previously with a pig-specific strain of FMD virus) (60). All these countries successfully eradicated outbreaks due to this strain by slaughtering affected and in-contact animals ('stamping out'), disinfection, controlling animal movements and, in South Korea, vaccination around the infected farms. None reported any significant aerosol spread of the virus between farms (78).

Trail of infection in the United Kingdom in 2001

The first infected farm in the UK epidemic was almost certainly a pig farm of approximately 500 pigs that were fed waste food. It was identified on 22 February, near Newcastle-upon-Tyne. The virus had probably been on the farm since the beginning of February, but the disease had not been reported by the farmer (1). If a worst-case scenario is assumed, and the infected pigs were producing aerosol virus in quantities consistent with infection due to the C Noville strain of serotype C (known to be produced in large quantities in pigs) (23), enough virus would have been generated for infection to have spread beyond the coasts of Denmark and Germany, assuming weather conditions in the previous three weeks were sufficiently compatible (70). Certainly, a large amount of virus would have covered the countryside surrounding the infected farm. Subsequent investigations showed that during that time, consistent with the epidemiology of strains in the Pan-Asia topotype, only ten farms in the area were likely to have been infected by long-distance aerosol, ranging in distance from 1 km to 9 km from the infected pig farm (39). Since infected pigs produce up to 3,000 times more aerosol virus than sheep or cattle, 500 infected pigs would be equivalent to 1,500,000 infected sheep or cattle. Yet, they had failed to spread an infectious dose of aerosol virus to more than ten nearby farms in a three-week period. An adjacent dairy farm remained uninfected throughout the whole epidemic. It was clear by the beginning of March that the epidemic strain was not spreading any significant distance as an aerosol, and the reduced aerosol output from pigs infected with this strain of FMD virus was soon confirmed experimentally (24).

Unfortunately, one of the farms infected by airborne aerosols from the pig farm was a mixed beef and sheep farm (39), and sheep from this farm that were incubating disease had been sent to market before the disease was recognised (36, 67). Sheep thus became the predominant species involved in the early spread of the epidemic. By the time the first case of FMD had been diagnosed, infections had already been spread by the movement of infected animals (mostly sheep) across the northern counties of England and as far south as Essex and Devon, so that 10 of the 12 geographic clusters that developed were infected (67). However, previous investigations in Italy during the 1993 outbreak, and in Greece during the 1994 and 1996 outbreaks, in which sheep were also affected, indicated that the spread and maintenance of FMD within sheep flocks was dissimilar to that in cattle and pig herds (59). Spread between sheep is often slow, and the virus may disappear before all the sheep are infected, as exemplified by low levels of seroconversion in infected flocks in Europe and North Africa (63, 65, 66). Thus, in 2001, after a complete national ban on the movement of FMD-susceptible animals was implemented on 23 February, there was no reason to assume that sheep would continue to drive the propagation of the epidemic. The low prevalence of infection within affected sheep flocks, and their low individual virus production (24), would make them a relatively low risk for spreading aerosol virus (probably to a maximum distance of less than 100 m) (24). Sheep would also pose a lower risk for spread by fomites, because less virus was being released into the environment.

So, how was the virus able to continue spreading after implementation of the national animal movement ban? Almost 80% of the virus spread in 2001 was classified as 'local' (36). However, without an explanation of how the spread had occurred, this really only reflected the difficulty of quickly and positively identifying sources of infection, due to the pressure on veterinary resources and the complexity of the real situation, where it is often

impossible to pinpoint actual sources and spread events. 'Local' spread (36, 81) was defined as having occurred if new infected premises were within 3 km of previously confirmed, infected premises, and if more than one possible conveyor of infection was identified. This does not, therefore, imply radial spread from infected premises (somewhat like the ripples that occur when a pebble is dropped into a pond) and bears little relation to the location of infected animals and actual contacts between them. Thus, it does not adequately describe the transmission mechanisms (e.g. direct contact between infected and susceptible animals, or short- or long-distance spread by fomites) at which control measures are targeted.

Possible mechanisms of FMD spread have been described above, and the only routes that seem likely, assuming compliance with the movement ban, would be:

– by very short-range (less than 100 m) aerosol transmission from affected flocks or herds until slaughter took place. However, where cattle were affected, these were predominantly housed until May, usually over 100 m from neighbouring herds;

– by mechanical carriage of the virus from infected to susceptible animals;

– through the movement of infected animal products, such as milk.

Subsequent analyses of field data revealed that only 5% of the premises contiguous to infected premises may have become infected by direct animal-to-animal aerosol transmission (49, 98), but that short- and long-distance spread by fomites was likely to be of major significance. Forty-three percent of infected premises in the Cumbria region of the UK (where over 40% of cases occurred) were more than 1.5 km away from the nearest infected premises that could have transmitted FMD virus to them (94). A significant proportion of affected premises in south-west Scotland were over 3 km from the nearest infected premises that could have transmitted infection to them, particularly during the last half of the epidemic (98). Spread by fomites was shown to be the main route of infection in the south-west of Scotland (98).

Control measures

Traditional measures

Before compulsory vaccination was introduced to mainland Europe in the 1960s, up to 30,000 outbreaks of FMD were reported each year. However, this was reduced to a few hundred a year within a decade, using a combination of vaccination, movement controls, biosecurity measures and co-operation between European countries, under the umbrella of the European Commission for the Control of FMD (57).

The duration of the 1967 to 1968 and 2001 UK epidemics was almost identical, and the epidemic curves showing the number of new affected farms per day were also very similar. Both epidemics began with the wide dissemination of infection. In 1967, this was due to the distribution of infected meat imported from South America, and in 2001 it was caused by the spread of infection among sheep at Longtown Market in north-west England, and their subsequent dispersal (14, 67, 88). Farming conditions in 1967 were different from conditions in 2001 and, in the 1967 to 1968 epidemic, predominantly pigs and cattle were involved. The lower aerosol production of the Pan-Asia O topotype of the virus should have made the 2001 epidemic easier to control than that of 1967 to 1968, as soon as effective movement restrictions and biosecurity were in place. A complete ban on the movement of FMD-susceptible animals was implemented on 23 February 2001. This differed from the 1967 epidemic, which had run for over three weeks before a national movement ban was enacted in England and Wales, and it was a further week before Scotland was included (13).

A key traditional control strategy is rapid detection and slaughter of all susceptible animals on infected premises, and identification of dangerous contacts (i.e. susceptible animals considered to have been exposed to infection) by tracing and veterinary assessment. Analyses have demonstrated the efficacy of traditional rapid slaughter on infected farms in controlling the 2001 epidemic (48, 97). Movements on and off infected premises during the previous 21 days, particularly of animals, people and vehicles, were traced in an effort to identify potential sources and the spread of infection. The danger and degree of exposure to infection of livestock on traced premises and premises next to infected premises was the subject of veterinary assessment. If it was judged that the likelihood of exposure to infection was high, the animals were classed as dangerous contacts, and all susceptible animals were slaughtered as soon as possible. If the judgement was that the likelihood of infection was low, but it could not be ruled out entirely, the premises were placed under restriction, the livestock isolated, and regular veterinary surveillance inspections were implemented.

Biosecurity measures were also taken to limit the spread of the disease. A 'Protection Zone', with a 3-km radius, and a 'Surveillance Zone', with a minimum radius of 10 km, were established around each infected farm, within which stringent movement restrictions were applied to animals, people and vehicles. Livestock within the zones were subject to veterinary surveillance. Later in the epidemic, larger 'Restricted Infected Areas' were defined, within which strict biosecurity measures and movement controls could be enforced.

During the 1967 to 1968 epidemic of FMD in the UK, in which 2,364 farms were clinically affected, 442,000 animals were slaughtered, compared with over four million in the 2001 epidemic (1). 'Traditional' slaughter was applied less aggressively in 1967 to 1968: dangerous contact animals were only slaughtered if they had arrived on a farm within 72 hours (h) of putative contact, otherwise they were isolated and subjected to regular clinical inspection (13). In 2001, all dangerous contacts were generally slaughtered. Also, in 1967 to 1968, following the tracing of dangerous contacts to Oswestry Market, the animals in the market (of which there were 3,299) were moved under licence to farms within the Protection Zone, and none developed the disease (13, 76). In 2001, sheep traced through certain markets were identified and slaughtered (102).

Model-driven control strategies

Early in the 2001 epidemic, policy decisions about the control programme were removed from the Ministry of Agriculture, Fisheries and Food (MAFF), now known as the Department for Environment, Food and Rural Affairs (DEFRA), and placed with the Cabinet Office Briefing Room (COBR) (also known as COBRA because it was Room A). Campbell and Lee (9) comment that: 'The incredible state of affairs in which a regulatory problem of livestock rearing and farm economics was thought to require a response by a government apparatus designed to deal with problems more akin to general insurrection has passed with little other than approving comment in the official reports'. (COBR was convened most recently in July 2005, in connection with the terrorist bombings in London.)

The COBR was advised by the Chief Scientific Adviser to the Government, who had established a 'Science Group' to help formulate this advice. The Science Group, which first met on 26 March, was dominated by four teams of modellers. To quote the then current MAFF Chief Scientific Adviser, David Shannon (89): '… A formally constituted scientific advisory committee would have looked considerably different'. One team had already, on 21 March, used the media to disseminate its dire predictions to the public on the eventual outcome of the epidemic (the course of which would include a general election), unless its advice was followed. The issue then assumed both technical and political dimensions, with the danger of scientists expressing 'convictions or opinions which (however scientifically founded) cannot in any way be identified with knowledge in the strict sense which science generally affords this term' (107).

The involvement of modelling with the control programme for the FMD epidemic was not part of the pre-arranged contingency plan, but came about in an ad hoc way. The 'Lessons to be Learned' inquiry report (2) describes how Sir John Krebs, Chairman of the Food Standards Agency, began speaking to a number of mathematical modellers in late February 2001, soon after the epidemic began. An ad hoc meeting, organised by Krebs, took place on 6 March. Mathematical modellers from Imperial College, London, Cambridge University and Edinburgh University gathered and discussed the data requirements for modelling the epidemic (45). Then MAFF supplied the data requested on 13 March and the groups of modellers began their analyses.

The 'Lessons to be Learned' inquiry report (2) states that the Imperial College group were furthest advanced at that stage and reported their initial findings to MAFF on 16 March. According to the report, the main advice at that point was that the delay between the reporting of the disease on premises and subsequent slaughter must be reduced. This advice simply reiterated longstanding doctrine (13), which has subsequently been confirmed by analysis of the field data (48, 98).

A meeting between the mathematical modellers, the Chief Scientific Adviser to the Government, the Chief Veterinary Officer and experts from the Institute of Animal Health and the Veterinary Laboratories Agency occurred on 21 March (101). Between 21 and 26 March, the modellers examined the potential effects of various culling policies. On 23 March, instructions (105) were issued to slaughter, as dangerous contacts, all FMD-susceptible stock (cattle, pigs, sheep/goats, llamas, alpacas) on premises that shared a boundary with an infected site that had been confirmed on or after 16 March. Following the first meeting of the FMD Science Group, on 26 March, instructions were issued to confirm disease on clinical signs alone, without awaiting laboratory confirmation for doubtful cases. In addition, all FMD-susceptible species on the infected premises were required to be slaughtered within 24 h of confirmation, and all susceptible animals on premises contiguous to an infected site, as well as on other farms designated as dangerous contacts, within 48 h (the '24/48 h' policy) (103). The classification of contiguous premises as dangerous contacts became automatic (i.e. not subject to veterinary assessment) on 29 March (104), (the 'pre-emptive contiguous cull') (100).

While such a policy might be practical (if not scientifically justifiable) if only a small number of farms are affected (as in the Republic of Ireland in 2001) (42), implementing this policy for the UK epidemic – in which the disease was spread over a wide geographical area – resulted in the destruction of many healthy animals and logistical problems of carcass disposal. Not surprisingly, the tourist industry was adversely affected by the images of cattle destruction and the movement restrictions for walkers in the countryside (8, 14, 29, 30). Mrs Wendy Vere, a West Country veterinarian, commented to the *Devon Independent*

Inquiry: 'Their idea was to control the disease by culling in contiguous farms. That is fine if you are sitting in front of a computer screen in London. However, it is different on the ground. A person in London will just see the numbers and will say that they have been taken out. That is why it was carnage by computer' (9, 84). This graphically exemplifies the isolation and abstraction of 'armchair epidemiology', whilst also poignantly highlighting the importance of personal involvement in disease control to gain complete insight into its impact. This concept is already well established in the social sciences, where feelings, responses and experience are considered necessary for a full understanding of reality (so-called 'experiential analysis') (75).

The peak in the number of confirmed new outbreaks occurred on approximately 29 March. If, as calculated by Woolhouse (112), the time between infection entering premises and those premises being declared infected was approximately eight days, then the new infections peaked on 21 March, almost a week before the 24/48 h policy was introduced (45). This is consistent with the conclusions of analyses of the epidemic (37, 44, 98), but conflicts with the notion that pre-emptive contiguous culling was an essential component of effective control, as proposed by various mathematical models (3, 41, 56, 109). In fact, the epidemic peak preceded the start of pre-emptive contiguous culling. Significantly, more than two weeks after the epidemic peaked, models failed to identify the time at which the epidemic was under control (86). Subsequently, modelling groups conceded that the epidemic was coming under control faster than the models had predicted (87), and that model projections of the course of the epidemic might have been 'over pessimistic' (85). For example, Ferguson *et al.* (31) estimated that, in the Cumbria, Dumfries and Galloway area, 79% of 5,000 farms would be infected (3,950 infected premises) by 28 March, assuming the model parameters remained unchanged from the status quo. The actual result in the main epidemic focus in North Cumbria (where, significantly, the automatic pre-emptive contiguous cull could not be implemented due to resource constraints) was that 24% of the 2,684 farms within the 3-km Protection Zone became infected and, over all, 50% were depopulated, leaving approximately 50% of premises with livestock (94).

Modelling in perspective

Modelling and scientific method

The disparity between the course of the 2001 epidemic and the model predictions demands an explanation. The numerical output of models has an air of intellectual superiority (noting that: '…mathematized theory in science is rarely so pellucid or so rigorous that its significance and bearing can be grasped immediately by distant readers' [74]), while also seeming entirely appropriate in a society where numbers can '… reassure by appearing to extend control, precision and knowledge beyond their real limits… wrong numbers, one might add, are worst of all because all numbers pose as true' (11). Numbers, therefore, may convey an illusion of certainty and security that is not warranted (43); for example, because of the use of whatever numerical data are available, regardless of their relevance and quality (38).

A model constitutes a theory, and a predictive model is therefore only a theoretical projection. This is clearly illustrated by the different conclusions generated by different models addressing the same issue (6, 26). A theory cannot be formally proved in the sense that propositions in logic and mathematics can. The degree of confidence in a theory depends on several factors (15), the most relevant of which are 'testedness' and 'refutedness'. To be well tested, a theory should provide predictions of what would happen in a variety of different circumstances. If these predictions have been extensively tested over a wide range of conditions (either in the field or experimentally), then the theory can be called well tested. 'Refutedness', as viewed by Bertrand Russell, refers to 'external confirmation': the theory must not contradict empirical facts. The degree of confidence in the 2001 predictive models is therefore low because they were not widely tested, and their conclusions (e.g. that pre-emptive contiguous culling was necessary to control the epidemic) have been refuted. Moreover, there are constraints on testedness in any case, because of the rarity of FMD epidemics, and the genetic plasticity of the organism, which can result in strain variation with consequent changes in the transmission characteristics of the virus. Predicting a chance, long-distance transmission event on the virus-contaminated hands of an unsuspecting stock-owner would also be impossible, other than to say it might occur. But researchers would be unable to specify where or when; and clearly this would vary, both over time in one epidemic, and between different epidemics. Additionally, models generated to assist in the control of a specific epidemic are 'tactical' rather than 'strategic' (46), and this further limits their testedness.

Appropriateness of model use in 2001

The stages in model-building are well documented (17, 68, 93). The model requires appropriate input parameters that accurately reflect the behaviour of the system that is being modelled. It must then be seeded with data. The level of understanding of the system, and the quality of the available data, determine the appropriate application of the model (Table I). Prediction should only be attempted if both are good. Finally, the model needs to be validated, to

Table I
Appropriate use of models in the context of epidemiological knowledge and data quality (47, 93, 96)

Epidemiological knowledge	Data quality and quantity	
	Poor	**Good**
Poor	Exploration of hypotheses	Hypothesis testing
Good	Simplified representation of past events, and guarded use for prediction of future events	Detailed representation of past events, and prediction of future events

establish if it behaves like the actual biological system that the model is designed to mirror. This should be undertaken by assessing the model against data not used in its construction (92).

The 2001 predictive models were constructed in an environment of poor-quality data (e.g. they used out-of-date census data for stock levels), and poor epidemiological knowledge (e.g. the transmission characteristics of the virus strain, and the distribution of the initially infected farms, were unknown). Therefore, their use as predictive tools was inappropriate.

An area of uncertain epidemiological knowledge that was crucial to the modelling was that of the source and spread linkages between infected premises. Modellers (31, 56, 110) used MAFF contact-tracing data to estimate key model parameters, including:

– the distance between source-infected premises and spread-infected premises

– the onset of infectivity in relation to the infection date and reporting date

– changes in the level of infectivity over time.

These parameters would have been crucial to model predictions about the necessity of a pre-emptive contiguous cull, as discussed below, but the tracing data (provided to the modellers on 13 March – just three weeks into the epidemic) were incomplete. For example, as the result of careful work during and after the epidemic, Mansley *et al.* (67) identified approximately 115 premises that were possibly already infected (through infected animals from Hexham and Longtown Markets) when the movement ban was imposed on 23 February. This information was not available to the modellers in March when they were advising on policy. In fact, it was thought at the time that, during the first week of the epidemic (20 to 26 February), only seven premises were infected (2). This would have had a profound effect on their calculations of R_0, the basic reproductive number (19), because the appearance of so many infected premises within a short period of time would have been assumed to result from continuing rapid propagation of the epidemic. Consequently, the modellers would have over-estimated the number of premises infected just after the movement ban (44). These early calculations provided the support for the announcement on 21 March by one of the Imperial College team that the epidemic was not under control (4). Furthermore, the model of Ferguson *et al.* (31) did not include separate species, and so modelled all farms with the same 'homogenised' species, even though virus output varies substantially between species.

There must have been many infected premises for which the source was either wrongly identified, identified simply as 'local', or identified as unknown. A definite source of infection was established for relatively few of the infected premises in 2001. According to Gibbens and Wilesmith (37), out of a total of 2,026 infected premises, a definite source was only identified for 101 (5%). In the absence of a definite source of infection, it was common to attribute the source to the nearest possible candidate infected premises (110) – a naïve exercise. One result of such inaccuracy in assigning the correct sources to infected premises appears to have been that the models incorporated parameters that conflicted with the known biology of the virus (as described earlier).

These conflicts centred around the periods between infection, the onset of infectivity and the onset of clinical signs (after which the case could be reported). Specifically, the models represented farms as becoming infectious one (32), three (31) or four (56) days after infection. These estimates allowed time for the disease to spread (in the models) before the appearance of clinical signs and reporting the disease. For example, in one model, animals become infectious five days before clinical signs appeared (56). These timings are at variance with the well-known variability in the incubation periods of infectious diseases (73, 82, 83), and ignore the effects of both species and the number of animals in determining virus output.

Not only did the models simulate a very early onset of infectivity, but that infectivity was modelled as immediately maximal and constant until the slaughter of the animals on the infected premises, implying that all animals were simultaneously infected. For example, Ferguson *et al.* (31): 'assumed constant infectiousness from three days after infection until slaughter (for an average of eight infectious days)', and, in a later model-based analysis, the same authors assumed constant infectiousness from the day after a farm is infected to the day its animals are culled (32). This ignores the well-established phenomenon of the intra-herd epidemic, where some animals in a herd may be infected up to a month after initial cases, depending on stock location and farm structure (52). Clear evidence of

the occurrence of an intra-herd epidemic on an infected site is provided by the clinical picture of the pig farm infected at the start of the epidemic (1). Here, pigs were found with a range of lesions, indicating that infection began in a few pigs (those with the oldest lesions), then spread to others over a period of time. The presence of seropositive animals with no lesions suggested even older infection. Work on dairy farms in Saudi Arabia (52) and in experimental infections (51) indicates that within-farm prevalence increases over time, and so the amount of virus being shed will also increase in the first few days of a clinical infection on a farm. Further evidence was also provided by field analysis of the 1967 to 1968 epidemic, where the herd serial interval was more than twice the mean incubation period, indicating that at least two cycles of infection (the second amplifying the first) were necessary before farms became infectious (50). This would suggest that the infectivity of an infected farm increases over time. It is clear that infected premises could not be equally infectious throughout the course of infection because, initially, only one or two animals would be infected. Moreover, particularly on cattle and pig farms, levels of infection would increase as the number of animals infected at a given time increased. Yet the possibility of an intra-herd epidemic was specifically excluded from the predictive models produced during the 2001 epidemic. Keeling *et al.* commented that (56): 'There has been some speculation about the role and existence of a within-farm epidemic. Clearly, if initially just one animal was infected, then there should be a build up of the within-farm epidemic over time and hence an increase in the farm's infectivity. However, there is no evidence for such a build up from the data – the rate at which secondary cases are generated is approximately constant throughout the infectious period. This may be due to the aggregated nature of infection, such that many livestock on a farm get infected at any one time.'

One important effect of simulating an epidemic where a rapid onset of infectivity to maximum levels occurs, resulting in a high proportion of infection spread before clinical signs appear, is that the value of rapid culling of the infected premises would be underestimated, because diseases with these particular characteristics require some form of pre-emptive action to bring them under control (34). It appears that the models did underestimate the true value of rapid culling of infected premises, because retrospective analyses have demonstrated the key role of culling speed in controlling the epidemic (48, 49, 97), whereas the predictive models advised that rapid culling alone would fail to control FMD (31, 56).

The models of Ferguson *et al.* (31, 32) and Keeling *et al.* (55, 56) addressed the spread of disease in a population of farms using 'black box' probabilities of infection, without attempting to model the actual mechanisms of disease spread (93). Central to the 'black box' approach is the 'spatial kernel', a probability construct that describes the probability of infection as a function of distance between infectious and susceptible farms. Construction of the spatial kernel also depended on the MAFF contact-tracing data referred to above. Ferguson *et al.* (31) state: 'contact tracing for all FMD-affected farms has produced unique data on the spatial scale of disease transmission, clearly demonstrating that farms closest to index cases of FMD are at greatest risk of infection … We estimate that farms 0.5 km, 1 km and 1.5 km away from a single farm affected by FMD would have probabilities 0.26, 0.06 and 0.02, respectively, of becoming infected.'

Modelling disease spread in this way, especially with spatial kernels that are heavily weighted towards short-distance spread, tends to produce simulations that show 'centripetal' spread of disease – that is, disease spreading radially and over short-distance increments from the initial seeded infection. See, for example, the animated simulation provided by Keeling *et al.* (55) in supplementary material to a recent paper. This pattern of spread is at variance with reality. A 2005 DEFRA project report (18) describes the spatial pattern of FMD spread in north Cumbria, subsequent to initial seeding, in which a high proportion of cases occur, with no possible source of infection within 1.5 km, in the first four or five weeks, rapidly expanding the confluent 3-km Protection Zone to almost its maximum extent before the majority of later cases 'filled in' the gaps between old infected premises. Disease that truly spreads centripetally could logically be tackled by pre-emptive culling of contiguous premises, but it is hard to see how this approach, rigorously applied from when the first case was confirmed, could have successfully prevented the rapid scattering of early cases that occurred in north Cumbria in reality.

As discussed above, and as the modellers themselves commented (32, 56), the tracing data, especially that provided early in the epidemic, would be biased towards short-distance transmission. Ferguson *et al.* (32) indicate that this could have been the case when writing about an analysis conducted later in the epidemic. 'The newly estimated spatial kernel differed significantly from that previously derived from the infectious contacts identified by DEFRA (MAFF), with considerably more long-distance transmission events being predicted.… The median distance of the newly estimated kernel is about 4 km, suggesting that most transmission probably occurred through the movement of animals, personnel or vehicles, rather than through animal contact or wind-borne spread.' Keeling *et al.* (56) also recognised that the tracing data could be biased and that this could be critical to the models they produced: 'it is crucial to quantify the spatial infection kernel or, at least, relative contributions of local and non-local spread …The contact tracing is probably biased towards short-distance infection, which may cause a similar bias in the transmission kernel.' In addition,

retrospective analyses of the field data have shown that a significant proportion of infected premises were further than 3 km from a possible source of infection (94, 98). Taylor *et al.* (94) indicate that the risk of infection faced by premises that did not neighbour an infected farm was sufficient to allow the tail of the epidemic in the area south of Penrith to continue to propagate, despite pre-emptive contiguous culling.

The significance of this is that a model with an unrealistically narrow kernel (i.e. where most disease transmission is over short distances) would tend to overestimate the efficiency of a local pre-emptive culling policy (i.e. culling premises contiguous to infected premises). In a paper describing an adapted version of their 2001 model to guide vaccination, Keeling *et al.* (55) admit: 'in terms of the total number of farms affected by the outbreak, wide diffuse kernels would mean that contiguous premises culling is an inefficient strategy as the infection is far less localised on the neighbouring contiguous farms'.

A further simplification in the models was the use of constant (throughout the duration of the epidemic) transmission parameters (31, 56). Such models are unable to include the possible disease control effect of improvements in biosecurity (e.g. the Restricted Infected Area regulations applied late in the epidemic) and were therefore limited to modelling control policies based on culling and/or vaccination only. Thus, these models were incomplete in an important area of decision-making for control policy.

Ferguson *et al.* (32) later modelled the epidemic using a model that allowed transmission rates to vary over time and concluded that changes in culling policies explained less than 50% of the observed variation in transmission rates, which in turn indicated that effective movement restrictions and rigorously maintained biosecurity were equally vital in reducing disease spread. This would suggest that the role of the contiguous cull in controlling the epidemic was less crucial than proposed by the earlier model.

The model that Ferguson *et al.* (31) presented to the Science Group in late March probably had the most influence on early policy decisions (93), specifically, the introduction of the pre-emptive contiguous culling policy. However, this model, and the Keeling *et al.* model (56) that was used to corroborate it, were assigned parameters that could not help but favour that policy, based on field tracing data that should have been viewed with caution. The models were highly sensitive to the accuracy of this information, in that these data determined the degree of disease transmission to be simulated before clinical signs and the distance over which the majority of transmission took place. Despite the fact that the modellers seemed to be aware of these issues, the models were used as strong support for the implementation of the contiguous cull.

The authors of this paper argue that the models were not fit for the purpose of predicting the course of the epidemic and the effects of control measures. The models also remain unvalidated. Their use in predicting the effects of control strategies was therefore imprudent.

In retrospect, very little of value was added to the FMD control policy by the use of predictive models. The latter therefore failed the most pragmatic 'litmus test': namely, usefulness (40; Hugh-Jones, quoted by 79). The key question for any model is whether decisions made with it are more correct than those made without it (17). However, the consequences of following the recommendations of these models were severe: economically, in terms of cost to the country; socially, in terms of misery and even suicides among those involved in the slaughter programme; and scientifically, in the abuse of predictive models, and their possible ultimate adverse effects on disease control policy in the future (see below).

In his description of the value of models during the 2001 epidemic (111), Woolhouse emphasised that, 'mathematical models should be one of the tools available to policy-makers', but that they are not, 'a substitute for experience and expertise in the control of FMD'; a view shared by Kao (54) when he said, 'all theoretical models are only one aspect to providing good scientific advice'.

During the 2001 epidemic, MAFF/DEFRA were using another model, InterSpread, on a daily basis to monitor the progress of the epidemic (71), but this model was not prominent in the decision-making process that led to the contiguous cull. The model was run to give regularly updated predictions of the overall size, duration and spatial extent of the epidemic. As with the other models, assumptions about the start of the infectious period were needed. Morris *et al.* (72) mention that, in InterSpread, infectivity starts on or just before clinical signs appear, stops when control measures are completed (i.e. the end of slaughter), and varies according to both the stage of disease and control measures. Both these characteristics (onset of infectivity and variability of infectivity over time) therefore differ considerably from those of the other models. InterSpread is a very detailed simulation model which attempts to represent the transmission of disease by specific contact routes, rather than using the 'black box' transmission kernel, and also includes the effects of differences between species on disease transmission, as well as other farm-level factors. This model therefore includes many epidemiological parameters and control strategy definitions. Most of these parameters were assigned values that were based on data from the 1967 to 1968 epidemic and a review of the literature, although the parameter governing the tendency for airborne spread was

reduced, to reflect knowledge about the behaviour of the 2001 epidemic.

When used to assess different control options early in the epidemic, InterSpread predicted optimal control of the epidemic if slaughter was achieved on infected premises within 24 h, and an average of between 1.1 and 1.4 premises were pre-emptively culled per infected set of premises (72) – a far lower level of pre-emptive culling than automatic contiguous culling. It should be noted that InterSpread uses assumptions about the sensitivity and specificity of the identification of dangerous contacts that simulate 'veterinary assessment', rather than selection based on the 'proximity of premises' to infected premises.

As InterSpread explicitly models different spread mechanisms, such as: movement of animals, airborne spread, spread by milk tankers and spread by other vehicles, it could be used by veterinary epidemiologists as an interactive tool to assist in understanding the field situation. When the real situation varied from the modelled situation, adjustments could be made to the modelled transmission mechanisms to understand what may be happening in the field. In fact, InterSpread modelling conclusions coincided with field observations that the continued spread of disease during the epidemic tail south of Penrith was largely being mediated by the movement of people or animals. This provided support for the introduction of improved biosecurity measures in the area (Restricted Infected Areas, in which movement and cleansing and disinfection of farm traffic were intensively targeted by the authorities), which finally brought the epidemic to a close.

In a lecture to the Royal College of Veterinary Surgeons (reported in the *Veterinary Record*, 26 July 2003), Lord May acknowledged that the use of mathematical models during the 2001 FMD epidemic had created controversy (nothing new, when mathematics 'invades' hitherto non-quantitative domains) (90), but suggested it was based on a lack of mutual understanding between veterinarians and modellers (69). But Lord May was not present during the Science Group meetings, in which models based on inadequate and inaccurate information were being used to formulate recommendations to the Prime Minister's Office to initiate changes in the FMD control policy. This was despite the fact that alternative, tried and tested strategies were being proposed by experienced veterinarians from the FMD World Reference Laboratory and MAFF. The 'Lessons to be Learned' inquiry reported that it was: 'unable to find a clear account of decision-making around that time' (2), highlighting problems within the FMD Science Group. The group was criticised as being a 'modelling sub-committee' although experts from other scientific disciplines were present. At times there were polarised views within the group but no mechanism for handling such conflict (2). It is not necessary to be mathematically literate to appreciate that no model will produce the right output when fed the wrong input. In the future, care should be taken to ensure that lessons are learned – a bad model is like a bad x-ray because it invariably results in erroneous conclusions and a wrong course of action.

It is inevitable that modellers will seek to improve their models. However, they tend to focus their attention on tractable issues of 'uncertainty' (that is, focusing on influential parameters whose probabilities are not known). This is common to scientific research, which thus ignores parameters that are less amenable to investigation (61). The net result is that, as uncertainty is decreased, 'ignorance' (essentially: not knowing what one does not know), which is a measure of the completeness and value of knowledge, increases (116). This apparent paradox therefore acts as a cautionary warning over the use of ever-more-detailed models as policy guides. Moreover, modelling will never present the full picture because, 'rarely if ever is a mechanism proposed that would account for all observed cases of disease, or all effects of all risk factors, measured and unmeasured. Background "noise", in the form of unaccounted-for effects and interactions, would easily obliterate any pattern sought for by the investigator' (77).

Alternative approaches to control

Recent analyses of the epidemic data have indicated that there was no significant relationship between the use of contiguous culling and the spread of infection (48, 97). Doubts have also been raised about the legality of the cull (10), where intervention 'occurred beyond formal legal doctrine' (62). This concern undoubtedly contributed to the speed with which new legislation, the Animal Health Act, 2002, for England and Wales (99), was enacted after the epidemic. The Act provides extended power to carry out any slaughter deemed necessary to control disease, dubbed by some as: 'the power to panic' (10).

Note, however, the consequences of such power. In 2001, only 65% of the 2,026 'infected' premises were confirmed positive by diagnostic analyses of the samples submitted to the laboratory at the Institute for Animal Health, Pirbright: 1.3 million animals were slaughtered on infected premises; 1.5 million animals were slaughtered on contact farms; and 1.2 million animals were slaughtered on adjacent premises, some of which were also considered dangerous contacts (33). On these figures alone, approximately three million healthy animals were slaughtered to control the epidemic, even allowing for the possibility that another 12% of the

infected premises were actually infected (i.e. 77% of the declared infected premises).

Farm restrictions, clinical surveillance and testing

The implementation of the pre-emptive contiguous cull policy meant that premises were declared infected from diagnosis on clinical signs alone, without laboratory confirmation. Clinical FMD in sheep can be very mild (59), and is easily confused with other causes of mouth ulceration or lameness (16). Not only were sheep flocks (and some cattle herds) being culled due to mistaken clinical diagnoses (as indicated by negative laboratory results when samples were taken), but the animals on adjacent farms were also slaughtered under the provision of the 48-h contiguous cull policy. The diagnostic tests used in the laboratories were extremely sensitive and specific for showing evidence of infection with FMD virus (114), and, assuming those animals suspected of FMD were the animals from which the samples were collected, and the samples were kept cool and submitted to the laboratory within 48 h (which they were), these results would give a very good indication of which flocks and herds had been infected. There was no compelling reason why the slaughter, particularly of sheep, which have low virus excretion rates (59), could not have been delayed until laboratory results were available. In some instances, laboratory results showed that the FMD virus had actually been in a flock for some considerable time before slaughter, and yet spread had not occurred to other farms (1). Therefore, in many suspect flocks awaiting the results of testing, the sheep could easily have been isolated and restricted at a distance from neighbouring animals and farms, to reduce the risk of potential virus spread (should the virus, in fact, have been present).

Veterinary-assessed dangerous contact culling

The value of using veterinary judgement in deciding which premises were at high risk of having been infected (i.e. incubating disease), and therefore which ones to cull – rather than using an automatic contiguous culling regime – was assessed from the results of the control programme in Cumbria (49). These results showed that automatic contiguous culling was unnecessary (49), and could be replaced by applying basic epidemiological principles to decide the risk of exposure to infection. Analysis of data in south-west Scotland also indicated the efficiency of veterinary assessment in detecting infection, while also failing to detect infection on any automatically contiguously culled premises, although many of these (most of which had the indicator species, cattle, on them) were slaughtered beyond the median incubation period of infection in relation to the time when adjacent premises could have infected them (97).

Control by vaccination

The reality of the 2001 epidemic of FMD in the UK was that more than six million animals were slaughtered to control disease and maintain animal welfare. In the Netherlands FMD epidemic, 60,000 animals (predominantly cattle) were slaughtered to help control the epidemic, and a further 200,000 FMD-susceptible animals, which had been vaccinated in the area surrounding the main focus of the epidemic, were also slaughtered to help quickly re-establish international trading status. The UK did not use vaccination to assist in controlling the epidemic, although vaccination programmes were planned, vaccination teams were trained and 50,000 doses of vaccine were ordered and ready for use in Cumbria. There was considerable discussion about potential vaccine use, but the issue was where to use it, since it was not initially clear where the disease was distributed, and there was concern that there would be no market for milk or meat from vaccinated cattle – even though deboned meat from vaccinated cattle in South America had been sold in the UK for 50 years. The MAFF officers acknowledged that the use of vaccination would primarily be to help relieve the limited resources then available, and that any vaccinated animals would later be slaughtered. Not unreasonably, if the animals were to be slaughtered after the epidemic, and if there was likely to be a problem selling the milk (some supermarket chains had indicated their unwillingness to sell milk from vaccinated cattle), farmers preferred their compensation during the epidemic, rather than later.

The World Organisation for Animal Health (OIE) defines guidelines for bilateral trade agreements involving live animals and animal products, to reduce the spread of diseases between countries, in particular, highly infectious diseases such as FMD (115). The OIE also advises the World Trade Organization on animal-related trade disputes. The OIE *International Animal Health Code* at the time of the epidemic specified that a country previously free of FMD, which had used vaccination to help control an epidemic, and which had not subsequently slaughtered all the vaccinated animals, could not re-apply for FMD-free status until 12 months after the last use of vaccination (115). If all the vaccinated animals were slaughtered, an application could be made three months after the slaughter of the last vaccinated animal, together with evidence that the virus had been eliminated (115). These conditions were based on the possibility that vaccinated cattle and sheep that had contact with live FMD virus during the epidemic could become persistently infected, and therefore cause fresh outbreaks.

The political repercussions of the 2001 FMD epidemic in Europe manifested themselves in a meeting in Brussels in December 2001, sponsored by the British and Dutch governments and the EU. At this meeting (27), Ministers

from both countries made it very clear that the slaughter that had taken place to control the FMD epidemics was no longer acceptable and alternative policies were required, notwithstanding the fact that much of the slaughter resulted from the nugatory pre-emptive cull, which need not – indeed, should not – be repeated in the future. Nevertheless, attention then focused on vaccination. Considerable publicity was given to a serological test that would distinguish animals that tested positive for antibodies against FMD virus following infection, from those that were positive following vaccination. In this way, persistently infected animals could be identified.

The test identified antibodies to the non-structural proteins (NSP) of FMD virus, in particular 3ABC (64). The vaccine against FMD is an inactivated preparation, and there is no viral replication or expression of the NSP, therefore few or no antibodies are made to these proteins. An infected and recovered animal would have NSP antibodies and thus be easily identifiable.

What the new test did not fully address was that vaccinated cattle and sheep that come into contact with live FMD virus can become persistently infected, without showing clinical signs or producing detectable antibodies to NSP (19). However, the use of high-potency vaccines may reduce the development of persistent infections (7).

The test had also not been validated to the standards set by the OIE for any species. However, in 2002, the OIE agreed to change the requirements for re-establishing FMD-free status: to six months after the last vaccination if the vaccinated animals were not slaughtered, and after the use of the NSP test to show that the FMD virus had been eradicated from the affected country. Questions arose from delegates of OIE Member Countries, when this was presented to the OIE International Committee in May 2002, because little was known of this test and its diagnostic sensitivity and specificity, particularly in vaccinated, persistently infected animals. Nevertheless, the political pressure for change was overwhelming.

Following the OIE decision, the EU also changed its Directive on measures for the control of FMD. No longer is vaccination considered the last resort, and considerable reliance is being placed on the use of the NSP test to mitigate its consequences. However, in spite of political assurances that using the NSP test will overcome the potential dangers of persistently infected animals, the new EU Directive states that, following a declaration of FMD freedom in a Member State: 'the dispatch from one Member State to another Member State of susceptible species vaccinated against FMD shall be prohibited'. It is probable that, if vaccination is used within specific zones within a country, free movement of vaccinated animals throughout that country would also be prohibited (28).

Conclusions

Epidemics of most infectious diseases are subject to mandatory control for which regulatory legislation has been passed. Governmental involvement in disease control, and controversies surrounding it, have a long history, dating back in the UK to the mid-19th Century, when the relaxation of trade restrictions and ensuing epidemics of FMD, sheep pox and, notably, rinderpest (cattle plague), saw a change in favour of veterinary policing of the country (113). Now, as then, urgent decisions may need to be taken when facts are uncertain (35). Such decisions are based on received scientific wisdom, which may be either central to regulatory mechanisms (the 'technocratic model'; 107) or subordinate to political considerations (the 'Weberian decisionist mode'; 106). In either case, the value of the facts must be judged, and scientific experts must be accountable, not only to government ministers but also to other experts. To date, this has not occurred in the context of the 2001 epidemic.

Modelling should only be countenanced if veterinarians and scientists agree that the design of the model and the information used to generate its results are correct (and plausible, from the known biology of the disease). Otherwise, models: 'become exercises in mathematical sophistry' (96). Moreover, the rift between the models and the practical reality of implementation may be so huge as to make the models irrelevant (5). Significantly, Michael Osterholm, Director of the Center for Infectious Disease Research and Policy, University of Minnesota, has commented: 'In 30 years in public health, I've never seen any statistical modelling that had any impact on public health' (26). The most appropriate use of models is as inter-epidemic tools, to aid retrospective analysis of real epidemics to gain an understanding of their behaviour. Hypothetical scenarios can then be modelled to develop insights into the relative merits of different strategies in different situations. In this way, decision-makers can be provided with *a priori* supporting guidelines, used in conjunction with veterinary wisdom and experience – not as a substitute for them.

The use of models during epidemics should be restricted to monitoring the epidemic and aiding short-term fine adjustments to strategies. Comparing real behaviour to 'expected' (model-generated) behaviour could alert epidemiologists to unexpected circumstances in the field, which could then be targeted for action. Models may also be useful to carry out limited 'what-if' simulations, to assess risks associated with various developments of the epidemic, so that appropriate contingencies could be made in resource planning. During epidemics, models can usefully support the requisition of resources needed for well-tried control measures, by graphically demonstrating

the possible development of an epidemic. However, the utility of predictive models as tactical decision support tools is limited by the innate unpredictability of disease spread between farms. With particular reference to deciding on the use of ring vaccination, James and Rushton (53) draw the following conclusion:

'The progress of an outbreak of FMD is extremely difficult to predict in the early stages of the disease. The course of an outbreak can be critically affected by minor and inherently unpredictable events, such as a single livestock movement. For this reason, predictive disease models, which depend on statistical probabilities of transmission, have not met with much success in predicting the spread of FMD from herd to herd, and still less the impact of control measures. Given these constraints on predicting the impact of ring vaccination on the progress and extent of an outbreak, it is difficult to envisage an economic analysis that would guide decisions on the possible use of ring vaccination. This leads to the rather unsatisfactory conclusion that, in most cases, the impact of using or not using ring vaccination is essentially unpredictable. By the time that it becomes apparent that ring vaccination would have been justified, it is likely to be too late to use this method of control.'

The consequences of the 2001 European FMD epidemic will probably not be restricted to Europe. There would likely be considerable pressure to use vaccination in other FMD-free countries affected by an epidemic. It is becoming more obvious, even to those to whom it was not obvious at the time (as analysis of the 2001 epidemic continues), that the slaughter that took place was grossly excessive. However, traditional methods of control (rapid slaughter of animals on infected premises, and veterinary assessment of dangerous contacts before slaughter – but excluding automatic pre-emptive slaughter of animals on farms that are merely cartographically contiguous to infected premises) have been shown to be effective, without the need for the draconian slaughter that occurred in 2001. Moreover, the small percentage of farms in 2001 likely to have been infected 'across the fence' (a non-preventable route), in contrast to the majority of farms in which infection entered 'through the gate' (a route susceptible to blocking by movement controls and biosecurity), suggests that, in FMD epidemics caused by a virus with strain characteristics similar to that which caused the 2001 epidemic, a suitable aphorism for control is 'prevent – not pre-empt'.

■

Utilisation et abus des modèles mathématiques : l'exemple de l'épidémie de fièvre aphteuse de 2001 au Royaume-Uni

R.P. Kitching, M.V. Thrusfield & N.M. Taylor

Résumé

La fièvre aphteuse représente une grave menace, non seulement pour les pays dont l'économie dépend des exportations agricoles, mais aussi pour les pays industrialisés qui préservent la santé de leur élevage national en éliminant les principales maladies infectieuses dans leurs populations animales. Les méthodes traditionnelles de lutte contre les maladies comme la fièvre aphteuse nécessitent la détection et l'abattage rapides des animaux infectés et de tous les animaux sensibles avec lesquels ils peuvent avoir été en contact, soit directement soit indirectement. Pendant l'épidémie de fièvre aphteuse de 2001 au Royaume-Uni, cette approche a été completée par une politique d'abattage sanitaire fondée sur des modèles prédictifs qui n'avaient pas été validés. Ainsi, l'épidémie et les mesures de lutte ont eu pour conséquences la mort d'environ 10 millions d'animaux, les protestations du public devant l'ampleur du massacre et la décision prise par les autorités d'adopter d'autres options, notamment la vaccination, pour lutter contre les futures épidémies. L'expérience du Royaume-Uni nous donne un avertissement salutaire sur l'abus que l'on peut faire des modèles si l'on pratique l'opportunisme scientifique.

Mots-clés

Abattage – Abattage sanitaire – Abattage sanitaire total – Épidémiologie – Fièvre aphteuse – Infectiosité – Modèle mathématique – Modélisation – Propagation du virus – Royaume-Uni – Transmission.

■

La epidemia de fiebre aftosa de 2001 en el Reino Unido como ejemplo de uso y abuso de modelos matemáticos

R.P. Kitching, M.V. Thrusfield & N.M. Taylor

Resumen

La fiebre aftosa constituye una grave amenaza, no sólo para países cuya economía depende básicamente de las exportaciones agropecuarias, sino también para los países industrializados que protegen la salud de su cabaña ganadera manteniéndola libre de las principales enfermedades infecciosas. Los métodos tradicionales de lucha contra dolencias como la fiebre aftosa exigen detectar y sacrificar con rapidez a los animales infectados y a cualquier otro animal sensible al patógeno que haya estado en contacto, directo o indirecto, con ellos. Durante la epidemia de fiebre aftosa que asoló el Reino Unido en 2001, este procedimiento se acompañó de medidas de sacrificio sanitario que respondían a modelos predictivos no validados. La epidemia y la aplicación de dichas medidas se saldaron con la muerte de unos 10 millones de animales, cosa que suscitó el horror ciudadano ante la magnitud de la hecatombe y condujo a la firme decisión política de utilizar en el futuro métodos alternativos, que comprendieran en especial la vacunación, para controlar toda epidemia. La experiencia británica constituye una saludable advertencia contra el uso incorrecto de modelos en beneficio del oportunismo científico.

Palabras clave

Elaboración de modelos – Epidemiología – Fiebre aftosa – Infecciosidad – Modelo matemático – Propagación de virus – Reino Unido – Sacrificio – Sacrificio sanitario – Sacrificio sanitario total – Transmisión.

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Factors impacting the acceptance of traceability in the food supply chain in the United States of America

P. Cheek

Global Technology Resources, Mississippi Research and Technology Park, 1 Research Blvd., Suite 104, Starkville, MS 39759, United States of America

Summary

Global demands for increased food safety and quality assurance programmes, increased global competition, changing government rules and regulations, political and trade barriers, bioterrorism, and identity preservation requirements in global markets are affecting the world's food supply chain. To satisfy changing market demands, all suppliers in the food supply chain must adapt to these global issues. Total asset visibility must be maintained in production, in process, in storage, and in transit.

Keywords

Agroterrorism – Asset visibility – Consumer – Disease – Food safety – Government – Surveillance – Traceability – Tracking.

Introduction

Since 2001, a plethora of new words have entered and dominated the global agricultural market place. Traceability, tracking, product integrity and quality assurance have become an important part of today's global food supply chain. Global events, including the attack on the World Trade Center in 2001 and the discovery of foot and mouth disease (FMD) in the United Kingdom (UK) the same year, have impacted global consumer concerns about existing food safety protection policies. In the past four years many countries have experienced the largest recalls of meat and vegetables in their history.

Today, global consumers are demanding a source-verified and disease-free food supply. Their call for enhanced traceability establishes the need for both operational deficiency identification and trace-back and trace-forward capabilities in a co-mingled environment. Recent global food-borne illness outbreaks underscore the importance and significance of traceability to the global food industry. Changing consumer attitudes have resulted in demands for greater food safety on the retail market.

Global trends indicate rapid mergers and the consolidation of retail supermarket chains. These retailers will continue to force consumer demands on the supply chain. Food safety will continue to be a dominant issue driven by consumer preference for product integrity. Retail power will continue to increase, thereby having a major impact on the retail value chain. Suppliers will be compelled to comply with the demands brought on by consumers and global commerce. Industries face many challenges in meeting these demands.

In drafting this paper the author has used the food supply chain in the United States of America (USA) as a case study. This is not to exclude other countries, as it is abundantly clear that there is a parallel, urgent need in all other countries for full traceability of food products from the farm to the table. Similarly, there are several tracking systems on the market but Global Track technology has been used as an example here because this is the one best known to the author.

Traceability challenges facing the global market place

Global standards for traceability are just now beginning to evolve in the market place. Success for any global programme relies on the standardisation of data and the form in which it is presented. These standards will allow item identification for the global tracking and tracing of all food products. Standardisation will allow the items to move effectively and efficiently throughout the whole supply chain.

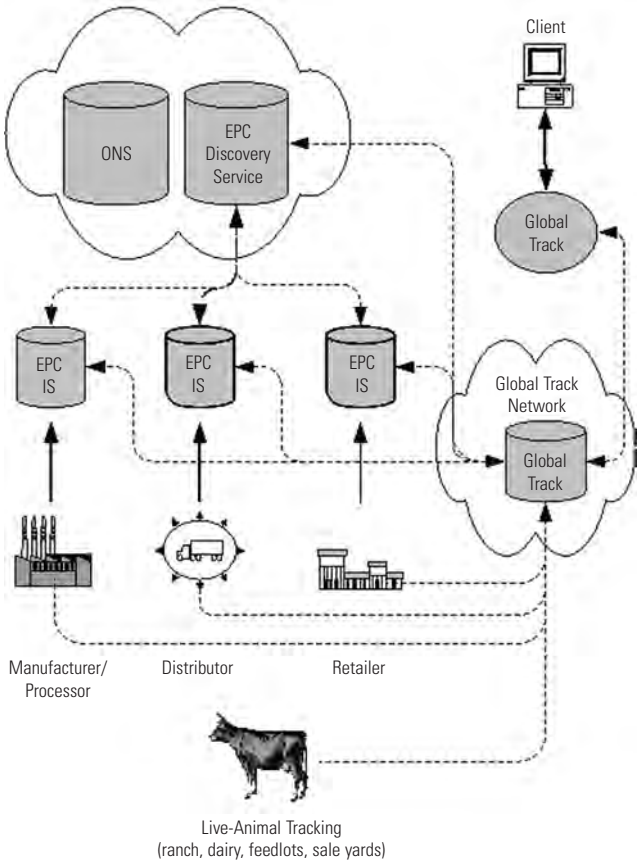
The Uniform Commercial Code Council, Inc. (UCC), now known as GS1, with their global trade item numbering system, is leading the way on both the North American and European continents in achieving standardisation. Electronic transfer of information continues to be at the forefront of this technology approach. The UCC has joined together with EAN (European Article Numbering) international to form EPC Global Inc., a consortium of supply chain partners working towards standardised information sharing.

Prior to the development of EPC Global Inc., there was no neutral body to develop globally recognised standards or method for collecting and communicating such information. The consortium has developed a system for bringing the benefits of electronic tagging to the global supply chain – the EPC Global Network. Prior to the development of the Network, there was no vehicle for data sharing and communications within the global supply chain. With the creation of the Network, there is now a medium within which information can be collected, utilised, and communicated across supply chains, across industry and around the world. Standardised global trade unique identifiers now allow items to be individually verified when tied into the EPC Global Network, resulting in a network of information that traces individual product movement in real time.

An example of the value of this global technology to the food supply chain is exhibited in Figure 1. GTR-DATASTAR, a US-based company uses this format in their patent pending Global Track technology. The illustration highlights the tracking of live animals throughout the supply chain, focusing on co-mingled environments. This technology was designed to be a fully distributed supply chain product tracking system, as well as a surveillance tool for rapid disease detection and mitigation. In addition, it provides critical decision support tools including mapping and geographic displays, satellite imaging and epidemiological data.

The Global Track system will utilise the EPC Global Network; it was designed to track sources of a product throughout the supply chain utilising both electronic tag components (RFID: radio frequency identification) or existing barcodes. This dynamic system allows for the flexible use of these two tracking components, as well as optical scanning technology. The Global Track system architecture employs a distributed web services model that provides the scalability, reliability and performance that is required for implementation on a global basis.

The system allows for the sharing of data throughout the supply chain and has a standard interface for the data collection and query system. If a partner is collecting the necessary data, the Global Track service will interface with the partner system to accomplish the tracing of co-mingled product, as in the cases of a food processor or cattle harvest plant. In cases where a supply chain partner does not have the capability to provide the necessary data, Global Track technology collects the data and identifies sources of the co-mingled product. The technology was designed to be flexible and work with supply chain partners to accomplish tracing requirements in the most efficient means possible. Global technology systems with the capability of utilising standardised systems like EPC Global Network and Global



EPC: EPC Global Inc. (a consortium of supply chain partners)
IS: identification system
ONS: object name service

Figure 1
The EPC Global network: a vehicle for data sharing and communications within the global food supply chain
Source: GTR-DATASTAR, 2005

Track are becoming critical in both the food safety and disease detection and mitigation areas.

The need to provide immediate real time individual product information anywhere in the world is critical. Adoption of real time electronic incident management and control systems for food safety and disease detection and mitigation is critical to the global economy. While the technology is available in the USA, acceptance is another issue.

Factors impacting the acceptance of traceability in the supply chain in the United States of America

Consumer demand has sparked the growth of quality assurance programmes in the European food sector. Food scares, outbreaks of food-borne illnesses and animal diseases, concerns over food produced through biotechnology and concerns over the humane treatment of animals in food production have all created a demand for food with known and documented characteristics and certifiable attributes (1).

In the USA new foreign trade demands brought on by the European Union changes, coupled with a more educated consumer, affect the entire food industry. These events highlight the need for traceability in the supply chain. Currently, the USA is suffering great economic penalties in both the beef and poultry export markets due to the existence of transboundary diseases. Since January 2004 the USA has experienced outbreaks of bovine spongiform encephalopathy (BSE), avian influenza, Newcastle disease, severe acute respiratory syndrome, and monkeypox. During the past three years, these occurrences have caused the largest red meat recalls in the history of the country. Each time, the companies and government agencies involved were unable to trace the total amount of meat or number of live animals involved in the recall. These serious events did not go unnoticed by US consumers and global inspection agencies. Food safety has swiftly become an important global issue with international trade and public health implications for the entire protein industry.

Corporate and producer resistance

Major corporations in the USA still see traceability as 'nice to have, but not necessary' due to perceived added costs. Firm resistance to both government-sponsored and mandated private sector programmes is strong. A good example is the county-of-origin labelling (COOL) mandate included in the 2002 USA Farm Bill. The labelling programme was to be voluntary until 30 September 2004, and then mandatory thereafter for fresh red meat, seafood, produce, and peanuts.

However, on 27 January 2004, President George W. Bush signed a law delaying the implementation of mandatory COOL rules for all covered commodities except wild and farm-raised fish and shellfish until 30 September 2006. Seafood was the only commodity held to the mandate, perhaps because this industry did not have the strength of major corporations or red meat industry lobbyists. In November 2005 the US Congress once again delayed mandatory COOL for two more years as a result of pressure from the meat processing industry and many producer organisations. Any legislation relating to mandatory traceability, record keeping, and certification procedures has been fiercely attacked by various industry groups, corporations, and producers.

Government-proposed identification and traceability system

The impact of the discovery of BSE in Washington state in 2003 and the inability of the government agencies to effectively locate all the potential cattle involved caused consumer groups to challenge the effectiveness of existing food safety procedures in the beef industry. These challenges, along with major red meat recalls forced government officials to pay greater attention to traceability in the country's supply chain.

As a result of this pressure, the US Department of Agriculture put forward a proposal for a National Animal Identification System (NAIS) in April 2004. From the start, industry groups debated issues for and against the development of the proposed system. Implementation of the NAIS system divided the animal industry into three groups: those endorsing a government-run programme, those who want a privatised industry programme, and those who want no programme at all (producers and suppliers).

The US Secretary of Agriculture Mike Johanns (7), responding to livestock industry concerns, said that NAIS should be a public-private partnership and that it would be established over time through the integration of three key components: premises identification, animal identification, and animal tracking. Currently, premise identification, the

first step in the programme, is underway. It is strictly voluntary and not mandatory. There are no current mandatory requirements for the implementation or enforcement of the NAIS programme. The programme is currently scheduled to come into effect in 2009. Industry concerns about confidentiality, private versus government data storage, and cost, will continue to hamper the success of this programme; it will continue to struggle unless a common ground is established by all parties, mandatory tracing requirements are put in place, and critical data are standardised, which will include ensuring that data can be used over secure shared networks.

Steve Krut, Executive Director of the American Association of Meat Processors, outlines many of the problems facing the industry as follows: 'There is no question that the public demands an ID system, and our worldwide trading partners will call for the same. Government will do the job if we as an industry are not up to the task. We will most likely be displeased with their solutions and costs. For almost 40 years, the tire industry has had to identify every tire produced, show where it was sold or installed, and have dealers record every serial number. If that meant crawling under cars or trucks to get the numbers, it had to be done, recorded and sent in and maintained. Nearly every apple or piece of fruit sold at retail has a small sticker that identifies the lot or source. Only a skeptic would believe that an animal worth US$ 500 or US$ 1,500 could not be, or should not be traced as to its location' (5).

