Textbook of Wild and Zoo Animals : Care and Management

Jacob V. Cheeran

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Textbook of Wild and Zoo Animals : Care and Management

(As per VCI Syllabus)

(Second Revised and Enlarged Edition)

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Dedicated

To my father who taught me how and why to love books

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Feedback

This textbook is written as per the syllabus prescribed for B.V.Sc. & A.H. students by the Veterinary Council of India. Author shall be thankful to receive your valuable feedback on various points like :

1. Nature of description.
2. Ambiguity on areas of scientific description.
3. Areas still to be covered.
4. Other relevant points if any.

Your responses may be e-mailed to jacob@cheerans.com or sent by post to :

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Preface

Management of wildlife both captive and free ranging is gaining importance now-a-days and veterinarians are often called to attend such situations. Consultancies to the veterinarian do not ordinarily end with treatment of diseases. It also extends to other aspects of wildlife management like housing, breeding and nutrition. It is in this context that Veterinary Council of India decided to include Wildlife Management as a course in the curriculum of B.V.Sc. & A.H. students.

Wildlife management is a multi-disciplinary branch of science and several advancements have taken place in this field in the recent years. The intention of this text book is to familiarise the students with the basics of wildlife management. Topics listed include taxonomy, habitat, principles of captive management of wildlife, methods of restraint and aquaculture. Discussion on the diseases affecting the wildlife is limited to the list of diseases reported among wildlife in India. This is because veterinary students get ample opportunity to learn such topics from their regular curriculum. Similar is the case with the chapter dealing with nutrition.

Author while teaching Wildlife Sciences at College of Forestry, Kerala Agricultural University has felt the need for a book on wildlife management dealing specially with Indian situations for teachers and students of wildlife science both at the graduate and postgraduate level. This book although written for B.V.Sc. & A.H. students, will be of use for students of Forestry, Biology and other Life Sciences, as well as for practicing Veterinarians and Foresters.

Diagrams are included with an idea to familarise the species to the reader. However it may be noted that the scales may vary for different species.

I request the readers to give their valuable feedback so that further changes can be incorporated in the coming editions for better use for a wider spectrum of students and practitioners.

Thrissur
22 June 2006

Jacob V. Cheeran

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Dr A.D. Antony, Associate Professor, Directorate of Extension Education (KAU), was kind enough to provide literature, drawings and relevant suggestions on aquaculture.

Dr M. R. Subadra, Prof. & Head, Dept. of Extension and Dr Joseph Mathew, Associate Professor, Dept. of Livestock Production Management, College of Veterinary and Animal Sciences (KAU) provided literature on Integrated Intensive Fish Farming.

Mr P.C. Anoop, National Diploma holder in Fine Arts prepared the drawings for this textbook. It was a difficult task to retain together the scientific aspects and artistic flavour of the diagrams.

International Book Distributing Co. did an excellent work in publishing and marketing the text book in its present form.

Digital Graphics, Thrissur gave timely assistance in reformatting the second edition.

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CONTENTS

Chapter 1

Taxonomy

The word animal is ordinarily used to warm-blooded homoiothermic furred creatures belonging to the group known as mammals. Mammals are a major group or class of animal kingdom. Their main characters are warm blood, backbone and ability to suckle the young one. The great swedish naturalist (Carolus Linnaeus, 1707-1778) who laid the foundation to the modern system of classification divided the class mammalia into three subclasses.

Animal Kingdom

The variety in animal kingdom is enormous. The number of species described is over a million, however, according to some scientists nearly ten times this number is yet to be described. Taxonomists identify, describe and name new species and arrange them in different groups according to their relation with other species, which are already described. A simple description of 'species' is – a group of organisms that can breed with one another in the wild to produce fertile offspring – and the assumption is that members of different species cannot interbreed to produce fertile offspring. Broader divisions like genus or family is classified by assessing the distinct relationships between each group. Family consists of related genera; related families are placed in the same order, related orders for phylum. Animal kingdom thus comprises of all phyla. Taxonomists identify newly described species based on the peculiarities in anatomy and physiology and in recent times, new species are classified based on differences and similarities of their DNA.

Mammals evolved from reptiles nearly 220-180 million years ago and are considered to be the most successful group of animals on earth.

They vary in size from 3 g (the diminutive marsupials) to over 6000 kg (The African elephant).

Prototheria is a subclass consisting of monotremes – the platypus and the echidna, which are unique to Australia. Platypus and echidna are egg-laying mammals. Their young ones hatch out from eggs by slitt opening the eggshell with a specialised organ called the egg-tooth. Marsupialia, the marsupials, occur in the Americas as well, but in Australia, they are seen in the most diverse forms.

Placental mammals, the eutheria are distributed world-wide.

Mammalian Characters

The following are the mammalian characters:

1. Secrete milk to feed young ones.
2. Hair over the body.
3. Unique jaw structure
4. Warm blood.
5. Larger brains in relation to body size.

Secretion of Milk

Nursing the young ones is unique in mammals. Unlike in higher mammals where milk is secreted through nipples or teats, in platypus and echidna, milk is secreted over the skin and drains over tuft of hairs. The weight gained by suckling young ones is tremendous in lower mammals. In some marsupials, the weaning weight of a litter can be three times the weight of the mother. Suckling echidnas are known to increase their body weight to 20 per cent of their birth weight in less than two hours and the feeding intervals may be several days. Echidnas have exceptionally high levels of total solids (55 per cent) in their milk. Kangaroos are known to produce milk with different composition at a time since they suckle two young ones on different age groups at a time. Nipple suckled by the older joey secretes milk with 20 per cent fat and the newborn joey is suckled fat free milk.

Hair Over the Body

Most land mammals have a thick hairy coat over their body. In lower mammals like echidnas the hair is modified as sharp spines. Mammals like water buffalo and elephant have little hair on their body.

Unique Jaw Structure

In reptiles lower jaw is made of several bones, whereas in mammals, it is made of a single bone and is attached to the skull by a hinge like joint. Teeth of mammals are also unique which help them to feed on different type of materials.

Warm Blood

Warm blood help mammals to maintain a constant body temperature and this has helped them to survive in extreme climatic conditions.

Large Brain

Larger brains help mammals to adapt better to different climatic and environmental situations.

Mammals

Mammalian Classification

Prototheria (egg-laying mammals)

Monotremata: duck-billed platypus and echidnas.

Metatheria (pouched mammals)

Marsupialia: kangaroos, wallabies, phalangers.

Eutheria (placental mammals)

1. Insectivora: insect eaters
2. Chiroptera: bats
3. Dermoptera: flying lemurs or colugos
4. Primates: tree shrews, lemurs, monkeys, apes, man
5. Edentata: sloths, armadillos, ant-eaters
6. Phoiidota: pangolins
7. Lagomorpha: pikas, rabbits, hares
8. Rodentia: rodents

9. Cetacea: whales, dolphins, porpoises
10. Carnivora: dogs, weasles, lions.
11. Pinnipedia: seals, sea-lions, walrus
12. Tubulidentata: aardvark
13. Proboscidea: elephants
14. Hyracoidea: hyraxes
15. Sirenia: manatees, dugong
16. Perissodactyla: horses, tapirs, rhinoceroses
17. Artiodactyla: pigs, camels, deer, giraffes, antelopes.

Prototheria, (Gr. *Protos*, first, *ther*, wild beast), As the name indicates, they are the most primitive of the mammals. Prototheria has only one order, the Monotremata (Gr. *monos*, single, *trema atos*, a hole). This is the lowest order of mammals having a single opening for both the genital and the digestive organs. Monotremata is represented by the echidnas (spiny ant-eater) and the duck-billed platypus. They show some reptilian characters and are egg layers. When the young ones hatch the mother suckles them. The milk glands do not have a teat or nipple. The milk exudes from the pores on the skin that are the forerunners of the nipple.

Spiny Ant-eater or Echidna

Marsupialia or pouched mammals, represent a further development stage of mammalian evolution. They belong to **metatheria**. The young ones are born in a very immature stage and find their way into the mother's pouch and remain there until the development is complete. The pouch contains teats for suckling. This order includes kangaroos, wombats, wallabies, opossums and pouched mice.

The **Eutheria** (Gr. *eu*, well, *ther*, beast) includes the placental mammals. As the name indicates they are in the most advanced stage in evolutionary terms. The young ones are retained in the uterus till they reach an advanced stage of development. Placenta provides nutrition and oxygen. Placental mammals are considered as successful in the evolutionary ladder and reflect, wide diversity and have no less than nineteen orders.

Order **Insectivora** comprises of small primitive creatures like hedgehogs, shrews and moles. They feed mostly on insects. **Chiroptera** (Gr. *cheir*, hand, *pteron*, wing) popularly known as bats, are either insect eaters or fruit eaters. The order **Dermoptera** ("winged skin") has only two species, the flying lemurs and they are leaf eaters. **Primates** are characterised by their ability to grab the objects. They may grab the objects with hand, legs and even with tail, e.g., monkeys of the new world. Their diets are usually mixed. The monkeys, apes, lemurs and human beings and possibly the tree shrews are all primates. The sloths, armadillos and termite eating ant-eaters, make up the order **Edentata.** They are seen in Central and South America. **Pholidota**, which are known, as pangolins are similar in many ways to armadillos but unrelated and are seen in Africa and Asia. Rabbits, hares and pikas are considered as rodents and included in **Lagomorpha** and are mainly herbivores. **Rodentia** consists of gnawing animals and is the largest of all the mammalian orders. They include a great variety of animals like mice, rats, guinea pigs, hamsters, porcupines, squirrels and beavers. **Carnivora** as the name indicates are flesh-eating animals. They are endowed with claws and the common carnivores are dogs, cats, lion, leopard, tiger, weasels, badgers otters and bears. The aardvark, which is a termite eater, is quite distinct in its anatomy and hence given an order of its own, **Tubulidentata**. The elephants both Asian and African with their distinctive trunk and tusk are included in the order **Proboscidea**. Rock climbing hyrax, once closely related to the elephants is placed in a separate order of its own, **Hyracoidea**. The hoofed animals that are known as ungulates are herbivores. Those with odd number of toes come under **Perissodactyla** (Gr. *perissos*,

odd, *daktylos*, finger/toe). They include the horses, tapirs and rhinoceroses. The rest of the large herbivores are even toed and called **Artiodactyla** (Gr. *artios*, even in number). It includes the cattle, sheep, deer, antelopes, pigs, giraffes, camels, hippopotami and goats. Sea mammals belong to three marine orders, **Pinnipedia** (Seals, Sea-lions and Walruses), **Cetacea** (Whales, Dolphins and Porpoises) and **Sirenia** (Dugongs and Manatees). They show considerable adaptation to the aquatic habitat.

The classifications of the mammals into different groups indicate their relationship with each other genealogically. Their capacity to adapt to their environment is most important. The environment include the surroundings, the conditions that influence the body forms and the habitat of the animal. It is characterised most easily by the vegetation. In an enlarged definition, environment includes both physical or abiotic and living or biotic environment. The abiotic environment includes the medium of life and the climate. This medium and the climatic conditions regulate and considerably affect the behaviour of the organism. Climatic conditions like the temperature, rainfall, day length, soil, topography all exert influence.

Order Insectivora

Insectivores are the most primitive placental mammals. 345 species are recognised. They have small narrow pointed snout and eat insects and other invertebrates. They include the Tree Shrews, Hedgehogs, Moles and Ground Shrews. As the name indicates Tree Shrews climb the trees. Moles are adapted for living and finding their food from underground. Hedgehogs and Ground Shrews are mostly terrestrial. Common species found in India are

Indian Tree Shrew (*Anathana elliotti*)

Malay Tree Shrew (*Tupaia belangeri*)

Long Eared Hedgehog (*Hemiechinus auritus*)

Eastern Mole (*Talpa micrura*)

Grey Musk Shrew (*Suncus murinus*)

Order Chiroptera

Order Chiroptera has 951 species. The name is derived from *cheir* means hand and *pteron* means wing. They are the only mammals capable of sustained flight. Usually they rest with their head hanging down. Bats in cold climates are found to hibernate. They are nocturnal and live on night flying insects. Sub-order megachiroptera include all frugivorous bats and that of microchiroptera eat insects. Some bats eat fish, frogs, birds and even other bats. Bats use echolocation to detect their prey and to sense obstacles. Echolocation means the perception of the objects using reflected sound waves, usually high frequency sounds. They use it for orientation and prey location. Their nose and ears are complex in shape. Fruit bats or Flying foxes eat fruits and leaves, and food is detected by smell. They are the largest of the bats and have large eyes and a head similar to that of a dog, i.e., small ears and a long muzzle. They have better vision than other bats and few use echolocation. Nearly a quarter of the living mammals belong to the group of bats.

The species found in India are **Flying Fox** (*Pteropus giganteus*), **Fulvous Fruit Bat** (*Rousettus leschenaulti*), **Short Nosed Fruit Bat** (*Cynopterus sphinx*)), **Bearded Sheath Tailed Bat** (*Taphozous melanopogon*), **Indian False Vampire** (*Megaderma lyra*), **Great Eastern Horse Shoe Bat** (*Rhinolophus luctus*), **Common Yellow Bat** (*Scotophilus heathii*) and **Painted Bat** (*Kerivoula picta*).

Order Primates

Primates are the highest order of mammals, including lemurs, monkeys, anthropid apes and man. This classification probably gives a pride of place for man in the animal kingdom. Physiologically there is nothing superior in primates when compared to the other living organisms. Comparatively the brain is well developed and is associated with higher intelligence. However, intelligence wise lemurs and some monkeys are not much better than some of the lower mammals.

The major distinctive character in primates is the structure of their hands and feet. They are designed for the purpose of grasping objects. This is an adaptation to the particular habits and mode of life of these creatures. The hands of apes, monkeys and lemurs are similar to that of human beings, but the thumb is opposable to the other fingers. This helps the primates to hand pick and hold objects. Unlike man, hands are their primary organs of locomotion for climbing trees and arboreal movements. Many apes have no thumb at all and in some they are small and useless. This adaptation helps in rapid movement, quick hooking and instant release. Quick progression through the branches may injure a protruded thumb. However unlike apes and monkeys, all lemurs have well developed thumbs and in some, the index finger is poorly developed. Double bones in the fore arm, which are equally developed and free, provide perfect movement for the wrist. The wrist can be turned upward, downward and rotated. The foot is provided with the same facility. The feet of primates have almost the same design as that of hand. The toes are long and flexible. The big toe is highly developed like the thumb and can oppose the other digits for grasping objects. In man, the grasping power of feet is lost. Gibbon has an extensively long arm, powerful chest and shoulders and a weak hindquarter, which is well adapted to its type of progression through the trees. In langur, arms are not excessively long, legs are longer than the arms and loins and thighs are well developed. They move fast, swinging from one branch to another and from tree to tree.

Tail helps them to balance while moving in leaps and bounds. Tails have variable features in different primates. In the new world monkeys they are used as an organ of prehension. Apes have no tail and they maintain balance with the help of outstretched arms.

While walking on the ground, or along a branch, gibbons walk erect on the soles of the feet and keep balance with stretched arms. Langurs and monkeys walk and run as other quadruped like dog. The whole palm is pressed to the ground, but not the entire sole, and the heel is raised above the surface. Monkeys in general are good swimmers, especially macaques. They swim vigorously in breaststroke style.

Apes, monkeys and lemurs eat flowers, leaves and fruits. The teeth of these herbivores can grind tough vegetable matter. Most lemurs thrust out their snout for food. Apes and monkeys use hands as prehensile organs to take food to the mouth. Some have large pouch in their cheeks in which they cram food, which they cannot immediately eat. They continue to eat even when the pouch is full. Baboons and macaques possess these pouches, but it is not seen in langurs. Stomach of langur is compartmentalised into three pouches, somewhat similar to that of ruminants. Langurs are herbivores and macaques are omnivores, and they eat grubs, spiders and insects. Some even eat lizards and frogs and one of the tribes even eat crabs. Lemurs are nocturnal, but monkeys feed only during the day. Monkeys get along very well with other animals. Some ungulates prefer to forage underneath the trees on which monkeys are feeding. Monkeys at times will drop wastefully and intentionally fruits and leaves. Ungulates feeding on the ground in turn eat them.

The main predators of monkeys apart from man are large cats, especially the panther, large snakes and crocodiles. They escape from the predators with the help of well-developed vision and hearing, and with extreme alertness and agility. Hiding behind the natural cover or concealment by deliberately drawing branches together is a common habit. The most common impulse is to flee from danger. Interestingly sometimes they slide down to escape from the predator. Why these arboreal animals come down exposing themselves more to danger and sometime get killed is yet to be explained. They get protection by living in collective groups, the troop. A threatened attack on any member of the troop draws aggressive reaction from other members. Alarm calls of langurs and macaques, when a large cat is on the prowl are well known. The hunters often notice this in the presence of a tiger or a leopard. An alarm call from anyone of the troop members makes the entire members to bolt without even finding out the reason for the threat. They never use tools in self-defence or to attack animals. They fight to protect themselves and their young ones or to establish dominance over other males for females. The monkeys usually live in the tropical climate, however some langurs and some like Assamese macaques

have extended territories in the very cold regions of the Himalayas. They are adapted with special winter coats for this purpose. Seasonal movements are influenced by the availability for food.

Monkeys cannot talk, not for want of intelligence but because of the anatomical peculiarity of their voice box. Many birds are capable of imitating human words. They vocalise several communications like pleasure, anger, fear, warning and calls to come together and show distinct facial expressions corresponding to different emotions.

Fur picking is not for hunting lice or ticks as is commonly believed. It is universal and is a form of emotive caress or courtship. Repeated indulgence in fur picking suggests a powerful bond and means of social communication between the members of the troop.

Each troop does not spread all over the habitat, but often confine to a specific territory. They may marginally overlap and fight for territory. This is rare in the wild. In urban environment, it is very much seen, often due to the shortage of food. Rhesus monkey is the common example for this type of behaviour. Males dominate the troop and are ranked in a linear manner similar to the pecking order in poultry. Different sub-groups are established in a particular tribe .

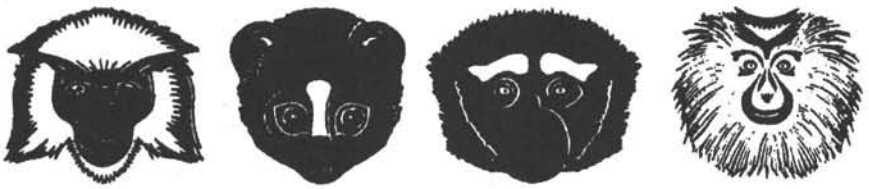
All primates give birth to single offsprings. Immediately after birth the young ones clings to its mother's body sucking her teat. It is able to hold fast on to the mother even during quick movements and jumps. While sitting, the mother supports the young one by holding the baby with its arms. Long tailed lemur supports its baby to her body with her tail. When the baby is grown up and can crawl on its own, it is carried on the back of the mother. A similar method of carrying the young ones is seen in bats, sloth and armadillos. Needless to say, marsupials carry the young ones in their pouch. Apes and monkeys suckle their young ones for a long time. A baby gibbon is suckled for nearly two years. The mothers do not ordinarily gather food for the young ones. It is interesting to note that the intelligent animals look after the young ones for a considerably longer period of time and have long period of maturity. Great apes and bigger monkeys take anything from six to twelve years

for mental development and to become independent. Smaller monkeys take 3-5 years and little lemurs that are physically smaller but with poorly developed intelligence take only two to three years to achieve full-grown status. It is reasoned that intelligent animals take longer period to reach adulthood, because they have to learn all the tricks of trade of the adult intelligent world.

A dominant monkey takes tremendous risks to protect its followers. A nursing mother protects the young ones even at the cost of her life. It has been found that mother monkeys continues to carry the dead body of the young ones. This may be due to the fact that it is not able to recognise death and carry around the young one purely on an instinct.

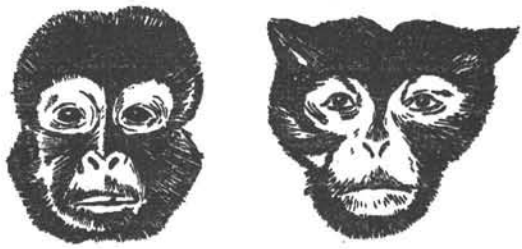
Indian Primates

There are apes, monkeys and lemurs in India. None of the great apes is seen in India. Gorilla and Chimpanzee are seen in Africa and Orangutan in the forests of Borneo and Sumatra. Hoolock Gibbon is the only tribe of ape seen in India in the forests of Assam and Chittagong. As mentioned earlier they are tail-less with well-developed arms that are longer than the legs. Indian monkeys belong to one Family viz. *Cercopithecidae* and two sub-families *Cercopithecinae* (Macaques) and *Colobinae* (Langurs). Macaques are sturdy solid and squat, while the langurs are slim and have long tail. Macaques have cheek pouch while the langurs have a pouched stomach. Among lemurs, only one family is found in India i.e., the *Lorisidae* or the Lorises.



Langur Loris Gibbon Macaque

Primate Groups of South Asia
(Courtesy : Zoo outreach Organisation)

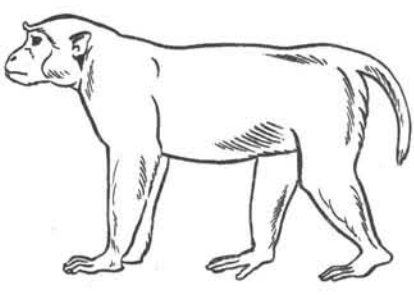


(a) (b)

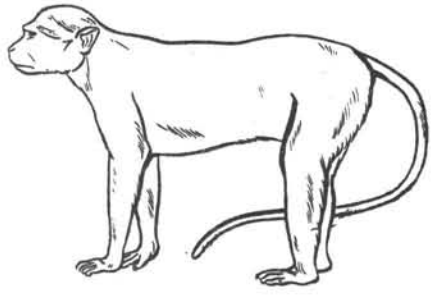
Monkeys - (a) New world (b) Old world

Hoolock Gibbon (*Bunopithecus hoolock*) Males are black in colour with white eyebrows. Females are brown. They feed on fruits, leaves and also on insect grubs and spiders. They travel along the top galleries of forest foliage and live in small groups. Young ones are covered with yellow tinted greyish white hair. They stand erect and are more than one metre in height and weigh 6.8 kg on an average.

Among macaques, **Rhesus Macaque** (*Macaca mulatta*) and **Bonnet Monkey** (*Macaca radiata*) are the common species. The human blood group classification is based on studies on rhesus monkey. They are present in North and Central India. Bonnet monkey has a longer tail compared to that of Rhesus. The temple monkeys of south India are bonnet monkeys and are commonly seen.

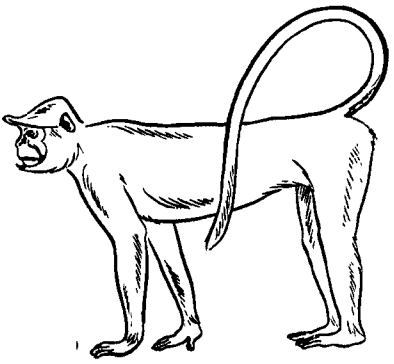


Rhesus Macaque



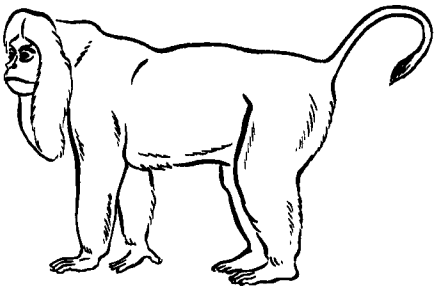
Bonnet Macaque

The other group of monkeys are langurs. **Common Langur** (*Semnopithecus entellus,* Old name *Presbytis entellus*) is distributed all over India and worshipped as Hanuman of Ramayana. However for some people Hanuman is from Deccan and should be Bonnet monkey.



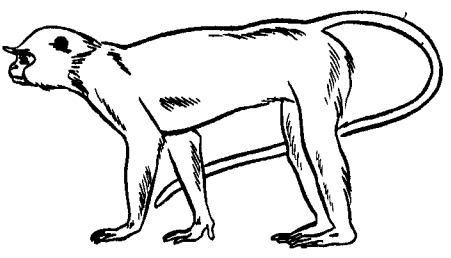
Common Langur

Lion Tailed Macaque (*Macaca silenus*) is found only in Kerala, Tamil Nadu and Karnataka. It is endangered and protected in the Silent Valley National Park. It eats lizards, snakes, and insects and also fruits and leaves. **Assamese Macaque** (*Macaca assamensis*), **Stump Tailed Macaque** (*Macaca arctoides*) and **Pig Tailed Macaque** (*Macaca leonina*).



Liontailed Macaque

Other langurs are, **Nilgiri Langur** (*Trachypithecus johnii,* Old name *Presbytis johnii*) as the name implies is seen in Nilgiris in Kerala, Tamil Nadu and Karnataka, **Capped Langur** or **Leaf Monkey** (*Trachypithecus*



Nilgiri Langur

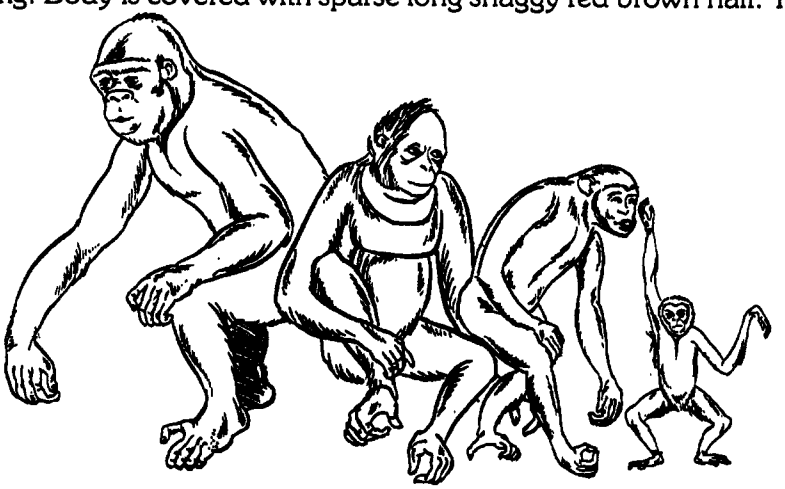
Capped Langur Golden Langur

pileatus, Old name *Presbytis pileatus*) and **Golden Langur** (*Trachypithecus geei*, Old name *Presbytis geei*).

Exotic Apes

Apes are anthropoid primates and comprise of lesser apes (Gibbon) and great apes (Orangutan, Gorilla and Chimpanzee). They differ from monkeys in not having a tail and they use their arms to swing through the trees.

Orangutan (*Pango pygmaeus*) is native to forests of Sumatra and Borneo. Height measures about 1.5 m and the animal weighs about 90 kg. Body is covered with sparse long shaggy red brown hair. The



(A) (B) (C) (D)

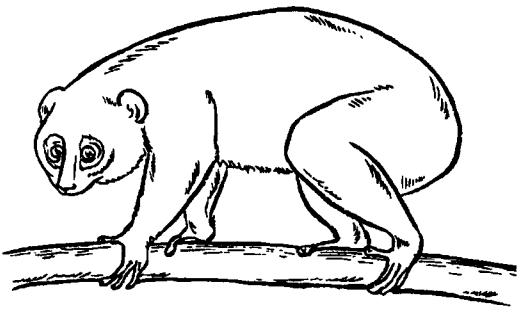
(A) Gorilla (B) Orang-utan (C) Chimpanzee (D) Gibbon

arm span is up to 2.25m. In adult males large naked fatty folds form a collar around the face. It is the largest anthropoid ape of Asia. Legs are short and bowed, with knees turned out and feet in. They feed mainly on fruits and buds of plants.

Gorilla (*Gorilla gorilla*) There are two varieties, the low land one of West Africa and Cameroon and the mountain variety of the Eastern Congo Basin. Gorilla is the largest primate and grows to a height upto 1.8 meters, weighs about 200 kg and has a massive and muscular body. Usually walks on all fours. Adult males have a marked crest and are black except in old males (Silver blacks), which have a silvery grey torso. Gorilla roams in the forest during the day in small family groups for fruits and plants and spends the night on the trees.

Chimpanzee is native to equatorial Africa, and they are believed to be the closest living relatives to human beings. Height 1-1.7 m. It has a black coat, and the hair on head is parted or directed backwards. The skin is pale, face is dark and the ears are naked. They are territorial and feed on plants and insects and use small twigs to get food. Two species are identified; **Chimpanzee** (*Pan troglodytes*) and the smaller black faced **Pigmy Chimpanzee** or **Bonobo** (*Pan paniscus*). They produce single offsprings at birth, may live up to an age of 35 years and are the most intelligent of apes.

Among lemurs, the two types seen in India are **Slow Loris** (*Nycticebus bengalensis*) and **Slender Loris** (*Loris lyddekerianus*) They have large eyes and are hence hunted to make products allegedly to improve the eyesight. Slender Loris is seen in south India and Slow Loris in northeastern India and is on the verge of extinction.



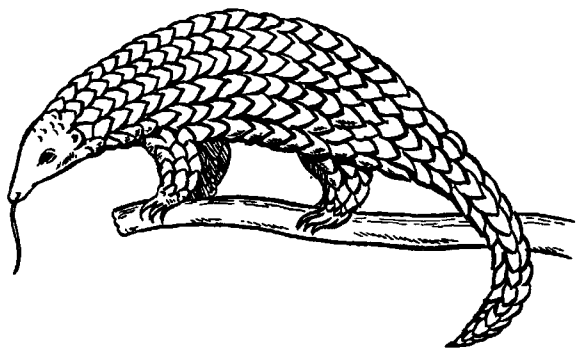
Slow Loris

Order Dermoptera

This order includes a primitive primate of Madagascar with large eyes and pointed snout. Most species have a long tail. 27 species in 3 families Lemur (*Lemuridae*), Mouse or Dwarf Lemur (*Cheirogalidae*) and Leaping Lemur (*Indridae*) have been described. Colugo or Flying Lemur is often regarded as a taxonomic puzzle. The head shows features of both lemurs and insectivores. Body is about 40 cm long and 'wings' of skin is stretched between the fore and hind limbs extending up to the shoulders. They are arboreal creatures and more efficient gliders than Flying Squirrels.

Order Pholidota

Pangolins or Scaly Anteaters of the old world belong to the order Pholidota with only one genus, *Manis*. Formerly they were classed under Edentata, meaning without teeth. They are seen in Africa and southeast Asia and have pointed heads with small eyes, long and broad tail, long tongue and no teeth. They feed on termites and ants. Body is covered with large overlapping plates and hence, known as Scaly Anteater.



Scaly Ant-eater or Pangolin

Genus *Manis* has seven species. **Indian Pangolin** (*Manis crassicaudata*) and race in India is *aurita*. It burrows and digs and at the same time can also climb. Another species **Chinese Pangolin** (*Manis pentadactyla*) is seen in Assam.

Order Proboscidea

Elephant comes under the Family Elephantidae, the only living member of the order Proboscidea that had many extinct forms unlike other mammals. Elephants are characterised by almost naked body with very few hairs, massive head, small eyes and modified upper incisors that form the tusks. The elongated snout with circular, radial and longitudinal muscles forms trunk. Ears are movable, which help in thermoregulation. The elephants are practically devoid of sweat glands. There are only two living species of elephants, the Asian and the African. The **Asian Elephant** (*Elephas maximus*), although literally means the bigger elephant, is smaller than the **African Elephant** (*Loxodonta africana*). There are three sub-species of Asian elephant (Sri Lankan, Mainland and Sumatran) and two in African elephant (Forest and Bush).

An adult Asian bull may reaches upto 3 to 3.2 metres in height (at the shoulders) and on an average they are 2.25 to 2.75 metres tall and females compared to the males are about 30 cm less in height. Only males grow tusks and females are with rudimentary tusks called tushes. There are males without tusks known as makhna which possess only tushes. Elephant being taxonomically different from other living mammals, they possess many physiological and anatomical peculiarities.

An elephant calf at birth weighs around 100 kg and gestation period is 21 months. They live as herds in the wild and the senior most female is the leader of the herd. The males are loosely attached to the herd. Adult bulls periodically come to a state of aggressiveness that is popularly known as musth. Animal becomes very aggressive during this period and may show excessive libido. Androgen level in the blood is raised several fold. However, males are sexually active irrespective of musth and mate when and wherever a female in heat is available. Tusks grow continuously in the males. Skin with wrinkles helps in heat dissipation, and is very thick and hence the name pachyderm. Even

though skin is thick elephants are very sensitive to pain. An elephants' life span is 60 -70 years. Main differences between the Asian and the African elephants are the following :

Table 1.1 Difference between the Asian and the African Elephant

	Asian	African
1. Ears	Small	Large and covers the shoulder (Shape resembles the continent)
2. Size Height (males)	2.25-2.75 m	up to 3.6 m
(females)	2.1-2.4 m	2.3 – 2.7 m
Weight (males)	3.7- 4.5 tonnes	4.1 - 5 tonnes
(females)	2.3-3.7 tonnes	2.3 - 4.0 tonnes
3. Tusk	Only in males (Makhnas-tuskless males)	Both sexes possess tusks
4. Trunk	One finger at the tip	Two fingers at the tip
	Less rings-more rigid	More rings-less rigid
5. Head	Two humps on forehead	Smooth and curved
6. Highest point	Top of head	Top of shoulder
7. Back (Dorsal side)	Convex	Concave
8. Ribs	upto 20 pairs	upto 21 pairs
9. Nails with front limb	5	4
10. Skin	Smooth	Loose

Both species of elephants are non-ruminant herbivores. Cellulose digestion takes place in the colon. There are two pairs of molars at a time, that are compound in nature and have several ridges. Teeth are replaced periodically by a unique way of progression. This is different from the usual mechanism of shedding and eruption that is the common method of replacement of teeth, i.e., milk teeth and permanent teeth. In an elephant's life span, a total of six sets of molars develop and replace each set one after another. Last molar is worn out by the age of 60 years and naturally this is the upper limit of life span of elephants in the wild. In captivity elephants are fed with cooked concentrate feed and hence they live for a longer period than in the wild.

Order Carnivora

Carnivores are primarily meat eating mammals. They prey mostly on other smaller vertebrates. Lower jaw moves only up and down and they have long canine teeth. Some of their cheek teeth, Carnassials, are specialised for cutting flesh and act like scissors. Carnivores have four to five clawed toes on each foot. Order Carnivora has seven families and 238 species.

Family Felidae

Cats belong to the Family Felidae and are the foremost of carnivores with 37 species. Their mouthparts are specially adapted for flesh eating. Claws are evolved to hold the struggling prey and teeth to bite, cut and tear. They stalk, pounce, capture, kill and eat the prey in a flash. Their intelligence is surpassed only by primates and their senses of hearing, smell and vision are highly developed.

Highly dilatable and contractile pupil helps them to adapt to any environmental condition. Cats are endowed with camouflage colouration, sharp claws that are usually retractable, and eat meat almost exclusively. Some of their nutritional requirements are seen exclusively in meat or food of animal origin. Since they walk on toes tracks or 'spoor' left by a tiger or even a house cat may show only the impressions of the toes and the great pads behind it, with no trace of heel as they walk on toes. Cats have five toes on the forefeet and four on the hind. Digit of the forelimb that corresponds to the thumb is set high up and leaves no mark on the ground. Deep cushioned pads of its feet muffle its tread and help in its stealthy noiseless stalking. Their limbs are adapted to strike and hold down the prey. Tongue is for most animals the organ of taste. Taste glands of the cat are small and set mainly in the margins of the tongue. There are numerous sharp and rigid points well suited for licking the bones and cleaning them like a rasp. Colouration helps the animal for camouflage in hunting, but it varies in lion, tiger and leopard and it helps them for successful hunting.

Tigers are considered to have evolved in North Siberia and Arctic Circle and migrated to southeast Asia. Fossils of lions have been found in Europe and now there are only two varieties of lions, Asian and African. Asian tribe has not spread much and is seen confined to the Indian sub-continent finding their way through the northwestern passes. They were present in Northern and Central India, from Sindh to Bengal, from Indus and Ganges and to the banks of Narmada. Limited distribution of lion indicates that it is a comparatively recent immigrant to India. It is worth noting that Sri Lanka never had a lion or tiger. In India the present wild population of lions is limited to the Gir National Park in Gujarat with a population of 200 plus. There are attempts to find a new home for the Asiatic lion in Kuno-Palpur Sanctuary.

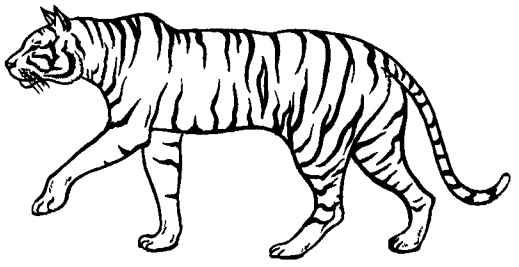
Panther is perhaps the most successful of all cats in spreading and holding on to its territory. It has established itself in the whole of Asia and Africa except the more Northern parts and sub-Saharan Africa. Lions live in groups referred to as pride and hunt as a family. It is the female that kills and the male gets the first bite. Tigers and leopards live a solitary life and joins with the opposite sex only during mating. Males usually leave the females after the cubs are born. Most of the cubs of large cats are blind when they are born. Occasionally some lion cubs are born with eyes open. Lion cubs have spots when they are born that disappear very soon.

Vocalisation is limited in cats, like the mating calls and the sounds produced by the mother to communicate with the cubs. No specific breeding season is identified in the wild but birth rate is seen more in certain seasons. Our knowledge about growth and maturity of beasts of prey is mostly from the captive population, hence it must be noted that captivity can make a difference with regard to the true facts. Lions and tigers attain full maturity by 3-5 years of age. However, males and females are found to breed even before they are two years of age. Leopards, lynxes and caracals are full grown in one and a half to three years.

The major wild cats seen in India are Tiger, Lion, Snow Leopard,

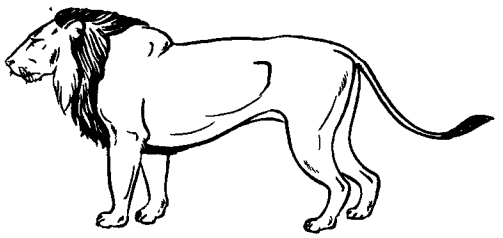
Clouded Leopard, Golden Cat, Desert Cat, Caracal, Lynx, Palla's Cat and Cheetah (extinct in wild).

Tiger (*Panthera tigris*) Extensive hunting has reduced the tiger population almost to the verge of extinction. Hence the Government of India and WWF started the Project Tiger in the year 1973. Average length of a tiger is 275-290 cm for males and 260 cm for females. Average weight of males varies between 180-230 kg and females weigh 45-50 kg less. Tigers found in cold climates are usually heavier compared to those found in the hot climate. Gestation period is 105-112 days. Litter size is between 2-3, age of maturity is three years for females and four years for males. Longevity is about 20 years.



Tiger

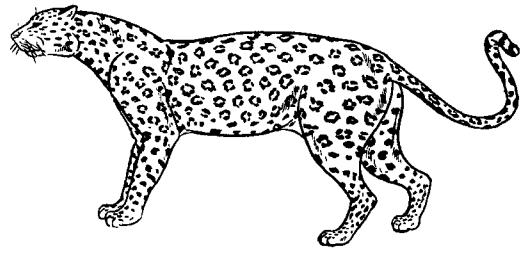
Lion (*Panthera leo*) lives in a pride and probably it is the only cat that hunts in a group, consisting mostly of females. Today Asiatic lion is seen in the Gir National Park in the erstwhile princely kingdom of Junagadh. Tigers and lions are usually not seen in the same jungle, even though leopards are found. Asiatic lion was once distributed in Iraq and Iran and over the whole of Northern and Central India as far as north of Narmada. There is no specific breeding season. In Gir many lions mate between October and November and cubs are born in January and February. Gestation period is 105-112 days. The litter size is about 2-5 cubs and they are often blind for the first 6 days. First litter is born when the lioness is 2.5 to 3 years old. A lion is



Lion

considered to be in his prime when it is 5 years old. A good sized male is 275 cm long including the 90 cm long tail and stands about 107 cm at the shoulder. Long hairy mane and long brush at the tip of the tail are characteristics.

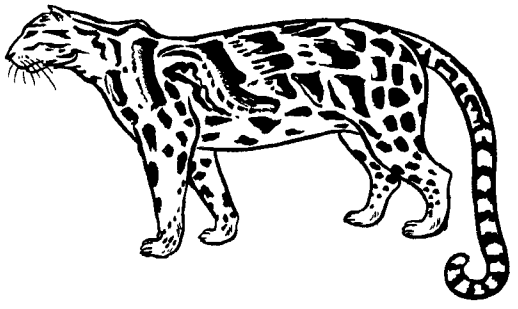
Leopard or Panther (*Panthera pardus*) is a small carnivore compared to the lion and the tiger. Leopard probably fills the niche between the two super predators. It is found both in Asia and Africa. Although smaller in size, it is more dangerous compared to the other carnivores. It can climb and drop on its victims. When it makes a kill, it drags the prey upon a tree away from the scavengers. There is much variation in the size of leopards seen in different parts of India. Average total length is 215 cm and for females it is about 30 cm less. Average weight is 50 kg for males and 40 kg for females. A typical panther is a sleek and shorthaired animal. The fur is generally deep yellow in colour with dark spots or rosettes and under parts are white. Black panther is a condition of melanism. Panthers breed year round producing the first litter at 2.5-4 years of age. Average litter size is two and gestation period of 87-94 days. Cubs open their eyes between 4th and 8th day after birth. **Jaguar** (*Panthera onca*) found from New Mexico southwards to Paraguay is similar to panther, but built more heavily. The dark rosette like spots are larger than that of Leopard. In comparison to Leopard, Jaguar has a larger head and short and stout limbs.



Leopard

Snow Leopard or Ounce (*Uncia uncia*) is smaller than the panther and lives near to the snow line of South Central Asia. It has a long tail and is a very shy animal. It is nocturnal and territorial in nature. It is ruthlessly hunted for its pelt and is nearing the verge of extinction.

Clouded Leopard (*Neofelis nebulosa*) is seen in the Northern part of India, Nepal, Bhutan, Sikkim, Myanmar, south China and Malaya. It is a fairly large animal and males measure nearly 2 meters and weigh 18-20 kg. It is largely nocturnal and arboreal and their upper canines are highly developed.



Clouded Leopard

Family Viveridae

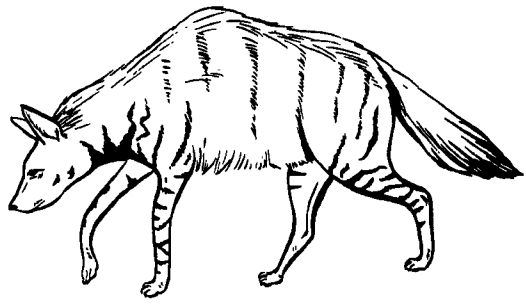
Viveridae is a small family of medium sized carnivores. There are 72 species and they are natives of old world. Important characters are long thin body, long tail, painted muzzle, short legs and a coat that is spotted or branded.

Civets: There are 17 species, mostly Asian. It is known as civet cat or bush dog. Civet has a long body, short limb, elongated head and pointed muzzle, quite distinct from the long limbs, rounded head and flattened muzzle of a cat. They are omnivorous. Civets have well-developed eyesight, sharp and acute sense of smell and hearing. Length varies from 35-90 cm and weight from 0.5 to 5 kg. The whiskers can be switched backward and forward and are used to sense food. Their main habitats are rainforest, woody grasslands and seen from sea level up to an altitude of 2000 m. Civets seen in India are **Spotted Linsang** or **Tiger Civet** (*Prionodon pardicolor*), **Large Indian Civet** (*Viverra zibetha*), **Malabar Civet** (*Viverra civettina*), **Small Indian Civet** (*Viverricula indica*), **Palm Civet** or **Toddy Cat** (*Paradoxurus hermaphroditus*), **Himalayan Palm Civet** (*Paguma larvata*) and **Binturong** or **Bear Cat** (*Arcticitis binturong*). Malabar Civet is almost extinct. Small Indian Civet can be easily tamed. Some are kept under domestication for regular extraction of 'civet' from the scent gland. **Civet** (*Viverra civetta*) is also seen in Africa.

Mongoose (Family - Herpestidae): Seen in south and southeast Asia and Africa. They are very adept in killing snakes and rats. There are 36 species and are more predatory than civets and do not have perfume glands. Six species are seen in southern Asia. Two of these, **Indian Grey Mongoose** (*Herpestes edwardsi*) with its long coarse fur is of uniform or rufous colour, darker on legs and **Small Indian Mongoose** (*Herpestes auropunctatus*) are common in India. All mongooses have stink glands like civets and skunks. Only two large species, **Stripenecked Mongoose** (*Herpestes vitticolis*) and **Crabeating Mongoose** (*Herpestes urva*) use it in self-defence. Crabeating Mongoose squirt out a foetid fluid as a means of defence. The fluid is shot backwards with great force from its large anal glands.

Family Hyaenidae

Hyena is a nocturnal, stocky, dog like animal with short back legs, large head with strong jaws, and inhabits the plains of southwest Asia and Africa. Family Hyaenidae has three species. Animal walks on the toes, four on each foot. Claws are short and blunt, with no protective sheath and are retractable. Hyenas do not have any scent glands, but have large anal glands. Jaws are extremely powerful and feeds on the carrion left by other predators, but will also kill ungulates. The share that hyenas get is often bones and coarse remains. Their powerful jaws and large teeth are very well adapted to crush the bones. **Striped Hyena** (*Hyaena hyaena*) is seen in peninsular India. It has a length of about 150 cm and height of 90 cm. It weighs about 35-40 kg; females weigh about 4-5 kg less.



Striped Hyena

Family Canidae

Family Canidae contains 37 species that include the wolves, jackals and foxes. **Domestic Dog** (*Canis familiaris*) evolved as a species in the Middle East ten to twelve million years ago. All the animals of Canidae family have a strong family likeness. Their general anatomical plan is a well-shaped head, long pointed muzzles, large erect ears and a muscular body with deep chest. Tail is bushy and limbs are with slender powerful tendinous muscle. Perfect digitigrade feet (on toes) have non-retractile claws. Claws are not very sharp and not very curved. All dogs have five toes (including dew claws) on the forefeet and four on the hind. Cape hunting dogs (seen in south of Sahara) have only four toes on each foot. Most members of the dog family have dark coloured coats, usually some shades of grey or yellowish/reddish brown without any markings or stripes. Sometimes they feed on vegetables, and some are even carrion eaters like the jackal. Whole family or pack joins for hunting, playing definite roles for each member of the pack, which can be compared to fielding in cricket. Canidae is one of the most widely distributed beasts of prey. They are believed to have emerged in the Northern hemisphere. Dingo or Wild dog of Australia is derived from the domestic dog originally brought from southwest Asia. In most canids vocal communication is well developed especially in tribes that live in packs. They may whine, growl, snarl, and express different feelings like fear, anger and similar emotions. There are mating calls and assembling calls. All canines have a scent gland typically marked by a black spot at the upper basal half of the tail. Scent is a powerful means of communication. Scent sent out by the female dogs in heat attracts many males.

Wolf (*Canis lupus*) Height 65-75 cm, length 90-105 cm, tail 35-40 cm, weight 18-28 kg. They are seen in several parts of India.

Jackal (*Canis aureus*) Height 38-45 cm, length of head and body 60-75 cm, tail 20-27 cm weight 8-11 kg. Jackal is smaller in size compared to the wolf. Its long drawn howl is more familiar than the animal itself. It is extensively distributed in the Indian sub-continent.

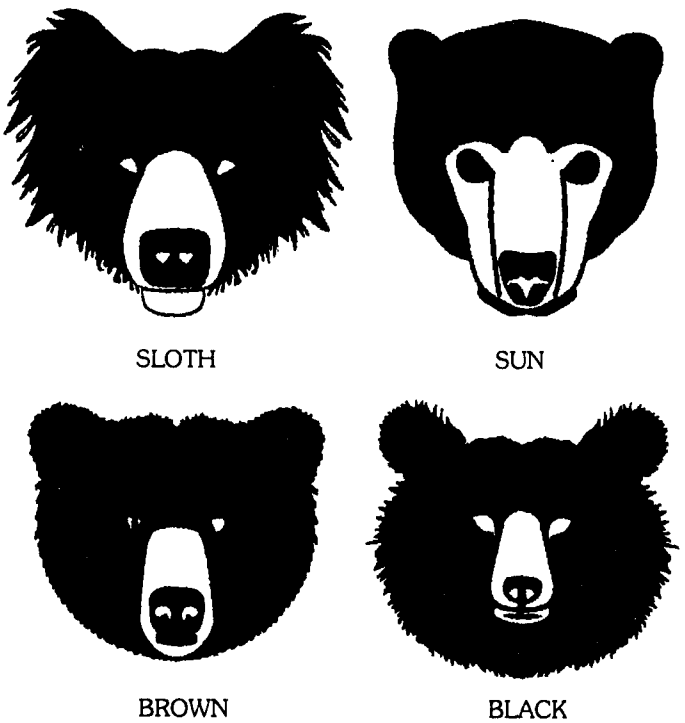
Indian Fox (*Vulpes bengalensis*) is the common fox of the Indian plains. It is small slim and slender. Size is 45-60 cm in length, tail 25-35 cm and weight 1.8 -3.2 kg. **Red Fox** (*Vulpes vulpes*) is distributed mostly in the Northern parts of India.

Dhole or **Indian Wild Dog** (*Cuon alpinus*) is widely distributed in India and looks very much like the domestic dog. Its dentition is different from the wolves, domestic dogs and jackal. It has 12-14 teats while the domestic dog has only ten teats. Three races are recognised, trans-Himalayan, Himalayan and Peninsular forms. Dholes do not bark, but yap or utter excited whimper when in sight of their prey. They vocalise with peculiar whistling sound and hunt in packs. Dholes get along well with domestic dogs and even mate with them. In peninsular India wild dogs breed round the year. It may be more pronounced in some seasons. Gestation period is 60-63 days in wolves, jackals and domestic dogs, 70 days in wild dog and 51-53 days in case of fox.

Family Ursidae

Family Ursidae has nine species widely spread in the Northern hemisphere. Grizzly bear, which is the largest carnivore, is about 260 cm long, 90-122 cm tall and weighs up to 360 kg. The Polar bear another large species of bear is classified under carnivores. A large head with short and round ears, long muzzle, bulky body with thick coat, that is usually shaggy and a very short tail makes the description of a bear. Dogs and bears have a common ancestral origin. Most of the bears live on grasses, herbs, roots, fruits and insects. Meat is not a must as a routine. A bear's legs are adapted for climbing and digging. Naturally it has massive limbs that can carry its heavy body up the trees, rocks and cliffs. Its paws are turned inward, which helps for a good grip on branches and the tree trunk. Claws are very big to help in climbing or digging. Paws are short, broad with five toes and having long curving non-retractile claws. A bear's sense of sight, hearing and smell varies with the species. In the wild, they are not very sensitive to the surroundings. They are trained as performing animals. Footprints of the hindlimbs of a bear are very much like that of a human being and

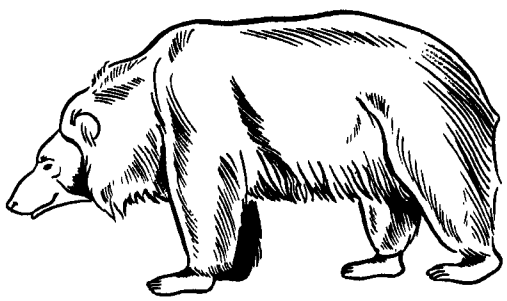
hence can easily be mistaken. Bears have a special skill to feed on termites. They break down the termite mounds with their big claws; blow away the dust and sucks up the termites. While sucking its pendulous upper lips keep the nostrils closed. They feed on the grubs of insects that travel underground or seen within the trunk of trees. Feet of polar bear are more adapted to walk on the ground (no trees around to climb on) and covered with hair for better grip on ice. Brown bears of Himalayas, which are seen in the Northern parts of Eurasia, have their sole covered with hair for the same reason. Only one bear is seen south of equator, the Spectacled Bear seen in Andes of southern Venezuela to Chile. It subsists mainly on vegetation, particularly fruits, nuts and buds. Vocalisation is very minimal. They may growl and grunt



Asian Bears
(Courtesy : Zoo ourtreach organisation)

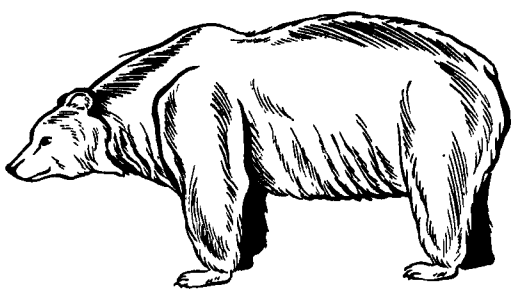
at one another. Bears usually lead a solitary life except during the mating season or when the females are with the cubs. Bears of cold climatic regions go on hibernation during winter. The animal enters into deep sleep, surviving on food reserves stored in its body as fat during the favourable summer period. Similar strategy for surviving a hot dry summer is known as aestivation. Bears living in hot climates do not hibernate. The bears seen in India are listed below :

Sloth Bear (*Melursus ursinus*) is specially an Indian type. Height 65-85 cm and weight 100-150 kg. They are brownish black in colour, with white V markings on the chest, pale whitish grey snout and long white claws. It is nocturnal and feeds on fruits, flowers and insects. Honey, termites and the intoxicating mahua flower when it blooms are delicacies for them. They carry the young ones on their back.



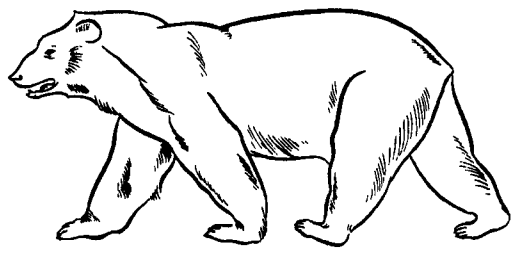
Sloth Bear

Brown Bear (*Ursus arctos*) They are the largest of Indian bears. A big male may be 210-250 cm long. They are seen in the higher regions of Himalayas. It thrives mostly on vegetation, but given an opportunity, it may kill a good-sized animal and as well eat the carrion. Brown bear rarely attack human beings. They reach maturity by three years of age and may live nearly upto 50 years. These bears hibernate during winter. They are seen in the whole of North Temperate Zone of Asia, Europe and North America.



Brown Bear

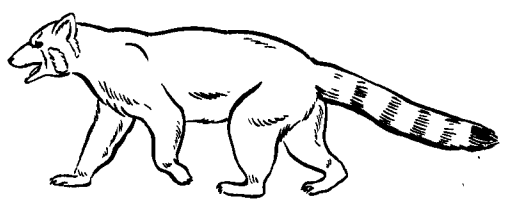
Himalayan Black Bear (*Selenarctos thibetanus*) Size: Males 140-165 cm from nose to rump. Large males measure up to 195 cm and weigh 90-115 kg. Before winter, with all the stored up fat, the body weight goes up to 180 kg. It has a short claw and the coat is smooth and black. Muzzle has a tan colour with white or buff chin. The 'V' shaped breast mark that may be white, yellow or buff is characteristic of this animal. Distribution is in the Himalayas, Assam, China, Japan, Myanmar or Malay countries. It is mostly nocturnal and sleeps during daytime in the caves and hollow trees. They are omnivores and their food comprises wild fruits and berries, nuts, apricots, honey, termites and beetle larvae. They are at times found to raid corn or maize fields. Some are found to enter villages and kill sheep, goat and even cattle. Attacks on human beings are not rare. Mating takes place usually in late autumn and cubs are born in late winter or early spring. One or two cubs are usually seen with the mother for a year or more. Gestation period is about 130 days. It is worth noting that they are poached for their fur.



Himalayan Black Bear

Family Ailuropodidae

Family Ailuropodidae is represented by **Red Panda** (*Ailurus fulgens*) and **Giant Panda** (*Ailuropoda melanoleuca*). These two species inhabit the bamboo forests in the mountains. Giant Panda



Red Panda

from China is bear like with large head, white with black legs, shoulders, chest, ears and round area around the eyes. Red Panda or Lesser Panda or Cat Bear is seen from south China to North Myanmar, Himalayas (Nepal and Sikkim). It is reddish brown in colour with black under parts and tail tip; and dark rings around the tail and white markings on the face.

Giant Panda

Family Mustelidae

Mustelidae (Mustelia = weasel) is a family of carnivorous mammals with over 67 species, found worldwide except in Australia and Madagascar. They are with long thin body, short legs and long tail. It is further divided into sub-families of Otters, Martens, Weasels, Ferrets, Badgers and Ratels.

Otter Their bodies are streamlined with a flattened muzzle and brown with pale under-parts. Tail has a thick base and the feet are usually webbed. They inhabit the rivers and lakes. There are twelve species in the genera Lutra (River Otters), Aonyx (Clawless Otters) and Petroura (Giant Otter). Coat is rough and waterproof. Tail acts as a rudder. It preys on fish, waterfowl, fresh water crayfish and other invertebrates. Three types of Otters seen in India are, **Common Otter** (*Lutra lutra*), **Smooth Indian Otter** (*Lutra perspicillata*) and **Clawless Otter** (*Aonyx cinerea*). Gestation period is 61 days and 2-3 young ones are found in a litter. Young ones are nursed for 2-3 months. They remain as a family group for 2-3 years.

Marten Genus marten has 7 species seen in Europe, Asia and North America. They have a solid body with sharp nose and long bushy tail. Their feet are adapted for running and climbing and claws are partially retractable. Only three types are seen in India, they are **Beach** or **Stone Marten** (*Martes foina*), **Yellow Throated Marten** (*Martes flavigula*) and **Nilgiri Marten** (*Martes gwatkinsi*).

Weasels, Polecats, Badgers and Ratels They are small carnivores with thin body, short legs and small head. Tail has nearly half the length of the body. Colour is mostly brown with pale under-parts. In winter it may have a white colour. Genus Mustela has nine species. Polecat resembles a large weasel (length 60 cm) and is dark with pale marks on the face and ear tips. Badgers have a length of 0.5-1 m and are usually grey brown with a black and white head and painted face. They are nocturnal and lives in burrows. Ratels are badger like mammals, dark brown on the top of the head and the centre of back is pale yellowish grey in colour. They have a very tough skin. They are fearless creatures. They eat small animals, carrion and vegetation. Ratel follows Honey Guide, small brownish bird that is said to lead these animals to beehives from which they take honey. Hence they are known as Honey Badgers.

Indian species are **Himalayan Weasel** (*Mustela sibirica*), **Marbled Polecat** (*Vormela peregusna*), **Ferret Badger** (*Melogale moschata*), **Hog Badger** (*Arctonyx collaris*) and **Ratel** or **Honey Badger** (*Mellivora capensis*).

Order Rodentia

Order Rodentia comprises of three sub-orders, thirty families and 1702 species. Nearly half the number of all living mammals are rodents. They have a worldwide distribution. Their chisel like upper and lower incisor teeth grow continuously and is kept in shape by continuous gnawing and is marvellously adapted to their feeding habit. They are comparatively small animals with a diversity of habits and mode of life. Common rodents in India are several species of squirrels, rats, mice, bandicoots and porcupines. **Indian Porcupine** (*Hystrix indica*) is commonly seen in India and Sri Lanka. Porcupines form a distinct family of rodents with hairs modified more or less completely into spines. **Red Porcupine** is a colour phase of Indian porcupine seen in southern India. They attack by charging backward with their erect spines. Porcupines grow their lost quills again.

Squirrels are one of the easily recognised rodents by their slender build and long body. They are mostly arboreal and some of them glide through the air and are popularly known as Flying Squirrels. Flying Squirrels have their limbs connected by a membrane and this acts as a parachute; by the outstretching of the limbs to the maximum extent possible. On other occasions it is tucked close to the body by its own elasticity. From very tall trees it can glide upto 100 meters. Altering the position of the limbs and the membranes attached, it can change the direction of flight. There are two groups of Flying Squirrels. Large Flying Squirrels have a body length of 35 cm and a tail length of 60 cm. Small Flying Squirrels have a comparatively lesser body length and tail length. They are distributed all over India, and the common species found are, **Common Giant Flying Squirrel** (*Petaurista petaurista*), **Large Brown Flying Squirrel** (*P. p. philippensis*), **Red Flying Squirrel** (*P. p. albiventa*), **Lesser Giant Squirrel** (*P. elegans*).

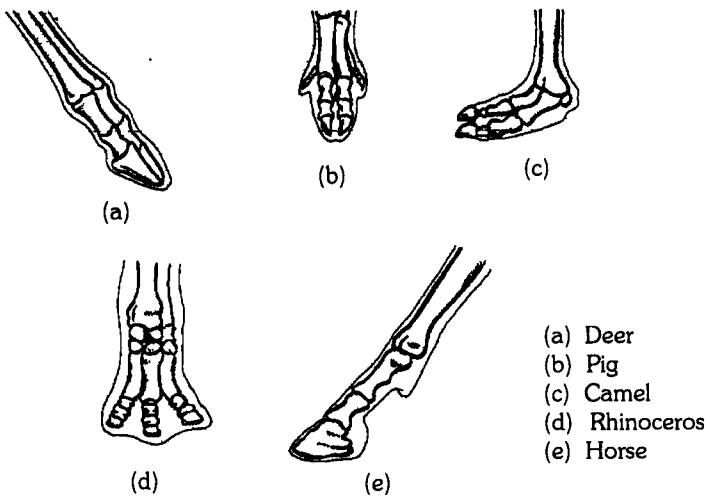
Order Lagomorpha

The mammalian order of Lagomorpha comprises of 58 species and virtually worldwide in distribution, and includes rabbits, hares, and pikas. Long soft fur, long ears, short tails, fully furred feet, slit like nostrils that can be closed are characteristics of lagomorphs.

There are no true rabbits in the wild in India. **Indian Hare** (*Lepus nigricollis*) is generally found in open bush country. They are mostly nocturnal and their main enemies are foxes, mongooses, wild cats and even stray dogs. The other hare seen in India is **Himalayan Mouse Hare** (*Ochotona roylei*) and is placed in a separate Family Ochotonidae.

Ungulates

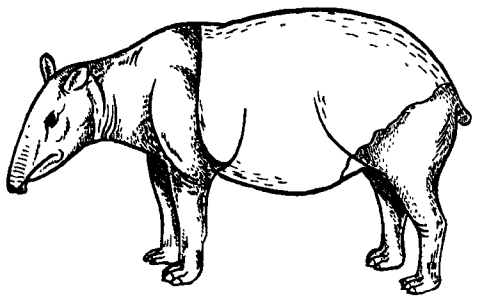
Ungulates are mammals in which the toes end in hooves, rather than claws. They include artiodactyls (even toed ungulates) and perissodactyls (Odd toed ungulates). They are usually large herbivores. Elephant, hyrax and aardvark are classified under primitive ungulates.



Perissodactyl and Artiodactyl Hooves

Order Perissodactyla

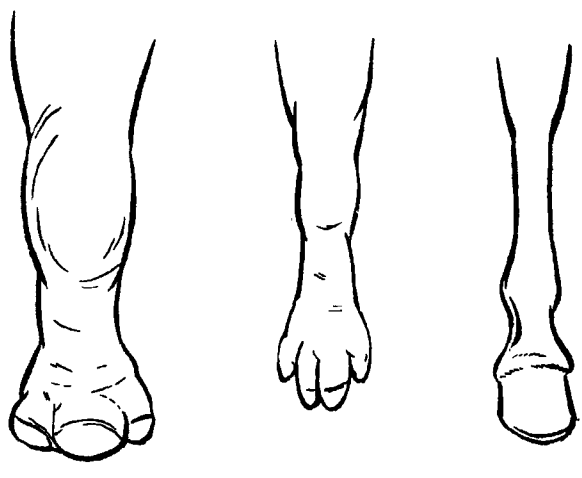
Perissodactyls are odd toed ungulates. There are sixteen species coming under this order. Foot is with one or three functionless toes, the first toe is absent in all feet and the fifth toe absent on the hind feet. Having their molar and premolar teeth in one unbroken series further marks the odd toed ungulates. The posterior molars resemble the molars in shape and size. Horses, Rhinoceros and Tapirs are the only surviving members of this group.



Tapir

Asiatic Wild Ass (*Equus hemionus*) is one of the two members of the horse family in the wild in India. The other is **Tibetan Wild Ass** (*Equs hemionus kiang*). Asiatic wild ass is seen in the deserts of Rann of Kutch and is a very fast runner. It can run long distances with a

speed reaching up to 50 km per hour. They are not easily tamed and trained. The Tibetan Wild Ass is darker and reddish than its Indian counterpart. It occurs in Tibet and Ladakh and across the trans-Himalayan regions.



(a) Rhinoceros (b) Tapir (c) Horse

Rhinoceros is a large ungulate seen in Africa, India, Nepal, Java and Sumatra. It is a perissodactyl mammal of the Family Rhinocerotidae. Skin is tough and thick (pachyderm) and without many hairs. Head is long with small eyes placed well forward. Nose has a horn, which is a fibrous outgrowth of skin made up of keratinised tissue. The horn is supposed to have aphrodisiac property and hence this animal is poached heavily. It is interesting that Rhino selects a spot to defecate and has a peculiar habit of walking backwards to this spot. This habit makes it more vulnerable to poaching. The thick skin is folded behind the shoulders and in front of the thighs. There are tubercles all over the body that may look like a riveted coat.

Formerly there were three species in India and now the only species surviving is the **Great One Horned Indian Rhinoceros** (*Rhinoceros unicornis*). The other two species are **Javan Rhinoceros** (*Rhinoceros sondiacus*) and the **Asiatic Two Horned Rhinoceros** (*Didermoceros sumatrensis*). Size wise it is in-between the black and white square lipped rhino of Africa. It stands 1.8 m at shoulder.

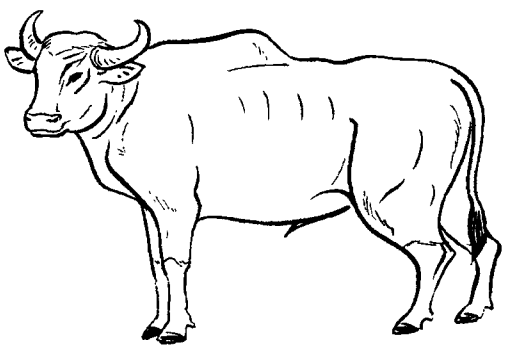
Order Artiodactyla

Artiodactyls (even toed) are large mammals, foot with two or four toes, first always absent, second and fifth are small or absent. Weight is carried on the third and the fourth toe that may form a cloven foot. Order Artiodactyla includes a large number of families of oxen, sheep, goat, deer, antelope, pig, camel, giraffe and hippopotamus.

Family Bovidae

The largest Family Bovidae includes all oxen, sheep, goats, antelopes and gazelles. They feed by grasping vegetation by tongue and cutting it with the lower incisor teeth. Adult males and females usually have horns. They have a keenly developed sense of smell. Many of them give out strong body odours and some have scent glands. Probably their olfactory sense keeps their herd together. Sheep have a face gland situated in the shallow depression of the skull just below the eye. They have a pair of glands in the groin and another gland between the toes of the feet. Typical oxen have no face glands and no inguinal glands. Glands may or may not be present in the forefeet and not in the hindfeet. Wild bovids include Gaur or Indian Bison, Banteng, Yak and Wild Buffalo.

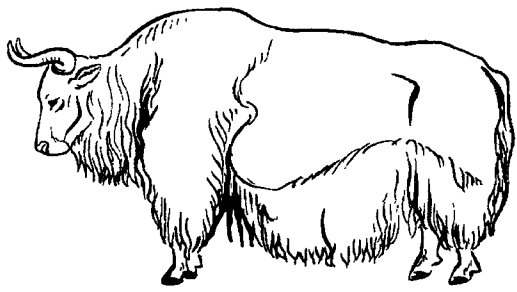
Gaur or **Indian Bison**, (*Bos gaurus*) A good sized bull may stand 190 cm at shoulder and on an average 175-180 cm and cows 10 cm shorter. A fully matured big bull may weigh a tonne. They are seen in the Western Ghats from south Maharashtra to the hill forests of Central and Southeastern peninsula and from West Bengal eastwards to Burma and



Gaur

Malay Peninsula. Gaur is one of the biggest oxen in the world. They often feed along with elephants in the wild.

Yak (*Bos grunniens*) It is a big herbivore seen in cold mountainous regions. They are seen up to an elevation of 6100 metres and are gregarious and live in small herds.