Need for traceability within the agriculture industry

Thus far, the author has reviewed some of the events that have impacted the food supply chain in the USA and it is clear that the principal problems that exist are as follows:

– current secure food supply systems, including production, manufacturing and processing, do not provide the level of assurances for quality and security that are required in today's environment

– current practices and processes do not provide a database of relevant information or traceability, accountability and reliability from raw product through process management to the consumer

– the latest system of standardisation, integration and technology applications using a multi-disciplinary approach has not been used

– the current processes lack the rapid early detection monitoring techniques and risk mitigation technology that would provide immediate notification and response action in the case of an event.

These deficiencies in the system have a negative impact on the safety of the supply chain and some of the changes needed to improve this situation have been outlined below.

Rapid access to information

Key decision-makers throughout the food supply chain require rapid access to integrated information decision support tools to prevent, respond and mitigate the spread of animal diseases and food-borne incidents in the USA. The requirements to provide a safe and secure food supply to the people, government and businesses of the USA necessitate the consolidation of the current fragmented approach to planning and response systems currently practised in the US food industry.

Ability to trace forward and backward

Mandatory traceability and tracking requirements will greatly enhance the detection and prevention of, and response to, the potential introduction into the food supply chain of foreign animal diseases and food-borne pathogens by terrorist activities or natural events.

Accept all data feeds

Immediate verification from production to consumption of critical food items using seamless technology is now a necessity for food safety.

The need for these changes to occur and the reasons why an effective traceability system is of such economic significance to the industry and the country are discussed in the next section.

Economics of traceability and value to the supply chain

Like all countries, the USA has a vested interest in employing mandatory tracking and traceability components in its food supply chain. According to an Institute of Food Technologists press release, the chain includes more than 200,000 companies that contribute to the nation's food supply. In addition, there are more than 900,000 restaurants with 12 million employees and approximately 100 million head of cattle being raised in 49 states. Food-related businesses comprise 13% of the US gross national product and 18% of the US employment base. Agriculture supply chain activities amount to more than US$ 1 trillion annually and exceed US$ 50 billion in exports (4). Economic devastation and the lack of control caused by FMD in the UK should have been a wake-up call

for government regulators and industry leaders in the USA. Immediate disease detection and mitigation programmes, as well as the ability to isolate exotic pathogens, all rely on the capability to rapidly trace forward and backward in the supply chain. Fairfield (3) noted the following impact of an outbreak of FMD on the grain and feed industry: 'The current value of US meat, dairy, and poultry products is approximately US$ 87 billion. About one million US jobs are directly related to the production of these products. According to estimates, a 10% value output reduction, related to FMD or another livestock disease, results in a loss of approximately 418,000 jobs throughout the US economy'. Financially, meat recalls and false alarms of BSE have had a major impact on stock market reaction. Events caused by product contamination and BSE concerns have seen shareholder value disappear in a matter of hours. In one confidential case such an event resulted in a US$ 120 million shareholder value loss for a major protein supplier in two hours.

In another example, a false FMD rumor from a Kansas sale yard ran rapid through the market place in 2001, causing the cattle futures to drop dramatically and major companies relying on beef to lose valuable shareholder equity. The following reflects the next-day market indicators of several major companies impacted by the false scare: Tyson Foods, Inc. down 2.6%; Smithfield Foods down 26 cents; ConAgra shares down 1%; Outback Steakhouse, Inc. down 3.1%; Wendy's International down 7 cents (8).

The announcement of BSE in Washington state in 2003 caused major economic loss to the largest protein suppliers in the USA. These corporations saw both their Moody's and Standard & Poor's unsecured bond ratings downgraded. In addition, the cost of insuring their debt in the derivatives market increased; one major protein company jumped from 45 basis points to 85 basis points (Reuters, New York, 29 December 2003). Leading USA protein suppliers were put under a negative credit watch.

One would think, with all the losses experienced by the announcement of BSE, the largest meat recalls in the history of the country, declining shareholder value, class action litigation, and negative brand impact that the message had been heard. Instead corporations, associations, and producer groups still battle against the need for mandatory traceability in the US supply chain.

Agroterrorism

The term 'secure supply chain' has taken on a whole new meaning to everyone involved in supplying food products to the US market, both domestic and global. Vertically integrated US supply chains allow for easy contamination of food products or the dispersion of airborne diseases by terrorists. Protecting the nation's food supply from potential terror attack is just starting to be seriously addressed by the Food and Drug Administration. Foreign animal and plant diseases, normally a natural occurring problem, are now a matter of national security.

Food defence for both pre- and post-harvest of food products is fast becoming a national 'buzz' word in the market place. Many entry points in the protein supply chain allow for an easy introduction of a pathogen by a terrorist. The US food supply chain is experiencing new and old pathogens at a rapid pace. Cupp, Walker, and Hillison (2) in their article 'Agroterrorism in the US: key security challenge for the 21st Century', emphasise the high likelihood of terrorist acts interrupting the production, processing and distribution of agricultural products. The following are findings that the authors cite in their research:

– the average distance one pound of meat travels from farm to table in the USA is 1,000 miles, presenting a large number of entry points located over a large geographical area. Some of the entry points are regulated or supervised by government agencies, but others are not, for example, stockyards, processing plants, and slaughterhouses are relatively open;

– in the live beef market, three packers hold 72% of the market;

– almost 70% of the beef cattle that are finished for slaughter in the USA are located in a 200-square-mile area;

– four meatpacking centres process about 80% of the animals in the USA sent to slaughter.

This information illustrates the immediate need for traceability programmes to handle crisis management in the protein supply chain. One event could impact the entire protein supply chain due to the demographics and vertical integration of the industry – the results would be devastating.

The need to isolate the problem and rapidly trace it backward or forward in the supply chain is mission critical. It is also important to protect and certify those in the supply chain who are free from the problem. Immediate certification of regional disease-free areas, free from product contamination or disease issues, will allow that portion of the US-global supply chain to proceed in the case of a disaster, hopefully with minimal negative economic impact. The US protein industry needs mandatory traceability; its survival in both the US and global market place may depend on it.

Conclusion

John Lawrence, Director of the Iowa Beef Center, clearly defines consumer sentiment on a global basis: 'We have traditionally operated on a "trust me" basis, but we are now entering a "prove it" world' (6). Participation of the USA in global markets, consumer demand at home, and food defence against terrorism all back up the need to 'prove it'. No longer will international consumers and foreign government agencies operate on a 'trust me' basis when it comes to agricultural trade.

Verification from production to consumption, auditing and third party certification, confirmation of testing procedures, agroterrorism prevention, rapid disease detection and mitigation technology must become a vital part of the food supply chain in the USA. Markets demand it – lives may depend on it. Will US industries and producers be proactive and adopt the changes needed for traceability in the supply chain, or will they wait until the next major event happens before they act? Unfortunately, the history of the USA shows that it takes a major event to make a change.

Facteurs intervenant dans l'acceptation de la traçabilité pour les produits de la chaîne d'approvisionnement alimentaire aux États-Unis d'Amérique

P. Cheek

Résumé
La demande mondiale de renforcement des programmes de contrôle de qualité et de sécurité sanitaire des aliments, l'essor de la concurrence à l'échelle planétaire, l'évolution des règles et réglementations gouvernementales, les barrières politiques et commerciales, le bioterrorisme et les impératifs de la préservation de l'identité des produits sur les marchés mondiaux ont des répercussions sur la chaîne d'approvisionnement alimentaire au niveau mondial. Pour répondre à l'évolution de la demande des marchés, tous les fournisseurs de la chaîne d'approvisionnement alimentaire doivent s'adapter à ces questions de portée mondiale. Il faut assurer une visibilité totale des ressources lors de la production, la transformation, le stockage et le transit.

Mots-clés
Agroterrorisme – Consommateur – Gouvernement – Maladie – Sécurité sanitaire des aliments – Suivi – Surveillance – Traçabilité – Visibilité des ressources.

Factores que influyen en la aceptación de la rastreabilidad en la cadena de suministro alimentario de los Estados Unidos de América

P. Cheek

Resumen
La demanda que en todo el mundo se deja sentir para que se instituyan más programas de seguridad sanitaria y garantía de calidad de los alimentos, la intensificación de la competencia mundial, la evolución de las normas y reglas de los gobiernos, las barreras políticas y comerciales, el terrorismo biológico y los requisitos para preservar la identidad de los alimentos en los mercados mundiales están influyendo en la cadena de suministro alimentario de todo el planeta. Para satisfacer las nuevas demandas del mercado, todos los proveedores de la cadena deben adaptarse a esta cambiante coyuntura mundial. Es preciso mantener la visibilidad total de los recursos en la producción, el tratamiento, el almacenamiento y el tránsito de los artículos alimentarios.

Palabras clave
Agroterrorismo – Consumidor – Enfermedad – Gobierno – Rastreabilidad – Rastreo – Seguridad sanitaria de los alimentos – Vigilancia – Visibilidad de los recursos.

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Institutos de investigación y seguridad biológica

G. Darsie, A.J. Falczuk & I.E. Bergmann

Centro Panamericano de Fiebre Aftosa, Organización Panamericana de la Salud/Organización Mundial de la Salud, P.O. Box 589, CEP: 20010-974, Río de Janeiro, RJ, Brasil

Resumen

La amenaza del uso de materiales biológicos con fines agro-bioterroristas se ha incrementado en los últimos años, lo cual obliga a los laboratorios de investigación, diagnóstico, bancos de agentes biológicos y otras instituciones autorizadas para ejercer actividades científicas, a implementar medidas de bioseguridad y seguridad biológica, para evitar favorecer estas acciones, y a desarrollar al mismo tiempo actividades de apoyo a la prevención y vigilancia de la introducción de enfermedades animales exóticas de forma accidental o deliberada.

Este trabajo resume los componentes básicos de bioseguridad (*biosafety*) y seguridad biológica (*biosecurity*) que deben ser atendidos y recomienda acerca de las estrategias organizativas que deben ser consideradas en los laboratorios en apoyo a los programas de prevención y vigilancia de actos agro-bioterroristas.

Palabras clave

Agente de riesgo – Agro-bioterrorismo – Bioseguridad – Seguridad biológica.

Introducción

La amenaza del uso de materiales biológicos peligrosos capaces de matar o causar daño a la salud humana, animal o vegetal, así como las estrategias usadas para alcanzar ese fin, han cambiado considerablemente en los últimos años. Históricamente, la amenaza de utilización de guerra biológica estuvo restringida a países en tiempos de conflictos bélicos declarados. Acuerdos multinacionales de no proliferación de armas biológicas han sido celebrados para controlar y limitar el desarrollo y uso de agentes biológicos como armas de destrucción en masa (7, 13). Esos esfuerzos estimularon a organizaciones y científicos involucrados en el desarrollo de armas biológicas a cambiar sus programas de investigación, desviando sus capacidades hacia actividades pacíficas.

Recientemente, ha aumentado la posibilidad y el temor de que actores no gubernamentales, ejecuten o amenacen con ejecutar acciones de agro-bioterrorismo, contra objetivos militares, civiles o productivo-económicos. Las motivaciones de estos grupos para provocar ataques pueden ser de índole económica, social, religiosa o política y la potencialidad de sus acciones, es motivo de preocupación. Estos grupos se ven actualmente favorecidos por el revolucionario avance de las comunicaciones, que han facilitado el libre acceso a informaciones antes restringidas (8, 10), así como por los desarrollos en el campo de la biotecnología, la automatización de procesos y la utilización de kits que simplificaron los pasos necesarios para realizar la selección y multiplicación a escala industrial de agentes biológicos, reduciendo el nivel de especialización antes requerido, y aumentando en consecuencia la disponibilidad de acceso. Esto ha posibilitado que con pocos recursos se puedan desarrollar, adquirir, amenazar con el uso o usar armas biológicas.

En este escenario se torna crítico el papel de los laboratorios de diagnóstico, investigación, bancos de agentes biológicos y otras instituciones autorizadas para ejercer actividades científicas, diseminados alrededor del mundo, ya que disponen de muestras virulentas viables, que en general están bien caracterizadas y purificadas. En cambio, los agentes biológicos encontrados en la naturaleza, son menos conocidos y están disponibles en menor cantidad. Frecuentemente, los mismos no reúnen las características necesarias para su uso inmediato. De cualquier forma esta posibilidad no debe ser descartada.

Los agentes susceptibles de ser usados con fines de agro-bioterrorismo han sido clasificados basándose en su transmisibilidad, letalidad, impacto en la salud, economía

y sus requerimientos de contención por el Centro de Prevención y Control de Enfermedades de Estados Unidos de América. La disponibilidad de recursos y la implementación de medidas tendientes a aumentar la protección frente a estos agentes deben ser prioritarias, teniendo en cuenta, como fuera mencionado, que algunos de los mismos, pueden ser un atractivo blanco para individuos o grupos interesados en realizar actos terroristas (4, 17).

Bioseguridad y seguridad biológica

Dado que no hay posibilidad de eliminar el riesgo de escapes accidentales o el acceso a agentes con potencialidad de ser utilizados con fines agro-bioterroristas, se deben usar todos los recursos técnicos, humanos y materiales para llevar este riesgo a una condición manejable, lo cual se traduce en la implementación de medidas y acciones de bioseguridad (*biosafety*) y de seguridad biológica (*biosecurity*). Estas medidas buscan la prevención, minimización o eliminación de los riesgos asociados a las actividades de investigación, producción, capacitación, desarrollo tecnológico y prestación de servicios que puedan afectar la salud humana, la sanidad animal, el medio ambiente, durante la manipulación de microorganismos.

La bioseguridad trata de los procedimientos, equipos e instalaciones que ayudan a reducir la exposición de individuos o ambientes a agentes biológicos potencialmente peligrosos durante su manipulación (14).

La seguridad biológica trata de las medidas aplicadas para proteger patógenos peligrosos de acciones de robo o sabotaje con la intención de practicar actos terroristas o fabricar armas biológicas (5).

Muchas veces estos conceptos se confunden, mientras que en otras ocasiones pueden resultar antagónicos, pero siempre es necesaria y se busca la complementariedad de ambos para alcanzar el nivel de seguridad requerido, siendo el objetivo primario de ambos el asegurar que esos patógenos no causen daño ni salgan del ámbito del laboratorio. En este contexto se tratarán brevemente los requisitos mínimos que ambos exigen.

Bioseguridad

La bioseguridad requiere la implementación de barreras de contención apropiadas en las instalaciones edilicias, así como asumir una "cultura" de responsabilidad de quienes manipulan, usan y transportan patógenos peligrosos. Esto implica el estricto cumplimiento de métodos de buenas prácticas de laboratorio (BPL) aplicando procedimientos operacionales estándar (SOP) bajo sistemas de aseguramiento de la calidad.

El riesgo inherente a la contaminación en el ámbito del laboratorio se reduce cuando se cumplen BPL. El uso de equipamientos de protección colectiva (cabinas de seguridad biológica), de equipos y materiales de protección personal, los procedimientos para el transporte seguro de materiales y especímenes dentro del área laboratorial, contribuyen al control y cuidado de no generar dispersión de patógenos, principalmente por aerosoles, evitando accidentes. Especial atención debe darse a los estudios que requieren inocular animales, ya que la cantidad de aerosoles generados, con altos contenidos de microorganismos, es extremadamente grande y difícil de controlar. Se debe restringir las actividades que requieren el uso de animales al mínimo indispensable, utilizando siempre cajas aisladoras apropiadas para animales de pequeño porte.

La construcción de laboratorios con instalaciones cuyo nivel de biocontención sea compatible con los riesgos asumidos, constituye actualmente un emprendimiento posible desde el punto de vista tecnológico, y a costos relativamente aceptables. Estos laboratorios deben contar con estructuras (estanqueidad) y mecanismos apropiados (tratamiento de efluentes: gaseoso, líquido y sólido), desarrollados para evitar los riesgos de escape accidental de los agentes patógenos que se manipulan en ellos. Brevemente describimos a continuación los principales aspectos que deben tenerse en cuenta para alcanzar ese objetivo.

Se debe dar especial atención al sistema de ventilación y tratamiento de aire (efluente gaseoso), ya que la gran mayoría de los agentes de riesgo son difundidos a través de aerosoles que infectan al huésped ingresando por la vía respiratoria, además de la posibilidad de diseminarse por grandes distancias. Los sistemas de inyección y de extracción del aire deben contar con filtros absolutos simples en su entrada y dobles en serie en la salida, instalados en soportes que permitan su desinfección *in situ*. Todas las áreas donde se manipulan agentes de riesgo conocidos o sospechosos deben operar en atmósfera de presión negativa en relación a las adyacentes. Estas deben ser permanentemente monitoreadas en tiempo real y contar con alarmas sonoras y visuales, para detectar eventuales fallas del sistema.

La otra gran fuente de riesgo de diseminación, es el efluente líquido generado en los laboratorios. Para su mitigación, todos los efluentes líquidos provenientes de las áreas en las cuales son manipulados los agentes de riesgo deben recibir un tratamiento primario validado como de alta eficiencia para la inactivación de los mismos y

posteriormente ser tratados por sistemas generales que utilicen el tratamiento térmico o químico. Al igual que el sistema de tratamiento de aire, el de tratamiento de efluente líquido debe ser proyectado para su operación constante, automatizada con monitoreo y registro permanente de todos los ciclos de inactivación realizados.

Todos los desechos sólidos y los materiales no descartables, que requieran ser retirados fuera de las áreas de alta seguridad deben ser esterilizados usando autoclaves de frontera de doble puerta.

Las instalaciones de seguridad deben contar también con equipos de desinfección de frontera para poder retirar en forma segura materiales que no soportan altas temperaturas (equipos o muestras biológicas que no deban ser inactivadas). Son utilizadas para tal fin las esclusas estancas de doble acceso que permiten la desinfección por fumigación gaseosa o por pulverización de líquidos.

Para que todo el sistema sea efectivo, es necesario considerar algunas características relacionadas con la construcción. Las paredes, pisos, techos, los pasos de tuberías de acceso de los servicios (luz, agua, gases) a través de las paredes, deben asegurar la hermeticidad del sistema. El cierre de puertas externas e internas y la selladura de las juntas de los equipos de frontera (autoclaves y esclusas de doble acceso) deben asegurar la estanqueidad requerida.

Todos los procedimientos deben estar validados y con registros trazables. La eficacia de los equipamientos y el buen funcionamiento de las instalaciones deben ser certificados por lo menos dos veces al año. El compromiso de cumplir las normas de seguridad y de confidencialidad debe estar documentado (14).

Es fundamental un programa de capacitación permanente para estimular la toma de conciencia del personal involucrado en las actividades del laboratorio, además de un programa de mantenimiento preventivo y correctivo, que cuente con los recursos necesarios para su ejecución.

Seguridad biológica

Un efectivo sistema de seguridad biológica incluye diferentes componentes, como la seguridad física, las limitaciones de acceso, la gestión del riesgo. Sin embargo el sistema no confía solamente en estos aspectos. En realidad, el aspecto más importante del sistema se apoya en pautas culturales y de procedimientos, lo que no demanda grandes recursos financieros.

La seguridad física de los laboratorios debe incrementar de forma concéntrica, hacia el núcleo central que es el área de mayor riesgo. En general existen tres áreas:

a) área de protección de la propiedad,

b) área restricta,

c) área de exclusión.

La primera debe estar delimitada por barreras físicas que definan claramente las fronteras de la propiedad y cuyo acceso a personas y vehículos debe ser controlado. Actúa como una defensa contra robos de bienes y contra atentados externos. Debe estar debidamente señalizada como área privada en la cual el acceso solo es permitido a las personas autorizadas.

La segunda, debe estar delimitada y contar con acceso controlado y restricto al menor número de personas posible. Un predio entero puede ser clasificado como área restricta en el cual el acceso de personal no perteneciente al cuadro de funcionarios solo debe ser permitido bajo escolta. Es el área apropiada para los trabajos con materiales de mediano riesgo y la guarda de documentos de circulación restricta.

La tercera, área de exclusión es aquella en la cual son manipulados o guardados los microorganismos de alto riesgo y los animales en experimentación. Debe estar protegida por las áreas *a* y *b* y contar con riguroso control de acceso. Todo el acceso al área de exclusión debe ser debidamente registrado, electrónicamente o en libro propio. Es recomendable que la regla de “dos personas” en cualquier actividad realizada en las áreas de exclusión sea obligatoria. Los contenedores de almacenaje, como congeladoras o refrigeradores, localizados en áreas restrictas, deben ser considerados como áreas de exclusión y tener la protección adecuada para permitir el acceso a sus contenidos solamente del personal autorizado y con estricto control de registros.

En los edificios, la línea primaria de defensa está relacionada con la seguridad física de las instalaciones que tiene por objetivo detectar y detener accesos desautorizados. En ese aspecto, es fundamental que el sistema garantice que puertas, ventanas, puertas de emergencia y cualquier otro dispositivo de posible acceso desde el exterior sea seguro y esté provisto de sistemas de alarma.

El acceso a las áreas de máxima seguridad, debe ser controlado y el número de personas autorizadas a ingresar a ellas y manipular y transportar los materiales de riesgo debe ser limitado.

Las condiciones de trabajo y la estabilidad económica y emocional del personal, son factores que deben tomarse en cuenta. Únicamente debe ser autorizado el personal necesario, cuyos antecedentes personales y profesionales hayan sido previamente evaluados. Deben ser regularmente entrenados en bioseguridad y en seguridad

biológica y sólo deben tener acceso a los materiales específicos, necesarios para el cumplimiento de sus labores. El acceso de otras personas, como visitantes y personal de apoyo solamente debe permitirse bajo escolta y responsabilidad de personal autorizado.

Para documentar el cumplimiento de esa disposición, las instalaciones deben contar con mecanismos de control automatizados, preferentemente de tipo biométrico o por lo menos por contraseñas de uso individual e intransferible de tipo alfanumérico. Las tarjetas magnéticas de control de acceso pueden ser robadas o clonadas, por lo que no se recomienda su uso. Estos sistemas permiten un completo registro de los accesos, la detección inmediata de tentativas de invasión, además de la formación de un banco de datos que facilite la trazabilidad de posibles escapes accidentales o intencionales.

Dado que eliminar del universo y de los laboratorios todos los patógenos peligrosos conocidos es una utopía, y su real conveniencia lleva a controversias, se deben instrumentar acciones que permitan evitar el riesgo de su uso con fines agro-bioterroristas.

Nada justifica que una institución de investigación o diagnóstico, de alcance oficial o privado, nacional, regional, o internacional trabaje con los patógenos que considere de interés académico o comercial sin tomar en cuenta los riesgos existentes y sin adoptar las medidas de seguridad apropiadas. El primer paso que debe adoptarse es el conocimiento de cuáles son los microorganismos de riesgo que justifican estudios, dónde pueden ser encontrados, cuáles son las instituciones pertinentes y bajo qué condiciones pueden y deben ser manipulados (3).

Para eso el nivel oficial central responsable debe censar las instituciones oficiales y privadas (universidades, institutos de investigación, laboratorios industriales y otros) que manipulan microorganismos de riesgo, así como llevar un registro actualizado de investigadores y líneas de trabajo. Estas instituciones deben contar con inventarios actualizados en tiempo real, con registro trazable de uso, altas y bajas. Se trata de aplicar las medidas apropiadas para proteger patógenos peligrosos de acciones de robo o sabotaje con la intención de practicar actos terroristas o fabricar armas biológicas (6, 16, 18).

El listado de agentes considerados de riesgo debe ser permanentemente evaluado, desde la perspectiva de intentar actualizar y abarcar todos los riesgos, así como intentando que el espectro de los agentes almacenados en la institución sea el realmente necesario (19).

Bajo la óptica que es necesaria la gestión de los riesgos, cada país tiene la facultad soberana de elegir los agentes patógenos que deben ser objeto de los más altos grados de seguridad. Al mismo tiempo, debe ser consciente de que microorganismos que para un territorio no son críticos, pueden ser de extrema importancia para otros. No obstante esto, algunos patógenos tales como el virus de la fiebre aftosa, el virus de la peste porcina africana, el virus de la enfermedad de Newcastle, el virus de la influenza aviar, el virus West Nile, el virus Nipah o el *Bacillus anthracis*, por ejemplo, deberían ser siempre manejados bajo máximas condiciones de bioseguridad y seguridad biológica.

Entendiendo que los costos financieros para la instalación y mantenimiento del sistema son significativos, muchas veces se justifica el adoptar la centralización de actividades que requieren seguridad biológica, en laboratorios de múltiple uso.

Contribución de los laboratorios para evitar actos agro-bioterroristas

La vigilancia epidemiológica y los laboratorios de diagnóstico e investigación son claves para la detección, identificación y la notificación temprana de la presencia de enfermedades de riesgo (12).

Los laboratorios adquieren especial importancia cuando se trata de evitar y enfrentar posibles acciones agro-bioterroristas o escapes accidentales. Su contribución a los sistemas de prevención y vigilancia es fundamental al desarrollar estrategias para proteger a los países, a la producción animal y a la industria productora de alimentos, de la introducción o reintroducción accidental o deliberada de enfermedades animales exóticas (1, 2, 9). Los programas de vigilancia, basados sobre un análisis de riesgo, deben clasificar los microorganismos como de alta, media y baja prioridad, y desarrollar sobre esa base manuales de contingencia para afrontar una eventual emergencia sanitaria o responder a ataques terroristas.

Una contribución fundamental al éxito de los programas de vigilancia es la de los laboratorios de investigación, que actualizan tecnologías para lograr una detección eficaz de los agentes de riesgo. La acción coordinada de estos laboratorios con los servicios oficiales de los países es fundamental para dar apoyo a la preparación y actualización permanente ante nuevas amenazas.

Los países deben organizar una red capaz de detectar, recoger, identificar, caracterizar agentes biológicos (exóticos o susceptibles de ser usados en acciones de agro-bioterrorismo), establecer su etiología, resistencia a antibióticos, medicamentos quimioterapéuticos y desinfectantes, estudiar la terapéutica apropiada o el uso de vacunas así como otras medidas, con el fin de evitar su diseminación (15).

Es necesario que los laboratorios que componen la red, integrando los niveles locales, regionales, nacionales e internacionales, trabajen con reactivos y procedimientos armonizados. Esto facilita el acceso a información confiable y transparente, haciendo equivalentes los resultados y las interpretaciones, evitando la duplicación de esfuerzos. Se contribuye así a restringir el movimiento de patógenos de riesgo entre regiones al mínimo necesario, limitando su posible dispersión y evitando a la vez confusiones cuando se trata de establecer el posible origen y la trazabilidad de un determinado evento.

Esta red requiere el compromiso del conjunto del personal, directivo, técnico y administrativo de todos los niveles involucrados. El laboratorio nacional debe estimular a los integrantes desarrollando programas de capacitación en bioseguridad y seguridad biológica, facilitando reactivos de referencia y manuales técnicos para la identificación y caracterización de microorganismos, procedimientos para el acondicionamiento y remisión de material de riesgo infeccioso o sospechoso, entre otros aspectos. Se requiere de laboratorios con la complejidad suficiente para poder trabajar con agentes capaces de ser usados en ataques agro-bioterroristas, y que dispongan de técnicas diagnósticas rápidas de alta sensibilidad y especificidad. Deben estar preparados y ser efectivos en el cumplimiento de este rol.

Sus planes de trabajo deben incluir procedimientos que contemplen como mínimo:

a) criterios para distinguir un evento accidental o provocado;

b) información sobre cómo acceder, ante un evento sospechoso, a otros laboratorios integrantes del sistema en temas específicos;

c) protocolos y algoritmos de diagnóstico;

d) desarrollo y disponibilidad de un amplio espectro de tecnologías que abarque los posibles escenarios de uso de agentes patogénicos. En este contexto, muchas veces esto supone que además de usar los métodos de avanzada, se preserven metodologías que aunque parezcan superadas, se justifican por sus ventajas intrínsecas;

e) el desarrollo y cumplimiento de guías de bioseguridad, seguridad biológica y BPL;

f) criterios y formas para la comunicación y notificación;

g) normas para el embalaje y transporte de material sospechoso o confirmado como infeccioso (11).

Como los eventos agro-bioterroristas pueden ser encubiertos como eventos naturales (19), los laboratorios integrantes de la red deben considerar como sospechosos los siguientes acontecimientos:

a) la detección de un agente no reportado antes en una determinada zona geográfica,

b) una patogenia atípica,

c) la falla en la respuesta a tratamientos ordinarios y vacunas,

d) un patrón genético similar en todos los orígenes de focos,

e) múltiples agentes patológicos identificados en un mismo animal o evento, indicando que posiblemente se han usado simultáneamente varios microorganismos mezclados,

f) el aumento de los índices de morbilidad y mortalidad esperados para una determinada enfermedad,

g) evidencias epidemiológicas de varios focos primarios en áreas sin asociación epidemiológica o de un solo foco distribuido masivamente con indicadores epidemiológicos inesperados,

h) enfermedad o muerte de animales centinelas,

i) ausencia del componente natural, vector o transmisor competente, necesario para que la enfermedad se exprese.

La detección y el reconocimiento de eventos emergenciales dependen de técnicos competentes, bien entrenados, capaces de reconocer y sospechar de hechos inusuales, así como de la participación del sector productivo y de la sociedad en general para declarar hechos sospechosos.

La mayoría de los agentes que pueden ser usados en este tipo de eventos son raramente aislados en la rutina diaria, por lo que muchas veces resulta difícil realizar un diagnóstico rápido. Se deben cumplir en estos casos algoritmos de pruebas preestablecidos, para afrontar estas dificultades, durante la manipulación de rutina de cultivos y material para diagnóstico.

Establecida la sospecha o ante un hallazgo se debe poner en acción un procedimiento de comunicación en el que estén definidas claramente las líneas de comunicación entre los distintos niveles, las líneas jerárquicas, especialmente cuándo, cómo y a quién se remite la información, a efectos de que se puedan establecer en tiempo y forma las acciones necesarias para minimizar el posible daño.

Conclusión

La amenaza del uso de materiales biológicos con fines agro-bioterroristas o de escapes accidentales es una realidad que necesita ser afrontada. Esto exhorta a las autoridades responsables de la sanidad animal en general y de los laboratorios en particular, a asumir los riesgos y afrontar los peligros, incorporando pautas culturales y de procedimientos que contemplen aspectos de bioseguridad y seguridad biológica.

Esto requiere contemplar los recursos humanos y materiales necesarios para establecer un programa preventivo que contribuya a proteger los países, la producción animal y la industria productora de alimentos, de la introducción o reintroducción accidental o deliberada de enfermedades animales.

Lo señalado requiere especial atención en los laboratorios, dado que son depositarios responsables de la mayor parte de los materiales e información que pueden interesar a los grupos terroristas para sus acciones. Los criterios muchas veces liberales de intercambio de material e información, en respuesta a genuinas necesidades científicas o comerciales deben ser revisados en cuanto a su impacto sobre la seguridad biológica y a las posibilidades de su uso con fines agro-bioterroristas, buscando alternativas que minimicen los peligros. Igualmente los enfoques de prevención deben contemplar el mantener un amplio espectro de técnicas de modo a anticipar las diversas estrategias posibles ideadas por los autores de agresiones terroristas.

Biological research and security institutes

G. Darsie, A.J. Falczuk & I.E. Bergmann

Summary
The threat of using biological material for ago-bioterrorist ends has risen in recent years, which means that research and diagnostic laboratories, biological agent banks and other institutions authorised to carry out scientific activities have had to implement biosafety and biosecurity measures to counter the threat, while carrying out activities to help prevent and monitor the accidental or intentional introduction of exotic animal diseases.
This article briefly sets out the basic components of biosafety and biosecurity, as well as recommendations on organisational strategies to consider in laboratories that support agro-bioterrorist surveillance and prevention programs.

Keywords
Agro-bioterrorism – Biosafety – Biosecurity – Risk agent.

Les institutions de recherche et la biosécurité

G. Darsie, A.J. Falczuk & I.E. Bergmann

Résumé
La menace d'une utilisation de matériels biologiques à des fins d'agro-bioterrorisme s'est considérablement accrue ces dernières années, imposant aux laboratoires de recherche et de diagnostic, aux banques d'agents biologiques et aux autres institutions autorisées à exercer des activités scientifiques de mettre en place des mesures de biosécurité et de protection biologique afin de prévenir ces risques, tout en contribuant à la prévention et à la surveillance vis-à-vis de l'introduction, accidentelle ou délibérée, de maladies animales exotiques.
Les auteurs résument les composantes essentielles de la mise en œuvre de la biosécurité et de la protection biologique, et font quelques recommandations

quant aux stratégies organisationnelles que les laboratoires peuvent envisager pour appuyer les programmes de prévention et de surveillance des risques liés à l'agro-bioterrorisme.

Mots-clés
Agent à risque – Agro-bioterrorisme – Biosécurité – Protection biologique.

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Microbial forensics for natural and intentional incidents of infectious disease involving animals

S.A. McEwen [1], T.M Wilson [2], D.A. Ashford [3], E.D. Heegaard [4], T. Kuiken [5] & B. Kournikakis [6]

(1) Department of Population Medicine, Ontario Veterinary College, University of Guelph, Guelph, Ontario, N1G 2W1, Canada
(2) United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, Emergency Programs, Armed Forces Medical Intelligence Center, Fort Detrick, MD, 21702-5004, United States of America
(3) United States Department of Agriculture, Animal and Plant Health Inspection Service, International Services, Riverdale, 4700 River Road, MD 20737-1231, United States of America
(4) Danish Center for Biological Defense, State Serum Institute, 5 Artillerivej, 2300 Copenhagen S, Denmark
(5) Erasmus Medical Centre, Institute of Virology. P.O. Box 1738, 3000 DR Rotterdam, The Netherlands
(6) Defence R&D Canada – Suffield, Box 4000, Station Main, Medicine Hat, Alberta, T1A 8K6, Canada

Summary

Microbial forensics is a relatively new scientific discipline dedicated to analysing microbiological evidence from a crime for attribution purposes. It builds on traditional microbiology and epidemiology but within a legal framework. Important motives for forensic investigations include interdiction of criminals, prosecution of justice, and ideally, deterrence of others from committing similar acts.

Forensic capabilities in animal health should focus on building capacity for detection and reporting of increases in infectious disease morbidity and mortality among animals that might reflect a covert release of a pathogen. Suspicion should be raised when epidemiological patterns are different from those expected for the animal population and the pathogen in question. Existing capacities for the detection and reporting of epidemic and even endemic diseases should be an international priority for the prevention of catastrophic losses in animal and potentially in human life. The veterinary community needs to be more aware of the legal requirements related to forensic investigations so that veterinarians will be prepared to handle evidence properly within their own fields.

Keywords

Animal – Biocrime – Bioterror – Forensics – Infectious disease – Law enforcement – Microbial forensics.

Introduction

The vast majority of infections in animals and zoonotic infections in humans happen naturally, without malicious intent or criminal negligence. Nevertheless, rare incidents involving the unlawful and deliberate exposure of susceptible populations to animal and zoonotic infections have occurred. In 1997 for example, persons unknown illegally introduced rabbit haemorrhagic disease virus into New Zealand, apparently to control the large wild rabbit population that was posing a problem for farmers (30). Humans have also been the targets of deliberate zoonotic disease exposure. In 1984, the Rajneeshee cult deliberately contaminated the food supply in The Dalles, Oregon (31). The ensuing outbreak affected at least 751 people and 45 of them were hospitalised. Criminal convictions were obtained for some of the perpetrators. In 2001, *Bacillus anthracis* spores were deliberately distributed through the postal system of the United States of America (USA) in the 'anthrax letters' incidents, resulting in at least 22 human cases of anthrax, five of them fatal (1). Thus far, no convictions have been obtained in the anthrax case.

The above are examples of deliberate exposure with infectious agents; however, illegal activity may also lead to unintentional exposure. For example, Thai eagles infected with highly pathogenic H5N1 influenza were smuggled into Belgium in 2004 (33).

Veterinary microbiologists and epidemiologists are familiar with investigation of naturally occurring outbreaks of infectious diseases, but most have little experience with forensic examination of evidence for the investigation of criminal cases, although some are called upon to provide expert testimony in court. One of the unique features of bioterror (the use of pathogens in terrorism) and biocrime (the use of pathogens in crimes) incidents such as those mentioned earlier, and even hoaxes of a similar nature, is the requirement for attribution of responsibility. Attribution is defined as 'the information obtained regarding the identification or source of a material to the degree that it can be ascertained' (26). Important motives for forensic investigations include interdiction of criminals, prosecution of justice, and ideally, deterrence of others from committing similar acts (8). When a biocrime involving animals is detected, characteristics of the infectious agent that is isolated, along with additional evidence, will be important information for the criminal prosecution of the case and implementation of medical countermeasures (1).

Concerns about bioterrorism, heightened by the 2001 'anthrax letters' incidents in the USA, are reflected in several recent reports concerning the nature of the problem and opportunities for increased detection, control and prevention of future bioterror and biocrime incidents (1, 7, 8, 9, 19, 25, 26). A number of reports (1, 8, 9, 25) give a more complete discussion of microbial forensic issues from the human health perspective than there is space for in this paper. While these reports focus mainly on the human health aspects, some include agricultural pathogens in their lists of potential bioterror pathogens. The reports note the devastation to national economies that could ensue from the introduction of some of these pathogens into susceptible animal populations.

The veterinary community needs to be more aware of the legal requirements related to forensic investigations so that veterinarians will be prepared to properly handle evidence within their own fields. Are veterinary laboratories prepared to deal with biocrime or are they in a position similar to the Public Health Laboratories (PHL) of the USA in 2001? Diane Barden, the weapons of mass destruction coordinator for the Connecticut State PHL, stated:

'there was one event prior to my start [March 2001]. … A threat letter was sent to an abortion clinic and the Federal Bureau of Investigation (FBI) hand-delivered the letter to the laboratory. That was the first contact we had with the FBI and handling criminal evidence. As you might imagine, it did not go very well' (4).

Veterinary laboratories must be prepared to deal with issues such as chain-of-custody, secure storage of evidence, tracking of individual items of evidence and their derivatives and all the other legal requirements for handling evidence (26). No matter how good a laboratory may be at microbial forensics, a case may well be lost if evidence is not admissible in court due to a problem with documentation of the chain-of-custody (28). The principal objective of this paper is to increase awareness of microbial forensics among those interested in infectious diseases of animals and zoonoses.

Microbial forensics

Forensics is defined as 'the use of science and technology to investigate and establish facts in criminal or civil courts of law' (2). It is a multidisciplinary endeavour involving pathology, toxicology, computer investigation, fingerprint analysis, anthropology, DNA technology and other elements. It focuses on the person or persons who perpetrated the crime, and also on the victims and their related microbiology. Microbial forensics is a new branch of the forensics field and not yet widely recognised, although recent bioterror events, especially the anthrax incident of 2001 in the USA, have highlighted its importance. At the same time, swift action is needed to limit the scale of any outbreak and reassure the public when events are under control. Microbial forensics has been defined as 'a scientific discipline dedicated to analysing evidence from a bioterrorism act, biocrime or inadvertent microorganism/toxin release for attribution purposes' (7, 19).

Microbial forensics builds on traditional microbiology and epidemiology within a legal framework. Investigations of suspected biocrimes have many similarities to epidemiological investigations of naturally occurring infectious disease outbreaks, but also some differences (Table I). In conventional forensics, testing and characterisation of human DNA from crime scene samples is important for the identification of individual persons. Microbial forensics also utilises genetic material, but again there are important differences. Investigation of human-derived specimens involves only one species, and forensics experts are able to use a set of only 10 to 17 microsatellite loci on the genome for most identifications (8). In contrast, microbial forensics is much more complicated due to the large number of potential bacterial or viral species involved, and to the complexity of microbial dynamics, evolution and spread. The large number of microbes that are candidates for biocrimes and bioterror places practical limits on the development of forensic signature assays, specimen archives and databases for use in forensic investigations.

Table I
Comparison of forensic and epidemiological outbreak investigations of infectious disease

Feature	Type of infectious disease investigation	
	Forensic	**Epidemiological outbreak investigation**
Direction	Police or other law authority	Veterinary or public health officer
Principal goals	Identify source to control outbreak, plus attribution – identify and successfully prosecute the perpetrator	Identify source to control outbreak, plus identify causal factors in order to prevent recurrence
Secondary goals	Deter other perpetrators	Contribute new scientific or risk management knowledge
Case definition	Yes	Yes
Describe and enumerate symptoms in cases	Yes	Yes
Infection distribution in population	Maybe	Yes
Establish mode of transmission	Yes	Yes
Compare odds of disease in exposed and unexposed individuals	Probably	Yes
Collect samples for analysis	Yes	Yes
Laboratory support	Veterinary and public health and forensic	Veterinary and public health
Standard protocols for chain-of-custody	Yes	Sometimes, but not as stringent
Identification of infectious agent	Greatest possible level of detail	To species level at least, may need greater definition
Identify source	Yes	Yes
Involves legal proceedings	Yes	Not usually

Need for collaboration and partnerships

Most veterinarians and public health officers have little or no experience with investigation of biocrime or bioterror incidents, and therefore are unlikely to be familiar with forensics. Is there a need to change this situation? To the extent that the societal risk from such deliberate incidents involving animals is low (that is, they continue to be rare and limited in scale), it may be sufficient in some countries to rely on the forensics capabilities of traditional law enforcement agencies. Whether the likelihood of deliberate incidents is increasing or not is not known, but it is known that the potential impact of deliberate introduction of animal disease (e.g. foot and mouth disease) or zoonotic disease (e.g. yersiniosis) is considerable. (For further information see papers in this publication by Hugh-Jones, Wilson *et al.*, Ackerman, Lyra, Woolridge, Ozawa *et al.*, Davies, and Domoradskiy and Orent.) Therefore, in countries that are especially vulnerable, existing animal health surveillance and disease control capabilities should be reviewed in order to enhance detection and management of bioterror and biocrime incidents, and to establish linkages with microbial forensics experts in the human field. It is logical that specialists in traditional and bioterror/biocrime forensics should help each other and collaborate closely. A synergy between the two will increase and widen their collective experience and expertise, building a resource for the future. There is also a pressing need for better integration and cooperation between public health and animal health surveillance programmes (18).

Capabilities in animal health should focus on building capacity to detect and report increases in morbidity and mortality among animals that might reflect a covert release of a pathogen. Suspicion should be raised when epidemiological patterns are different from those expected for the animal population and the pathogen in question. Existing capacities for detecting and reporting even endemic diseases should be an international priority for the prevention of catastrophic losses in animal and potentially human life. In the case of a covert attack (an unannounced intentional release), animal or public health authorities will initially be directing the investigation. Investigations should routinely be conducted in a manner that preserves the integrity of potential crime scenes and evidence for future forensic and criminal investigations. It is important that investigators should consider the possibility of deliberate disease introduction at an early stage, otherwise the opportunity to investigate the incident properly may be delayed or missed.

Veterinary laboratories must be prepared to deal with issues such as chain-of-custody, secure storage of evidence, the tracking of individual items of evidence and their derivatives, and all the other legal requirements for handling evidence (26). Chain-of-custody protocols provide a documented unbroken chain of records showing who had control of the evidence as well as each transfer of its possession by secure and traceable means. This process begins with the original sample, which must be labelled with the date and time of collection as well as the initials of the person collecting it and identifiers (e.g. a code or numbering system that will distinguish this sample from

others collected at the scene). Any one of the individuals in the chain-of-custody may be called into court to testify to the identity of the sample (28).

Once at the laboratory the evidence must be kept secure to prevent unauthorised access and the risk of contamination, misidentification or tampering (26, 28). There are several levels of security to consider, ranging from levels of security within the building itself (e.g. restricted access zones and high security zones), methods of controlling access for authorised staff into these zones (e.g. electronic keypads or keys), and security features of the storage unit where the sample itself is held (e.g. exhibit locker, fridge). For example, the storage unit itself should be locked with a high security lock and there should be only two keys per lock. One key is signed out to the individual responsible for the sample and the other stored in a sealed envelope in a safe.

These examples illustrate only a few of the legal requirements needed to maintain the admissibility of evidence at a trial. The chain-of-custody is a complicated series of events with potential for errors at any point. The veterinary community looks at this issue from the viewpoint of providing solid evidence for a trial or legal proceedings; however, viewing the situation from the perspective of a criminal defence lawyer can provide useful insights into possible weaknesses in the laboratory's procedures. A variety of tactics may be used to discredit forensic experts and laboratory results. These may include:

– reviewing past laboratory assessments for deficiencies

– demonstrating conflicts of interest for scientists and staff who own or hold shares in the lab, or in companies that produce diagnostic tests used there

– acquiring laboratory documentation on quality assurance (QA) and quality control

– acquiring laboratory bench notes and using them to develop questions that would be difficult for any expert to answer (17).

When crimes are overt – that is to say, identifiable as such from the beginning or announced in advance by the perpetrator – law enforcement officials will immediately assume direction of the investigation, but may request assistance from animal or public health officials. Whether intentional releases of pathogens and ensuing outbreaks among animals are overt or covert, unobstructed and direct communication between animal health and law enforcement officials is necessary. Also, public health services may be involved to mitigate the effect by initiating medical countermeasures. A report by the American Academy of Microbiology proposed that training in forensics should be given to personnel responsible for the first responses to attacks on human populations (1). Whether such training could in practice be worthwhile for veterinarians is debateable, given the rarity of biocrimes involving animals. The potential impacts of such crimes are highest for foreign animal disease introduction, and it would therefore be prudent to provide some degree of forensics training to veterinarians responsible for the first response to foreign animal disease incursions. As 'war games' practising responses to routine outbreaks can lose their novelty, the occasional and unannounced use of a bioterrorist scenario will provide the opportunity for training in forensic response.

Forensics laboratories may not have microbiological capabilities, and especially the proper facilities to handle samples contaminated with dangerous pathogens or to isolate and characterise these pathogens. This is a logical area for partnership, with a well-equipped veterinary laboratory or PHL providing the facilities for microbiological work, and the forensics experts providing the expertise in handling and forensic examination of evidence (8). In the USA, such a partnership has been established in the human field, and involves the FBI and the Bioforensics Analysis Center at Fort Detrick, Maryland. The partnership will also include the Plum Island Foreign Animal Disease Laboratory. In the veterinary field, the USA has undertaken a pilot project for a National Animal Health Laboratory Network involving federal and state laboratories with the aim of enhancing the speed of responses to animal health emergencies (32).

Laboratory techniques

An important role of microbiological testing is to compare isolate characteristics (e.g. species, serotype, phage type, genetic profiles) among evidence samples and reference cultures and strains, to determine whether the various isolates are from the same source or lineage, or conversely at least to confirm an independent origin (7). Observed differences may or may not be sufficient to demonstrate that microbes are from the same source or lineage or of independent origin, depending on the accuracy and precision of the test procedure, the characteristics of the test organisms (e.g. laboratory or wild strains) and the expected mutation rates. For example, minor differences at rapidly evolving sites in the genome may not alone justify the conclusion that the organisms derive from different lineages from the reference strains or known recoveries, or are meaningfully different from the other field isolates. Adding to the potential confusion, natural outbreaks can sometimes involve multiple strains; an example would be livestock anthrax from feed containing contaminated bonemeals (8).

Microbial forensics examinations share many techniques with conventional diagnostic or research examinations, including culture and speciation of isolates, phenotyping,

phage typing, fatty acid composition analysis, and genetic characterisation (9). Newer techniques, such as microarrays and isotope analysis, may also be important. For example, in the investigation of the 2001 anthrax bioterror incident in the USA, a multilocus variable number of tandem repeats analysis was used to identify the *B. anthracis* spores as belonging to the Ames strain (8). Other techniques that may be employed include microsatellite and minisatellite loci typing and real-time polymerase chain reaction (PCR) (8).

Although microbial forensics employs genetic tools for strain identification, it is important to draw a distinction between this and the use of human DNA analysis in conventional forensics. Human DNA analyses are important tools in modern forensics. They are used for attribution to specific individuals when matches are found between DNA in crime-scene samples and samples from suspects of the crime. Conversely, DNA analyses may be important in eliminating suspects when mismatches are found. In contrast, the power of genetic analyses in microbial forensics is more limited, due to the clonal nature of microbial populations and the lack of high-quality microbial population and phylogenetic databases (8, 10); it is not possible to distinguish among members of a clone that may be widely dispersed, and microbial databases are not organised with forensics in mind. However, as demonstrated in the examples described below, useful qualitative information concerning attribution may be obtained, and mismatches are quite useful in eliminating individuals or premises from the list of suspects.

Genomics is increasing the power of microbial forensics by assisting in the design of gene-based diagnostic tests and guiding interpretation. The genomes of some of the important zoonotic pathogens (e.g. *Salmonella* Typhimurium and *Escherichia coli* O157:H7) have been sequenced, as have various strains of important threat-level biological agents (e.g. *B. anthracis*) (1, 8). However, the costs and technical demands of sequencing, and the difficulty of identifying distinguishing genetic markers, place practical limits on these techniques for use in animal-derived infectious disease outbreaks. Bioinformatics tools (e.g. software) are important for finding genetically related organisms represented in databases and ascribing statistical confidence limits on matches (8). Suitably validated methods are obviously preferred for forensics purposes because they are more likely to be recognised in courts of law.

Forensic testing errors have become increasingly evident, since human DNA testing has supported the wrongful conviction of numerous individuals on the basis of inappropriately used forensic evidence (involving hair, ballistics, fingerprints and similar tests). Such cases have cast doubt on some long-accepted procedures, many of which had not been fully validated (25). There has also been a belated recognition of poor standards in individual laboratories, unfortunately sometimes of long standing. In the USA the current standard for admissibility of scientific evidence in the courtroom is the so-called 'Daubert test', which states that the admissibility of scientific testimony should be based on sufficient facts or data, and that these data should be the product of reliable, internally validated methods which have been stringently applied (25). Thus, great emphasis is placed on the methods used in forensics.

Information networks

Localised outbreaks of disease may be quickly identified by alert veterinary and public health officers. However, special systems may be helpful for rapidly detecting spatially and/or temporally dispersed outbreaks, and for identifying local clusters as part of larger outbreaks, such as food-borne outbreaks that are spread nationally by the wide distribution of a contaminated product. Some systems of this type have been developed for naturally occurring disease; one example is the PulseNet System for subtyping food-borne pathogens (e.g. *E. coli* O157:H7) by pulsed-field gel electrophoresis (PFGE) (29). PulseNet is a US national network of local, state and national PHLs with its headquarters at the Center for Disease Control (CDC) in Atlanta, with collaborative networks in other countries and regions, such as Canada, Latin America and Europe. Using standardised PFGE protocols, participating laboratories can submit DNA patterns of strains of *E. coli* O157:H7, *Salmonella*, *Shigella, Listeria* or *Campylobacter* to the CDC database. The database is open for use by participants, which facilitates rapid comparison of PFGE patterns. There is a need in animal and human healthcare for additional systems that can track infectious disease incidents in real time to improve detection capability and the speed of response.

Quality assurance

Quality assurance is an important aspect of forensic examinations, and the recent emergence of the field of microbial forensics has benefited from QA experience in human DNA testing (19). Recently, a Scientific Working Group on Microbial Genetics and Forensics was created to develop laboratory guidelines (26). The recommendations cover many features familiar to conventional diagnostic laboratories, including documentation of laboratory organisation and management, personnel qualifications and training, sample control, analytical procedures, standard operating procedures, calibration and maintenance, documentation and report writing, and auditing, among other aspects. Special considerations for forensics include the need for personnel security

clearances, facilities for the secure storage of evidence, tighter procedures for sample control (e.g. records of the names of individuals involved in sample collection and transport) and chain-of-custody within the laboratory. Method validation is very important for the credibility of forensics data in legal proceedings.

Examples involving animal or zoonotic infections

The 2001 'anthrax letters' incident in the USA has already been mentioned as highlighting the importance of microbial forensics and is a good example of the type of situation for which law enforcement and public health officials need to prepare (1). Fortunately, nothing like this has recently been detected in the animal health sector. There have however been several historical and recent incidents involving animals where criminal activity or criminal negligence may have directly or indirectly threatened the health of livestock populations or the public. A few are briefly summarised here.

Deliberate infection of animals in time of war

During the First World War the Germans carried out a variety of biological attacks on different types of livestock. Unlike chemical warfare programmes, this biological programme was not well documented and is the subject of some debate (27). The best-known example was the case of Dr Anton Dilger, a German-American physician living in a northwest suburb of Washington, D.C. Supplied with seed stocks of *B. anthracis* (anthrax) and *Burkholderia mallei* (glanders) by the Imperial German government, he set up a small laboratory in his home and is believed to have produced about a litre of agent. Assisted by Captain Frederick Hinsch, this effort was claimed to have resulted in the infection of 3,500 horses, mules and cattle waiting to be shipped to Allied forces in Europe (13, 34). The Germans were also reported to have successfully infected 4,500 mules in Mesopotamia with glanders. Other attempts by German agents were aimed at livestock in Romania, France, Norway and Argentina (5, 13, 16).

During the Second World War, in 'Operation Vegetarian' the United Kingdom (UK) developed and produced 5 million anthrax-laden linseed-oil 'cattle cakes' that were intended to be dropped from aircraft over German pastures to infect and kill beef and dairy cattle (16, 24). Each cake was 2.5 cm in diameter, weighed 10 g and contained 5×10^8 anthrax spores in a glass capillary tube (6, 14, 24). Prior tests showed that the cattle would die within 5.25 days after consuming a cake and it was estimated that about 80% of distributed cakes would be consumed within two weeks of being airdropped (14). Although everything was in place to carry out the plan in the summer of 1944, the Normandy invasion had taken place and the operation was cancelled. At the end of 1945 the cattle cakes were incinerated at Porton Down in the UK (24).

Following the Second World War the USA biological warfare programme tested hog cholera (classical swine fever) and Newcastle disease, using experimental bombs that released virus-coated feathers that would float down into farms (16).

An unusual anthrax outbreak occurred in Zimbabwe from 1978 to 1980, which may have been due to deliberate spread. Nass has suggested that:

'[an] explanation for the sudden peak of anthrax in the Tribal Trust Lands beginning in November, 1978, is that one or more units attached to the Rhodesian military may have airdropped anthrax spores in these territories. This action would expose cattle to the disease through ingestion or inhalation (or both) of anthrax spores' (20).

However, it is also possible that the outbreak was caused by natural events such as excessive rains, exacerbated by the civil conflict (e.g. failure of proper vaccination, and absence of veterinary services or inspection). *Bacillus anthracis* isolates from this outbreak may never have been characterised, indicating a possible role for microbial forensics. This case is an example of the difficulty of establishing or ruling out deliberate contamination, particularly in time of war.

Bird smuggling and influenza

In October 2004, customs officials at Brussels International Airport seized two crested hawk-eagles that were smuggled from Thailand (33). Virus cultured from the euthanised birds was identified as highly pathogenic H5N1 influenza virus on the basis of haemagglutination inhibition and RT-PCR testing. Follow-up investigations and actions resulted in the destruction of over 650 birds in quarantine, as well as medical examination of more than 25 persons who had been in direct or indirect contact with the birds, followed by oseltamivir prophylaxis. This case demonstrates the potential importance of animal smuggling in the unintentional international spread of important infectious diseases.

West Nile virus in North America

West Nile virus (WNV) is a zoonosis that first appeared in the New York City area in 1999 (11). In retrospect, it is evident that the infection first caused mortality in several wild bird species, then illness and mortality in humans.

Investigations of the outbreaks in humans and birds were conducted independently, and a lack of early and effective collaboration among the public health and animal health programmes probably delayed the timely recognition of the incursion (15). Previously, the virus had been found only in the eastern hemisphere, specifically in Asia, Africa, the Middle East and Europe. Since 1999, WNV has firmly established itself in a large portion of the USA and Canada (22). The epidemic strain of WNV was closely related to a strain circulating in Israel between 1997 and 2000, so the Middle East was the most likely source (21). How the virus arrived in North America is unknown but was the subject of much speculation, including the possibility of deliberate introduction (23). Probabilities include a human traveller infected in another part of the world, smuggling of infected birds, or inadvertent transport by an insect vector in an airplane. The history of WNV incursion into North America is important because it shows that delay in effective collaboration between public health and animal health surveillance programmes inhibits the rapid detection of outbreaks.

Escherichia coli and *Campylobacter* from cattle and contamination of municipal water supply

In May 2000, an outbreak of waterborne illness in Walkerton, Canada, due to *E. coli* O157:H7 and *Campylobacter jejuni*, caused approximately 2,300 cases of illness and seven deaths (3). Epidemiological and hydrological investigations were conducted to identify the source of the contamination. Evidence of bacterial contamination was found in one of the wells supplying the town. Faecal and environmental samples were collected from 13 farms in the vicinity of the town wells. While *Campylobacter* spp. were identified on nine farms, and *E. coli* O157:H7 were found on two farms, on only two farms were both pathogens found, including one farm adjacent to the contaminated well. Strain characterisation of the *Campylobacter* spp. isolates (heat-stable and heat-labile serotyping, phage typing, biotyping, fla-restriction fragment length polymorphism typing and PFGE testing) and the *E. coli* O157:H7 (phage typing and PFGE) showed that samples from that farm were identical to those found in most of the human cases (3, 12).

A subsequent public judicial inquiry into the incident concluded that the primary source of the outbreak was manure spread on the farm adjacent to the contaminated well. The inquiry found that the farmer was not at fault, because he had been following good farming practices. Other factors that were thought to have contributed to the well contamination were unusually heavy rainfall, poor well construction, and a failure to ensure proper chlorination and water quality monitoring (21).

Deliberate introduction of rabbit calicivirus disease (rabbit haemorrhagic disease) into New Zealand

In August 1997, rabbit calicivirus disease (RCD) was diagnosed by the Animal Health Laboratory in Wallaceville, New Zealand, using an antigen capture enzyme-linked immunosorbent assay from the World Organisation for Animal Health (OIE) Reference Laboratory in Brescia, Italy (see paper by Peter O'Hare in this publication; 30). An exotic-disease response was initiated by the Chief Veterinary Officer, and the vicinity of the outbreak was designated as a controlled area, with restrictions on animal and human movement. A criminal investigation was initiated to determine if the virus had been deliberately introduced. At a subsequent meeting of farmers and agriculture ministry staff, farmers admitted to widespread use of RCD in inoculated carrots and oats as a biological control of rabbits. Within a few days, additional outbreaks were detected in other regions of the South Island. Agriculture ministry staff concluded that eradication and containment of the infection was not feasible, and controls were lifted. The disease was initially detected only a few weeks after a government announcement that RCD virus would not be legally imported into New Zealand as a biological control agent for rabbits (30). No charges were apparently laid.

Deliberate *Salmonella* contamination of the food supply: The Dalles, Oregon

In September and October 1984, at least 751 persons contracted *Salmonella* gastroenteritis in The Dalles, Oregon (31). Ten restaurants were identified as the source of infection in most of the cases. Eating from salad bars was the main risk factor, although implicated foods on the salad bars differed among restaurants. The epidemiological investigation showed that no common mechanisms, such as specific foods or food handlers, were responsible for the contamination. Suspicious events associated with the outbreak were reported to local, State and Federal police. Police, with technical assistance from the Oregon PHL, investigated the facilities of the local Rajneeshee religious commune and seized a sample of *Salmonella* Typhimurium (indistinguishable from the outbreak strain and subsequently determined to have been obtained from a commercial supplier) from the commune clinic. Criminal investigations showed that members of the commune intentionally contaminated the salad bars. The apparent motive was to test a programme to incapacitate voters in an upcoming local county election. In 1986, two members of the commune pleaded guilty to charges of conspiring to tamper with food products by poisoning food, and were sentenced to 4.5 years in prison.

It is noteworthy that the initial epidemiological investigation did not recognise the outbreak source. It was

more than a year later that sufficient evidence was obtained to link the commune to the outbreak. The possibility of intentional contamination was considered early in the epidemiological investigation but was initially rejected for several reasons: no motive was apparent; no one claimed responsibility; the epidemic curves suggested that salad bars were contaminated on various occasions over several weeks; police investigation of initial questionable activities did not establish a pattern; no disgruntled employees were identified; and the investigators recognised that sources of outbreaks sometimes remain unidentified (31). This incident shows the challenges involved in early identification of deliberate contamination.

Conclusions

Incidents of deliberate animal-related infectious disease outbreaks are rare, although the potential health and economic impacts of such incidents on animals and the public are considerable. Enhanced capacity to investigate biocrimes and bioterror incidents will enhance national and international security. The most advanced capabilities in microbial forensics should be concentrated at the national level and focus on bioterror and agroterror. Cooperation is needed between traditional forensics laboratories and laboratories equipped to deal with level-3 and level-4 pathogens of animals and humans that may be used by terrorists or criminals. Only a few countries are likely to have the infrastructure to enable sophisticated microbial forensics capabilities, so there is a need for international cooperation on methods and facilities for the rapid and thorough processing of microbial forensics evidence. There is also need for better integration and cooperation between public health and animal health surveillance programmes. International organisations such as the OIE, World Health Organization and Food and Agriculture Organization have an important role in facilitating this cooperation. While specialised forensics training is of doubtful value for most veterinarians, public health officers and laboratory diagnosticians, these individuals should be cognisant of the possibility of criminal involvement in outbreaks of animal-related infectious disease, and recognise where they need to cooperate with law enforcement and traditional forensics investigators at an early stage. Quality assurance is very important to veterinary diagnostic and forensic laboratories alike. Therefore implementation of credible QA in veterinary laboratories, especially in relation to sample chain-of-custody, should strengthen the role of these laboratories in assisting the investigation of crimes.

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La microbiologie médico-légale lors d'épisodes de maladies infectieuses d'origine naturelle et intentionnelle impliquant des animaux

S.A. McEwen, T.M Wilson, D.A. Ashford, E.D. Heegaard, T. Kuiken & B. Kournikakis

Résumé

La microbiologie médico-légale est une discipline scientifique relativement récente qui consiste à analyser les données microbiologiques afin d'identifier les coupables d'un crime. Elle se fonde sur la microbiologie et l'épidémiologie classiques, mais dans un cadre juridique. Les principaux motifs des enquêtes médico-légales sont la recherche des coupables, leur poursuite en justice et, dans l'idéal, l'effet de dissuasion qui peut empêcher d'autres personnes d'accomplir de tels actes.

Dans le domaine de la santé animale, la recherche médico-légale devrait viser surtout à renforcer les capacités pour détecter et déclarer une augmentation de la morbidité et de la mortalité chez les animaux qui pourrait s'expliquer par la dissémination cachée d'un agent pathogène. L'existence de caractéristiques épidémiologiques autres que celles attendues pour la population animale et l'agent pathogène en question doit éveiller les soupçons. Les capacités existantes de détection et de déclaration des maladies épidémiques et même endémiques devraient constituer une priorité au niveau international pour que l'on puisse prévenir des pertes catastrophiques de vies animales et peut-être humaines. La communauté vétérinaire doit prendre davantage conscience des exigences juridiques liées aux enquêtes médico-légales afin d'être mieux armée pour gérer efficacement les preuves qui apparaissent dans son domaine.

Mots-clés
Animal – Biocriminalité – Bioterrorisme – Exécution de la loi – Maladie infectieuse – Médecine légale – Microbiologie médico-légale.

Microbiología forense para casos de enfermedades infecciosas de origen natural o intencionado que afecten a animales

S.A. McEwen, T.M Wilson, D.A. Ashford, E.D. Heegaard, T. Kuiken & B. Kournikakis

Resumen
La microbiología forense es una disciplina científica relativamente nueva que se ocupa de estudiar indicios microbiológicos para identificar al o los autores de crímenes. Se basa en la microbiología y epidemiología tradicionales, pero opera dentro de un marco jurídico específico. Entre las importantes razones que motivan una investigación forense cabe citar la prohibición de entrada o circulación de criminales, las actuaciones judiciales y, en el mejor de los casos, la disuasión de terceros a la hora de perpetrar actos similares.
En el terreno de la sanidad animal, la labor forense debería centrarse en reforzar los medios para detectar y notificar eventuales aumentos de la morbilidad y mortalidad de enfermedades infecciosas en los animales que pudieran ser indicativos de la diseminación encubierta de un patógeno. Cabe contraer sospechas cuando se observen patrones epidemiológicos anómalos en la población animal o el patógeno en cuestión. La capacidad de detectar y notificar enfermedades epidémicas o incluso endémicas debería constituir una prioridad internacional para prevenir pérdidas catastróficas de vidas animales e incluso humanas. Los círculos veterinarios deben conocer mejor los requisitos legales relacionados con las investigaciones forenses y estar así preparados para manejar correctamente las pruebas dentro de su propia jurisdicción.

Palabras clave
Animal – Aplicación de la ley – Bioterrorismo – Crimen biológico – Enfermedad infecciosa – Medicina forense – Microbiología forense.

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Toxins of concern to animals and people

T. Garland [1] & E.M. Bailey [2]

(1) Indiana Board of Animal Health, 805 Beachway Drive, Indianapolis, IN 46224, United States of America
(2) Department of Veterinary Physiology and Pharmacology, College of Veterinary Medicine, Texas A&M University, College Station, TX, 77843-4466, United States of America

Summary

Historically veterinarians have diagnosed accidental poisonings and identified possible terrorist events before they have come to the attention of public health authorities. There are many toxins that pose a threat to both humans and animals and the authors examine several of them here, namely, anthrax, tricothecenes, staphylococcal enterotoxin B, botulinum toxins, ricin, saxitoxin and dinoflagellate toxins. By discussing exposure routes, clinical signs and differential diagnoses the authors demonstrate how veterinarians are in a unique position to recognise zoonotic diseases, toxin exposure, and acts of bioterrorism. The work of veterinarians protects the food supply and contributes to human health and this article highlights the importance of coordination and communication between veterinarians and physicians. Sharing information is critical in confirming diagnoses and, in the case of intentional toxin attacks, could also be beneficial in identifying the perpetrators of the crime.

Keywords

Bioterrorism – Botulinum toxin – Ricin – Saxitoxin – Staphylococcal enterotoxin B – Toxin – Tricothecene.

Introduction

Veterinarians are in a unique position to be the first to observe an act of bioterrorism. They are trained to recognise zoonotic diseases and are in contact with animals that may be sentinels or targets of diseases spread by terrorists. The devastating effect on the livestock industry and the people associated with the industry was witnessed in the United Kingdom with foot and mouth disease, and has been seen in the western United States of America (USA) with Newcastle disease virus. However, with as much devastation and destruction as has happened, it was not as terrible as it could have been if either of these diseases had been a significant zoonotic disease.

There are a number of weaponised zoonotic diseases available to our enemies. Some of the diseases of concern to both humans and animals are anthrax, plague, smallpox, brucellosis and botulism. Toxins of concern to both humans and animals include T-2 toxin (also known as 'yellow rain'), ricin, staphylococcus enterotoxin B (SEB), botulinum, saxitoxin, aflatoxin and endotoxins, which are associated with some diseases such as anthrax.

Toxins are substances produced by an animal, plant or microbe, but which do not reproduce themselves. Toxins can be natural or man-made and produced by molecular biological techniques or by chemical synthesis. Generally, toxins are not volatile and do not directly affect the skin. Exceptions are the tricothecene mycotoxins and some of the algal toxins.

Some could be food or water contaminants. Some toxins are not regarded as the ideal weapon of mass destruction, possibly because they may be difficult to manufacture or to effectively disseminate. Toxins not considered here include those associated with the blue-green alga, some plant toxins such as abra or aconitine, and such marine toxins as tetraodotoxin.

When one considers the epidemiology of toxins, there are a few things to consider. Toxins are dose dependant, so large doses will produce a more rapid response than small doses. Also, some toxins, such as botulism, are so potent, that even tiny amounts may cause death very quickly. Toxins are pre-formed, so there is no incubation time necessary; there may be a latent period, largely dependent on dose and route of exposure, between exposure and the

onset of clinical signs. Toxins are not contagious between animals. Rather, animals must encounter the toxin individually. Therefore, it is often appropriate to look for a common source, such as food, feed, or water. Aerosolised toxins are likely to produce the same clinical signs in animals over a wide area, at essentially the same time. In the case of aerosolised toxins, multiple species may be affected. However, in the case of contaminated feedstuffs a particular species of animal is more likely to be affected more than any other species. Investigations into the possible source of a toxin should examine a change in source of feed, or commodities, or even employees handling the feedstuffs. Investigations should also examine water sources, including algae found on or in the source of water.

Some specific toxins

Anthrax

In 2001 anthrax made the news with events possibly related to terrorism. Anthrax can be acquired by contact, ingestion, or inhalation. Clinical signs vary depending upon the method by which the bacterium is acquired. When inhaled, the affects are much more rapid. Animals generally acquire the disease through ingestion of the spores. However, animals are also susceptible to the disease by inhalation. Clinical signs in animals are dyspnoea, trembling, collapse, convulsive movements, and sudden death. Cardiac and respiratory distress may be evident, and possibly a rise in body temperature. The body may not bleed from its orifices, depending upon the strain of anthrax. Signs and symptoms in human beings are dyspnoea, chest pain, headaches, as well as possible cardiac disturbances and a rise in body temperature.

Recently, a series of three toxic protein factors associated with anthrax have been identified. The three proteins are the protective antigen (PA), oedema factor (EF) and lethal factor (LF). The PA binds to the cell-surface receptors on the host's cell membranes. Following cleavage by a protease, PA binds to the two toxic enzymes EF and LF and mediates their transportation into the cytosol where they exert their pathogenic effects. The LF, the crucial pathogenic enzyme of anthrax toxin, and the EF cause cellular disruptions and imbalance in eukaryotic cells. This new understanding of this aspect of the bacterium may lead to new formulations for prevention and treatment.

Tricothecenes

One of the tricothecenes, T-2 mycotoxin, gained notoriety during the Vietnam-America war, when it was used in a chemical attack and became better known as 'yellow rain'.

The tricothecenes are comprised of about 150 structurally related compounds and are produced by several genera of fungi including *Fusarium, Myrothecium* and *Stachybotrys* (4). The naturally occurring mycotoxins in foods and feeds produced by *Fusarium* species include: deoxynivalenol (DON), also known as vomitoxin, T-2 toxin (yellow rain), nivalenol and diacetoxyscirpenol. The alimentary toxic aleukia which occurred in Russia in the early 1940s is thought to have been caused by T-2 toxin, but this has never been proven. T-2 toxin will produce an almost identical disease in animals. *Stachybotrys*-contaminated hay will induce a disease syndrome in cattle and horses and has been incriminated in a disease in humans. Tricothecene mycotoxins produce several disease syndromes in domestic animals. Tricothecenes have been found in corn, wheat, commercial cattle feed and mixed feeds. As a group, these mycotoxins can induce digestive disorders, haemorrhage, oedema, oral lesions, dermatitis and leucopaenia, all of which are radiomimetic-like effects (3).

Manifestations are the result of the inhibition of protein synthesis in rapidly proliferating tissues. Regardless of the route of exposure, intoxication has haematopoietic and immunosuppresive effects, central nervous effects, and vascular effects leading to hypotension and shock. Local route-specific effects may include: oral exposure with lesions to the upper gastrointestinal tract; local cutaneous necrosis and inflammation (dermal exposure); and corneal injury (ocular exposure) (9).

Clinical signs in human beings are recognisable after a variable latent period. The effects are seen between 2 and 5 minutes with ocular exposure, less than 1 hour after exposure via the respiratory route, between 1 and 3 hours following oral exposure and effects following dermal exposure may not be evident for 6 to 12 hours. Clinical signs in human beings include airway effects such as nose and throat pain, nasal discharge, itching, sneezing, coughing, dyspnoea, wheezing, chest pain and haemoptysis. Effects involving the skin include skin pain, pruritus, redness, vesicles, necrosis and sloughing of the epidermis. Prostration, weakness, ataxia, collapse, shock and death may follow severe intoxications. Clearly, this toxin affects many organ systems through the varied routes of dermal exposure, inhalation or ingestion. Some of these same signs may be evident in animals. Furthermore, it is possible for the slightly oily substance to transfer from the hair of animals to people. Animals and people can die from this exposure.

Decontamination may be effected by washing exposed areas of people and animals with soap and water. Penetration through the epidermal tissue is fairly rapid. However, decontamination will stop or decrease further exposure.

Intoxication caused by some of this family of toxins manifests as feed refusal in animals, especially in swine. Vomiting and dermal necrosis are also common. Goats standing in feed pans have suffered dermal necrosis, primarily on feet and legs, from contact with the toxin in the feed. Other animals have been similarly affected by tricothecenes. In the event of widespread use of T-2 mycotoxin, such as occurred in Southeast Asia, it is likely animal deaths would occur in multiple species including cattle, pigs, sheep and goats, chickens and ducks.

Staphylococcal enterotoxin B

Staphylococcus aureus produces a number of exotoxins, one of which is staphylococcal enterotoxin B (SEB). The toxins are excreted from the organism but exert their effects within the intestine; they are enterotoxins. The SEB is a pyrogenic toxin associated with food poisoning in humans. Clinical signs are markedly different if the toxin is ingested rather than inhaled.

Staphylococcal enterotoxins belong to a group of potent immune stimulants known as bacterial superantigens. There is a direct stimulation of a large population of T-helper cells by bypassing the usual antigen processing presentation. There is an intense inflammatory response that injures host tissue. The subsequent released cytokines are thought to mediate many of the toxic effects of SEB.

Clinical features are manifest after a latent period of 3 h to 12 h after inhalation or 4 h to 10 h after ingestion. Oral exposure results in predominantly gastrointestinal signs including vomiting and diarrhoea. Inhalation exposures produce predominantly respiratory signs, such as cough, dyspnoea, and possibly chest pain. Gastrointestinal symptoms may accompany respiratory exposure due to inadvertent swallowing of the toxin after normal mucocilliary clearance. Fever may last for up to five days. The cough may persist for four weeks. Human patients are essentially incapacitated. Companion animals are likely to be affected in much the same manner as human beings. Livestock may be affected similarly when exposed by the inhalation route, and colic may be seen in horses exposed through ingestion (12).

Differential diagnoses would include influenza, the adenoviruses and mycoplasma diseases. However, treatment is supportive in most of these.

Botulinum toxins

The previously mentioned toxins are very much of a concern with large impacts when used inappropriately. However, the toxic dose of botulism is extremely small and as such, more time in this chapter will be devoted to this particular toxin.

Botulism is a disease caused by one or more of the seven toxins which may be produced by various strains of *Clostridium botulinum*, a spore-forming, obligate anaerobic bacillus, commonly found in the soil and very easily isolated (22). The clostridial neurotoxins are the most toxic substances known, and only tetanus toxin from *C. tetani* and *Shigella* neurotoxins appear to have potencies of the same order of magnitude (5, 18).

Botulinum toxins have a history of being used or prepared for use in biological warfare, for example, in the 1930s the Japanese biological warfare group (Unit 731) fed *C. botulinum* cultures to prisoners in Manchuria, and the biological weapons programme in the USA, which was ended in 1970, produced botulinum toxin and botulinum toxoid in the 1940s in response to suspected German toxin weapons (22). Botulism is characterised by an acute, afebrile, symmetric, descending flaccid paralysis that always begins in the bulbar musculature in humans, but it causes a progressive, symmetric, ascending paralysis in dogs (5, 21). Botulinum toxin remains a potential terrorist weapon delivered either by contaminating food and/or feed stuffs or in an aerosol form. The likelihood of botulinum toxin contaminating municipal water supplies is highly unlikely because the toxin is rapidly inactivated by standard potable water treatments, and large amounts of toxin would be required (5). There are some doubts whether botulinum toxin could be weaponised because of constraints in concentrating and stabilising the toxin for aerosol dispersion (22). A deliberate release of a point-source aerosol botulinum toxin in an urban environment could, in theory, incapacitate or kill approximately 10% of the exposed human population (22). At a minimum, the same percent morbidity and mortality could be expected of an exposed animal population. In such an event the locations of affected and unaffected animals, along with parallel information on the human population, theoretically could be used to determine the area of exposure and therefore provide information on the mode of dispersal and potentially the volume released.

The seven distinct botulinum toxins (A-G) are defined by their antigenicity (22). In addition to *C. botulinum*, other clostridial strains may produce the toxins. The toxin is a dichain polypeptide weighing approximately 150 kD, which consists of a 100-kD 'heavy' chain and a 50-kD 'light' chain. Botulinum toxin in solution is colourless, odourless, and as far as is known, tasteless. It is inactivated by heat (> 85°C for 5 min) (22). The seven types of botulinum toxin do not necessarily cause disease in all mammals. Types C and D normally occur in domestic animals and wildlife, and type G is a soil isolate from South America. Primates are susceptible to aerosol samples of all three (22, 34). Types A, B, E, and F have been isolated in food poisoning cases in humans. Humans may be exposed to naturally occurring botulinum toxin by consuming poorly preserved food; small animals, dogs and cats may

be exposed by ingesting carrion, spoiled meat and compost piles; and herbivorous animals may become infected by ingesting decomposing animal carcasses (17, 21, 23, 34).

The LD_{50} (intravenous [IV] and intraperitoneal [IP]) of the various botulinum toxins range from 0.1 ng/kg to 40 ng/kg (1 ng = 0.000001 mg) (13). The cattle IV median lethal dose (MLD) is 0.388 ng/kg (23). It is estimated that the lethal oral dose of botulinum toxin is 500 to 700 times greater than the lethal parenteral dose and 77 to 100 times greater than the lethal inhalational dose (22). The estimated human parenteral lethal dose is 1.3 ng/kg to 2.4 ng/kg, and the parenteral minimum lethal dose in animals is estimated to be 1.0 ng/kg. The human inhalational lethal dose is approximately 0.01 ng/kg, and the oral lethal dose is 1.0 ng/kg (5). Most avian species, including domesticated and wild fowl, are affected by botulinum toxin (13, 28). Based on a limited sample of birds, the American turkey vulture (*Cathartes aura septentrionalis*) appears to be resistant to the effects of botulinum toxin (5, 22, 28).

Botulinum toxins may be absorbed via any mucosal surface, but most commonly they are absorbed through the gastrointestinal tract following oral exposure (22). In the case of inhalational exposure, botulinum toxins may be absorbed through the lungs as has been shown experimentally in primates and in humans following a laboratory mishap (19, 34). The evidence of this toxin's ability to affect the lungs led to it being developed as a weapon. Botulinum toxins may be absorbed through devitalised wounds containing anaerobic tissue. The toxins do not penetrate through intact skin. The botulinum toxins are distributed by the blood to the various tissues, but they do not penetrate the blood-brain barrier. The biotransformation mechanisms, distribution kinetics, and excretion of the botulinum toxins are unknown (3).

Botulinum toxin binds to the presynaptic membrane at the neuromuscular synapse, but the structure of the receptor(s) is (are) unknown. The receptor-bound toxin is internalised by a mechanism known as receptor-mediated endocytosis, and the vesicles are transported within the cell (22). The light (50 kD) chain is cleaved from the heavy chain, leaves the vesicle, and prevents the synaptic vesicle containing acetylcholine from fusing with the neuronal membrane. This action prevents the release of the acetylcholine and results in a flaccid paralysis where the muscles are unable to contract (5).

With naturally occurring botulism, there may be a history of unsupervised animals with access to carrion, garbage, and compost piles (21). In the case of inhalation exposures, presenting animals may be the first indication of a terrorist action in the area. The chief complaint is a progressive rear end weakness or paresis starting 12 h to 6 days post-exposure. Possible signs include progressive, symmetric paresis and/or paralysis beginning in the pelvic limbs, and ascending to include the thoracic limbs. Cranial nerve signs include mydriasis, slow pupillary light response, decreased jaw tone, decreased palpebral and gag reflexes, and weak vocalisation. Keratitis and conjunctivitis may occur because of weak palpebral reflexes. The respiratory pattern is characterised by diaphragmatic respirations with limited costal respirations. Bradycardia, constipation, and urinary retention are very common. As in humans, there is no loss of mental awareness or pain perception. Interestingly, in dogs the tail wag is usually still present (21). Megaesophagus and aspiration pneumonia may be complicating factors (32).

There are no common laboratory abnormalities typical of botulism (21). The occurrence of secondary bacterial infections may cause white blood cell abnormalities, and depending upon the time sequence, an increased packed-cell volume may be seen if dehydration is occurring (30). An electromyogram may or may not be beneficial. Because megaesophagus commonly occurs, thoracic radiographs are indicated.

The definitive diagnosis depends upon toxin identification. In the case of oral exposures, most diagnostic laboratories require at least 4 ml of serum and 50 g of vomitus, faeces, or ingested food samples. It is best to call the laboratory that is doing the testing in advance and find out what samples are most appropriate and how to properly preserve them. In the case of inhalational exposure with botulinum toxins, the toxins cannot be identified in body fluids other than nasal secretions. Therefore the best diagnostic sample for immunological identification is from nasal mucosal swabs obtained within 24 h of exposure (22).

Treatment in cases of botulism normally includes supportive therapy consisting of maintaining hydration and nutritional support (21, 30). If the animal is hypoxaemic, oxygen therapy, including a tracheostomy and intermittent positive pressure ventilation, may be indicated. In animals able to swallow, hand feeding and watering may be used (30). If the animal is unable to swallow, enteral feeding via a nasogastric tube, esophagostomy tube, or gastrostomy tube, will be indicated (30).

Soft bedding with frequent repositioning will be required to prevent decubital ulcers and prevent atelectasis leading to the development of pneumonia. Animals with megaesophagus may develop aspiration pneumonia. Additional nursing care may include eye ointment to prevent keratitis, warm water enemas, and periodic expressing of the urinary bladder (21).

A licensed antitoxin is available, but is of no value for toxins already internalised into the neurons (22). If

available, 5 ml of the antitoxin should be administered IV or intramuscularly (IM) once as early as possible, but within five days of exposure (21). The antitoxin is made from horse serum; therefore the clinician should administer a test dose of the antitoxin intradermally before administering the antitoxin to determine any hypersensitivity. The clinician should be ready to treat an allergic reaction.

The prognosis for clinically affected animals is guarded to poor.

No specific gross or histological changes have been reported.

Differential diagnoses should include tick paralysis, coonhound paralysis, myasthenia gravis, the dumb form of rabies, coral snake bite, chronic ionophore poisoning, macadamia nut ingestion, and chronic low-dose exposure to some organophosphate (OP) insecticides (21, 32). Some animals are extremely sensitive to OP insecticides.

In the case of tick paralysis, there will be a history of finding either *Dermacentor variabilis* or *D. andersoni* in the USA or *Ixodes holocyclus* in Australia (21, 32). There are no cranial nerve abnormalities as are present in botulism toxicosis. The clinical signs rapidly abate following tick removal and/or removing the ticks with organophosphate insecticide solutions along with appropriate nursing care. Organophosphate insecticide may be among the acracides used to rid the animal of the ticks.

Animals with coonhound paralysis generally have a slower onset of signs (seven to nine days) (21, 32). There is usually pronounced muscle atrophy present, and cranial nerve signs are either mild or absent.

In animals with myasthenia gravis, the signs are episodic and most commonly related to exercise (21, 32). Edrophonium causes an improvement of clinical signs and may be treated with supportive care and/or anticholinesterase drugs. A large number of these animals may have a spontaneous recovery (32).

Animals with the dumb form of rabies sometimes exhibit muscular weakness (21). Immunisation status should be confirmed and the possibility of exposure to rabid animals explored. Appropriate safeguards must be instituted until a diagnosis is made.

Coral snake venom will cause an ascending flaccid paralysis and depression in dogs and cats (27). The onset of the clinical signs may be delayed for 10 h to 18 h. This is in contrast to the 12-h to 6-day delay of onset of signs in botulism. A history of exposure and/or the presence of bite wounds should assist in the diagnosis (21).

Dogs and especially cats may develop a general neuromuscular weakness syndrome following a chronic low-dose exposure to some organophosphate insecticides (2, 16). This syndrome has been characterised as the 'intermediate' syndrome (16). Many of these animals respond to appropriate doses of atropine and pralidoxime (2-PAM) and occasionally the oral or intramuscular administration of diphenhydramine (4 mg/kg, IM or PO), b.i.d. for several days (2, 16). Acetylcholinesterase levels may be depressed at the time of presentation.

Ricin

Ricin has previously been used as an agent of assassination. Ricin is still a threat to humans and animals.

Ricin is a naturally occurring toxin isolated from the castor bean plant (*Ricinus communis*) (7). The ricin concentration in the plant is approximately 1% to 5% by weight. Approximately 1 million tons of castor beans are processed annually in the production of castor oil for lubrication and medicinal purposes (11).

Ricin is a large glycoprotein, which is a water soluble, white powder in pure form, stable under ambient temperature conditions, but heat labile (7). Heating the compound to 80°C for 10 min or 50°C for 50 min. effectively inactivates the protein. Ricin has a molecular weight of 66 kDa, which is slightly smaller than albumin, and consists of two chains, A and B (14). Two haemagglutinins are associated with ricin, but their significance is unknown (11).

Ricin is easily obtained in small or large quantities throughout the world. Criminal use is commonly in domestic murders. It is a potential terrorist weapon, but not likely as a chemical warfare agent because large quantities would be required in an aerosol form (31). It can be used to contaminate food or small bodies of water, but aerosolisation would be required in most potential terrorist or weapons of mass destruction activities (11). Ricin has been used for assassination and suicidal activities in humans (26). Toxicities have been associated with accidental ingestions of castor beans in humans, dogs, and horses (1, 6, 7, 25, 29, 33). Ricin occurs as a residual product from the plant material after oil extraction. The material remaining after oil extraction requires additional purification before use (1, 7, 33) as a feed. The residual 'cake' is used in some parts of the world for fertilizer and cattle feed, but the latter is used only after heat treatment (7, 33). Castor oil does not contain ricin and is used for lubricants and as an irritant laxative (14, 33).

The toxic or lethal dose of ricin depends upon the species exposed and the route of exposure (14). There is greater than a 100-fold difference between the susceptibility of

various species (6). The oral lethal dose of seed material (assuming 1% to 5% ricin concentration) has been reported for the following species:

– chicken = 14 g/kg (140 mg to 170 mg of ricin/kg);

– swine = 1.3 g/kg (13 mg ricin/kg to 65 mg ricin/kg);

– rabbit = 0.9 g/kg (9 mg ricin/kg to 45 mg ricin/kg) (20);

– horse = 0.1 g/kg (1 mg ricin/kg to 5 mg ricin/kg) (7, 14).

The reported toxic oral doses of pure ricin are:

– mice = 20 mg/kg (LD_{50}) (10);

– horse = 1 to 5 mg/kg;

– dog = unknown, but probably similar to mice (10);

– humans = it is speculated that the lethal dose is 1.0 mg/kg, but some authors question if ricin is that toxic to humans (7, 14).

The intravenous toxic doses of ricin have been reported as being:

– mice = 5 µg/kg (LD_{50}), with the minimum lethal dose varying from 0.7 µg/kg to 2.7 µg/kg (10);

– human = unknown, but 1 µg/kg to 10 µg/kg is the suggested toxic dose;

– dog = the MLD is 1.6 µg/kg to 1.75 µg/kg (7, 10, 14, 31).

The inhalation toxic doses are:

– mice = 3 µg/kg to 5 µg/kg (LD_{50}) (10);

– monkeys = 21 µg/kg to 42 µg/kg is the reported lethal dose) (14, 35).

The IP LD_{50} in mice is 22 µg/kg (10, 14). Subcutaneous or intramuscular toxicity of ricin ranges from 24 µg/kg (LD_{50}) in mice, 33 µg/kg to 50 µg/kg in rats (lethal dose [10, 15]), and 70 µg/kg is apparently a lethal dose in humans, but an individual receiving an estimated 140 µg/kg survived with hospitalisation (7, 14).

Ricin is a large protein molecule, which is poorly absorbed from the gastrointestinal tract (14). After an oral exposure, most of the ricin is found in the large intestine 24 h after ingestion, illustrating the limited systemic uptake of the protein (7). Based on mouse toxicity (LD_{50}) data, approximately 0.025% of the ingested ricin is absorbed following oral administration, but other work has shown that up to 0.27% of the ingested ricin may be absorbed (20, 24). Once absorbed, ricin is most likely distributed throughout the extracellular fluid space in the body (7, 14, 32). Ricin appears to be readily absorbed via the inhalation route, but dermal absorption is unlikely to occur through intact skin (7, 14). Intravenously administered ricin distributes primarily to the spleen, kidneys, heart, and liver, and intramuscularly administered ricin distributes to draining lymph nodes (7).

The B chain of ricin binds to galactoside-containing proteins on cell surfaces, which allows for the internalisation of the A chain by triggering an endocytotic uptake (7, 14). This is the probable cause of the 8-h to 24-h latent period associated with ricin and/or castor bean intoxication because the transport may be slow in some instances (14). The A chain binds with the 28S RNA subunit of eukaryotic cells, killing the cell through the inhibition of protein synthesis (14). Ricin has also been shown to disturb calcium homoeostasis in the heart, leading to myocardial necrosis and cardiac haemorrhage. Ricin may target Kupffer cells, which give rise to the hepatotoxicity that is often reported (7, 25). It has been speculated that the lesions seen in ricin and/or castor bean intoxications may be due to effects on endothelial cells, causing fluid and protein leakage along with tissue oedema (7). Inhaled ricin binds to ciliated bronchiolar lining cells, alveolar macrophages, and alveolar lining cells (14). It is of note that castor beans and leaves also contain a pyridine compound, ricinin, which may cause neuromuscular weakness as a result of an interference with acetylcholine binding at nicotinic receptor sites (8).

The clinical signs associated with ricin exposure vary with the dose and route of exposure. With respiratory and/or inhalation exposures, there may be a preclinical dose-dependent delay of 8 h to 24 h (reported in rats and primates) before the onset of the clinical syndrome (10, 14). Anorexia subsequently develops, and there is a progressive decrease in physical activity, probably caused by developing hypoxaemia and the generalised toxic cellular effects of ricin (14). Respiratory distress starts developing, and there are increased inflammatory cell counts and increased protein from bronchiolar lavage at 12 h post-exposure. At 18 h post-exposure, alveolar flooding and pulmonary oedema develop, and at 30 h post-exposure, severe arterial hypoxaemia and acidosis are present. In humans a primary allergic syndrome has been reported in workers exposed to castor bean dust, but this type of syndrome has not been reported in animals (7, 14). Post-mortem airway and pulmonary lesions associated with inhalation exposure to ricin include marked to severe fibrinopurulent pneumonia, diffuse necrosis and acute inflammation of airways, alveolar flooding and peribronchial vascular oedema, acute tracheitis, and marked to severe purulent mediastinal lymphadenitis. The lung lesions are sufficiently severe to cause death. Adrenalitis and hepatic lesions may or may not be present.

Oral exposures to castor beans have been reported in dogs and humans (1, 25, 29). It should be noted that the beans must be broken or masticated for the ricin to be released

(1, 29). There may be a latent period of 8 h to 24 h following oral exposures to either ricin or castor beans. The gastrointestinal signs which may develop include vomiting (with or without blood), depression, diarrhoea (with or without blood), abdominal pain, and anorexia (1, 25, 29).

In humans there have been cases of intramuscular exposure to ricin and castor beans (14, 26). The initial signs have included localised pain and muscular weakness within 5 h of exposure. At 15 h to 24 h after exposure, high body temperatures, nausea and vomiting, tachycardia with normal blood pressures, swollen regional lymph nodes, induration at the injection site, and a leucophilia (26,000/mm^{22}) have developed in these individuals. At 48 h after exposure, hypotension, tachycardia, and vascular collapse developed in these individuals. At 72 h, anuria, vomiting blood, complete atrioventricular conduction block, and a white blood cell count of 33,200/mm^3 developed in these individuals. Death occurred very rapidly in spite of heroic resuscitation efforts.

The development of abnormal organ-specific biochemical values may not occur for 12 h to 24 h after exposure. The minimum database to be developed in cases of suspected exposure to ricin or castor beans should include serum alanine transaminase, serum aspartate transaminase, blood urea nitrogen, serum creatinine, CBC, PCV, and total serum solids.

Analytical methods exist for ricin, but they are not readily available at veterinary diagnostic toxicology laboratories.

There are no post-ingestion antidotes for ricin. Normal therapy for oral exposures should include induction of emesis if indicated, administration of activated charcoal (1 g/kg to 5 g/kg in a slurry), a cathartic – magnesium sucralfate (250 mg/kg, administered orally [PO]) or sorbitol (70%, 3 ml/kg, PO) – unless the animal already has diarrhoea, and the placement of at least one indwelling catheter for fluid therapy and other supportive medications. The hypotension which normally develops should be treated vigorously as in any emergency situation. Any seizures should be treated with diazepam (0.5 mg/kg to 1.0 mg/kg, IV). Sucralfate (0.25 g to 2 g, PO, t.i.d.) should be used as needed. The affected animals should be fed a soft, bland diet.

It is interesting to note that in 98 cases of castor bean toxicosis in dogs reported over an 11-year period, clinical signs developed in 76% of the cases, but only seven died. This is a fatality rate of 7.1% of total cases or 9% of those cases in which signs developed (three were euthanised, giving a true case fatality rate of 5%) (1). In more than 751 human cases of castor bean ingestion, 14 died, giving a 1.8% fatality rate (29).

Lesions caused by ingested ricin or castor beans include: liver necrosis, spleen necrosis, kidney necrosis, along with haemorrhagic gastroenteritis (14, 33). The lesions reported following intramuscular ricin exposure in humans included: severe local lymphoid necrosis, gastrointestinal haemorrhage, hepatic necrosis, diffuse splenitis, and mild to moderate pulmonary oedema. Similar lesions have been reported in experimental animals (11, 20).

The differential diagnoses could be many, depending upon the locale. Those which should be included are garbage poisoning, any other intoxications resulting in gastrointestinal distress (e.g. zinc phosphide, *Abrus precatorius* [precatory bean], inorganic arsenic, lead, mercury, thallium and DON), and numerous bacterial, viral, neoplastic, and inflammatory gastrointestinal insults.

Saxitoxin and dinoflagellate toxins

Saxitoxin is an extremely toxic water soluble substance produced by certain algae, principally dinoflagellates, which include *Alexandrium tamarense, Gymnodinium catenatum* and *Pyrodinium bahamense*. Many of the dinoflagellates produce the toxin associated with red tide (a phenomenon whereby water turns a dark reddish hue due to a sudden rise in algae population and the resultant high density of pigmented cells). The red tide toxins are most often associated with skin and respiratory irritation, and gastrointestinal distress if sufficient amounts of contaminated water are swallowed. Human intoxications have generally been related to the ingestion of infected molluscs. Paralytic shellfish poisoning is fairly well characterised. However, saxitoxin becomes a lethal weapon of concern when it is aerosolised. The inhalation LD_{50} of saxitoxin is 10 µg/kg of body weight. Approximately 2 mg inhaled is sufficient to kill a 70 kg person. Saxitoxin is a neurotoxin and causes respiratory paralysis. The most likely route of exposure is by inhalation or by toxic projectile.

Saxitoxin is a potent sodium channel blocker and like botulinum toxin has some medicinal uses, but although there are some medicinal uses for sodium channel blockers, saxitoxin is now regulated in the USA according to the terrorism prevention act which makes the possession of saxitoxin illegal. Although it may be obtained for medical and research reasons, it is not easily acquired through official channels. American Type Culture sold it with some degree of regularity before the terrorism prevention act. Earlier in the toxin's history it was only obtainable through the dinoflagellates. However, it can now be chemically synthesised and manufactured. Consequently, it becomes a very likely weapon of the terrorist.

Sampling

In most cases of intoxications, samples of feed, feed commodities, and other feedstuffs, such as hay or silage should be collected. Samples of water and any algae should be collected. Prompt refrigeration of the water samples may be necessary to preserve the algae and its toxin while the samples are being transported to the laboratory.

Biological samples, such as blood or serum, urine, and/or vomitus may be useful in determining the toxin. In some circumstances, hair samples with the suspect toxin may be useful in identifying the toxin.

Most veterinary diagnostic laboratories will be helpful in answering questions as well as providing a diagnosis, if one is not readily apparent. Furthermore, the diagnostic laboratory is a great source of information in an emergency.

Conclusions

Coordination between veterinarians and physicians is critical. This cannot be over-emphasised. Outbreaks in people and animals may occur virtually simultaneously. While the diagnostic cause in either animals or people may be readily apparent, communication with the other sector may be critical in determining and confirming the diagnosis. The coordination of information may be beneficial in identifying the perpetrators of crimes as well.

Clinical signs of intoxications in animals and humans can be quite similar. Companion animals may be a source of exposure to humans. If the toxin remains on the hair coat of the animals, when their owners rub, comb or brush the hair surface that is holding a dermal contaminant, then the owners may be exposed. Similarly, humans can expose animals by feeding them table scraps. The concordance and discordance of species affected is of extreme importance in determining the source of exposure and the probable nature of the event, whether it was normal but unfortunate, or intended. Communication between veterinarians and public health authorities is necessary as clinical signs of intoxications are very similar between people and animals. The public health authorities are well versed in communicating with the public about any necessary precautions that should be taken. Public health officials are frequently one of the first sources of information the public will turn to when seeking answers.

Veterinary and human medical authorities and law enforcement personnel should have pre-existing agreements to jointly assist the other departments in solving crimes and diagnostic mysteries. These three groups of agencies are the most likely to receive telephone calls from the public in the event of a terrorist release of one of these toxins, which are capable of causing sudden, multiple deaths in humans and animals.

■

Toxines constituant une menace pour les animaux et l'homme

T. Garland & E.M. Bailey

Résumé

Dans le passé, les vétérinaires ont diagnostiqué des intoxications accidentelles et identifié des actions terroristes possibles avant qu'elles soient portées à l'attention des autorités de santé publique. Nombreuses sont les toxines qui représentent une menace pour l'homme et les animaux ; les auteurs en passent en revue plusieurs, à savoir l'agent de la fièvre charbonneuse, les mycotoxines de tricothécènes, l'entérotoxine staphylococcique B, les toxines botuliniques, la ricine, les saxitoxines et les toxines produites par les dinoflagellés. En examinant les voies d'exposition, les signes cliniques et les diagnostics différentiels, les auteurs montrent que les vétérinaires sont particulièrement bien placés pour détecter les zoonoses, l'exposition aux toxines et les actes de bioterrorisme. Les

vétérinaires, dans l'exercice de leur profession, protègent l'approvisionnement alimentaire et contribuent à la protection de la santé publique. Le présent article souligne l'importance de la coordination et de la communication entre vétérinaires et médecins. L'échange d'informations est crucial pour la confirmation des diagnostics et, dans le cas d'attaque intentionnelle par une arme à toxines, il pourrait également être utile pour l'identification des auteurs du délit.

Mots-clés
Bioterrorisme – Entérotoxine staphylococcique B – Ricine – Saxitoxine – Toxine – Toxine botulinique – Tricothécène.

Toxinas importantes por sus efectos en personas y animales

T. Garland & E.M. Bailey

Resumen
Históricamente, los veterinarios han diagnosticado casos de envenenamiento accidental y detectado posibles actos terroristas antes de que se ocupen de ellos las autoridades de salud pública. Hay muchas toxinas que son peligrosas tanto para personas como para animales, y los autores se detienen en varias de ellas: ántrax, tricotecenes, enterotoxina estafilocóccica B, toxinas botulínicas, ricina, saxitoxina y toxinas de dinoflagelados. Explicando las vías de exposición, la sintomatología clínica y el diagnóstico diferencial, los autores demuestran que los veterinarios se encuentran en posición idónea para reconocer enfermedades zoonóticas, casos de exposición a toxinas o actos de bioterrorismo. La labor de los veterinarios protege el aprovisionamiento alimentario y contribuye a la salud humana, y los autores subrayan la importancia que revisten a este respecto la coordinación y comunicación entre veterinarios y médicos. Compartir información es fundamental no sólo para confirmar diagnósticos sino también, en caso de ataque intencionado con toxinas, para ayudar a identificar a los autores del crimen.

Palabras clave
Bioterrorismo – Toxoide botulínico – Enterotoxina estafilocóccica B – Ricina – Saxitoxina – Toxina – Tricotecene.

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It is hard to predict the future: the evolving nature of threats and vulnerabilities

G.A. Ackerman

WMD Terrorism Research Program, Center for Nonproliferation Studies, Monterey Institute of International Studies, 460 Pierce St, Monterey, California, 93940, United States of America

Summary

This paper describes the evolving nature of threats and vulnerabilities associated with biological disasters with animal origins, and introduces some of the pitfalls and opportunities associated with anticipating future threats. Evolving threats and vulnerabilities include continued deforestation and encroachment on virgin habitats, the effects of globalisation on trade and transportation, the increased interdependence and social vulnerability of modern society, the commingling of intensive agriculture and traditional farming methods, the periodic appearance of pandemics and epizootics, and indications that numerous human actors are displaying an increasing interest in and capability of using biological agents as weapons. These developments must be viewed in the context of various impediments to accurately gauging future threats, such as the appearance of new elements that depart from current trends and the inherent difficulty in anticipating human, and especially terrorist, behaviour. The paper concludes with some broad recommendations for structuring a policy response to the threat in an environment of uncertainty about the future.

Keywords

Emerging disease – Epizootic – Foreign animal disease – Pandemic – Prediction – Simulation – Terrorism – Threat assessment.

Introduction

'Prediction is very difficult, especially about the future.'

Niels Bohr (1885-1962)

'For man does not even know his hour: like fish caught in a fatal net, like birds seized in a snare, so are men caught in the moment of disaster when it falls upon them suddenly.'

Ecclesiastes 9:12

The previous offerings in this volume have described the dangers stemming from biological disasters with animal origins and what is currently being done at both national and international levels to address the threat. Yet, looking forward, we are confronted with myriad uncertainties. The future is an 'undiscovered country' that lies forever just beyond the horizon of our perceptions and our present efforts. Where will a new major epizootic or pandemic arise, and what social and political environment will it emerge into? Who will pose the greatest bioterrorist threat in the next twenty years, and how do we stop them? As responsible actors in the fields of animal and public health, we cannot sit on the sidelines with a smug fatalism and provide hollow commentary after a biological disaster occurs. We place upon ourselves the burden of ameliorating some of the worst possible futures by preparing and planning for biological disasters. Thus, no matter how difficult this may prove, we are forced to explore the nebulous region of future environments and events. This paper will describe the evolving nature of threats and vulnerabilities associated with biological disasters with animal origins, and introduce some of the pitfalls and opportunities related to anticipating future threats.

Before embarking on the discussion, it is necessary to draw a distinction between two generic types of prediction that occupy opposite ends of a continuum. 'Strategic prediction' seeks to describe general trends and the existence and magnitude of future threats, whereas 'point prediction' focuses on the precise nature of future events, such as their exact timing and location. Generally speaking, the closer one moves towards seeking point predictions, the more difficult the enterprise of anticipation becomes. One must therefore be cognizant of the level or 'granularity' of prediction required for any particular question about the future, since it is not always necessary to expend a large amount of resources on attaining point predictions when strategic predictions will suffice to guide a particular policy decision.

Evolving threats and vulnerabilities

Several of the authors who have contributed to this volume – like many other contemporary experts – have alluded to a variety of important dynamics related to biological disasters with animal origins. To the extent that the past is a valid guide to future possibilities, these dynamics could yield perceptible patterns that are manifest as either ongoing trends or cyclical repetitions of past events. The following discussion is hardly comprehensive, and each element has been discussed in detail elsewhere, but the list should give the reader some idea of current phenomena that might contribute towards the future threat of biological disasters with animal origins.

Continued deforestation and encroachment on virgin habitats

Population pressures in many developing countries, together with increased demand for natural resources, suggest that current levels of deforestation and encroachment on natural areas are likely to continue, at least for the foreseeable future. Human beings have had little or no former contact with some of these areas (such as virgin rainforests in the Amazon or central Africa) and, as human settlement moves into these areas, the probability of hitherto unknown pathogens crossing over from indigenous wildlife to large human populations increases. Several serious human diseases (including human immunodeficiency virus, filoviruses such as Ebola, and arenaviruses such as Lassa and Machupo) are believed to have originated in previously remote areas and then crossed over to the human populations that have encroached on these areas, often through an animal vector. The emergence of a particular new pathogen could be regarded as a 'wild-card' event that cannot be predicted with accuracy; the environmental conditions that increase the likelihood of such an event do however constitute a discernible trend.

Globalisation: transportation and trade

The growth of global markets and the dramatic increases in flows of goods, animals and persons across national borders are often accused of causing harmful side effects. One area where such concerns are well founded is global public and animal health. Globalisation has made it far more difficult to keep animal diseases from spreading, and almost impossible to keep highly infectious human diseases contained. Previous global pandemics, such as the Black Death or the Spanish flu, took years or months to spread across far-flung geographic regions. Air transportation and uncontrolled immigration flows mean that today a pathogen could spread globally in a matter of days or weeks. Recent experience with SARS (which is less infectious than many other organisms) and avian flu indicate the difficulties associated with containing disease outbreaks in the 21st Century. Barring remedial measures such as greatly enhanced surveillance and international controls, the speed with which a highly infectious agent could spread worldwide is unlikely to decrease in coming years.

Increasing societal vulnerability

In addition to increased global interconnectedness, there are several aspects of modern society that arguably increase its vulnerability to biological disasters. These include:

– the growing dependence on networks that can fail catastrophically

– increased urbanisation and local population densities

– widespread use of antibiotics (in both animals and people) leading to increasing antibiotic resistance

– the ossification of public health and veterinary capabilities in many countries.

Moreover, many developed nations have not experienced a major human or animal disease outbreak in over half a century and their publics and governments are unused to coping, both politically and socially, with large-scale infectious disease. In short, the trend seems to be moving along the direction of greater societal vulnerability to either intentional or naturally occurring biological disasters, including those with animal origins.

Compromised immunogenesis and availability of treatment

A number of factors are contributing towards a diminution in the levels of immunity to disease. Increasing microbial

resistance to antibiotics and lower vaccination rates in ever denser populations are two areas of concern. The developing world faces particular problems in this regard, as famine and malnutrition negate immunogenesis (which may have been, for example, a complicating factor in the severe symptoms observed in the East African Rift Valley fever outbreak in 1997 to 1998) and pharmaceutical research continues to focus on more profitable treatments for maladies in the 'First World' (the so-called 'orphan disease' phenomenon).

Intensive agriculture and traditional farming

The rise in intensive farming methods in the livestock industry, including the centralisation of animal markets and high-density livestock rearing, has been singled out as an important contributor to disease outbreaks. Proponents of such farming methods have countered that it is traditional farming methods in which different species are raised in close proximity that facilitate pathogen mutations that cross the species barrier and lead to new outbreaks. We may indeed be getting the worst of both worlds – traditional farming that is still practised in many parts of the world, such as Asia, can precipitate new pathogens, while intensive farming practices can allow the new disease to spread quickly. The combination of two very different farming methods may therefore be making us increasingly vulnerable to emerging disease.

Periodic pandemics/epizootics

The above trends can also be viewed in a historical context. The past century has borne witness to periodic global outbreaks of certain diseases, such as influenza. Until we discover exactly how and why such pandemics and epizootics periodically reoccur, we would be foolish to believe that this pattern will not continue.

The increasing motivation and capabilities of non-state actors to use biological agents as weapons

The past decade has revealed an increasing interest by a variety of terrorist and other groups, from religious fanatics like Al-Qaeda to apocalyptic cults, in using biological weapons. This is reflected by many cases in the Monterey WMD [weapons of mass destruction] Terrorism Database (9). Thus far most of their attempts have ended in failure, as exemplified by the Aum Shinrikyo cult's series of unsuccessful attempts to use biological weapons. As the old adage goes, however, where there is a will there is a way; the successful preparation of weapons-grade anthrax spores by the unknown perpetrator of the 2001 'anthrax letter' mailings in the United States of America suggests that at least some terrorists or other nefarious state or non-state actors could soon attain a biological weapons capability. It is certainly conceivable that these actors might employ or target animals as part of their implementation of a bioterrorist attack. The effects of technological advances and ideological shifts on terrorist capabilities and motivations must be carefully considered. For example, rapid developments in synthetic biology and the advent of microbiological 'kits' may facilitate the capabilities of both state and non-state actors in this regard. Moreover, an assortment of persistent and burgeoning factors, from resource scarcities to intractable ethnic and religious disputes, means that general levels of conflict are hardly likely to decrease over the next twenty years. All else being equal, the greater the number of disaffected individuals, organisations and countries that resort to violence, the greater the probability that at least some will embrace biological attacks as a tactic.

In addition to the ominous (although by no means determinative) dynamics listed above, there is also the possibility of serendipitous events, so-called 'wild-cards', which could heighten the possibility of biological disasters with animal origins. An example would be the accidental or intentional production of completely new and incredibly virulent pathogens as a result of advances in synthetic biology. On the other hand, developments in fields such as synthetic biology could also lead to radical new treatments or prophylaxes that drastically reduce the threat of biological disasters.

Another factor that must be considered is that the actions of governments and the international community can have a large impact on the scale of the future threat. For instance, if governments adopt shortsighted and obstructionist approaches to disease surveillance (as several commentators have accused the People's Republic of China of doing in recent years), the threat of biological disaster will increase, whereas closer international cooperation and an increase in the resources devoted to monitoring both animal and human disease could greatly reduce the threat. Equally, the manner in which governments approach socio-political grievances at both the domestic and international levels can dramatically influence the number of would-be perpetrators of violence, including those who might choose to utilise biological means.

Impediments to anticipating future threats

Having considered some of the apparent trends in threats and vulnerabilities related to biological disasters with animal origins, policy-makers might be tempted to jump to

hasty conclusions. Before either overreacting or dismissing the trends as fantastic doomsaying, we need to take a step back and examine the very notion of prediction itself. There are a series of impediments, both conceptual and practical, which hamper any attempt to predict the nature of future biological disasters accurately. It is only by better understanding these that we can begin to address them and approach threat anticipation more wisely. The most important of these impediments are discussed below.

The fundamental unpredictability of certain classes of events

Most of us are aware of the basic epistemic distinction between 'those things we know that we don't know' and 'those things we don't know that we don't know', and recognise that the latter present more of a problem than the former. However, policy-makers often fail to realise that, when dealing with certain domains and systems, there are things that we absolutely cannot know. Philosophers and mathematicians have long known that truth in some systems cannot be attained (see, for example, Gödel's Incompleteness Theorems [5]), but such concepts have only appeared relatively recently in the biological and social sciences, with the broader application and publication of theories of chaos and complexity. For general, non-technical introductions to these topics, see James Gleick (4) and Mitchell Waldrop (13). David Snowden and Cynthia Kurtz, in their award-winning paper 'The new dynamics of strategy: sense-making in a complex and complicated world' (7), describe both the complex domain, in which patterns can emerge and be perceived but cannot be predicted, and the chaotic domain, which is devoid of cause and effect. The important implication of this for policy-makers is that if a question or aspect of a question (such as 'Where will the next major epizootic occur?') resides in one of these domains, the best strategy is not to attempt to predict an answer, but rather to ameliorate the threat by probing or shaping the environment in which the threat might arise.

Signals versus noise

There is currently more information available to scientists and policy-makers than ever before, from huge genomic databanks to myriad news and scientific publications. The sheer volume of information makes it impractical for any individual to monitor every possible information source to detect early signs of impending disaster, even if we knew what signs to look for. Those seeking to predict future threats therefore must rely on information sharing, extensive collaboration, and automated tools. Unfortunately, none of these, whether alone or in combination, has thus far been implemented in a manner that would comprise a robust method for finding the needle of true threat in the haystack of superfluous data.

The past as an indicator of the future

Most anticipation of future threats is based either implicitly or explicitly on extrapolation from past events. There is a variety of opinions on the utility of relying on past observables as indicators of future probabilities, ranging from viewing the past as an indispensable guide to the future to believing that concentrating on past experiences is, to quote the philosopher Nassim Nicholas Taleb, like 'drivers looking through the rear view mirror while convinced they are looking ahead' (11), so that we are blind to substantial future changes. The objective state of affairs probably lies somewhere in between. While the philosophers Thomas Hobbes and David Hume did a good job of highlighting the perils of induction (deriving general rules from a finite number of observations), there are many trends that are both observable and consistent, such as the worldwide increase in urbanisation with concomitant specific implications for public health. Past and present events can serve therefore as one (not the only) guide to anticipating future biological disasters, as long as one bears the following caveats in mind:

a) threats, especially in the biological realm, which includes such phenomena as rapid mutations of infectious organisms, are dynamic. If future disasters will look very different from those of today, we must be careful not to act like the proverbial generals fighting the last war by preparing responses applicable only to past disasters;

b) in many cases, the sample size of previous events for a particular threat is zero and we cannot rely on the past at all; for instance, no terrorist has ever synthesised a pathogen from scratch, but this does not mean that it will not happen. We must be especially cautious about using similar events as proxies, since the variance of outcomes presaged by indicators that differ only in seemingly minor aspects can be substantial;

c) in using past events, we often place undue emphasis on past observables: that is, we impute causation to those factors which we are able to measure and for which we have data. Since many less tangible aspects of historical cases are not recorded, we can develop false trend models and expectations of future events.

Outliers and discontinuities

Related to the above discussion is the very consequential impact of sudden, unexpected events that constitute radical departures from previous trends and experience. Although an extensive discussion of this topic is outside the scope of this paper (10, 11), any attempts at prediction must take into account so-called 'wild-cards', surprises and other rare events. This is compounded by the fact that these unexpected events often have large (and deleterious) impacts precisely because we are not prepared to respond to them. As William Freudenburg warns us, 'there is a

possibility that as time goes by and very rare and catastrophic events do not occur, an agency's risk assessors may begin to disregard the risk of those types of events entirely' (3). The sudden appearance of a new pathogen or the emergence of a terrorist group with completely novel characteristics are two examples of outlier (unpredicted and atypical) events that can have devastating consequences. One general strategy for dealing with such events is to develop flexible response plans that can adapt to a wide spectrum of threats, even those that are quite different from what we might expect.