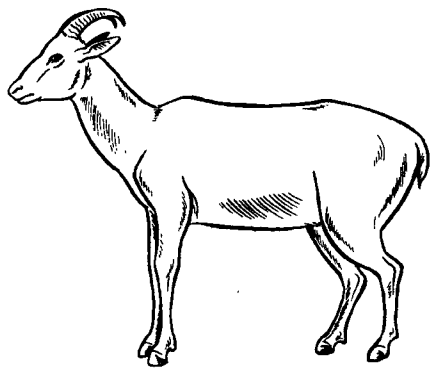


Yak

Wild Buffalo (*Bubalus arnee*) They are seen in the grassy jungles of Assam as well as in Dhanna-Karanya forests and look very much like buffaloes and wallows in mud and swamps. They mate with domestic buffaloes also and may attack without provocation. Wild buffaloes have excellent power of hearing and scent. They very much look like domestic Swamp Buffalo with large curved horns.

Banteng (Tsaine, *Bos banteng*) may stand a height of 170 cm at shoulder. Distribution is mostly in Burma, Thailand, Malay Peninsula, Borneo and Java. About five races have been identified and are reported in the hills of Manipur.

Wild Sheep found in India are **Sleapur Urial** (*Ovis orientalis*), **Great Tibetan Sheep** (*Ovis ammon hodgsoni*), **Marco Polo's Sheep** (*Ovis ammon polii*) and **Blue sheep** (*Pseudois nayaur*)



Nilgiri Tahr

Wild Goats found in India are **Ibex** (*Capra ibex*), **Wild Goat** (*Capra hircus*), **Markhor** (*Capra falconeri*), **Nilgiri Tahr** (*Hemitragus hylocrius*) and **Himalayan Tahr** (*Hemitragus jemlahicus*)

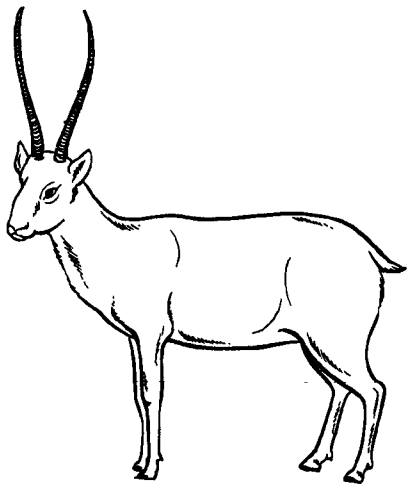
Goral (*Nemorhaedus goral*) is a small goat like antelope, native to the high mountains of East Asia, with thick yellow grey coat, pale throat and both sexes are having short horns. It is also known as Himalayan Chamois.

A ntelopes and Gazelles

Antelopes and gazelles are sub-divisions of Family Bovidae. It is assumed that antelopes represent the original stock from which oxen and sheep evolved. There are a number of sub-species of which these two, i.e., Pantholopinae and Antilopinae are relevant to India.

Pantholopinae has only one genus, **Chiru** (*Pantholops hodgsoni*) commonly known as Tibetan antelope, is related to Saiga antelope of the Russian steppes.

Saiga

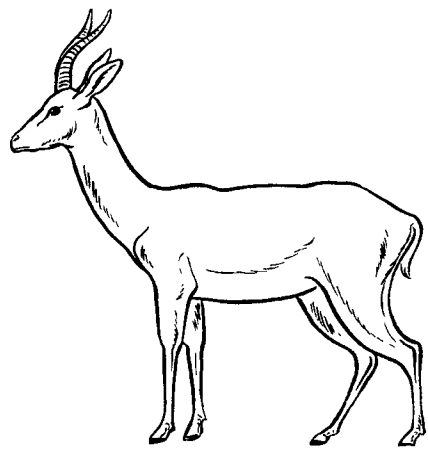


Chiru

Both of them have the same curious trunk like development of the muzzle. Antilopinae include the other antelopes and gazelles.

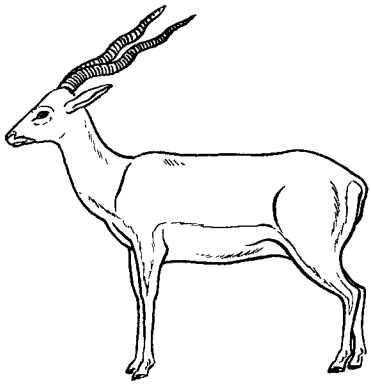
Chinkara or **Indian Gazelle** (*Gazella bennettii*) is a small, slender and gracefully built animal. The body above is light chestnut, the colour deepening when it joins the white of the under-parts. There is a white

disc around the tail in Tibetan Gazelle. Distribution is mainly in the plains and low hills of northwestern and Central India. Horns of the males are ringed while those of females are smooth and at times females are hornless too.

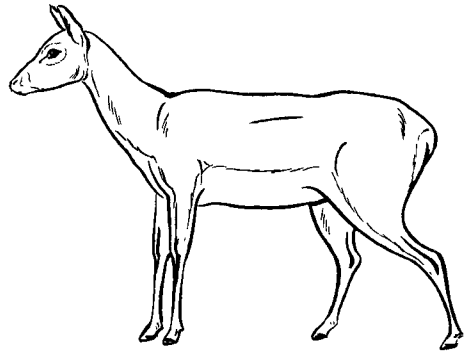


Chinkara

Black Buck (*Antilope cervicapra*) is known as Indian antelope, is the only antelope of India coming under the genus Antelope. It is an attractive animal with striking colour and beautifully spiralled horns. A good sized buck



Black Buck (Male)

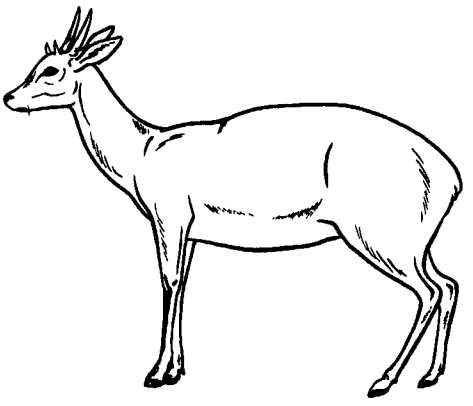


Black Buck (Female)

stands 80 cm at the shoulders and weighs about 40 kg. Horns may be 20-25 cm long. In young ones and does, the coat is yellowish fawn in colours. In males by about three years of age the coat turns to black colour. It is distributed practically all over the plains except in the southwestern coast. They generally avoid hilly terrain.

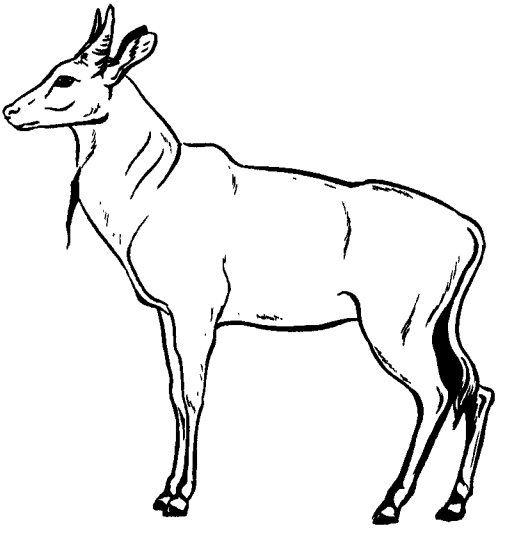
Four Horned Antelope or **Chowsingha** (*Tetracerus quadricornis*) and Nilgai are distinguishable from true antelopes (Antelopinae) by

various characters like horns that are not ringed as in true antelopes. They are grouped in a separate Sub-family Boselaphinae. Chowsingha is the only member of this group with only two pairs of horns and exclusively seen in India. The front pair of horns is shorter. Often the first pair is no more than a horny covered stud or a knob of bony projection covered with skin. Another exclusive feature of Chowsingha is the presence of a pair of well-developed glands between the false hooves of the hind limbs. This is present both in the male and the female. They are mainly distributed in south Himalayas in woody and hilly tracts.



Four Horned Antelope

Blue Bull or **Nilgai** (*Boselaphus tragocamelus*) Nilgai is one of the largest Indian antelopes found in the dry open forests and savannah. It stands 140 cm at the shoulder. Males have a small smooth slightly curved horn measuring up to 25 cm. The coat is bluish grey in colour and both sexes have a small neck mane. Males have a distinctive tuft of black stiff hair at the throat. Nilgai is seen in northern India from the base of Himalayas up to Karnataka and Andhra Pradesh. Nilgai is seen only in India and in many places

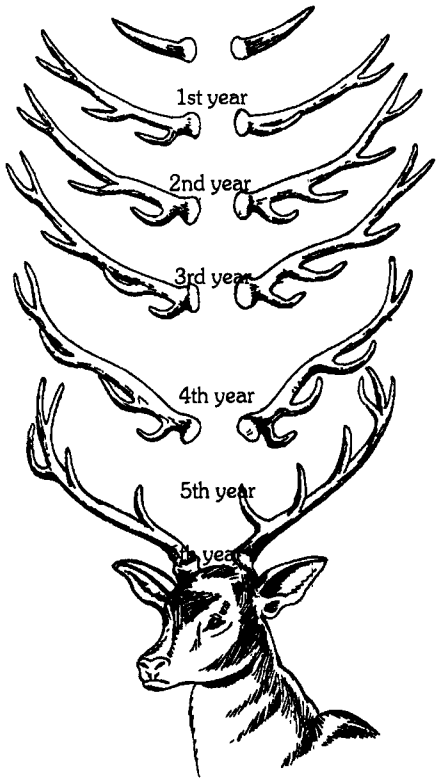


Nilgai

it is considered sacred like the cow and protected. Recently they have multiplied in large numbers leading to crop depredation. They move in herds, run fast and feed both by grazing and browsing.

Family Cervidae

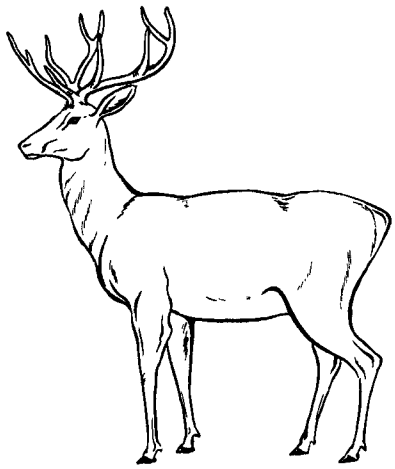
Deer includes hoofed mammals of the Family Cervidae, true deer with 36 species, *Moschidae* (Musk deer) and *Tragulidae* (Mouse deer). Only true deer have antlers, usually found in or near woodland. Male is called a stag or a buck and female, hind or doe. Young ones are called fawns or kids. Antlers are bony outgrowths from the head of the true deer, seen only in males, except in **Reindeer**, (*Rangifer tarandus*) also known as Caribou. Chinese Water Deer in the UK and France is the true deer without antlers. Antlers in male deer start to grow after the first year. Initially the antlers are covered by soft skin known as velvet. Antlers are usually shed at the end of the mating season. Antlers grow again every year and attain maximum with the sixth re-growth. Antlers are used in display, defence and competition for mates. They are shed each year and unlike horns of other ruminants, anters grows larger the following year. It is also known as deer-horn. A distinctive feature of the deer is a large fissure or opening in the skull below each eye called the "lachrymal fissure". Tushes or canine teeth are well developed in deer, which is another distinction from the ox family. Gall bladder is



Deer Antlers

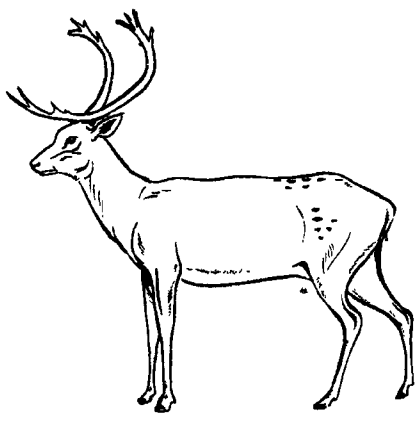
absent in deer with the single exception of the musk deer. Indian subcontinent has more varieties of deer than any other country. There are nine species of deer in the Indian subcontinent.

Kashmir Stag or **Hangul** (*Cervus elaphus hanglu*) as the name indicates it is seen in the high altitudes of Kashmir valley ranging from 2500 to 3500 m. Recent studies have shown that there are only 250-300 Hanguls left in the wild. Once spread across Himachal Pradesh and Kashmir, territory of Hangul has now shrunk to a point where 95% of these animals are confined to Dachigam National Park near Srinagar. It is related to **Red Deer** (*Cervus elaphus*) of Europe. Currently the animal is threatened and has been brought in the Red Data Book of IUCN. Project Hangul was started in 1970 by IUCN/WWF and a sanctuary has been established (Dachigam Wildlife Sanctuary near Srinagar).



Kashmir Stag

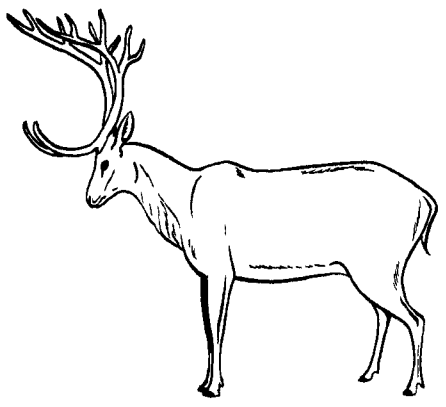
Brow Antlered Deer (*Cervus eldii*) is also known as the Manipur deer. It is locally known as Sangai. The Indian sub-species is *C. eldi eldi*. It was once regarded as extinct till it was located again in a small area known as Keibul Lanjao and the area was declared as a sanctuary in 1966. Thamin, one of three sub-species of Sangai carries the smallest pair of antlers. It is present in Myanmar and



Thamin

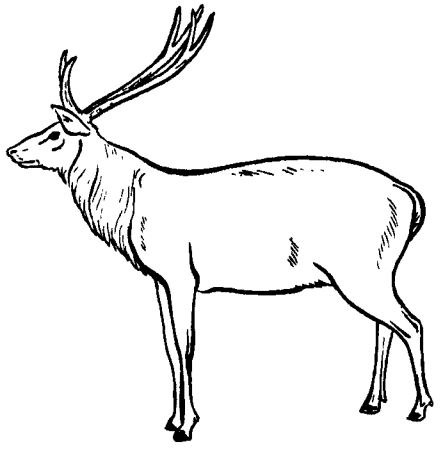
Thailand. They move around on vast morass of floating organic matter called the Phum or Phumdi. This movement over the phumdi forces the deer to constantly shuffle its feet to keep the balance and hence they are also called as dancing deer.

Swamp Deer or **Barasingha** (*Cervus duvaucelii*) The word Barasingha signifies the presence of 12 tines on the antler. This is a splendid deer and attains its finest development in Madhya Pradesh. It is seen in the Terrai regions of UP, Assam and Sunderbans. Two distinct types are recognised with a wide range of intermediary patterns. It stands 135 cm at the shoulder and weighs 170-189 kg. An average horn measures 30 cm round the curve with a girth of 13 cm at the mid beam.



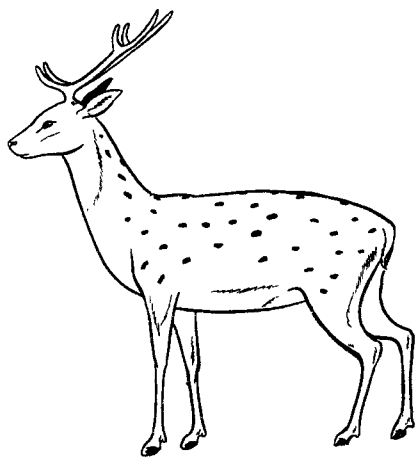
Swamp Deer

Sambar (*Cervus unicolor*) inhabits the well-wooded areas of India and Sri Lanka and its range extends to southeast Asia. Sambar is the largest Indian deer and carries the grandest horns. This large deer stands 150 cm at the shoulder and weighs between 225 to 320 kg and the three tired antlers are about 120 cm long with a span of nearly 100 cm. Coat is dark brown and pale on the under-parts. Hair is coarse and wiry that is longer on neck and throat and forms an erectile mane. Tail is small and thick. It is nocturnal in habit and rarely seen in large herds.



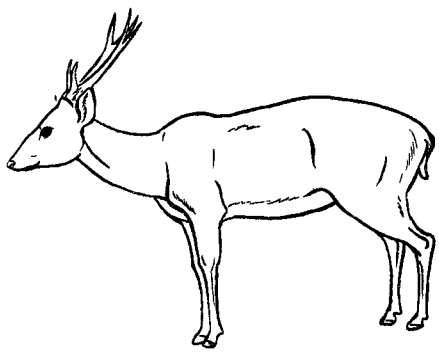
Sambar

Spotted Deer or **Chittal** (*Axis axis*) is a very beautiful and widely distributed Indian deer. It is a prolific breeder and stands about one metre at the shoulder and weighs about 85 kg. It is distributed all over India, forest regions of southern Asia and Sri Lanka. It is not common in the arid regions of Punjab and Rajasthan. Along with Sambar it forms the main food for the large carnivores like tiger.



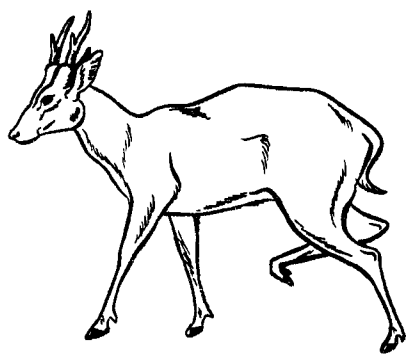
Chital

Hog Deer (*Axis porcinus*) is a small deer hardly 60 cm at the shoulders, seen in the grasslands of Northern India and Sri Lanka. While running it keeps its head low down and moves without the usual bouncing action, characteristic to a deer and hence the name, Hog Deer.



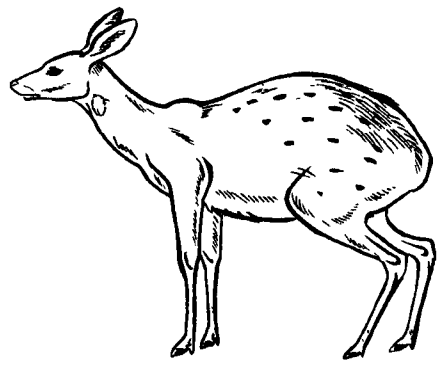
Hog Deer

Muntjac or **Muntjak** (*Muntiacus muntjak*) is a true deer native to India and southeast Asia and Sri Lanka. Face has V shaped ridges, the arms of V continue as freely projecting columns. Its canine teeth project out and hence also known as Rib Faced Deer. Its call resembles that of a dog barking and hence is also known as Barking Deer. Genus Muntiacus has five subspecies.



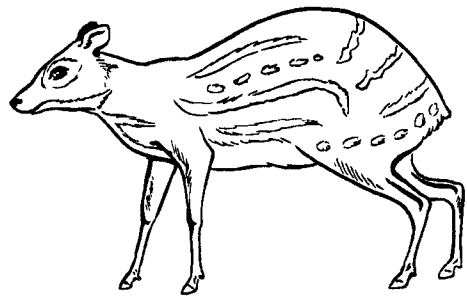
Muntjac

Musk Deer (*Moschus chrysogaster)* stands about half metre at shoulder. It is seen in the wet mountain forests of East Asia. It comes in between a deer and an antelope. Musk deer has a kangaroo like head, no antlers, has gall bladder and males have a gland on the abdomen producing a pungent oily jelly known as musk. Musk is used in perfumes and Ayurvedic medicines. Hence this animal is mercilessly poached. Genus Mochus belongs to the Family Moschidae and there are three species in the genus. Highly developed canines of the males are probably the compensation for horns.



Musk Deer

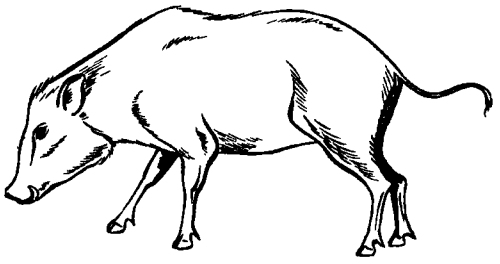
Mouse Deer or **Indian Chevrotain**, (*Tragulus meminna*) is the smallest deer in India and measures about 25-30 cm at the shoulders and are the smallest of hoofed animals. It is a timid forest dweller with a narrow head and pointed muzzle. Neither sex has horns or antlers, but males have long protruding upper canines. It is mostly seen in southern India up to an altitude of 1900 m. It is also found in Sri Lanka and Myanmar. Because of its small size it is otherwise known as deerlet. The African species, **Water Chevrotain**, is heavily built than the Asian. Family Tragulidae has four species.



Indian Chevrotain

Family Suidae

Family Suidae has nine species. In India there are two sub-genera, *Sus*, the Wild Boar and *Porcula*, the Pigmy Hog.



Indian Wild Boar

Indian Wild Boar (*Sus scrofa*) is a simple stomached artiodactyl with stout body and coarse hair, short thin tail, face in front of the ears and very long muscular snout, flattened and disk like. They are courageous and determined to fight and are seen all over India and Sri Lanka. They are prolific breeders and piglets of wild boars have longitudinal stripes. They are often a pest deprading crop.

Exotic Mega Mammals

African Elephant (*Loxodonta africana*) lives in herd and is seen all over tropical Africa. They are larger than the Indian Elephant. Males and females have tusks. The enormous "Africa shaped ears", convex forehead and two finger like protrusions at the tip of the trunk are important differences from the Asian elephant. Most of the behavioural and physiological features are similar to Asian elephant. Like the Indian species they are looked after by mahouts in zoos and used for rides.

Bear: Apart from the Indian species of bears, other important species are **Alaskan Brown Bear** (*Ursus arctos*), **Grizzly Bear** (*Ursus horribilis*), **Malayan** or **Sun Bear** (*Helarctos malayanus*), **Polar Bear** (*Thalarctos maritimus*) and **Spectacled Bear** (*Tremarctos ornatus*).

Giraffe: (*Giraffa camelopardalis*) Giraffes are seen from Somalia and Sudan to southern Africa and westwards to Northern Nigeria in open acacia savannah. It is a ruminant, and is the tallest land animal (Height 5.5m). They have extremely long legs and neck. Head has two blunt horns. Colour of body is pale with large angular brown blotches in reticulate form; it is reddish brown with a network of fine yellow lines. Tail is medium sized and tipped with a large tuft of black hairs. Tongue

is long and protrusible and with prehensile upper lips. Legs are straddled to lower the head to drink water. It takes defence from predators with its speed of running and hooves. Inspite of its long neck, like other mammals Giraffe also has seven cervical vertebrae. Their so-called horns are unbranched skin covered bony protruberances. They lack a gall bladder and have four mammary nipples. The blood pressure of the head of Giraffe, when lowered and lifted is balanced with the help of valves in the carotid arteries.

Hippopotamus, (Gr. River horse, Hippos, a horse potamos, arivea): Hippopotamus is an artiodactyl mammal belonging to the Family *Hippopotamidae* and there are two species. Hippos have a complex stomach system composed of four distinct sections, but are not ruminants. Microbial fermentation takes place in the fore stomach producing volatile fatty acids. Intestines are long and undifferentiated without a caecum. Kidneys are lobulated and there is no gall bladder. (*Hippopotamus amphibius*) of the tropical African rivers that have large barrel shaped body and spend most of the time in water and emerges out on to land only at night. Head is large and oblong. Four webbed toes are seen on each foot. Canine teeth are very large and curve backwards. Like the nostrils, small rounded ears can also be closed when submerged in water. It is 365-425 cm long and stands 100-150 cm at the shoulders. Young ones weigh 30 kg and can walk and swim within five minutes after birth. Since this animal defecates in the pond, cleaning of the pond is a difficult task in captive management. **Pigmy Hippopotamus** (*Choeropsis liberiensis*) seen in West Africa inhabits swamps and forests. Shoulder height is only 75 cm. A reddish brown secretion that exudes from the skin gives an erroneous impression that hippos sweat blood. In fact this is a thick oily secretion of modified sebaceous glands. This secretion protects the skin from both water and desiccation. Water loss is very high through the skin and their water balance gets upset when they are kept out of water, especially during hot weather.

Rhinoceros (*Diceros bicornis*) There are two species in Africa, black

and white. The black variety is more common and is seen in the Central and East Africa. Both have thick slate grey coloured hide. The white variety has a blunt truncated muzzle. There are two horns made of compressed keratin. The front horn is larger and measures about 50 cm. Digestive system of Rhinoceros is similar to that of equines, with a simple stomach, small intestine, large caecum and colon; and no gall bladder.

Zebra: Stocky with bold black and white stripes. Three species are identified. **Grevy's Zebra** (Imperial zebra or Hippotigris) (*Equs grevyi*) with narrow stripes, **Mountain Zebra** (*Equus zebra*) with short crosswise stripes on the hindquarters and **Common Zebra** (Main Zebra or Burchell's Zebra) (*Equus burchelli*) with variable markings.

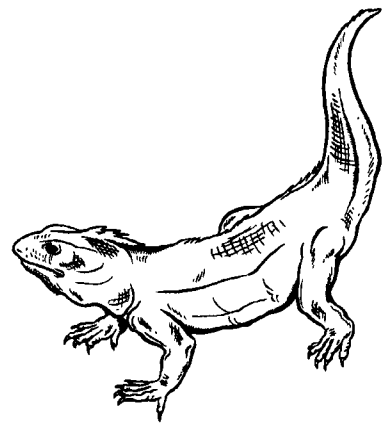
Marine Mammals

The main group of marine mammals are Cetacea (79) species e.g., whales, dolphins, and porpoises, Sirenia e.g., sea cows(Dugong - *Dugong dugon*) and Pinnipedia e.g., seals, sea lions and walruses. Pinnipedia are not found in the Indian waters. Unlike many other marine mammals they give birth to their young ones and spend the entire life in water. Most species of whales and dolphins congregate as herds. Dugongs and manatees belong to the Order Sirenia and are related to whales and seals. Manatees are seen in the Northern Hemisphere while dugongs are seen in the Indian Ocean and south western Pacific Ocean.

Reptiles

Reptiles are a group among the four classes of the land vertebrates, others being amphibians, birds and mammals. The class reptilia has 6547 species and evolved from primitive amphibians. Reptiles have lungs and no gills, dry waterproof skin with horny scales which are not separated as in fish, but are folds of skin. Reptiles are further classified into four orders :

1. Squamata. (Snakes and Lizards),
2. Chelonia (Tortoises and Turtles),
3. Crocodylia (Lorica-Crocodiles and Alligators)
4. Rhyncocephalia (Tuatara - a rare lizard like reptile of New Zealand).



Tuatara

Reptiles evolved 70 million years ago and in number they are almost double of the living species of mammals. Birds and mammals evolved from reptiles.

Table 1.2 Reptiles and their Species Distribution

Reptiles	Number of Species	
	World	India
Crocodiles	22	3
Turtles	242	32
Lizards	2800	155
Snakes	2750	244

Majority of the reptiles are carnivorous especially the snakes. The land turtles (tortoises), Marine Green Turtle and Green Iguana are herbivores. Egg laying reptiles lay eggs on the land and bury them with mud for incubation. Most of the snakes lay eggs except the Vipers that give birth to young ones. Teeth of most reptiles are replaced throughout their life, but turtles and tortoises have no teeth at all. Most of the reptiles have well-developed vision, but have poor and rudimentary central nervous system. Reptiles are poikilothermic and the changing environments regulate their temperature. Naturally they do not live in extreme cold climates. Since the reptiles need not keep a steady body temperature, their energy requirements are comparatively less and they can go without food for long intervals, extending up to months. All snakes, crocodilians, turtles and some species of lizards are protected under The Indian Wildlife (Protection) Act (1972).

Order Squamata

Snakes

Snakes evolved in the late Jurassic age, 135 million years ago from lizards. They are also known, as serpents with about 2750 species found worldwide except in very cold regions and some islands. Snakes have separate jaw bones connected by ligaments, hence their jaw bones can move apart and this helps snakes to swallow prey much wider than their head. Snakes do not chew their prey which includes animals and eggs, but swallows them. They have long cylindrical body without limbs and eyelids. Their skins moult several times a year. There are 300 venomous species, of which more than 50 are dangerous to human beings. Reticulate Python seen in India is one of the largest snakes in the world and may measure 8.5-10 m. India has the largest poisonous snake, the King Cobra and the smallest, non poisonous the Common Worm Snake or the Common Blind Snake with a maximum length of 17 cm.

Most of the snakes are oviparous, e.g., Rat Snake, Cobra, Krait and Python. All Vipers and Green Vine Snake are viviparous. Some snakes are ovo-viviparous i.e., embryo inside the egg develops inside the body of the mother and the young ones are born e.g., Sand Boa. Usually once the eggs are laid, the snakes do not take care of them, but the Indian Cobra guards the eggs. Snake egg shells are not hard but leathery. Indian Blind Snake is unique in the manner that it is parthenogenetic and only female specimen is seen. King Cobra is the only snake that builds its own nest with the help of leaves on the ground and lay eggs into it and incubates them by coiling around. During incubation the Indian Python, but not the Reticulate Python, regulates its body temperature by contracting and relaxing of its muscles.

Since the vision is well developed, snakes hunt by sight. Some snakes like Python and Pit Vipers have heat sensors and hence hunt by sensing the warmth given off by the prey, which is often an animal. Forked tongue acts as an organ of smell and not for taste. Scent particles

from the air are transferred to the Jacobson's organs situated inside the mouth. Jacobson's organ is chemo-sensitive and distinguishes the smells. Since snakes do not have external and middle ear, they cannot perceive sound waves. Their lower jaw picks up the ground vibrations and transmits to the inner ear. However some species of snakes can pick up sound waves in the air of low frequency of 100-700 Hz or cycles per second. Once bitten by the snake, the prey can hardly escape since their teeth are backwardly directed. Eyes of snakes are devoid of eyelids and the transparent cornea changes alongwith the skin when it moults. Two exclusive feeders in India are King Cobra and Indian Egg Eating Snake. Hence King Cobra is placed under the genus Ophiophagus meaning snake eating. Similarly the Indian Egg Eating Snake seen in Bengal and Bihar eat only eggs.

King Cobra (*Ophiophagus hannah*) is the largest venomous snake in the world. Body colour varies from deep olive green to yellowish brown with a jet-black tail tip. Dorsum of the body has regular lighter shaded cross banding and hood region is more elongated than that of the cobra. They attain an average body length of three metres. Head scales are edged with black and body has large smooth shiny scales. Antivenin against the venom of King Cobra is available only in Thailand. King Cobra is confined to the Western Ghats, Assam and Andamans. They behave with intelligence and awareness that is often unusual in snakes.

Cobra (*Naja naja naja*) is the most widely distributed of the three sub-species seen in India. Colour varies from dark brown to yellowish brown. Presence of a hood with spectacle mark is the characteristic feature. Average length is one metre. It has a smooth scaled body and black eyes. Cobra is often confused with Indian Rat Snake. They feed on insects, lizards, frogs and toads. Venom affects the nervous system leading to respiratory paralysis and cardiac failure.

Russell's Viper (*Daboia russelli*) is a heavy rough scaled snake with vertical pupils. Body colour is brown or yellowish brown with pattern of dark, round spots edged with black and white. Head is distinctly triangular. Body has three longitudinal rows of reddish brown or dark

brown rings that form a chain like pattern. Venom is haemotoxic. They are viviparous and give birth to around 20 to 40 young ones at a time. They eat other snakes, lizards, mice and scorpions.

Saw Scaled Viper (*Echis carinatus*) is a small rough scaled snake. This is the smallest of the venomous snakes in South India. Head is slightly wider and the scales are heavily keeled. Body is brown in colour and with a dark dull pattern on the back and distinct cross lance mark on the head. Venom is haemotoxic. Females give birth to 4 to 8 young ones at a time. They are distributed throughout India and feed on mice, lizard, frog and arthropods. Average body length is 30 cm.

Krait (*Bungarus caeruleus*) is a bluish black coloured snake with distinct paired white cross bands, around 40, on the dorsal part of the body. Head and neck are free from the cross bands. There is an enlarged chain of large hexagonal scales on the dorsal surface in the middle. Ventral scales beyond the anus to the tip of the tail are not divided. Venom is neurotoxic. Krait is a short fanged snake with a bulldog grip, very fast and active at night. Average body length is one metre. Kraits thrive on snakes, lizards and rodents. Kraits are true cannibals.

Pythons belong to the family Pythonidae. There are 27 species, native to Africa, South and Southeastern Asia, and Australia and a single species is seen in Central America. It is a constrictor snake that wraps its body tightly around its prey and induces suffocation by squeezing. Their teeth carry no venom. Snakes of Boa family are constrictors. One of the largest snakes, a Boa from South America is the Anaconda (*Eunectus murinus*) that reaches 11 m in length and 500 kg in weight. There are two species of pythons in India, viz. Indian Python or Indian Rock Python and Reticulated Python.

Indian Rock Python (*Python molurus*) is the second largest, non-poisonous and heaviest of all Indian snakes. It ranges from 2.5 m to 4.5 m in total length; maximum length recorded is 7 m and weighs about 85 kg. Head is demarcated from the neck and has symmetrical shields: the rostrals, anterior supralabials and anterior and posterior infralabials, which are distinctly pitted. Its eyes have vertical pupils.

Dorsal scales on the body are remarkably smooth and are arranged in 60-75 rows. The body is short and colour of the body varies from pale grey to yellow, above and is yellow below. The flanks are pale as compared to the dorsal and ventral aspects. A dorsal series of large walnut coloured crown saddles alternate with pinkish laterals. Structures of the blotch pattern or markings, which are pigmented and darker than the body colours of the snake, are used in the identification. It is distributed in the whole of India including the high altitudes like Darjeeling and Sikkim. Apart from India the species is found in Pakistan, Nepal, Bangladesh and Sri Lanka. Indian python is subjected to heavy commercial exploitation. It is protected under Schedule I of Indian Wildlife (Protection) Act, 1972 and listed in Red Data Book of IUCN. No reliable information on the population, habit and habitat of this magnificent snake is available. The species is a serpent of the marshes, gallery forests and wet rocky areas near the streams and pools. It is a good climber and sometimes suspends from the branches of trees waiting motionless to catch its prey. It is extremely fond of water and is an expert swimmer. Python is nocturnal than diurnal in its habits. Diet is largely restricted to reptiles, birds and smaller mammals. It is oviparous and exhibits parental care. The mother python coils around the egg clutch that may be 60-100 in number, till they hatch.

Reticulated Python (*Python reticulatus*) is the largest and heaviest of all the Indian snakes. It generally attains a length of about 10m. The young at birth measures 60-70 cm in its total length. A reticulated python, more than 10 m in length, has been recorded from Nicobar group islands. It resembles Indian rock python in most of the characters except circular rhomboidal spots, often confluent with each other. Each spot is edged with black and yellow. It is whitish or yellowish at the ventral aspects. Reticulated Python is seen all over India and distributed in southeastern Asia through Myanmar. It inhabits the wet evergreen forests and is semi-aquatic in habits. It largely feeds on small mammals, reptiles and birds. Occasionally it feeds on medium sized mammals like wild boar, deer, cattle and even man. It lays eggs in large clutches upto 100 in number. Reticulated Python is the most threatened species

among the Indian serpents. The species is considered endangered and has been enlisted and included in Appendix I of the Convention of International Trade on Endangered Species of Wild Flora and Fauna (CITES), according to which trading on the species and its product and any sort of commercial exploitation are strictly prohibited.

Sea Snakes are considered to have evolved from land snakes about 25 million years ago and are seen only in the warm waters and estuaries. Among the 60 species of sea snakes in the world, only 20 species are seen in the Indian sub-continent. They vary in length from 45-180 cm. Respiration is mostly through the lungs and hence the sea snakes have to come to the water surface for respiration. They live usually in the shallow waters, although they can dive to depths of 100 m. They can live only for half an hour underwater at a time. Skin also supplements in respiration. In sea snakes, the lungs function like swim bladder in the fishes, which is a hydrostatic organ. Unlike land snakes olfactory senses and vibrations in water facilitate sea snakes in predation. Salt glands in the mouth help them to excrete the excess salt in the body absorbed through the skin. Most sea snakes give birth to live ones except the laticaudids, that include four species that lay eggs. Young ones are born in sea and the egg layers i.e., laticaudids lay their eggs on land like crocodiles and turtles. Most sea snakes have flattened tails that help them to move in water. Most of the sea snakes are highly venomous and their venom is 4-10 times more potent than that of cobra. The quantity of poison obtained from **Hook-nosed Sea Snake** (*Enhydrina schistosa*) at one collection is enough to kill fifty human beings, but bites of sea snakes are very rare and they usually avoid human beings.

Some Common False Beliefs about Snakes

1. Green Snake bite on the eyes (Being arboreal the bites are often on the upper side of the body or even head).
2. Cobra mates with rat snake.
3. When killed other snakes of the same species gather to take revenge (Some snakes emit distress pheromones which attracts other snakes, very similar to the distress call in crows which attracts other crows).

4. Red Sand Boa is double headed (Its round shaped tail is an anatomical adaptation for easy and quick movement in the sandy terrain).
5. Cobra especially old ones carry precious stones in their head (Snake catchers have never become rich overnight!).
6. Cobra sways its head in response to the charmer's music (It is in tune with the swaying of the pipe).
7. They are slimy to touch (Their skin is dry).
8. Snakes enjoy drinking milk (It is not a mammal and cannot relish milk).
9. Bites of snakes especially that of Sand Boa can cause skin diseases (No scientific proof till now).
10. Bronze Back Tree Snake, climb on a tree after its victim succumb to its bite and enjoy the funeral pyre. (It is a non-poisonous snake and hence this cannot happen).

Lizards

Lizards are seen all over the world except in the coldest regions. They differ from snakes in having eyelids and an obvious ear opening. Lizards comprises of Home Lizards (Gecko), Garden Lizards, Chameleons and Monitor Lizards. There are 2800 species of lizards in the world and out of which 155 species are seen in India. Very few lizards are kept in zoos except few like Varanus and Komodo Dragon. The smallest lizard is 4 cm long and weighs only 2 gm. Like reptiles most lizards lay eggs, but some bear live young. Lizards do not incubate their eggs and their young ones are able to fetch for themselves when hatched.

Common Monitors found in India are **Common Monitor** (*Varanus bengalensis*), **Water Monitor** (*Varanus salvator*) and **Yellow Monitor** (*Varanus flavescens*). Water Monitor may grow up to 1.75 m long and is a voracious hunter of fresh and dead creatures. Common Monitor is seen all over India and hunted for flesh and skin. Skin of its belly is used in the making of a musical instrument known as Kanjira. Unfortunately people believe that its body fat has medicinal property

and they are hunted.

Komodo Dragon (*Varanus komodoensis*) Natural habitat is in Indonesian islands and Komodo. They grow up to 3 m long and weigh 140 kg. Komodo Dragon is not poisonous but its saliva is rich in pathogenic bacteria and hence its bite often becomes fatal due to secondary bacterial infection and septicaemia. Komodo dragon is seen in islands of Flores, Pintja and Pador, apart from Komodo, Indonesia. Occasionally it attacks and kills people. It is also known as Komodo Lizard or Ora.

Komodo Dragon

There are no poisonous lizards in India, and there are only two poisonous lizards in the world **Gila Monster** (*Heloderma suspectum*) and **Beaded Lizard** (*Heloderma horridum*) both found in parts of US and Mexico.

Cases of food poisoning attributed to home lizard falling into food are not due to the poisonous nature of the flesh of the lizard. It is often a case of salmonella or other bacteria either present with the lizard or otherwise.

Order Chelonia

Tortoises, Turtles and Terrapins come under the order Chelonia. In USA, all species are included while in UK, only marine species with legs modified, as paddles are included under tortoises. Terrapins are fresh water dwelling species. In India there are 32 species out of 242 species in the world. Sizewise they vary from very small ones to very large ones.

Mud Turtle (*Kinosterron subrubrum*) 8 cm long

Galapagas Tortoise (*Geochelone elephantopus*) 1.2 m
Aldabra Tortoise (*Geochelone gigantea*) 25 cm and 250 kg
Leather Back Sea Turtle (*Dermochelys coriacea*) 200 cm and 650 kg

Turtles appeared on the face of earth about 200 million years ago and they are considered as the longest living reptiles. Although accurate records are difficult to locate it is assumed that they live upto or over 100 years. Turtle shells have two parts, the upper one, carapace and the lower one, plastron that are joined on either sides. Organs like legs, head and neck can easily be drawn into the shell. Turtles are seen on all parts of earth from temperate to warm climates, but they are more numerous in warmer climates. Mouth is devoid of teeth and jaws are equipped with sharp and serrated edges. Eyesight is excellent and some species are capable of identifying colour. Hearing faculty is poorly developed and vocalisation is also very poor. Most of the time they remain silent, but at times they produce barking and grunting noises. Aquatic turtles are carnivorous, but the **Green Sea Turtle** (*Chelonia mydas*) is herbivorous and mainly feeds on seaweeds. Some aquatic turtles are omnivorous.

Tortoises (Land turtles) are herbivorous and feed on plants. They lay leathery eggs varying in number from 1-200. Incubation depends on the warmth of the soil and incubation period can vary from few weeks to ten months, depending on the species. Low temperature produces males and high temperature females, as opposed in crocodilians. Turtles are scavengers of aquatic ecosystem.

Order Crocodylia

Crocodilians include crocodiles, alligators and gharials. They are native to tropical rivers and estuaries worldwide. Crocodiles grow up to 7.5 meters in length. Unlike alligators fourth tooth from the front on each side of the lower jaw is exposed in crocodiles, when the jaws are closed. They feed on a range of vertebrate preys and are descendants of an ancient reptile group, the archosaurs, which included the extinct

dinosaurs and the petrodactyls. Eggs of crocodiles are hard unlike the leathery ones of the snake. They first appeared on earth 150 million years ago and are the last survivors of the dinosaurs that dominated the earth for 150 million years and then became extinct 65 million years ago. Under the order crocodilia, Family Crocodilidae has 14 species and there are three crocodilians in India. i.e., Mugger or Marsh Crocodile, Salt Water Crocodile and Gharial. In water, crocodiles swim very fast with their powerful tails and on land they can fast strides for short distances. They can hold their breath for long periods up to one hour and hence can remain underwater for long time. They forage at night usually near the edge of water and have sharp teeth, which are replaceable.

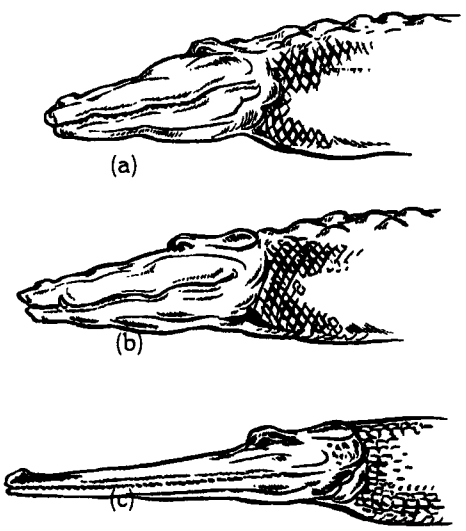
Mugger or **Marsh Crocodile** (*Crocodylus palustris*) is found out throughout India, Sri Lanka, Nepal, Pakistan and westward as far as south of Iran.

Gharial or **Ghavial** (*Gavialis gangeticus*) is found in North India, Pakistan, Nepal, Bangladesh and Myanmar. There is only one species of Gharial in the Indian sub-continent. It may grow to a length of 6.6 metres and has a very narrow snout. In males tip of nostrils is swollen as a bulbous 'pot' (Ghara in Hindi means pot).

Salt Water Crocodile (Esturine Crocodile or Indo-Pacific Crocodile) (*Crocodylus porosus*) It is found from the northeast coast of India and Sri Lanka eastward through southeast Asia, New Guinea and Philippines to Northern Australia, Solomons and Fiji islands.

Crocodiles live in captivity for upto 50-60 years. The esturine species may venture into the sea but it is not a marine mammal. Mugger and Salt Water Crocodiles walk on land with its belly and attain a speed of 5 km/hr. Gharial is poor in walking and hence hardly strays away from water. Crocodiles keep their mouth open to cool their body by allowing evaporation. Teeth are numerous in number and are replaced every two years. Since the nasal opening is situated at the tip of the snout, they can breathe even if the rest of the body is submerged in water. This is also true with their eyes and their range of vision is

very wide and sharp. A prey at a distance of 100 metres is easily located and the presence of tapetum lucidum adds to its capacity of night vision. Auditory faculty is highly developed and they can listen to under water sounds. Unlike other reptiles, crocodilians cannot stick out their tongue since it is fused with the lower jaw. Upper jaw is fixed and the lower jaw moves downward. Interestingly the muscles used for closing the jaws are very strong while the muscles for opening the jaw are very weak. Hence a quick snap can generate several thousand kg/sq. cm pressure. Its mouth can be kept shut by human beings and is a common means of physical control. Tail is flattened laterally which helps in swimming. Major food is fish, crustaceans, turtles, birds and small mammals. Large crocodiles like the Mugger and Salt-water crocodiles may prey on dog, deer, monkey or even buffalo. Muggers are not man-eaters, but salt-water crocodiles and Nile crocodiles are reported to be man-eaters. Number of eggs laid varies from 5-150 depending on species, size and age of the animal. Mugger is the only crocodilian that lays two clutches of eggs in a year. Crocodiles usually lay eggs in nests built on land near water. Salt-water crocodiles lay their eggs on elevated mounds made up of earth and plant materials. Sex of the hatchling depends on the incubating temperature of the eggs. Low temperature produces females and high temperatures produce males, this is opposite in case of turtles.



(a) Alligator (b) Crocodile (c) Gharial

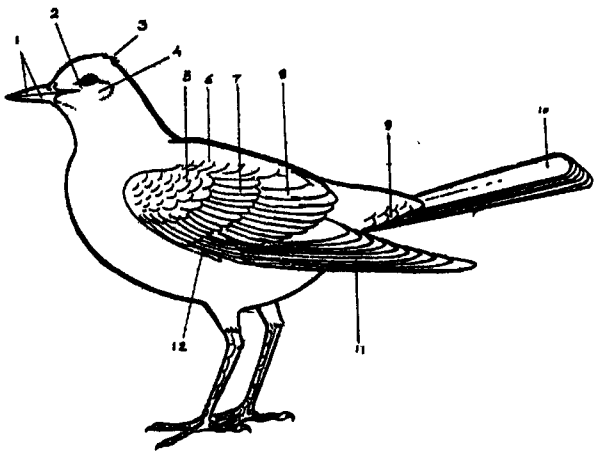
There are seven species of alligators in the world, six in America

and one in China. Alligators though not native to India are found in many of the Indian zoos. Alligators belong to the Family Alligatoridae. Fourth tooth from the front on each side of the lower jaws are hidden, unlike that in crocodiles. Tooth is accommodated in a bony pit in the upper jaw. **American Alligator** (*Alligator mississippiensis*) is from the southeast USA and another rare one is **Chinese Alligator** (*Alligator chinensis*).

Cayman (*Caiman crocodilus*) is a member of the alligator family and there are five species. They are native to the Central and South America and inhabit the rivers and swamps. It may grow up to one metre in length.

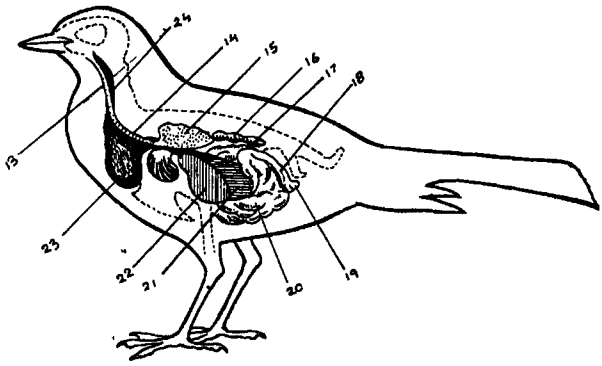
Avifauna

Birds evolved 150 million years ago from reptiles. Forelimbs of birds are modified as wings. Teeth are absent and jaws are modified into bills or beaks. Females lay eggs with hard shells. Body of birds are adapted for flight and hence bones of most birds are hollow reducing their weight. Wings and tail are composed of long feathers that are strong and light. Body of birds is streamlined with feathers that are smooth and overlapping. It is interesting to note that no bird with a weight of more than 13 kg can fly in still air. Heavy birds like Emu and Ostrich are flightless. There are approxi-mately



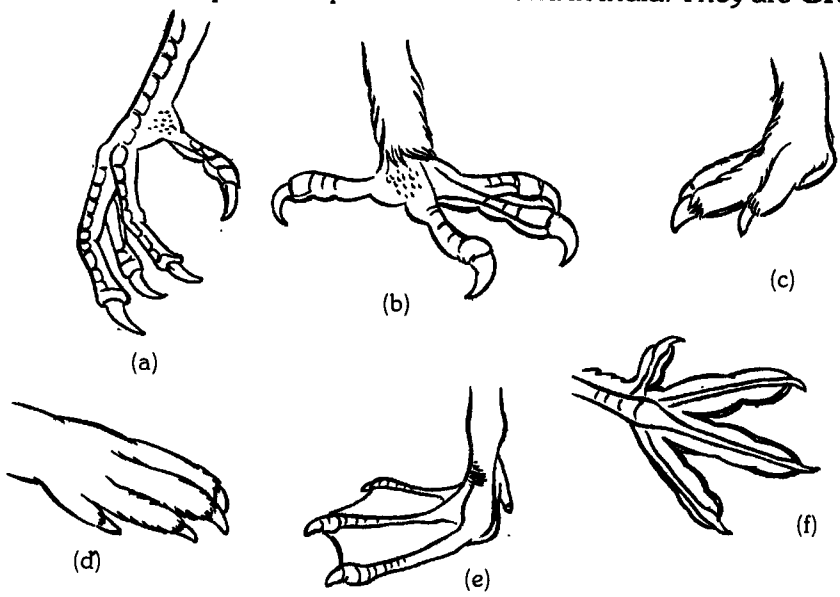
(1) Culmen (2) Lore (3) Crest (4) Ear feathers (5) Lesser wing coverts (6) Scapulars (7) Greater wing coverts (8) Secondaries (9) Upper tail coverts (10) Rectrices (11) Primaries (12) Primary

8600 living species of birds grouped into 29 orders and 181 families. India is rich in avifauna. The main varieties of birds seen are Pelican, Painted stork, Duck, Flamingo, Vulture, Eagle, Falcon, Jungle Fowl, Indian Peafowl, Saras Crane, Siberian Crane (migratory), Great Indian Bustard, Gull, Tern, Parakeet, Koel, Owl, Kingfisher, Hornbill, Barbet, Woodpecker, Drongo, Crow, Myna, Babbler, Baya or Weaver bird, Tailor Bird etc.



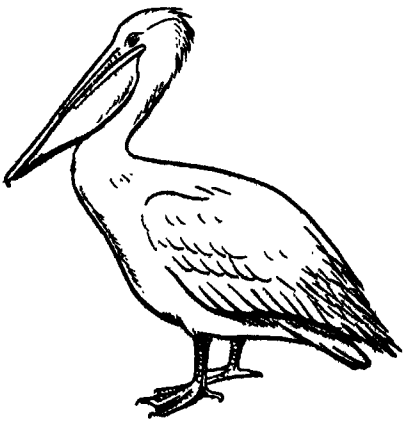
(13) Trachea (14) Syrinx (15) Lung (16) Kidney (17) Testes (18) Rectum (19) Cloaca (20) Intestines (21) Gizzard (22) Liver (23) Crop (24) Oesophagus

Pelican Three species of pelicans are found in India. They are **Grey**



(a) Passeriformes (b) Galliformes (c) Columbiformes (d) Ralliformes (e) Falconiformes (f) Anseriformes

Pelican (*Pelecanus philippensis*), **Dalmatian Pelican** (*Pelecanus crispus*) and **Rosy Pelican** (*Pelecanus onocrotalus*). Pelican can fill its beak as much as its belly can, goes the saying. This is because of its large beak with a sack below. Pelicans are large and heavy birds with graceful flight. They glide in the upper warm air current. They can hardly swim down because of the hollow bones and air sacs in their wings. They are usually seen in shallow waters and they as a group herd fish to a corner and scoop them in their bills. Water is drained through the small holes in their sac. They usually perch on the trees growing in the middle of lakes or other water bodies.



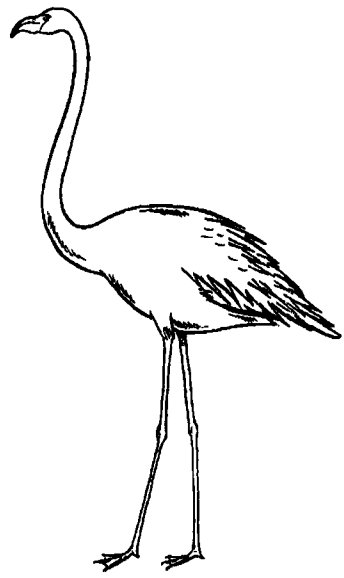
Grey Pelican

Painted Stork (*Ibis leucocephalus*) is similar to the herons. They are large birds with long neck and long stout bill. They fly with their neck and legs outstretched. They are silent and do not produce any sound; however during the breeding season both the sexes make grunting noises by clasping the mandibles. Painted stork is as big as the vulture with a white plumage above, barred with glossy greenish black and black band across the breast. Near the tail, the feathers are rosy pink and hence the name. Face is unfeathered and the bill that is curved at the tip is yellow. They are seen as large or small flocks near the lakes and marshes. They wade in shallow and muddy waters with their beaks opened partially and immersed in water. The prey mostly fish, which is flushed out with one foot and wing of the same side. They also feed on frogs, insects, crabs and snails. Usually they soar up in the sky during the heat of the day. The flight pattern is powerful wing strokes, followed by gliding. Nest is made up of sticks as a large platform with a depression in the centre. Eggs are dull white with white spots and streaks.

Open Bill Stork (*Anastomus oscitans*) is common in wetlands. This bird got its name because of the gap in the mandible. It is a gregarious bird.

Ducks (Anseriformes) **White Winged Duck** (*Cairina scutulata*) is one of the rarest birds of India. These birds are on the verge of extinction and eggs are artificially hatched to build up their population. Another duck, the Pink-headed Duck is already extinct. Majority of the ducks are winter migrants from the Northern hemisphere and use India as their wintering ground. During summer they fly back. Duck shooting was a big past time of winter during olden days and this has taken a heavy toll of the ducks. Indian resident ducks are **Spot Billed Duck** (*Anas poecilor* - Hyncha), **Cotton Teal** (*Nettapus coromandelianus*) **Comb Duck** or **Nukta** (*Sarkidiornis melanotos*) and **Lesser Whistling Teal** (*Dendrocygna javanica*). Migrant ducks, **Grey Legged Goose** and **Bear Headed Goose** come to Northern India and to certain parts of southern India.

Flamingos (Family Phoenicopteridae) Flamingos are large wading birds seen in South America, Africa, Southern Europe and West Asia. Plumage is white or pink and they inhabit shallow sod and brine lakes. They swim well and form immense flocks. They have downwardly curved directed stout bill. They feed with their head in water, sifting food particles with their brush-lined mouth. Family Phoenicopteridae has 55 species. The species seen in India are **Larger Flamingo** (*Phoenicopterus roseus*) and **Lesser Flamingo** (*Phoeniconaias minor*). They breed in the Rann of Kutch and fly across the country to the east coast. They are spread from Chilka lake of Orissa to Sri Lanka.



Flamingo

Vultures are birds of prey that feed on carrion. Head is often without long feathers. There are two groups, old world vultures (Family Accipitridae, 14 species) and the new world vultures or Cathartid vultures (Family Cathartidae, 7 species). They are scavengers in the environment and dispose animal carcasses in no time. Hence it is of great importance to India where many animals die naturally without being slaughtered. Their powerful beaks and naked or near naked neck help them in tearing animal flesh. The most common vulture of India is **White Backed** or **Bengal Vulture** (*Gyps bengalensis*). It is a heavy dark brown bird with naked head and neck, and a white back. The other common vulture is the **Longbilled Vulture** (*Gyps indicus*). **White** or **Scavenger Vulture** (*Neophron percnopterus*) is seen in the drier parts of the peninsula. This is a kite like bird with yellow naked neck and black quills on the wings. This species visits the famous Hindu temple Thirukoizhikundram, near Chennai everyday, punctually and the priests feed them. This species is very useful in cleaning the village garbage and it feeds also on the human faeces. They spend most of the time gliding effortlessly in the sky, by proficiently using the atmospheric thermals. With their powerful eyesight they locate the carcasses and zoom down at an astonishing speed. Olfactory faculty is poorly developed. Vultures build large nests with twigs and leaves on big trees, ruined buildings or cliffs and usually lay one or two large eggs.

Eagles are large bodied birds of prey that kill its own food. They belong to the Family Accipitridae with 30 species. (Smaller birds of prey are falcons, hawks, harriers or kites). They have moderate or sharply hooked bills and powerful pointed and hooked claws to tear flesh. Eagles are a common sight in the forests and semi jungles and play a key role in the biological control of the rodent pests. They also feed on snakes. Eagles are often persecuted by the farmers for snatching chicks and young livestock. Being a predator, eagles are at the apex of the food web in the ecosystem and have an important role to play in controlling the rat and snake population. In India two species of eagles are seen, Crested Serpent Eagle and Short Toed Eagle. **Serpent Eagle** (*Spilornis*

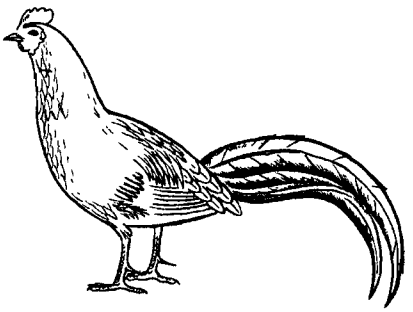
cheela) is a large dark brown bird with a black and white crest and nape of the neck. They rest upright on prominent perches and often vocalise three or four note calls when flying. Major foods include snakes, lizards, rats and birds. During breeding season they show elaborate courting manoeuvres. **Short Toed Eagle** (*Circaetus gallicus*) is a heavy brown bird with white under-parts below the heart, broadly barred with dark brown. Legs are naked without feathers and they feed mainly on snakes and lizards. Their nests are large, platform like made up of leaves and twigs and lay only one egg.

Falcons are birds of prey belonging to the Family Falconidae with approximately 60 species and include the carrion eating Caracara, the Forest Falcon (large eyes, acute hearing, hunts in near darkness) and true falcon (a fast flying predator that usually kills the prey in flight.) Their sharp "tooth" on upper mandible are used to hunt birds and falconry is popular in some countries. Falcon sports medicine is a developed branch of veterinary science. **Shaheen Falcon** (*Falco perigrinator*) is a local variety of **Perigrine Falcon** (*Falco perigrinus japonicus*). It is famous for its swift manoeuvres in flight and is one of the fastest birds in the world. It sweeps down on the prey with an incredible speed of 280 km per hour. It may dive vertically on to the prey or chase in flight. It is also known as the Duck Hawk. Shaheen is usually seen in the hilly terrain. The seized prey is taken to a favourite perch and eaten after removing its feathers. **Red Headed Merleen** (*Falco chicquera*) hunts flying birds. The male and the female join in the pursuit of hunting. One of them flushes the quarry out and the other chases and attacks it. The prey is then taken to the perch and shared. This bird is bluish grey dorsally and white below which is slightly barred and has a chestnut head and nape. They usually rest on inaccessible rough steep rocks or deserted nests of other birds. Shaheen

Shaheen Falcon

uses the same nesting sites every year and this becomes regular if left undisturbed. Eggs are laid in a clutch of three or four in each nest.

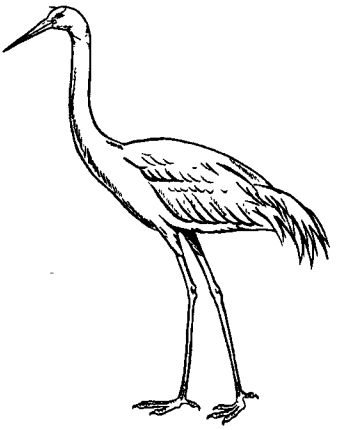
Jungle Fowl (Galliformes). They come under the true pheasants and the genus Gallus has four species. Jungle fowl inhabits the forests and scrub and is ancestral to the domestic fowl. They are stocky birds, with round wings and sturdy legs. Males have spurs, which are claw like projection at the back of the cock's leg. Stout blunt claws help to scratch the soil. Common species seen in the peninsular India is the **Grey Jungle Fowl** (*Gallus sonneratii*). It is restricted to the well-wooded parts and the thick scrublands of western peninsula. The male is streaked with grey and with black sickle shaped tail. It is brown above and white below with black scaly markings. They cackle loudly in early morning and late evening and other cocks follow the calls. In Northern India, the **Red Jungle Fowl** (*Gallus gallus*) is common and is considered as the ancestor of all modern domestic breeds of poultry. In appearance the Red Jungle Fowl very much looks like Bantam breed of poultry.



Grey Jungle Fowl

Peafowl (*Pavo cristatus*) Peafowls are seen in India and other countries of southeast Asia. Peacock is known for its resplendent train extending up to 1.5 m in which each feather end with brightly coloured, ring shaped design often called as the 'eye'. Peacock displays its tail by raising it above and behind its head. Males are usually blue green or green bronze in colour. Pea hens are green or brown and lack a train. These birds are known for their ill temper. They are found as flocks of 3-6 with a cock and hens. After breeding season segregated parties of adult males and females with their immature broods are common. These birds possess extremely good eyesight and hearing. Their call resembles a hard metallic trumpet.

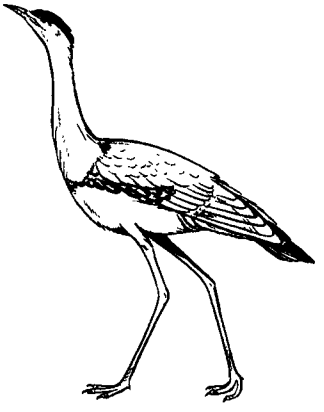
Saras Crane (*Grus antigone*) Family Gruidae has 15 species. Saras Crane is a tall crane with a plumage entirely grey in colour. Lower neck and the tip of the wings are whitish and crown is naked and red. It stays very close to human habitation and not often bothered by human presence in the near vicinity. They are seen in pairs and at times with one or two grown up chicks. Saras Crane is one of the tallest flying birds and males may stand up to a height of 1.6 metres and weigh 12 kg. It is believed that if one bird dies the other cannot stand the separation and ultimately dies. Hence poets often refer to the ideal family as *Karuncha mithuna* or Saras crane couple.



Saras Crane

Siberian Crane (*Grus leucogeranus*) It is one of the most graceful birds. They breed near the Tundra River of former USSR. They are winter migrants to Keoladeo Ghana National Park (Bharatpur) and are becoming rare year after year. Earlier about fifty birds used to come to India every year. It is suggested that some plants and their roots available at the Bharatpur are the main attractions for these birds.

Great Indian Bustard (*Choriotis nigriceps*) Bustard is a large, long legged grand living bird seen in Asia, southern Europe, Africa and Australia. Family Otididae, to which the Bustard belongs, has 24 species. They often walk on the ground, even though they are capable of good flight. This bird is hunted heavily for its meat. During mating season they perform ritualistic courting dances. Eggs are laid on the ground and camouflaged. They make a peculiar sound of call very

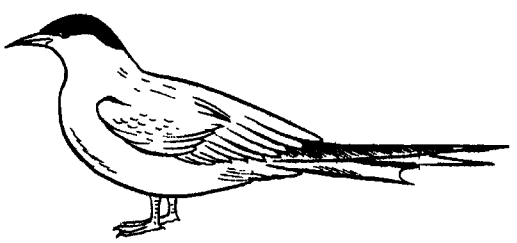


Great Indian Bustard

much similar to the horn of an olden day motorcar or bus with the air bellow. Clandestine hunting has reduced their number drastically. They are hunted using firearms as well as by trained falcons. This bird is protected by The Indian Wildlife (Protection) Act, 1972.

Gulls (*Laridae*) are medium or large birds found worldwide usually near water sources. Feet are webbed, plumage white, grey and black. Wings are large and slender with long stout bills. Family Laridae has 44 species. Gulls are excellent oceanic fliers, but poor swimmers. They are seen in flocks of few to several hundreds over, seas, oceans and harbour or seashore. They often scavenge on the refuse and other floating garbage. Fish and other marine mammals also form their food. They make simple nests on the ground in large colonies. Gulls are a common sight along the extensive coastlines of India. Common species found in India are **Brown Headed Gull** (*Larus brunnicephalus*) and **Black Headed Gull** (*Larus ridibundus*). Latter is a migrant to India during the winter months. The former has a brownish head in summer, but in winter they assume a greyish colour of the head. They are seen in plenty near harbours, coastal fishing villages, hovering over the ships and fishing boats on the look out for garbage thrown into the water or alight on water and feed. In inland they also feed on insects grubs and young tender shoots of vegetation. Brown headed gulls breed in the high altitude lakes of Ladakh and Tibet. Nest is made using waterweeds and the bird lays 2-3 eggs at a time.

Terns (Laridae) Terns are small gull like sea birds seen worldwide. Plumage is usually pale with a black cap and forked tail. Head may be with an erectile crest or smooth. It is usually put in Laridae, but some classify them in a separate Family Sternidae. Terns are oceanic birds and are excellent fliers. They often rest on the shores on their short legs. They are seen as



Indian Whiskered Tern

flocks over the coasts, marshlands and inland waterways. They are slender than the gulls, but with larger and more pointed wings. Both resident and migrant terns are seen in India. Resident terns are **Whiskered Tern** (*Chlidonias hybrida*); **River Tern** (*Sterna aurantia*) and the migrant varieties include **Caspian Tern** (*Hydroprogne caspia*) and **Gull Billed Tern** (*Gelochelidon nilotica*). They often spend their time flying in the air and swoop down after locating the prey.

Parrots and Parakeets (Pscittacidae) Parrots are colourful birds found in the warm climates with a large hooked bill. They are good at mimicking human voices. Family Psittacidae has nearly 300 species. Parakeets are small parrots with large pointed tails with approximately 37 species. Legs are strong with two toes pointing backward and two pointing forward. This helps the bird to climb on the branches. Often the hooked bill helps to climb the trees as a third foot. The common Indian species are the **Rose Ringed Parakeet** (*Psittacula krameri*), **Large Indian Parakeet** (*P. eupatria*) and **Blossom Headed Parakeet** (*P. cyanocephala*). Rose ringed parakeet is grass green in colour with a long pointed tail. A black and pink ring is seen around the neck in male birds. They are commonly seen in gardens orchards both in rural and urban areas. The latter two species prefer wooded country to the first. The large Indian parakeet as the name suggests is larger and has a maroon patch over the shoulder in males. The blossom headed parakeet is smaller with a red head in the male and grey head and yellow collar in females. They are popular cage birds and as flocks they turn out as pests for fruit growers. They are trained to mimic human words and "talk". Nests are made on the tree trunks, walls and cliffs. They lay four to six eggs, white in colour, at a time. Several pairs may nest in the same area.

Koel (*Eudynamys scolopacea*) Koels and Cuckoos seen worldover belongs to the Family Culculidae with 130 species. About fifty species are described. They do not build their nests, but lay eggs in the nests of other birds and the young are reared by the foster parents (brooder parasite). Males and females look differently. Males are black like crow, but slimmer with longer tail, shiny black. Eyes are red. Females are

brown with white specks. The males drive the crows in a chase meanwhile the female lay eggs in the crow's nest. Since the eggs of koel look very much like that of crow, the female crow brood on the eggs and hatch them.

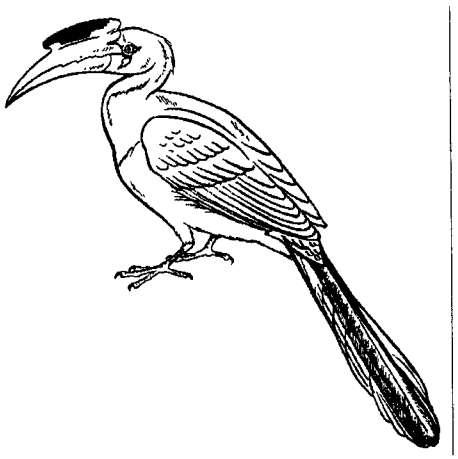
Owls (Strigidae) Owls are predatory birds, nocturnal in habit seen worldwide. They have a broad flat face and forwardly directed eyes. This gives them stereoscopic vision that is important for a predatory bird. They have acute vision and sharp hearing senses. There are two families; typical owls (Strigidae, with about 120 species) and barn owls, grass owls and bay owls (Tytomidae, 11 species) Tytoninae differ in having smaller eyes, long slender legs, serrated middle claw and a face that is heart shaped (order Stringiformis). **Barn Owl** (*Tyto alba*) is the most common owl having worldwide distribution. Their legs are feathered and feed on small vertebrates especially rats. They also feed on insects and are considered as friends of farmers. Genus Tyto coming under Family Tytonidae has six species. Other small owls are **Jungle Owlet** (*Glaucidium radiatum*), **Collared Owlet** (*Otus bakkamoena*). Large owls include **Great Indian Horned Owls** (*Bubo lubo*) and **Brown Fish Owl** (*Bubo zeylonensis*).