Predicting human behaviour

The obstacles to threat anticipation mentioned above apply to all events, whether intentional or 'naturally' occurring. There are, however, several aspects of intentional acts by human beings that make prediction especially difficult and that come into play in any consideration of bioterrorism. First, human threats are even more dynamic than evolutionary factors, in that human beings can adapt their behaviour instantaneously, can strategise to avoid defences and can concentrate their efforts on vulnerabilities. Second, human beings display an exquisite diversity of action rarely observed in the natural world, with innovation a common occurrence amongst human adversaries. Lastly, while many natural processes are quite well understood and at least relatively well defined, the study of human mental processes is in many ways still very primitive, with few well-defined features and hardly any predictive tools with general application.

The extreme case of extremist behaviour

General difficulties in predicting human behaviour are exacerbated in the case of extremists such as terrorists, who are particularly wily and adaptive and often have obscure motivations for action. The most obvious (and serious) complication stems from the fact that terrorists and many other dangerous actors, by their very nature, operate clandestinely, thus making proactive identification and data collection especially difficult for the threat assessor.

Untangling the threads

It may appear that, with apparent trends that may or may not be indicative of future threats and the possibility of unforeseen factors that we do not or even cannot discern, we are left on even less solid ground than we were at the beginning of this paper. In fact, following Confucius' dictum that 'real knowledge is to know the extent of one's ignorance', we are now far better equipped to understand the uncertainties of the future and incorporate them into our decision making. In this vein, the following recommendations are offered as high-level approaches for dealing with future biological threats, including those with animal origins.

Do not ignore current trends, but approach them judiciously

Despite the caveats about relying on extrapolations of past and current events, these can at least provide a baseline from which to explore future threats. Many of the trends pertaining to biological disasters carry with them significant probabilities of continuing and are thus important, so long as we do not allow our thinking to be constrained by existing patterns. Paying attention to current trends, while remaining sensitive to outlying possibilities and non-linear dynamics, is thus a prudent strategy.

Manage, rather than try to eliminate, uncertainty

Once we come to terms with the fact that uncertainty is a pervasive element in any predictive effort, we can incorporate uncertainty into our strategies and policies, rather than attempting to minimise or eliminate it. This can include structuring preparations and responses to biological disasters to cover a broad range of possible events, including wild-cards and other currently unforeseeable possibilities. This argues for greater weight to be placed on robust, broad and holistic approaches to animal and public health instead of specific fixes to the particular threat (or disease) that is currently most prominent in the minds of the public or policy-makers.

Simulation can be a helpful tool

One way in which we can examine a variety of possible futures, in terms of looking at both the landscape of possible threats and the efficacy of alternative responses, is to use simulation of various types. Current approaches to simulation include mathematical epidemiological modelling (1) and agent-based computational simulation (see for example Epstein *et al.* [2]). One recent and quite promising development is the increasing attention paid to the social and political aspects of potential disease outbreaks, in addition to the health and economic effects. Prototypes of this are the EpiSims Project at Los Alamos National Laboratory and the BioWar Project at Carnegie Mellon University. While most current simulation efforts are aimed at the spread of disease amongst human populations, many of these same techniques can be applied to animal disease outbreaks and animal-to-human transmission. One area requiring further development is

the simulation of terrorist decision-making and targeting choices, although this has received renewed attention in the past five years.

Situational awareness is crucial

In order to confirm current trends and provide early indications of radical departures from expectations, more work will be needed to address the signal-to-noise problem that was discussed earlier. In the context of biological disasters with animal origins, this could require new thinking regarding disease surveillance, such as probability-driven active surveillance – where risk analysis would identify periods of heightened danger and would initiate specific active monitoring efforts – in place of the current predominance of passive disease surveillance measures (12).

Concluding thoughts

Disease outbreaks in the past, both in animals and humans, have not only damaged people's health and livelihoods; on occasion they have wrought irreparable damage on entire societies, undermining long-held social beliefs and overturning stable political systems (6, 8). While human and animal populations eventually recover from such upheavals in most cases, the cost in lives, productivity and suffering is often great. Threats of future biological disasters may be impossible to predict with any degree of certainty, but if we proceed cautiously and utilise all available tools, we can provide ourselves with far better guidance about where to allocate resources to prevent and mitigate such outbreaks. Much work, however, remains to be done in assessment of threats in this area, and the author hopes that the current volume can help foster greater understanding of the likelihood and possible consequences of biological disasters with animal origins among the policy-making community. It is through understanding and a proactive orientation towards this threat that we can prepare, to the best of our ability, for whatever the future may bring.

■

Il est difficile de prédire l'avenir : des menaces et des vulnérabilités en évolution constante

G.A. Ackerman

Résumé

Le présent article décrit le caractère fluctuant des menaces et des vulnérabilités en matière de catastrophes biologiques d'origine animale, et présente certains écueils et possibilités associés à l'anticipation des menaces futures. Les nouvelles menaces et les vulnérabilités sont constituées, entre autre, par la poursuite du déboisement et de l'empiètement sur les habitats naturels, les effets de la mondialisation sur le commerce et les transports, l'interdépendance accrue et la vulnérabilité sociale de la société moderne, la coexistence des méthodes de culture traditionnelle et d'agriculture intensive, l'apparition périodique de pandémies et d'épizooties, et la constatation que nombre

d'acteurs affichent des capacités et un intérêt accrus pour l'utilisation d'agents biologiques en tant qu'armes. Ces phénomènes doivent être considérés dans le contexte des diverses entraves qui empêchent d'évaluer avec exactitude les menaces futures, telles que l'apparition de nouveaux éléments qui se démarquent des tendances actuelles et la difficulté intrinsèque que représente l'anticipation du comportement humain, en particulier terroriste. L'article conclut par des recommandations générales permettant de structurer une riposte à la menace dans un climat d'incertitude quant à l'avenir.

Mots-clés
Appréciation de la menace – Épizootie – Maladie animale exotique – Maladie émergente – Pandémie – Prédiction – Simulation – Terrorisme.

Las dificultades de predecir el futuro, o la cambiante naturaleza de las amenazas y los puntos vulnerables

G.A. Ackerman

Resumen
El autor describe el carácter cambiante de las amenazas y los puntos vulnerables en relación con los desastres biológicos de origen animal, y expone algunas de las dificultades y oportunidades ligadas a la predicción de futuras amenazas. Entre otros peligros y puntos débiles que van cambiando continuamente, cabe destacar la incesante deforestación y la invasión de hábitats vírgenes, los efectos de la mundialización sobre el comercio y los transportes, el mayor nivel de interdependencia y fragilidad social de las sociedades modernas, la mezcla de métodos de agricultura intensiva y tradicional, la eclosión periódica de pandemias y epizootias, y los indicios de que muchos grupos muestran un creciente interés por utilizar agentes biológicos con fines bélicos y están adquiriendo la capacidad de hacerlo. Para tener en cuenta esta evolución hay que colocarla en un contexto en el que diversos obstáculos impiden evaluar con exactitud las futuras amenazas, por ejemplo la aparición de nuevos elementos que divergen de las tendencias actuales y la dificultad de predecir el comportamiento humano, sobre todo en el caso de terroristas. El autor concluye formulando una serie de recomendaciones generales para estructurar una respuesta política a las amenazas en un contexto de incertidumbre respecto al futuro.

Palabras clave
Enfermedad animal foránea – Enfermedad emergente – Epizootia – Evaluación de amenazas – Pandemia – Predicción – Simulación – Terrorismo.

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International cooperation and preparedness in responding to accidental or deliberate biological disasters: lessons and future directions

J. Lubroth

Emergency Prevention System for Transboundary Animal Pests and Plant Diseases (EMPRES), Animal Health Service, Animal Production and Health Division, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, Rome 00100, Italy

Summary

Preparations for international cooperation in response to disease disasters at the regional or continental levels are poorly coordinated and cooperation is limited, although intergovernmental and international organisations have been advocating for years that emergency responses to infectious disease outbreaks should be planned for and prepared at the national level. National governments are responsible for contingency planning to protect the public; however, this responsibility needs to be broadened to encompass regional and international approaches. Little public domain information is available on international coordinated responses to the deliberate introduction of biological pathogens. Terrorist events in the early 21st Century have increased awareness of the risks, but solid commitment and internationally resourced initiatives are still lacking. The current avian influenza disaster has largely been addressed by the three global agencies: Food and Agriculture Organization (FAO), World Organisation for Animal Health (OIE) and World Health Organization (WHO), using the underlying precepts that shape the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs). The GF-TADs offers a substantial base to improve regional epidemiological and environmental information, diagnostic networking, trend analysis and intervention against the important epidemic animal diseases. International prevention, preparedness and response require multidisciplinary teams working in an environment of intergovernmental cooperation that encompasses numerous ministries and agencies. This paper focuses on known international aspects of collaboration on emergency preparedness and addresses the FAO/OIE initiative to strengthen veterinary and public health systems involved in controlling and preventing serious health threats.

Keywords

Agroterrorism – Animal health – Bioterrorism – Biowarfare – Emergency preparedness – Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases – Food and Agriculture Organization – Transboundary animal diseases – Veterinary public health – World Health Organization – World Organisation for Animal Health (OIE).

Introduction

The international organisations continue to argue for emergency preparedness measures at the national level and, recently, have called for recognition of the crucial roles of regional organisations and economic trade blocks in such preparations. Although many models have been established, guidelines have been provided, and manuals and protocols published or made available on line, the countries themselves must take responsibility for developing contingency plans, as there are no reliable generic blueprints that will address any individual

country's specific constraints, cultures, risks, geography, legislation and political structure, or climate (11, 13, 14, 15, 17, 22). Yet most nations around the globe neglect such forward thinking and fail to develop contingency plans and prepare for emergencies.

Zoonoses and most emerging human infectious diseases are likely to have an animal component in their transmission cycle. Response to an emergency therefore requires collaboration among those responsible for veterinary and human medical services and systems, but also among a much wider range of personnel (11, 26). Professionals who can bring critical skills include climatologists, ecologists, wildlife specialists, sociologists and anthropologists, security officials (police and armed forces), communication and information technologists, and financial administrators. In the case of deliberate releases of pathogens or pests, intelligence and police forces are likely to lead the attempts to find the culprits, but the technical and medical care response would still be the responsibility of the veterinary or public health officials. The urgent requirements of one agency must not obstruct the technical work of the others; thus there must be awareness of the various needs, and of the methods and strategies used. Joint contingency planning is essential, along with exercises to practise coordination measures.

The term 'agroterrorism' was coined some 12 years ago to highlight the vulnerability of agricultural production, stability and safety in the food and feed supply, and safe food distribution. Agroterrorism can be defined as the deliberate introduction of an animal or plant disease in order to disrupt agro-livestock production, cause economic damage, or generate fear (1, 12, 18, 19, 20, 24, 26, 36). This paper focuses on the known international factors affecting collaboration in the prevention of such immoral and wanton threats to agricultural-livestock production, and other multilateral aspects from which the animal-producing regions can learn.

Deliberate releases of pathogens

The effects of an agroterrorist assault on a country's agriculture production system and food chain could include a collapse of the economy, loss of confidence in government services, economic costs to individual or business capital and credit, and illness among the animal and possibly human populations (1, 5, 18, 20, 24, 36). If the food chain is adulterated, humans could be at risk in terms of food safety or public health. Colossal damage could be inflicted on a national economy if even the most limited of outbreaks were identified. To control even these small events, there must be an adequate infrastructure in place for sub-national zoning measures of inspection, and for compartmentalising food or farm production systems and commodity distribution. If there is no adequate infrastructure to identify and then isolate outbreaks, the detection of a single case of disease could signal disaster.

Detection of such an agent in the agricultural sector could result in local and seasonal job losses, gluts or scarcities, increased storage requirements for unconsumed goods (or their total loss due to decomposition or non-marketability), market-chain food losses to service providers and loss of employment among transporters, with a ripple effect that would extend into the international market place. The burden of increased costs would be increased by the financial investment required to undertake disease-control measures: containment, eradication, surveillance and infection search, up-scaled diagnostics, compensation requirements, disinfection measures, environmentally sound disposal and long-term recovery. Economic losses would not only be felt in the husbandry, production, processing and marketing sectors, but are likely to be passed on to consumers through market adjustments. If agricultural damage were deliberately inflicted, the disruption of the market place would be likely to cause national or regional instability. However, the results would not necessarily be felt at the international level, thanks to demand-conscious brokers seeking other suppliers. There would be other producers of products and commodities that would fill the demand, and this would exacerbate economic problems in the affected countries that were attempting to recover their lost position in a competitive market place.

The Center for Nonproliferation Studies, located at the Monterey Institute of International Studies, maintains the 'database of incidents involving sub-national actors and chemical, biological, radiological, or nuclear materials', which lists 21 known incidents that could be classified as attacks against agricultural targets (21). Attacks against crops or animals are not new, and have been conducted both by nation-states and by subversive sub-state groups. At least nine countries had documented agricultural bioweapon programmes during some part of the 20th Century: Canada, France, Germany, Iraq, Japan, South Africa, the United Kingdom, United States of America (USA) and Russia (as well as Kazakhstan and Uzbekistan at the time when they were republics of the Union of Socialist Soviet Republics). Four other countries are believed to have or have had agricultural bioweapons programmes (Egypt, the Democratic People's Republic of Korea, Rhodesia [now Zimbabwe] and Syria) (21). Glanders caused by the bacterium *Burkholderia mallei* was used against horses and mules of the allied forces during the First World War, and again in Afghanistan in the 1980s; the bacterium causing anthrax, *Bacillus anthracis*, and rinderpest virus (Paramyxoviridae) were allegedly used during the Second World War in the Asian-Pacific theatre (21).

In the current environment of increased worldwide awareness, an outbreak of a disease in livestock would be investigated by the competent veterinary authority. Investigators would probably assume the event was due to natural causes or to a spread of disease that followed known epidemiological principles, and the investigation would be focused on confirming or eliminating a range of suspected causes (medically referred to as differential diagnosis, and more commonly as 'rule-out lists' or 'look-alike diseases'). Forensic medicine would not be seen as very important; outside the sphere of classical medical epidemiology, incident management would not prioritise measures to ensure the evidence was not disturbed, as would happen at a known crime scene. The call to undertake clinical or post-mortem examinations and further investigation is likely to come through the normal channels – owner, producer, private veterinarian – who would subsequently submit samples to a veterinary diagnostic centre (27). The 'crime scene' would certainly, though unknowingly, be interfered with, and a formal chain of custody of samples would not even be considered.

It is difficult to predict exactly when the suspicion may first arise of the intentional introduction of a pathogen or pest. Several factors are likely to come into play. One of the most important is the molecular characterisation of the agent, which would serve as a 'fingerprint' to answer the primary question of 'what' – the biological cause of the outbreak. While investigators must consider the possibility that there may be more than one agent acting in synergy or predisposing an affected host, the molecular fingerprint may also give some indication of the 'who' – the person or persons responsible. The other classical descriptive epidemiological questions of 'where' and 'when' remain essential, but the 'how' may become a very complex question to answer.

International organisations

International cooperation in addressing problems such as rinderpest (also known as cattle plague) – a transboundary veterinary problem – is probably best exemplified by the first signatory countries in 1924 to create the Office International des Épizooties (OIE), today known as the World Organisation for Animal Health. The OIE now has a membership of 167 nations.

Three international organisations are directly involved in human and animal health: the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO), and the World Organisation for Animal Health. None of the three organisations currently have mandates to intervene, police, give opinions or assist in bioterrorism or agroterrorism events. However, during the May 2002 55th World Health Assembly held in Geneva, a resolution entitled 'Global public health response to natural occurrence, accidental release or deliberate use of biological and chemical agents or radionuclear material that affect health' was adopted (37, 38). Under this resolution, the WHO established, under the leadership of the Communicable Disease, Surveillance and Response team, a series of initiatives addressing issues of the intentional release of pathogens; the aim was to improve international and national emergency preparedness to counter specific diseases and intoxications. In addition, the Global Outbreak Alert and Response Network (GOARN) was established to tap into the expertise of partner institutions and individuals and support the WHO's Alert and Response Operations group (ARO). The four areas under implementation are:

a) international preparedness – where the objective is to respond to the Member States' requests for technical assistance to national programmes of chemical and biological weapon preparedness and response, and training

b) global alert and response – which is to provide the 192 Member States with a framework for monitoring conditions that may require international alerts on threats and developing the ability to make field assessments with GOARN experts that would make effective containment possible

c) national preparedness – which combines parallel work with international preparedness plans and coordinates guidance for national laboratories and epidemiology units and training by the United Nations (UN) Disease Management and Training Programme

d) preparedness for 11 selected diseases and intoxications.

Of the 11 threats mentioned in (d), five are considered to be potential biological weapons (anthrax, botulism, plague, tularaemia and smallpox), but all are zoonotic agents (37).

At a WHO-organised meeting held at Lyon, France, in February 2005 on biological laboratory safety and biological laboratory security, Interpol, the International Criminal Police Organization, explained their role in investigating criminal acts of pathogen introduction, while highlighting their reliance on technical international inputs for understanding mechanisms of transmission risks and implications. A newly established unit funded by the Alfred P. Sloan Foundation is to focus on bioterrorism: that is, to raise awareness of the threat, develop police training programmes, strengthen efforts to enforce existing legislation, promote the development of new legislation, and encourage inter-agency cooperation in combating bioterrorism (16). The presence of FAO and OIE at the meeting provided an opportunity to share knowledge of the dangers and implications of agroterrorist threats.

The Codex Alimentarius Commission (Codex) was established in 1962 by FAO and WHO to develop international standards to protect the health of consumers and to help ensure fair practice in the food trade. With the establishment of the World Trade Organization (WTO) and its international trade agreements, the importance of the *Codex* increased substantially. The Codex became the reference organisation for international food safety standards under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (43). To date, the Codex has not addressed specific actions or provided agenda items to protect food security or food safety in the event of the deliberate introduction of a pathogen or adulteration of the food supply. There are, however, several guidance documents developed by the Codex Committee on Food Import and Export Inspection and Certification Systems that can orient countries in food security and safety programmes. Specific areas that are covered include:

– design, operation, assessment and accreditation of food import and export inspection and certification systems

– food import control systems

– the exchange of information in food control emergency situations.

Other issues are currently being studied; they include:

– working principles for risk analysis

– traceability guidelines for the tracking of food products

– principles and guidelines on microbiological risk management.

All of these are relevant to food safety issues and possible adulteration (35, 43).

The Interim Commission on Phytosanitary Measures, which sets international standards for phytosanitary measures, oversees the International Plant Protection Convention (IPPC) (10).

The IPPC is a multilateral treaty for cooperation in plant protection that had its beginnings with the agreement by 12 countries to regulatory measures for grapevines under the Phylloxera Convention of Berne in 1881. This convention represented the first efforts at formalising international cooperation in plant protection and led to the recognition of the need to address other plant pests and enlist cooperation among all countries.

At present the convention covers a wide range of issues to secure cooperative action to prevent and control the spread and introduction of agricultural plant pests. The main tasks of the IPPC are standard setting, information exchange and technical assistance; as such it works in parallel with the OIE, which is primarily responsible in the realm of animal health, while there are also substantial contributions from FAO's resources on animal production and health, food, feed safety, and the array of collaborating and reference laboratories. As of 2 September 2005, there were 139 signatory parties to IPPC.

During the Uruguay Round (1986 to 1994) of the General Agreement on Tariffs and Trade, which covers international trade in goods, the need became clear for enforceable guidelines for preventing the transmission of diseases, while discouraging unjustified restrictions in international trade. After the establishment in 1994 of the WTO and the signing of the SPS Agreement, the OIE became responsible for the oversight of and guidance on trade issues and animal diseases. The OIE publishes guidelines such as the *Terrestrial Animal Health Code* (42), the *Aquatic Animal Health Code* (41), the *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals* (40) and the *Manual of Diagnostic Tests for Aquatic Animals* (39).

Yet neither FAO nor the OIE have received a mandate from their governing bodies to act in the event of a deliberate release of a biological agent, develop confidence-building measures, undertake inspections or perform risk analyses. Nor, considering their existing missions and portfolios, do they have the necessary resources to fund a dedicated staff capable of developing intervention or prevention plans on the complex issues of food security and food safety in relation to the intentional adulteration of food production or processing, or to implement the proper investigative methods. As said above, the people responsible for responding in the initial stages of an outbreak would probably not suspect a deliberate attack. Both FAO and the OIE, however, have within their staff experienced individuals who understand the agroterrorism issues and can mobilise support from numerous reference laboratories, collaborating centres and a list of recognised experts who, if asked, would contribute sound technical services and judgement (27).

As of December 2004, the number of state parties to the 1972 Biological Weapons Convention (BWC) was 169, of which 153 had ratified the Convention, while 16 had signed but had not yet ratified it through their national government bodies; an additional 25 countries had observer status but had yet to sign or ratify (2, 32, 33). It is a daunting task to obtain effective and improved compliance with the Convention, for which legally binding instruments are lacking. As stated eloquently in a Federation of American Scientists document:

'An effective mechanism for investigating alleged use of biological and toxin weapons will not only enhance compliance with the BWC by deterring use, but will also assure States Parties that any suspicious incident occurring on their territory will be investigated at their request. It will

also offer a means by which countries wrongly suspected of violation can demonstrate their compliance, and it will discourage unfounded and destabilising accusations' (9).

At present, the mechanisms for inquiry and inspection are unstructured; there is no funding to prepare for the alleged use of a biological (or chemical or radiological) weapon, nor any authority over governments to ensure compliance with the treaty. The General Assembly of the UN (Resolution 42/37 C, 1987, and Resolution 43/74 A, 1988) has authorised the Secretary General 'to compile and maintain lists of qualified experts provided by Member States whose services could be made available at short notice to undertake such investigations, and of laboratories with the capability to undertake testing for the presence of agents the use of which is prohibited' (2, 32, 33). However, there is discontent within some of the signatory state parties, who argue that the current system should be re-evaluated. Specifically there is a call for:

– a more formal mechanism of inspection and compliance measures

– greater balance in the issues surrounding the listed expertise with regard to global representation or political governing structures

– measures to address the problem that the present system, in the event of an investigation, has no legally binding consequences for the state party in question.

There is little evidence of official international or multilateral cooperation in the public domain. Several international conventions and treaties have been signed by member states, and these exemplify the nearest approach to international and multilateral cooperation (examples are the BWC, which has 169 signatory party states, and the IPPC with 139). Yet these conventions are not effective in terms of ensuring and assuring compliance. Though treaties and conventions essentially operate at the national (ratification) and international (agreement) governing levels, the current reality is that the one unifying characteristic of the recent terrorist events has been their non-nationalistic ideology. Attacks have been mounted by sub-state groupings, often on a trans-national scale; to demonstrate that any particular state party or country is responsible for such actions is difficult, and may be impossible.

For effective national protection, more international outreach and investment is required. At the same time, domestic preparedness operations should be planned and practised, and a transparent system of compliance agreed upon. Under a more ideal system, international staff should be available to provide international liaison, technical support, and the services required for rapid and effective deployment of multidisciplinary investigation teams – including veterinarians, physicians, epidemiologists, microbiologists – that can augment local expertise (that is, the local practitioners) and, if necessary, provide leadership. This international support group should similarly be able to secure on demand the services of additional individuals and institutes with a record of the necessary expertise (geospatial analysis, wildlife, markets, ethnomedicine and meteorology, for instance). In these interventions, the international team should be capable of controlling activities in the field and liaising with local and central government authorities.

The Federal Association of American Scientists recognises the added value of the WHO, FAO and the OIE:

'a protocol to the BWC should strengthen the reporting expectation by incorporating a legally-binding requirement to report unusual outbreaks, and [this protocol] should specify that the reports should be directed to an appropriate international health organisation rather than to an arms control organisation. Reporting of human, animal, and plant outbreaks should be required; examples of appropriate international health organisations would include the WHO, the FAO, and the OIE' (9).

A national approach with international outreach

Perhaps the country with the greatest awareness (or fear) of the agroterrorist threat is the USA, a country highly dependent on its agricultural production to meet its national needs, and one that has a vast and powerful agro-livestock industrial export portfolio (1, 5, 6, 18, 21, 24, 25, 28, 29). Though the focus of this paper is on international cooperation, most references to cooperation in gathering intelligence about and preventing – and recovering from – an agroterrorist event are examples of national and intergovernmental activities, or between government and industry (e.g. the creation of the Department of Homeland Security, or the independent Aon Corporation's establishment in the USA of the 2005 Agroterrorism Assembly, which met in Sacramento in August 2005). The Department of Homeland Security in the USA, established only in 2003, is one country's attempt to ensure oversight and administration over critical agencies and government services that are mandated to ensure national security and safety, including specific components of the agriculture and livestock sectors.

The US Congress introduced a bill in March 2005, referred by the Subcommittee on Europe and Emerging Threats to the House of Representatives, that was designed to foster cross-border cooperation in Northern Europe via the Northern Europe Initiative. The bill was an attempt to develop inter-regional cooperation within the conceptual

and operational framework of US policy, extending cooperative measures outside the national boundary of the USA. The initiative focused on developing a regional cooperation network in several important areas, including public health. In addition, 2005 saw the enactment of the US Agricultural Security Assistance Act concerning agricultural safety measures, which defined the measures that the country should undertake to improve coordination with international organisations (28).

A regional approach with international application

In Europe, a specific committee was formed to develop a programme through the European Commission Task Force on Bioterrorism (BICHAT), which utilises the expertise of employees within the European Commission, third-party countries and the WHO. The aims of the programme are:

a) to develop a mechanism in relation to attacks with biological and chemical agents for information exchange, consultation and coordinated management activities on emerging issues

b) to identify European expertise that would be readily available to detect and identify the use of chemical and biological weapons in the early stages of any terrorist attack

c) to create a stockpile of medical supplies, a database of health services, and an emergency unit able to deploy its health personnel and dispense medical care and medicines rapidly in the case of such attacks

d) to establish:

– ethical guidelines to standardise the activities of health professionals

– regulations to coordinate a European response, and to facilitate contacts and exchange of information with developing countries and international organisations (3, 6).

In a series of directives, the European Union (EU) identified the key role of a well-articulated emergency preparedness system, which should be able to differentiate cases of disease emergence due to deliberate dissemination of biological agents from other clinical occurrences of disease, whether unusual or commonly encountered (6, 7, 8). The European effort would:

– expand and reinforce the epidemiological systems of surveillance already in existence as well as the diagnostic capacities of microbiology laboratories

– develop and adopt standardised procedures of intervention

– provide common guidelines on disease and emergency management.

The final outcome of these proposals and directives was the creation in July 2003 of the European Centre for Disease Prevention and Control (http://www.ecdc.eu.int/), analogous to the Public Health Service's Centres for Disease Control and Prevention in the USA (4). The latter is part of the Department of Health and Human Services in the USA, but has on its staff, among others, professionals representing the agricultural, veterinary and military sectors.

In its original proposal submitted to the European Parliament, the programme of the Environment, Public Health and Consumer Policy Committee for 2001 to 2006 stated:

'Achieving the overall aim and the general objectives of the Programme requires effective co-operation of the Member States and dialogue with all key partners such as non-governmental organisations. Institutions, associations, organisations and bodies in the health field are encouraged to submit projects for implementing specific priorities, defined on an annual basis by the Commission' (30).

The European public health programme and international cooperation builds on experience acquired in the international context, and puts particular stress upon the importance of cooperation with international organisations such as the WHO. In most of these proposals and initiatives, FAO and the OIE are not mentioned, leaving the agricultural-livestock sector financially and politically unprotected.

Global and trans-Atlantic partnerships to confront terrorism have existed for much of the 20th Century, and events occurring early in the 21st Century have increased society's awareness of potential threats to agricultural and food security. However, there is still a lack of solid, focused and well-resourced initiatives. The North Atlantic Treaty Organization (NATO), though originally created as a military pact in the aftermath of the Second World War, has established the Programme for Security Through Science, which offered support in 2005 for international collaboration on priority issues such as 'Defence Against Terrorism' and 'Countering Other Threats to Security' (23). This approach and other proposals from specific countries or institutions should be encouraged, when they apply to threats against the agriculture and livestock sectors.

The New Defence Agenda (NDA) was established as a neutral platform to discuss NATO and EU security policies. The NDA's Bioterrorism Reporting Group and the Chemical and Biological Arms Control Institute proposed a system for the United States and Europe to cooperate to counter bioterrorism (5). The paper highlights the

solidarity after the events in New York and Washington in September 2001, and the strain in transatlantic relations related to pre- and post-war Iraq. The failure to find weapons of mass destruction in Iraq, and the failings of the reported and publicised intelligence on both sides of the Atlantic, further alienated governments and peoples, but the perceived reality of such a weapon threat has not diminished. With advances in biotechnology and increasing global access to information, the potential for abuse of science and conventional weapons proliferation are central security issues which must be addressed by the transatlantic relationship and the international community as a whole.

In January 2005, in a transatlantic international exercise named Atlantic Storm, a fictitious scenario depicted a summit meeting of transatlantic leaders being forced to respond to a smallpox bioterrorist attack (5, 29). The transatlantic leaders were played by current and former officials from several countries and organisations (particularly NATO allies and EU representatives). The exercise was designed to extract decisions and stimulate discussions among the representatives on a series of bioterrorism preparedness and response issues. The tensions created during the exercise revealed the difficult decisions to be made about 'domestic politics and international relations, the challenge of controlling the movement of people across borders, and an international shortage of critical resources'. The exercise showed 'that existing international organisations – such as NATO, the EU, or the UN – are not well suited to respond to the challenges posed by a bioterrorist attack of this scope and complexity' (34).

The post-exercise analysis of another emergency exercise, Global Mercury (31), reinforced the lessons of Atlantic Storm. The analysis emphasised that the international community was inadequately prepared and unable to respond effectively to attacks by Class A biological warfare agents. Such agents use pathogens that are dangerous to human health and can be easily disseminated or transmitted from person to person; they cause a high mortality, have a potential for major public health impact, and may trigger public panic and social disruption. In an agricultural-livestock setting, such parallel disease-causing pathogens would probably be the same diseases that FAO's Emergency Prevention System programme addresses. Special action is required to prepare an effective response to protect the public in the event of such an attack.

Four major lessons could be learnt from the Atlantic Storm and Global Mercury exercises (5, 29, 31):

– 'the difficulties involved with international exchange of information during an emergency'

– the lack of 'international perspectives' in national smallpox plans

– the need for a common terminology to describe the magnitude and extent of a public health emergency

– the need for 'robust and reliable communication systems' to be tested on a regular basis.

The importance of these exercises, though they were not specific agricultural-livestock scenarios, does highlight the need for investment and serious planning and practising at the international cooperative level to control such emergencies. Among the aspects that FAO and the OIE emphasised as being of great concern are:

– the social disruption that would follow an outbreak of disease, including the loss of confidence in food quality and availability

– the effectiveness of responses by government and relevant international and regional organisations

– the inadequacy of information available at the local level

– the environmental impact associated with controlling problems related to agriculture.

Desk-top and field exercises are required in this sector as well, since contamination of the food supply and its sources would constitute a public health emergency.

The BICHAT has listed 25 actions that would be necessary to respond to a bioterrorism event, grouped under four specific objectives:

a) To set up an alert and information exchange mechanism, coordinated by the Health Security Committee, to be responsible for exchanging information on health-related threats, on preparedness and response plans, and the development of crisis management strategies.

b) To create a mechanism for rapid detection and identification of pathogens and chemical agents that might be used in an attack, in line with Decision 2119/98/EC of 24 September 1998 on the surveillance and control of communicable diseases. A list of biological agents likely to be used in bioterrorism has already prioritised these agents on the basis of criteria such as infectiousness, virulence, persistence in the environment and ease of spread. Council Regulation 1334/2000 also lists biological and chemical agents linked to export control arrangements, and the ability of regulators to detect and identify the agents.

c) To create a database on stockpiles for medicine, medicine formulation facilities, and all available health service providers in the event of an attack.

d) To prepare and disseminate guidelines and regulations on mechanisms for response, especially coordinating the EU response, and to establish procedures for links with other countries and international organisations (3, 7, 8).

While it is notable that concerns about a terrorist event aimed at the agricultural or livestock production sector are omitted, much can be learnt from priority setting and the proposals to make better use of the established links between member countries, regional bodies and international organisations; these lessons can be applied to the food-producing sectors.

Emergency preparedness plans to counter the possible introduction of a transboundary animal disease are essential. Once developed, these plans must be tested through simulation exercises to identify deficiencies and gaps. The author is aware of over 50 such simulation exercises that have been performed in various countries around the world in recent years. Despite this work at the national level, however, there is little evidence of a regional collaborative approach.

The NAFTA region is a partial exception to this general weakness. In November 2000, Canada, the USA and Mexico participated in 'Tripartite Exercise 2000', where a simulated outbreak of foot and mouth disease (FMD) was used to test existing emergency disease response plans. The exercise demonstrated that a multinational crisis would pose serious, large-scale challenges in terms of communications, logistics and infrastructure. In this special scenario, the fictitious FMD epidemic started in Texas, spreading geographically into Mexico and through animal transport into Canada because of trilateral open-border policies. The USA and Mexico conducted a follow-up FMD exercise in May 2003, and another was preformed by the USA and Canada in March 2005.

The author is not aware of other multilateral exercises at such a detailed level or with the participation of all national Chief Veterinary Officers of the countries concerned. However, there have been numerous international capacity-building exercises where participants from several countries (usually neighbours) simulated fictitious field outbreaks and undertook follow-up epidemiological and disease containment training for several days. Such training is important and welcome, but is often undertaken only at the official veterinary level; ideally, training should also involve other stakeholders, including high-ranking decision-makers (as in Atlantic Storm), so as to increase the value of such exercises and integrate official action with increased financial resources and contributions from the private commercial sector.

A way forward

The FAO/OIE initiative Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) is designed to safeguard the worlds' animal health and production through concerted international action to control animal (and zoonotic pathogens) at source (11, 27). Both FAO and the OIE have considerable experience in international cooperation and providing technical assistance in organising preparations and contingency plans for the prevention and control of transboundary animal diseases, using a regional approach with other partners. (Examples of such work include measures to control rinderpest through the Global Rinderpest Eradication Programme, and the New World Screwworm in North Africa, the Programme Against African Trypanosomiasis, Caribbean Amblyomma Programme, classical swine fever in the Americas, FMD in South-East Asia, FMD in Europe, and the highly pathogenic avian influenza in Asia.)

Along with rinderpest control and eradication in Asia and Africa, one of the longest regional approaches for disease control is the Pan-American Health Organization's work on FMD in South America (which has continued for over 50 years). Another example is the successful European Commission for FMD Control, whose Secretariat is hosted by FAO. Generic models of ways to develop preparedness and contingency plans, which include explanatory notes, rationale, structure and conceptual coordination features, have been published and could be useful references for countries or agencies that see gaps within their veterinary or public health systems (13, 14, 15).

Global or regional contingency plans for veterinary or public health disasters per se do not exist. Perhaps the largest exception is unfolding at the time of writing: the outbreaks of highly pathogenic avian influenza type A/H5N1 in Asia and parts of Europe, and of other pathotypes elsewhere. The world community is concerned that the circulating avian influenza viruses may reassort with human or other mammalian viruses, undergo mutations or otherwise adapt to humans, and prompt a human influenza pandemic that might cause millions of human fatalities and social disruption across all continents; in the worst scenario, medical systems would be unable to cope with the high case loads and huge demands for hospital care, while many medical and support staff would be absent from the workplace because they were ill, taking care of infected family members, or frightened of being exposed to infection.

Beginning in late August 2005, the UN called upon select agencies to develop coordinated plans for strategic interventions throughout its system and in all parts of the world. FAO, the OIE and WHO have been providing assistance to control and prevent outbreaks, and to establish networks at the national, regional and global levels since the crisis first came to international attention in January 2004, However, these concerns have only recently been raised at the highest levels of the UN system, and given sufficient priority that now emergency coordination may well be handled from the UN Headquarters in

New York. The UN Development Group and Humanitarian Agency Standing Committee is seeking technical advice from the leading three health organisations in preventing, preparing and responding to pandemic (human) influenza.

However, key stakeholders and developers for preparedness and strategic response include a broad range of other international and regional bodies who would be involved at different phases of the theoretical pandemic. These bodies include:

– political structures (the UN General Assembly and Association of South-East Asian Nations)

– development institutions (the UN Development Programme, United Nations International Children's Emergency Fund)

– national agencies and organisations for international development and assistance, including non-government organisations

– economic institutions (e.g. the World Bank, International Monetary Fund, Islamic Development Bank)

– partnership governing bodies (the European Commission)

– logistic support agencies (the UN Humanitarian Air Service, UN Peacekeeping Operations, NATO, International Red Cross and Red Crescent)

– private foundations and government donation coordinators

– real-time communications and public media agents.

All the institutions and agencies described need to recognise – and probably do – that ultimate success is measured at the local level in terms of health, livelihood, rehabilitation and opportunities for a promising future.

Another important factor that must be incorporated further into the GF-TADs is the need for immediate access to a logistical apparatus to contain outbreaks of geoeconomic importance. In this realm much can be learned from other UN agencies, such as the High Commission of Refugees, the World Food Programme, and Office for the Coordination of Humanitarian Affairs, and the European Community Humanitarian Office (ECHO) Humanitarian Aid (European Commission). The OIE and FAO are currently making progress in this field as they have begun participating closer with the WHO's ARO group, GOARN, and the WHO Global Influenza Programme.

From a global point of view, the major epidemic diseases of livestock occur most often in the developing world, jeopardising local and regional production of healthy animals, and posing the risk of infection spreading to disease-free countries. Yet even in areas afflicted by religious animosities, political disenchantment, economic strife and poverty, the occurrence of these pathogens can be controlled and the lives of millions, even billions, of people improved. If the necessary financial resources are provided and focused on the problem, the disease-causing agents can be constrained, reducing the risks that pathogens will spread to areas far from their endemic occurrence.

The GF-TADs initiative does not directly address the discontent that may incite organised groups or disaffected individuals to obtain or isolate, weaponise, and release a pathogen that affects livestock, wildlife or human health. The initiative does, however, move in the direction of limiting endemic or sylvatic diseases through:

– use of advanced epidemiological tools

– promotion of international information exchange

– monitoring of suspect disease events through verification and validation procedures (early warning and detection)

– provision of contingency funds and urgent-intervention (early response) instruments

– strengthening of veterinary services

– promotion of integrated human, animal and environmental health objectives.

Properly funded, GF-TADs and its global early warning (and response) system can provide the international and sub-regional tools for the same objectives of transatlantic cooperation that the EU has set up. The initiative also embraces food security and safety at the local level through better veterinary care delivery, participatory epidemiological approaches and development of strategies to identify the sources of infection. In the case of human influenza pandemic preparedness, it would be cost effective – not only in terms of direct financial costs, but also in terms of preventing the disruption of people's lives, maintaining business, manufacturing and service sectors, avoiding emotional pain and the like – if more funding and resources were available to avert the human threat at the source. This means paying attention to poultry farms and markets, flock hygiene and good farming practices, animal production biosecurity, improved avian influenza vaccines and diagnostics, and enhanced veterinary surveillance.

Additional areas of concern that require international convention and cooperation

One aspect that has been poorly explored by the international community, though numerous state agencies

are actively tacking the problem, is the introduction of non-native species that may out-compete existing native species and are thus likely to create environmental imbalance. Examples include rabbits or cane toads (*Bufo marinus*) in Australia, northern snakehead fish in North America (*Channa argus*), or the Asia tiger mosquito (*Aedes albopictus*), which today appears in many parts of the world and is a competent vector for several diseases of animals and humans. The international veterinary and public health communities, including FAO and WHO, should incorporate into their structures and activities better ecological understanding of pathogens and hosts, environmental triggers, and the modelling and integration of such imbalances in order to provide better control and mitigation measures.

A second aspect for which greater awareness and action are required is the strengthening of veterinary and human public health education schemes and improving the quality of their curricula. In the case of veterinary medicine, the glut of veterinary schools in many countries around the world makes for a less than optimal environment to learn the profession as thoroughly as is necessary; similarly, once qualified, many veterinarians find it difficult to practise the profession and receive fair remuneration for their services.

Ancillary to the education of veterinarians and physicians is the parallel education and training of biologists, microbiologists, molecular geneticists and other bioengineers. Good basic laboratory practices are needed to instil a high code of conduct for agent handling, laboratory procedures, documentation and reporting; systems are also needed to integrate these skills into national and international preparedness planning. The introduction of good laboratory practices early in the education of such specialists is directly related to the later levels of biosafety, biosecurity and expertise required in an emergency. National standards must be instituted and professional organisations promoted, and there needs to be a widespread incorporation of international accreditation of institutes, schools and laboratories which can foster productive international collaboration, networks and synergy in peaceful (as opposed to dual-purpose) research.

A systematic scheme for prevention, preparedness, response and recovery requires multidisciplinary teams of professionals and auxiliary staff working in an environment of national and regional intergovernmental cooperation that encompasses decision-makers from the Ministries of Health, Agriculture, Livestock, Environment and Natural Resources, Public Works, Police and Defence; most important of all, perhaps, is the creation and pre-financing of emergency contingency plans, for which Ministers of Planning and Finance must be responsive, responsible and accountable. Networking through regional and international collaboration leads to greater trust and mutual respect that is based on a sound and tested appreciation of worth. Good governance of the national, regional and international institutions is bound to improve confidence at all levels, from individual consumers to individual ethnic groups, and to individual countries. Greater inter-professional confidence comes from experience in productive interactions, critical thought, shared information, joint problem-solving and sound decision-making.

The vital conclusion is that we live on one globe. There is only one health that we should strive for, which encompasses wildlife and domestic animals, humans and the environment. To succeed we have to share knowledge and resources, and improve international interactions to build the necessary trust for a promising future.

■

Coopération internationale et préparation face aux catastrophes biologiques d'origine naturelle ou intentionnelle : leçons et orientations futures

J. Lubroth

Résumé

La préparation des plans de coopération internationale pour réagir aux catastrophes sanitaires à l'échelle régionale ou continentale n'est pas suffisamment coordonnée et la coopération reste limitée, bien que les organisations intergouvernementales et internationales répètent depuis des années qu'il faut planifier au niveau national et préparer les interventions d'urgence face aux foyers de maladies infectieuses. Certes, les gouvernements sont responsables des plans d'urgence pour la protection de la population, mais cette responsabilité doit être élargie pour couvrir les crises régionales et internationales. Le domaine public ne dispose guère d'informations sur la coordination des réactions internationales en cas de diffusion volontaire d'agents biologiques pathogènes. Les actions terroristes au début du 21e siècle ont fait prendre davantage conscience des risques, mais les engagements fermes et les initiatives appuyées sur des ressources internationales font toujours défaut. La crise actuelle due à l'influenza aviaire a fait l'objet de travaux très poussés de la part de trois organisations internationales, l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO), l'Organisation mondiale de la santé animale (OIE) et l'Organisation mondiale de la santé (OMS), sur la base des mêmes principes sur lesquels repose le Plan-cadre mondial pour la lutte progressive contre les maladies animales transfrontalières (GF-TADs). Le GF-TADs offre une base solide pour améliorer l'information épidémiologique et environnementale au niveau régional, les réseaux de diagnostic, l'analyse des tendances et l'intervention contre les épizooties importantes. La prévention, la préparation et l'intervention au niveau international nécessitent des équipes pluridisciplinaires qui travaillent dans un cadre de coopération intergouvernementale regroupant de nombreux ministères et organismes. Le présent article se concentre sur les aspects connus de la collaboration internationale en matière de préparation aux situations d'urgence et aborde l'initiative FAO/OIE qui vise à renforcer les Services vétérinaires et de santé publique impliqués dans le contrôle et la prévention des menaces graves pour la santé.

Mots-clés

Agroterrorisme – Bioterrorisme – Fièvre aphteuse – Fièvre charbonneuse – Guerre biologique – Influenza – Maladie animale transfrontalière – Organisation mondiale de la santé – Organisation mondiale de la santé animale (OIE) – Organisation pour l'alimentation et l'agriculture – Peste bovine – Préparation aux situations d'urgence – Santé animale – Santé publique vétérinaire – Système de prévention des urgences pour les ravageurs et les maladies transfrontières des animaux et des plantes.

Cooperación internacional y preparación para responder a desastres biológicos de origen natural o intencionado: experiencia y orientaciones futuras

J. Lubroth

Resumen

La cooperación internacional para dar una respuesta de ámbito regional o continental a desastres sanitarios no sólo es escasa, sino que además está poco preparada y coordinada, pese a que las organizaciones intergubernamentales e internacionales llevan años propugnando que la respuesta de emergencia a brotes infecciosos se planifique y prepare a escala nacional. Los gobiernos de los países son responsables de elaborar planes de emergencia para proteger a su población, aunque es preciso ampliar estas responsabilidades para que den cabida a intervenciones de alcance regional o internacional. Hay poca información de dominio público sobre medidas internacionalmente coordinadas para responder a la introducción deliberada de patógenos biológicos. Aunque los atentados terroristas de principios del siglo XXI han generado una mayor conciencia de los riesgos, siguen faltando un sólido compromiso e iniciativas dotadas de financiación internacional. De la actual crisis de la influenza aviar se han ocupado básicamente tres organismos mundiales: la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), la Organización Mundial de Sanidad Animal (OIE) y la Organización Mundial de la Salud (OMS), utilizando los preceptos que subyacen al "Marco mundial para el control progresivo de las enfermedades animales transfronterizas" (GF-TADs). Este programa sienta sólidas bases para perfeccionar a escala regional la información epidemiológica y ambiental, las redes de diagnóstico, el análisis de tendencias y las actuaciones contra las enfermedades epizoóticas importantes. La prevención, preparación y respuesta internacionales requieren la presencia de equipos multidisciplinares que trabajen en condiciones propicias a la cooperación intergubernamental, con participación de numerosos ministerios y organismos. El autor se centra especialmente en los aspectos conocidos de la colaboración internacional en torno a la preparación para emergencias, y examina la iniciativa de la FAO y la OIE para reforzar los sistemas de salud pública y veterinaria que intervienen en el control y la prevención de amenazas sanitarias de gravedad.

Palabras clave

Agroterrorismo – Bioterrorismo – Carbunco bacteridiano – Enfermedad animal transfronteriza – Fiebre aftosa – Guerra biológica – Influenza – Organización Mundial de la Salud – Organización Mundial de Sanidad Animal – Organización de las Naciones Unidas para la Agricultura y la Alimentación – Peste bovina – Preparación para emergencias – Salud pública veterinaria – Sanidad animal – Sistema de prevención de emergencias para enfermedades de animales y plantas.

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Investment in preventing and preparing for biological emergencies and disasters: social and economic costs of disasters versus costs of surveillance and response preparedness

J. Rushton [1] & M. Upton [2]

(1) Consultores Epidemiólogos Veterinarios Y Economistas Pecuarios, Casilla 10474, La Paz, Bolivia
(2) University of Reading, School of Agriculture, Policy and Development, P.O. Box 237, Reading RG6 6AR, United Kingdom

Summary
Biological emergencies such as the appearance of an exotic transboundary or emerging disease can become disasters. The question that faces Veterinary Services in developing countries is how to balance resources dedicated to active insurance measures, such as border control, surveillance, working with the governments of developing countries, and investing in improving veterinary knowledge and tools, with passive measures, such as contingency funds and vaccine banks. There is strong evidence that the animal health situation in developed countries has improved and is relatively stable. In addition, through trade with other countries, developing countries are becoming part of the international animal health system, the status of which is improving, though with occasional setbacks. However, despite these improvements, the risk of a possible biological disaster still remains, and has increased in recent times because of the threat of bioterrorism. This paper suggests that a model that combines decision tree analysis with epidemiology is required to identify critical points in food chains that should be strengthened to reduce the risk of emergencies and prevent emergencies from becoming disasters.

Keywords
Biological disaster – Emergency – Response preparedness – Socio-economic impact – Surveillance.

Introduction

Avoiding and reducing the social and economic impact of biological emergencies and disasters has become the focus of Veterinary Services in the majority of developed countries over the last decade. A biological emergency is defined as an event, such as an animal disease outbreak, that can affect livestock production systems and livestock product supply from national herds or flocks, either due to the presence of the disease itself and/or the control and eradication measures imposed by the government. The definition stated above does not, however, describe how a disease entered a country, which will be discussed later in this paper. Whether a biological emergency turns into a disaster depends on how the government and the private sectors of the livestock industry react with regard to control and possible eradication of the disease outbreak. In the recent past, the foot and mouth disease (FMD) epidemic in the United Kingdom (UK) turned into a disaster that resulted in a range of social and economic costs related to the widespread nature of the outbreak and also the control measures that were adopted (31). In contrast, the biological emergency that followed the discovery of a single case of bovine spongiform encephalopathy (BSE) in Canada resulted in the implementation of a number of restrictions on

international trade that severely affected the Canadian cattle sector and had an impact as far afield as Mexico in terms of cattle movement and the prices of cattle for fattening (1). In the UK in the 1980s, the report of a salmonella outbreak in poultry flocks caused panic in consumers that severely affected egg and poultry consumption for a short period.

These examples demonstrate that some of the social and economic impacts of a biological emergency can be out of the control of individual governments, which can turn such emergencies into disasters that have widespread international social and economic impacts.

The question posed in this paper is – what is the best strategy for the management of biological emergencies in developed countries:

– to adopt active measures to increase the probability of avoiding biological disasters and to reduce the impact of an emergency, or

– to take a more relaxed attitude and wait to see if these irregular events will occur, dealing with them as they do?

In order to examine this issue in more detail, the authors will present the context in which this question is posed, the types of threats that developed countries face, and the strategies available to confront the threats. A conceptual model for assessing the risk of biological emergencies that will assist in determining a balance between active and passive insurance policies in the face of the threat of such emergencies will be proposed.

Context

The rural economy, agriculture and livestock systems

The economy, agriculture, and livestock systems of rural areas in developed countries have experienced rapid changes in the last 20 years, which are continuing to occur. There has been a slow reduction in the proportion of the population living in rural areas. Moreover, in most countries, less than 10% of the rural population work in the agricultural sector (Table I) and the importance of agriculture has declined consistently since the 1950s (2, 8, 10).

Eastwood *et al.* (3) report that farm sizes in Europe and North America have been increasing on average since 1950. This average, however, masks the observation that there has been a divergence in farm size, with a growth of large farms that are commercially viable, and the continued existence of small farms that are run by part-time farming families (32). The change in farm size and structure has been accompanied by changes in the rural economy: agriculture is no longer a primary source of growth, and other sectors of the rural economy have become more important (8). The primary driving forces behind the changes in the rural economy are economic developments that have generated better paid employment outside the rural areas, particularly in non-agricultural sectors. Rural economies in many places are now being overtaken by new activities, such as tourism. The implication of these changes is that disruption of rural areas due to the occurrence of a transboundary disease and the resulting control measures can have impacts on other areas of the economy; an excellent example being the impact on the tourist industry during the FMD epidemic in the UK during 2001 (31).

The changes in the rural economy and agricultural systems are reflected in changes in livestock production systems, such as changes in the number of holdings, number of head of livestock, and herd/flock size. An example of such a change is presented in Table II, which shows the rapid reduction in the numbers of UK livestock holdings between 1998 and 2003. In general, livestock populations have decreased (except for the poultry broiler population), while average herd or flock sizes (except for sheep, fattening pigs and poultry layers) have increased. The sheep population and number of sheep producers was severely affected by the FMD epidemic in 2001, and it is suspected that for this reason the values for the sheep industry do not fit the general trend reported for the livestock sector (Table II).

Changes in livestock holdings and herd sizes have been accompanied by increases in output per animal and per day of labour and greater investments in technologies and fixed costs. In very general terms, these alterations are illustrated by the large increases in output per head of cattle in developed countries between 1980 and 2000 (Tables III and IV).

What is of interest is that while the share of total world production for cattle products from the developed countries has reduced between 1980 and 2000, the productivity in these countries in terms of output per animal has greatly increased in relation to world productivity levels.

The above analysis indicates that there has been heavy investment in genetics, nutrition, and management technology and infrastructure. A cost structure with high fixed costs makes farm businesses very vulnerable to small changes in output and, therefore, vulnerable to biological emergencies (20). Protection from biological disasters is, thus, a necessity. On the positive side of change, the technification of farming systems has included increasing use of computerised monitoring systems (35), which, if well used, could provide the basis for grassroots systems of surveillance (11).

Table I
Rural population statistics in North America, Europe, Japan, Australia, and New Zealand in 1980 and 2000

Country or region	1980			2000		
	Rural population (total number) ('000)	Rural population (% of total country population)	Percent of the rural population working in agriculture	Rural population (total number) ('000)	Rural population (% of total country population)	Percent of the rural population working in agriculture
North America [a]	66,745	26.1	7.1	65,908	20.9	5.2
Europe [b]	265,214	25.3	16.5	294,065	22.1	9.2
Japan	47,230	40.3	13.3	44,240	34.8	6.3
Australia and New Zealand	2,591	14.7	22.5	2,320	10.1	26.6

Source: (7), authors' analysis
a) Canada and the United States of America
b) 15 countries in the European Union

Table II
Livestock holdings and head of livestock in different livestock systems of the United Kingdom in 1998 and 2003 (2)

System / species	1998			2003		
	Number of holdings ('000)	Head of livestock ('000)	Average flock or herd size	Number of holdings ('000)	Head of livestock ('000)	Average flock or herd size
Dairy	35.4	2,422.4	68	26.6	2,192.3	82
Beef	71.5	1,928.4	27	59.6	1,699.1	29
Sheep	87.2	21,063.8	242	79.2	17,599.3	222
Breeding pigs	9.9	765.7	77	5.4	512.0	95
Fattening pigs	10.7	5,193.2	485	6.9	3,148.1	456
Broilers	2.9	97,173.3	33,508	2.9	116,791.7	40,273
Layers	28.6	42,691.6	1,493	32.3	38,906.8	1,205
Total	**246.2**			**212.9**		

Table III
Cattle population and meat production in 1980 and 2000 in North America, Europe, Japan, New Zealand, and Australia

Country or region	1980			2000		
	Total cattle population ('000)	Beef		Cattle population ('000)	Beef	
		Production ('000 MT)	Average carcass weight (kg)		Production ('000 MT)	Average carcass weight (kg)
North America	123,368	10,970	269	111,399	13,561	327
Europe	97,287	8,514	240	82,160	7,443	275
Japan	4,248	418	339	4,588	530	414
Australia and New Zealand	34,334	2,060	174	36603	2,560	214
Overall	**259,237**	**21,962**	**246**	**234,750**	**24,094**	**306**
Percent of total world beef production and percent of world average carcass weight		48.2	126.8		42.3	150

Source: (7), authors' analysis

Table IV
Dairy cattle population and milk production in 1980 and 2000 in North America, Europe, Japan, New Zealand, and Australia

Country or region	1980			2000		
	Dairy cattle population ('000)	Milk		Dairy cattle population ('000)	Milk	
		Production ('000 MT)	Average lactation yield (l)		Production ('000 MT)	Average lactation yield (l)
North America	12,572	65,656	5,222	10,313	84,113	8,156
Europe	32,074	132,325	4,030	20,483	127,062	6,008
Japan	1,422	6,504	4,574	1,251	8,497	6,792
Australia and New Zealand	4,162	12,265	2,847	6,060	23,418	4,251
Overall	50,230	216,750	4,254	38,107	243,090	6,870
Percent of total world milk production and percent of world average lactation yield		46.6	215.6		41.9	318.9

Source: (7), authors' analysis

The processing sector

In the processing sector, the changes are similar to the changes occurring in production systems (i.e. there is an increase in the number of animals being slaughtered in factories that have the capacity to kill large numbers of animals per day). The factories receive animals from a range of farming enterprises and are reliant on long-distance transport of livestock. Probably the most extreme case is the transport of sheep from the UK to Italy. Traditional livestock markets have become less important as the number of sellers has decreased and live animal sales and purchases are increasingly becoming a direct transaction between buyer and seller without going through intermediate livestock market systems (33).

However, the rate of change is being accelerated by the growing dominance of supermarkets in developed countries, which have considerable power over the food that is supplied to the consumers. In some cases, the supermarkets have driven down producer livestock product prices close to production costs (e.g. milk prices in the UK were severely discounted during the 1990s). They have also imposed standards on food, such as the hazard analysis critical control point system and systems of traceability. These standards are now affecting farm production systems (farm certification in the UK is becoming the norm, rather than the exception). Such control over the food chain is becoming an increasingly important selling point for supermarkets, and could also be an important aspect of future animal disease information systems.

One additional effect that supermarkets have on the food supply has arisen from their need to find cheap and reliable food products. As these companies do not have any national allegiances, food products are purchased from whichever country can provide them at the lowest cost. There are two impacts of this practice: the animal health and food standards of developed countries are now being transmitted through trade to developing countries and the animal health status of an importing developed country will reflect the animal health status of the developing countries that it imports from.