Great Horned Owl

Kingfishers (Coraciformes) Kingfishers have worldwide distribution. They are more abundantly seen in the tropics of the old world. It is a short tailed bird with large head with a long and straight bill. Feathers are bright coloured with blue green black. They belong to the Family Alcenidae with 85 species. Kingfishers predate mostly on fish. The commonest species is **White Breasted Kingfisher** (*Halcyon smyrnensis*), which is myna-sized bird with brilliant blue wings and chocolate coloured under-parts. Breast is white coloured. They make loud ringing call. They are commonly seen perching on branches near riverbanks and ponds, occasionally diving into water to catch fish.

Small Blue Kingfisher (*Alcedo atthis*) is only of the size of the sparrow. Many species feed largely on terrestrial insects and other small creatures and they are less dependent on water.

Hornbill (Bucerotidae) This is a large bird native to South Asia and Africa. Family Bucerotidae has 45 species. They have large bill, often brightly coloured and having an ornamental outgrowth on the top. Plumage is black brown and white. They are mostly fruit eating, but also feed on insects, lizards and small mice. A special thing about hornbill is that the female is kept sealed in the hollow of a tree with a small opening through which it is fed by the male. Different types of hornbills seen in India are **Large Indian Pied Hornbill** (*Anthracoceros malabaricus*), **Malabar Pied Hornbill** (*Anthracoceros coronatus*) and **Great Indian Hornbill** (*Buceros bicornis*).



Malabar Pied Hornbill

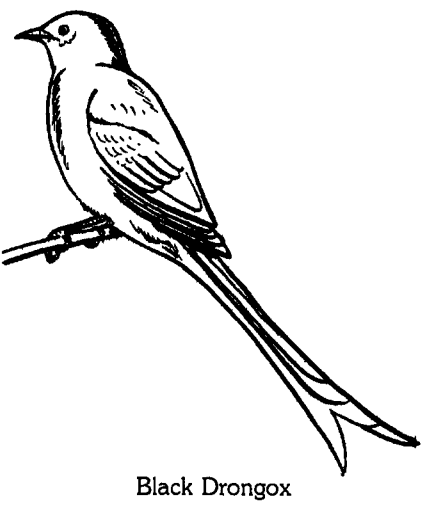
Barbets (Capitoridae) Barbets are small tropical birds with a bristly beak. They are grass green in colour, with yellow throat and green streaked yellowish underparts. They feed mostly on fruits and are practically entirely arboreal. Usually they are seen solitary or in pairs. Sometimes a flock upto a dozen can also be seen. They are seen in large numbers at some feeding sites like fruit bearing trees along with bulbuls, mynas, green pigeons and other frugivorous birds. They vocalise more during the hotter parts of the day and are often silent during the colder parts and when it rains.

Woodpeckers (Piciformes) They belong to the Family Picidae (198 species). They cling to the tree trunks with a stiff tail that presses against the tree except in small species like piculets, Sub-family Picuminae has

27 species. There are several species of woodpeckers in India. They feed on wood boring beetles and grubs that damage the trees. Beetles and grubs are taken in with its chisel like bill and long protrusible bar tipped tongue. The tongue is a real adaptation to its feeding habits. The whole apparatus slides over to protrude the tongue far beyond the bill. The feet have two toes pointing forward and two pointing backward to hold and climb on vertical trees. Common species seen in India are **Golden Backed Woodpecker** (*Dinopium benghalense*) and **Mahratta Woodpecker** (*Dendrocopos marattensis*) Nesting is done in holes chiselled out on decaying branches of trees and they lay upto three eggs. On horizontal branches they make a hole at the under surface probably to keep the rain out. Both male and female incubate the eggs.

Mahratta Woodpecker

Drongo (*Dicrurus adsimilis*) A bird native to the tropics having a glossy black plumage, forked tail, often seen in woodlands. They belong to the Family Dicruridae with 20 species. Drongo is often called as the King Crow and often feed on insects. One of the large varieties, called **Racket Tailed Drango**



Black Drongox

(*Dicrurus paradiseus*) is a forest dweller, while others are seen in plains. Racket Tailed Drongos are often seen close to troops of Lion Tailed Macaque. The troop moves around disturbing the insects resting on the branches and these birds leap on the branches to catch them. Sometimes the chirping noise of Racket Tailed Drongos leads to the monkey troop. These birds are good at aerobics and sometimes display it while catching flying insects.

Crows (Corvidae) The name crow is used as a common name for the whole family or for the 40 species coming under the genus Corvus. Crow is one of the most intelligent birds. **Common Crow** (*Corvus splendens*) is seen close to human habitations. They feed practically on anything and hence are good scavengers. **Jungle Crow** (*Corvus macrorhynchos*) is all black and larger. Its neck is black in colour unlike the ordinary crow that has a grey neck. They build nests on tree branches and on electric posts. Hence crow guards with sharp pointed spikes are fitted on electrical installations. Jungle Crow feeds on carnivore kills and hence their presence may indicate the presence of a kill nearby.

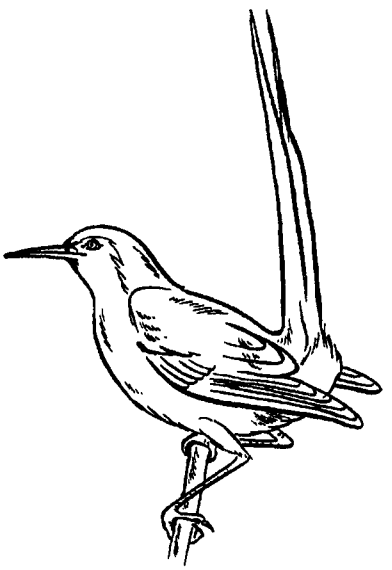
Mynas (Sturnidae) Myna is a bird of Starling Family (13 species) native to India and southeast Asia. It is very good at imitating sound and speech. Nearly half a dozen varieties are seen in India. They follow grazing cattle to catch insects and this is a common sight. They roost at night in large numbers and make plenty of noise in the morning and evening. The ability to mimic speech makes them good pets. Interestingly there is a competition being held in Malaysia for talking Mynas. **Hill Myna** (*Cracula religiosa*) is the best among the mynas for imitating speech.

Babblers (Timalinae) Babblers are songbirds of warm tropics of old world. They possess short wings and the plumage is soft and fluffy. Family Timalidae has over 250 species. They are noisy birds, popular visitors to the gardens and the seven sisters are unique. They remain in groups of seven or more and hence the name and are capable of imitating voices of other birds. Their continuous and incessant chatter

gave them the name of babblers. While feeding a pair of them descend to the ground followed by the "rest" of the sisters. At the slightest disturbance, all of them lift off to tree branches. Common Babbler has a slate coloured head, yellow eye and red or brownish red belly. Seven sisters really make the garden and the surroundings live.

Bay or **Weaverbird** (*Ploceus philippinus*), very much look like sparrows. But not all species weaves nests that hang from the branches. By monsoon the males grow a bright yellow patch on its head and chest. Male builds a nest on a Palmyra palm or babul. The female comes and has a look at the half built nest and chooses its mate whose nest appeals to her most. Then they work as a team to complete the nest. Eggs are white in colour. Female broods and looks after the hatched chicks. Meanwhile the male may build another nest and raise another family. They are sociable and are seen as flocks. The bottle like nest is with two entrances, one real and another fake, probably to keep the snakes off. Since they build and weave its nest, it got the name weaverbird.

Tailor Bird (*Orthotomus sutorius*) It is a warbler, coming under Family Sylvidae, native to India and southeast Asia. They make a nest by folding a large leaf and sewing the edges together. Stiches are separate and made with wool, silk or spider's web and hence the name, tailorbird. Genus Orthotonus has nine species. It keeps its tail wagging up and down. They are commonly seen among bushes and trees going in search of insects.



Tailor Bird

Exotic Flightless Birds

Ratites are flightless running birds. Breast bones of these birds have lost their keel and are flat.

Ostrich (*Struthio camelus*), Family Struthionidae, is the largest living bird and may measure upto a height of 2.75 metres and weigh up to 150 kg. Although provided with a wing, it cannot fly. While running the wings are stretched to keep balance and direction and interestingly it is the fastest bird on two legs. Long legs and stride help it to reach a speed of 70 km/h. Ostrich lays the largest egg of any living bird. It inhabits the dry areas of Africa.

Emu (*Dromaius novaehollandiae*), Family Dromaidii, is a flightless bird native to Australia. It is the second largest living bird after Ostrich. It reaches a height of 1.9 metres and reaches a speed of 50 km/h while running.

Cassowary (*Casuarius casuarius*) is a large flightless bird native to New Guinea. Head is naked and has a bony outgrowth, casque, used as a shovel to uncover food. Feet are provided with long claws and hence its kick may prove fatal. There are three species in the Genus Casuarius and Family Casuariidae.

Rhea (*Rhea americana*) is a South American Ratite and resembles Ostrich, but smaller. They reach a height of upto 1.5 metres. Plumage is dull and wings are large. It is a good swimmer. It is also known as *Ema nandu* or American Ostrich. Rhea belongs to Family Rheidae and there are two species.

Kiwi (*Apteryx sp.*) is a nocturnal flightless bird native to New Zealand. They have small eyes and an acute sense of smell that is rare in birds. Bill is long and curved with nostrils at the tip. Legs are strong. Kiwi belongs to the Family Apterygidae, Genus Apteryx and three species are described.

Chapter 2

Habitat

Habitat is a place in an ecosystem where a particular organism lives. It is described in terms of its climatic, vegetative and topographic factors. These factors vary in space and time for different habitats. In a forest, the thick canopy at the top is a different habitat compared to the ground level. This assumption holds well between seasons also. The term microhabitat describes a very small area, like a few square centimetres. e.g., undersurface of a stone or a fallen tree.

Climatic Zones of the World

The climatic zones of the world are classified into distinct zones based on the latitude but modified by the altitude and proximity to the sea. This zonation is seen both in flora and fauna. Globally habitats are classified as given below :

1. Polar regions
2. Coniferous Forests
3. Deciduous Forests
4. Mediterranean Scrub
5. Evergreen Forests
6. Grassland
7. Deserts
8. Tropical Rain Forests
9. Mountains
10. Oceans.

Zoogeography

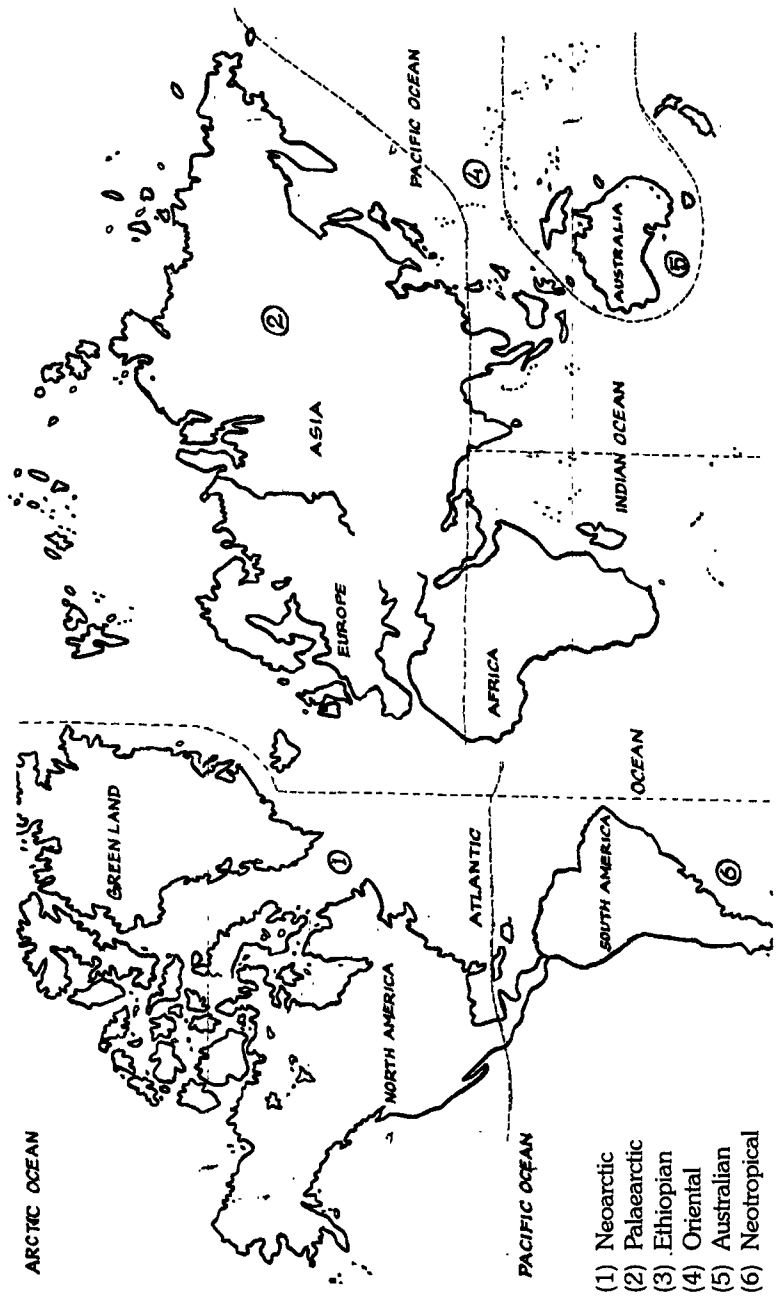
As a consequence of the continental drift the world today can be divided into nine zoogeographical regions.

Table 2.1 Zoogeographical Regions of the World

Region	Areas
1. Neoarctic	North America and Green Land (Floristically southern parts of US and Mexican highlands belong to the Neotropical regions).
2. Palaearctic	Eurasia (Except India) Iceland, Canary Islands, Korea, Japan, Northern Africa.
3. Ethiopian	Africa and Sub-Saharan region.
4. Oriental	India, Indochina as far as the Wallace line, which runs through the strait of Macassar; which runs between Borneo and Celebes and Lombok strait between Bali and Lombok.
5. Australian	Australia, New Guinea and Islands east of the line named after Richard Lydekker.
6. Neotropical	South and Central America including the Antilles.

Adaptation

Every animal is a bundle of adaptations. To avoid competitions within a particular environment, animals adapt to the life in one part of the environment, a habitat within a habitat that is known as ecological niche. This is very marked in the rain forest where there is a rich diversity. Animals use different food resources (e.g.; graze and browse). Herbivores are most numerous and along with insectivores and smaller carnivores contribute to the food source of the larger carnivores. Most herbivores especially the hoofed stock that lives in open country depend on speed, herding instinct (any herd-mate can notice danger) and colouration that blends with the background to help them to escape from predation. They are endowed with larger area of vision (eyes are situated on either sides of the head) and greater olfactory faculty. Horns and antlers are the major means of defence. Primates escape from the predators by their ability to climb on the trees and leap or glide. Smaller mammals seek burrows and holes. Specialised defence mechanisms like the offensive discharge of the skunk, quill (spine) of porcupine and hedgehog and armour plating of the armadillos and pangolins are examples for this. Carnivores feed on the meat of smaller and weaker animals. Typical examples are the lion and tiger. They move quickly


ARCTIC OCEAN
GREEN LAND
NORTH AMERICA
ATLANTIC
OCEAN
PACIFIC OCEAN
SOUTH AMERICA
EUROPE
ASIA
AFRICA
INDIAN OCEAN
PACIFIC OCEAN
AUSTRALIA
(1) Neoarctic
(2) Palaearctic
(3) Ethiopian
(4) Oriental
(5) Australian
(6) Neotropical

and intelligently for short distances to catch the prey after stalking silently. Their colouration often blends with the surroundings until the last moment. Strong sharp claws, well-developed incisors and stout limb muscles are the characteristics of the flesh eaters. Predators are having stereoscopic vision for proper depth assessment and pouncing. There are species like hyaena, which are both hunters as well as scavengers. Many rodents are omnivorous in habit and hence they can take advantage of any available food.

Ecological Sub-divisions of India

It will be convenient to look at the ecological sub-divisions to have an idea of the flora and fauna in the Indian sub-continent. Present physiography and the climate of the Indian sub-continent took shape during the late Pliocene period and support a wide variety of habitats that in turn supports distinctive types of flora and fauna.

1. Himalayan Mountain Region

Animals in the high altitude are mostly the Palaearctic type. Animals like bear, wild pig, tiger and snow leopard are found on either sides of Himalayas. They might have come to this side of Himalayas immigrating through the narrow passage way seen at the flood plains and the gorges of the Brahmaputra and Ganges river systems or they were there before Himalayas grew up in altitude and became insurmountable as it is today. Changes are seen in a latitudinal as well as eastwest variation in the region. They are :

(i) Himalayan foothills that cover the eastern frontiers of Kashmir and Assam.
(ii) Higher altitudes in the western Himalayas from Kashmir including Ladakh and Kumaon.
(iii) The eastern Himalayan regions.

2. Peninsular Indian Sub-region

The northern part is the alluvial plains of the Ganges, the Indus and the Brahmaputra rivers and their tributaries. It is a triangular plateau with an altitude ranging from 300 to 900 meters. The other boundary comprises of the Western Ghats, Eastern Ghats and the

Vindhya Mountains. This is the true home for Indian fauna like Spotted Deer, Nilgai, Black Buck, Four Horned Antelope and Sloth Bear. The other species like Guar, Sambar and Muntjac occur both in India and Malay countries.

3. Tropical Evergreen Forests or the Indo-Malayan Sub-regions

The fauna has similarities between both Indian as well as Malayan and Indo-Chinese fauna. The rain forests and the Western Ghat are climatically similar to other tropical rain forests of the region. A wealth of species fauna like Red Panda, Gibbon, Tree Shrew, Tapir, Giant Squirrel and Flying Lemur are exclusively seen in this region.

4. Desert Region

Desert regions are seen globally on the western margins of the landmasses like the deserts of Peru, California, Arizona, Mexico, Kalahari in South Africa and the desert areas of Western Australia. Examples for the deserts in the interior land masses are Thar and the Gobi desert of Eurasia, Sahara of North Africa which extend from one coast to another.

The Indian desert regions consist of the trans-Indus districts of Punjab, Western Sindh and Baluchistan valley, forms the eastern limits of a great desert region that extends through Iran, Iraq and Arabia to the desert portions of North Africa. The desert wildlife differs very much from the rest of the Indian subcontinent. They are more akin to Ethiopian realm. Desert regions of India were a fertile land some 5000 years ago and historians called it the Indus Valley Civilisation. Poor agricultural practices, deforestation and overgrazing by the livestock, probably destroyed the wildlife. Even now the nomadic tribes of Rajasthan are mainly pastoral and have large herds of livestock. The process of desertification is continuing and it is estimated that the desert is extending nearly 8 km in every decade in the northwest periphery.

5. Tropical Rain Forest Region

As the name indicates this region consists of heavy rainfall areas. They are northeastern India (Khasi-Jainta hills and lower Himalayan

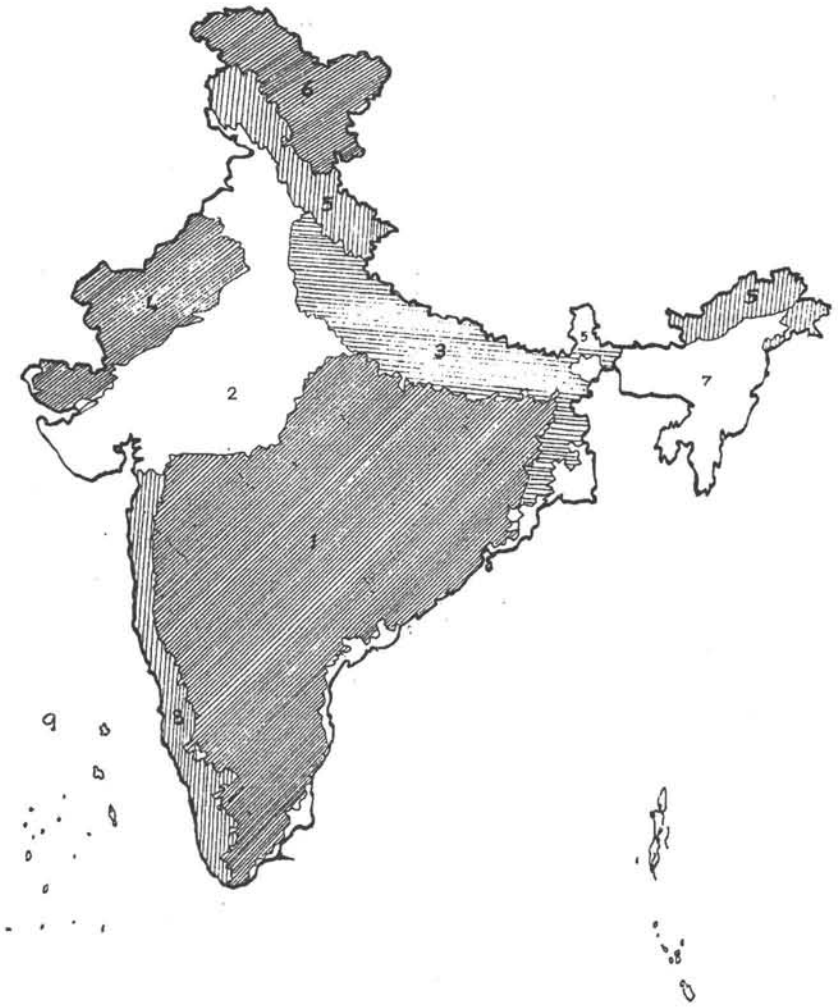
slopes consisting of Arunachal Pradesh, Assam, Meghalaya, Nagaland and Tripura) and Western Ghats of the south including Malabar Coast that has a sharp contrast to adjoining dry areas of the Deccan. The Nilgiris which is an off shoot of the Western Ghats has extensive grassy downs and table lands interspersed with dense forest gorges known as the Sholas.

Fauna: This rich habitat provides environment, to a number of animals. On the ground many herbivores are seen (i.e., elephant or solitary deer like the barking deer). Many of them are good climbers and fliers. Important tree dwellers are non-human primate like Hoolock Gibbon, the only ape of India, seen in Arunachal Pradesh and Assam, Leaf Monkey or Capped Langur, Assam Macaque, Pig Tailed Macaque. In south, Lion Tailed Macaque that is endangered and rare, Nilgiri Langur and the Bonnet Macaque. Slender Loris is seen in northeastern India. Bats are widespread, Giant Squirrel and Civets. Binturong and Red Panda are both rare and seen in the eastern regions only. Other species are Flying Squirrels, Nilgiri Mongoose, Stripe Necked Mongoose, Spiny Mouse and Malabar Civet. In the high altitudes of Nilgiris and Anamalais, fauna of Himalayan type are seen e.g. Thar, Pine Marten and European Otter.

Table 2.2 Biographical Classification of India

	Regions	%*
1.	Trans-Himalaya	5.6
2.	Himalaya	6.4
3.	Desert	6.6
4.	Semi-Arid	16.6
5.	Western Ghats	4.0
6.	Deccan Peninsula	42.0
7.	Gangetic Plain	10.8
8.	Coasts	2.5
9.	Northeast	5.2
10.	Islands	0.3

* Represents percentage of the total geographical area of India: 3287263 sq. km. (*Source: Rodgers, Panwar & Mathur 2002*)



India : Biogeographic Zones

1. Deccan peninsula
2. Semi-Arid
3. Gangetic plain
4. Desert
5. Himalaya
6. Trans-Himalaya
7. Northeast
8. Western Ghats
9. Coasts
10. Islands

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Chapter 3

Principles of Captive Management of Wildlife

Collection of wild animals for entertainment and curiosity started very early and such a collection with the name of Menagerie started centuries before. They can be called as living natural history museums. The menageries were the efforts of the kings and chieftains. They subsequently graduated into zoological parks as living museums and they were to act as conservation centres. In India a milestone in this regard was the formation of an autonomous Central Zoo Authority (CZA) in 1991. Central Zoo Authority has a membership of 12 persons (half officials and half non-officials) chaired by the Minister of Environment and Forests. The objectives of CZA are concerned with the following aspects of zoos :

(1) Minimum standards,
(2) Evaluation and recognition,
(3) Captive breeding management,
(4) Training professional development and research, and
(5) Public education.

The CZA has a generous budget, the major portion of which is distributed to zoos on a 50% matching scheme with their administrative authorities to improve their facilities for various animals and their visitors. The primary objective of zoo is now conservation, education and research while entertainment is only secondary. The Central Zoo Authority has published a book with a title *Zoos Instrument for Conservation* very often called as the "Blue Book", contains the National Zoo Policy and Statistics and Guidelines related with Zoo Management. Apart from general rules on recognition of zoos and

National Zoo Policy, this book gives guidelines on Safari parks, Deer parks, upkeep of elephants, population control, creation of rescue centres, disposal of carcass, euthanasia, *ex-situ* conservation and IUCN guidelines for, state gift of animals and re-introduction guidelines. The book gives a list of animals under Schedule I and Schedule II of Wildlife (Protection) Act, 1972, as well a list of important zoos.

Housing and Sanitation

Housing forms an important aspect of husbandry practice. Designing an enclosure for a wild animal depends on the animal's physical activities like climbing, burrowing, jumping and wallowing. Climate and biological requirements of the social group in wild has to be considered. Some animals in the wild live as single (e.g., Tiger) while most of the herbivores live in herds and primates in troops. Enclosure design should ensure that the animal does not escape and at the same time gets enough space to meet its biological needs. Provision to have a safe buffer zone between the visitor and the animal is important for human safety, safeguard against visitor disturbances and to prevent zoonoses. It should ensure easy handling of animals on a daily basis by the keeper for feeding, cleaning and if necessary for monitoring the animal closely for veterinary purposes. Enclosure should have provision for easy viewing by the visitors as well as shifting, treatment and crating.

Adequate living space depends upon the species to be exhibited, providing free movement and exercise as well as protecting from extremes of temperature. All Indian zoos should have enclosures confirming to "Recognition of Zoo Rules — 1992". This prescribes size of feeding area, retiring cubicle/enclosure requirements for important mammalian species kept in the zoo (see Appendix Nos. 2 & 3 for space requirements of different species of animals). There must be enough ventilation for comfort and welfare of the animal and lighting depending on the nature of the animal like nocturnal or diurnal. The biggest problem that is encountered in the zoos is the division of the enclosures when the animals multiply. Population control

is the need of the hour in Indian zoos from the point of view of physical as well as economic management. The quality and type of enclosure are of great importance depending upon the different type of species. Broadly based upon the nature of the animal four types of classification are made.

1. Flying, climbing or arboreal i.e., animals that often prefer to be above the ground. e.g., primates, birds, bears.
2. Terrestrial (walking, hopping, crawling) e.g., Deer, antelope.
3. Burrowing or digging e.g., Pangolins, burrowing snakes.
4. Aquatic or needing water frequently or always e.g. Dolphins, Crocodiles, Hippopotami, Rhino, Waterfowls.

Hence enclosures are designed and maintained in such a way that it looks like a "home away from home" as far as possible to meet the biological needs of the animal. The biological, physiological and socio-psychological needs vary from taxa to taxa. The enclosure should be furnished to enrich the environment. Environment enrichment has grown into a full-fledged branch of science. Enriched environment helps the animal to enjoy the liberty, display their natural habits and instincts and perform breeding rituals like dancing, courting, play, chase, explore, display or establish their dominant hierarchy. This is more important in animals of high intelligence, like primates, bear and elephant. Otherwise they tend to develop stereotypic movements like pacing, circling, head swinging and similar symptoms. Enclosures should have resting and retreating places (sleeping shelves, perches, platforms, trees, caves or sand banks), hiding places (dens, burrows, holes, bushes, stone heaps), place to give birth or brood (nesting boxes, nesting materials and hollow trees), grooming (for skin and claws-pawing logs, stones, pools, wallowing pools, mud bath, dust bath), camouflage (trees and branches, various types of vegetation) and mental stimulation (swings, balls, poles) that can be changed periodically to avoid boredom. Objects for play are very important for animals. These stimulates their play with litter-mates. Enclosures should be free from health hazards like broken glass, nails, toxic fruits, sharp corners or any similar objects or poisons that could be hazardous to the animals.

Provision to keep the animal in confinement like moats (dry or wet) can cause injury or even death to the animal. Wide and deep moat with steep and high gradient from the animal's side is hazardous. Animals either accidentally or during a fight or play may fall into the most and get drowned or injured. Hence the sides should be made in such a way that animals can climb up without much difficulty and without external assistance. The wet moat without sufficient water itself is a health hazard providing a breeding ground for mosquitoes algae and decomposition of the plant waste materials and ultimately the moat itself starts stinking.

Fence barriers like chain link fence may not give a visual barrier for the timid animals. When they are frightened and chased they run helter and skelter and hit the chain links injuring themselves. Lack of binocular vision in ungulates adds to this by poor depth or distance assessment. A hard floor is required for hoofed stock to prevent the overgrowth of the hooves. Unhygienic tethering site of the elephant can lead to foot rot that is not easily cured. Soft-footed animals should have soft ground, otherwise it can cause sore paws. Similarly pawing logs of soft wood prevents in-growing of nails. Elephant and rhino rub their body on tree trunk and this has beneficial effect for skin in addition to the pleasure they derive out of it. Hence debarking of trees by elephants and many other herbivores has to be considered. A hiding place from the crowds and pestering visitors often helps the animal to avoid stress.

Nocturnal animals require poorly lit areas and hence in many zoos special nocturnal houses are designed to avoid stress and strain. Exothermic animals like reptiles are heat sensitive and hence serpentarium should have provision to keep the temperature in moderation. At least one area of the enclosure should not have access to visitors. This helps the animal to retreat to that area when disturbed by the visitors.Provision for cleaning the left over food, excreta and even flushing if necessary, should be available.

Everyone is aware of the importance of sanitation. However, it is very difficult to maintain the zoo premises clean, especially those ones that are old and overcrowded. Zoo premises are the ideal places for the pathogenic organisms to remain dormant as well as concentrated. The excreta and the left-over food, must be properly discarded. This is more important for carnivore homes. Hard floors should be cleaned with pressure washer and kept free from cracks. Drainage should be sufficient and efficient to keep the animal home clean. Other areas in the zoo where sanitation has to be carefully looked into are picnic spots, toilets, food kiosks, cafeteria and soft drink vending points. A good and effective disinfectant has to be selected. Phenolic compounds are better avoided in feline enclosure, as they are sensitive to carbolic acid. A range of modern compounds are now available in the market.

Moats, wet or dry are another source of infection. Faeces and urine, left over food, hair and refuses thrown by the visitors, often pollute them. Hence they are to be cleaned regularly and refilled if necessary with clean water. Feeding utensils, water trough and food storage containers are other important places to be checked periodically and prompt cleaning measures should be taken.

Stray dogs and cats, crows, rodents, snails and insects transmit various diseases both passively and actively. Stray dogs in deer paddocks can cause accidents and even death. Hence strict control on their breeding and elimination of them are to be carried out regularly. Lime treatment of the soil and burning the ground, when found necessary, must be done. A hand held kerosene run blowpipe can be used to sterilise cracks and crevices in animal houses and iron cages.

Cleaning of the post-mortem room and disposal of carcasses after autopsy are very important. Central Zoo Authority has given guidelines for disposing carcass of animals in zoos. Sufficient precaution has to be taken that dogs, foxes and jackals do not dig out the carcass. Installation of incineration facilities has to be encouraged.

Regular management must include :

1. Daily inspection of all the enclosures,
2. Extra care of the neonates,
3. Close watch of newly introduced animals,
4. Avoid intra or interspecies fighting,
5. Avoid fighting during breeding and at feeding place for dominance, and
6. Extra care during capture and relocation.

Table 3.1 Safe Upper Limit of Toxic Substances in Drinking Water

Substance Level	Safe Upper Limit (mg/lt or PPM)
Arsenic	0.2
Cadmium	0.05
Chromium	1
Cobalt	1
Copper	0.5
Fluoride	2
Lead	0.1
Mercury	0.01
Nickel	1
Nitrate	100
Nitrite	10
Vanadium	0.1
Zinc	25

Nutrition and Feeding

A well-balanced formula for nutrition and palatability is a real problem while feeding animals in the zoo, especially if collection is of varied type. The zoo may have a King Cobra that will need a live snake to feed on and a vulture that is a carrion eater or another creature like pangolin that normally feeds on ants or termites. Free ranging herbivores change their feeding habits based on the availability and phenology. They are classified as preferred food, emergency food or starvation

food. Nutrient content of plants varies with season and types of fodder and its stages of growth. Animals may be a grazer, browser or both. Often the cut fodder provided in the zoos is of the same variety and can cause deficiency diseases.

Depending upon the food they eat animals are classified into carnivores, herbivores; omnivores, frugivores and insectivores. Depending upon the natural feeding habits their nutritional requirements vary. In addition, the digestive system of various animals is adapted to particular types of feed. Since it is not possible to obtain food at all times, a mixed diet of different ingredients fortified with adequate nutrients like protein, vitamins and minerals is compounded and fed.

Food should be qualitatively and quantitatively sufficient to maintain proper health as well as breeding. Selection of diet should be as far as possible similar to the natural feed of the species. The requirement of protein, fat, carbohydrate, vitamins and minerals varies for different species, but there will is similarity among related taxa. Animals that live in social groups tend to feed less when isolated or separated from the group. Similarly animals caught from wild initially feed less due to stress. Reptiles, especially snakes may refuse to feed for a long time when caught from the wild or during moulting.

Animals, when in social groups feed better than in isolation. However dominant animals may take over, at the feeding site in a social group. Several feeding points are an alternative for this. Other factors that determine the food requirements are age, sex, size and physiological status of the animal like pregnancy, nursing, growth and sickness. Ruminants like deer and non-ruminant herbivores like elephant, a colon fermenter require large amount of roughage. It may occasionally lead to constipation and intussusception of the intestine. Cervids that replaces antlers periodically need extra minerals. Similarly carnivores are often fed with muscle meat only. Often they are not fed with liver, adrenal, bone and lungs, which are part of their normal food. They need additional vitamins and minerals to compensate this, especially vitamin A, which is obtained from liver.

Gallinacious birds are usually ground feeders. Peafowls and pheasants are included in this group. They require a high level of protein which in nature is usually met by feeding on insects and other food material of animal origin. The birds of prey need both roughage and minerals.

High nutritional needs of young, pregnant and lactating animals are to be identified and feeding schedules modified accordingly. Since animals especially herbivores feed on a variety of feeds, in captive feeding, variety is to be introduced as far as possible. This maintains good appetite and avoids nutritional deficiency.

Feeding behaviour varies with different taxa. There are nocturnal feeders and diurnal feeders. If the nocturnal feeders are fed late in the evening, the wastage will be minimal. Peafowls are rather continuous feeders and snakes like Python and King Cobra are occasional feeders. Carnivores are usually fed for six days a week and fasted for one day while herbivores are fed daily. Herbivores especially ruminants spend a lot of time foraging. Even though concentrates may meet their nutritional and energy requirements, reduced foraging time gives them plenty of idling time. This leads to stereotypic behaviour like movements of the tongue, lip, neck and head.

Most of the herbivores like deer are group feeders, while large cats are individual feeders. The group feeders should have enough feeding space and points. Otherwise the dominant male and its harem consumes major share of the food and the animals low in the hierarchy do not get chance to feed. This is important when drugs are administered along with the feed. This also prevents infighting and injury. Carnivores are usually fed individually since they do not tolerate the presence of other animals in the proximity. They are fed separately and preferably simultaneously. Snakes too must be fed individually and simultaneously, to avoid two snakes seizing the opposite sides of the same prey.

Depending upon the nature of feeding, animals are classified as

euryphagous (prefers a variety of food) stenophagous (feed on specialised food) and monophagous (eating only one kind of food, e.g., Indian Pangolin - ants, Gharial -live fish, King Cobra - live snake) Feeding is influenced by physiological conditions like skin casting in snakes, hibernation, winter sleeping and rutting.

Feeding a newly captured animal is often a problem. The animal often shuns people and try to hide away. The fear factor makes the animal to starve rather than to feed normally. Only when they start feeding in the presence of man, we can be sure that they have adapted to the captive condition. It must be ensured that the same person should handle as well as feed the animal to avoid the additional fear for strangers. If the animal lives in social groups, isolation again makes the animal to fast for several days. Acclimatisation with the members of the group alleviates this condition to some extent. This has to be done carefully. Some species resent, maul and even kill, if a new member is suddenly added to the social group. There is fight for social dominance and hierarchy. Once they are accepted in the social hierarchy there is dramatic improvement in feeding.

Nature of the food whether hard or soft, and positions of the feeding trough (e.g., Giraffe) are all important. Rodents need hard food as they have continuously growing incisors. Seed eating birds like parrots need a feed to crack. In any case feeders must be protected from contamination from faeces and urine as well as rain and should be away from flooded areas of the paddock during rainy season.

Water is a major source for many diseases and availability of clean water is a necessity. Water source, its storage and distribution channel, are to be checked periodically. Like water, the quality of food is also important. This is more important in carnivores than in herbivores as meat is likely to get decomposed easily than food of plant origin. In fodder, there may be the presence of snails that can be intermediary hosts, accumulation of some industrial wastes from commercial establishments and presence of anthrax spores.

Daily inspection of the food items at the supply points, store and

in the enclosure shall ensure good feeding. A diet chart is prepared which will ensure proper feeding and for cross checking.

Accidental ingestion of foreign bodies is not uncommon in zoo animals. This can occur due to negligence from the workers as well as from vandalism of the visitors. Plastic containers are banned in many zoos nowadays. Safe and careful use of ectoparasiticides and rodenticides are to be taken seriously. Coins, rubber balls, key-chains, handkerchiefs, glass, wire, nails are all found in the enclosures.

The following points are to be checked with regards to feeding :

1. Ensure the quality and quantity of the feed that is fed to the animal. If any change is to be made it must be done gradually and recorded properly.
2. Time of feeding should be strictly adhered to unless there are unavoidable reasons.
3. Necessary changes may be made depending upon the physiological needs of the animal (e.g., pregnancy, lactation, disease and convalescence).
4. As far as possible one person should feed one set of animals on a regular basis.
5. Have enough feeding points in social groups like herds of deer, to avoid competition.
6. Remove the leftovers promptly.
7. Ensure that rodents, birds and other vermins do not take the feed.
8. Check for abnormalities suspected to be of nutritional origin.
9. Feeding of ectotherms require attention to the ambient temperature. Large snakes like Python and King Cobra are fed only once a week. Most amphibians are active and feed well at 20°-25°C. Similarly crocodiles, turtles, snakes and lizards are active between 25°-35°C. But the diurnal lizards and crocodiles may be given voluntary access to higher temperatures between 32^0- 37^0C.
10. During winter nutritional requirement of some animals are less (aquatic animal, reptiles, winter sleep, true hibernation) and hence

feeding is modified accordingly.

Zoos have a number of animals of different taxa. Hence their variety both in their nutritional requirements as well as physical form has to be varied. The management has their constraints in processing the type of food required at the same time providing feed without affecting the health of the captive animals and birds.

Nutrients are essentials that are required for growth and maintenance. Not all animals require all the nutrients in the same proportion in their diet. For example the dietary requirements of the canids differ from the felids. Dietary requirements and nutritional requirements must be differentiated. Ascorbic acid or vitamin C is a dietary requirement for man, monkey and guinea pig but a major metabolic requirement for most animals. To those animals for which it is not a dietary requirement, it is synthesised in the body. Similarly many herbivores get their B complex vitamins from the microbial synthesis in the gastro intestinal tract. Ruminants can synthesise vitamin B_{12} in the rumen if cobalt is available and sulphur containing amino acids, if sulphur is available.

Principal nutrients of food are protein, carbohydrate, fat (lipid), vitamins and minerals and water *ad libitum*. They are to fulfil three important functions of the body viz., energy source, structural component and regulation of metabolism. Structures of the body like muscles, skin, and hairs are mostly made up of protein and, it along with the lipid, forms the cell membrane. Nutrient requirement is mostly for energy maintenance, work, repair, reproduction and control of the body temperature. Calorie-wise, fat supplies 9.3 kcal/g, Carbohydrate 4.1 kcal/g and protein 4.5 kcal/g. Vitamins and minerals are in general required for regulation of the metabolism and activation of the enzymes, hence deficiency of any vitamin or mineral result in symptoms that reflect the aspect of metabolism that is impaired. Take the case of Anurin (Thiamine, vitamin B_1). Its function is to assist co-enzymatic conversion of pyruvic acid to acetyl co-enzyme A (Acetyl Co A) in cellular metabolism. Hence the deficiency in the body results

in the accumulation of pyruvic acid in blood and causes polyneuritis. This is caused by the action of pyruvic acid on the nervous tissue.

Deficiencies resulting out of major nutrients like carbohydrates, fats and protein are not common in zoo animals. However deficiencies arising out of vitamins and minerals are often seen and have been recorded.

Vitamin A and D deficiencies are noticed in turtles and tortoises. Fat-soluble vitamins are stored in the liver and often are not a composition of the feed and hence wild felids ordinarily suffer from vitamin A deficiency. They have no capacity to convert carotene to vitamin A. Hence fish liver oil rich in vitamin A and D_3 is supplemented in the diet of wild cats in zoos. Fish liver oil fortified with vitamins A and D_3 is often used for this. Primates and often young giraffes suffer from vitamin A deficiency. Among minerals calcium deficiency is most common. It is common both in carnivores and herbivores.

Sodium supplementation is important for herbivores since the plants are generally rich in potassium and deficient in sodium. This deficiency is more pronounced in camel.

A general knowledge of feeding behaviour in the wild, their digestive system as well as social group will help to formulate effective feeding strategy for optimum health and reproduction status. Other physiological status like growth, lactation, convalescence are to be taken care of. However simulated feeding behaviour in the case of Edentata (ant-eaters) can be adopted. In the case of King Cobra, naturally, it has to be fed with live snakes.

Herbivores

Herbivores from the most important consumers in the ecosystem and their digestive system is designed to utilise cellulose. Mammals by themselves cannot digest cellulose, hence these animals have evolved a gastrointestinal tract with a provision for symbiotic microbial population. These microbes help to digest nutrients that cannot be

digested by the host, the mammal.

Among herbivores there are foregut fermenters and hindgut fermenters. Among hindgut fermenters there are colon fermenters (large herbivores) and caecum fermenters (small herbivores). Horse, zebra and elephant belong to colon fermenters and caecal fermenters are rabbits, guinea pigs and capybara (largest living rodent, native of South America and allied to guinea pig). Animals like rabbits and hares produce a soft faecal pellet in the early morning hours, called caecotroph and it is directly ingested from the anus. This is different from the hard faecal pellets produced later in the day that forms the defecation. Caecotrophs are rich in protein, fibre and water as well as B complex vitamins. They are hence called pseudo ruminants. There are pre-gastric fermenters like hamsters, voles, kangaroos, pigs and hippopotami. Herbivores do not ordinarily require B complex group of vitamins as well as vitamin K. Animals like elephant and rhino are poor digesters but compensate by continuous feeding and they need vitamin E. The same strategy is seen in Giant Panda, which is classified in carnivores, subsisting mainly on bamboo shoots.

Carnivores

Carnivores are a major attraction among the zoo animals. Carnivorous zoo animals include not only mega species like tiger, lion, leopard but also snakes, birds and turtles. Carnivores are more specialised in their feeding habits. Their food should contain highly digestible and practically all nutrients. Some of their dietary requirements are more than their metabolic requirements. For example cats need taurine that is exclusively of non-vegetarian origin. They have to be fed with vitamin A, since they cannot convert beta-carotene, which is plenty in plants, to vitamin A. Cats need an essential fatty acid arachidonic acid. Taste is another important factor. A list of taste buds present in some class of animals gives an idea about the importance of taste of the feed to be given.

Table 3.2 The Number of Taste Buds in Various Species of Animals

Species	Number of taste buds
Chicken	24
Duck	200
Cat	473
Dog	1,706
Human	9,000
Swine	15,000
Goat	15,000
Rabbit	17,000
Calf	25,000
Source: Leibetseder, 1980	

Table 3.3 The Number of Olfactory Cells in Various Species

Species	Olfactive epithelium (per cm^2)	Olfactive cells (x 10^6)
Human	10	10
Swine	–	20
Rabbit	9.3	100
Cat	20.8	67
Dog	200	200
Source: Le Magnen, 1951.		

Omnivores

This is a large group comprising small birds to bears. Many apes, monkeys, pigs, rodents, bats and sloth belong to this group. Their gastro-intestinal tract falls in between that of herbivores and carnivores. Majority of the nutrient is carbohydrate that forms upto 50% of the diet. The remaining is protein and fat either of animal or of plant origin. One of the extreme specialisation in the gastro-intestinal tract is seen in case of vampire bats. Like blood sucking parasites, their gastro-intestinal tract is reduced to a tube since it feeds only on blood.

Special Adaptive Food Habits

Animals adapted for arid conditions like camel can go without

water for a considerable period of time. Water requirement and frequency of providing water vary with the water turn out of the animal. Camels incidentally require large quantity of salt (122 g/day) compared to other animals. Total amount of water in animals body is almost constant on daily basis. Body gains water through ingestion and metabolism, and loses water through urine, exhaled air, skin, faeces, and milk. Equilibrium of water in the body is regulated by the water turnover capacity of each species.

Table 3.4 Water Equilibrium in Omnivores

Species	Body Weight (kg)	Total Body Water (ml/kg)	Water Turnover (ml/kg/24 hr)	Atmospheric Temp.(°C)
Camel	655	680	104	25
Donkey	304	625	200	25
Short horns	332	649	308	25
Merinos	41	559	151	25
Goats	40	690	185	37
Buffalo	333	786	524	36
Banteng	355	773	427	36
Santa gertrudis	522	629	384	36
Zebu	531	614	361	36
Guernsey	520	630	276	21
Ayrshire X Zebu	235	735	364	21

Ref: Phillipson, A. T.(Ed.), Physiology of Digestion and Metabolism in the Ruminant, 1st ed. (1970), 366 pp, Oriel press.

Table 3.5 Water Turnover in Animals

Climate	Animal	Water Turnover (ml/kg/day)
Tropical, Moist	*Bos bubalis*	200
	Bos taurus	161
	Bos indicus	123
Desert, Dry	Boran Cattle	1356
	Sheep	107
	Goat	96
	Camel	61
	Rein Deer	128
	Moose	111
	Sheep	62
	Musk ox	35
	Sminthopsis crassicaudata	461
	Dasycerus cristicaudata	134
	Dasycercus byrnei	125

Porcupines often need bone not only for gnawing to keep their

teeth in good condition, but also to meet the requirements of calcium and phosphorus. Birds need grit to grind the feed in the gizzard, since they are devoid of teeth for grinding the food. Broken shells provided in a hopper will not only provide the grit but also meet the calcium requirements. Marble chips are provided depending on the availability.

African elephants suffer from infertility of nutritional origin if the feed is converted to grass from the browse; which often happens in captivity. Similarly the preference of Koala (Australian arboreal animal) to eucalyptus leaves and Giraffes to acacia leaves are well known.

Vitamin C is not a dietary requirement for many animals although it is a metabolic requirement. Certain species like Red Vented Bulbul, frugivorous bats, guinea pigs and monkeys require ascorbic acid (vitamin C) in their diet. This is because they lack the enzyme L-Gluconolactone oxidase, required for the *denovo* synthesis of vitamin C. Similarly vitamin D is required in the D_3 form for squirrels monkeys and fowl family and not in the D_2 form as required by others. Certain species of primates like Colombus langur and proboscis monkeys are mostly leaf eaters and have complex foregut fermentation mechanisms. They have to acquire the microbes from the parents to ensure proper fermentation, like the ruminants.

In captive facilities, feed consists of roughage, concentrates, minerals and vitamin supplements and non-nutritive feed additives. Roughage is mostly meant for herbivores. They include grass, browse, hay, straw, silage and agricultural by-products like corncob, shells and hulls. Concentrates are low in fibre but high in energy and often in fat, proteins and minerals. Cereals, oil cakes, milling by products (wheat and rice bran), molasses, pulp of beet or citrus, fishmeal and milk powder are all examples and given to animals depending on their feeding pattern and nutritional requirement.

Feed Supplements

Minerals: These include apart from sodium, major minerals like Ca and P. Other micro-minerals like Fe, I_2, Cu, Co, Ma, Mg, Se, Zn are all added depending upon the species requirement.

Table 3.6 Formula for Mineral Mixture

Suggested Formula for Mineral Mixture		Parts
Sterilised bone meal, fine powdered		45
Ground chalk		10
Dicalcium phosphate		12
Common salt		30
Yellow oxide of iron		0.5
Potassium iodide		0.25
Starch		0.75
Sodium carbonate		0.75
Sodium thiosulphate		0.75
	Add for 50 kg	**g**
	Cobalt chloride	22
	Copper sulphate	113
	Manganese sulphate	141
	Zinc sulphate	140

Vitamins: Of the vitamins, A and D is important to most animals. B complex vitamins are not ordinarily a need for herbivores. Vitamin E is important in elephants and rhino. Requirement of vitamin C is already mentioned.

Composition of Vitamin Mixture

Table 3.7 Composition of One gram of the Vitamin Mixture

1. Vitamin A	2000 IU
2. Vitamin D	200 IU
3. Vitamin E	10 IU
4. Vitamin K (Menadione)	0.5 mg
5. Thiamine	0.5 mg
6. Riboflavin	0.8 mg
7. Pyridoxine	0.5 mg
8. Calcium Panthothenate	4.0 mg

9. Niacin	4.0 mg
10. Inositol	10.0 mg
11. Para amino benzoic acid	10.0 mg
12. Biotin	40.0mcg
13. Folic acid	0.2 mg
14. Vitamin B_{12}	3.0 mcg
15. Choline chloride	200.0 mg

Non Nutritive Feed Supplements : This group ordinarily include growth promoters, flavouring agents, emulsifiers, enzymes anti-oxidants and binders for pelletisation of concentrates, probiotics coccidiostats and antibiotics.

Feeding Strategies

Data on nutritional requirements of various animals were not available earlier. Recently a number of publications and literature are available on this. Even ready to feed foods are now available. Most of them are extrapolations from domestic animals like cats and dogs and are often label conversions. The label claims of reputed companies can be relied upon and additions are made according to requirements. Local availability and uninterrupted supply are other needs to be considered. Incorporation of local ingredients is important to reduce the cost as well as to check the quality.

Deterioration of quality on keeping is to be considered and the additional points to be noted are :

1. Check the microbial contamination, especially coli and salmonella in food of animal origin.
2. Antivitamins like thiaminase in fishes like carp and herring.
3. Stability of Vitamins.
4. Ensure availability of sulphur containing amino acids like cystine and methionine (Supplementing cereals with pulses).
5. Rancidity of oils and fats.
6. Presence of urea (Non Protein Nitrogen) commonly added in commercial ruminant feeds.
7. Quality of milk and milk powder.

8. Heat treatment of Soyabean meal to destroy the enzyme trypsinase.
9. Contamination of feed while storing. This not only results in loss of quality but also in the spread of diseases like leptospirosis from rodents.
10. Feed should be as natural as possible.
11. Physical form should be made so as to stimulate natural conditions like biting, chewing and dressing (elephants).
12. Many commercial feeds avoid fibres to make the preparation more energy concentrated.

Table 3.8 Feeding Strategies

Nutrients	Carnivore	Omnivore
Carbohydrates	Minimal or Nil, cannot tolerate fibre >2%	>50% of diet with 4-5% fibre
Protein	High (20-30 %)	12-18%
Fat	High (20-30%)	4-5%
Energy	From Fat and Protein	From Carbohydrate and Fat
Vitamins	High requirement of all vitamins	Moderate
Minerals	High requirement especially all macrominerals	Moderate
Nutrients	**Ruminants**	**Hindgut Fermenters**
Carbohydrates	High % of roughage. Poor utilisation of starch and sugars	8-10% of roughage+ 30-40% Starch and sugars
Protein	Low	8-10%
Fat	Low	>2%
Energy	<2% Carbohydrate	Carbohydrate
Vitamins	No B-complex and K only A,D_3 & E	No B-complex & K Only A, D_3 and E
Minerals	Low	Low

Breeding

Breeding has to be managed scientifically in captive animal facilities. The two major problems are inbreeding and excessive breeding.

Inbreeding is a problem in captive animal facilities. Inbreeding occurs because of mating of individuals, more closely related than the average degree of the relatedness of all individuals in the population.

Inbreeding increases the chances of inheriting the same alleles from both the parents. This leads to build up of homozygosity in the population. Alleles (allelomorph) are of two or more alternative forms of a gene, only one of which can be present in a chromosome. Two alleles of a particular gene occupy the same relative position on a pair of homologous chromosomes. i.e., a pair of chromosomes of similar shape and size and having identical gene loci. Inbreeding is being carried out in farm animals to establish homozygosity for the selected desired alleles to cause a considerable random loss of genetic variation. With successive generations this leads to loss of performance in the individuals. This is known as inbreeding depression. This is because many genes work best in heterozygous state. Although hitherto concealed, deleterious characters are brought to light by homozygosity and some of these are lethal.

The most severe inbreeding can happen in zoos by mating of parent and offspring or full brother and sister. Both conditions lead to homozygosity of 25% of the genes. Mating of half sibs, aunt/uncle X nephew/niece gives 12.5%. Full cousin mating gives 6.25% homozygosity. Line breeding is another form of inbreeding. Line breeding involves repeated crossing to one animal or its close descendants or relatives.

Since the foundation stock in most of the zoos is very small, inbreeding often happen unless care is taken. Maintaining a studbook and checking the lineage often help to avoid this. Hence, most of the zoos maintain an effective population size. Effective population size is the number of individuals that when held in the manner of an idealised population would give rise to the same rate of inbreeding as the population under consideration. Thus, it allows different number of males and females to be taken into account in calculating the average inbreeding coefficient for the population.

A planned and scientific breeding programme can eliminate deleterious effects of inbreeding like congenital abnormalities, stillbirth, early mortality and abortions. Hence it is a common practice

to introduce 'new blood' or 'fresh blood' frequently to a captive population. This can be from another zoo or from animals caught from the wild and introduced into the captive facility. Cheetah is currently facing an inbreeding depression in many captive populations and in some wild populations also.

Disturbances during pregnancy can cause abortion, premature birth or even stillbirth. Human intereference during parturition may result in rejection of the newborn by the mother. Cannibalism is prevalent in carnivores. Hence the pregnant animals are separated and isolated from the rest of the animals. It is not proper to keep a single animal. This may lead to behavioural problems, breeding difficulties, boredom and stress. Making the animals engaged both physically and mentally in itself has developed into a science known as environment enrichment. Environment enrichment is more important in animals that are intelligent like primates, carnivores and elephants. Boredom leads to behavioural problems like stereotype movements and at times aggressive behaviour. Stress can make the animal susceptible to diseases and even cause death. There are various kinds of stress. It may be capture operation, shifting or transportation, sudden and excessive changes in ambient temperature or even proximity to the cage or enclosure that is not compatible with the behaviour patterns of the animal. Visitors contribute to the stress by provoking to the extent of inflicting injury and throwing unwanted things into the enclosures.

New animal should not be introduced to an enclosure without prior acquaintance lest it may lead to intraspecific fighting with resultant injuries. Injuries from minor to major, even causing death can happen. These may be from snakes, feral animals, stray dogs and cats, free-living primates and even from constant pecking by the crows. Stray animals from large ones to small rodents may eat the feed given and deprive the animal of its normal ration, as well as soil the enclosure and spread diseases. A good and effective enclosure management can counter this problem.

Periodical inspection of the enclosures is a necessity. This will

help to detect the presence of any foreign bodies like plastic bags and containers that are really dangerous if it contains edible materials. Empty packs of fruit juice with aluminium foils coated inside can be swallowed by the animal resulting in choking or blockage of a part of the gastro-intestinal tract. Even large animals like elephants have suffered from this problem. Hence it will be a good practice to ban the use of all plastic materials inside the zoos.

Population control is another important aspect in any zoo. In nature, there is a dynamic equilibrium of prey predator relationship. In captivity they breed as in nature. However, mortality is less due to increased care given in the management. Prey species do not suffer from predators as in the wild. This will increase their numbers in a short time, putting pressure on the management, health care and even feeding. Releasing the excess population into the wild is not a wise proposition since the captive animals may carry diseases along with them into the wild population. These animals are more prone to predators. Hence it is better to control the captive animal population by various methods. Separation is the easiest method to practice. This reduces the fighting injuries arising out of fight for mate. Surgical sterilization is another simple and permanent method of controlling the population. Since safe anaesthetic and remote injection methods are now available this method is not difficult. Vasectomy is ideal than castration. If the animals are castrated they lose all the secondary sexual characters like mane in the case of lion and it will have the appearance of a lioness. In herbivores it is usually caudectomy. This does not reduce the injuries from fight for the female during mating season. Subcutaneous implantation of depot preparation of hormones is also used. They are expensive and have to be repeated.Implants are not available locally.

Diseases

Disease is defined as the manifestation of the disturbance in the physiological process leading to structural and functional alterations in the cells of the living body of an individual and occurs as an aftermath to the collision between disease causing factors and the susceptible

host. Several factors contribute to the occurrence of the disease, like the environmental factors, age, inherent disease resistance and the species. Environmental factors include air, water, food, fodder, and space in the enclosure, social group and climate. Preventive measures include the following.

Quarantine

Any new animal introduced into the collection is a potential source of disease. Hence proper quarantining of a newly received animal is very important. Ascertain whether the animal has to be de-wormed and vaccinated before being transferred to the new facility. Quarantine period depends upon the species involved and the health status of the animal. The minimum period usually practiced is 40 days. The period may be extended up to 3-6 months. Needless to mention, quarantine enclosures should be away from the display area and the zoo hospital.

Quarantine shelter helps the animals to adapt themselves to the new environment, recover from the stress of capture and transportation. Animal under quarantine should be carefully observed for any abnormal behaviour, appetite, or symptoms suggestive of any disease. Physical examination of the animal whenever possible must be conducted. Injuries, wounds and presence of ectoparasites are to be checked. Examining faecal matter, preferably for three consecutive days, helps to check the presence of endoparasites. Clinico-pathological examination of blood, urine and skin-scrapings can also be done. Samples for this may be collected when physical examination is conducted. This avoids frequent handling of the animal. All possible cleanliness in the quarantine enclosure has to be ensured.

Isolation

Isolation is practised when an animal is found to be suffering from any infectious disease. Suspected animals are isolated as early as possible to avoid the possible spread of the disease. Animal is given the required treatment after isolation.

Vaccination

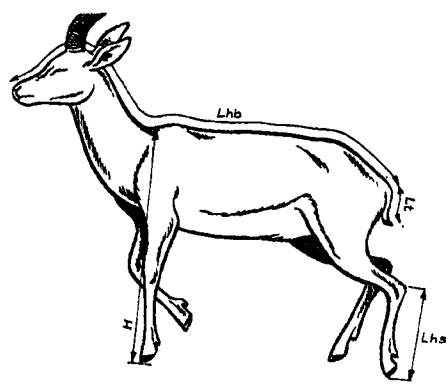
Although vaccination is recommended for many diseases that are seen in domestic livestock, it may not always be advisable. This is because the dose and vaccination schedule has not been fixed for most of the wild stock.

Veterinary Medical Record System

A standard veterinary medical recording system has to be followed. Records of birth, weaning, health, disease and mortality must be recorded on a daily basis. In big zoos a computerised system with appropriate software package can be used. This will help in easy retrieval of the data whenever required for analysis. Manuals on wildlife and elephant post-mortem examination should be available in the zoo. This points to another important aspect of maintaining a good library for reference in the zoo. Reference books that are needed in the zoos are not easily procured, but important to have. Nowadays there are several related internet sites both free and subscribed giving important information.

Postmortem Examination

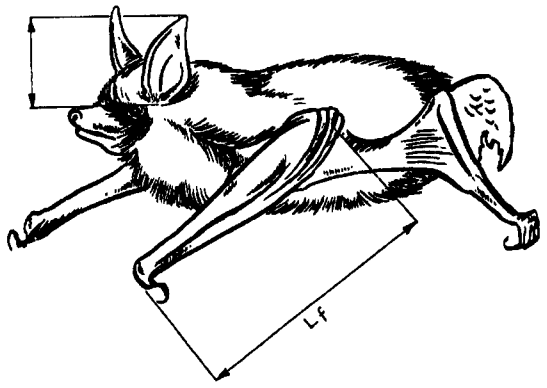
Postmortem examination has to be conducted in every case of death. At the same time exceptions when the animal is suspected to have died of anthrax has to be considered. The anatomical peculiarities of each taxonomic species are to be considered to avoid mistakes. e.g., consider absence of pleural cavity and gall bladder and presence of bifid apex of heart in elephant.



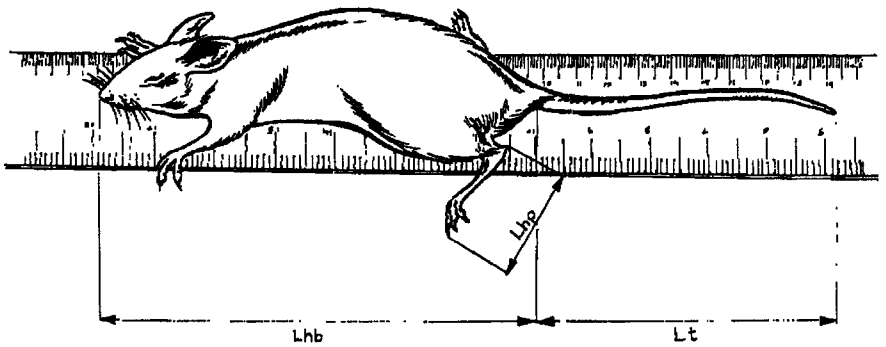
Measuring large Mammals : Lhb, Head and Body length; Lt, Tail length; height at shoulder; Lhs, length of the sole of hind body

Zoo Veterinary Hospital

The Central Zoo Authority has prescribed the number of qualified veterinarians required in a zoo depending upon the size of the zoo as per the classification and norms. Zoo veterinary hospital must be under the control of a qualified and experienced veterinarian. It should have mobile squeeze cages, syringe



Measuring chiropterans; Lf, forearm length; Le, length of the Na; Ltr, length of the Tragus



Measuring small Mammals; Lhb, Head and body length; Lt, Tail length; Hp, length of the sole of the hindfoot.

projector and immobilisation drugs apart from the common pharmaceutical and surgical equipment and other sundries used in the veterinary hospitals. Other tools of physical restraint must be stocked. Antivenin, if poisonous snakes are kept is a good precaution. A good clinical lab must be available, X-ray unit and other modern diagnostic equipments help in diagnosing and treating diseases. A compendium for drug dosage for the different taxa should be made available.

Diseases Reported among Non-domesticated Livestock in India

In India diseases of wild animals are poorly documented. This is more so in case of free ranging wildlife. Most of the Veterinary Colleges and Research Institutes undertake routine investigations on domestic animals only. Diseases of wild animals whether in captivity or free ranging largely resemble that of domestic stock. Wild animals get exposed to diseases of domestic stock when they go into the forest for grazing, ungulates like cattle and goat in case of herbivores and stray dogs in the case of carnivores. Animals in captive facilities are more prone to diseases of zoonotic importance especially air borne organisms. Tuberculosis is very much prevalent in zoo animals. Increased awareness and communication between the zoo and wildlife veterinarians have brought many diseases, which were not diagnosed and reported previously to limelight. Zoos Print, an exclusive journal dealing with zoo matters is now being published in India. This has facilitated the interaction between zoo and wildlife veterinarians in India. The details of the diseases like aetiology, incidence, susceptibility, transmission, pathogenesis, clinical signs, pathology, diagnosis, prophylaxis and control are given in standard textbooks of Veterinary Medicine. Diseases reported among non-domesticated livestock in India are the following :

Table 3.9 Diseases among Non-domesticated Livestock in India

Viral Diseases	Bacterial Diseases
African Horse Sickness	Anthrax
Canine Distemper	Clostridial Infections
Foot and Mouth Disease (FMD)	Corynebacterial infections
Infectious Bovine Rhinotracheitis	Enteric Infections
Infectious Feline Enteritis	Aeromonas infection
Infectious Hepatitis	*E. Coli* infections
Infectious Peritonitis	Salmonellosis
Japanese Encephalitis	Shigellosis
Kyasanur Forest Disease	Leptospirosis
Pox	Mycoplasmosis
Rinderpest (RP)	Nocardiosis

Paratuberculosis
Pasturellosis
Plague
Pseudomoniasis
Staphylococcosis
Strangles
Streptococcosis
Tuberculosis

Rickettsial Diseases

Anaplasmosis
Coxiellosis
Ehrlichiosis

Mycotic Diseases

Aflatoxicosis (Fungal poison)
Mycoses

Protozoan Diseases

Babesiosis
Balantidiosis
Coccidiosis
Entamoebiasis
Giardiosis
Leishmaniosis
Plasmodiosis
Sarcocystosis
Theileriosis
Toxoplasmosis
Trichomonosis
Trypanosomiasis

Helminthic Diseases

Trematodosis
- Echinostomosis
- Fasciolosis and Fasciolopsis
- Paragonimosis
- Paramphistomosis
- Schistosomosis

Cestodosis
- Anoplocephalosis
- Diphyllobothrosis
- Dipylidiosis
- Echinococcosis
- Monieziosis
- Spirometrosis
- Stilesiosis
- Taeniosis

Nematodosis
- Ancylostomatidosis
- Ascaridosis
- Capillariosis
- Filaroidosis
- Oesophagostomosis
- Oxyuriosis and Enterobiosis
- Protostrongylidosis and Filaroidosis
- Rictularid infection
- Spiruroid and allied infections
- Stephanuriosis
- Strongyloidosis
- Trichenellosis
- Trichostrongylidosis and Ollulanosis
- Trichuriosis

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Chapter 4

Methods of Restraint

Wild animals either captive or free ranging need to be restrained and controlled for various reasons. It may be for observation in close quarters, capturing, treatment, translocation and for various other purposes. Knowledge of the different methods of restraint is important for successful wildlife management.

While approaching a wild animal for restraint, the following points must be taken note of :

1. Type of the animal,
2. Nature of plight,
3. Natural type of combat or defence of the animal, and
4. Personal safety.

Type of the Animal

Needless to say the ways to approach a trapped fawn and a leopard are different. A carnivore can reach out through the bars, this is especially true in case of big cats. Human approach not only frightens the animal but also cause injury to the animal in the attempt to escape. If the cage is not strong enough it can easily break it and attack. Even aiming at a leopard will provoke the animal to pounce on you; may it be a live gun, tranquilliser gun or even a camera.

Nature of Plight

Trapped in well with or without water.
Drowning after sedation.
Chased to high rise building.
Trapped in strong water current/flood.
Man made trap and snares.

Natural Type of Combat or Defence

The versatile trunk and tusk of an elephant are typical examples. The safest place near an elephant is underneath the belly. Mahouts are found to rest in this place usually, but this is not possible in wild conditions. After sedation standing on either side close to the body is safe. In a fallen animal (lateral recumbency) dorsal aspect is safe. Biting and mauling by carnivores and primates, kicking and biting by equidae, kicking and use of antlers or horns by cervids and antelopes are well known. Snakes bite only by the forward movement. This habit is often used by the snake charmers to baffle the public by kissing on the top of the hood of a cobra. Unlike predators and birds of prey, herbivores do not have stereoscopic vision (three dimensional view) and hence they lack depth of vision. They have a wider area of vision since the eyes are located on both sides of the head. So when a deer is chased it runs in all directions, hits on trees and walls and injures itself causing serious injury. It may give an impression that the animal is blind. Escape bids like climbing on a tree (among cats, panther is notorious in climbing and even gets on to primates) getting into burrows and holes or even flying in case of birds should be taken care of.