This positive development has lead to some spectacular improvements in the international animal health situation in the last 10 to 15 years. These gains have been mostly associated with countries that are traditional exporters of livestock products, such as Argentina, South Africa, and Uruguay, but more recently improvements in the animal health status of other countries, such as Brazil, Chile, Mexico, Botswana, and Thailand, has promoted entry of these countries into the international animal trade market. However, it is recognised that these gains are fragile, as demonstrated by the classical swine fever (CSF) epidemic in Mexico in the late 1990s, the FMD epidemics in Argentina and Uruguay in 2000 and in Brazil in 2005, and the highly pathogenic avian influenza (HPAI) epidemic in Thailand.

Animal health status and systems

One of the success stories of the last 20 years has been the control, and in many cases, eradication of the major transboundary diseases in developed countries (Table V).

It is recognised that there have been setbacks in transboundary disease control. In addition, new problems related to food-borne pathogens have emerged. Table VI presents the most difficult of these in a worldwide context with a comment on how well the developed countries have dealt with them in terms of limiting the scale of the biological disaster within their own regions.

In general, the improved animal health status has been supported by the rapid detection, control, and eradication

Table V
Status of major transboundary diseases in developed countries (36)

Country or region	Foot and mouth disease	Tuberculosis and brucellosis	Classical swine fever	Newcastle disease
North America	Eradicated in Canada in 1952 and in the United States of America (USA) in 1929 Not reported since these dates	Tuberculosis and brucellosis in the USA are known to be present or have been reported, but are limited to specific zones Last brucellosis outbreak in Canada in 1989 Tuberculosis in Canada is known to be present or has been reported, but is limited to specific zones	Canada has been free of CSF since 1963 The USA has been free of CSF since 1974 No outbreaks have been reported since these dates	Last occurrence in Canada in domestic birds in 1973. In 2003, outbreaks occurred in colonies of double-crested cormorants In the USA, the last outbreak was in southern California and adjacent states in 2002-2003, but it was controlled and eradicated
Europe	Free of FMD during the 1990s FMD epidemic in 2001, but disease free status re-established relatively quickly	Sporadic outbreaks of brucellosis in Austria in 2003 and France in May 2003 Tuberculosis has been reported or is known to be present in most countries	Sporadic outbreaks, but otherwise under control	Sporadic outbreaks, but otherwise under control
Japan	Last outbreak in May 2000, but quickly controlled	Last outbreak of brucellosis in February 2002 Tuberculosis is known to be present or has been reported	Last outbreak in December 2002	Known to be present or has been reported, but limited to specific zones
Australia and New Zealand	Last outbreak in Australia in 1871 Never reported in New Zealand		Last outbreak in Australia in 1962 and in New Zealand in 1953	Last outbreak in Australia in November 2002 In New Zealand, the disease is suspected to be present, but the presence has not been confirmed

of transboundary diseases by animal health systems, which are a combined force made up of Veterinary Services and the livestock sector of developed countries. The control of FMD in the Netherlands and France in 2001 and Newcastle disease in the UK in 2005 demonstrated the capability of the animal health systems to effectively manage a disease outbreak (36). The impact of these important changes has been the reduction in animal health costs at farm level and an increasing efficiency in livestock systems in these countries.

The analysis presented in this paper highlights the following issues:

– once present, transboundary diseases can spread quickly in naïve populations and create a disaster if detection and response are slow

– countries in a transition phase between being declared 'disease-free with vaccination' and 'disease-free without vaccination' require new skills in surveillance and identification of potential foci of infection (17, 22)

– countries that do not have transboundary disease surveillance systems need to actively involve producers in the detection of disease

– there is a need for tools that can help decision-makers balance active and passive insurance policies at national and international levels.

The future

Looking into the future, it is predicted that the concentration of poultry enterprises has probably reached its limits, but there is likely to be an increase in the concentration of intensive swine and dairy systems and to a lesser extent feedlots for beef production. The disadvantages of such systems in an animal health context

Table VI
Recent biological emergencies, impacts of the disease, and success of the control measures implemented

Biological disaster	Major impact	Successes	Comments
FMD in Europe	Severe disruption of the tourism industry Costs to the government and the general public (e.g. losses due to animal destruction and compensation of producers) Loss of image of animal health professionals	Largely limited to England and Wales with small controlled outbreaks in Ireland, the Netherlands, and France	Slow detection of the initial outbreak indicated weaknesses in the surveillance system Slow response to the first reported suspect case indicated a poor understanding of the livestock economy and animal movement
FMD in Argentina, Uruguay, and Paraguay	Loss of international markets Severe economic hardship suffered by the livestock sectors in these countries	FMD did not spread to importing countries	Poor understanding of the risks involved due to recent changes in vaccination regulations
FMD in Zimbabwe	Loss of international markets	FMD did not spread to developed countries	The slow undermining and breakdown of livestock institutions had a crucial role in the spread of the disease
BSE in Europe	Destruction of affected cattle, which resulted in huge financial costs to the government and taxpayers Loss of human lives Disruption of beef markets Destruction of all animals older than 30 months of age in the UK	Largely limited to the UK	In July 2005, the European Commission adopted the TSE Roadmap, which provided an outline of possible future changes to European Union measures on BSE in the short, medium, and long-term
BSE in Canada and the USA	Disruption of international trade	More than 250 Federal and State veterinarians throughout the USA have been trained to recognise FADs, including BSE	Overreaction of trading partners, particularly given the limited number of cases that were reported and evidence that human risks are very low
CSF in Europe in 1997/98 epidemic	Destruction of swine population Loss of image of animal health professionals (16)	Controlled within the Netherlands, Belgium, and Germany	Wildlife reservoirs are still sources of diseases such as CSF Difficulty in controlling animal movements
CSF in Mexico in the late 1990s	Disruption of national swine markets	CSF did not spread outside of Mexico	Poor understanding of the risks involved due to recent changes in vaccination regulations
HPAI in Europe	Destruction of poultry flocks	Mainly limited to the Netherlands Experience gained in controlling the impact of HPAI in humans (15) Documentation of lessons learned (5, 25)	Surveys and investigations have since been carried out to assess risk factors (30) and the prevalence of low pathogenic AI (34)
HPAI in South-East Asia	Death and destruction of poultry flocks Loss of human lives (23)	Hong Kong successfully controlled and eradicated HPAI on three different occasions	It is likely that this problem has been incubating for a number of years in the region (the origin of the sporadic outbreaks of HPAI in Hong Kong in the 1990s has never been fully explained) World response to this problem has been slow
Newcastle disease in the USA	Death and destruction of poultry flocks Financial costs to the government	Investigations have taken place to assess the effectiveness of ND vaccines (13)	There is a relationship between the USA outbreak of ND virus and outbreaks in Mexico and Central America (18)

AI: avian influenza
BSE: bovine spongiform encephalopathy
CSF: classical swine fever
FADs: foreign animal diseases
FMD: foot and mouth disease
HPAI: highly pathogenic avian influenza
ND: Newcastle disease
TSE: transmissible spongiform encephalopathy
UK: United Kingdom
USA: United States of America

is that their intensive nature means that transboundary diseases can spread very quickly through a very large number of animals. This, in turn, can create a monstrous source of infection, facilitating rapid spread of diseases around a region and over long distances. The advantage of intensive production systems to animal health control is that there will be fewer farms, herds, and flocks to monitor and, hence, the occurrence of a disease should be easier to detect. Intensive production systems are reliant on computer technology to assist in the day-to-day operation of the livestock enterprise (35), and the challenge will be to incorporate the farms into government database systems that regularly monitor livestock movement and disease (11).

The increasing concentration of intensive livestock enterprises will not eliminate small farms as there appears to be evidence of a divergence between big commercial farms that are economically viable and small farms that are run by part-time farmers with other primary occupations (32). The small farms are mainly comprised of cattle, sheep, and exotic species that require relatively low levels of labour. These farms generally do not use computers for livestock management, although the farmers have access to computers and the internet (35). The challenge for animal health services will be to ensure that the smallholder livestock owners are well informed about livestock diseases. This will require a mixture of a field presence of animal health and/or veterinary professionals and information provision through traditional and internet channels.

Assessments of the impact of biological emergencies and disasters have traditionally focused on the production costs of the disease and the costs of the control and eradication measures. In the future, there will be an increasing need to consider the necessity for changes in national and international trade regulations due to public (i.e. consumers) and international (i.e. government) reactions and sometimes overreactions. An increasingly important aspect of animal disease systems will be the ability to manage and communicate a biological disaster as well as implement appropriate control measures in terms of environmental protection, food supply and safety, and international trade negotiations.

The main client of future animal health services and systems in developed countries will almost certainly be the consumer. Consumer demands will be for livestock products that are reasonably priced (food security), have little risk of disease (food safety), and are from systems that treat animals humanely (animal welfare). The current services and systems have been very successful in meeting food security demands, as shown by the reduction in prices of food products relative to other goods. They have also been largely successful in ensuring food safety (see reference 4 for the reduction in gastrointestinatal infections in humans), an issue that through the demands of the supermarkets is becoming increasingly complex. Commercial livestock systems will probably become part of an information system that will require little State activity beyond setting regulations and monitoring their implementation.

Threats

Four principle potential causes of biological emergencies and disaster are identified as being:

a) transboundary diseases from local wildlife populations, for example tuberculosis in badgers and possums and CSF in wild boars;

b) transboundary disease movement from migratory animals and birds, which is particularly important for Newcastle disease and HPAI;

c) transboundary diseases from the movement of livestock and wildlife products exported from developing countries. Exports may include:

– the legal movement of livestock from regions with a relatively well-known animal health status and certified livestock product processing systems

– the illegal movement of livestock from regions with an unknown animal disease status. This issue commonly involves poor communities in developing countries and relatively rich immigrant communities in developed countries that are linked by:

  – cultural preferences of the communities for specific meat and livestock products

  – economic incentives to ship products due to the large price differences between regions;

d) emerging problems due to changes in livestock production, such as feeding practices, and livestock product processing systems, such as increased scale of slaughter. These changes are associated with problems such as:

– BSE and other transmissible spongiform encephalopathies (TSEs)

– food-borne diseases, such as salmonellosis and *Escherichia coli* O157.

The new threat of bioterrorism can be added to this list. Although a bioterrorism event has not yet happened, such an incident would be capable of covertly transmitting transboundary diseases over great distances without the movement of animals or livestock products. Tharratt *et al.* (29) found that the awareness of potential bioterrorism events by state level veterinarians in the United States of America was low.

Regions with unknown or uncertain animal disease status generally have weak governments and Veterinary Services, and the majority of livestock are kept in extensive systems on communal grazing pastures or land resources (24). Such regions are often isolated, have poor trading links, and are found in poor countries and poor zones within developing countries. These regions are problematic for transboundary disease control for various reasons, including:

a) difficulty in vaccinating animals – many owners are unsure of exactly how many animals they own and catching and handling the animals add a significant cost to the vaccination process

b) poor economic returns on disease control in extensive systems (12, 19)

c) poor provision of veterinary services that could be due to a lack of sufficient personnel and inadequate training and incentives for field veterinarians to provide the services demanded by the livestock producers

d) poor provision of veterinary inputs, such as vaccines, antibiotics, etc., which can be related to the low quantity of inputs and a lack of cold storage capabilities that renders the inputs inadequate when finally applied to the animals.

The poor trading links with these regions means that the threat of a disease outbreak to developed countries is not likely to be that high. However, these areas harbour transboundary diseases, and as the international animal health status continues to improve these regions need to be incorporated into the international animal health system.

A summary of the threats associated with biological emergencies that developed countries may be confronted with is presented in Figure 1.

Measures

There are several measures that can be taken to combat the threats of a biological emergency, as follows:

a) protective measures at the borders, which can have varying degrees of sophistication. Rushton *et al.* (20) present a review of measures adopted by a wide range of countries;

b) strategies for wildlife disease control, such as the successful campaigns to control rabies in foxes in Europe;

c) surveillance measures that require the implementation and use of improved database technology (11);

d) established response mechanisms to disease outbreaks (proven with simulation exercises) that should include:

– the logistics of managing and controlling a disease outbreak

– the technical aspects of managing and controlling a disease outbreak

– the socio-economic impacts of a disease outbreak

– transparent communication of a disaster and the control measures that are implemented to avoid overreactions in national markets (consumers) and international markets;

e) mobilisation of delegations to go to regions where transboundary disease risks exist to work with:

– foreign governments with a known disease status to ensure that production and processing systems are not affected by transboundary and emerging diseases. This has to be a win-win situation, as developed countries continue to have a regular supply of safe and plentiful livestock products and the foreign (developing) countries reduce the risks of disruption to their livestock sector. Furthermore, this strategy would maintain a rotating cadre of veterinarians experienced in diseases that the local veterinarians may not be familiar with;

– foreign governments with an unknown disease status and/or weak animal health disease control systems. This support has traditionally focused on the eradication of the transboundary disease, but may have a more wide ranging and beneficial role in terms of animal health services and input provision, which is mainly focused on vaccines. Good examples of this type of collaboration are the programmes run in various countries by the United States Department of Agriculture Animal and Plant Health Inspection Service, the projects organised by the Pan African Programme for the Control of Epizootics in Africa, and the recently approved Southern African European Union project to harmonise animal health information systems;

f) financial investment in the development of programmes for the control, eradication, and prevention of transboundary diseases. This could range from vaccine development (19) to the improvement of epidemiological and economic models to predict disease risk and spread and highlight the need for changes or additional investments;

g) contingency funds, such as insurance policies, government reserves, and producer or livestock sector funds, to deal with problems that may arise in the case of an outbreak;

h) established vaccine banks.

Points *a*) to *f*) are classified as active insurance measures that should reduce the risk of a biological disaster, improve

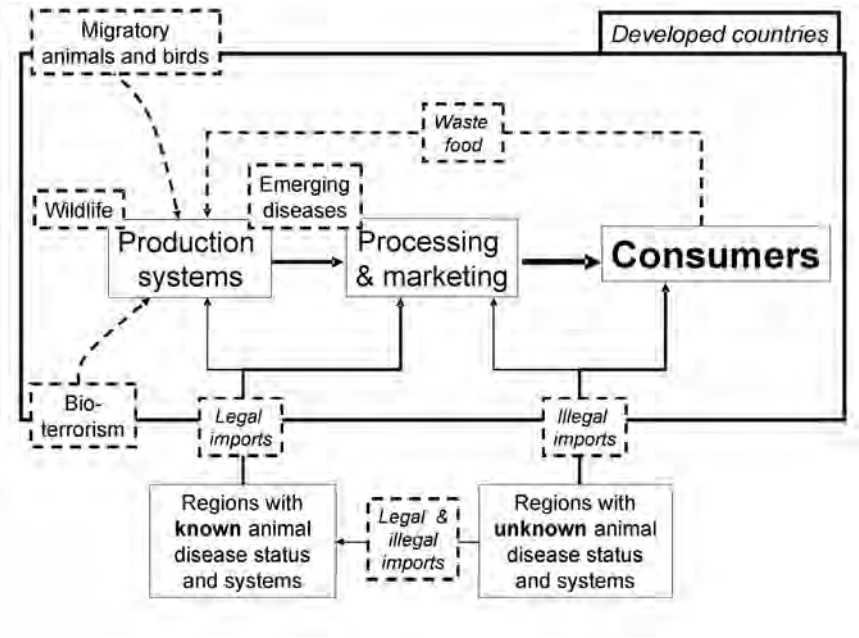

Fig. 1
Summary of the threats associated with biological emergencies that developed countries may be faced with

the speed of detection of a transboundary disease, and/or reduce the impact of a biological disaster if it occurs. Points *g*) and *h*) are passive insurance measures that would be influenced by the sophistication of measures *a*) to *f*). For example, good protection at the borders and the provision of aid to developing countries should lead to a reduced likelihood of outbreaks, and good surveillance and response systems should lead to early detection, quick control, and eradication of diseases with minimal costs.

Obtaining balance

The question posed at the beginning of this paper indicated that there was an 'either/or' choice between using active or passive measures to confront biological disasters. This should not be the case, for two reasons: biological disasters will almost certainly continue to occur in developed countries and active measures used to confront the disasters will influence the level of passive measures required. The interesting question is what economic tools are required to produce a balance between the use of active and passive measures. Based on earlier work, the authors (1, 21) suggest that decision tree analysis (9, 33) combined with epidemiological analysis would be the best method for developing a strategy to confront biological disasters. This approach could perhaps be taken a step further by using an optimisation process, such as dynamic programming, to determine a unique solution (26). However, given the number of unknowns for a biological disaster, it is unlikely that optimisation would be possible. Furthermore, the value of models used for the prediction of solutions is questionable (14, 27, 28). Figure 2 presents a simple representation of the model proposed above.

The value of such modelling is the actual process of working through the problems and issues rather than the identification of a final solution. It has been suggested that determining the critical risk points and the most costly aspects of a biological disaster would help in prioritising human and economic resources used to confront biological disasters. It is suggested that a balance of active and passives measures should be employed, but that because of the unknown level of threat from bioterrorism, the need to strengthen internal surveillance measures and policies to address the needs of countries with unknown animal disease status is a priority.

Conclusions

First it is necessary to ask whether a change in animal health systems in developed countries is needed. There is strong evidence that the animal health status in developed countries has improved and is relatively stable. In addition, through the international trade of animals and animal products, developing countries are becoming part of an international animal health system, the status of which is improving, though with occasional setbacks. However, there are new threats associated with biological disasters that cannot be ignored. These do not relate to the issues that have been dealt with in the past (e.g. wildlife

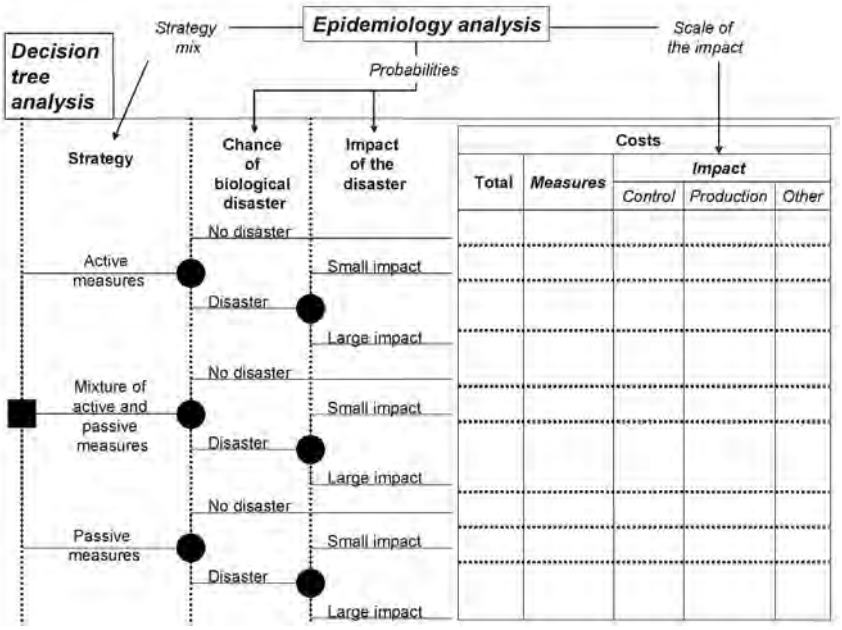

Fig. 2
Model for assessing the balance between the use of active and passive measures to confront biological emergencies

reservoirs of disease, legal and illegal imports of livestock products, and emerging problems due to changes in livestock production and livestock processing systems), but to the new threat of bioterrorism, which would mean that a disease could be transmitted over a long distance without animal or livestock product movement. Modifications of the models of surveillance and response are, thus, necessary in developed countries to ensure that the social and economic impact of a biological disaster is limited. The threat of bioterrorism changes the risk analysis, which is the basis of decision-making for preventive measures, and calls for greater thought on how surveillance measures can be made more efficient and how responses to a biological disaster can be made more effective. The latter does not just concern field actions, but also refers to the management and communication of biological disasters to avoid overreaction by trading partners and consumers. Overreaction to biological disasters often does far greater damage than the disease and the control measures themselves.

On the positive side, changes in livestock production systems in developed countries, such as increased farm sizes, will reduce operating costs and greater use of technology will enable data to be transmitted more quickly. Complete reliance on technology has to be tempered with the knowledge that small livestock enterprises will probably continue to be operated and will require field activities and information provision via more traditional channels. In addition, international trade in livestock products is having a positive impact on the international animal health status as producers around the globe become part of larger animal health control and surveillance systems. The current challenges lie in ensuring that all regions within countries and countries that are not members of the international animal trade market become part of the international animal health system and begin to benefit from an improved animal health status and livestock service delivery systems. Given that these regions and countries are usually poor, in some cases isolated, and have extensive livestock systems in which animals are kept on communal land resources (24), it is necessary to determine how to improve the livelihoods of livestock keepers through better animal healthcare. This could have a number of payoffs, such as improved international animal health disease status, less risk of a biological disaster in developed countries, and fewer poor livestock keepers. The Food and Agriculture Organization (6) has recommended that developed countries should be working towards ensuring that poor livestock keepers:

a) have guaranteed access to basic inputs, such as land, water, and animal feed

b) have access to input (veterinary services, veterinary drugs and treatments, animal feeds, etc.) and output (live animals and animal products) markets

c) have sustainable expansion of livestock production.

If developed countries can help to implement these simple rules there is a strong possibility that there will be fewer people willing to destroy existing and successful animal health systems and that such systems will expand, hence guaranteeing the continuing improvement of the international animal health status.

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Investir dans la prévention des urgences et catastrophes biologiques et les moyens de s'y préparer : les coûts sociaux et économiques des désastres comparés aux coûts de la surveillance et de la préparation des interventions

J. Rushton & M. Upton

Résumé

Les urgences biologiques comme l'apparition d'une maladie exotique transfrontalière ou émergente peuvent aboutir à des catastrophes. La question qui se pose aux Services vétérinaires dans les pays en développement consiste à trouver un équilibre entre d'une part les ressources consacrées aux mesures actives d'assurance comme le contrôle aux frontières, la surveillance, la coopération avec les gouvernements des autres pays en développement et les investissements dans l'amélioration des connaissances et des outils en matière vétérinaire, et d'autre part les ressources consacrées aux mesures passives, comme la constitution de fonds d'urgence et de banques de vaccins. Il est amplement démontré que la situation zoosanitaire dans les pays développés s'est beaucoup améliorée et qu'elle est relativement stable. En outre, les pays en développement, par leur commerce avec les autres pays, s'intègrent au système international de la santé animale, qui progresse malgré certains échecs. Toutefois, en dépit de ces améliorations, le risque de catastrophe biologique demeure et s'est même aggravé récemment en raison de la menace de bioterrorisme. Ce document propose un modèle qui combine la construction d'un arbre de décision avec les données de l'épidémiologie afin d'identifier les points critiques de la chaîne alimentaire qui doivent être renforcés pour réduire le risque de situations d'urgence et empêcher qu'elles ne se transforment en catastrophes.

Mots-clés

Catastrophe biologique – Impact socio-économique – Préparation des interventions – Surveillance – Urgence.

Las inversiones para prevenir y preparar emergencias y desastres biológicos: costo social y económico de los desastres comparado con el costo de la vigilancia y la preparación de la respuesta

J. Rushton & M. Upton

Resumen

Las emergencias biológicas como la aparición de una enfermedad transfronteriza o emergente exótica pueden cobrar proporciones catastróficas. En los países en desarrollo, los Servicios Veterinarios tienen ante sí la difícil tarea de encontrar un buen equilibrio entre los recursos que destinan a medidas de seguridad activas (control de fronteras, vigilancia, colaboración con gobiernos de países en desarrollo e inversión en mejores conocimientos e instrumentos veterinarios, por ejemplo), por un lado, y los que invierten en medidas pasivas (como fondos para imprevistos o bancos de vacunas), por el otro. Todo parece indicar que en los países desarrollados la situación zoosanitaria ha mejorado y es relativamente estable. Además, gracias al comercio con otras naciones, los países en desarrollo están pasando a integrarse en el sistema zoosanitario internacional, que cada vez es más sólido, pese a ocasionales contratiempos. No obstante esa positiva evolución, el riesgo de desastre biológico no sólo sigue latente sino que ha aumentado en los últimos tiempos debido a la amenaza del bioterrorismo. Los autores postulan que se necesita un modelo que combine el análisis epidemiológico y los árboles de decisión para determinar los puntos críticos de las cadenas alimentarias que conviene reforzar para reducir el riesgo de emergencias e impedir que éstas lleguen a convertirse en desastres.

Palabras clave

Consecuencia socioeconómica – Desastre biológico – Emergencia – Preparación de respuestas – Vigilancia.

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Ensuring good governance to address emerging and re-emerging animal disease threats: supporting the Veterinary Services of developing countries to meet OIE international standards on quality

B. Vallat [1] & E. Mallet [2]

(1) World Organisation for Animal Health (OIE), 12, rue de Prony, 75017 Paris, France
(2) École nationale des services vétérinaires, BP 83, 69280 Marcy-l'Étoile, France

Summary
As an effect of increased globalisation, animal diseases, in particular those transmissible to man, have an immediate global economic and social impact. This fact, dramatically illustrated by the current avian influenza epizootic in South-East Asia and Eastern Europe, clearly demonstrates the crucial importance of the national Veterinary Services (VS) for the prevention, early detection and response for the efficient control of animal diseases. Complying with this mission for the VS presupposes the existence of appropriate governance and legislation and of an official system to control their quality and reliability – an obvious weakness in many developing and in transition countries. The World Organisation for Animal Health (OIE) has therefore developed a project aiming at strengthening the VS in those countries facing the greatest animal health threats and to bring them into line with OIE international standards already adopted by the same countries. Based on the evaluation of the VS and subsequent actions at the global, regional and national levels, the project will have a significant beneficial impact on the targeted countries as well as the international community as a whole, not only in the fields of agriculture, food security and production, and food safety, but also for the local and global prevention of emerging and re-emerging diseases of veterinary and public health importance. The project will be implemented in strong collaboration with the Food and Agriculture Organization. The actions proposed must be considered eligible for the concept of International Public Good.

Keywords
Animal disease – Avian influenza – Developing country – Emerging disease – Evaluation – International public good – International standard – Quality – Veterinary Service – Zoonosis.

Introduction

Today, more than at any time in the past, outbreaks of certain animal diseases, especially zoonotic diseases, can cause considerable economic and social disruption and be a source of panic on an increasingly global scale. The recent sanitary crises involving bovine spongiform encephalopathy and foot and mouth disease are ample illustration of this new trend. The current avian influenza epizootic in South-East Asia and Eastern Europe also shows the extent to which a serious sanitary event affecting the animal kingdom can have direct consequences both for the rural economy of a continent and for the economy of world public health. Globalisation is conducive to the appearance of emerging diseases and greatly increases their impact.

The World Organisation for Animal Health (OIE) *Terrestrial Animal Health Code* defines the Veterinary Services (VS) of a country or group of countries as 'the national Veterinary Administration, the Veterinary Authorities and all persons authorised, registered or licensed by the Veterinary Statutory Body', and both the public and private components of national mechanisms for the control and prevention of animal diseases. They are the very core of the prevention and control of animal diseases, including those transmissible to humans. They play a major role in every country as guarantors of animal health and associated public health issues. This essential mission is clearly demonstrated, for example, by their official mandates for the sanitary certification of animals and animal products and for the early detection and rapid response in the event of an emerging or re-emerging animal disease occurrence. This mission presupposes the existence of appropriate governance and legislation, and an official system to control the quality and reliability of their decisions and those of all their private sector partners helping them to fulfil their missions.

Indeed, as regards the sanitary certification of animals and animal products destined for cross-border trade or certification of the quality of public animal health services, all the importing countries of the world will accept certification only if it has been issued under the responsibility of the Government of the exporting country.

The proposals presented in this article form part of an OIE three-year action plan aimed at helping those developing countries facing the greatest animal disease threats to have an effective VS, capable of detecting animal disease outbreaks as soon as they occur and responding rapidly to bring the diseases immediately under control, thereby achieving credibility in the eyes of the international community. These proposals are designed to bring the VS into line with OIE international standards in terms of governance, organisation and functioning, and encourage an active partnership with the private sector. This project benefits from the political and technical support provided by the 167 Member Countries of the OIE. The OIE standards are recognised as the reference by the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures as a means of building a sustainable global, regional and national organisational framework for the VS.

The programme will be implemented in partnership with the Food and Agriculture Organization (FAO).

Bringing the quality of the VS into line with international standards will have a significant beneficial impact on the countries concerned and on the international community as a whole. This can impact not only the fields of agricultural economy, public health (including food safety and the supply of animal protein) and access to international markets, but also local and global prevention of emerging and re-emerging diseases that present a danger to humans and are on the increase due to globalisation. For this reason the actions proposed hereafter must be considered eligible for the concept of International Public Good.

The project will be described along two main lines:

– actions to be undertaken according to the degree of urgency (short term, medium term or long term)

– the most appropriate level of coordination for the different actions proposed (global, regional, national).

An approximate preliminary estimate of the costs is appended to the present document (Appendix I).

Due to the present situation, the proposals of the three-year plan that are described in this article are focused on the control of avian influenza in those countries currently affected or at risk of becoming affected in the months ahead.

In this document, the term 'standards' refers to the international standards issued by the World Organisation for Animal Health (OIE) with the aim of controlling animal diseases worldwide.

Urgent action and longer-term planning

Short-term actions

The actions to be taken in the short term are emergency measures aimed essentially at rapidly controlling the regional and global spread of highly pathogenic avian influenza. They are designed to control the virus at its animal source and prevent its spread. This type of measure can also be applied to control several other emerging zoonoses (severe acute respiratory syndrome [SARS] is a recent example). All the recommendations outlined below have been designed in accordance with the recommendations of the World Health Organization (WHO) Strategic Plan: responding to the avian influenza pandemic threat (3).

Early detection of outbreaks

Should an outbreak occur in a previously uninfected country, the first and most urgent objective is to prevent the disease from spreading among farmed bird populations. To do this efficiently there must be a system in place for rapid detection. Following detection one can immediately apply a classical disease-control policy, based on the subsidised culling of infected or in-contact animals and the introduction of strict movement restrictions for animals and humans. The implementation of early detection measures is of the utmost importance in at-risk countries that share borders with countries currently infected or are prone to become infected

by migrating wild birds. At this level, it is vital for there to be immediate and fair compensation mechanisms for livestock producers. This, more than anything else, positively encourages livestock owners to report their early suspicions.

Rapid response to outbreaks

Technical and financial support for disease control is essential in countries that are infected but have been unable to mobilise the necessary resources quickly enough to halt the progression of the disease on their territory. While temporary mass vaccination should in this case be used as a last resort before reverting to the classical sanitary control policies referred to above, its planning should precede any outbreak because of the need for speed. Financial aid is extremely important for mass vaccination due to the costs involved, for example, in Vietnam, the first blanket vaccination of poultry against avian influenza cost approximately US$ 40 million.

The emergency measures to be implemented in the short term are described in the FAO/OIE Strategic Plan for the eradication of avian influenza (2), a plan that will have to be constantly updated to take into account developments in the disease worldwide. This strategic plan is directly based on the FAO/OIE general mechanism – the Global Framework for the control of Transboundary Animal Diseases (GF-TADs) (1).

The OIE and FAO have also set up a worldwide network of laboratories and specialists with expertise in avian influenza (5). As well as providing expert advice this network is also responsible for providing the animal virus strains to the WHO Reference Laboratories. These strains will eventually be used in the early production of human vaccines.

The responsibilities of Veterinary Services

If the spread of newly emerging or re-emerging epizootic diseases, including avian influenza, is to be limited the capacity of States to develop the necessary tools to rapidly detect their presence and take the appropriate emergency actions to immediately eliminate the pathogen(s) in question needs to be strengthened. Immediately eradicating an emerging disease as soon as it occurs will logarithmically reduce the cost of eradicating it. For this reason, steps must first be taken to ensure the efficacy of the specialised public services responsible for formulating the relevant legislation and effectively controlling its application.

In all countries of the world, the VS, with their public and private components, are specifically responsible for coordinating national animal disease prevention and control activities.

To ensure that these Services fulfil these missions eligible for the concept of Public Good in an effective, transparent and verifiable manner, the OIE has established an 'Animal Health Code' instituting scientific, technical and organisational standards which the Member Countries have unanimously voted for and undertaken to apply. Specific instruments are also available that enable States to carry out an internal evaluation of their VS to verify their compliance with the standards. In this respect, the audit procedure, entitled *Performance, Vision and Strategy for Veterinary Services* (4) is due to be incorporated into the guidelines published by the OIE (6) as the reference instrument approved by the Member Countries.

In the countries currently infected with avian influenza and in those at high risk, actions in the short term will include an emergency partial audit of the VS to verify as a first priority their technical capacity and authority to do the following:

a) to prepare and implement emergency plans

b) to confirm clinical and laboratory diagnoses

c) to prevent the entry and spread of diseases in the country

d) to obtain the necessary financial resources to promptly compensate livestock producers

e) to conduct, where necessary, national vaccination campaigns, for example, whenever and wherever the disease has become endemic

f) to update national legislation, emergency plans, and control systems, to verify their application in the aforementioned fields, and to involve the private sector in prevention activities.

In October 2005, the countries infected with avian influenza (H5N1, Asia strain) in farmed birds were as follows: Vietnam, Thailand, Cambodia, Laos, Indonesia, the People's Republic of China, Russia, Mongolia, Kazakhstan, Romania, and Turkey. At the same time, the countries considered to be 'most at risk' were as follows: Myanmar, the Philippines, Malaysia, India, Kyrgyzstan, Egypt, Iran and Pakistan.

The list is likely to grow in the months ahead, to include other European countries as well as countries in Africa and the Middle East.

Medium-term actions

The actions to be taken in the medium term involve the restructuring of the VS of developing countries, in association with their public and private sector partners. The guidelines to be used in this process will be established following global and regional consultation and arbitration (see sections 'Global level' and 'Regional level'). The medium-term action programme is in three stages:

a) thorough evaluation of the VS and the actions needed to improve their governance and bring them into line with OIE standards

b) training of personnel in project identification and formulation, followed by their participation in the preparation of projects and the assessment of their economic feasibility

c) implementation of projects.

Each of these three programme components will be examined in more detail below.

Thorough evaluation of national Veterinary Services

Evaluation of the VS in the countries targeted by the project will begin by determining normative deficiencies in terms of governance, organisation, functioning, and resources.

The evaluation will measure the capacities of the VS in the following areas:

a) awareness of and compliance with international standards, including the OIE *Terrestrial Animal Health Code*

b) recruitment and training procedures for public and private sector staff, including initial training and continuing professional education

c) independent and sustainable funding of restructuring activities

d) conditions under which policies are implemented and their application monitored, including for laboratories

e) independence from the political authority, notably in terms of the transparency of the country's animal health status

f) consultation and involvement of public and private sector partners that are beneficiaries of their actions, including consumers

g) participation in the work of international bodies

h) conditions for accreditation when delegating public services to partners who are private operators

i) implementation of programmes in partnership with the private sector.

The capacity of the VS will also be evaluated in terms of access to regional and international markets for animals and animal products, with respect to:

j) compliance of legislation with OIE standards

k) quality and reliability of export certification

l) equivalency agreements with countries that are trading partners

m) measures relating to traceability of animals and animal products and their implementation

n) application of the concepts of zoning and compartmentalisation.

Institutional and technical partners at the national level (e.g. scientific agencies responsible for risk evaluation, diagnostic laboratories) and private sector professionals involved in the management of animal health and veterinary public health (e.g. local veterinarians, livestock producers and their animal health organisations) will be involved in the evaluation procedure in their capacity as partners of the VS. Agri-food industry operators (e.g. processors, distributors, caterers) will also be party to the evaluation, notably due to their responsibility for the safety of food products, as partners of the official food inspection services (see above, *j*), and as major economic players.

Weaknesses in governance and normative deficiencies will be identified, recorded and prioritised, to enable remedial action to be taken where necessary (with the appropriate public and private investments).

In liaison with the various components of the private sector working in partnership with the VS, the required changes that have legislative or regulatory implications will be identified and proposed to the competent authorities. The relevant necessary public and private sector investments will also be described and evaluated with a view to achieving compliance with OIE standards and to strengthen operational capabilities (e.g. logistic support, material, laboratories).

A contingency fund for use in the event of an animal health crisis will be set up and managed jointly by the different partners.

Preparation of national projects

Once the phase of determining the normative deficiencies of the VS and their partners has been completed, national projects aimed at restructuring the VS and bringing it into line with OIE standards will be drawn up and submitted at the national level, and, where appropriate, to external funding agencies.

The private sector (livestock producers, veterinarians, processors, distributors, consumers, exporters), including the insurance sector, will be always consulted in the preparation of projects, with the aim of involving it in the entire process. Private sector participation in carrying out and jointly financing some of the components will be sought, notably for participation in the activities and costs relating to disease-control policies, including insurance and financial compensation for livestock farmers. Funding from major donors will be on condition that the projects are designed to enable the VS to meet OIE standards and involve private sector participation.

The OIE will be in charge of launching national seminars with the Veterinary Administration and all relevant stakeholders.

Project implementation

The projects will be implemented during a preliminary pilot phase in the following regions:

– Asia-Pacific

– Africa

– Middle East

– Eastern Europe

– Central and South America.

These regions have permanent OIE regional offices, each of which provides the permanent regional secretariat for the regional Steering Committees of the FAO/OIE GF-TADs.

Developing and in transition OIE Member Countries have expressed an interest in receiving support to bring their VS into line with OIE standards. At least forty of these will require urgent significant financial aid. The number of countries that can benefit from additional funding will therefore depend on the availability of external financial support. The initial budget for the three-year plan has been drawn up on the basis that 141 countries will receive technical support and training (Appendix II).

Actions eligible for external funding, as a counterpart to public and private national funding, will include:

a) implementation of the audit of compliance with standards, in preparation for the external (international) evaluation of the VS under the auspices of the OIE, which will be transparent and published by the OIE

b) technical support for the preparation or upgrading of governance and legislation

c) support for institutional and organisational restructuring and the training of the various players, this will involve:

– carrying out audit missions and consultations with key players in the beneficiary States and in regional and sub-regional organisations that have a proven interest in animal health

– holding training seminars and seminars to define regional and national veterinary health policies

– holding training seminars and workshops for relevant partners in the private sector, specifically private operators, livestock producers, agri-food firms, and insurance firms

– carrying out studies to verify the justification for economic investment in projects of importance to national, regional and global veterinary public health

d) the development of priority infrastructure (technical materials [i.e. cars and cold chain facilities], logistics, and technical investments, such as the modernisation of veterinary laboratories).

Long-term actions

The results, methods and resources used during the three years implementation of the first national projects will be assessed after a preliminary evaluation and a permanent follow-up will be established between the OIE and beneficiary Member Countries. If deemed successful the investments accorded will be extended to other developing and in transition countries whose VS do not yet meet OIE standards.

Organisation of the different levels of coordination

This section of the paper deals with the way the short-, medium- and long-term actions described above are to be distributed between the global, regional and national levels.

Global level

Coordinating mechanism

At the global level, the action plan will be managed by the OIE and the World Bank, with the participation of the FAO, the WHO, interested funding agencies, and representatives of world federations in the agri-food (livestock producers, processors, distributors, including the major catering groups) and insurance sectors. A global Service Centre to promote the work of this mechanism acting as a coordinating body will be set up jointly by the OIE and the World Bank at OIE headquarters.

The role of this coordination body will be primarily to define and promote suitable governance for veterinary health policies at the global level in accordance with the standards adopted by the international community. To this end, the coordinating group will have a fund at its disposal in order to define, evaluate and fine-tune these policies, where necessary with the help of technical consultants/assistants. This World Animal Health Fund was agreed upon and voted for by OIE Member Countries in May 2003. This Fund will enable policy promotion actions to be financed at the regional level (see section 'Regional level' below) along the same lines as those proposed at the global level. It will also be used to facilitate new alliances among relevant international organisations, private sector and consumer associations, and to develop new mechanisms for a common strategy regarding risk communication in relation with threats of pathogens of animal origin. In addition, the Fund will be used to carry out economical studies comparing the costs of establishing and maintaining early detection and response systems, versus the costs of managing crisis without proper preparation.

Priority actions

The creation of the World Animal Health Fund will enable the OIE and its partners to do the following:

a) promote the appropriate global control policies for avian influenza (in animals) and other emerging and re-emerging animal diseases (see section 'Short-term actions')

b) build new alliances among international organisations, private sector and consumer associations, to support global, regional and national programmes for the prevention and control of animal diseases

c) define and implement mechanisms for harmonising official and media communication strategies related to the risks linked with threats from pathogens of animal origin

d) coordinate, support and monitor mirror regional policies

e) perform economic studies comparing the costs of establishing and maintaining early detection and response systems, versus the costs of managing crisis without proper preparation.

Regional level

Structures involved

Regional responsibility will include promoting the relevant governance models, implementing capacity building programmes and providing technical support for the preparation of projects aimed at bringing the within-region national VS into line with standards. Capacity building will firstly be targeted at national public and private sector leaders in developing countries in each of the regions involved in the action plan. This will include regular meetings between the 'champions' of both developed and developing countries in each region, for example the countries of North, Central and South America, and those of Western and Eastern Europe. Other seminars will be organised to define policies at the regional level for representatives of all the developing and in transition countries involved.

The OIE Regional Representations team will be in charge of the regional coordination of the programme. They are already in place and will set up Regional Animal Health Centres, managed jointly with the FAO, to provide their Member Countries with technical support. They will evaluate national projects, backed up where necessary by OIE Collaborating Centres (see below) and outside consultants.

The regional coordination mechanisms will be entrusted to the OIE Regional Representations listed below, which are also involved in the current formal partnership set up jointly by the OIE, the FAO and the WHO, and set out in the GF-TADs Agreement. The Regional Animal Health Centres will operate directly within the framework of the GF-TADs.

The OIE Regional Representations and Sub-Regional Offices which may potentially be involved are:

– Asia-Pacific: Tokyo and Bangkok

– Africa: Bamako and Gaborone

– North and South America: Buenos Aires

– Central America and Carribbean countries: San Salvador (Organismo Internacional Regional de Sanidad Agropecuaria)

– Middle East: Beirut

– Eastern Europe: Sofia.

Activities to strengthen the capabilities of national public and private sector 'champions' of all the developing countries involved will take the form of regional and sub-regional seminars, designed to achieve economies of scale, and create synergies and harmonised approaches between countries.

With regard to the training of the various key national players who will be responsible for field activities in the pilot countries selected in each region (e.g. public sector VS officials, private sector veterinarians, livestock producers and economic operators), the OIE Regional Representations will have the permanent support of the OIE's global network of Collaborating Centres, in particular those specialised in the training of official veterinarians. Such Collaborating Centres are already in place (e.g. the École Nationale des Services Vétérinaires, France) and others are currently being set up to deal with training programmes focused on the management of official Veterinary Services (Minneapolis, United States of America; Buenos Aires, Argentina; Abu Dhabi, United Arab Emirates). The current OIE network of 15 collaborating Centres specialise in a variety of areas, e.g. epidemiology, vaccinology, risk analysis and GIS technologies.

The Regional Animal Health Centres involved in training leaders, evaluating the national VS, and preparing and formulating new projects, will be located in the OIE Regional Representations. They will work jointly with the FAO, which will implement other specific programmes. The Centres will also benefit from the support of the OIE's worldwide Collaborating Centres. They will operate within the general framework of the FAO/OIE GF-TADs.

Priority actions

Priority actions at regional level are:

a) improvement of governance and capacity building by the national public and private sector leaders of all

developing and in transition countries, by means of regional seminars

b) creation of Regional Animal Health Centres to provide the relevant countries with technical assistance

c) institutional and organisational restructuring and training of key players, in particular in the fields of VS compliance with OIE standards, in the pilot countries of each region

d) technical and methodological support by the Regional Animal Health Centres to assist with the technical and economic preparation of projects for the two countries in each region that are the subject of pilot projects.

National level

Action at the institutional level

In liaison with the global and regional levels of coordination and their Service Centres and Collaborating Centres, the national coordination bodies due to be set up in those countries in each of the five regions where pilot programmes are to take place, will be responsible for:

a) providing technical support for a self-evaluation of the VS, primarily based on tools provided by the OIE, the global mechanism described in the section 'Global level', the VS evaluation instrument *Performance, Vision and Strategy* and the OIE *Terrestrial Code* standards

b) confirming the deficiencies and gaps in the VS requiring legislative and regulatory adjustments, and helping to identify the investments needed to modernise their infrastructure

c) providing support for the definition of veterinary health policies, and for the organisation and functioning of the VS, so as to ensure rapid detection of emerging and re-emerging diseases, rapid response to outbreaks, and effective control of food-borne pathogens, with the assistance of the private sector (e.g. livestock producers, private veterinarians, processors, distributors), this will include the participation of national insurance organisations and reinsurance organisations at the regional and international levels

d) providing support for the technical and economic evaluation of national investment projects, with recourse to additional international resources where necessary

e) suggesting technical assistance mechanisms where necessary, with the FAO and/or other multilateral or bilateral external players playing a vital role, notably within the framework of the GF-TADs.

The utilisation of resources allocated at the national level will be managed directly by the recipient country.

Compliance of veterinary health policies with OIE standards at the national level and monitoring of investment programmes will be the subject of external audits under the auspices of the OIE.

The main condition governing the provision of external funding of national projects will be a commitment by the different States to comply with international standards for the quality of VS and private sector involvement in support of the public sector.

Priority actions and investments

The activities of the OIE at national level will be focused on, and limited to, capacity building and creating or strengthening alliances, through national seminars with the Veterinary Administration and stakeholders, throughout the first phase of launching the new national programmes.

Priority actions at national level are as follows:

a) support to bring national governance and veterinary health legislation into line with OIE international standards

b) support for the definition of mechanisms of governance, such as the design of a national chain of command, and for negotiations between Government, veterinarians, livestock producers, processors and distributors, including the legal framework for the distribution of missions and financial participation among stakeholders

c) preparation of emergency plans and systems for early detection, rapid response, surveillance for priority diseases, and, especially, emergency intervention teams

d) support for technical feasibility and ex ante economic evaluations of programmes (in liaison with the Regional Animal Health Centres)

e) strengthening the capabilities of public and private national players

f) support for producers' and processors' organisations

g) creation of a compensation fund for livestock producers, if possible with the involvement of insurance firms

h) bringing diagnostic laboratories' capabilities to diagnose and confirm priority diseases into line with international standards

i) support for the creation of national stocks of the relevant vaccines and antigens.

The list of priority diseases was agreed by the Member Countries of the OIE. It is regularly updated and is available on the OIE website (see www.oie.int).

Appendix I

Financial forecast for the OIE three-year plan to improve Veterinary Services in developing countries

Financing of an OIE three year action plan aimed at eradicating and/or controlling avian influenza by improving the quality of national Veterinary Services, through capacity building programmes, by evaluating their compliance with international standards and by providing scientific expertise [a]

Financial forecast (euros) at 26 December 2005	Year 1	Year 2	Year 3	Total
1. Actions at global level: World Fund				
Definition of world good governance policies				
1 technical coordination assistant (200,000 euros grant obtained for 2006)		200,000	200,000	400,000
7 support missions of 15 days each to the regions				
Travel 3,000 euros × 7	21,000	21,000	21,000	63,000
Daily allowance 105 days × 130 euros	13,650	13,650	13,650	40,950
Administrative support staff (1 full-time officer) – year 1: DGF from World Bank [b]		50,000	50,000	100,000
Communication media, e.g. leaflets and DVDs	150,000	100,000	100,000	350,000
Subtotal 1	**184,650**	**384,650**	**384,650**	**953,950**
2. Actions at regional level: Regional Representations and Sub-Regional Offices				
Mirror actions defined by the global policies				
2.1 Africa (OIE Regional Representation in Bamako)				
1 technical coordination assistant (in post for 2006)		200,000	200,000	400,000
Organisation of two seminars (African decision-makers) 100,000 euros × 2	200,000	200,000	200,000	600,000
4 support missions of 15 days each to the region				
Travel 3,000 euros × 4	12,000	12,000	12,000	36,000
Daily allowance 20 days × 130 euros	2,600	2,600	2,600	7,800
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.1	**219,600**	**419,600**	**419,600**	**1,058,800**
2.2 Africa (Gaborone OIE/SADC Sub-Regional Representation)				
Organisation of two seminars 100,000 euros × 2	200,000	200,000	200,000	600,000
3 support missions of 5 days each in the sub-region				
Travel 1,500 euros × 3	4,500	4,500	4,500	13,500
Daily allowance 15 days × 130 euros	1,950	1,950	1,950	5,850
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.2	**211,450**	**211,450**	**211,450**	**634,350**
2.3 Africa (Maghreb OIE/UMA Sub-Regional Representation)				
1 technical coordination assistant	150,000	150,000	150,000	450,000
Organisation of two seminars 100,000 euros × 2				
3 support missions of 5 days each in the sub-region	200,000	200,000	200,000	600,000
Travel 1,500 euros × 3	4,500	4,500	4,500	13,500
Daily allowance 15 days × 130 euros	1,950	1,950	1,950	5,850
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.3	**361,450**	**361,450**	**361,450**	**1,084,350**
2.4 Eastern Europe (OIE Office to be opened in Brussels)				
1 technical coordination assistant	180,000	180,000	180,000	540,000
Organisation of 3 seminars 100,000 euros × 3				
8 support missions of 5 days each in the region	300,000	300,000	300,000	900,000
Travel 2,000 euros × 8	16,000	16,000	16,000	48,000
Daily allowance 40 days × 130 euros	5,200	5,200	5,200	15,600
Administrative support staff (1)	50,000	50,000	50,000	150,000
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.4	**556,200**	**556,200**	**556,200**	**1,668,600**
2.5 Middle-East (OIE Regional Representation in Beirut)				
1 technical coordination assistant	180,000	180,000	180,000	540,000
Organisation of two seminars 100,000 euros × 2				
8 support missions of 5 days each in the region	200,000	200,000	200,000	600,000
Travel 1,500 euros × 8	12,000	12,000	12,000	36,000
Daily allowance 40 days × 130 euros	5,200	5,200	5,200	15,600
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.5	**402,200**	**402,200**	**402,200**	**1,206 600**
2.6 Asia (OIE Regional Representation in Tokyo)				
1 technical coordination assistant	200,000	200,000	200,000	600,000
Organisation of 4 seminars 100,000 euros × 4				
10 support missions of 5 days each in the region	400,000	400,000	400,000	1,200,000
Travel 1,500 euros × 10	15,000	15,000	15,000	45,000
Daily allowance 50 days × 130 euros	6,500	6,500	6,500	19,500
Office expenses (including the hire of premises)	35,000	35,000	35,000	105,000
Subtotal 2.6	**656,500**	**656,500**	**656,500**	**1,969,500**

Financial forecast (euros) at 26 December 2005 (cont.)	**Year 1**	**Year 2**	**Year 3**	**Total**
2.7 Asia (OIE/SEAFMD Sub-Regional Office in Bangkok)				
1 technical coordination assistant (in post for 2006 and 2007)			180,000	180,000
Organisation of two seminars 100,000 euros × 2				
6 support missions of 5 days each in the region	200,000	200,000	200,000	600,000
Travel 1,500 euros × 6	9,000	9,000	9,000	27,000
Daily allowance 30 days × 130 euros	3,900	3,900	3,900	11,700
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.7	**217,900**	**217,900**	**397,900**	**833,700**
2.8 Americas (OIE Regional Representation in Buenos Aires)				
1 technical coordination assistant	150,000	150,000	150,000	450,000
Organisation of 3 seminars 100,000 euros × 3				
6 support missions of 5 days each in the region	300,000	300,000	300,000	900,000
Travel 1,500 euros × 6	9,000	9,000	9,000	27,000
Daily allowance 30 days × 130 euros	3,900	3,900	3,900	11,700
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.8	**467,900**	**467,900**	**467,900**	**1,403,700**
2.9 Americas (Sub-Regional Office OIE/OIRSA for Central America and Caribbean countries)				
1 technical coordination assistant	150,000	150,000	150,000	450,000
Organisation of two seminars 100,000 euros × 2				
4 support missions of 5 days each in the region	200,000	200,000	200,000	600,000
Travel 1,500 euros × 4	6,000	6,000	6,000	18,000
Daily allowance 20 days × 130 euros	2,600	2,600	2,600	7,800
Office expenses	5,000	5,000	5,000	15,000
Subtotal 2.9	**363,600**	**363,600**	**363,600**	**1,090,800**
Subtotal 2	**3,456 800**	**3,656 800**	**3,836 800**	**10,950,400**
Subtotal 1 + 2	**3,641,450**	**4,041,450**	**4,221,450**	**11,904,350**
3 OIE/FAO OFFLU network				
1 technical assistant to be provided by the FAO with French financing	–	–	–	
Office logistical support	5,000	5,000	5,000	15,000
Administrative support staff (1)	50,000	50,000	50,000	150,000
10 scientific missions of 2 people for 6 days in the infected or at-risk countries (Asia, Africa, Middle-East, Eastern Europe)				
Travel 3,000 euros × 20	60,000	60,000	60,000	180,000
Daily allowance 60 days × 2 people × 130 euros	15,600	15,600	15,600	46,800
Shipping of organ samples 15 × 4,000 euros	60,000	60,000	60,000	180,000
Subtotal 3	**190,600**	**190,600**	**190,600**	**571,800**
Subtotal 1 + 2 + 3	**3,832,050**	**4,232,050**	**4,412,050**	**12,476,150**
4 Actions at national level: actions in the infected and at-risk countries in conjunction with the FAO and the WHO				
4.1.Technical support for the preparation and launching of national projects and evaluation of Veterinary Services (47 countries/year =141) [(c)]				
4.1.1 National evaluation and training seminars for public veterinarians (administration) and implementation of mechanisms for the national compensation fund for livestock producers 45,000 euros × 47	2,115,000	2,115,000	2,115,000	6,345,000
4.1.2 National training seminars for livestock producers and private veterinarians and operators 45,000 euros × 47	2,115,000	2,115,000	2,115,000	6,345,000
4.2 Support to the OIE Collaborating Centres [(d)] for the elaboration of pedagogical material and support and participation in the seminars				
10,000 euros × 47 the first year + 8,000 euros × 47 for each of the subsequent years	470,000	376,000	376,000	1,222,000
Subtotal 4	**4,700,000**	**4,606,000**	**4,606,000**	**13,912,000**
Total 1 + 2 + 3 + 4	**8,532,050**	**8,838,050**	**9,018,050**	**26,388,150**
Total cost for three years				**26,388,150**

(a) within the framework of strategies elaborated jointly by the OIE and the FAO
(b) Development Grant Fund attributed to the OIE by the World Bank
(c) 141 (see Appendix II) of the 167 OIE Member Countries are involved in the action plan. Some countries will receive more than one support mission within the three year period of the programme
(d) National Veterinary Services School (École Nationale des Services vétérinaires) – Lyons (France). Two other Collaborating Centres for the training of Veterinary Services are currently in creation (Minneapolis, United States of America and Buenos Aires, Argentina)
OFFLU: Joint OIE/FAO worldwide scientific network for the control of avian influenza
OIRSA: Organismo Internacional Regional de Sanidad Agropecuaria
SADC: Southern African Development Community
SEAFMD: South-East Asia Foot and Mouth Disease Campaign
UMA: Union du Maghreb Arabe (Arab Maghreb Union)
NB : resources for GLEWs Programme are presented by FAO and WHO and includes resources to be implemented by the OIE

Appendix II

List of countries (141) at risk for avian influenza and benefiting from the project

Africa 47 countries	East Asia and Pacific 16 countries	Europe and Central Asia 20 countries	Latin America and the Caribbean 31 countries	Middle East and North Africa 19 countries	South Asia 8 countries
– Angola	– Cambodia	– Albania	– Antigua and Barbuda	– Algeria	– Afghanistan
– Benin	– China (People's Rep. of)	– Armenia	– Argentina	– Bahrain	– Bangladesh
– Botswana	– Fiji	– Azerbaijan	– Barbados	– Djibouti	– Bhutan
– Burkina Faso	– Indonesia	– Belarus	– Belize	– Egypt	– India
– Burundi	– Kiribati	– Bosnia and Herzegovina	– Bolivia	– Iran	– Maldives
– Cameroon	– Korea	– Bulgaria	– Brazil	– Iraq	– Nepal
– Cape Verde	– Lao PDR	– Croatia	– Chile	– Jordan	– Pakistan
– Central African Rep.	– Malaysia	– FYR Macedonia	– Colombia	– Kuwait	– Sri Lanka
– Chad	– Mongolia	– Georgia	– Costa Rica	– Lebanon	
– Comoros	– Papua New Guinea	– Kazakhstan	– Dominica	– Libya	
– Democratic Republic of Congo	– Philippines	– Kyrgyz Republic	– Dominican Republic	– Morocco	
– Rep. of Congo	– Samoa	– Moldova	– Ecuador	– Oman	
– Côte d'Ivoire	– Thailand	– Romania	– El Salvador	– Qatar	
– Equatorial Guinea	– Timor-Leste	– Russian Federation	– Grenada	– Saudi Arabia	
– Eritrea	– Vanuatu	– Serbia and Montenegro	– Guatemala	– Syrian Arab Rep.	
– Ethiopia	– Vietnam	– Tajikistan	– Guyana	– Tunisia	
– Gabon		– Turkey	– Haiti	– United Arab Emirates	
– Gambia		– Turkmenistan	– Honduras	– West Bank and Gaza	
– Ghana		– Ukraine	– Jamaica	– Yemen	
– Guinea		– Uzbekistan	– Mexico		
– Guinea-Bissau			– Nicaragua		
– Kenya			– Panama		
– Lesotho			– Paraguay		
– Liberia			– Peru		
– Madagascar			– St. Kitts and Nevis		
– Malawi			– St. Lucia		
– Mali			– St. Vincent and the Grenadines		
– Mauritania			– Suriname		
– Mauritius			– Trinidad and Tobago		
– Mozambique			– Uruguay		
– Namibia			– Venezuela		
– Niger					
– Nigeria					
– Rwanda					
– São Tomé and Principe					
– Senegal					
– Seychelles					
– Sierra Leone					
– Somalia					
– South Africa					
– Sudan					
– Swaziland					
– Tanzania					
– Togo					
– Uganda					
– Zambia					
– Zimbabwe					

Améliorer la gouvernance pour mieux prévenir et contrôler les maladies animales émergentes et ré-émergentes : aider les Services vétérinaires des pays en développement à respecter les normes internationales de qualité de l'OIE

B. Vallat & E. Mallet

Résumé

Sous l'effet des progrès de la mondialisation, les maladies animales et en particulier celles transmissibles à l'homme ont désormais un impact économique et social immédiat à l'échelle mondiale. Cette réalité, spectaculairement illustrée par l'épizootie actuelle d'influenza aviaire en Asie du Sud-Est et en Europe orientale, démontre clairement l'importance cruciale que revêtent les Services vétérinaires nationaux pour la prévention, la détection précoce et l'efficacité des interventions visant à contrôler les maladies animales. La condition préalable pour que les Services vétérinaires puissent s'acquitter de cette mission tient à l'existence d'une bonne gouvernance et d'une législation appropriée ainsi que d'un système officiel permettant de contrôler la qualité et la fiabilité de ces services, exigence qui fait manifestement défaut dans de nombreux pays en développement et en transition. En conséquence, l'Organisation mondiale de la santé animale (OIE) a conçu un projet visant à renforcer les Services vétérinaires dans les pays exposés aux menaces zoosanitaires les plus graves et à veiller à ce qu'ils respectent les normes internationales de l'OIE déjà adoptées par ces mêmes pays. Le projet, fondé sur l'évaluation des Services vétérinaires et les actions ultérieures menées à l'échelle mondiale, régionale et nationale, aura des effets bénéfiques importants sur les pays ciblés ainsi que sur la communauté internationale tout entière, non seulement dans le domaine de l'agriculture, de la sécurité et de la production alimentaires et de la sécurité sanitaire des aliments, mais aussi dans celui de la prévention locale et mondiale des maladies émergentes et ré-émergentes ayant un impact sur la santé publique et la santé publique vétérinaire. Le projet sera mis en œuvre en collaboration étroite avec l'Organisation des Nations unies pour l'alimentation et l'agriculture. Les actions proposées doivent pouvoir être considérées comme relevant du concept de Bien public international.