Personal Safety

Safety of the people who are part of the team as well as on-lookers is important. There is no dearth of people to see the *tamasa*, who offer unsolicited assistance and cause risk unnecessarily. The team leader should take utmost care in this regard. Accidents can happen both from the animals as well as from the members of the team who are carrying live guns as a means of defence. Thick jackets, padded gloves or even gloves reinforced with metal chain (to protect from crushing bites) and gum boots are all used depending upon the situation. Canned lacrimators (tear gas), and capsicum sprays, which are used for personal defence by human beings are available now. This may be useful against animals in limited escape range. Fire extinguisher (foam type) may come in handy. Shields can be used to protect from direct attack. Transparent perspex glass with a handle is a see-through device. It is

fully transparent and the animal can see the intruder. Cane shields, the type that is often used by the police, which are light and can easily be handled, are useful. It provides some visibility too. A light cane chair or a teapoy or even a foldable steel chair will be easily available.

Psychological Restraint

There are visual things that are not strong, but make the animal to feel a physical barrier. The light built funnel like structure in khedda, used to capture elephants, is an example for this. Opaque plastic sheets are used to drive a herd of deer in a given direction.

Voice is an important tool that can be used especially in animals that have escaped from captivity. The keeper is the best person to use this. If he is not confident it is better to avoid this. Animals can "smell" the cold sweat. Some handlers like to have a "drink" to muster confidence, but this has to be discouraged. He may be courageous without competency, because of the alcohol and ends up in disaster. The handler must be well aware of the anatomy and physiology of the species he is handling. This will give him an idea of the limbs that can reach to kick, strike or bite. He should be aware of the speed and agility of the animal he is going to handle. Many of the sluggish animals turn out to be incredibly agile if provoked or when found itself in danger.

The psychology of the animal is another factor. Animals in a social group, which are emotionally bound, may attack if one of its herd-mates is handled (attacked). Elephant is a typical example for this. Another example is the reaction of the mother, when the young ones are handled. Cow elephants with a calf at foot, tiger with cubs are all examples. The response of an animal to a violation of its flight distance is important. It may flee or attack with all its strength and capacity.

Reduction of Sensory Stimuli

Sight, sound and smell are all sensory stimuli that can evoke response in an animal. Once the animal is confined to an area, say a cage, it may be covered with a large opaque cover, like tarpaulin.

Control the visitors. Similarly a nocturnal bird is less active in broad daylight and vice versa. Sounds, which are not familiar to the animal in the wild, will produce aggressive/defensive reaction from the animal. Avoid talking as well as blaring of radios and other similar things around. Animals having sharp olfactory sense must be handled properly. Many professional hunters know this and use this, to approach an animal. Even if the animal is in limited escape range, stimuli from the sense of smell should be avoided. A wild animal always resents palpation (touch) by humans. Reaction of herd-mates to a newly introduced animal to the captive group may be unpredictable. In some animals like the herbivores, smell of the dung of the same animal or species may have a quietening effect.

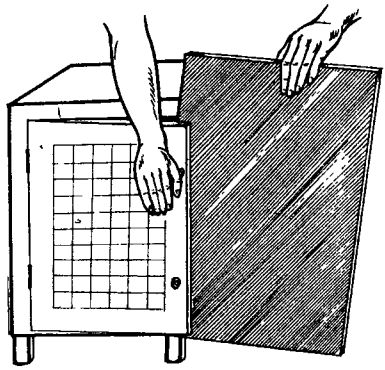
Physical Restraint

Confinement is more or less subjective and varies considerably depending on the species and situation. Even a large fenced area may be a confinement to a free-living large adult wild animal. A squeeze cage with provision to trap is an extremely useful device. Anatomical and physiological needs of the animal should be met.

A cat bag is useful for handling small carnivores and cubs. Wrapping with a thick towel is another method for small animals. Parrots and young carnivores are handled like this. Small birds and mammals like rodents and reptiles can be put into a plastic tube.

Other physical tools of restraint are ropes, snares and nets. A welder's gloves may be used. However, a thick and heavy glove reduces the perception of the handler, like how tightly he is grasping the animal or bird.

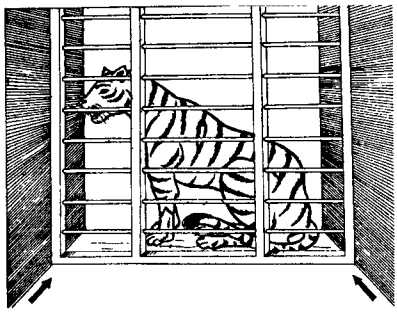
An opaque shield like a board of plywood can be used to transfer a small animal from one cage to



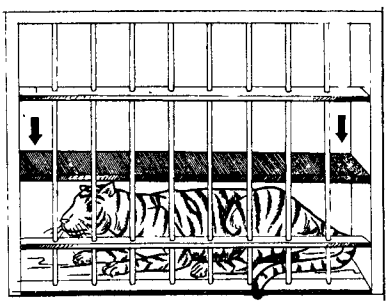
A shield for transferring a small animal from a swinging door cage

another, having swing doors. The board can be inserted with the door partially opened and then the door is fully opened with board covering the entire opening. Then bring the other cage and keep in apposition with the cage having the animal. Gradually close the swing door, slowly drawing the board and simultaneously closing the cage with the animal i.e., the second cage. This will be exactly in the reverse order of closing the first cage. It will be a good practice to weigh the empty cages before letting the animals in. This can help to determine the weight of the animal and is important if a sedative is to be used for handling subsequently. Dose of the drug can be computed according to the weight of the animal.

Operation of Squeeze Cage

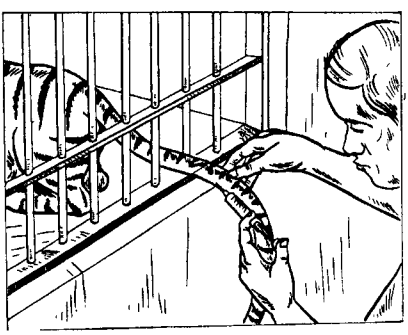


Lateral Squeezing



Vertical Squeezing

Squeeze Cages: They are designed and produced in different sizes to control and transport various species of animals. One of the walls is movable and the animal can be squeezed to the opposite side. This is a simple device for a short period of handling as for giving injections. Some of them are mounted on wheels for easy transport. The cages of animals are to be designed to keep the squeeze cages in apposition and drive the animal into it.

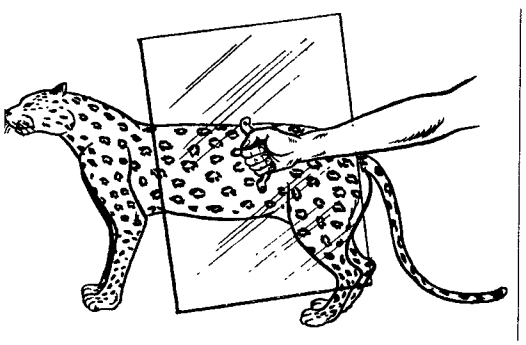


Intravenous injection using squeeze cage

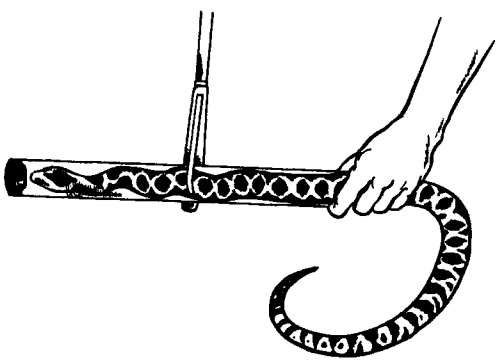
Physical Examination

Mammals vary in their size, behaviour and method of defence and combat. Echidnas and Pangolins are relatively slow moving, but the sharp spines covering their body make them difficult to handle. They are picked up from the ground by inserting a gloved hand between the body and the floor. This enables the animal to be grasped by the hind foot which is pulled backwards and upward and the animal is lifted by its two hindlimbs. A Platypus can be caught with a hoop nest. Bats are easy to be restrained physically. The animal is held with heavy gloves in such a way that the wings are pinned to the sides and wrapped in a cloth enclosing the claws on the feet. Primates like adult monkeys are very powerful and dangerous. Their canines are very sharp and being temperamental they can inflict deep wounds. Only very young of the species or primates to the size of macaques can be physically restrained. Rodents like rabbits, can be handled like a pet. Their powerful hind limbs and sharp toe nails can inflict painful scratches. Carnivores are difficult to be handled physically and hence squeeze cages are used for close examination, collection of blood and administration of drugs by injection. Elephants in

Holding a long legged bird

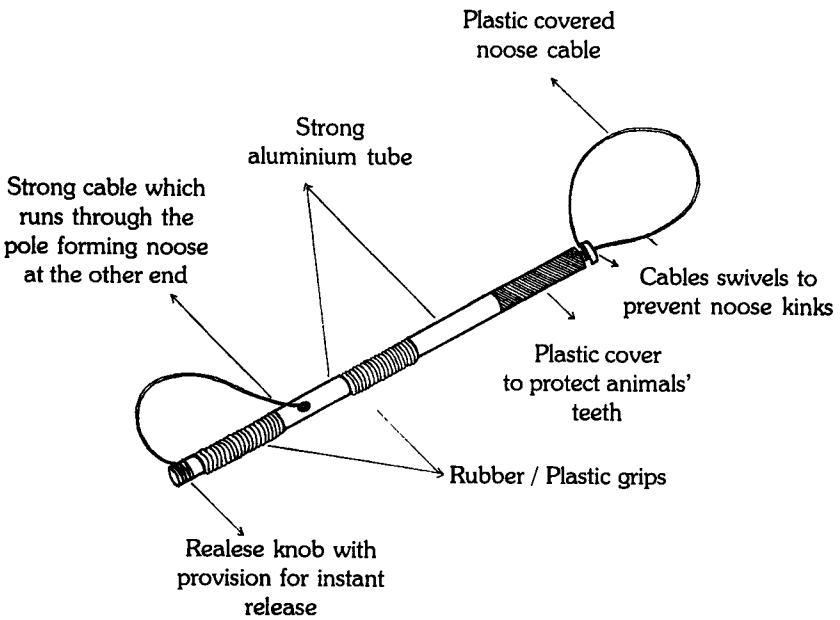


Transparent plastc shield for closer inspection



Restraining a poisonous snake with a plastic tube

range countries are controlled by mahouts using traditional chains like leg chain, hobbles etc. While examining an elephant ensure that the mahout is always present between the animal and the veterinarian. Physical examination of the ungulates has to be done very carefully since some of the delicate ones may even succumb to shock.



"Dog-holder" to hold small carnivores

Chemical Restraint

Introduction

Early records of chemical immobilisation go back to the Indians of the Amazon basin, upper Orinoco basin, Guyana and Eastern Ecuador where naturally occurring curare compounds were used.

Although chemical capture began in Africa in the late 1950's only recently it has become popular in India. The first drug tried was succinyl choline chloride, a paralysing chemical that proved to be highly useful in the antelopes. This being unsuitable to certain other animals, a reversible type of chemical like gallamine was tried, however the narrow margin of safety made the pharmacologists to work on different drug combinations. This proved to be a successful and safe method for capturing wild and captive animals. Chemical capture of the wild animals is not a simple procedure. Failure is likely to be met with when a new chemical, technique or weapon is tried. To acquire mastery in any technique needs considerable effort. Since some of the modern immobilising drugs are not routinely used by the veterinarians necessary expertise must be sought from available sources.

Chemical capture makes many biological investigations possible that were previously impossible. These include tagging, radio tracking, physiological telemetry, various diagnostic tests like blood sampling, collection of the parasites and large number of veterinary indications from the hoof trimming to obstetrics and even euthanasia. Routine conservation methods like restocking and vaccination have gained popularity and acceptance. Prior to immobilisation of an animal or a group of animals several considerations must be made.

1. Chemical immobilisation should be the last resort if there is a better method by which the animal may be restrained to attain the objectives.
2. Safety of the handlers must be ensured. (a) When using potent opiates, antidotes for human beings must be available and its use understood by the participants. (b) Proper gun safety measures should be followed (c) Dangerous species should be dealt with caution.

3. Adequate planning and arrangements to handle and care the immobilised animals must be made. A person with the knowledge of monitoring the vital signs should available.

The actual mechanics of capture include approach, remote injection, tracking the injected animal, treatment/marking if any, post immobilisation treatment and release of the animal.

Approach

This will depend on the flight distance of species. Previous human disturbance in the area, terrain and vegetation, size of the animal and its reactions to the disturbance, the accuracy of the syringe projector, skill of the marksman and the capture team, population and the rarity of the species and whether the animal is a predator or not, all these count in taking an appropriate decision for approach.

Often vehicular transport is only of limited use. This depends on the area and the species of the animal. Approach on foot, taking a vantage point with camouflage, considering personal safety, direction of wind and avoiding noise are the important practical aspects in our forest terrain. Approach from air by means of helicopters is not useful in the tropical evergreen forests of India. It may be possible in grasslands with animals like elephants that are not much disturbed by such flight machines.

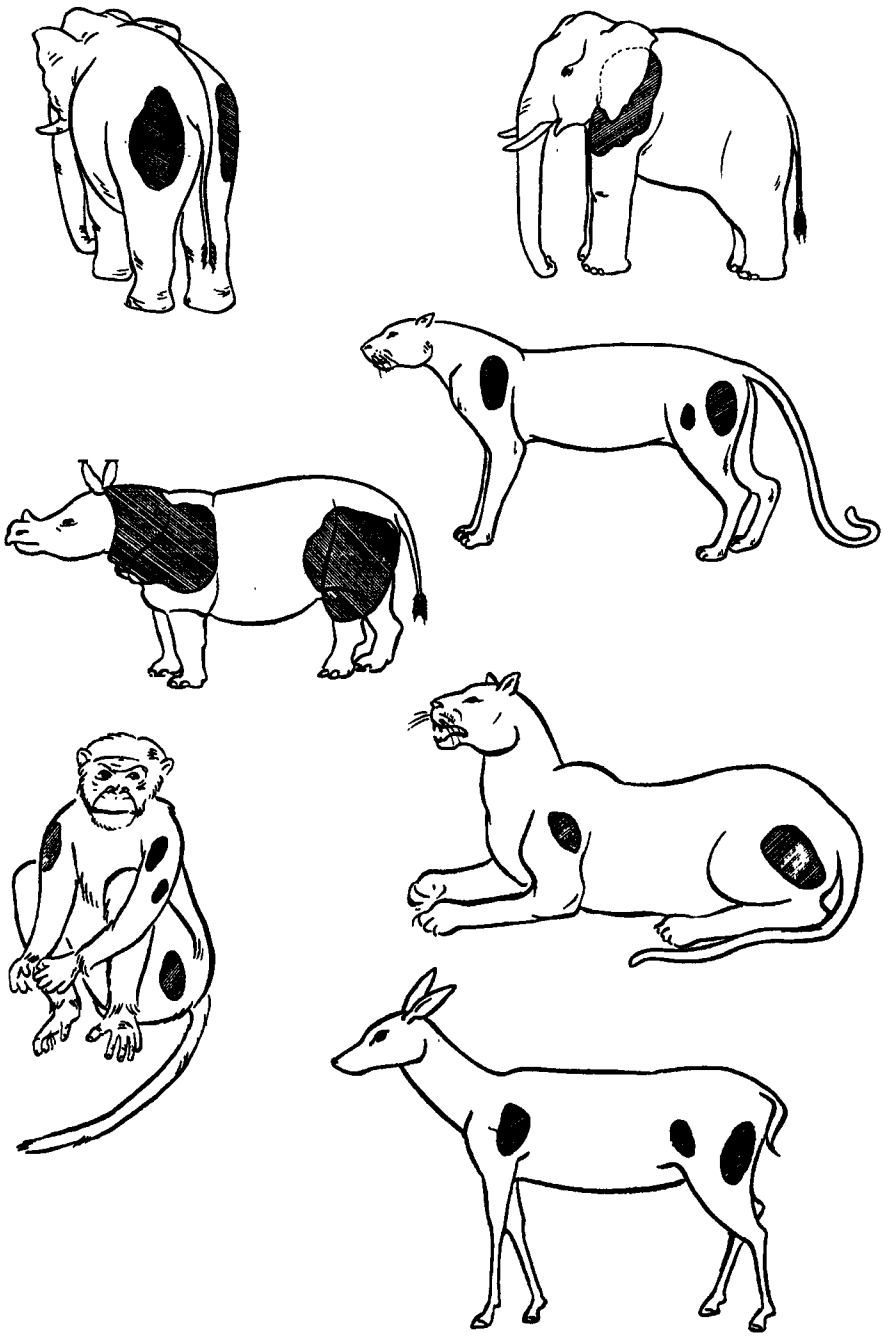
Prey animals are difficult to approach. Animals like elephants, and carnivores that are predators can be approached in an easy manner. Personal safety is an important factor in this context.

Drug Delivery

Drugs can be delivered or administered by different routes:

1. Oral

Baiting of animals can be resorted to in certain conditions. Pre-baiting to remove the bait-shyness is important. Strong smell, colour and taste of the chemical may mar successful baiting



Sites for Darting in Various Animals

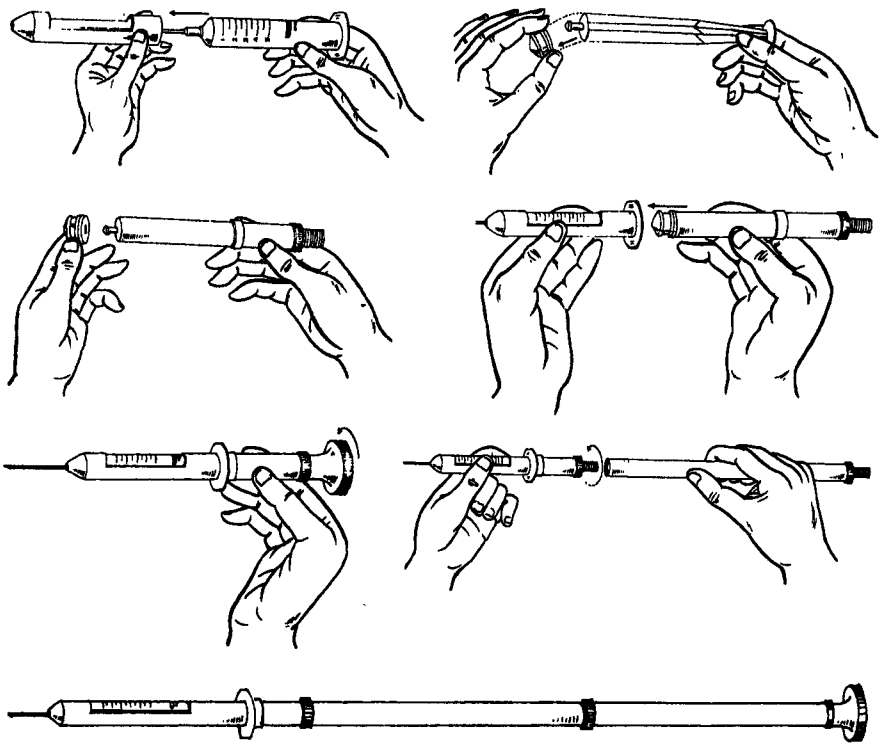
2. Parenteral

Remote Injection and Drug Immobilisation

Parenteral administration of drugs using a hypodermic needle is an old practice. Giving an I/M injection, let alone I/V route, is a problem faced by veterinarians who are dealing with fractious domestic animals and still worse with wild animals in their free ranging conditions.

Pole Syringe (Jab Stick)

This is a device that comes in handy for animals in cage or animals that can be approached in close quarters without any risk, like deer. This is a modified syringe with the piston that is extended with a rod. This rod can be held in the hand and jabbed on to a muscular region.



'Prodject' - Pole Syringe

The barrel of the syringe is housed in a tube with a window to see the volume of the drug present and push out the air if, present. The handle that acts as an extension of the piston helps to push in the drug when jabbed or prodded.

Projectors :

Blowpipe

Usually this is a plastic tube with smoothened inside. A mouthpiece may be attached to one end for the ease of blowing. Plastic syringes up to a capacity of 3-5 ml can be darted to a distance of 3-5 meters ordinarily.

Blowgun

Blowgun with an extension to blowpipe is used for long ranges. A foot pump with a pressure gauge is used. Because of the unwieldy size it is not very popular.

Crossbow

This is more of a sports weapon than a professional gadget. However a quantity of 3 ml can be injected by the inertia developed by the arrow shaft. Attachments to cross bows with explosive capsule syringes are available. The weapon is very powerful and should be used with caution in small animals. Crossbow is very inconvenient in the field with heavy under growth and cannot easily be concealed from the target animal.

Shotguns/Rifles/Pistols

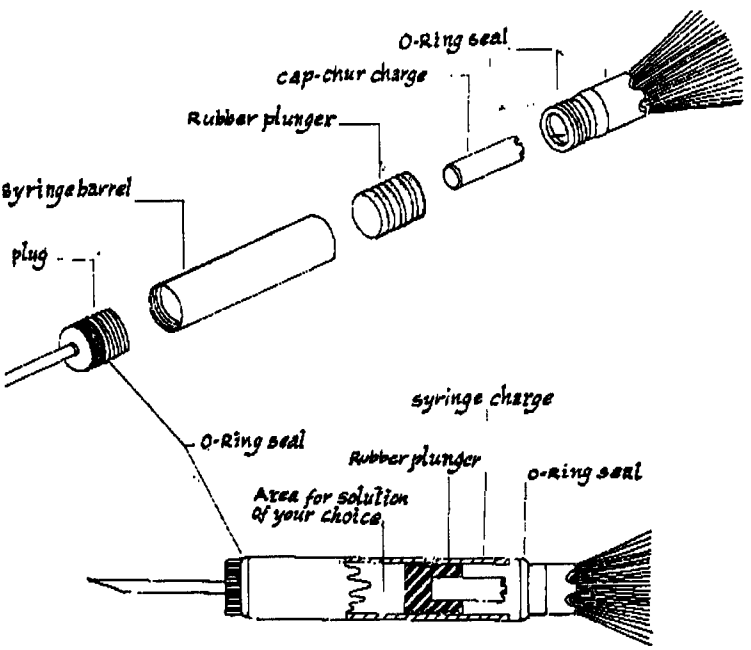
Depending on the range to which the syringe is to be projected, it could be a simple air gun with a break open principle. Carbon dioxide cylinders or NO_2 is used. Maximum range can be attained by using blank powder cartridges. However an effective range more than 60 metres is difficult to achieve. Even this is done by a parabolic trajectory. Depending upon the power of the blanks (0.22) it is called as "very

low", "low", "medium", and "high". Some manufacturers prefer to designate by the colour of the charge as red, black, orange and yellow.

Some rifles have an adjustable rear sight to enable to get an accurate trajectory. Certain models use the same powder cartridge but increasing or decreasing the explosive chamber by turning a knurled knob regulates power.

Projectiles (Darts or Syringes)

Once the dart syringe hits the animal the needle penetrates. The injection of the drug is effected by pressurising the rear side by the air, butane, LPG or by generation of carbon dioxide (citric acid + soda bicarb with water). A quick injection is achieved by using a cartridge that will explode when the dart syringe hits the animal. This is the most commonly used technique and is very convenient in the field conditions, especially for large animals. The syringe after the impact must deliver the drug intramuscularly. The plunger activation can also be achieved



"Cap-Chur" Syringe

by a pressurised chamber behind the piston or by an impact detonating mechanism otherwise called as the explosive capsule. The plunger can be pushed forward by (a) compressed air pumped from behind the plunger, (b) generation of carbon dioxide by mixing an acid with an alkali or (c) a spring held in compression. For these types of plunger activation, the tip of the needle is closed and holes drilled on the side. A sleeve is put and this slides back when the needle penetrates the muscle making the hole patent facilitating the injection of the drug.

The needles are provided with collars or barbs to ensure attachment to the animal that assists in following it prior to its falling down. The needle to be used on elephants and rhinos are to be reinforced to avoid the breakage on impact and provided with holes on the sides. In general the pressurised syringe mechanisms are more suitable for small and thin-skinned animals, while the explosive types are used for thick skinned large animals.

Tracking the Injected Animal

Most of the animals are disturbed by the impact of the dart syringe and may disappear quickly in the thick cover. While using a dart syringe, the injection is given intramuscularly. It may take anything from a few to several minutes to produce the desired effect.

Tracking an injected animal is difficult and dangerous both for the injected animal and also for the team. Horses if available, trained dogs and elephants, vehicles wherever possible or boats if near a waterway can be employed for this purpose. Of late radio-signalling tailpiece for dart syringe has come into vogue in certain countries. Radio contact with the team and the darting personnel will be extremely useful. The animals should be shadowed and not chased.

Immobilised animals must immediately be taken care of. Some of the postures of fallen animals may prove fatal. e.g., sternal recumbency in elephants and the position of the neck that causes respiratory difficulty. Over dosage if any and other side reactions should be taken note of and appropriate treatment instituted immediately.

The symptom of adequate sedation or immobilisation for safe approach will depend upon the type of the drugs used and this is to be taken into consideration before the animals are handled.

Signs Indicating Drug Action

1. Slight behavioural changes.
2. Drooping of the eyelids.
3. Relaxation and protrusion of the penis.
4. Standing but reluctant to move.
5. Relaxation of the tail.
6. Keeping the head lowered.
7. Increased salivation.
8. Aimless walking.
9. Moving away from the group.
10. Agitated walking and running.
11. Hackneyed gait.
12. Kneeling or straddled leg stand.
13. Recumbency.
14. Lateral recumbency.

Additional means to secure the animal may be resorted to depending upon the purpose for which the animal is immobilised.

Care of the Immobilised Animal

1. Position

Take the animal from the creek or water or cliff, correct the posture to the normal recumbency if possible e.g., sternal for ruminants and lateral for elephants.

Assure easy respiration.

Avoid regurgitation - head not downhill.

Protect the eyes from the direct sunlight and dirt.

2. Check the Vital Signs

(a) State of consciousness by checking the sensory reflexes.

1. Visual first to go	}	Proper level
2. Auditory		
3. Touch		
4. Loss of pain		
5. Loss of corneal reflex	}	Danger
6. Loss of respiration		
7. Heart stops		

(b) Evidence of external or internal bleeding

(c) Colour of mucosa

Pale	- Anaemia or haemorrhage
Pink	- Normal
Blue	- Oxygen deficiency
Grey	- Nearing death

(d) Respiratory rate

Should be regular - may be slower than normal

Abdominal + thoracic - not dangerous, dangerous if abdominal only.

(e) Heart rate

Should be regular may be slower than normal

(f) Body temperature

Control extremes of temperature variation, provide shade, use water or snow for cooling

(g) Bloat

Prevent bloat in ruminants

Position properly - on sternum with head up in ruminants.

3. Secondary Concerns

(a) Ambient temperatures - Protect from cold or heat.

(b) Minimise physical restraint
(c) Remove dart

Examination of the Sedated Animal

1.	Nose	-	Blood, mucus
2.	Eyes	-	Injury dirt, protect from sun.
3.	Mouth	-	Colour of mucous membrane, condition of the teeth—age, excessive salivation
4.	Ears	-	Blood
5.	Chest	-	Gargling or rattling sound on auscultation
6.	Abdomen	-	Bloat.

Treatment and Handling

This includes the veterinary assistance to be rendered or other biological studies to be made with the animal. Depending upon the type of handling, either additional drugging or other physical restraints like roping can be done for the purpose of safety. Blindfolding is a simple but useful method to prevent excitement. For operations like marking or an attachment of a collar, further drugging may not be necessary. Collar or marking should not in any case help predator animals to track down the marked/collared animal.

Post-Immobilisation Treatment

Any animal before release should not have a bléeding wound. Free blood attracts flies, crows and predators, and is therefore, detrimental to the survival of the animal. The skin of the animal has to be washed if it is soiled with blood. Cuts and needle puncture should be properly treated. Antiseptic ointment with a fly repellent may be used for this purpose. Antibiotics to prevent infection and abscess formation are given in certain cases. Anti-tetanus injection and any other vaccination if necessary are given before the release.

Release

If reversible compounds are used, withdrawal of the personnel before the recovery of the animal is important. Before the final injection of the antidote is given, persons not needed for the procedure should withdraw to a safe place after gathering the implements and equipment. After administering the antidote the last person should move away leaving the animal to recover on its own. In this way the association with man is reduced. The animal is not likely to rise before it has recovered sufficiently and will walk off at a slow pace adjusting to the upright posture and restoring normal blood flow to the limbs, instead of running off to escape. A repeat dose of antidote must ordinarily wait for half an hour. Coaxing to get up by beating is not recommended. If rapid return to upright posture is required, buckets of water thrown over the body or on the head may give enough stimuli. Introduction of one or more fingers into the anus may prove to be a strong stimulus to many animals, when respiration is very poor.

If reversal necessarily has to be delayed, vigilance on signs of bloat, hampered breathing, and fall into abnormal recumbency are to be checked, till the animal becomes viable. A viable animal does not fall prey to the hyaena or other larger predators or meet with death in other ways.

Ideal Drug Delivery

Characteristics of an ideal drug delivery system are listed below :

1. Capable of delivering large quantities of the drug.
2. Effective over a wide range.
3. Accurate.
4. Simple in design, easy to handle and reliable for field use.
5. Safe.
6. Minimum damage for the animal.
7. Re-usable syringe and darts.
8. Sterilizable.
9. Inexpensive.

All these requirements can not be combined into one single equipment, but these factors may be considered before a choice is made.

Ideal Drug

Criteria for evaluating the ideal immobilising drug are as follows :

1. Rapid absorption and action.
2. Concentrated form—small quantity for injection via syringe dart.
3. Wide range of tolerance or safety margin—low mortality.
4. Safe for the handler.
5. Reversible by the injection of an antidote.
6. No side effects.
7. Effective anaesthesia level with retention of reflexes.
8. Not subject to dangerous drug licensing.
9. Permitted for use in animals used for human consumption.
10. Low cost.

Most of the drugs used nowadays for large ungulates qualify for four or five of the above specifications.

Factors Modifying Drug Action

1. **Species:** Relative sensitivity to opiates in cats is well known. Different species of animals take varying doses for immobilisation. Xylazine that is effective in a dose of 80-120 mg/tonne in elephants may give only a transient effect in pigs even with 20-50 mg/kg body weight.
2. **Physiological Factors:** Smaller animals have comparatively larger surface area and higher basal metabolic rates. Age and disease may modify the detoxification and excretion rate of the drugs thereby changing the net results. Opiates and cyclohexamines cross placental barrier and may sedate the foetus.
3. **Physical Condition:** Body weight of the animal must be known before the drug is injected. It is often difficult to estimate the weight of the animals in the wild and reference to the literature

may not always prove useful. The dart may be loaded for a deer weighing 80 kg and a deer weighing only 40 kg may present itself to the dartman. Temptation to dart during such situations must be resisted unless the drug has a wide margin of safety and reversibility. Malnutrition and obesity are other factors to be considered.

4. **Emotional Status:** An aggressive and excited animal may take a large quantity of tranquilliser as against a normal and quiet animal. It is noticed that larger dose is required in immobilising elephants aggressive during musth and a smaller dose is required for similar sized elephants when quiet and non-aggressive. Accordingly feral, captive, tamed and captive animals respectively take a decreasing dose level of drugs to achieve a similar degree of sedation or immobilisation. An excited animal shot with a phenothiazine tranquilliser may suffer from immediate hypotension due to adrenolytic action of these compounds. Metabolic acidosis that may develop can be treated with administration of sodium bicarbonate solution. Successful immobilisation is a scientific art and it depends on several factors listed below.

Failure to Inject

1. **Breaking of the Needle**: A wrong angle or high impact may lead to breakage of the needle and the same may get embedded in the muscle mass of the animal, and is difficult to retrieve.
2. **Telescoping of the Needle**: If the needle is not fixed properly, on impact, the needle may retract into the syringe through the nosepiece. This can be avoided by suitably modifying the nosepiece hole to which the needle is inserted.
3. **Failure of the Charge to Explode**: Failure of the charge to explode in a percussion cap and insufficient pressure to project the syringe in a carbon dioxide projector can be experienced. Percussion caps are to be protected from moisture using silica gel. Occasional desiccation of the charge is useful. Rainy weather, left out solutions of drugs in syringes kept in the same kit bags contribute to the increased moisture that will be absorbed by the charges. In very cold climates carbon dioxide projection will yield only very low propulsion force. Equipment where in dif-

ferent charges are to be used for different distances, may pose problems when the target is sighted at a distance that does not correspond to the charge that is already loaded. Inaccurate estimation of the distance can contribute to this type of error. A range finder is useful in this context.

4. **Large Bore Needles**: Large bore needles especially in thick skinned animals like elephants may cut a plug into the needle and block the tip, preventing discharge of the drug. This can be avoided providing holes on the sides of the needle.
5. **Wobbling of the Syringes**: Presence of air in the syringe, matted and unclean tailpieces may wobble the syringe and this can be avoided by taking appropriate precautions.
6. **Faulty Weapons**: Weapons are often not properly cleaned, lubricated, or repaired properly. Charges are kept outside and exposed to moisture. The old dictum of "Take care of your weapon before you take care of yourself" is a very important rule. The weapon should be cleaned off the grease and oil before use.
7. **Wrong Site of Injection**: Injections into the fat depots, fascia and subcutaneous area may prolong the induction time. Injections with syringes using an explosive cap may cause a local haematoma and reduce the rate of absorption. A wrong site of injection may result in the needle striking body prominence and causing the needle to bounce back, or resulting in the fracture of bones in small animals.
8. **Improper Charge**: A long distance (powerful) charge is not recommended in small animal capture since the whole syringe may be driven into the animal. Delivery of a syringe using a blowgun will not cause such a condition.
9. **Premature Explosion**: This may happen with impact detonation mechanism. If the charge is placed in the reverse direction the inertia developed on projection of the syringe may lead to the explosion of the charge and discharge of the drug before the dart reaches the animal.
10. **Infection of the Injection Site**: Most often aseptic precautions cannot be taken and this may lead to infection in the area. Wound infection occurs more frequently when there is an exten-

sive contusion at the impact site. Highly concentrated and irritant chemicals like pure alkaloid of nicotine may cause sterile abscess.

11. **Bouncing of the Syringe**: Syringe may bounce back immediately on impact or fall down before the complete injection of the drug. This is avoided by using collared or barbed needles. Barbed needles sometimes necessitate an incision to retrieve the syringe and a stitch to close the wound.
12. **Fatal Fall of the Immobilised**: Sudden onset of paralysis, especially when peripherally acting drugs are used, may cause stumbling of the animal. Once an elephant, after immobilisation stumbled into a rocky pit, and died. On two occasions elephants could not be immobilised since they ran into a river and on another occasion into the sea. Sternal recumbency in elephants is another fatal condition, if maintained for more than twenty minutes.