Mots-clés

Bien public international – Évaluation – Influenza aviaire – Maladie animale – Maladie émergente – Norme internationale – Pays en développement – Qualité – Service vétérinaire – Zoonose.

Mejorar la gestión para prevenir y controlar las enfermedades animales emergentes y reemergentes: prestación de apoyo a los Servicios Veterinarios de los países en desarrollo para que cumplan las normas internacionales de la OIE en materia de calidad

B. Vallat & E. Mallet

Resumen

Debido a la creciente mundialización, las enfermedades animales, sobre todo las transmisibles al hombre, tienen una influencia inmediata y a escala planetaria sobre la economía y la sociedad. Este hecho, que ilustra de forma elocuente la actual epizootia de influenza aviar en el Sudeste asiático y Europa Oriental, deja claramente sentada la gran importancia de los Servicios Veterinarios (SV) nacionales a la hora de prevenir y detectar con rapidez enfermedades animales y de responder eficazmente a la amenaza. Para que los Servicios Veterinarios puedan cumplir esta misión deben existir los oportunos mecanismos legislativos y de gobierno y un sistema oficial para controlar la calidad y fiabilidad de su trabajo, elementos a todas luces ausentes en muchos países en desarrollo y en transición. De ahí que la Organización Mundial de Sanidad Animal (OIE) haya puesto en marcha un proyecto para fortalecer los SV en los países más amenazados desde el punto de vista zoosanitario y para conseguir que dichos servicios cumplan las normas internacionales de la OIE que sus países ya han aprobado. El proyecto, basado en la evaluación de los SV y una serie de actuaciones subsiguientes a escala mundial, regional y nacional, resultará muy beneficioso para los países destinatarios y la comunidad internacional en su conjunto, no sólo en lo concerniente a la agricultura y la seguridad, producción e inocuidad de los alimentos, sino también para la prevención a escala local y mundial de enfermedades emergentes y reemergentes que afecten a la salud pública y animal. El proyecto se ejecutará en estrecha colaboración con la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO). Para ser aceptadas, las actividades propuestas deben encajar con el concepto de bien público internacional.

Palabras clave

Bien público internacional – Calidad – Enfermedad animal – Enfermedad emergente – Evaluación – Influenza aviar – Norma internacional – País en desarrollo – Servicio veterinario – Zoonosis.

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Challenges and options for animal and public health services in the next two decades

S.E. Heath

United States Department of Agriculture, Animal and Plant Health Inspection Service, 4700 River Road, Riverdale, MD 20737, United States of America

The opinions expressed in this paper are of the author and not his employer.

Summary

Trade in livestock and livestock products makes up approximately one sixth of global agriculture trade. This trade is demand driven, primarily by growing human populations, changing economies, and consumer preferences in developing countries. Different rates of population growth, economic growth, urbanisation, environmental sustainability, and technology transfer will determine which countries will reap the greatest benefits. Global trends in demand and supply for food, not terrorism, will drive the future of animal and public health service delivery.

To benefit the greatest number of people and countries, animal and public health services should support policies that temper growing disparities among rich and poor countries, city and rural populations, and the sexes. Economic growth is critical to overcoming disparities between countries and best supported by integrated animal health, public health, labour, and foreign policies. Opportunities for job growth will be the greatest along the value added chain of food production and will require significant investments in science- (risk-) based education.

Keywords

Animal health service – Economic growth – Education – Environmental stewardship – Livestock – Livestock product – Poverty – Public health service – Trade – Urbanisation – Value added – Women.

Introduction

Already during the 'Green Revolution' livestock production was the fastest expanding sector of agriculture worldwide. Although much smaller in scope than arable agriculture, the increase in the livestock production index from the early 1980s to the late 1990s was consistently higher, in both middle- and low-income countries, than that of crops (Table I). Today trade in livestock and livestock products (LLPs) makes up approximately one sixth, by value, of all agriculture trade worldwide (11). Meat exports (mainly beef, pork, and poultry meat) represent about half the total value of the global livestock trade. As a group, developed countries account for more than three-quarters, in quantity, of the world trade in LLPs. Developing countries are net importers, and dairy produce is the largest single import item (11).

The steady growth in production, productivity, and trade in LLPs is demand driven in response to growing human populations, economies, and consumer preferences for meat and dairy products (3). These growth trends are associated predominantly with developing countries (Table II). Despite concerns in the developed world over the excessive intake of calories and fat, much of the developing world will benefit from increased food intake, especially food of animal origin (Table III). There is plenty of opportunity for increased production and consumption of food of animal origin in developing countries. The growth of the livestock industry presents animal and public health services with the major challenge of

Table I
World crop and livestock production indices (base 1980)

Country income category	Crops		Livestock	
	1979-1981	1998-2001	1979-1981	1998-2001
Middle Income	74.5	128.2	69.3	153.7
Difference between periods	53.7		84.4	
Low income	71.6	124.4	68.4	131.2
Difference between periods	52.8		72.8	

Source: World Bank (13)

providing a scientific and regulatory framework that will meet increasing demand for and production and consumption of LLPs in all countries.

Overall, the trends for production and consumption of food of animal origin are positive and represent macro shifts in demand for and production and consumption of LLPs in the world. However, not all countries will benefit to the same degree from these positive trends because there are equally magnanimous factors that will affect the impact of these trends in different countries. In general, factors affecting differences in the effect of these changes between countries are related to population growth, economic growth, urbanisation, environmental sustainability, and the use of and access to new technologies. The different rates at which these factors change and the degree to which countries and industries seek a competitive advantage will determine the extent of disparities in economic growth, purchasing power, and food consumption between high-, middle-, and low-income countries over the next twenty years. If these trends continue as predicted, the resulting changes in demand for and supply of food of animal origin among different countries will probably be prominent forces shaping the expectations and delivery of veterinary and public health services throughout the world.

Table II
Actual and projected meat consumption by world region

Region	Annual growth of total meat consumption (percent)		Total meat consumption (million metric tons)		
	1982–1994[a]	1993–2020[b]	1983	1993	2020
People's Republic of China	8.6	3.0	16	38	85
Other East Asia countries	5.8	2.4	1	3	8
India	3.6	2.9	3	4	8
Other South Asia countries	4.8	3.2	1	2	5
Southeast Asia	5.6	3.0	4	7	16
Latin America	3.3	2.3	15	21	39
West Asia/North Africa	2.4	2.8	5	6	15
Sub-Saharan Africa	2.2	3.5	4	5	12
Developing world	5.4	2.8	50	88	188
Developed world	1.0	0.6	88	97	115
World	2.9	1.8	139	184	303

a) actual data
b) modelled data
Source: International Food Policy Research Institute (3)

Table III
Average daily food intake per person in countries with different income levels (1997)

Country income level	Calorie intake per day	Protein intake g/day (% increase since 1970)	Fat intake g/day (% increase since 1970)
Low	2,166	65 (30.7%)	55 (96.2%)
Middle	2,743	78 (17.6%)	76 (39.5%)
High	3,371	105 (14.3%)	134 (22.4%)

Source: United Nations Development Programme (10)

For animal and public health services to contribute constructively to global development in the future these services will have to assume a mediatory as well as a regulatory role. This will probably require animal and public health services to support policies that temper growing inequalities and include preferential opportunities for low-income countries, rural populations, and women.

It is likely that the current functions of animal and public health services will be insufficient to meet those demands. Rather members of the animal and public health services will have to engage in an economic and social debate to identify choices that best serve all parties equitably.

Economic growth

Per capita gross domestic product (GDP) is lowest in countries with high rates of population growth and high rates of population growth are positively associated with the proportion of GDP derived from agriculture (Table IV). This is because many low- and middle-income countries derive much of their GDP from agriculture. For example, low-income countries derive on average 26% of their GDP from agriculture, but developed countries, such as countries in the European Union, derive only 2% of their GDP from agriculture. In countries where agriculture makes a large contribution to the GDP, a large proportion of the workforce is employed in the agriculture sector. Low-income countries generally employ over 50% of their population in agriculture, middle-income countries employ on average less than 40% of their population in agriculture, and approximately 4% of the population in high-income countries work in the agriculture sector. Furthermore, less value added occurs in agriculture in low-income countries compared to high-income countries and even less value added is generated as the agricultural contribution to a country's GDP increases. This low productivity is in part due to low-income countries having the lowest levels of mechanisation (number of tractors, machines, and mechanised transportation) to manage crops (Table V), and having to rely more heavily on physical labour to plant and harvest crops. These factors result in low rates of economic growth within poor populations and effectively create a vicious cycle of poor economic growth and lack of opportunity. Disparities between countries, such as those listed in Tables IV and V, are reflected in a growing gap in the vitality of high and low-income countries.

Table IV
Projections of population growth and urbanisation, and indicators of agricultural economic power in countries with different income levels

Country income level	1975	1998	2015
	Per capita gross domestic product (US $)		
Low	350	2200	n/a
Middle	2,160	6,110	n/a
High	6,200	23,100	n/a
	Population (millions)		
Low	2,268.9	3,499.9	4,389.0
Growth rate (%)	1.9	1.3	
Middle	1,001.9	1,455.8	1,740.2
Growth rate (%)	1.6	1.1	
High	746.6	864.1	911.1
Growth rate (%)	1.1	1.1	
	Urban population (% of total)		
Low	19.0	30.8	41.6
Middle	52.7	65.9	72.9
High	75.0	78.2	81.9
	Percentage of population working in agriculture		
Low	66 (1970)	64	60
Middle	54	40	18
High	ND	2	2
	Contribution of agriculture sector (% of total) to gross domestic product		
Low	43 (1970)	26	23
Middle	20 (1970)	10	10
High	18	8	5

Sources: United Nations Development Programme (9) and World Bank (17)

The role women play in society is critical to economic growth in low-income countries because women represent on average 50% of a nation's capable workforce and account for an even greater proportion of the labour force in the agriculture sector. In low-income countries, women make up over 70% of the labour force in agriculture, whereas women only make up 22% and 7% of the agriculture workforce in middle- and high-income countries, respectively (13). High rates of population growth are, in turn, often associated with low levels of education and unequal rights of women. In low-income countries, the literacy rate of females is only 76% of the literacy rate of males, while in middle-income countries it is 94% (13). These associations have huge implications for animal and public health services because providing education and employment opportunities to women is critical to break the vicious cycle of poverty and lack of opportunity in low-income countries.

If animal and public health services cannot facilitate education and employment opportunities to low-income countries, rural populations, and women and improve poverty in the next two decades, these services will probably be used preferentially by wealthy countries and industries. In this case, animal and public health services will be simply bystanders to a widening of the gap between countries that already have an excess of resources and countries with few resources, which, in turn, could render animal and public health services redundant. The purpose of this article is to illustrate some ways in which animal and public health services may be able to play a strategic role in equalizing opportunities between countries as the global demand for foods of animal origin continues to grow.

Table V
Mechanisation within the agriculture sector in countries with different income levels

Country income level	Tractors per 1,000 agricultural workers		Tractors per 100 hectares of arable land	
	1979-1981	1996-1998	1797-1991	1996-1998
Low	2	5	20	69
Middle	8	11	103	126
High	519	927	896	953

Source: World Bank (12)

Urbanisation

The projections for urbanisation are that low- and middle-income countries will have massive cities in the foreseeable future. Although the proportion of the population living in urbanised areas is the lowest in developing countries, the much larger populations of these countries indicates that the future cities in developing countries will be the largest in the world (Table IV). The factors driving urbanisation are limited access to jobs, economic growth opportunities, health services and education; poor infrastructure in rural areas; and the perception that cities will bring good fortune.

Animal and public health services can do two things to adjust to the projected trends in urbanisation: provide a framework for job growth in food safety and handling within the cities and support job growth along the value added chain in rural areas. (The value added chain involves jobs within the processing sector of animal food products, mainly related to sales beyond the farm).

Framework for urban employment

In cities there is and will continue to be a huge demand for services that ensure the safety of food and adequacy of food distribution. Providing safe and abundant food is essential for a vigorous workforce, without which cities cannot prosper. There will be a demand for the creation of new jobs in food safety and handling in the areas of food processing, packaging, distribution, storage, and retail, with the objective of providing 'just-in-time delivery' of food to the cities. Massive training initiatives will be required to re-educate professionals and educate persons entering new jobs in food safety and handling. Development of performance standards for new positions, training curricula, and training of teachers and management experts should be the responsibility of the animal and public health professions, and, by requiring appropriate standards, these services will secure the commitment of the public and private sectors, and with that facilitate the creation of new jobs.

Value added employment opportunities

A lack of access to infrastructure is a major hindrance to economic vitality in rural areas, especially for areas with agriculture systems that depend heavily on a functional transportation infrastructure to deliver goods to markets. Costs of transportation depend on the condition of the transportation routes and, in many cases, the cost of energy (fuel) delivery to rural areas to power vehicles. The costs of transportation and fuel have to be recovered in the sale price of goods, which under the conditions prevalent in many developing countries are high and unattractive to city customers. As a result of the high cost of domestically produced food, cities seek alternate sources of food from overseas that can be delivered cheaply and in bulk to the burgeoning populations. The high price of domestically produced food in low-income countries places rural areas at a considerable disadvantage with the imported food market. The low demand for domestic food produced in rural areas, where purchasing power is already low, is a significant disincentive for economic growth in rural areas.

To break the cycle of high cost of production and low demand for expensive domestically produced foods, either rural infrastructure has to improve or energy delivery costs have to decrease. A potential solution lies in generating biofuels (ethanol and biodiesel) in rural areas to provide a cheap source of energy on-site. Ethanol is a high octane alternative to petroleum-based fuels and can be produced economically using locally produced crops, such as sugar cane, cassava, and switch grass. Local production and substitution of petroleum-based fuels with biofuels will promote mechanisation of agriculture and lead to the development of infrastructure from within rural areas. Furthermore, by-products of biofuel production, such as brewers grain present additional opportunities. Brewers grain can be used as animal feed to support the development of local livestock production and animal waste can be recycled into methanol. Hence, biofuels and livestock production are intricately linked and animal and public health services should become engaged in the development of integrated biofuels/livestock industry complexes. Specifically, increased livestock production will create a demand for animal and public health services in

rural areas to support the expanding livestock production and help improve the productivity of the livestock enterprises. Furthermore, while cities will probably continue to import food, local production and consumption of domestically produced food will support the growth in jobs in food processing in rural areas. Increasing the availability of food in rural areas is an important factor contributing to the vigour of the workforce (5).

Environmental stewardship

Similar to the need for animal and public health services to facilitate opportunities for job growth in cities and rural areas, opportunities for economic development need to be created through environmental stewardship. Agriculture has large-scale impacts on water, soil, and air. In low- and middle-income countries, the percentage of land area used for arable and permanent cropland is increasing (Table VI), and in developing countries agriculture accounts for most of the freshwater withdrawals. These trends are the opposite of those seen in high-income countries where the amount of land used for agriculture is decreasing and industry utilises the greatest amount of water (Table VI).

To reduce the adverse negative environmental impacts of agriculture on water, soil, and air, wide area solutions have been proposed (7). In addition to risk dispersion models, economic models need to be developed to convert the economic externalities of farm waste production into jobs, such as waste management, recycling, and water conservation. Although internalising the costs of meat production may initially increase the cost of meat, over the long term, employing more people will increase purchasing power and lead to greater environmental sustainability. Also, as the amount of land used for agriculture increases, additional animal and public health experts will be needed to identify, respond to, and control new and emerging diseases. Pristine bat and other wildlife habitats that are encroached upon by the expansion of the agriculture sector may expose naïve populations of humans and animals to diseases, such as severe acute respiratory syndrome (SARS), Nipah virus, and Hendra virus.

Technology

Technological advances are expected to occur in diagnostics, correlating genetic markers in livestock with production, product tracing, informatics, and vaccine development. These technologies will be widely adopted if they can be shown to reduce the costs of production and trade. The role of animal and public health services will be to keep abreast of the emerging technologies and facilitate rapid and broad application of new technologies, while, at the same time, protect the intellectual property rights of the originator of the idea(s) and credit the principal source (e.g. genetics) of the intellectual property. It is important that animal and public health services are educated about new technologies so that these organisations can give countries of all income levels optimum early opportunity to take advantage of new developments.

It is foreseeable that the application of these new technologies will lower the marginal costs of trade by making it easier to verify the disease status of individual shipments of LLPs, instead of relying on the disease status of a country as a basis for safe trade, and will effectively create a basis for compartmentalisation of diseases for trade purposes. If countries agree to use such technologies, it is likely that rapid expansion of the production of LLPs could occur, which will offer countries that are able to use this type of technology an economic advantage over countries that are unable to apply the technology.

If access to cost-saving technology is not made generally available, the intended purpose of many regulations could be defeated simply because of relative cost differences in using the technologies between high- and low-income countries. In the worst-case scenario, differences in the relative cost of the technologies between countries could

Table VI
Comparison of the percentage of land area used for arable and permanent cropland and water withdrawal between countries with different income levels

Country income level	Percent land for arable cropland		Percent land for permanent cropland		Percent annual water withdrawal by sector		
	1980	1998	1980	1998	Agriculture	Industry	Domestic
Low	11.8	13.0	1.0	1.4	87	8	5
Middle	7.9	8.9	1.0	1.0	74	13	12
High	12.0	11.8	0.5	0.5	30	59	11

Source: World Bank (14, 15)

lead to two categories of trade partners: countries that trade under the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and countries that trade in spite of the guidelines of the SPS Agreement. There are indications that this distinction may already be occurring, reflected by a trend indicating increasing trade of animals and animal products from FMD-infected countries with FMD-free and other FMD-infected countries (Fig. 1). For animal and public health services to play a meaningful role, these services will have to strive to make emerging technologies equally available to countries of different economic status.

There are, of course, many predictions about which particular technology will emerge and play a role in livestock production, public health, and international trade. However, it is not helpful for animal and public health services to speculate on which individual technologies will be adopted in the future because the type of technology adopted will be determined by prevailing economic forces. It would be of greater benefit for animal and public health services to identify the greatest constraints facing countries and to take a leadership role in promoting advancement of products that will benefit the maximum number of people. One of the greatest opportunities for leadership is support for a onetime vaccine against Newcastle Disease, a disease which is probably responsible for more loss of animal protein than any other animal disease in the world.

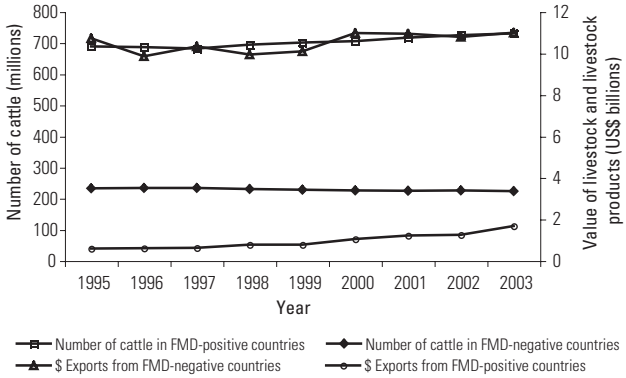


Fig. 1
Number of cattle and value of livestock and livestock product exports grouped by country foot and mouth disease status
Sources: OIE Handistatus II, UN Trade Statistics, FAOStat Agricultural data

Livestock trade

Approximately 75% of the world's cattle live in low- and middle-income countries; however, exports from these countries account for less than 15% of the global value in LLP trade. Part of the reason for this paradox is that many countries in the developing world have cattle infected with FMD (and many other diseases that restrict trade) (Fig. 1).

This paradox of supply and value in LLP trade is a reflection of unequal opportunities between countries for the trade of livestock and livestock products related to a country's animal disease status. Unequal opportunities result from differences in relative costs that are incurred for a country to become disease free and, once free of disease, to prove and maintain disease free status. Although absolute costs may be similar for all countries, these costs can be proportionately large for low- and middle-income countries and small for high-income countries. In other words, animal and public health services are not available at an equal relative cost to countries with different levels of income and, therefore, potentially this discrepancy presents a preferential advantage to the users of animal and public services in countries with a high-income status.

The role that animal and public health services can play to reduce relative cost differences is to become an equalizing force by providing a fair regulatory framework for trade. If this role is not adopted, the services may be utilised only by countries and industries that can afford them and become redundant in those which cannot. As animal welfare standards for trade continue to progress, great care will have to be taken to prevent animal welfare standards from creating an environment in which countries that cannot meet certain standards are discriminated against.

Animal and public health services can help overcome disparities between low- and high-income countries through efforts supporting mutual accountability. Mutually accountable programmes utilise the expertise and resources of participating partners and involve collaboration, interdependency, and sharing of responsibilities between countries. Both partners are, thus, mutually accountable for the outcome. For example, a mutually accountable approach to risk assessment utilises the local expertise within a country of origin to elucidate risk factors and the importing country assists with analytic analysis. The establishment of mutually accountable programmes does not require changes to the SPS Agreement. Rather, it requires the leadership in the animal and public health service communities to accept mutual accountability as a viable approach to build on partners' strengths and to reduce differences in the relative costs of trade. Promoting programmes of mutual accountability in which the exporting and importing countries share their expertise and strengths in risk management will lead to an overall reduction in the costs of trade, create economic opportunities for exporting countries, and increase variety in the diets of the importing countries.

Value added export

As with many economic principles, trade has winners and losers. Those in favour of trade will argue that trade is universally positive, in part because exports provide added value to the economy. However, this argument is not equally applicable to all aspects of all economies. In a flourishing economy, such as the United States of America (USA), it is estimated that every US$ 1 million value added to agricultural commodities (crops) through exporting meat supports approximately 5,000 domestic jobs. In the USA, this large number of jobs is thought to be, in part, a result of livestock practices in which cattle are fattened on corn and soy diets (in economic terms beef is value added to arable commodities) and sales of packaged meat. Similar observations are reported for poultry exports from Brazil and swine exports from Taipei China. In all cases, much of the value added chain supports employment beyond the farm gate, such as jobs related to fattening livestock; livestock transportation; and processing, packaging, distribution, and retail of livestock products. For example, it is estimated that value added to agriculture supports as many as 16% of all jobs in the USA, which makes agriculture the nation's single largest economic sector. Under these conditions, even though the individual producer benefits little directly from trade, the economy benefits as a whole. Thus, although the agriculture work force constitutes less than 5% of the country's population, the large number of jobs supported by agriculture leads to broad-based support for exporting agriculture goods.

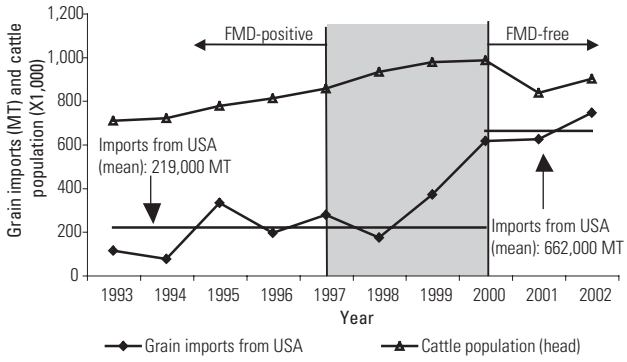
In contrast, in countries where large populations are directly employed in agriculture; livestock are pasture raised; and diseases, such as FMD, are frequently present and can lead to trade restrictions; little value is added to the economy as a result of LLP trade. The low value added manifests predominantly as trade in live animals rather than processed meat (Table VII).

A role for animal and public health services is to promote value added LLP production and trade by practices that increase productivity, such as feeding cheap imported feed. However, underlying successful value added programmes is disease control. Disease control programmes reduce trade restrictions and this provides a long-term incentive to improve productivity of livestock. The effects of successful disease eradication can be illustrated using a recent example in Syria (Fig. 2). When Syria became free of FMD in 2000, the country dramatically increased feed grain imports; cattle numbers did not increase but production rose incrementally. In other words, eradication of FMD in

Table VII
Comparison of live animal and processed meat exports from countries with and without foot and mouth disease

Species	Export value ($ X1,000)		Proportion of global exports		Proportion of live versus processed commodity exports	
	FMD-free	FMD-infected	FMD-free	FMD-infected (%)	FMD-free	FMD-infected (%)
Cattle (live)	2,126,426	93,609	18.4	0.8	20.1	9.7
Beef (processed)	8,435,267	872,424	73.2	7.6	79.9	90.3
Sub-total	10,561,693	966,033	91.6	8.4	100	100
Pigs (live)	634,302	309,697	7.1	3.5	7.9	34.6
Pork (processed)	7,369,407	586,456	82.8	6.6	92.1	65.4
Subtotal	8,003,709	896,153	89.9	10.1	100	100
Sheep (live)	318,512	115,938	15.3	5.6	16.6	71.2
Mutton (processed)	1,595,730	47,001	76.8	2.3	83.4	28.8
Subtotal	1,914,242	162,939	92.1	7.9	100	100
Goats (live)	8,797	30,826	12.4	43.5	27.2	80.0
Chevron (processed)	23,597	7,697	33.3	10.9	72.8	20.0
Subtotal	32,394	38,523	45.7	54.4	100	100
Total live animals	3,088,037	550,070	13.7	2.4	15.1	26.7
Total meat	17,424,001	1,513,578	77.2	6.7	84.9	73.3
Total	**20,512,038**	**2,063,648**	**90.9**	**9.1**	**100**	**100**

FMD: foot and mouth disease
Sources: OIE Handistatus II, UN Trade Statistics, FAOStat Agricultural data (1995-2003)



Shaded area denotes the final stages of the FMD eradication programme, when the country was either FMD-free with vaccination or free without vaccination, but still under intensive surveillance to prove freedom of disease

Fig. 2
Changes in feed grain imports (from the United States of America) and cattle numbers following the declaration of FMD free status in Syria in 2000

Syria led to improvements in livestock productivity. More meat was produced from a similar number of cattle, therefore, increasing protein availability and the added value of the cattle to the economy. As stated earlier these benefits accrue over the long term and, hence, sustained support for the policies underlying the advancements is required. This support can only come from ensuring hiring of permanent and experienced staff in animal and public health services.

Marginal costs

Another argument in favour of trade is that the marginal costs associated with exports can also have an effect on the domestic market by increasing local prices and improving farmer profits. Marginal costs of trade are the costs associated with establishing and maintaining export markets. Verifying the animal disease status within the exporting and importing countries accounts for a portion of the marginal costs. In effect these costs are the product of the SPS Agreement. Exporters are happy to pay these costs because global markets often offer a more secure outlet for sales than domestic markets and because the higher price paid on the international market covers the additional costs. Sales to stable customers and the opportunity to save costs by selling in bulk encourage many large-scale producers in low-income countries to preferentially sell their products on overseas markets. The domestic buyers are, thus, forced to compete with international traders who are willing to pay a higher buying price, which enables producers to charge more on the domestic market as well.

However, different relative marginal costs of exports on domestic prices have different implications in high- and low-income countries. In high-income countries the higher domestic prices for meat resulting from trade are small when compared to the average cost of food, and because of the value added effects the economy as a whole benefits. In contrast, in many developing countries increases in domestic meat prices have the potential to lower purchasing power and many people with an already limited income may be denied easy access to abundant local supplies of food (meat and dairy products). Furthermore, in developing countries that rely heavily on agriculture as the GDP, the increase in domestic food prices that result from the marginal costs of trade can disproportionately and negatively affect large numbers of poor people in rural areas (7). Trade can, thus, worsen the state of poverty and because many of the poor employed in agriculture are women can further suppress opportunities for women.

All countries have to weigh the costs of disease control and eradication against investments in other programmes. In low-income countries, meeting SPS requirements through disease eradication programmes can lead to higher domestic prices for food, which is a strong disincentive to the implementation of other similar programmes. In contrast, control programmes, such as vaccination campaigns, directly support jobs and maintain purchasing power. Regrettably, this is true even if the programmes are ineffective at controlling disease. In the long term, however, ineffective disease control programmes are detrimental to economic growth because the horizon for growth is limited. To overcome the disincentives for trade and turn livestock exports into a viable export commodity, countries have to invest in jobs in domestic agriculture-allied industries that allow people to gain from employment through the value added of exports.

The role of animal and public health services in developing countries is to support policies that facilitate job creation in the value added chain of food production. Options for increasing jobs in animal and public health services in cities and rural communities have been discussed in the preceding sections of this paper. To create new opportunities for job growth, animal and public health services should strive to have coherent labour, trade, and agricultural policies.

Disease outbreaks (accidental)

Although there is much concern and talk about the impacts of intentional versus accidental introductions of disease, much of this discussion fails to acknowledge that acts of terrorism are a minor driving force for change compared to the massive global changes in consumer food demands resulting from shifts in population demographics and economic opportunity. Ultimately, it is these global trends,

not terrorism, that will drive the adaptation of animal and public health service delivery.

There is also a tendency to overlook considerable differences in the likelihood that a particular country will be a target of terrorism, the capability of a country to respond to disease outbreaks, and the political will of a country to eradicate or live with a disease. To remain relevant in the debate on disease introductions and subsequent control and eradication, animal and public health services will need to consider these and other factors.

Political will

Political will reflects political priorities and is the willingness of decision makers to support and implement programmes. Several situations in which the political will of a country could have more strongly supported disease control measures exist. For example, in the United Kingdom (UK) the cost of direct subsidies to producers was in direct competition with the cost of implementing FMD eradication measures and may have played a role in the delayed response and large number of animal deaths during the FMD outbreak in 2001. In Taipei China, public concerns over the negative domestic environmental impact of swine farm waste resulting from animals produced for export have compromised the political will to eradicate FMD since 1997. In the USA, animal rights proponents brought about court rulings to override established control measures to limit the spread of equine infectious anaemia in New Mexico in 1994. The new rulings allowed foals to be kept alive for life long observation. Political will that is supportive of animal and public services will most likely be gained through studies that demonstrate transaction and opportunity costs associated with animal and public health service programmes that are superior to costs related to other programmes.

Transaction costs

Typically the costs associated with disease eradication are presented as cost tallies, i.e. summaries (counts) of expenditures related to disease outbreak response measures. However, these estimates do not measure the true cost of an outbreak response. During the response to a disease outbreak money is transferred from agriculture to other sectors of the economy, e.g. from paying farm labour (agriculture sector) to paying technicians to euthanize animals, dispose of carcasses, and clean and disinfect premises (service sector). Yet, because the money remains in the economy as a whole, the immediate costs to a country from the response to a disease outbreak are not indicated by the tally but rather by the cost of transferring money from one sector of the economy to another. These costs are the transaction costs, and there are very few estimates of transaction costs in agriculture. The FMD hoax of 2005 in New Zealand provides one example of transaction costs associated with a potential disease outbreak. The response to a letter threatening the introduction of FMD cost over US$ 2 million. All of these costs were associated with money transferred from the agriculture sector to the service sector, and none of the costs were associated with disease control operations.

Opportunity costs

Once money has been transferred from one sector of the economy to another sector, the final analysis has to be a comparison between the returns of investing in agriculture by supporting the response to a disease outbreak versus investing in other sectors of the economy. Because agriculture is typically not as productive a sector as, for example, the manufacturing or service sectors, the long-term costs (or gains) from relocating investments from agriculture to a different sector of the economy begs the question in which sector of the economy is the money most productive and over what time period do these comparative advantages exist. The answer to this question directs the political will that dictates in which sector investment would be more beneficial to the economy as a whole.

Tipping points

As countries progress economically, they rely less on agriculture as a source of national revenue and employment and other sectors add greater value added to the economy than agriculture (16). This change can consequently alter political will and can have dramatic and unexpected influences on the level of support politicians are willing to provide for animal and public health programmes. For example, the response to FMD in the UK has been questioned technically and scientifically and the slow response time to the outbreak resulting in excessive animal deaths was widely criticised. However, many of these criticisms overlook the political situation in which national policy decisions and political will were major determinants. In the UK, in 1999 the agriculture sector provided only 1% of value added to the GDP, whereas the services sector added 74% value to the GDP (16). Furthermore, in 2000 although agriculture added £6,617 million value to the overall economy, £2,187 million (33.1%) of this amount was redistributed to livestock farmers in the form of subsidies (4). Therefore, when the FMD outbreak occurred in the UK in 2001, the country was at a tipping point, and the extensive culling programme to control FMD resulted in a reduction of subsidy payments to livestock farmers of £264 million, an amount then available to other economic sectors with greater potential to add value to the overall economy than agriculture.

In large disease outbreaks politicians have to decide which choice will do the least harm or have the greatest economic benefit. The opportunity costs of placing resources into disease control versus other programmes becomes a tipping point for decision making: when the transaction costs of disease control become greater than the opportunity costs for disease control, the decision by a country to live with the disease becomes an economically viable option. Living with an animal disease is a feasible option for countries in which the livestock sector provides only a small contribution to the nation's GDP, either because the sector is small in size or because it contributes little value added.

The future credibility of animal disease control programmes will probably depend on long-term studies that allow true comparisons of transaction versus opportunity costs. Support for the notion that freedom from disease is automatically better is fading because of expectations that disease control and eradication programmes should result in more than a zero sum gain to a country. Also, a continued reliance on tallies to estimate the cost of animal disease outbreaks will mean that decisions and actions to control disease outbreaks will continue to be made in a highly charged political setting. A politically charged environment frequently lacks adherence to a vision, which is why politically based decisions have a strong potential to discriminate in the allocation of resources and give preference to those special interest groups with the most immediate access to decision makers. In the future, support for disease outbreak response, control, and eradication programmes will depend increasingly on the ability of animal and public health services to demonstrate the beneficial aspects of disease control programmes through long-term holistic benefit–cost analyses.

Holistic long-term economic analyses present a fertile ground for animal and public health services to remain viable and credible in the eyes of decision makers. These types of studies allow for the comparison of the true cost of disease control programmes with other emergency and non-emergency programmes and provide a better understanding of who benefits and who loses from disease control measures. Knowing which groups gain or lose in disease outbreaks helps identify principal stakeholders and decision makers who would need to be consulted during a disease outbreak and allows for early engagement of these groups during a response.

Existing animal health status and infrastructure

It is important to remind ourselves that all high-income countries that have recently been infected with a new animal disease and that had the political will to implement disease control measures have been able to eradicate the disease. This is likely to remain the case because high-income countries can usually absorb the transaction costs of disease eradication into their existing animal health infrastructure and the economy as a whole.

The situation is different for low- and middle-income countries in which diseases may already be endemic or epi-endemic and the diseases often reside in livestock owned by poor people who are politically marginalised and live in dispersed, inaccessible, or remote areas. An issue confounding the interest in controlling diseases of trade is that many diseases of trade, such as FMD, have limited impact on the production and productivity of small-scale farmers, e.g. a producer is only adversely affected if a cow aborts or a draught animal is infected when it is needed for ploughing. Hence, control of diseases of trade is often not a high priority for small-scale farmers. Small-scale farmers are usually more concerned with access to clean water, maternal health care, and education of their children, all of which directly affects the health and prospects of the farmers and their families. Animal diseases, such as Brucellosis, coenuriasis, and oncocerciasis, may be much more important to small-scale farmers than diseases of trade. The chronic and zoonotic nature of these diseases can have large-scale impacts on the economic potential of local communities and families (8). Animal and public health services have to consider these priorities when attempting to control diseases of trade in small-scale farms.

In spite of the poor conditions in many developing countries, when a disease outbreak occurs, the country is often capable of responding to the outbreak. For example, when FMD resurged in South America or when SARS emerged in Asia, the countries and the international community mounted effective responses that brought the disease under control. Regrettably, response alone is insufficient to break the vicious cycle of outbreak and response and may actually exacerbate it because the outbreak response cycle invariably favours producers that are the best prepared and protected. The best prepared and protected producers are large-scale farmers who often have safety networks, such as wealth that is diversified in a multitude of investments, and are, hence, already less vulnerable to an outbreak than small-scale farmers who have much of their wealth invested in livestock. As a result of this differential burden, the risk of adverse consequences to the livelihood of wealthy producers is less than the risk to small-scale farmers, and this disparity in preparedness capabilities of large- versus small-scale farmers increases with repeated outbreaks.

In extreme cases and over repeated outbreak response cycles, the differential capability of recovering from a disease outbreak results in the livestock industry being restructured and consolidated, which favours large-scale enterprises and leaves many small-scale producers with fewer resources for disease control than they had before the

outbreak and in some cases dropping out of production all together (1). This situation increases the risk of disease outbreaks if the source of disease is retained in livestock owned by poor small-scale farmers and international traders maintain and expand susceptible herds in the same agriculture system. It should not come as a surprise that under these conditions small-scale farmers develop a sense of resentment towards decision makers who prioritise disease control programmes for diseases of trade instead of focusing on disease control programmes that are important to the small-scale (artisan) farmers. The role of animal and public health services, therefore, is to break the outbreak response cycle by linking policies that protect the livelihoods and needs of the poor and control diseases of trade.

The solution to limiting the segregation of livestock production between the rich and the poor is to institute programmes and economic policies with mutual accountability. For example, wealthy countries and farmers should provide technical assistance to low- and middle-income countries, but rely on these countries to implement the programmes themselves. Wealthy countries and farmers should link disease identification and eradication efforts to economic opportunities for the poor. This can be done by engaging the private sector and providing farmers with incentives to participate in disease control programmes. For example, government officials who already have secure jobs should play only a limited role in the operational aspects of disease control and eradication because these measures (e.g. stamping out) effectively remove the livelihood of the affected farmers, whose herds are probably the principal source of income, and it is these farmers who need jobs (income). A better solution is for animal and public health service officials to contract the private sector, including farmers, to conduct the operational aspects of disease control. Government services should maintain official oversight to ensure adherence to standards. Such mutual accountability models provide the framework for disease outbreak response, control, and eradication programmes and, through providing incentives for interdependent and proportionate economic activities, enhance economic opportunities for all involved parties.

Impacts beyond the livestock sector

Large-scale disease outbreaks have implications that go beyond the livestock industry. For example, a widespread outbreak of FMD in North America could potentially impact the national grain industry, which, in turn, could have widespread global consequences. The USA supplies approximately 70% of the world's feed grains (Fig. 3) and is a major supplier of feed grains to the livestock industry in Canada and the USA (livestock in Canada and the USA are finished on corn and soy diets). Thus, if North American livestock were infected with FMD, huge volumes of feed grains would become available on the global market as a result of stamping out procedures and poor feed conversion. The excess amount of feed grains on the global market could destabilise global soy and corn prices for many years, much to the detriment of developing countries trying to compete in global agriculture commodity markets.

Disease outbreaks in countries that purchase large volumes of feed grains also have large impacts on the supply and prices of global feed grains. For example, since the FMD outbreak in Taipei China in 1997, there has been a long-term reduction in the importation of soybean meal (Fig. 4). Alternative markets in which the soybean meal could be sold had to be identified, resulting in transaction costs associated with finding and supporting the new markets. These types of impacts can be minimised through preventing disease outbreaks and establishing alternative

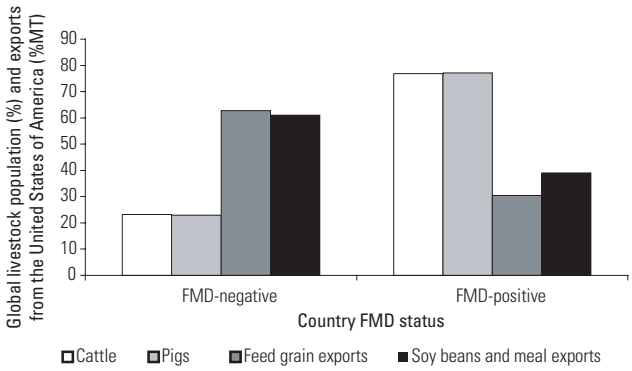


Fig. 3
Global livestock populations and feed exports from the United States of America – countries grouped by foot and mouth disease status (five year mean, 1997-2001)
Source: OIE Handistatus II, USDA-ERS FATUS database

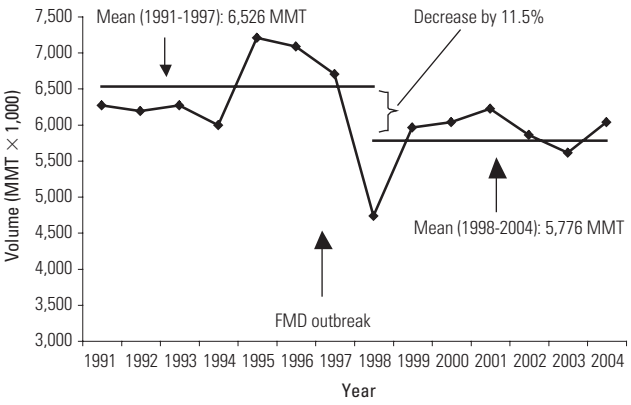


Fig. 4
The reduction in the importation of soybean meal following the 1997 foot and mouth disease outbreak in Taipei China

markets ahead of time by creating strategic alliances with trade partners and allied private sector industries. By engaging the private sector, which responds more rapidly to market demands than the public sector, it is also more likely that early indicators of the successes and failures of animal and public health service programmes will be detected at a time when corrective actions can keep the programmes on course.

Disease outbreaks (intentional introductions)

Many of the same factors that are involved in a naturally occurring disease outbreak will also be associated with an intentional introduction of a disease. However, any discussion about intentional introduction of an animal disease should first take several considerations into account, including:

– Would an intentional introduction of a disease be industrial sabotage or terrorism?

– Why would a particular group/organisation/person intentionally introduce a disease?

– Who is the most likely perpetrator - foreign or domestic?

– How will the attacked country react?

Because the answers to these questions are different for each country, not all countries are at equal risk of being a target and the consequences of a deliberate introduction of disease will differ between countries.

Industrial sabotage

The motivation to commit an act of industrial sabotage is to gain a competitive advantage over another country or industry, such as by capturing the affected country's or industry's market share. However, reviews of previous disease outbreaks indicate that changes in market share cannot be predicted or assured. Hence, the potential for success of an industrial sabotage operation is limited. History supports this view and has shown that there have been very few, if any, proven attempted, let alone successful, cases of industrial sabotage in agriculture.

Terrorism

The motivation to commit an act of terrorism is different from the motivation to commit an act of industrial sabotage. Terrorists aim to shock persons, institutions, and governments with a different world view and, at the same time, compromise the persons and organisations that are the target of the attack. The degree of damage that a terrorist could inflict in a country using a biological agent that the country is already infected with is limited. Therefore, terrorists are most likely to attack countries with disease agents that do not already exist in the country. Because most low-income countries have a poor livestock disease status, these countries are unlikely targets for terrorism.

Attribution

Much of the impact of terrorism is the shock value and the identification of the cause or perpetrator. Attributing the introduction of a disease to a perpetrator would probably significantly facilitate response efforts by providing valuable information on when and where the disease was introduced. By getting intelligence needed to rapidly identify and control the spread of disease, the scope of the attack would probably be reduced.

International versus domestic terrorism

Because most developed countries will, in the foreseeable future, always have a sufficient food supply through domestic food production and international trade, a terrorist attack against agriculture in a food exporting country with disease free livestock would probably have a limited direct impact on the country's domestic food supply. However, agroterrorism would probably have far reaching consequences for the countries that depend on food exports from the affected countries. If food shortages were to arise, the food exporting country would simply divert food destined for export back into the domestic markets. An alternative scenario arises in affected countries that produce food in excess of domestic consumption and are trade restricted. The affected countries in this situation would seek alternative markets in which the disease does not present an added risk to the importing country. For example, when Argentina became infected with FMD in the early part of the century, beef that could not be sold in FMD free markets was sold to Peru, where little to no additional risk existed from importing beef from another FMD infected country. Also, producers could restrict production until the markets reopen. In either scenario, terrorism against agriculture in countries with excess food production would hurt the affected countries less than it would hurt their trade partners. Hence, an attack against agriculture in a high-income country would be disproportionately detrimental to the developing countries that rely on imports from the affected country. Assuming international terrorists have an understanding and appreciation for the interconnectedness of global economies, including agriculture, limits the likelihood that foreign terrorists will target agriculture in high-income food exporting countries.

There is a much greater potential for a domestic versus international terrorist attack against the agriculture sector of high-income countries. Domestic terrorists cannot be assumed to appreciate the global interdependencies of food production and may actually be opposed to the agricultural practices that underlie the global food supply. Being opposed or oblivious to the global relationships makes domestic terrorists the most likely perpetrators of an intentional introduction of contagious disease to disease-free countries. It is clear from statements made by some animal rights groups (that would rejoice at the introduction of a livestock disease, thinking it would disrupt or stop intensive agriculture), that the greatest threat to agriculture is domestic in origin. This is a threat that is more or less exclusive to high-income countries.

Reaction

The impact of terrorism depends to a large extent on the reaction to an attack. An example of a poor reaction to a biological attack was the response to the release of small amounts of anthrax in the USA in 2001. It should have been clear from scientific data available at the time that the case fatality, even for 'weaponised' anthrax, is low (< 1:1,000) (6). Although great effort was made to identify and treat all persons known to be at risk, many other actions were undertaken without first attempting to get a clear understanding of the actual risks of infection or benefits of the responses. Even now as officials conclude, from reviewing the attacks and extrapolating from the two outlier cases, that tens of millions of Americans were probably exposed to anthrax spores via their mail and remained healthy, there remains an irrational interest in anthrax and, with that, huge opportunity costs to other aspects of animal and public health services, such as programmes for the control of preventable diseases and the infrastructure needed to deliver these programmes.

The role of animal and public health services in combating terrorism

Because the tactical aspects of a response to an intentional and accidental disease outbreak are the same and depend on factors such as a country's level of preparedness, resources, and political will, the future role for animal and public health services will be to provide the framework for strategic counterterrorism. Developing such a framework begins by accepting that an inappropriate response to terrorism brings with it much greater adverse consequences than the impact of an actual terrorist attack. An inappropriate response results from the failure to realise that terrorism is rooted in differences in philosophical values, and is fuelled by a politicized understanding of risk.

Terrorism (and martyrdom) has occurred throughout history during times of rapid changes in the predominant economic power, and with that, changes in the predominant culture. Many of the countries that have recently given rise to terrorists are low-income countries where there is little opportunity for prosperity and where there are large numbers of young unemployed people. Widespread access to the internet means that they are well aware of the wealth and choices available in high-income countries and the impact of this is an increasing sense of resentment towards those who live in high-income countries. This resentment is enabled by a lack of government support for (science) education. The lack of investment in education results in religious institutions assuming the role of educators and curricula being driven by the values of extremely motivated spiritual leaders.

Because the philosophical basis for terrorism is not rational, and, hence, terrorists cannot be reasoned with, the only long-term solution to terrorism is to change the environment that leads to the mind-set of a terrorist. Animal and public health communities can help to achieve this objective by creating and supporting an environment that promotes equitable job growth and economic opportunities, especially in countries with deteriorating economic status. Specifically, animal and public health services can help reduce terrorism by generally supporting investments in science education in low-income countries.

Science education can also reduce the consequences of terrorism in high-income countries where there is a need to reinforce the scientific meaning of risk. Risk should be defined as the probability of consequences based on the product of the likelihood of a hazard and the vulnerability of a country/industry to adverse events, including acts of terrorism. Unlike the political use of the term risk, which often equates to an imprecise or indefinite eventuality or threat, science education in general and scientific understanding of risk allows countries to meaningfully identify and prioritise the threats and the actions needed to reduce all countries' vulnerability to terrorism.

Natural disasters

Natural disasters are a burden to many countries and cause great tragedy. Natural disasters affect animal and public health in two ways. First, disasters, such as droughts and floods, can have a significant effect on animal movements and, therefore, disease spread. The classic example is the rinderpest pandemics in Sub-Saharan Africa following the droughts in the early 1980s. The droughts during this time led to increased animal movement and congregation at watering holes, which, in turn, increased animal contact and the spread of disease. Secondly, damage to the animal and public health infrastructure as a result of a natural disaster and preoccupation with response efforts can seriously compromise the capability of these services to

identify and control disease. To be prepared, animal and public health services should include emergency preparedness into programme continuity planning and develop excess capacity to be able to operate under conditions of sudden resource constraint.

Priorities

It is not possible to predict the future, however, knowledge of past, present, and predicted trends can help anticipate the events that are likely to occur as a result of ongoing trends. So far much of the focus of this paper relates to highly contagious diseases (of trade) and the role of animal and public health services in responding to outbreaks of these diseases, but there are many other diseases that will affect the future of animal and public health services that receive little attention. These diseases deserve more than a mention as they may emerge as one of the world's most significant concerns over the next two decades.

Insidious disease

In developing and developed countries insidious disease may pose a larger problem than many other topics discussed in this paper so far. Insidious diseases may be difficult to recognise early, their impact is often delayed, and it is difficult to garner political support for their control. The emergence of bovine spongiform encephalopathy in the UK in the 1980s may be the best current example of the difficulty in acting quickly enough to control the spread of an insidious disease at a time when huge negative impacts could have been averted.

But the question is, have we learnt from the British experience or are we overlooking another insidious emerging disease already among us? We may not know, but a likely candidate is Johne's disease. If Johne's disease were introduced into Africa and Asia it could have devastating effects on livestock and human health through lost livestock productivity, decreased protein availability and significant job losses from the value added chain. If Johne's disease were to also affect wildlife species, the introduction of this disease to Africa could potentially change the diversity of wildlife forever and with that remove a significant source of tourist revenue from an entire continent. The identification and control of insidious disease will need to be based on scientific risk assessments so that critical diseases can be identified and prevented from spreading.

Zoonotic disease

As mentioned earlier zoonotic diseases are among the most important diseases to small-scale farmers in low-income countries, and because these farmers represent the largest number of agricultural workers in the world, animal and public health services must focus on the control and prevention of these diseases. Regrettably the three major zoonotic diseases, brucellosis, coenuriasis, and oncocerciasis, are chronic diseases and do not elicit significant attention from influential decision makers, who often rely on political and bureaucratic momentum to set priorities. Nevertheless, there are effective preventive interventions for the aforementioned diseases, and, therefore, top priority should be given to the control, if not global eradication, of these diseases. It is likely that the eradication of diseases, such as FMD, will not be possible unless the participation of owners of cattle with FMD is encouraged by linking FMD eradication with animal and human treatments against zoonotic diseases. This could be accomplished by offering simultaneous programmes for FMD eradication and control of zoonotic disease. In the case of bovine brucellosis, vaccine technology has progressed to a point where global eradication is possible, and if animal and public health services were to attempt to implement a global eradication programme they would probably gain tremendous access and support from many communities where other animal diseases are prevalent.

Conclusions

Poverty is prevalent in areas of low economic growth. Factors contributing to poverty are an unequal distribution of wealth and access to health, education, and economic opportunity, and, in poor countries with many natural resources, a highly skewed wealth distribution. Most rational people would probably agree that the growing discrepancies in wealth and basic opportunity in the world will have dire consequences if left unchecked over the next two decades. Therefore, the challenge facing animal and public health professions is to recognise and anticipate likely changes and to adjust their modus operandi in such a way that all countries, industries, and populations benefit from the structure, effectiveness and relevance of the animal and public health professions.

Ways in which animal and public health services can build on existing strengths are by supporting policies that temper growing inequalities, such as providing preferential opportunities for low-income countries, rural populations, and women. Shifts in global trends in demand and supply, not terrorism, will drive the adaptation of animal and public health service delivery. To ensure that they are able to serve all parties equitably, animal and public health services will have to engage in an economic and social debate. To gain better support for disease control programmes, these services should create strategic alliances with private sector industries.

Veterinarians have traditionally seen the farmer as their customer because it is the animal owner who pays the practitioner's bills. This model is no longer sufficient for animal and public health services. To survive, or better yet, to become a leader, veterinarians will have to become part of a larger movement that contributes to global economic vitality. To assume such a role, government animal and public health services will have to find incentives and policies that encourage private sector veterinarians to play a significant part in supporting the global economy.

Animal and public health services can provide the framework for job growth in food safety and handling and support job growth along the value added chain in livestock production. To support environmental sustainability, the economic externalities of farm waste production has to be converted into jobs, such as by creating employment opportunities in waste management, recycling, and water conservation. As the use of land for agriculture increases, more people with animal and public health expertise will be needed to identify, respond to, and control new and emerging diseases that are encountered as pristine bat and other wildlife habitats are encroached upon, exposing naïve populations of humans and animals to diseases such as severe acute respiratory syndrome, Nipah virus, and Hendra virus.

The control and eradication of diseases of trade will not be possible unless the owners of animals afflicted with these diseases are also provided with animal and human treatments against zoonotic diseases. In the case of brucellosis, vaccine technology has progressed to a point where global eradication is possible. Global eradication of bovine brucellosis should become a high priority for animal and public health services in the next two decades.

Promoting access to health and education services in low- and middle-income countries results in a vigorous workforce and this may be the single biggest, albeit indirect, benefit that animal and public health services can provide over the next 20 years. Animal and public health services stand at a critical juncture where the challenge is to support not hinder progress. These services will hinder progress if they contribute to or exacerbate disparities in wealth, education, and access to economic opportunity between low and high-income populations. The services will support progress if they contribute to the proliferation of jobs within countries.

Whereas as at the beginning of World War II scientists argued that they were only responsible for getting the rocket into the air, by the end of the war scientists recognised that it was their moral responsibility to consider where the rocket will land. Whereas physicists have known for over half a century that they can use their discipline to either destroy the world or create wealth, biologists are only just now realising that diseases are powerful tools of destruction. It can only be hoped that the animal and public health communities will soon realise the role of their professions in the modern world and, following the lead of other scientists, use their knowledge to create wealth. The time has come for the animal and public health professions to enter into a debate on the socio-political impacts of the regulations and standards of disease control and to pursue policies that apply biological sciences to overcome the predicament of the 21st Century: disparate access to opportunity.

■

Les défis et les options pour les services de santé animale et de santé publique pendant les deux prochaines décennies

S.E. Heath

Résumé

Le commerce des animaux et des produits d'origine animale représente approximativement le sixième des échanges agricoles dans le monde. Ce commerce est tiré par la demande, principalement à cause de la croissance démographique, de l'évolution des économies et de la préférence des consommateurs dans les pays en développement. Les différences de taux de croissance démographique, de croissance économique, d'urbanisation, de viabilité environnementale et de transferts de technologie déterminent les pays qui vont récolter les plus grands bénéfices de cette situation. Ce sont les tendances mondiales de la demande et de l'offre de nourriture, et non le terrorisme, qui détermineront l'avenir de la prestation de services de santé animale et de santé publique.

Pour bénéficier au plus grand nombre de personnes et de pays, il faut que les services de santé animale et de santé publique soutiennent des politiques qui réduisent les disparités croissantes entre pays riches et pauvres, populations urbaines et rurales, hommes et femmes. La croissance économique est essentielle pour surmonter les disparités entre pays et elle repose sur l'intégration des politiques de la santé animale, de la santé publique, du travail et des relations avec l'étranger. Les possibilités de croissance de l'emploi seront les plus nombreuses le long de la chaîne de valeur ajoutée liée à la production alimentaire et elles nécessiteront des investissements importants dans l'éducation fondée sur la science (le risque).

Mots-clés
Bétail – Commerce – Croissance économique – Direction de l'environnement – Éducation – Femme – Pauvreté – Produit d'origine animale – Service de santé animale – Service de santé publique – Urbanisation – Valeur ajoutée.

Desafíos y alternativas para los servicios de salud pública y veterinaria en los dos próximos decenios

S.E. Heath

Resumen
El comercio de ganado bovino y sus derivados supone aproximadamente una sexta parte del comercio agropecuario mundial. Es una actividad muy dependiente de la demanda, tributaria esencialmente del crecimiento de las poblaciones humanas, la evolución de las economías y los nuevos hábitos de consumo en los países en desarrollo. De las distintas tasas de crecimiento demográfico y económico, urbanización, sostenibilidad ambiental y transferencia de tecnología dependerá a la postre cuáles sean los principales países beneficiarios. Serán las tendencias mundiales de la oferta y la demanda de alimentos, y no el terrorismo, las que determinen el rumbo futuro de la prestación de servicios de salud animal y de salud pública.
Para beneficiar al mayor número posible de personas y países, los servicios de salud animal y de salud pública deberían secundar políticas que redujeran las crecientes disparidades que existen entre países ricos y pobres, poblaciones urbanas y rurales, hombres y mujeres. El crecimiento económico es fundamental para superar las disparidades entre países, y la mejor forma de favorecerlo es la integración de las políticas zoosanitaria, de salud pública, laboral y de relaciones exteriores. Las oportunidades de creación de empleo serán inmejorables en los distintos eslabones de la cadena de producción alimentaria con valor añadido, lo cual, a su vez, exigirá importantes inversiones en una enseñanza que tenga en cuenta criterios científicos (de riesgo).

Palabras clave
Comercio – Crecimiento económico – Educación – Ganado – Gestión ambiental – Mujer – Pobreza – Producto de origen animal – Servicio de salud pública – Servicio de sanidad animal – Urbanización – Valor añadido.

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Conclusion

Biological disasters of animal origin
The role and preparedness of veterinary and public health services

Risk of bioterrorist acts

The probability of a bioterrorist attack is uncertain but the possibility exists. What can be counted on is that if one is successfully carried out, especially if with modest sophistication, it will certainly be imitated and repeated. On the other hand, natural outbreaks do occur and have the potential to move between countries close and distant. These we must prevent, control when they occur, and recover from efficiently. If we can do that with natural outbreaks, there is no reason to doubt that we can also effectively and confidently handle an intentional event.

It is important that a government's concern with terrorism should not be allowed to limit its abilities to effectively and efficiently manage and control natural disasters and disease outbreaks. Priorities must reflect reality.

Need for improved regional disease and agent intelligence

There have been significant, and sometimes unbelievable, improvements in countries reporting disease outbreaks, thanks in great part to the ongoing efforts of the World Organisation for Animal Health (OIE), but in reality and too often events are not reported promptly and when they are it is reluctantly and only in part. Countries forget that efficient and transparent reporting makes for greater international trust, respect and confidence in the Veterinary Services involved. While it would be naive to not expect some countries to take a crude trade advantage of such reports, respect translates into a quicker appropriate relaxation of any protective barriers. We inhabit a small globe and like in a family – what happens to one, happens to us all. Quick reporting protects our neighbours and makes for a better neighbourhood. This translates into the need by countries to have efficient epidemiological investigation capacities. Making definite claims about the source of infection in an outbreak without scientific backup indicates incompetence, and/or bureaucratic shuffling, and how then can we trust anything else that country reports? Similarly, the OIE and Food and Agriculture Organization (FAO) need to be less gentlemanly and more aggressive in obtaining information. To defend ourselves against the possibility of new outbreaks, of transboundary disease spread, the first defence is information, fast and accurate information.

And in this day of molecular testing we need to be routinely fingerprinting these pathogenic agents. For those doing this, a way must be found to have this information promptly available on the web, because a small sequence change may be meaningless in one laboratory but explain all to investigators in another country. The available information should include details of live and dead vaccines, and authorised and unauthorised commercial vaccines. The use of live vaccines should be monitored because they are sometimes not apathogenic; they can

reveal themselves by atypical outbreaks in distant countries, sometimes without the benefit of official visas. And it is a sad commentary that dead vaccines occasionally seemingly mimic Lazarus and though labelled 'dead' are in fact fully potent and cause disease.

Latterly, Asia has been apparently rife with an extensive trade in meats through informal and illegal channels and through smuggling, which by the nature of their production are more likely to be carrying pathogens. The high costs of this are borne by other countries. International agencies can of themselves have only a limited direct impact on this. The responsibility rests more heavily on the host governments of the countries concerned. Which brings us back to transparent disease-reporting. A poor capacity for the latter seems to foster, and not inhibit, the smuggling trade.

And lastly there is a deep need for improved epidemiological training of veterinary officers. If they are incompetent, the system collapses. Various advanced countries now spend more time on molecular analyses and mathematical model building. But the truth is in the farmyard and that can only be determined by skilled investigators. Genomics and models assist them but cannot replace them.

Collaboration and intercommunication between veterinary and public health agencies

A constant problem in efficiently handling disease outbreaks is setting up and maintaining good communications between agencies, especially when handling zoonotic diseases. Veterinary and public health agencies must be talking and interacting with each other before an outbreak occurs. If they wait until an emergency happens their efforts to communicate and cooperate will often be too little, too late. Sometimes these collaborations are counter-intuitive, but the United States Department of Agriculture and the United States Forestry Service are cost-effectively synergistic in efficiency when handling major outbreaks of disease. The United Kingdom Department for Environment, Food and Rural Affairs has found that the military fills a similar need for them by efficiently organising animal carcass disposal. Collaboration comes from doing it, not just talking about it, as part of the success comes from knowing each other both as organisations and as people. The larger the epidemic the more agencies will be involved, so precedence, collaboration, and chains of command must be established before the confusion of events clouds and delays solution.

Improved regional collaboration

In recent years, thanks to severe acute respiratory syndrome (SARS) and avian influenza, we have seen, and welcome, a significant improvement and strengthening of international and inter-agency collaboration and coordination. This has expanded reporting obligations for human diseases in the new World Health Organization (WHO) International Health Regulations, which were unanimously adopted by the World Health Assembly in May 2005. Under the revised regulations, which are scheduled to enter into force in June 2007, countries have much broader obligations to build national capacity for routine preventive measures as well as to detect and respond to public health emergencies of international concern. Under the previous rules, WHO member states only had to report cases of cholera, plague and yellow

fever. Now they must report all events that may constitute a public health emergency of international concern. Countries must also put into place the infrastructure to make sure they can do this – meaning laboratories and staff who can diagnose disease outbreaks. And countries must report any public health risks they are aware of even if they fall outside their territories. This latter obligation means that if cases are detected by the military of a foreign country or by a regional or international reference laboratory it will be their responsibility to report directly to the relevant international organisation (WHO, OIE, FAO); they should not leave it to the discretion of the national (host) government.

In parallel, the OIE and FAO have developed an initiative – the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) of which the Global Early Warning System (developed jointly with WHO) will be an integral part. This will ensure the sharing of information on animal health and human zoonotic diseases among the three organisations; the OIE will be responsible for verification. The GF-TADs offers a substantial base for improving epidemiological and environmental information, diagnostic networking, trend analysis, and intervention against the important epidemic animal diseases. At the same time, the OIE standards will be actively used to harmonise animal disease control and prevention legislation. The OIE guidelines for laboratory biosecurity are recommended for the safe management of biological agents. Member countries of the OIE and FAO are strongly advised to comply with OIE guidelines, standards and recommendations for surveillance and prompt notification of livestock and wildlife disease and with the principles of the FAO Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases. All this is for naught if the member countries cannot or are unable to improve the quality and efficiency of their Veterinary Services in compliance with OIE standards to guarantee vigilance in disease monitoring, surveillance and early warning/early detection.

Mathematical models

Mathematical models have their place in understanding and handling epidemics. But the British experience has expensively demonstrated that they must never be allowed to robotically drive that process. Models, however clever, are pointless and dangerous if they cannot be validated, and this must be a dynamic ongoing process even as the epidemic rages, not an academic retrospective activity. It is important to emphasize that mathematical models produce at best theories and more usually hypotheses, not proven facts. Like all other theories, they should be tested in the real world before being accepted as accurate. This is in no way to dismiss them. In complex situations they are sometimes the best way to plot a preliminary way through the forest of possible alternative actions. And with unique events they can be the only way of judging their probability. But one should not throw away common sense and experience when listening to the models' advice.

One hymnal

In this day there is no need for paper documents except for forensic and related legal purposes. Data, including accurate site locations, and information can be collected in the field with handheld electronic devices remotely connected to dedicated websites, error checked, and uploaded into central databases in the time it takes to read this sentence. Similarly, laboratory

analytical equipment that processes large numbers of field samples can be set up to automatically add the test results to these databases without transcription errors. With data entry and editing restricted, reading can be open to all those with secure access. If everyone has access to the same information – a common data source – it reduces errors and delays as everyone is acting on the basis of the same data – singing from the same hymn book. Obviously there must be reliable data security and confidentiality.

Laboratory confirmation

Animal-side field tests and remote sample analyses are becoming available and validated. They can only become more common with time, and even more reliable and cheaper. They are particularly important in the initial phase of an outbreak or epidemic, especially if movement controls are to be quickly invoked and tracing started. At this time, and for the immediate future, laboratory confirmation will still be necessary. The balanced use of these two techniques (field analysis and laboratory confirmation) will emerge through experience. But field analyses test limited numbers of suspect animals and are concerned with events with a high positive predictive value. When there are indications that the event might be unnatural a dedicated forensic team must be brought in promptly to set up its parallel investigation uninterrupted. The validation of decisions will depend on the processing of significant numbers of herd and flock bleedings and potential agent samplings. For this there must be a surge capacity in the supporting laboratories, with transparent and patent quality controls on validated tests, and an archival policy so that situations can be revisited either contemporaneously or retrospectively. Genomic identification is important initially in identifying probable sources and ways must be found to make this a normal rapid routine event. It is also needed for surveillance of the epidemic and in maintaining control efficiency, which means that if possible it must move out of the confirmatory laboratory and into the front line of field laboratory support.

Herd management

Stakeholders, major and minor, must be included in disease control. Efforts must be made to get their input and to keep them informed before events occur. Uninformed stakeholders are most unlikely to support government actions, especially when their doubts, either through ignorance or from disagreement, are ignored and disregarded. Transparent stakeholder involvement and participation – tiresome though it may be to the traditionalists – pays off, especially when navigating the questions of slaughter, vaccination, and post-vaccination policy and strategies.

Stakeholder involvement must include their cooperation in establishing animal and farm identification systems. Owner reluctance can be overcome when they can see the benefits, plus it then results in fewer delays in updating the information. The systems must therefore be under continuous review and improvement.

Epidemiology teams

When there is a major disease outbreak the first duty, after stopping livestock movement, is to confirm the initial diagnosis. When this is done the control management takes over and the

field epidemiology team must trace back from the index case to find the primary case, which may have been some while before. And from that case to sort out how this outbreak came about and trace its source. This we all know. It is a vital responsibility of the Epidemiology A team and is achieved through proper training. But also, while an epidemic is being managed, this same team should be monitoring the control procedures. Is it progressing at the expected rate? If new cases are occurring, why? Any reasons put forward should be questioned and tested. We think we do this, but the reality is that convenient working answers are too often accepted unquestioned because there is neither the time, the funds nor the official support.

With a major epidemic it is important to set up and fund an additional Epidemiology team 'B' with the responsibility during the epidemic of collecting – sometimes frankly rescuing – and storing outbreak samples, and amassing data and documentation that will allow a cold retrospective analysis of what worked, what did not, and what needs to be done better next time. This is not to ascribe blame. In the demands of the moment decisions have to be made, some of which are good and others maybe be later regretted. Only those with epidemic experience know how stressful it can be. But if we are to learn what should have been done, how the cost might have been less, the data and samples must be on hand to answer those questions and honestly explore alternatives.

Shared costs, shared responsibilities, shared benefits

New policy is needed to change the prevailing wisdom that government is solely responsible for excluding disease, responding to introductions, and compensating farmers for losses during eradication programmes. Effective border control and domestic preparedness programmes depend upon government and industry working together in a process that is comprehensive, adequately funded and performing to measurable benchmarks with costs falling upon those responsible in the form of 'user fees', not the general public through tax revenues. Compensation of livestock owners for stock slaughtered during outbreak control should be covered by private insurance. Costs of keeping transboundary livestock diseases out should primarily be borne by those passing across the country's borders or importing animals or goods of any kind that might carry these infections. Government and industry should share the costs of an effective surveillance, diagnostic and response system. The surveillance system must achieve or approach real-time understanding of the disease situation at all stages and in all places and be accessible over the Internet by diverse government agencies and stakeholders in-country and abroad. Traditional responses – sweeping quarantines, mass slaughter and burning or burial of millions of carcasses – and scientifically outdated trade embargoes must be abandoned because they encourage terrorism. Only the ways we have chosen to respond to transboundary diseases in the past allow terrorists to threaten us with them in the future. Regulatory approval processes must be modernized to keep up with new technology. Similarly, developed countries must provide the tools, technologies, and infrastructure that will enable developing countries to eliminate diseases. Increased private sector involvement is essential to bridge governmental programme gaps, deliver technology, and eliminate disease at the village level.

Communication with the public

One hopes that due attention will be given to constructing communication strategies with partners at all levels of the government, because risk communication can tip the scales between peace in the streets and public panic. Ordinary people may cancel travel plans and orders for durable goods. This can affect industry and commerce in powerful ways if they keep their purses closed because of the fear of an infection. Again, with so little funding allocated to these efforts, risk communications may be given lower priority. If so, that is a pity, because risk communication requires planning, strategising – and frankly, practice – in order to make it work effectively. One notices with some scepticism how risks, such as currently with virulent avian influenza H5N1, are talked up by those likely to benefit from the additional funding. 'Currently we have far too many voices competing against each other for airtime to deliver messages of impending pandemic gloom and doom to the general public. Ordinary people are already scared of avian influenza. Urgent efforts should be made to quell their immediate fears and convince them that those with a mandate to protect them are doing all that they can do' (L.M. Kelley, in *Health Policy Outlook*, November-December 2005). Timely and transparent dissemination of clear, accurate, science-based, culturally competent information about disease risks and the progress of the response can build public trust and confidence. The public is frequently much wiser than governments give them credit for and especially when they are transparently informed.

The next twenty years

In determining the optimum future situation it is prudent to pay attention to current trends, while keeping our awareness open to outlying possibilities and non-linear dynamics. One should manage, rather than try to eliminate, uncertainty. This argues for greater weight to be placed on robust, broad and holistic approaches to animal and public health instead of specific fixes to the threat (or disease) du jour. International veterinary and public health communities, including the OIE, FAO and WHO, should incorporate into their structures and activities better ecological understanding of pathogens and hosts, environmental triggers, modelling and integration of such imbalances for better control and mitigation measures. This should include an awareness of the risks from non-native invasive species, which can include vectors and alien pathogens, as well as the ecological changes wrought by invasive species that can change ecologies and therefore alter traditional epidemiological patterns. One area requiring further development is the simulation of terrorist decision-making and targeting choices.

Models combining decision tree analysis with epidemiology are required to identify critical points in food chains which should be strengthened to reduce risks of emergencies occurring and to prevent emergencies becoming disasters. Such a model, however, is unlikely to provide a unique and long-lasting answer, in part because the livestock sectors of developing countries change quickly. Given the unknown threat of bioterrorism, models of surveillance and response must be flexible to ensure that the social and economic impacts of a biological emergency disaster are limited. With the potential for transboundary diseases spilling over from developing countries much closer working relationships are needed with these countries with both known and unknown animal disease status if these diseases are to be controlled or eradicated. Veterinary Services must be strengthened, as should human public health services.

It is strange, but one factor diminishing veterinary training is the glut of veterinary schools in many countries. This makes for a less than optimal environment in which to learn the profession in its required depth or to practice the profession and receive just compensation for services. This can be readily seen to negatively impact the quality of the profession in those countries. At the same time, there is a true need, frequently unmet, for the education and training of biologists, microbiologists, molecular geneticists and other bioengineers. They should receive training in basic, good laboratory practices which instil a high code of conduct for agent handling, laboratory procedures, documentation and reporting. Furthermore, systems for their integration into national and international preparedness planning should be developed. The introduction of good laboratory practices early in a professional education is directly related to the later levels of biosafety, biosecurity, and expertise of the type required in an emergency. National standards must be instituted and professional organisations promoted. In addition, there should be a widespread system of international accreditation for institutes, schools, and laboratories, which will foster better productive international collaboration, networks, and synergy in peaceful research.

Trade in livestock and livestock products make up approximately one sixth of global agriculture trade. This trade is demand-driven primarily by growing human populations, economies and consumer preferences in developing countries. Different rates of population growth, economic growth, urbanisation, environmental sustainability, and technology transfer will determine who reaps the greatest benefits. Global trends in demand and supply for food, not terrorism, will drive the future of animal and public health service delivery.

To benefit the largest number of people and countries, animal and public health services should support policies that temper growing disparities among rich and poor countries, city and rural populations, and the sexes. Economic growth is critical to overcoming these differences and is best supported by integrated animal health, public health, labour and foreign policies. Opportunities for job growth will be greatest along the value-added chain of food production and will require significant investments in science- (risk-) based education.

Lastly, the vital conclusion is that we live on one globe. There is only one health that we should strive for, that of wildlife and domestic animals, humans, and the environment. By striving to protect the planet and maintain animal health we are also protecting human health, and vice versa. To succeed we have to share knowledge and resources, and improve international interactions to build the required trust for a promising future.

Martin Hugh-Jones
Professor Emeritus
Environmental Studies Department
School of Coast & Environment, Rm 2279
Energy, Coast & Environment Building
Louisiana State University
Baton Rouge, LA 70803-5705
United States of America

Conclusions

Catastrophes biologiques d'origine animale
Le rôle et la préparation des Services vétérinaires et de santé publique

Risque d'attaque bioterroriste

La probabilité d'attaque bioterroriste est difficile à déterminer mais la possibilité existe. On peut toutefois être sûr que, si une tentative réussit, surtout si elle est relativement élaborée, elle sera imitée et renouvelée. D'autre part, des foyers naturels surviennent et ils peuvent se propager dans des pays proches et lointains. Nous devons prévenir ces foyers, les contrôler quand ils surviennent et redresser la situation avec efficacité. Si nous pouvons le faire pour les foyers d'origine naturelle, il n'y a aucune raison de penser que nous ne pourrions pas réussir à surmonter une attaque intentionnelle.

Il est essentiel que la crainte du terrorisme ne limite pas la capacité des gouvernements à gérer et à contrôler efficacement les désastres naturels et les foyers de maladie. Les priorités doivent refléter les réalités.

Nécessité d'améliorer l'information sur les maladies et sur les agents pathogènes

On constate des progrès remarquables, parfois même incroyables, dans la notification par les pays des foyers de maladie, en grande partie grâce aux efforts persévérants de l'Organisation mondiale de la santé animale (OIE), mais en réalité il arrive trop souvent que les événements ne soient pas signalés rapidement et quand ils le sont, c'est avec réticence et partiellement. Les pays oublient qu'une notification effective et transparente accroît la confiance et le respect entre les nations, ainsi que la crédibilité des Services vétérinaires concernés. Il serait certes naïf de croire qu'aucun pays ne va tirer des notifications un avantage commercial trop facile, mais le respect mutuel l'obligera rapidement à remettre les barrières de protection à leur juste place. Nous vivons sur une petite planète et, comme dans une famille, ce qui touche l'un de nous nous touche tous. Quand nous déclarons rapidement les maladies, nous protégeons nos voisins et nous améliorons nos relations avec eux. Pour cela il faut que les pays aient des capacités suffisantes d'investigation épidémiologique. Émettre des jugements définitifs sur la source de l'infection dans le cas d'un foyer sans s'appuyer sur des éléments scientifiques, c'est faire preuve d'incompétence et/ou de mauvaise volonté bureaucratique. Dans ces conditions, comment pourrait-on faire confiance à d'autres informations provenant de ces pays ? Dans le même ordre d'idées, l'OIE et l'Organisation des Nations unies pour l'alimentation et l'agriculture (FAO) doivent se montrer moins accommodants et plus combatifs dans leur quête d'informations. Pour nous défendre contre la possibilité de nouveaux foyers, de propagation transfrontalière d'une maladie, la première ligne de défense est l'information, une information rapide et exacte.

En outre, à notre époque de tests moléculaires, il faut recourir systématiquement à la typification de ces agents pathogènes. Pour les personnes qui feront ce travail, il faut trouver

un moyen afin que les informations soient rapidement disponibles sur Internet, parce qu'une petite modification de séquence peut n'avoir aucune signification dans un laboratoire mais tout expliquer pour les enquêteurs d'un autre pays. Les informations disponibles devraient comporter les détails des vaccins vivants et inactivés, ainsi que ceux des vaccins commercialisés autorisés et non autorisés. L'utilisation de vaccins vivants doit être surveillée parce qu'ils ne sont pas toujours dénués d'effets pathogènes ; ils peuvent se manifester par l'apparition de foyers atypiques dans des pays lointains, parfois sans avoir bénéficié d'un visa officiel. Il est triste de constater que les vaccins inactivés semble imiter la résurrection de Lazare : on peut croire qu'ils sont morts mais en fait ils gardent toute leur nocivité et provoquent des maladies.

Récemment, l'Asie a été en proie à un vaste trafic de viandes qui passe par des voies informelles et illégales, ainsi que par la contrebande. En raison de la nature de leur production il est plus probable que ces viandes véhiculent des agents pathogènes. Or, les coûts élevés de ce trafic sont supportés par les autres pays. Les organisations internationales ne peuvent exercer par elles-mêmes qu'une influence limitée sur cet état de choses. La responsabilité incombe en majeure partie aux gouvernements des pays hôtes. Cela nous ramène à la question de la notification transparente des maladies. Quand un pays n'a pas la capacité d'accomplir cette tâche, il encourage la contrebande au lieu de la combattre.

Enfin il est absolument nécessaire d'améliorer la formation épidémiologique du personnel vétérinaire. S'ils sont incompétents, le système s'écroule. Plusieurs pays développés passent aujourd'hui plus de temps aux analyses moléculaires et à la construction de modèles mathématiques. Pourtant la vérité se cache dans la cour des fermes et seuls des enquêteurs qualifiés peuvent la trouver. La génomique et la modélisation les aident mais elles ne peuvent pas les remplacer.

Collaboration et communication entre les vétérinaires et les organismes de santé publique

La gestion des foyers de maladie pose en permanence le problème de créer et de maintenir de bonnes communications entre organisations, surtout dans le cas des zoonoses. Les organismes de médecine vétérinaire et de santé publique doivent rester en contact et en interaction avant l'apparition d'un foyer. S'ils attendent qu'une situation d'urgence survienne, leurs tentatives de communication et de coopération se résument souvent à trop peu, trop tard. Quelquefois ces collaborations paraissent peu évidentes ; pourtant le Département de l'agriculture des États-Unis d'Amérique et le Service des forêts des États-Unis d'Amérique appliquent une synergie efficace et économique dans la gestion des foyers importants de maladie. Le Département de l'environnement, de l'alimentation et des affaires rurales du Royaume-Uni a constaté que les militaires répondent à un besoin analogue en organisant efficacement l'élimination des carcasses d'animaux. La collaboration consiste à agir et pas seulement à parler, puisque le succès vient quand on se connaît bien, entre organisations comme entre individus. Plus l'épidémie est généralisée, plus nombreux sont les organismes concernés, par conséquent il faut déterminer la hiérarchie, la collaboration et les chaînes de commandement avant que les événements ne viennent brouiller la situation et retarder la solution.

Amélioration de la collaboration régionale

Ces dernières années, à cause du syndrome respiratoire aigu sévère et de l'influenza aviaire, nous avons constaté, et nous nous en félicitons, une amélioration et un renforcement remarquables de la collaboration et de la coordination entre pays et entre organisations. Ce progrès s'est traduit par un accroissement des obligations de déclaration pour les maladies humaines dans le nouveau Règlement sanitaire international de l'Organisation mondiale de la santé (OMS), adopté à l'unanimité par l'Assemblée mondiale de la santé en mai 2005. Selon le règlement révisé, qui devrait entrer en vigueur en juin 2007, les pays ont des obligations beaucoup plus larges de renforcer leur capacité de prendre systématiquement des mesures de prévention, ainsi que de détecter les situations d'urgence sanitaire d'importance internationale et d'intervenir. Selon les règles précédentes, les États membres de l'OMS étaient seulement tenus de déclarer les cas de choléra, de peste et de fièvre jaune. Désormais, ils doivent déclarer tous les événements qui risquent de représenter une urgence pour la santé publique à l'échelle internationale. Les pays doivent aussi mettre en place l'infrastructure qui leur permettra d'accomplir cette tâche – à savoir des laboratoires et un personnel capables de diagnostiquer les foyers de maladie. Ils doivent aussi signaler tout risque pour la santé publique dont ils ont connaissance même s'il se présente en dehors de leur territoire. Cette dernière obligation signifie que, si des cas sont détectés par les militaires d'un pays étranger ou par un laboratoire de référence régional ou international, il leur incombera de les déclarer directement à l'organisation internationale concernée (OMS, OIE, FAO) ; ils ne devront pas laisser la déclaration à la discrétion du gouvernement du pays (hôte).

Parallèlement, l'OIE et la FAO ont lancé une initiative – le Plan-cadre mondial pour la lutte progressive contre les maladies animales transfrontalières (GF-TADs) dont le Système mondial d'alerte rapide (élaboré conjointement avec l'OMS) sera une partie intégrante. Ce dispositif assurera le partage d'informations sur la santé animale et les maladies humaines zoonotiques entre les trois organisations ; l'OIE sera responsable de la vérification. Le GF-TADs offre une base solide pour l'amélioration de l'information épidémiologique et environnementale, du diagnostic en réseau, de l'analyse des tendances et de l'intervention contre les épidémies importantes de maladies animales. Dans le même temps, les normes de l'OIE seront utilisées activement pour harmoniser les législations applicables au contrôle et à la prévention des maladies animales. L'utilisation des lignes directrices de l'OIE relatives à la biosécurité des laboratoires est recommandée pour la gestion des agents biologiques en toute sécurité. Les Pays membres de l'OIE et de la FAO sont vivement incités à se conformer aux lignes directrices, normes et recommandations de l'OIE en matière de surveillance et de notification rapide des maladies des animaux d'élevage et de la faune sauvage et à obéir aux principes du Système de prévention des urgences pour les ravageurs et les maladies transfrontières des animaux et des plantes de la FAO. Mais toutes ces dispositions ne serviront à rien si les Pays membres sont dans l'impossibilité ou dans l'incapacité d'améliorer la qualité et l'efficience de leurs Services vétérinaires conformément aux normes de l'OIE afin d'assurer la plus grande vigilance dans le suivi, la surveillance et l'alerte rapide/la détection rapide des maladies.

Modèles mathématiques

Les modèles mathématiques ont leur utilité pour la compréhension et la gestion des épidémies. Pourtant, l'expérience britannique a démontré aux dépens de ce pays qu'il ne faut jamais les laisser gérer automatiquement ces situations. Les modèles, quel que soit leur

raffinement, sont inutiles et dangereux si l'on ne peut pas les valider, et leur utilisation doit constituer un processus dynamique et continu au moment où l'épidémie fait rage, et non une activité académique rétrospective. Il est important de souligner que les modèles mathématiques produisent au mieux des théories et le plus souvent des hypothèses, et non des faits démontrés. Comme toutes les autres théories, celles-ci doivent subir l'épreuve des réalités avant d'être reconnues exactes. Cela ne veut pas dire qu'il faille les écarter. Dans les situations complexes les modèles constituent parfois le meilleur moyen de tracer un premier chemin dans la forêt des actions possibles. Face à des risques exceptionnels, ils peuvent être le seul procédé pour évaluer leur probabilité. Mais il ne faut pas que leurs avis nous fassent renoncer au bon sens et à l'expérience.

Un seul recueil de données

Dans le monde actuel on n'a plus besoin de documents en papier, sauf pour des raisons médicolégales et juridiques en général. On peut collecter sur le terrain des données, y compris relatives à la localisation précise d'un événement, avec des appareils électroniques portables connectés à distance à des sites spécialisés, qui détectent les erreurs, et les entrer dans des bases de données centrales dans l'intervalle de temps qu'il faut pour lire cette phrase. De même, les équipements d'analyse des laboratoires qui traitent un grand nombre d'échantillons recueillis sur le terrain peuvent être conçus pour intégrer automatiquement les résultats des tests dans la base de données, sans erreurs de transcription. Quand l'entrée des données et l'édition font l'objet de restrictions, toutes les personnes bénéficiant d'un accès sécurisé peuvent consulter les données. Si tous les spécialistes ont accès aux mêmes informations, les risques d'erreurs et de retards diminuent. De toute évidence, il faut un système fiable de sécurisation des données et de confidentialité.

Confirmation par le laboratoire

Les tests de terrain et les analyses d'échantillons à distance sont désormais disponibles et validés. Ils ne peuvent que se généraliser avec le temps et devenir encore plus fiables et économiques. Ils jouent un rôle particulièrement important pendant la phase initiale d'un foyer ou d'une épidémie, surtout si l'on doit rapidement contrôler les déplacements et commencer à en rechercher l'origine. Toutefois, pour le moment, et dans l'avenir immédiat, la confirmation par le laboratoire restera nécessaire. L'utilisation équilibrée de ces deux techniques (analyse sur le terrain et confirmation par le laboratoire) sera le fruit de l'expérience. Toutefois, les analyses sur le terrain ne testent que des nombres limités d'animaux suspects et portent sur des événements dont la valeur prédictive est élevée. Quand il existe des indications montrant que l'événement pourrait ne pas être naturel, il faut faire rapidement appel à une équipe médicolégale spécialisée pour qu'elle mène son enquête parallèlement sans être interrompue. La validation des décisions dépendra du nombre de prises de sang dans le troupeau et le cheptel et des prélèvements d'agents potentiels réalisés. Pour ce faire il faudra renforcer considérablement la capacité des laboratoires d'appui, avec des contrôles de qualité transparents et ouverts et une politique d'archivage pour que l'on puisse réétudier les situations soit immédiatement soit rétrospectivement. L'identification génomique est importante au début pour identifier les sources probables et il faut trouver les moyens de la rendre systématique. Elle est également nécessaire pour surveiller l'épidémie et maintenir l'efficacité du contrôle, et cela signifie qu'elle doit, si c'est possible, sortir du laboratoire de confirmation pour aller en première ligne apporter son soutien au laboratoire de terrain.

Gestion des troupeaux

Les parties prenantes, quelle que soit leur importance, doivent participer à la lutte contre la maladie. Il faut s'efforcer d'obtenir leurs avis et de les tenir informés avant qu'un événement survienne. Si les parties prenantes sont mal informées, il est peu probable qu'elles soutiendront les actions du gouvernement, surtout quand on ne tient pas compte de leurs doutes ou les rejette, par ignorance ou parce qu'on n'est pas d'accord. L'implication et la participation des parties prenantes en pleine transparence – même si elles peuvent gêner les traditionalistes – sont payantes, surtout quand il est question d'abattage, de vaccination, de politique et de stratégie après vaccination.

L'implication des parties prenantes doit comporter leur coopération pour la création de systèmes d'identification des animaux et des exploitations. On peut surmonter les réticences des propriétaires quand ils perçoivent les avantages qu'ils peuvent en tirer et cela permet de réduire les délais de mise à jour des informations. Les systèmes doivent par conséquent être revus et améliorés en permanence.

Équipes épidémiologiques

Quand survient un important foyer de maladie, la première tâche, après que l'on a arrêté les déplacements des animaux, consiste à confirmer le diagnostic initial. Cela fait, la gestion des mesures de lutte prend l'affaire en main et l'équipe d'épidémiologistes de terrain doit trouver l'origine de la maladie à partir du cas de référence pour retrouver le cas primaire, qui peut être apparu quelque temps avant. À partir de ce cas elle doit ensuite déterminer comment le foyer est apparu et trouver sa source. Cela, nous le savons tous. C'est la responsabilité cruciale de l'équipe d'épidémiologie A et elle ne peut l'exercer qu'après une formation adéquate. Mais cette même équipe doit, pendant la gestion d'une épidémie, suivre de près les procédures de contrôle. La lutte progresse-t-elle à la vitesse que l'on avait prévue ? Si des nouveaux cas apparaissent, pourquoi ? Il faut mettre en question et vérifier toutes les raisons qui sont avancées. On croit le faire mais en réalité on accepte trop souvent les réponses toutes faites sans se poser de questions, parce que l'on n'a ni le temps, ni l'argent ni le soutien des autorités.

Dans le cas d'une grave épidémie il est essentiel de mettre en place et de financer une seconde équipe épidémiologique « B » chargée pendant la durée de l'épidémie de collecter, parfois même de sauver de la destruction, et de conserver des échantillons, de recueillir les données et la documentation qui permettront d'analyser à froid ce qui a fonctionné, ce qui n'a pas marché et ce qu'il faudra améliorer à l'avenir. Il ne s'agit pas de désigner des coupables. Dans l'urgence on est obligé de prendre des décisions dont certaines sont justifiées et d'autres feront peut-être l'objet de regrets par la suite. Seules les personnes qui ont l'expérience des épidémies savent à quel point cette situation peut être pénible. Pourtant, si nous voulons savoir ce que nous aurions dû faire, comment nous aurions pu réduire les coûts, il faut que nous disposions des données et des échantillons pour répondre à ces questions et envisager honnêtement d'autres solutions.

Partage des coûts, des responsabilités et des bénéfices

Il faut une nouvelle politique pour changer l'idée reçue selon laquelle l'État est le seul responsable de l'éradication de la maladie, de la réaction devant les introductions d'agents pathogènes et de l'indemnisation des exploitants pour les pertes subies du fait des programmes d'éradication. L'efficacité des programmes de contrôle aux frontières et de préparation nationale aux situations d'urgence dépend de la collaboration des autorités et des entreprises dans une action exhaustive, disposant d'un financement suffisant et évaluée selon des critères mesurables, dont les coûts incombent aux personnes responsables sous la forme de « redevances d'utilisation », et non à la collectivité sous la forme d'impôts. L'indemnisation des propriétaires pour les animaux abattus pendant la lutte contre le foyer devrait être couverte par une assurance privée. Le coût de la prévention des maladies animales transfrontalières devrait être supporté principalement par ceux qui franchissent les frontières ou importent des animaux ou des marchandises susceptibles de transporter ces infections. Le gouvernement et les entreprises devraient partager les coûts des systèmes de surveillance, de diagnostic et d'intervention. Le système de surveillance doit arriver à saisir, en temps réel ou presque, la situation de la maladie à toutes ses étapes et dans tous les lieux, et il doit être accessible par internet aux divers organismes publics et parties prenantes dans le pays et à l'étranger. Les réactions traditionnelles – quarantaines généralisées, abattage massif et incinération ou enfouissement de millions de carcasses – et les embargos qui ne sont plus justifiés scientifiquement doivent être abandonnés parce qu'ils encouragent le terrorisme. Ce sont les moyens que nous avons choisis dans le passé pour réagir aux maladies transfrontalières qui permettront aux terroristes de nous menacer dans l'avenir. Il faut moderniser les processus réglementaires d'approbation pour suivre les progrès de la technologie. Dans le même ordre d'idées, les pays développés doivent fournir les outils, les technologies et l'infrastructure qui permettront aux pays en développement d'éliminer les maladies. L'implication du secteur privé doit être accrue pour combler les lacunes des programmes publics, assurer l'apport de technologies et éliminer la maladie au niveau du village.

Communication avec le public

Il faut espérer que l'on prêtera suffisamment attention à l'élaboration de stratégies de communication avec les partenaires à tous les niveaux du gouvernement, étant donné que la communication sur les risques peut faire pencher la balance du côté de la paix civile ou de la panique généralisée. Dans l'incertitude, les gens ordinaires peuvent renoncer à leurs projets de voyage et annuler leurs commandes de biens durables et cela peut affecter gravement l'industrie et le commerce s'ils tiennent serrés les cordons de leur bourse parce qu'ils ont peur de l'infection. Ici encore, étant donné le peu de fonds qui sont consacrés à ces efforts, la communication sur les risques peut ne pas être considérée comme hautement prioritaire. C'est regrettable, parce que cette communication exige une planification, le choix d'une stratégie – et pour tout dire une expérience pratique – pour fonctionner efficacement. On constate avec un certain scepticisme que les risques, comme dans les cas actuels d'influenza aviaire hautement pathogène due au virus H5N1, sont exagérés par les personnes qui sont susceptibles de bénéficier des financements supplémentaires. « À l'heure actuelle il y a trop de

voix qui rivalisent pour se faire entendre dans les médias et adresser au public le message d'une catastrophe pandémique imminente. Les gens ordinaires ont déjà peur de l'influenza aviaire. Il faut donc d'urgence s'efforcer d'apaiser leurs craintes actuelles et les convaincre que ceux qui sont chargés de les protéger font tout ce qu'ils peuvent » (L.M. Kelley, dans un article paru dans *Health Policy Outlook*, novembre-décembre 2005). La diffusion rapide et transparente d'informations sur les risques qui soient claires, exactes, fondées sur la science et adaptées à la culture locale peut renforcer la confiance de la population. En effet, l'opinion publique est souvent beaucoup plus raisonnable que les gouvernements veulent bien l'admettre, surtout quand elle est bien informée.

Les vingt années à venir

Quand on envisage la situation optimale pour l'avenir il est prudent de prêter attention aux tendances actuelles, tout en gardant l'esprit ouvert aux possibilités qui s'offrent et à la dynamique d'une évolution non linéaire. Il faut gérer l'incertitude et non essayer de l'éliminer. Cela implique qu'il faut attacher plus d'importance à des approches solides, amples et holistiques de la santé animale et de la santé publique au lieu de se focaliser sur la menace (ou la maladie) du jour. Les organisations concernées par la médecine vétérinaire et la santé publique, y compris la FAO, l'OIE et l'OMS, devraient incorporer à leurs structures et leurs activités une meilleure compréhension écologique des agents pathogènes et des hôtes, des seuils de déclenchement environnementaux, la modélisation et l'intégration de ces déséquilibres, afin de prendre des mesures de contrôle et d'atténuation plus appropriées. Cette démarche devrait comporter une prise de conscience des risques dus aux espèces invasives non indigènes, ce qui peut inclure les vecteurs et les agents pathogènes exotiques, ainsi que les changements environnementaux provoqués par les espèces invasives qui peuvent modifier l'écologie et par conséquent transformer les schémas épidémiologiques traditionnels. Parmi les domaines qui nécessitent des recherches plus poussées, il faut citer la simulation de la prise de décision par les terroristes et de leur choix de cibles.

Il faut construire des modèles qui combinent l'analyse par arbre de décision et l'épidémiologie afin d'identifier les points critiques de la chaîne alimentaire qui doivent être renforcés pour réduire les risques de situations d'urgence et empêcher qu'elles se transforment en désastres. Toutefois, les modèles de ce type ne sont pas susceptibles de donner une réponse unique et durable, en partie parce que le secteur de l'élevage évolue rapidement dans les pays en développement. Étant donné que la menace de terrorisme est incertaine, les modèles de surveillance et d'intervention doivent être flexibles afin de limiter les effets sociaux et économiques des catastrophes biologiques. Comme le risque de maladies transfrontalières peut se propager à partir de pays en développement, il faut construire des relations de travail beaucoup plus étroites avec ces pays, quel que soit leur statut zoosanitaire, si l'on veut contrôler ou éradiquer ces maladies. Les Services vétérinaires doivent être renforcés, et il en va de même pour les services responsables de la santé humaine.

Cela peut sembler étrange, mais un facteur qui freine la formation des vétérinaires est l'engorgement des écoles vétérinaires dans beaucoup de pays. Pour cette raison, les étudiants ne se trouvent pas dans un climat optimal pour se former à cette profession en profondeur ou pour la pratiquer en recevant une juste rémunération de leurs services. On comprend facilement que cette situation a des conséquences négatives pour la qualité de la profession dans ces pays. En même temps, il existe un besoin, souvent non satisfait, d'enseignement et

de formation de biologistes, microbiologistes, spécialistes de génétique moléculaire et autres spécialistes du génie génétique. Ils devraient recevoir une formation aux pratiques de base des laboratoires qui fixerait un code de conduite exigeant pour la manipulation des agents, les procédures de laboratoire, la documentation et la notification. En outre, il faudrait mettre en place des systèmes pour que ces spécialistes soient intégrés dans la planification des interventions à l'échelle nationale et internationale. L'initiation aux bonnes pratiques de laboratoire dès le début d'un enseignement professionnel a un effet direct sur les niveaux de biosécurité et d'expertise dont on aura besoin dans une situation d'urgence. Il faut instituer des normes nationales et promouvoir les organisations professionnelles. En outre, on devrait créer un système généralisé d'accréditation pour les instituts, écoles et laboratoires qui faciliterait le développement de réseaux plus productifs de collaboration internationale et la synergie en recherche pacifique.

Le commerce des animaux et des produits d'origine animale représente approximativement le sixième des échanges agricoles dans le monde. Ce commerce est tiré par la demande, principalement à cause de la croissance démographique, de l'évolution des économies et de la préférence des consommateurs dans les pays en développement. Les différences de taux de croissance démographique, de croissance économique, d'urbanisation, de viabilité environnementale et de transferts de technologie déterminent les pays qui vont récolter les plus grands bénéfices de cette situation. Ce sont les tendances mondiales de la demande et de l'offre de nourriture, et non le terrorisme, qui détermineront l'avenir de la prestation de services de santé animale et de santé publique.

Pour bénéficier au plus grand nombre de personnes et de pays, il faut que les services de santé animale et de santé publique soutiennent des politiques qui réduisent les disparités croissantes entre pays riches et pauvres, populations urbaines et rurales, hommes et femmes. La croissance économique est essentielle pour surmonter les disparités entre pays et elle repose sur l'intégration des politiques de la santé animale, de la santé publique, de l'emploi et des relations avec l'étranger. Les possibilités de croissance de l'emploi seront les plus nombreuses le long de la chaîne de valeur ajoutée liée à la production alimentaire et elles nécessiteront des investissements importants dans l'éducation fondée sur la science (le risque).

Enfin, la conclusion essentielle est que nous vivons sur une seule planète, où il n'y a qu'une seule santé à protéger : celle des animaux sauvages et domestiques, des êtres humains et de l'environnement. Quand nous nous efforçons de protéger la planète et de préserver la santé animale, nous protégeons du même coup la santé humaine, et vice-versa. Pour réussir dans cette tâche il nous faut partager les connaissances et les ressources, et accroître les interactions entre pays afin d'édifier la confiance nécessaire pour un avenir riche de promesses.

Martin Hugh-Jones
Professeur honoraire
Environmental Studies Department
School of Coast & Environment, Rm 2279
Energy, Coast & Environment Building
Louisiana State University
Baton Rouge, LA 70803-5705
États-Unis d'Amérique

Conclusiones

Desastres biológicos de origen animal
Papel y preparación de los servicios de sanidad animal y salud pública

El riesgo de actos de bioterrorismo

Existe la posibilidad de que se produzca un ataque bioterrorista, aunque no se sabe cuál es la probabilidad de que ello ocurra. Lo que sí cabe dar por seguro es que si llega a haber uno después será imitado y replicado, sobre todo si no exige medios muy sofisticados. Por otra parte, los brotes naturales también existen, y son capaces de propagarse de un país a otro, recorriendo distancias a veces muy grandes. Es necesario trabajar eficazmente para prevenirlos, controlarlos cuando surjan y recuperarse de sus efectos. Si podemos hacer tal cosa con los brotes naturales, no hay motivos para pensar que no podamos hacer frente con eficacia y confianza a un ataque deliberado.

Es importante que la preocupación de un gobierno por eventuales actos terroristas no vaya en detrimento de su capacidad para afrontar y combatir eficaz y efectivamente los desastres naturales y brotes infecciosos. Las prioridades deben responder a la realidad.

La necesidad de mejores servicios de información regional sobre enfermedades y agentes patógenos

Gracias en buena parte a los continuos esfuerzos de la Organización Mundial de Sanidad Animal (OIE), ha habido progresos importantes, a veces hasta un punto increíble, en la notificación de brotes infecciosos por parte de los países, aunque de hecho sigue ocurriendo con demasiada frecuencia que las autoridades nacionales no comuniquen tales episodios de inmediato, o que lo hagan con reticencia y sólo en parte. Los países olvidan que la eficacia y transparencia de las notificaciones ayudan a que los Servicios Veterinarios en cuestión inspiren mayor confianza y gocen de más respeto y credibilidad en el plano internacional. Aunque sería ingenuo pensar que ningún país aprovechará la situación creada por esa información en beneficio de su propio comercio, el respeto de las normas se traduce en una relajación más rápida de las eventuales medidas de protección en cuanto las circunstancias lo permiten. Vivimos en un pequeño planeta, en el cual, como ocurre en las familias, el problema de uno es el problema de todos. El hecho de notificar rápidamente un brote protege a los países contiguos y ayuda a mantener mejores relaciones de vecindad. Ello significa que los países deben contar con medios eficaces de investigación epidemiológica. Hacer afirmaciones tajantes sobre el origen de un brote infeccioso sin contar con sólidas pruebas científicas denota incompetencia y/o confusión burocrática, y en tal caso, ¿cómo confiar en cualquier otra información que emane del país? Análogamente, la OIE y la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO) deben mostrarse menos caballerosas y más enérgicas a la hora de obtener información. Para defendernos de todo nuevo brote y de la propagación transfronteriza de enfermedades, el primer baluarte radica en una información rápida y exacta.

En esta era del análisis molecular es preciso recurrir sistemáticamente a la tipificación genética de los agentes patógenos. Conviene encontrar el modo de que quienes se ocupan de ello dispongan rápidamente de este tipo de información en Internet, pues un cambio menor en una secuencia génica puede ser insignificante a juicio de un laboratorio y sin embargo explicarlo todo para los investigadores de otro país. La información que se ofrezca debe contener datos detallados sobre vacunas vivas y muertas y sobre vacunas comerciales tanto autorizadas como no autorizadas. Convendría seguir de cerca el uso de las vacunas vivas, pues a veces no son del todo inocuas, y sus efectos pueden manifestarse en forma de brotes atípicos en países lejanos, desde luego sin necesidad de visado. También es triste observar que las vacunas muertas parecen inspiradas a veces en la figura de Lázaro, pues de "muertas" sólo tienen el nombre, y en realidad conservan toda su potencia y provocan enfermedades.

En fechas recientes parece haberse extendido en Asia un vasto comercio de carne que discurre por cauces extraoficiales o ilegales, cuando no por la simple vía del contrabando. Estos productos, dado su origen, tienen más probabilidades de contener patógenos, lo que entraña costos elevados que deben asumir otros países. Poco pueden hacer por sí solos los organismos internacionales para influir en tal situación, de la que son responsables sobre todo los gobiernos de los países afectados. Y ello nos devuelve a la cuestión de la transparencia en la notificación de enfermedades: la falta de transparencia no parece inhibir, sino más bien estimular, el comercio clandestino.

Es indispensable, por último, mejorar la formación en epidemiología de los veterinarios oficiales. Si son incompetentes en este terreno, el sistema se viene abajo. Aunque varios países avanzados invierten ahora más energía en realizar análisis moleculares y elaborar modelos matemáticos, la verdad reside en los corrales, y sólo está al alcance de investigadores capaces. La genómica y los modelos podrán ayudarlos, pero nunca substituirlos.

Colaboración y comunicación entre veterinarios y organismos de salud pública

A la hora de afrontar con eficacia los brotes infecciosos siempre se plantea el problema de instituir y mantener una comunicación fluida entre organismos, sobre todo cuando se trata de enfermedades zoonóticas. La aparición de un brote debe encontrar ya a los organismos de salud pública y veterinaria dialogando y trabajando conjuntamente, pues si esperan a que se declare una emergencia sus esfuerzos por comunicarse y colaborar resultarán a menudo insuficientes y tardíos. Aunque este tipo de colaboración pueda parecer a veces contranatura, el Departamento de Agricultura y el Servicio Forestal de los Estados Unidos consiguen gran rentabilidad y eficacia trabajando de modo sinérgico para hacer frente a brotes infecciosos de importancia. El Departamento de Medio Ambiente, Alimentación y Asuntos Rurales del Reino Unido ha descubierto que el ejército puede satisfacer este mismo tipo de necesidad organizándose eficazmente para eliminar a los animales muertos. La colaboración se hace colaborando, no filosofando al respecto, pues parte del éxito proviene del conocimiento mutuo, tanto institucional como personal, entre las partes. Cuanto más extensa sea una epidemia mayor será el número de organismos que intervengan, por lo que es preciso definir claramente el orden de precedencia, los mecanismos de colaboración y la cadena de mando antes de que el vértigo de los acontecimientos siembre la confusión y retrase posibles soluciones.

Una colaboración regional más eficaz

En los últimos años, y gracias al síndrome respiratorio agudo severo (SRAS) y a la influenza aviar, hemos visto (con satisfacción) cómo mejoraban y se intensificaban sustancialmente la colaboración y coordinación internacionales y entre organismos. Ello se ha traducido en un endurecimiento del deber de notificar enfermedades humanas según el nuevo Reglamento Sanitario Internacional de la Organización Mundial de la Salud (OMS), aprobado por unanimidad por la Asamblea Mundial de la Salud en mayo de 2005. El Reglamento revisado, que en principio entrará en vigor en junio de 2007, impone a los países un mayor conjunto de obligaciones a la hora de dotarse de medios de acción para adoptar medidas preventivas sistemáticas y de detectar emergencias de salud pública de importancia internacional y responder a ellas. El anterior Reglamento sólo obligaba a los Estados Miembros de la OMS a notificar los casos de cólera, peste y fiebre amarilla. Ahora deben comunicar cualquier episodio que pueda dar lugar a una emergencia de salud pública de importancia internacional. Asimismo, deben dotarse de los medios necesarios para tener la seguridad de que pueden cumplir esa obligación (laboratorios y personal capaces de diagnosticar brotes infecciosos). Los países, además, deben informar de cualquier riesgo de salud pública del que tengan conocimiento, aun cuando surja fuera de su territorio. Ello significa que si el ejército de un país extranjero o un laboratorio de referencia internacional detectaran casos de enfermedad, tendrían el deber de comunicar directamente los hechos a la organización internacional competente (OMS, OIE, FAO), sin dejar la decisión en manos del gobierno del país en cuestión (anfitrión).

Paralelamente, la OIE y la FAO han puesto en marcha una iniciativa, el "Marco mundial para el control progresivo de las enfermedades animales transfronterizas" (GF-TADs), de la que será parte integrante el Sistema mundial de alerta rápida (elaborado conjuntamente con la OMS), que servirá para garantizar el intercambio de información sobre sanidad animal y enfermedades humanas zoonóticas entre las tres organizaciones. A la OIE incumbirá en ese contexto la función de verificación. El GF-TADs constituye un buen punto de partida para mejorar la información epidemiológica y ambiental, las redes de diagnóstico, el análisis de tendencias y las actuaciones contra las enfermedades epizoóticas importantes. Al mismo tiempo, se utilizarán activamente las normas de la OIE para armonizar los textos legislativos sobre control y prevención de enfermedades animales. Para manejar de forma segura agentes biológicos se recomienda aplicar las directrices de la OIE sobre bioseguridad en laboratorio. Se aconseja vivamente a los Estados Miembros de la OIE y la FAO que observen las directrices, normas y recomendaciones de la OIE en materia de vigilancia y pronta notificación de enfermedades del ganado y la fauna salvaje y cumplan los principios enunciados en el "Sistema de prevención de emergencias para enfermedades de animales y plantas" de la FAO. Sin embargo, de nada sirve todo ello si los Países Miembros no logran mejorar la calidad y eficacia de sus Servicios Veterinarios de acuerdo con las normas de la OIE para garantizar una correcta labor de control, vigilancia y alerta y detección rápidas.

Modelos matemáticos

Los modelos matemáticos tienen su utilidad a la hora de entender y afrontar las epidemias. La experiencia británica, sin embargo, demostró (a un elevado precio) que nunca hay que confiar ciegamente en ellos a la hora de dirigir el proceso. Por bien concebidos que estén, los modelos

son estériles y peligrosos a falta de validación, y ésta debe ser fruto de un proceso continuo, incluso en los momentos álgidos de una epidemia, y no de una labor universitaria retrospectiva. Es importante recalcar que los modelos matemáticos generan, en el mejor de los casos, teorías, y más frecuentemente hipótesis, pero no hechos probados. Como ocurre con todas las demás teorías, antes de aceptar la exactitud de un modelo es preciso contrastarlo con el mundo real. No se trata en modo alguno de desmerecerlos, pues a veces, en situaciones complicadas, los modelos son la mejor forma de encontrar el buen camino entre una jungla de alternativas. Además, en el caso de episodios singulares, quizá ofrezcan el único medio de calcular probabilidades. Pero a la hora de extraer conclusiones de un modelo no cabe olvidar el sentido común ni las lecciones de la experiencia.

Un único libreto

Actualmente ya no hay necesidad de documentación impresa excepto con fines forenses o jurídicos. Ahora es posible utilizar aparatos electrónicos manuales conectados a sitios Web para obtener datos (incluidas coordenadas geográficas exactas), filtrar posibles errores y cargar la información en bases de datos centrales en menos tiempo del necesario para leer esta frase. Asimismo, también se pueden configurar aparatos de laboratorio capaces de analizar un gran número de muestras para que incorporen automáticamente los resultados de las pruebas a dichas bases de datos sin errores de transcripción. Cabe ofrecer libre consulta de esos datos a cuantos usuarios dispongan de un acceso seguro, restringiendo al mismo tiempo la posibilidad de introducir y editar información. El hecho de que todos los usuarios dispongan de los mismos datos (procedentes de una fuente común) reduce errores y retrasos, en la medida en que actúan basándose en idéntica información, o dicho de otro modo: todos ellos utilizan el mismo libreto. Evidentemente, para que ello sea posible deben existir mecanismos fiables que garanticen la seguridad y confidencialidad de los datos.

Confirmación de laboratorio

La realización de pruebas inmediatas sobre el terreno y el análisis de muestras a distancia son posibilidades que ya existen y se están validando. Sólo es cuestión de tiempo que se conviertan en moneda corriente y lleguen a ser incluso más fiables y baratas. Resultan especialmente importantes en las primeras fases de un brote o epidemia, sobre todo cuando convenga controlar sin tardanza los movimientos de animales y poner en marcha sistemas de rastreo. Pero todavía es necesaria, y seguirá siéndolo en un futuro inmediato, la confirmación de laboratorio. El adecuado punto de equilibrio entre estos dos procedimientos (análisis sobre el terreno y confirmación de laboratorio) vendrá dado por la experiencia. Cabe señalar, sin embargo, que las pruebas sobre el terreno se aplican a un escaso número de animales sospechosos y sólo en los casos en que un resultado positivo tenga elevado valor predictivo. Cuando haya indicios de que el episodio en cuestión pueda tener causas no naturales, conviene enviar sin demora a un equipo forense especial para que empiece a investigar paralelamente sin demora. La validación de las decisiones dependerá del procesamiento de un número significativo de muestras sanguíneas de rebaños y bandadas y de muestras del posible agente patógeno. Para ello los laboratorios de apoyo deben ser capaces de responder a puntas de trabajo, aplicando pruebas validadas y sujetas a controles de calidad transparentes y evidentes y una política de archivos que permita estudiar sobre la marcha o *a posteriori* una situación determinada. Es preciso encontrar la forma de hacer de las

técnicas de identificación genómica, importantes en las primeras etapas para determinar posibles fuentes de infección, un procedimiento normal, rápido y sistemático. Dichas técnicas también son necesarias para vigilar la epidemia y mantener controles eficaces, lo que significa, en la medida de lo posible, desplazarlas desde el laboratorio de confirmación hasta la primera línea de batalla, esto es, el laboratorio de apoyo sobre el terreno.

Gestión de los rebaños

Todos los colectivos afectados, grandes y pequeños, deben participar en las labores de control zoosanitario. Hay que esforzarse por pedirles aportaciones y tenerlos informados antes de que se produzcan los episodios. Si carecen de información es menos probable que apoyen las acciones de la administración, sobre todo cuando se hayan obviado o desatendido sus dudas, ya se deban éstas a la ignorancia o al desacuerdo. La implicación y participación transparente de esos interlocutores, por fatigoso que ello pueda resultar a los partidarios de los métodos clásicos, da buenos resultados, especialmente al abordar temas como las estrategias y políticas de sacrificios, vacunaciones y medidas post-vacunación.

La participación de las partes afectadas debe plasmarse, entre otras cosas, en su colaboración para instaurar sistemas de identificación de animales y explotaciones. Los recelos de los propietarios pueden ir desapareciendo a medida que tomen conciencia de las ventajas que de ahí se siguen, tanto más cuanto que ello se traduce en plazos más cortos para actualizar la información. Los sistemas deben estar por consiguiente sometidos a un proceso continuo de revisión y perfeccionamiento.

Equipos de epidemiología

Cuando se produce un brote infeccioso de importancia, lo primero que hay que hacer, tras suspender todo desplazamiento de ganado, es confirmar el diagnóstico inicial. Hecho esto, la primacía corresponde a la gestión de la lucha, y un equipo de epidemiología debe trabajar sobre el terreno para remontar la pista que lleve del caso índice al caso primario, que puede haberse producido un tiempo antes, y a partir de ahí desentrañar el modo en que puede haberse generado el brote y localizar su origen. Esto no es un secreto para nadie. Ahí estriba la responsabilidad primordial del equipo A de epidemiología, y para lograr buenos resultados se precisa una formación adecuada. Pero además, mientras la lucha contra la epidemia sigue su curso, el mismo equipo debe ocuparse de vigilar los procedimientos de control. ¿Avanza éste al ritmo previsto? Si surgen nuevos casos, ¿por qué ocurre tal cosa? Cualquier hipótesis debe ser puesta en tela de juicio y sometida a prueba. Aunque creamos hacerlo, la realidad es que demasiado a menudo aceptamos respuestas útiles y convenientes sin cuestionarlas porque no disponemos del tiempo, los fondos y el apoyo oficial necesarios.

Cuando surge una epidemia de grandes dimensiones, es importante establecer un segundo equipo 'B' de epidemiología y dotarlo de los medios necesarios para que durante la epidemia se ocupe de reunir (lo que a veces significa rescatar) y almacenar muestras, datos e información que luego permitan analizar sosegada y retrospectivamente lo que funcionó bien y mal, y determinar el proceder idóneo para una próxima vez. No se trata de buscar culpables. En el fragor de la batalla hay que tomar decisiones, algunas de las cuales son buenas y otras quizá hayan de lamentarse posteriormente. Sólo quienes ya han pasado por ello saben hasta qué punto tal situación puede

ser angustiosa. Pero si deseamos aprender cómo hacer mejor las cosas, cómo se hubiera podido reducir el costo de una epidemia, es preciso disponer de datos y muestras para responder a tales interrogantes y buscar con honestidad posibilidades alternativas.

Costos comunes, responsabilidades comunes, beneficios comunes

Se necesita una nueva política para cambiar la arraigada mentalidad según la cual el gobierno es responsable único de erradicar enfermedades, responder a la introducción de patógenos e indemnizar a los ganaderos por las pérdidas que hayan sufrido a resultas de programas de erradicación. El control eficaz de las fronteras y los programas nacionales de preparación dependen de que el gobierno y la industria trabajen conjuntamente en un proceso amplio, dotado con fondos suficientes y referido a objetivos cuantificables, proceso cuyos costos no deben sufragar los contribuyentes con los impuestos sino los responsables a través de "derechos de usuarios". Las indemnizaciones que perciban los ganaderos por los animales sacrificados para luchar contra un brote deben ser cubiertas por aseguradoras privadas. El costo de las medidas para impedir la penetración de enfermedades transfronterizas del ganado debe recaer principalmente en quienes crucen las fronteras del país o importen cualquier tipo de animales o bienes susceptibles de transmitir esas infecciones. El gobierno y la industria deben compartir el costo de la aplicación de un sistema eficaz de vigilancia, diagnóstico y respuesta. El sistema de vigilancia debe servir para conocer en tiempo real o casi real la situación sanitaria en todo momento y lugar, y los diversos organismos y colectivos afectados del país y el extranjero deben tener acceso a él por Internet. Es preciso renunciar a las tradicionales medidas de respuesta (cuarentena generalizada, sacrificios masivos e incineración o inhumación de millones de canales) y a los embargos comerciales científicamente obsoletos, porque alientan el terrorismo. Si los terroristas pueden amenazarnos con enfermedades transfronterizas es sólo gracias a la forma en que hasta ahora hemos tratado de responder a ellas. Es necesario modernizar los procesos de aprobación de reglamentos para incorporar la aparición de nuevas técnicas. En el mismo orden de ideas, los países desarrollados deben proporcionar las herramientas, tecnologías e infraestructuras necesarias para que los países en desarrollo sean capaces de erradicar enfermedades. Para subsanar las carencias de los programas oficiales, transferir tecnología y eliminar enfermedades en las zonas rurales es fundamental una intervención creciente del sector privado.

Comunicación pública

Uno tiene la esperanza de que la elaboración de estrategias de comunicación concertadamente con todos los niveles de la administración reciba la atención que merece, pues de la comunicación relativa a los riesgos puede depender que en la calle se respire sosiego o, por el contrario, cunda el pánico. Los ciudadanos pueden suspender viajes previstos o dejar de adquirir bienes de consumo duraderos. La industria y el comercio se encontrarían en difícil tesitura si la población empezara a abstenerse de gastar por temor a una infección. De nuevo hay que señalar la posibilidad de que, al haber tan pocos fondos dedicados al tema, la comunicación se convierta en el pariente pobre, y ello sería una lástima porque es un proceso cuyo eficaz funcionamiento exige planificación y estrategia (y también, a decir verdad, práctica). Uno asiste con cierto escepticismo a las alarmistas advertencias de quienes podrían recibir fondos complementarios, como ocurre

actualmente con la influenza aviar causada por la cepa virulenta H5N1. "Hay demasiadas voces compitiendo entre sí para gozar de tiempo de antena y transmitir al gran público el agorero mensaje de una inminente pandemia. El ciudadano de a pie tiene miedo de la influenza aviar. Urge tratar de apaciguar sus temores inmediatos y convencerlo de que quienes tienen encomendada su protección están haciendo todo lo posible" (L.M. Kelley, en un reciente artículo de *Health Policy Outlook*, noviembre-diciembre de 2005). La difusión oportuna y transparente de información clara, exacta, científicamente fundada y adaptada a la idiosincrasia cultural de cada sociedad sobre los riesgos de enfermedad y los avances para responder a ellos puede inspirar confianza al gran público. Éste suele ser mucho más sensato de lo que piensan los gobiernos, en especial cuando se le informa con transparencia.

Los próximos veinte años

A la hora de determinar la situación futura que resultaría idónea es prudente prestar atención a las tendencias actuales, sin dejar por ello de tener en cuenta posibilidades más remotas y dinámicas no lineales. Uno debe manejar la incertidumbre, no intentar eliminarla. Y ello exige que se haga mayor hincapié en planteamientos sólidos, generales y holísticos en materia de salud pública y animal en lugar de recurrir a la chapuza de turno para afrontar la amenaza (o enfermedad) "del día". Los círculos internacionales que se dedican a la salud pública y veterinaria, en particular la OIE, la FAO y la OMS, deben integrar en sus estructuras y actividades una mejor comprensión ecológica de los patógenos y sus huéspedes, los factores ambientales desencadenantes de un brote, la elaboración de modelos y la integración de esos desequilibrios para definir medidas más eficaces de lucha y reducción, y ello incluye el conocimiento de los riesgos que planteen especies alóctonas invasivas, ya se trate de patógenos foráneos o de vectores, y de los cambios ecológicos que traen consigo especies invasivas capaces de modificar la ecología y alterar con ello los patrones epidemiológicos tradicionales. Por otro lado, la simulación de los procesos de decisión y selección de objetivos por parte de los terroristas es un ámbito en el que queda aún mucho trabajo por hacer.

Se necesitan modelos que combinen análisis epidemiológico y árboles de decisiones para determinar los puntos críticos de las cadenas alimentarias que conviene reforzar para reducir el riesgo de emergencias e impedir que éstas lleguen a convertirse en desastres. Un modelo semejante, sin embargo, pocas veces ofrecerá una respuesta única y duradera, en parte porque el sector agropecuario de los países en desarrollo cambia con gran rapidez. Dada la incertidumbre que rodea la amenaza del bioterrorismo, es preciso que los modelos de vigilancia y respuesta sean flexibles para reducir al mínimo las consecuencias sociales y económicas de todo desastre biológico. La posibilidad de que una enfermedad transfronteriza salga de un país en desarrollo impone relaciones de trabajo mucho más estrechas con esos países, se conozca o no su situación zoosanitaria, para controlar o erradicar dicho tipo de enfermedades. Para ello hay que reforzar los Servicios Veterinarios y los de salud pública.

Por extraño que parezca, uno de los factores que van en detrimento de la formación veterinaria es la saturación de las facultades en muchos países, pues en tales condiciones resulta difícil aprender el oficio con la profundidad necesaria o ejercerlo a cambio de una retribución adecuada. No cuesta mucho imaginar los efectos negativos que ello tiene sobre la calidad de la profesión en los países afectados. Al mismo tiempo, existe una verdadera necesidad, a menudo insatisfecha, de capacitar a biólogos, microbiólogos, genéticos moleculares y otros profesionales de la bioingeniería, que necesitan una formación en técnicas básicas y buenas prácticas de laboratorio

que les inculque normas estrictas de conducta en cuanto a manipulación de patógenos, protocolos de laboratorio, documentación y notificación de enfermedades. Además, conviene crear sistemas para integrarlos en los procesos nacionales e internacionales de planificación de respuestas. La introducción de buenas prácticas de laboratorio en las primeras etapas de la formación de profesionales guarda estrecha correlación con los niveles observados posteriormente de seguridad y protección biológicas y con la presencia del tipo de especialistas que se necesitan en una emergencia. Conviene instituir normas de ámbito nacional y promover las asociaciones de profesionales. Debería existir además un sistema general de homologación internacional de institutos, facultades y laboratorios, lo que en el plano internacional favorecería una colaboración más estrecha y productiva, redes más eficaces y relaciones de sinergia enmarcadas en investigaciones pacíficas.

El comercio de ganado y productos de origen animal supone aproximadamente una sexta parte del comercio agropecuario mundial. Es una actividad muy dependiente de la demanda, tributaria esencialmente del crecimiento demográfico y económico de los países en desarrollo y de los nuevos hábitos de consumo de sus habitantes. De las distintas tasas de crecimiento demográfico y económico, urbanización, sostenibilidad ambiental y transferencia de tecnología dependerá a la postre cuáles sean sus principales beneficiarios. Serán las tendencias mundiales de la oferta y la demanda de alimentos, y no el terrorismo, las que determinen el rumbo futuro de la prestación de servicios de salud pública y veterinaria.

Para beneficiar al mayor número posible de personas y países, los servicios de salud pública y veterinaria deberían secundar políticas que redujeran las crecientes disparidades que existen entre países ricos y pobres, poblaciones urbanas y rurales, hombres y mujeres. El crecimiento económico es fundamental para superar esos desequilibrios, y la mejor forma de favorecerlo es la integración de las políticas zoosanitaria, de salud pública, laboral y de relaciones exteriores. Las oportunidades de creación de empleo serán inmejorables en los distintos eslabones de la cadena de producción alimentaria con valor añadido, y ello exigirá importantes inversiones en una enseñanza que tenga en cuenta criterios científicos (de riesgo).

Se impone por último una conclusión fundamental: vivimos todos en un solo planeta, y hay una sola salud que proteger, la de la fauna salvaje y doméstica, la de los seres humanos y la del medio ambiente. Cuidando del planeta y de la salud animal también estaremos cuidando de la salud humana, y viceversa. Para tener éxito debemos compartir conocimiento y recursos, además de mejorar las interacciones internacionales a fin de generar la confianza necesaria para un futuro prometedor.

Martin Hugh-Jones
Profesor emérito de estudios ambientales
Environmental Studies Department
School of Coast & Environment, Rm 2279
Energy, Coast & Environment Building
Louisiana State University
Baton Rouge, LA 70803-5705
Estados Unidos de América

Instructions to Authors

Aims and scope of the *Review*

The *Review* is the principal scientific and technical publication of the OIE, fulfilling two of the statutory functions of the Organisation, namely:

– to promote and co-ordinate experimental or other research work concerning contagious diseases of livestock for which international collaboration is deemed desirable

– to publish all facts and documents likely to be of interest to Veterinary Services worldwide.

The *Review* presents information on veterinary activities which may involve international co-operation in the fields of both animal and public health.

Another objective of the *Review* is to inform readers of the activities of OIE Member Countries and of the Organisation in both of the above-mentioned fields.

The *Review* is indexed in the databases *Agris* (FAO, Italy) and *Littérature vétérinaire francophone* (Canada), in the abstract journals *Index Veterinarius* and *Veterinary Bulletin* (CABI databases, United Kingdom), *BIOSIS, Capsule Report, Current Contents*® / *Agriculture, Biology and Environmental Sciences, Fish and Wildlife Worldwide, Focus On*®: *Veterinary Science & Medicine, Index Medicus, MEDLINE* and *SciSearch*® (United States of America), *Zoological Record* (United Kingdom), *Electre* (France) and on the current awareness service *Veterinary journals: table of contents* of the Faculty of Veterinary Medicine of the University of Montreal, Canada.

Content

At least two of the three issues published in each volume are devoted to a specific theme. For these issues, an internationally-renowned expert is designated as co-ordinator, and specialists in the field are invited to contribute papers, thereby providing readers with a comprehensive overview of the topic under discussion.

Issues of the *Review* which are not devoted to a central theme are generally presented in four sections. A significant part of each issue is devoted to comprehensive reviews and original articles. The various sections may be outlined as follows:

Reviews

Reviews offer detailed studies on a specific and topical subject, such as epizootiology, diagnosis, treatment and control of those animal diseases and zoonoses of greatest importance to the international community. Other subjects which may be covered include: the administration of Veterinary Services, legislation, information systems, animal health and economics. Reviews may take the form of one paper written by a single author, or may include a series of articles which present different aspects of a given theme.

Original articles

These may be papers on research or on the diagnosis, control and treatment of animal diseases, and they should be of interest internationally. Original articles may also cover other issues relating to international co-operation between Veterinary Services.

Communications

The subject matter in this section is identical to that of original articles, but communications are shorter in length or discuss a more limited aspect or area. Furthermore, the content need not be original but may review published work.

Reports

These summarise the proceedings of scientific and technical meetings held by the OIE or other organisations.

Conditions for accepting manuscripts

Contributors to the *Review* undertake to submit articles which have not been published elsewhere, either in part or in full, and which do not require prior authorisation for publication by the OIE. In submitting a manuscript, the authors agree for the copyright of their article to be transferred to the OIE if and when the article is accepted for publication. The Editor will, however, consider all requests made by authors for permission to reproduce articles.

Manuscripts may be submitted in any one of the three official languages of the OIE: English, French or Spanish. Authors not writing in their primary language are encouraged to seek professional editorial assistance prior to submitting their manuscript.

The first (or corresponding) author receives immediate notification of receipt of the article which is then submitted for appraisal to the Scientific Advisory Board. The author is subsequently advised of the decision of the Board.

The first author is informed of any stylistic changes made to bring a manuscript into conformity with the standards of the *Review*. Manuscripts are returned to this person for approval of these changes. A response from authors within a week is essential at this stage.

It is the responsibility of the first author to ensure that all co-authors concur with changes made prior to publication.

The Editorial Board reserves the right to publish certain of the articles accepted for publication in all three of the official languages of the OIE.

Presentation of manuscripts

Authors should address an electronic version of the original manuscript to a.souyri@oie.int or send the article on a disc/CD to:

The Editor
Scientific and Technical Review
World Organisation for Animal Health (OIE)
12, rue de Prony
75017 PARIS, France.

Manuscripts should be typed double-spaced with wide margins using A4 paper (29.7 × 21 cm). Word-breaks at the end of a line should be avoided and all pages should be numbered. The various sections should be arranged in the following order:

1. Title, names and addresses of authors
2. Summary and keywords
3. Text
4. Acknowledgements (if applicable)
5. References
6. Tables

7. Legends for figures
8. Figures.

Guidelines are given below for the preparation of manuscripts. For concrete examples, authors are invited to consult a recent issue of the *Review*.

1. Title, names and addresses of authors

The title should be concise (no more than 70 characters) and should not contain abbreviations. Standard terminology should be used in the title to facilitate information retrieval and indexing; for example, 'Epidemiological survey of blackleg in cattle in France' (topic, disease, species, country).
The family names of authors should be preceded by their initials and followed by a superscript bracketed Arabic number. The position and full address of each author should be given below the list of names, as follows:

H. Jones [(1)], M.L. Smith [(2)] & M. Webber [(2)]

(1) Department of Animal Studies, Centre for Environmental Research, 12 Wellbeck Street, London WI 6AB, United Kingdom
(2) Institute of Veterinary Research, 4 Portsmouth Road, Southampton 4GY 6NW, United Kingdom

2. Summary and keywords

It should be remembered that in cases where the entire text is not translated, readers of the other two languages depend heavily on the content of the summary. For this reason it is important that it provides an outline of the entire text, including the principal findings and conclusions. It should be written in the original language and not exceed 150 words. Abbreviations used for the first time should be preceded by the expression in full. Eight to ten keywords should be provided after the summary.

3. Text

Manuscripts should not exceed 4,000 words (14 to 16 typed pages). When an author wishes to submit a paper of greater length, agreement should first be sought from the Editor. Unnecessarily long paragraphs should be avoided. In general, paragraphs should not be longer than 200 words (or 20 lines).
Authors should make every effort to write clearly and concisely. Experimental work and epidemiological studies should be presented using the following standard lay-out: introduction, materials and methods, results, discussion, conclusions and references.
Units of measurement should be expressed using the metric system and, where appropriate, SI units. New diagnostic methods should be described in sufficient detail (e.g. reference standard, nature of the antiserum or antigen, specificity, sensitivity, etc.). Well-known methods, or those already described in an international journal or review, should be mentioned and referenced.
Veterinary drugs, reagents and laboratory materials should be referred to in the text by the generic name (and, only if necessary, the commercial name).
Abbreviations and acronyms should be defined the first time they are used. Footnotes should be incorporated in the main text.
Tables and figures should be mentioned in the text at the place where the author wishes them to be incorporated.

4. Acknowledgements

Acknowledgements may be made to persons who have contributed substantially to the article. Authors are responsible for obtaining permission from the persons acknowledged by name.

5. References

All published documents that are referred to in the text must be included in the reference list. The numbered references should be listed in alphabetical order of authors. In the text, references to the literature should be made by number and enclosed in brackets. For an article on research, it is recommended that the number of references be limited to fifty. For review articles this number may be doubled.

Before submission of the paper, authors are requested to verify the accuracy of all references and to check that all of these have been cited in the text. The names of journals and reviews should be abbreviated unambiguously. If in doubt, the full title should be given. For examples of title abbreviations and the bibliographical format used in the *Review*, authors are advised to consult the reference sections of recent issues.

Unpublished data and personal communications should be referred to in the body of the text and not in the list of references. Authors are required to obtain approval from sources quoted as unpublished data and personal communications before submission of the paper for publication.

Each reference should list the names – followed by the initials – of all authors, the year of publication, full title, journal, volume, issue and page numbers, as shown in the examples below. Please note that papers by the same author should be listed in chronological order (placing works by a single author first, followed by those written with co-authors).

– Article from a journal or review:

Baldock N.M. & Sibly R.M. (1990). - Effects of handling and transportation on heart rate and behaviour in sheep. *Appl. anim. Behav. Sci.*, **28** (1), 15-39.

– Article in press:

Cheek P. (2006). - Factors impacting the acceptance of traceability in the food supply chain in the United States of America. *In* Biological disasters of animal origin: the role and preparedness of veterinary and public health services. *Rev. sci. tech. Off. int. Epiz.* (in press).

– Chapter of a book or conference report (for conference reports please include the name and location of the publisher as well as the dates and location of the Conference):

Read P., Cousins C. & Murray R. (1992). – Assessment of the immunogenicity of different strains of *Bacteroides nodosus*. *In* Proc. 4th Symposium on sheep diseases (P. Morris & G. Roberts, eds), 12-14 February 1991, Paris. Vigier, Paris, 894-897.

– When citing documents which were obtained from the Internet authors are requested to indicate the date on which they consulted these documents. Website addresses, without reference to a specific document or piece of information, cannot be included in the reference section. References to web pages must include a publishing date, so please refer to the 'last update' date that usually appears at the bottom of the screen:

European Union (EU) (2004). – Revision of Directive 86/609/EEC on the protection of animals used for experimental and other scientific purposes. Available at: www.europa.eu.int/comm/environment/ chemicals/lab_animals/revision_en.htm (accessed on 11 April 2005).

– References to electronic versions of paper publications should, where possible, be treated as any other paper publication and include the usual publishing details. In these cases the web address is helpful additional information:

Scientists' Working Group on Biosafety (1998). – Manual for assessing ecological and human health effects of genetically engineered organisms. Part one: introductory text and supporting text for flowcharts. Part two: flowcharts and worksheets. The Edmonds Institute, Edmonds, WA. Available at: www.edmonds-institute.org/manual.html (accessed on 25 April 2005).

6. Tables

Tables should be given titles and assigned Roman numerals. Each table should be typed double-spaced and presented on a separate page at the end of the text. All columns should be headed, with individual values replaced, as far as possible, by mean values and standard deviations. Notes, comments or explanations relating to numerical values should be indicated using superscript letters (e.g. [(a), (b), (c), (d)]) and table footnotes. Abbreviations which are not widely used should be explained. Tables should illustrate, not duplicate, information in the text.

7. Legends for figures

Each figure should be presented at the end of the text with the corresponding legend on a separate page. Titles should be self-explanatory, so that the need to refer back to the text is minimised. The subject, site and date should be given, where possible. This information can be completed by providing units, sources and explanatory notes.

8. Figures

The use of figures to illustrate papers is strongly encouraged. Photographs (digital or traditional), graphs, diagrams, drawings and maps are all considered as figures. They should be numbered using Arabic numerals in the order in which they are cited in the text. Digital photographs should be sent in one of the following formats: .jpg, .tiff or .eps. They should be between 455 and 2055 pixels wide (8.35 cm - 17.4 cm) and have a resolution of no less than 250 pixels per inch (dpi). Traditional photographs, including photographs of original documents, can also be accepted, but should be no bigger than 8 cm $\times$ 10 cm (the number of the figure and the name of the first author should be written in pencil on the back of each photograph, with an arrow indicating the top). Graphs can only be accepted if submitted as an Excel® or Powerpoint® document (giving the data used to create the figures as well as the figure itself). Diagrams, drawings and maps should ideally be submitted in a format which allows for the figures to be edited, i.e. .eps, .ai (Illustrator®) or .fr (Freehand®). Figures that cannot be edited can still be accepted, but only if the resolution is the same quality as that of a digital photograph, i.e. 250 dpi.

Reprints

Fifty reprints are sent, free of charge, to the first author of the paper. Orders for additional reprints should be addressed to the Editor once the article has been accepted for publication.
All authors and co-authors receive a complimentary copy of the issue in which their paper is published.

Instructions aux auteurs

Objectifs de la *Revue*

La *Revue* est la principale publication scientifique et technique de l'OIE; elle est un des moyens dont dispose l'Organisation pour s'acquitter de deux de ses fonctions statutaires, à savoir :

– promouvoir et coordonner toutes recherches ou expériences concernant les maladies infectieuses du bétail pour lesquelles il y a lieu de faire appel à la collaboration internationale ;

– porter à la connaissance des Services vétérinaires du monde entier tous les faits et documents susceptibles de les intéresser.

La *Revue* diffuse des informations relatives aux activités vétérinaires pouvant impliquer une coopération internationale en matière de santé animale, mais aussi de santé publique.

Ella a également pour objet de faire connaître à ses lecteurs les actions conduites par l'Organisation et ses Pays Membres dans ces deux domaines.

La *Revue* est indexée dans les bases de données *Agris* (FAO, Italie) et *Littérature vétérinaire francophone* (Canada), dans les bulletins signalétiques *Index Veterinarius* et *Veterinary Bulletin* (bases de données du CABI, Royaume-Uni), dans *Biosis, Capsule Report, Current Contents® / Agriculture, Biology and Environmental Sciences, Fish and Wildlife Worldwide, Focus On®: Veterinary Science & Medicine, Index Medicus, Medline*, et *SciSearch®* (États-Unis d'Amérique), dans *Zoological Record* (Royaume-Uni), ainsi que dans *Électre* (France) et sur le service d'alerte *Veterinary journals: table of contents* de la Faculté de médecine vétérinaire de l'Université de Montréal, Canada.

Contenu

Chaque volume comporte au moins deux numéros spéciaux consacrés à un thème particulier. Ces numéros sont préparés sous la responsabilité d'un auteur de renom international auquel des spécialistes du domaine considéré sont invités à soumettre des contributions afin de proposer aux lecteurs un ensemble des textes couvrant les différents aspects du sujet traité.

Les numéros de la *Revue* qui ne sont pas thématiques comportent généralement quatre rubriques. Une place importante est consacrée dans chaque numéro aux synthèses et aux articles originaux. Les différentes rubriques sont brièvement décrites ci-après.

Synthèses

Les synthèses présentent des mises au point détaillées sur un thème spécifique d'actualité, par exemple l'épizootiologie, le diagnostic, le traitement et la prophylaxie des maladies animales les plus importantes pour la communauté internationale, y compris les zoonoses. Les synthèses peuvent aussi traiter de sujets tels que l'administration des Services vétérinaires, la législation, les systèmes d'information, l'économie de la santé animale. Leur forme peut être celle d'un article rédigé par un seul auteur, ou d'une série d'articles présentant les différents aspects du thème traité.

Articles originaux

Ces articles peuvent être des rapports de recherches, des comptes rendus d'expériences dans le domaine du diagnostic, de la prophylaxie et du traitement des maladies animales. Ces travaux doivent présenter un intérêt international. Les articles originaux peuvent traiter de tout autre sujet en rapport avec la coopération internationale des Services vétérinaires.

Communications

Les thèmes traités sous cette rubrique sont identiques à ceux des articles originaux, mais les communications sont de longueur moindre ou sont consacrées à un aspect plus limité de ces sujets. Par ailleurs, leur contenu peut ne pas être original mais se référer à des travaux publiés.

Rapports

Il s'agit de brefs comptes rendus de réunions scientifiques et techniques de l'OIE ou d'autres organisations.

Conditions d'acceptation des manuscrits

Les auteurs s'engagent à soumettre à la *Revue* des articles qui n'ont pas été publiés ailleurs, en partie ou en totalité, et dont la publication par l'OIE ne nécessite pas une autorisation préalable. En soumettant leur manuscrit, les auteurs acceptent que le copyright de leur article soit transféré à l'OIE lorsqu'il est accepté pour publication. Cependant, la Rédaction prend en considération toute demande des auteurs pour une éventuelle reproduction de leur article.

Les manuscrits peuvent être rédigés dans l'une des trois langues officielles de l'OIE: français, anglais ou espagnol. Les auteurs ne rédigeant pas dans leur langue maternelle sont invités à faire relire leur manuscrit par un réviseur professionnel avant de l'adresser à l'OIE.

Un accusé de réception est adressé au premier auteur (ou à l'auteur chargé de la correspondance avec l'OIE), dès l'arrivée de son manuscrit. Celui-ci est ensuite soumis à l'appréciation d'experts du Comité de lecture de la *Revue*, dont l'avis sera communiqué à l'auteur.

Le premier auteur (ou l'auteur chargé de la correspondance avec l'OIE) est consulté au sujet de toute modification stylistique proposée par souci de conformité aux normes de la *Revue*. Les manuscrits lui sont retournés pour approbation des modifications éventuelles. Il est essentiel à cette étape que les auteurs adressent leur réponse dans la semaine qui suit.

Le premier auteur (ou l'auteur chargé de la correspondance avec l'OIE) est prié d'informer les autres auteurs des modifications apportées au texte avant la publication de celui-ci.

Le Comité de rédaction se réserve le droit de faire paraître dans les trois langues officielles de l'OIE certains articles acceptés pour publication.

Présentation des manuscrits

Les auteurs doivent adresser une version électronique du manuscript original à l'addresse email a.souyri@oie.int ou sur disquette/CD à :

Le Rédacteur en chef
Revue scientifique et technique
Organisation mondiale de la santé animale (OIE)
12, rue de Prony
75017 PARIS, France.

Les manuscrits doivent être dactylographiés en double interligne, avec de larges marges, sur du papier de format A4 (21 × 29,7 cm). Les césures de mots en fin de ligne doivent être évitées. Chaque page doit être numérotée et les éléments disposés dans l'ordre suivant:

1. Titre, noms et adresses des auteurs
2. Résumé et mots-clés
3. Texte
4. Remerciements (s'il y a lieu)

5. Bibliographie
6. Tableaux
7. Légendes des figures
8. Figures.

Les auteurs trouveront ci-après des instructions pour la préparation de leurs manuscrits. La consultation d'un numéro récent de la *Revue* leur fournira des exemples concrets.

1. Titre, noms et adresses des auteurs

Le titre de l'article doit être concis et ne pas dépasser 70 caractères. Il ne doit pas contenir d'abréviations. Pour faciliter la recherche de l'information et l'indexation, il convient d'utiliser dans le titre la terminologie courante. Exemple : « Enquête épidémiologique sur le charbon symptomatique chez les bovins en France » (sujet, maladie, espèce, pays).
Les noms des auteurs seront précédés des initiales de leurs prénoms. La situation et l'adresse complète des auteurs seront indiquées dans l'ordre, à la suite des noms d'auteurs et en utilisant des numéros, comme suit :

J.-P. Dupont [(1)], R.L. Calvey [(2)] & M. Sansom [(2)]

(1) Laboratoire d'immunopathologie, Centre national de recherches vétérinaires, B.P. 495, 36120 Basse-Ville, France
(2) Institut supérieur de recherches en immunologie, 14, rue de Paris, 98150 Froment Cedex, France

2. Résumé et mots-clés

Le résumé, rédigé dans la langue originale, ne doit pas dépasser 150 mots. Il présentera la méthodologie, les principaux résultats et les conclusions de l'étude. Dans certains cas, seul le résumé est traduit dans d'autres langues ; pour les lecteurs qui n'ont pas accès au texte intégral, le résumé doit donc refléter l'essentiel du contenu de l'article. Les abréviations seront précédées de leur expression en toutes lettres lors de leur première citation. Le résumé sera suivi de huit à dix mots-clés.

3. Texte

La longueur d'un manuscrit ne doit pas dépasser 4 000 mots (14 à 16 pages dactylographiées). Les auteurs souhaitant publier un article plus long doivent obtenir l'accord préalable de la Rédaction. Dans la mesure du possible, les paragraphes comporteront, au plus, une vingtaine de lignes (200 mots environ). Les auteurs rechercheront avant tout dans leur rédaction la clarté et la concision. Les travaux expérimentaux et les enquêtes épidémiologiques seront présentés selon le plan standard suivant : introduction, matériels et méthodes, résultats, discussion, conclusions, bibliographie.

Les unités de mesure seront exprimées en utilisant le système métrique et, si nécessaire, les unités SI. Les nouvelles méthodes de diagnostic seront décrites avec des détails suffisants (par exemple : standard de référence, nature de l'antisérum ou de l'antigène, spécificité, sensibilité, etc.). Les méthodes connues ou déjà décrites dans un journal ou une revue d'audience internationale seront simplement mentionnées avec leurs références.

Les médicaments vétérinaires, réactifs et matériels de laboratoire seront désignés dans le texte par leur nom générique (et, éventuellement, leur nom commercial).

Les abréviations et les acronymes seront définis lors de leur première citation. Le texte ne doit pas comporter de notes infra-paginales. Les précisions souhaitées peuvent être incorporées dans le texte.

Les tableaux et les figures seront mentionnés dans le texte à l'emplacement souhaité par l'auteur pour leur insertion.

4. Remerciements

Les auteurs peuvent adresser des remerciements aux personnes ayant apporté une contribution substantielle à l'article. Il incombe aux auteurs d'obtenir des personnes dont ils citent le nom l'autorisation de le faire.

5. Bibliographie

Toutes les références bibliographiques citées dans le texte doivent figurer dans cette section. Dans la bibliographie, les références seront classées dans l'ordre alphabétique des auteurs et numérotées dans cet ordre. Les références bibliographiques citées dans le texte doivent être signalées par un numéro entre parenthèses. Pour un article de recherche, il est recommandé de limiter à 50 le nombre des références ; ce nombre pourra être doublé pour un article de synthèse.

Avant de soumettre leur article, les auteurs sont priés de contrôler l'exactitude de toutes les références et de vérifier que toutes sont citées dans le texte. Les noms des journaux et revues seront abrégés sans ambiguïté. En cas d'équivoque possible, ils seront retranscrits intégralement. Des exemples de titres abrégés et de présentation des références selon les normes de la *Revue* peuvent être trouvés dans les bibliographies de numéros récents.

Les données non publiées et les communications personnelles seront citées dans le corps du texte et non dans la bibliographie. Avant de soumettre leur article, les auteurs sont priés d'obtenir auprès des personnes ou organismes concernés l'autorisation de citer les sources non publiées ou les communications personnelles.

Chaque référence doit indiquer les noms suivis des initiales de tous les auteurs, l'année de publication, le titre complet, le nom du périodique, le volume, le numéro et les pages, conformément aux exemples ci-après. Les articles d'un même auteur doivent être énumérés par ordre chronologique, en commençant par les références signées par l'auteur seul (sans co-auteur).

– Article de journal ou de revue :

Duval B., Martin L., Roussel V. & Clément P. (1982). – Étude de la persistance des anticorps aphteux chez les veaux issus de mères vaccinées. *Rev. sci. tech. Off. int. Epiz.*, **1** (2), 875-892.

– Article sous presse :

Duval B., Martin L. & Roussel V. (2006). – Étude de la production d'anticorps aphteux chez des bovins carencés en protéine. *Rev. sci. tech. Off. int. Epiz.* (sous presse).

– Chapitre de livre ou rapport de conférence (pour les actes de conférence, il convient d'indiquer également l'éditeur et le lieu de publication, ainsi que le lieu et les dates de la conférence) :

Raimond P., Cousin C. & Mouthon R. (1992). – Évaluation du pouvoir immunogène de diverses souches de *Bacteroides nodosus*. *In* Comptes rendus du 4e Symposium sur les maladies ovines (P. Morice & P. Raimond, édit.) Paris, 12-14 février 1991. Vigier, Paris, 894-897.

– Les références à des documents disponibles sur Internet doivent comporter la mention de la date à laquelle ces documents ont été consultés. Le renvoi à la page d'accueil d'un site Internet sans mention d'un document particulier ne peut être considéré comme une référence bibliographique. Lorsqu'une page web présente une information non datée, l'année de publication sera celle de la dernière mise à jour figurant en bas de la page web:

Union européenne (UE) (2004). – Revision of Directive 86/609/EEC on the protection of animals used for experimental and other scientific purposes. Page web : www.europa.eu.int/comm/environment/chemicals/ lab_animals/revision_en.htm, (consulté le 25 avril 2005).

– Lorsqu'un document existe en version électronique et en version papier, il convient de fournir les données bibliographiques complètes de la version papier, en ajoutant, à titre indicatif, la voie d'accès à la version électronique:

Scientists' Working Group on Biosafety (1998). – Manual for assessing ecological and human health effects of genetically engineered organisms. Part one: introductory text and supporting text for flowcharts. Part two: flowcharts and worksheets. The Edmonds Institute, Edmonds, WA. (Page web: www.edmonds-institute.org/manual.html, consulté le 25 avril 2005).

6. Tableaux

Chaque tableau doit porter un titre et être numéroté avec un chiffre romain. Les tableaux seront dactylographiés en double interligne et présentés sur des pages séparées à la fin du texte. Chaque colonne sera désignée par un intitulé. Les valeurs individuelles seront autant que possible remplacées par leurs moyennes et leurs écarts types. Les notes, commentaires ou précisions sur les données numériques seront annoncés par de petites lettres en exposant (par exemple : [(a), (b), (c), (d)]) et leur texte donné en note sous le tableau. Les abréviations d'usage peu courant seront explicitées. Les tableaux doivent illustrer les informations contenues dans le texte et non faire double emploi avec celles-ci.

7. Légendes des figures

Chaque figure doit être présentée à la fin du texte, avec la légende correspondante sur une page séparée. Le titre doit être suffisamment explicite pour éviter au lecteur de se reporter au texte. L'objet, le lieu et la date seront mentionnés si possible. Ces informations peuvent être complétées par l'indication des unités de mesures et des sources et par des notes explicatives.

8. Figures

Les auteurs sont vivement encouragés à proposer des figures pour illustrer leur article. Les photographies, diagrammes, graphiques, schémas et cartes géographiques sont considérés comme des figures. Les figures seront numérotées en chiffres arabes dans l'ordre de leur citation dans le texte. La Rédaction accepte pour publication les figures réalisées en formats Excel® et Microsoft® PowerPoint et comportant les données numériques pertinentes.
Les diagrammes, les cartes et les dessins devront être enregistrés dans des formats acceptant les retouches : par exemple, fichiers .eps, .ai (Illustrator®) ou .fr (Freehand®). Sont également acceptés tous documents numériques de qualité photographique. Les photographies numériques devront être enregistrées sous un format .jpg, .tiff ou .eps., largeur 455 - 2055 pixels (soit 8,35 cm - 17,4 cm), résolution minimale 250 dpi (pixels par pouce). Les photographies traditionnelles et reproductions photographiques de documents originaux, au format maximum de 8 × 10 cm, sont également acceptées et devront porter au dos, écrits au crayon, leur numéro, le nom du premier auteur et une flèche indiquant le haut de la figure.

Tirés-à-part

Cinquante tirés-à-part seront envoyés gratuitement au premier auteur de l'article. Les commandes de tirés-à-part supplémentaires doivent être adressées à la Rédaction après acceptation de l'article.
Les auteurs et co-auteurs recevront chacun un exemplaire du numéro de la *Revue* où est parue leur contribution.

Instrucciones para los Autores

Objetivos de la *Revista*

La *Revista*, principal publicación científica y técnica de la OIE, cumple con dos de las funciones fijadas por sus Estatutos, a saber:

– promover y coordinar investigaciones y experiencias acerca de enfermedades infecciosas del ganado para las que cabe llamar a la colaboración internacional, y

– poner en conocimiento de los Servicios Veterinarios del mundo entero todos los hechos o textos y documentos que pudieran interesarles.

La *Revista* difunde informaciones relacionadas con las actividades veterinarias que pueden implicar una cooperación internacional tanto en materia de sanidad animal como de salud pública.

Otro de sus objetivos es dar a conocer a sus lectores las actividades de la OIE y de sus Países miembros en estos dos ámbitos.

La *Revista* está repertoriada en las bases de datos *Agris* (FAO, Italia) y *Littérature vétérinaire francophone* (Canadá), las fichas descriptivas *Index Veterinarius* y *Veterinary Bulletin* (bases de datos del CABI, Reino Unido), en *Biosis, Capsule Report, Current Contents® / Agriculture, Biology and Environmental Sciences, Fish and Wildlife Worldwide, Focus On®: Veterinary Science & Medicine, Index Medicus, Medline* y *SciSearch®* (Estados Unidos de América), en *Zoological Record* (Reino Unido), en *Electre* (Francia) y en el servicio de alerta *Veterinary journals: table of contents* de la Facultad de Veterinaria de la Universidad de Montreal, Canadá.

Contenido

Cada volumen de la *Revista* incluye como mínimo dos números especiales, consagrados a un tema específico, para los cuales se designa a un experto de renombre mundial y se solicita la contribución de especialistas en el campo considerado con objeto de ofrecer el panorama más completo posible sobre el tema tratado.

Los números de la *Revista* que no son temáticos comprenden generalmente cuatro secciones y cada número reserva especial importancia a las síntesis y los artículos originales. A continuación se describen brevemente dichas secciones.

Síntesis

Las síntesis presentan estudios completos sobre un tema específico de actualidad, como, por ejemplo, la epizootiología, el diagnóstico, el tratamiento y el control de las zoonosis y demás enfermedades animales de mayor trascendencia para la comunidad internacional. Además, esta sección puede abordar también otros temas como la administración de Servicios Veterinarios, la legislación, los sistemas de información o la economía en sanidad animal. Las síntesis pueden presentarse en forma de artículo redactado por un solo autor o de series de artículos sobre diferentes aspectos de un tema determinado.

Artículos originales

Estos artículos pueden tratar de investigación, técnicas de diagnóstico, experiencias y resultados en los campos del tratamiento y del control de enfermedades animales y deben ser de interés internacional, pero también pueden referirse a otros temas vinculados con la cooperación internacional de los Servicios Veterinarios.

Comunicaciones

Los temas tratados en esta sección coinciden con el desarrollado en los artículos originales, pero las comunicaciones son de menor longitud o, en todo caso, abordan un aspecto más limitado del asunto. Por otra parte, su contenido puede no ser original y referirse a trabajos ya publicados.

Informes

Se trata de breves reseñas de reuniones científicas y técnicas de la OIE o de otros organismos.

Condiciones para la aceptación de manuscritos

Los autores se comprometen a entregar a la *Revista* artículos que no hayan sido publicados antes, ni parcialmente ni en su totalidad, y cuya publicación por la OIE no requiera autorización previa. Al someter su manuscrito, y únicamente en caso de ser aceptado para publicación, los autores aceptan que el *copyright* de su artículo sea transferido a la OIE. No obstante, la Redacción considerará todas las solicitudes de autorización por parte de los autores con fines de reproducción de sus artículos.

Los manuscritos pueden ser presentados en cualquiera de los tres idiomas oficiales de la OIE: español, francés o inglés. Se recomienda a los autores que no escriben en su lengua materna que acudan a un relector profesional antes de enviar su artículo a la OIE.

El primer autor (o el autor encargado de la correspondencia con la OIE), recibe de inmediato un acuse de recibo de su manuscrito, el cual es sometido luego a la apreciación del Consejo Asesor de la *Revista*, cuya decisión se comunica posteriormente al autor.

Así mismo, el primer autor o el autor corresponsal es informado de los cambios de estilo que puedan aportarse al manuscrito con objeto de respetar las normas de la *Revista*. El manuscrito modificado se remite al primer autor o al autor corresponsal para su aprobación; resulta esencial que éstos respondan en un plazo de una semana.

Se ruega al primer autor que informe a los demás autores sobre los cambios efectuados en el texto antes de su publicación.

El Consejo Editorial se reserva el derecho de publicar los artículos aceptados en los tres idiomas oficiales de la OIE.

Presentación de manuscritos

Los autores deben enviar una versión electrónica del manuscrito original a la dirección electrónica a.souyri@oie.int o un fichero grabado en un disquete o CD a:

Jefe de Redacción
Revista científica y técnica
Organización Mundial de Sanidad Animal (OIE)
12, rue de Prony
75017 PARÍS, Francia.

Los manuscritos deben estar mecanografiados a doble interlínea, con márgenes anchos, en papel de tamaño A4 (21 × 29,7 cm). Las palabras no deben cortarse en final de línea. Todas las páginas deben ir numeradas y la presentación ha de respetar el siguiente orden:

1. Título, nombre y dirección de los autores
2. Resumen y palabras clave
3. Texto

4. Agradecimientos (si procede)
5. Bibliografía
6. Cuadros
7. Leyendas de las figuras
8. Figuras.

A continuación, se presentan algunas directivas para la preparación de los manuscritos. Para quienes deseen ejemplos concretos, se sugiere consultar un número reciente de la *Revista*.

1. Título, nombre y dirección de los autores

El título del artículo debe ser corto (máximo 70 caracteres) y no incluir abreviaturas. Para facilitar la búsqueda de información, debe utilizarse una terminología estándar. Por ejemplo: "Encuesta epidemiológica sobre el carbunco sintomático de los bovinos en Francia" (tema, enfermedad, especie, país).
Los apellidos de los autores irán precedidos de las iniciales de sus nombres y seguidos de uno o más números de llamada. El lugar de trabajo de cada autor con su dirección completa deberán indicarse a continuación, en el orden de los autores. Por ejemplo:

M.L. Bastos [(1)], J.C. Esteban [(2)] & D. Tamborenea [(2)]

(1) Laboratorio de Inmunopatología, Centro Nacional de Sanidad Animal, Mansilla 2923, 4025 Buenos Aires, Argentina
(2) Centro de Inmunopatología, Facultad de Agronomía y Veterinaria, Avda. Centenario 203, Montevideo, Uruguay

2. Resumen y palabras clave

El resumen, redactado en el idioma original y de 150 palabras como máximo, debe presentar la metodología, los resultados principales y las conclusiones del estudio. Debe recordarse que en algunos casos, sólo el resumen es traducido a los dos otros idiomas; por lo tanto, es importante que refleje lo esencial del contenido del artículo para los lectores que no lo leerán en su versión integral. Las abreviaturas, en su primera aparición, deben ir precedidas de la expresión completa que representan. A continuación del resumen, el autor incluirá entre ocho y diez palabras clave.

3. Texto

La extensión de los manuscritos no debe ser superior a 4.000 palabras (14-16 páginas mecanografiadas). Si desea publicar un artículo más largo, el autor deberá solicitar la aprobación de la Redacción. Los párrafos no deberán ser demasiado largos; en general, no sobrepasarán las 20 líneas (200 palabras).
Los autores deberán esforzarse en redactar de manera clara y concisa. Los trabajos experimentales y estudios epidemiológicos se presentarán según la siguiente estructura: introducción, materiales y métodos, resultados, discusión, conclusiones, bibliografía.
Las unidades de medida se expresarán en el sistema métrico y, cuando sea necesario, en unidades SI.
Las técnicas de diagnóstico nuevas se describirán con detalle suficiente (por ejemplo: estándar de referencia, tipo de antisuero o antígeno, especificidad, sensibilidad, etc.). Las técnicas conocidas o ya descritas en un periódico o revista de audiencia internacional no se describirán, sino que se mencionarán con las referencias bibliográficas correspondientes.
Los medicamentos veterinarios, reactivos y materiales de laboratorio se designarán en el texto por su nombre genérico (y, ocasionalmente, su nombre comercial).
Las abreviaturas y acrónimos deberán explicarse la primera vez que se utilicen. En la medida de lo posible, las notas se incorporarán al texto.
Los autores deberán indicar en qué parte del texto desean que se incluyan los cuadros y figuras.

4. Agradecimientos

Se podrán incluir agradecimientos a las personas cuya contribución para la realización del artículo haya sido fundamental. Cada autor se encargará de obtener la correspondiente autorización para citar a dichas personas.

5. Bibliografía

Todas las referencias bibliográficas mencionadas en el texto deben incluirse en esta seccíon. En la bibliografía, las referencias se numerarán siguiendo el orden alfabético de autores. En el texto, las referencias bibliográficas se indicarán mediante el respectivo número entre paréntesis. Para un artículo de investigación, se recomienda limitarse a cincuenta referencias. Tratándose de artículos de síntesis, este número podrá duplicarse.
Antes de entregar su artículo, se ruega a los autores que comprueben la exactitud de las referencias y verifiquen que todas vengan citadas en el texto. Los nombres de periódicos y revistas deberán abreviarse sin ambigüedad posible. En caso de duda, se escribirá el título completo. Para tener ejemplos de abreviaturas de títulos y del formato bibliográfico utilizado en la *Revista*, se sugiere a los autores consultar un número reciente.
Los datos aún no publicados y las comunicaciones personales se citarán en el cuerpo del texto y no en la bibliografía. Los autores habrán obtenido previamente la autorización de citar estos datos y comunicaciones personales.
En cada referencia, deben figurar los apellidos, seguidos de las iniciales de sus nombres, de todos los autores, el año de publicación, el título completo, el nombre del periódico o revista, el volumen, el número y las páginas, de acuerdo con los ejemplos siguientes. Los artículos de un mismo autor deben citarse en orden cronológico, empezando por las referencias firmadas por el autor solo (sin coautores).

– Artículo de periódico o de revista:

  Basualdo L.S., Gonzalez A.L. & Zemborain N. (1982). – Estudio de la producción de anticuerpos aftosos en bovinos con carencia de proteínas. *Rev. sci. tech. Off. int. Epiz.*, **1** (2), 875-892.

– Artículo en prensa:

  Basualdo L.S., Gonzalez A.L. & Zemborain N. (2006). – Estudio de la producción de anticuerpos aftosos en bovinos con carencia de proteínas. *Rev. sci. tech. Off. int. Epiz.* (en prensa).

– Capítulo de libro o informe de conferencia (debe incluir la editorial, el lugar de publicación, así como el lugar donde se celebró la conferencia y sus fechas):

  Castilla D. & Diaz Arredondo G.H. (1992). – Evaluación del poder inmunógeno de varias cepas de *Bacteroides nodosus*. *In* Actas del IV Simposio sobre enfermedades ovinas (P. Laurentín & E. Ramírez, edit.), Madrid, 12-14 de febrero de 1991. Galerna, Madrid, 894-897.

– Los autores que desean citar documentos bajados del web deben indicar la fecha en que han consultado las páginas citadas. La página principal de un sitio web, sin referencia a un documento particular, no se considerará como une referencia bibliográfica. Cuando el documento no tiene fecha explícita, se considerará como año de publicación el de la última actualización de la página web, que suele indicarse al pie de página:

  Unión Europea (UE) (2004). – Revision of Directive 86/609/EEC on the protection of animals used for experimental and other scientific purposes. Sitio web: www.europa.eu.int/comm/environment/chemicals/ lab_animals/revision_en.htm (fecha de consulta: 11 de abril de 2005).

– Las referencias a documentos que existen en forma electrónica y en versión papel incluirán todas las indicaciones bibliográficas habituales, agragando la dirección web como una información adicional para el lector:

  Scientists' Working Group on Biosafety (1998). – Manual for assessing ecological and human health effects of genetically engineered organisms. Part one: introductory text and supporting text for flowcharts. Part two: flowcharts and worksheets. The Edmonds

Institute, Edmonds, WA. (sitio web: www.edmonds-institute.org/manual.html, fecha de consulta: 25 de abril de 2005).

6. Cuadros

Cada cuadro debe tener un título y un número romano y presentarse mecanografiado, con interlínea doble, en una página separada al final del texto. Cada columna tendrá su propio encabezamiento y los valores individuales se reemplazarán, en la medida de lo posible, por sus promedios y sus desviaciones estándar. Para los comentarios, notas y precisiones relativos a los datos numéricos, se utilizará como llamada una letra minúscula en exponente (por ejemplo: [a], [b], [c], [d]) que remitirá al texto al pie del cuadro. Las abreviaturas poco usuales deberán explicarse. Los cuadros deben ilustrar, y no repetir, la información contenida en el texto.

7. Leyendas de las figuras

Todas las figuras se adjuntarán al final del texto y cada una llevará su respectiva leyenda en una página separada. Los títulos deben ser explícitos, de manera que el lector no tenga que buscar su significado en el texto. Cada vez que sea posible, se indicarán el objeto, el lugar y la fecha, pudiendo completarse esta información con unidades de medida, fuentes y notas explicativas.

8. Figuras

Se recomienda a los autores utilizar figuras para ilustrar su artículo. Se consideran figuras los diagramas, gráficos, fotografías, dibujos y mapas. Las figuras se numerarán con números arábigos, en el orden en que son citadas en el texto.
La Redacción aceptará publicar únicamente los gráficos realizados en Excel® y Microsoft® Power Point, siempre que se acompañen de la planilla de cálculo asociada. Los diagramas, así como los dibujos y mapas deberán de presentarse idealmente en formato de dibujo trazable, como por ejemplo: .eps editable, .ai (Illustrator®), .fr (Freehand®); aunque se aceptarán documentos con las mismas características que las fotografías digitales. Las fotografías digitales deberán entregarse en formato .jpg, .tiff o .eps. Con un ancho de entre 455 y 2055 pixels (8,35 cm y 17,4 cm) y una resolución de no menos de 250 dpi (pixels inch).

Las fotografías tradicionales, tendrán un formato máximo de 8 cm × 10 cm. También se aceptarán reproducciones fotográficas de documentos originales. Éstas, deberán llevar al dorso, escritos con lápiz, su número, el nombre del primer autor y una flecha que indique su parte superior.

Separatas

El primer autor recibirá cincuenta separatas de cortesía. Los pedidos de separatas suplementarias deberán remitirse a la Redacción cuando el artículo haya sido aceptado.
Los autores y coautores recibirán un ejemplar del número de la *Revista* en que su artículo es publicado.

Nota

Nomenclature – Reference documents:

Mammal Species of the World, Second Edition, 1993
Distribution and Taxonomy of Birds of the World, 1991
Virus Taxonomy – Classification and Nomenclature of Viruses, Seventh Report of the International Committee on Taxonomy of Viruses, 1995
Approved Lists of Bacterial Names, Amended Edition, 1989 and *Index of the Bacterial and Yeast Nomenclatural Changes*, 1992

The articles published in the OIE *Scientific and Technical Review* are regularly analysed and indexed in the databases *Agris* (FAO, Italy) and *Littérature vétérinaire francophone* (Canada), in the abstract journals *Index Veterinarius* and *Veterinary Bulletin* (CABI databases, United Kingdom), in *Biosis, Capsule Report, Current Contents©/Agriculture, Biology and Environmental Sciences, Fish and Wildlife Worldwide, Focus On©: Veterinary Science & Medicine, Index Medicus, Medline* and *SciSearch©* (United States of America), in *Zoological Record* (United Kingdom), in *Electre* (France) and on the current awareness service *Veterinary journals: table of contents* of the Faculty of Veterinary Medicine of the University of Montreal, Canada.

Nomenclature – Ouvrages de référence :

Mammal Species of the World, deuxième édition, 1993
Distribution and Taxonomy of Birds of the World, 1991
Virus Taxonomy – Classification and Nomenclature of Viruses, Seventh Report of the International Committee on Taxonomy of Viruses, 1995
Approved Lists of Bacterial Names, édition corrigée, 1989 et *Index of the Bacterial and Yeast Nomenclatural Changes*, 1992

Les articles publiés dans la *Revue scientifique et technique* de l'OIE sont régulièrement analysés et indexés dans les bases de données *Agris* (FAO, Italie) et *Littérature vétérinaire francophone* (Canada), dans les bulletins signalétiques *Index Veterinarius* et *Veterinary Bulletin* (bases de données du CABI, Royaume-Uni), dans *Biosis, Capsule Report, Current Contents©/Agriculture, Biology and Environmental Sciences, Fish and Wildlife Worldwide, Focus On© : Veterinary Science & Medicine, Index Medicus, Medline* et *SciSearch©* (États-Unis d'Amérique), dans *Zoological Record* (Royaume-Uni), ainsi que dans *Électre* (France) et sur le service d'alerte *Veterinary journals: table of contents* de la Faculté de médecine vétérinaire de l'Université de Montréal, Canada.

Nomenclatura – Obras de referencia:

Mammal Species of the World, Segunda edición, 1993
Distribution and Taxonomy of Birds of the World, 1991
Virus Taxonomy – Classification and Nomenclature of Viruses, Seventh Report of the International Committee on Taxonomy of Viruses, 1995
Approved Lists of Bacterial Names, edición corregida, 1989 e *Index of the Bacterial and Yeast Nomenclatural Changes*, 1992

Los artículos publicados en la *Revista científica y técnica* de la OIE son analizados e indicados regularmente en las bases de datos *Agris* (FAO, Italia) y *Littérature vétérinaire francophone* (Canadá), las fichas descriptivas *Index Veterinarius* y *Veterinary Bulletin* (bases de datos del CABI, Reino Unido), en *Biosis, Capsule Report, Current Contents©/Agriculture, Biology and Environmental Sciences, Fish and Wildlife Worldwide, Focus On©: Veterinary Science & Medicine, Index Medicus, Medline* y *SciSearch©* (Estados Unidos de América), en *Zoological Record* (Reino Unido), en *Electre* (Francia) y en el servicio de alerta *Veterinary joumals: table of contents* de la Facultad de veterinaria de la Universidad de Montreal, Canadá.

Notes / Apuntes

Directeur de la publication: B. Vallat

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