Immobilisation Emergencies

1. Aspiration
2. Bloat
3. Capture myopathy
4. Convulsions
5. Dehydration
6. Frost bite
7. Hyperthermia
8. Hypothermia
9. Respiratory arrest
10. Seizures
11. Shock
12. Vomiting
13. Injuries

A Brief Note on Drugs for Wildlife Captures

1. Peripherally acting drugs.
   (a) Paralysing agent e.g., Nicotine.
   (b) Muscle relaxants e.g., Curare, Gallamine, Succinyl choline.

2. Centrally acting drugs
   (a) Opiates e.g., Morphine, Etorphine, Fentanyl, Carfentanyl, Surfentanyl.
   (b) Sedatives.
      1. Phenothiazines e.g., Acepromazine.
      2. Butyrophenones e.g., Azaperone, Haloperidol, Droperidol.
      3. Benzodiazepins e.g., Diazepam, Midazolam.
   (c) Dissociative anaesthetics
      1. Cyclohexamines e.g., Ketamine, Tiletamine (used with zolazepam), Phencyclidine (now discontinued).
      2. Xylazine.
      3. Meditomidine, Ditomidine.
3. Adjunct drugs
   (a) Hyaluronidase.
   (b) Atropine sulphate.
4. Reversing drugs
   (a) Alpha blockers: Yohimbine, Tolazoline, Phentolamine, Atipamezole.
   (b) Opium antagonists: Diprenorphine, Levallorphan, Nalaoxone, Naltrexone, Nalmefene.
5. Supportive drugs
   (a) Eye ointments
   (b) Antibiotics
   (c) Steroids
   (d) Fluids
   (e) Stimulants
   (f) Vitamins.

Nicotine is an alkaloid only of historical importance in present day wildlife immobilisation. However, several tamed Asian elephants, which became uncontrollable due to musth were immobilised with nicotine. The initial stimulation, which is noticed in other animals, is not observed

in elephants. Quick onset and predictable results in spite of external disturbance are the important advantages of this alkaloid when elephant immobilisation in a festival crowd is required. Easy availability and low cost make it a drug of choice for stray dog control. However poor margin of safety, lack of antidote and individual idiosyncrasy prevent its use in regular wild animal immobilisation.

Muscle Relaxants There are two groups of muscle relaxants, reversible and non-reversible. Succinyl choline chloride, which is a non-reversible drug, has been in use for deer immobilisation. However, the assessment of accurate body weight and lack of antidote have reduced its extensive use.

Both curare and gallamine are reversible type of muscle relaxants and their use in domestic animals has given good results. High solubility of gallamine helps its use in large animals like elephants. In elephant it has given satisfactory results but the animal that has been reversed with neostigmine may again became paralytic. Atropine will have to be incorporated with these drugs to avoid excessive vagal depression on heart when neostigmine is used to reverse the drug action. The reversal is dramatic with neostigmine. The animal is fully conscious and experiences pain. Hence it is not recommended.

Centrally Acting Drugs

Opiates The original opiate, morphine has been given only a limited trial. The later compounds like etorphine, fentanyl and carfentanyl have been approved as the most useful immobilising agents. They are very compatible with other chemicals and their action can be reversed. Like all other opiates, felines and certain equines do not tolerate this compound. These can be combined with tranquillisers of phenothiazine group, butyrophenones and xylazine. Depression of respiratory centre and stringent narcotic regulations prevent its widespread use.

Sedatives

Phenothiazines Amongst the phenothiazines, acepromazine is the most extensively used drug. As a sedative it produces relaxation of penis and this may be a problem in transportation of male elephants on foot under sedation for long distances. In India only chlorpromazine and trifluprom azines are available which are very less potent.

Butyrophenones Among butyrophenones only haloperidol and droperidol are available in India. Haloperidol being long acting is not used much for animal immobilisation. Haloperidol gives satisfactory sedation in elephants. This group is reputed for pigs. Haloperidol can be used to acclimatise recently captured animals. Azaperone and droperidol are commonly used for immobilisation.

Benzodiazepine All compounds of benzodiazepins like chlordiazepoxide, diazepam, and nitrazepam are available in India. They are very mild and can be used for transport, acclimatisation and taming. A new, compound midazolam can be used as a synergist along with drug immobilisation.

Dissociative Anaesthetics

Cyclohexamine Among the cyclohexamines, Ketamine is the most commonly used chemical. Phencyclidine once extensively used is not manufactured now. Tiletamine, a butyrophenon, in combination with zolazepam is used. Ketamine provides very interesting catatonia. Glassy eyes in monkeys are characteristic. Ketamine can be combined with acepromazine or xylazine or diazepam.

Xylazine is a non-narcotic, sedative analgesic and muscle relaxant. Animals appear to be sleeping and produce snoring. In elephants and bulls it causes relaxation of penis. A seemingly sedated animal may rouse explosively. Disturbance during the induction period may delay or even nullify the effect. The elephants may stand and sleep with xylazine. Once an apparently sedated elephant when approached by the crowd ran for a distance of two kilometres and then became immobilised. Xylazine with Acepromazine or ketamine in elephants

can produce photosensitisation if the animal is exposed to solar radiation.

Adjunct Drugs

Hyaluronidase This is an enzyme mixed with immobilising drugs to increase the rate of absorption from the injection site. The enzyme breaks down connective tissue, and thus, speeds absorption. The drug is marketed in India as Hylase. Generally 150 to 300 I.U. are added to each immobilising dose. It has been used with succinyl choline chloride, etorphine and fentanyl with apparent decrease in the latent period.

Atropine sulphate This drug is used primarily to decrease salivation that is often seen with phencyclidine and ketamine. Atropine blocks the parasympathetic nervous system to decrease salivation. It decreases sweating, gut motility, bladder tone, gastric and respiratory secretions. Since there is dialatation of pupil, eyes must be protected from sunlight. Atropine may be mixed with the immobilising drug, but is often given after the animal is down. Ideal way is to atropinise before immobilising drugs are given.

Reversing Drugs

This class of drugs is used to reverse the effect of another drug and is often called as antagonists. They are used to negate the effects of an immobilising drug so as to enable the animal to be on its feet and on its own.

(a) **Cyprenorphine** (M 285) This was the original antagonist used for etorphine, but has generally been replaced by diprenorphine (M 50 50).

(b) **Diprenorphine** (M 50 50 or Revivon): This is the antagonist primarily used to reverse the effects of etorphine. It is marketed as M 50 50 (2 mg diprenorphine per ml in a 20 ml vial) and Revivon (3 mg diprenorphine per ml).

(c) **Nalorphine hydrobromide** or **hydrochloride** These drugs have a structure similar to morphine and compete with morphine at the receptor sites to act as a reversing drug. They are used mainly

against fentanyl and carfentanyl. The drugs are marketed as Lethidrone NC and Nalline.

(d) **Naloxone hydrochloride** This drug has similar action as nalorphine, but does not produce the agonistic effects similar to those of morphine. Naloxone is preferred to nalorphine for reversing the effects of fentanyl. Naloxone may also be used to reserve etorphine and is the preferred human antidote. The drug is marketed as Narcan. (0.2 and 0.4 mg naloxone HCl per ml in one ml ampoule).

Supportive Drugs

This class of drugs is used in association with chemical immobilisation. An immobilised wild animal may show indications for use of many other drugs as supportive therapy. In all instances these drugs are to be used after the animal is immobilised and examined.

(a) Eye ointments: These may be used in preventing infections into the eye and drying of the cornea, when the animal is immobilised in the field. It is suitable with ketamine since the eyes are kept open by the immobilised animal.

(b) Systemic antibiotics: These are generally given if the animal has evidence of infection or has potential for infection through injury or dart wound. Since the animal is to be released in the wild, a long acting antibiotic is preferred.

(c) Steroids: May be used for supportive therapy in animals under stress.

(d) Intravenous fluids: May be used in animals that are severely affected by dehydration or suffering from acidosis.

(e) Respiratory and cardiac stimulants : These drugs may be indicated but should be used with extreme caution under veterinary supervision.

(f) Injectible vitamins: May be given as a boost for severely debilitated animals.

Capture myopathy, shock, hypothermia, respiratory failure, cardiac failure, bloat, pneumonia, miscellaneous injuries and secondary infections are some of the problems that require immediate attention and appropriate treatment.

Hence it is a necessity that some trained personnel are present to handle these situations during captures operations.

Drug Dosages

Discussion of the dosages will entail a textbook, considering the variety of drugs that can be potentially used and the innumerable species involved. Guidelines are often provided as an insert along with the dosage, with the drugs, but they are not always reliable due to species variation. Most of the species have been immobilised at one time or other with various products and a review of the literature regarding the immobilisation of that particular species should precede any project. Information on doses of different species may be obtained from standard textbooks on drug immobilization.

In India where drug dosages have not been worked out for many species, it would be desirable for professionally qualified persons, ordinarily a veterinarian, to monitor such programmes. Never hesitate to get professional assistance and advice from experienced people for successful capture operations.

Transport

Transportation of wild animals of different taxa requires great amount of experience and expertise. Snakes can be transported in small carry bags where as elephants are transported in big trucks under sedation. Often captive elephants are transported long distances on foot. Care should be taken while transporting carnivores. They can reach out through the bars and maul the attendants.

Transport cages should show the details of the dispatcher, place, date and time of dispatch, short note on the background of the animal and medications done if any. Transporting personnel should also carry a detailed note on the source of the animal, purpose of transport, receiver's address, telephone number and other details that are required to contact in case of emergency. Details of the transponder, if implanted, should also be available. International transport of wild animals needs

official permit from the governments concerned, health certificates and details of preventive vaccinations and de-worming schedules followed from a qualified veterinarian. Animals that are endangered require CITES permit and preferably a transponder implant.

If the transportation enclosures are heavy, they must have a provision to be loaded using a forklift or for hoisting using a crane, especially when the transport is of a multi-modal nature. There must be provision for providing food and water depending upon the distance to be transported. During transportation the cages may be covered to avoid the external stimuli as well as to prevent excitement and stress. Depending on the distance of travel, sedatives, preferably long acting ones, can be given. However heavy sedation for long periods can cause bloat in ruminants.

Aquatic and wallowing animals have to be sprinkled periodically with water during transport to prevent drying of the skin. Transportation of animals in general must be done during the cooler hours of the day and preferably at night when the animal is less active. Provision for rest for the animal as well as for the crew has to be considered especially during long distance transportation. Presence of leftover fodder or even dung of the same animal or the same species in the cage will have a relieving effect on the transporting animal. Prey species like deer may hesitate to get inside a cage in which a predator species like tiger was transported, due to the smell, especially when the cages are not cleaned properly. Even when the prey species is forced inside the cage it may cause stress to the animal.

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Chapter 15

Aquaculture

Aquaculture is an ancient science. Man started fishing even before engaging in formal agriculture. In recent years aquaculture has gained more importance. Several technological developments have taken place in aquaculture, like the intensive methods of plant and animal production. Similar to intensive animal production, a well-managed environment is of paramount importance; the water is the most important aspect. Fish must be fed based on the scientific principles of nutrition. The space requirement is to be kept based on stocking densities. Stocking density will vary depending upon each stage of production. General principles of hygiene for the prevention, control and eradication of diseases are very important. The diseases vary with each type of aquaculture species. Although in many parameters, aquaculture is similar to intensive animal rearing, there are various other factors that make it complicated, the most important being the environment i.e., water. Contamination of water in intensive aquaculture occurs quickly and at times difficult to quantify and rectify. The variety of fish that are cultured are of different species, with some of them being of different taxa. Hence both their environmental and nutritional requirements are different. Many of them have complicated life cycle like migration. The breeding stock is often the wild stock and hence genetic standards are often difficult to optimise. In spite of all these, various technologies are being evolved to develop aquaculture into a scientific and economic activity.

Extensive and serious outbreaks of diseases are common in aquaculture that can lead to total closure of the operation. Changes in the quality of aquatic environment, both physical and chemical can lead to this calamity. Accumulation of nitrogenous waste

materials, difference in the ambient temperature and depletion of oxygen lead to this. Industrial and agricultural contamination is another threat. Pathogens are very difficult to control in an aquatic environment. In addition several non-commercial aquatic animals may act as carriers without visibly exhibiting disease. Frequent movement of the fish population from the culture ponds to the feral or wild situation and vice versa add to this further.

A variety of vertebrate and non-vertebrate animals are reared for economic reasons. Important aquacultural or maricultural species are finfish species (Salmon, Tilapia, Carp, Trout, Catfish, Eel), tropical ornamental and bait fish. In India invertebrate species like molluscs, clams, oyster, mussels, squids, cuttle fish and octopus form an important resource. Crustaceans like lobsters, shrimp and cray fish are also important. Other marine creatures found in the Indian waters are **Fiddler Crab** (*Uca uca*), **Robber Crab** (*Birgus latro*), **Cowries** (*Cypraeidae*), **Eels** (*Anguilli formes*), **Jelly Fish** (*Aurelia aurita*), **Marine turtles** (Testudines 7 species of 2 families), **Mud Skipper** (*Periophthalmus koelreuteri*), **Octopus** (*Octopus vulgaris*), **Rays** (*Hypotremata*), **Snails** (*Gastropoda*), **Sea Horse** (*Hippocampus*), **Sea Snakes** (*Hydropdiae*), **Shark** (*Scoliodon sorrakowah*) and **Star Fish** (*Asteroidea*).

Classification

Superclass Pisces

Class I Chondrichthyes (Cartilaginous fishes)

E.g., Shark (*Scolidon sorrakowah*)

E.g., Electric ray (*Narcine timlei*)

Class II Oseichthyes (Bony fishes)

Order Isospondyli (Fins without spines – Herrings)

E.g., Oil sardine (*Sardinella longiceps*)

E.g., Brown tront (*Salma trutto*)

Order Ostariophysi (Anterior vertebrae form a chain of bone – Weberian ossicles – connecting air bladder with the ear)

Suborder Cyprinoidea (Scale-less head, body with large scales, toothless mouth, air bladder present) E.g., Carp (*Catla catla*)
Suborder Siluroidea (Cat fishes – presence of barbels around mouth, toothed jaws, air bladder present)
E.g., Magur (*Clarias batrachus*)
Order Apodes (Body elongate and naked)
E.g., Eel (*Anguilla bengalensis*)
Order Heteromi (Deep sea fishes)
E.g., Notocanthus
Order Mesichthyes (Soft finrays)
E.g., Mosquito fish (*Gambusia affinis*, *Aplochilus lineatus*)
Order Acantopterygii (Anterior rays of dorsal and ventral fins form spines)
E.g., Murrel (*Channa striatus*)
Climbing perch (*Anabas scandens*)
Flat fish (*Cynoglossus cynoglossus*)

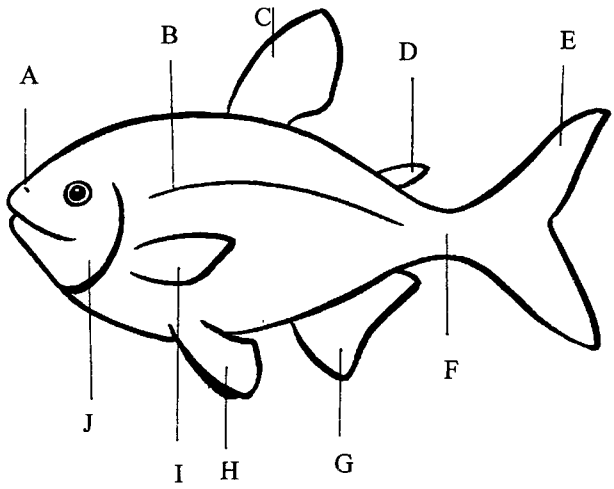
Elementary Fish Physiology

Fish are poikilothermic and hence the temperature of water affects a lot of their developmental stages. Salt water fishes are hypo-osmotic and fresh water fishes are hyper-osmotic to their environment. Hence, extensive lesions on the skin are detrimental due to the loss of fluid balance and finally the collapse of the circulatory system.

Lymphatic system is not well developed and do not have Kupffer's cells, which are phagocytic cells seen in the sinusoids of the liver. These are important in the breakdown of haemoglobin after the phagocytosis of the red blood cells. Phagocytosis mainly takes place in the haemopoietic tissue of spleen and kidney and in the atrium. It may be noted that fish is having a two-chambered heart. Kidney varies very much in different species and usually has an anterior portion and a posterior portion. This is often designated as 'head' kidney and caudal kidney. Kidney is located ventral to the vertebral column and performs the function of haemopoesis, endocrine secretion and excretion. Gills

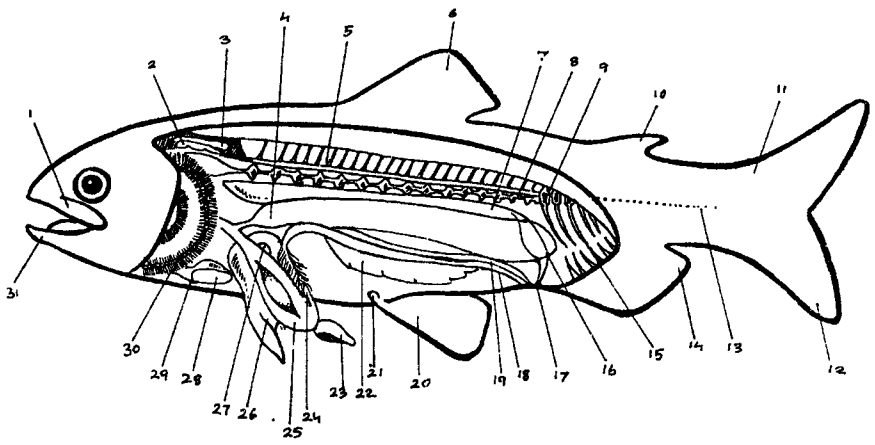
act as excretory organs, mostly of nitrogenous waste materials. Hence both kidneys and gills are critical organs in fish.

Bony fish have swim bladder and is an appendage of foregut. As the name indicates it helps to maintain the buoyancy. It can also be used for sound production. Gas present in the swim bladder is either absorbed or secreted to the required level to maintain the required buoyancy, depending upon the environmental water condition. The sensory system is located along the lateral side of the body. The afferent impulses from these sensory bodies are received by the Central Nervous System and results in appropriate responses.



(A) Nose or nares (B) Lateral line (C) Dorsal fin (D) Adipose fin (E) Tail or Caudal fin (F) Caudal peduncle (G) Anal fin (H) Paired ventral or Pelvic Fin (I) Paired pectoral or Breast fin (J) Gill cover or Operculum

A humoral antibody system is present in the fish. It varies with different species. Specific antibodies are present in the body. Their production is greatly influenced by the environmental temperature. B-lymphocytes that produce the antibodies are seen in the liver and spleen. Fish lack Ig G, which is a potent immunoglobulin seen in other animals. In response to antigens, Ig M is produced as seen in other higher animals. Ig G antibodies with gamma heavy chains appear later in the immune responses are more abundant in higher animals. Ig M has (μ) heavy chains. They are polymerised type antibodies secreted usually as early response to antigens. Environmental temperature considerably



(0) Adipose Tissue (0) al Fin (0) Erti Brac (0) Heart (0) Orsal Fin (0) Remexilla (2) Brain (3) Supra Occipital (4) Gas Bladder (5) Neural spine (7) Kidney (8) Spinal cord (10) Adipose Fin (11) CAudal Peduncle (12) Caudal Fin (13) Lateral line 15) Hernal spine (16) Vrinary Bladder (17) Anus (18) Intestine (19) Testes (20) Pelvic Fin (21) Pelvic Girdle (23) Spleen (24) Pyloric Caeca (25) Stomach (26) Liver (27) Gall Bladder 29) Pectoral Gridle (30) Ventral Aorta (31) Dentary

augments the antibody production, both during infection and after vaccination. The optimum ambient temperature varies with the species like whether it is a warm water or cold water fish. Temperature considerably higher than what is seen in the normal habitat has an inhibitory effect on the antibody production. T lymphocytes are present in fish. T cells occupy definitive sites in the secondary lymphoid system. They undertake direct immune activities including the destruction of the virus-infected cells (cytotoxicity) or of cells carrying foreign antibodies. Unlike in higher animals immunity is not age dependent. Very young fish respond very well to vaccination. Antibodies are usually present on the skin and the GI tract, which are the common routes of entry. However the duration of immunity does not last long as in mammals. Immunisation is done both by individual injection and by bath method. Immunity lasts longer in parentral vaccination than in bath method. Individual vaccination is time consuming and labour oriented and hence it is difficult to practice in mass culture.

Fish Medicine

Aquatic animal medicine was mostly confined to exotic aquatic animal collection and ornamental fishes that are kept as pets. Recently the aquaculture has grown into a big industry with a lot of economic stake and the special division, aquatic animal medicine has developed. Marine invertebrates and finfish are now extensively used in pharmacology and toxicology. Aquatic animal medicine is getting specialised broadly into two aspects. The first one is the population medicine practised in large-scale aquaculture. This can be compared with livestock industries like herd health management, nutrition and disease control. In pet fish medicine, it is individual type medicine as done in companion animal medicine. In the first type of specialisation sacrificing of a number of fish may be required to establish the cause of the disease, its spread and control. In pet fish industry a lot of sophisticated and specialised diagnostic methods has been developed. Similarly many therapeutic approaches including surgical management have been evolved.

Diseases

Diseases that are affecting fishes can be classified into environmental, nutritional, parasitic, bacterial, mycotic, viral and miscellaneous.

Environmental Diseases

This is the most important and common disease condition. Poor environmental conditions is likely to predispose, the fish to various infectious and non-infectious diseases.

Periodical and frequent assessment of water quality must be made a regular practice. Nowadays several field kits are becoming popular. When veterinarians are called to attend an aquaculture facility, they should have some fundamental knowledge on various parameters of water quality. Major parameters are dissolved gasses, salinity, carbonates and nitrogen compounds. Of the dissolved gases nitrogenous waste materials affect all type of fishes.

Chlorine is commonly added in public health water systems. Often chlorine is added to water without assessing the requirement and such residual chlorine can harm the fish. A concentration of 0.02 to 0.04 mg/l can result in death of the fish. Sodium thiosulphate can effectively be used to neutralise the dissolved gases. The ratio is 7.4 mg of $Na_2S_2O_3$ for 1 mg chlorine /l of water.

Dissolved Gases: Oxygen is the most important. Algae are the common source of oxygen in aquaculture. The oxygen production increases during the daytime and decreases during night. The demand for dissolved oxygen varies with different types of fishes. The mortality is often noticed in the early morning when the oxygen level is the lowest. Large fishes are more affected than smaller ones. When the level of dissolved oxygen decreases, the fish comes near the surface of water and try to gulp the air especially in the morning. High nitrogen content causes gill diseases and other similar conditions. Prolonged cloudy weather and destruction of algae and pond turn over, affect the turn over of dissolved oxygen. Oxygen level is monitored and aeration is resorted to if necessary.

Another condition is super saturation of water with a gas. This may result in gas bubble disease. It often results when very cold water with a lot of dissolved air is warmed up without the provision of time to volatilise excess air. Similarly water from the deep wells will often have high levels of CO_2 or N_2. Hence water from the wells should be aerated before being used for aquaculture in tanks. Symptoms of the gas bubble disease include protruded eyes and tiny gas emboli in the fins and tissues. Gas emboli in the fins are almost diagnostic. Treatment involves mostly, quick and vigorous agitation of water to volatilise the excess gases.

Another environmental condition related to the gas is the presence of hydrogen sulphide, which is highly toxic to fishes. The presence of hydrogen sulphide is easily noticed by the smell. Decaying of coconut husk in the backwaters of Kerala, for the production of coir, leads to the production of H_2S. Although test kits are available, the characteristic smell helps to diagnose the condition.

Nitrogenous Waste Materials

Nitrogen is normally produced in the fish from protein metabolism. In fish, nitrogen is eliminated through the gills as ammonia by way of passive diffusion. Once the ammonia is released the nitrogen gets into the usual nitrogen cycle. Bacteria convert the ammonia to nitrite and nitrate ions. Nitrate is finally converted to nitrogen anaerobically and leaves the water. The plants or algae in the water use the nitrogenous compounds. Another source of nitrogen is the areas of decomposed fish feed. Fish food is rich in protein, and contains approximately 38% protein. Naturally this can contribute to a great extend to the nitrogen contamination of the system.

In the intensive aquaculture, excess ammonia is an important factor. Ordinarily a dynamic equilibrium is established between NH_3 and NH_4. Alkaline pH and high temperature favour NH_3 production, which is highly toxic to the fish. When the pH becomes higher than 8.5, NH_3 invariably proves toxic to the fish and the reasons are to be investigated. Usually in a healthy aquatic environment, the bacteria quickly utilize NH_3 released by the fish. (Nitrosomonas species). The test kits ordinarily measure only the total N_2 i.e., the combined value of NH_3 and NH_4, where in NH_3 is highly toxic for the fish.

Failure of the biological filter or overfeeding, at times change of feed, can lead to excessive ammonia. Immediate corrective measures are reduced feeding, change of water and reassessment of stocking density.

Another condition due to the environmental degradation is Brown Blood Disease. This is due to the formation of methhaemoglobin in the blood by the nitrogen entering the blood stream through the gills. Fresh water fishes are more susceptible to this. Characteristic symptom is the chocolate brown colour of the gills. Since methhaemoglobin cannot carry oxygen, the fish suffer from chemical anoxia. The fish crave for oxygen and come to the surface and try to gulp the air. Immediate remedial measure is often, to increase the chloride level by adding sodium chloride. Increased chloride (Cl^-) ions in water exert a competitive inhibition against

NO_2 at the gill epithelium. If the chloride ions are raised to a level of six parts to one part NO_2, the methhaemoglobin level can be brought down immediately. Common salt (NaCl) will provide Cl^- ions. Addition of 4.5 lb (10 kg) of salt to one acre-foot (0.4 Hectare-30 cm) of water will add Cl^- at the rate of 1 mg/l.

Carbonate Compounds. Level of carbonates in the water and its interaction with various components in the water are very complex and is governed by various factors. Production of CO_2, total alkalinity, total hardness and pH all interact to produce its effect in the aquaculture system. The presence of large plant mass or algae can greatly influence the CO_2 concentration in a diurnal manner. The pH change arising out of this affects the fish. Many species of fish can tolerate a pH change between 4 and 10. Marine species ordinarily tolerates pH changes within 8.2 to 8.3. Hydrated lime (CaOH), dolomite (double carbonate of calcium and magnesium), or calcium carbonate are all used to adjust the pH. If they are not added without proper assessment, it may do more harm than good. The lime requirement is calculated by taking different measurements and calculations.

Salinity of seawater is a complex system with several electrolytes and their unique contribution. Hence simple sodium chloride addition does not compensate for the same. Seawater ordinarily contains 3% salt. In marine aqua systems the salts present in the sea contribute many micronutrients. Common salt as such is useful only in fresh water systems to adjust osmolarity, and to act as ectoparasiticides, (*q.v.*). Salinity is often measured using a hydrometer or with a clinical refractometer. Ready to use sea salts are used in small facilities where marine fishes are kept.

Environmental pollution mostly man made may harm the fish. Effluents from distilleries, acid rain, and heavy metals from smelters are only a few of them. The role of carcinogens thrown into water bodies is to be ascertained. The large number of tumours detected in fishes can be due to effluents containing carcinogenic compounds. Further controlled studies are needed to arrive at an inference.

Ornamental fishes are often subjected to accidental or malicious poisoning from feeds, detergents, medication and disinfectants. Aflatoxins and other mycotoxins are found to be responsible for death in fish especially in rainbow trout and salmon. Hepatoma is the common lesion and often mortality is high.

Nutritional Diseases

Fish keeping has grown from the fancy of hobbyist to a commercial establishment. Often ready to feed fish food is used for both commercial establishments and ornamental farming. Usually fish feed is a high protein feed and the protein component is mostly made up of fishmeal. Vitamin C (Ascorbic acid) is a dietary requirement for the fishes. Vitamin C is a very labile compound and hence it is added in the fish feed in the stabilised form.

Table 5.1 Nutrient Deficiencies and Symptoms

Nutrient	Symptoms
Vitamin A	Retinal atrophy and stunted growth.
Vitamin E	Myopathy.
Ascorbic acid	Vertebral collapse (Broken neck).
	Thiamine (B_1) Neurological symptoms (Convulsions and death).
Thiamine (chronic)	Stunted growth, oedema, loss of equilibrium.
Riboflavin (B_2)	Corneal vascularity, hyper pigmentation, eyes: cloudy and haemorrhage.
Niacin, Pyridoxine, Biotin.	Neurological signs (Spasms and convulsions).
Folic acid	Poor growth and anaemia..
Panthothenic acid	Gill affections.
Selenium	Skeletal muscle abnormality.

Feeding Schedule: Growing phase: 3-5% of the body weight, maintenance: 1-2% of body weight. Observe the fish during feeding. The feeding should be active. Any sudden loss of appetite is indicative of illness. Feeding points should be distributed to avoid unnecessary competition. As for other animals, small fish should be given smaller quantities of feed at frequent intervals. There are several published

data about fish feed standards especially for Catfish, Salmon, Trout, and other warm water and aquarium fishes. Rancid feed may result in steatitis.

Parasitic Diseases

Fish act both as an intermediary host as well as final host for several parasites. It is often noted that, apparently healthy fish have a heavy parasitic burden.

Helminths

Trematodes are seen on the gills and skin. The genera noticed are *Gyrodactylus* and *Dactylogyrus* that are the common skin parasites. Organophosphorus compounds are used in the treatment in non-food species. Trichlorophon is an OP compound used for this purpose. Prolonged bath (0.25 mg/l) is effective and treatment is done in the early morning. Some metacercaria may affect the gill and result in mortality. Though direct treatment is not effective, control measure using a molluscicide can be tried. Ensure that the molluscicide is not harmful to the fish as such. Molluscicides can be applied 1-2 weeks before stocking.

Cestodes: tapeworms both in the larval and adult forms are common in the fish. *Diphyllobothrium latum* is the tapeworm of zoonotic importance. Tapeworms seen in fish are *Corallobothrium* species, *Proteocephalus ambloplites* (larva) and *Bothriocephalus acheilognathus*. The standard anticestodal drug praziquantel is given as a bath (10 mg/l for 3 hours) or given in food. Another drug is Di-n-butyltin oxide at the rate of 250 mg/kg of fish orally for 3 days. Acathocephala is another tapeworm of importance. Larvae are seen in the tissues and adults in the intestine. Arthropods act as intermediary hosts.

Nematodes are commonly present in the fish in the wild because of the presence of intermediary hosts. Aquarium and culture facilities may get nematode infections if intermediary hosts are present (e.g.:

Crustaceans). *Cyclops* and *Daphnia* species are some of the intermediary hosts for certain nematodes like Philometra species These nematodes are pathogenic to aquarium fish like guppies. Fenbendazole and Levamisole can be tried. Ivermectins are toxic to most species.

Leeches not only bleed the fish but also transmit Trypanasoma, Cryptobia and haemogregarines that cause severe anaemia. Wild fishes are most commonly affected, but pond and aquarium fishes may at times get infected. Trichlorfon at the rate of 0.5 to 1 ppm in water is found to be effective.

Copepoda

They are an order of fresh water and marine Crustaceae. Some are called water fleas. Some are ectoparasites of both warm blooded and cold-blooded aquatic vertebrates. Parasitic copepods of fish and whales are having organs that are highly modified for deep penetration of the skin. Some of them have suckers or hooks with which they hold on to the body e.g., Argulus, fish lice. Certain copepods (Cyclops, Diatoms) are important as intermediate hosts of broad fish tape worm of man (*Diphyllobothrium latum*) and guinea worm of man (*Dracunculus medinensis*).

Lice (*Branchiuria*) are related to parasitic copepods and are treated with Trichlorphon at the rate of 0.25 ppm of water, but not approved for use in fish-food by FDA.

Protozoan Parasites

Ciliates are the most common group of parasites in fish. Of these the ciliates *Ichthyophthirius multifilis* is the most important. Ciliates may be found within the epithelium, attached to the body or even in the motile form. Infection from the *I. multifilis* can cause mortality. The immature stages of these parasites penetrate the mucus of the epidermis as well as gills, where they get encysted. Encysted form is refractory to treatment. Copper sulphate is the chemical of choice for treatment that is to be repeated every 2-3 days in warm climate and

only once in 3-5 weeks in cold climates. Formalin is used in tank fish. Potassium permanganate is not recommended, as the repeated administration may damage the gills. A similar infection in the marine fish is caused by *Cryptocaryon irritans* and treatment is again by copper sulphate at a concentration level of 0.2 mg/l for 3 weeks. Other ciliates of pathological importance are *Chilodonella* species, *Brooklynella* species, (in marine), *Trichodinids, Tetrahymena corlissi.* But *Ambiphyra* and *Apiosoma* species are pathogenic only if present in large numbers.

Flagellates *Ichthyobodo* species are the most common. *Oodinium* and *Amyloodinium* are other two species that infect the fish. Neither formalin nor potassium permanganate is effective. Adjustment of salinity to the appropriate level is recommended.

Internal protozoan parasites that are commonly noticed ones are *Hexamita* (*Octomitus*) species, *Spironucleus* species, *Cryptobia* and *Trypanasoma* species are the other protozoan parasites noticed. Parasites of protozoan nature like sporozoans (e.g., coccidia), myxosporidians and microsporidians are noticed.

Mycotic Diseases

Fungal infections are often secondary to an injury. Iodophores are used to disinfect non-food fish eggs at 100 ppm iodine for 10-15 minutes. Only eggs can be treated in this method, as hatched fish will not tolerate this treatment. Eggs of food fish are treated with formaldehyde at the rate of 2000 ppm for 15 minutes. Common fungal infections are *Saprolegnia* species, *Ichthiophonus* species and *Branchiomyces* species Other minor mycotic infections of fish are *Alchyla, Aphanomyces, Dermocystidium, Ichthyosporidium, Basidiobolus, Phoma Candida, Cladosporium, Fusarium, Pencillium, Ichthyochytrium species*

Persistent fungal infection indicates poor sanitary conditions and high organic load.

Bacterial Diseases

Bacterial diseases occur usually in epizootic form and the most

important contributing factor is environmental degradation like poor quality water, heavy organic load, non-optimum level of temperature and salinity. Stress and resultant poor health make the fish susceptible to pathogens. Most bacterial pathogens of fish are gram-negative rods. Most common bacteria are Aeromonas species. Antibiotic treatment is resorted after doing the culture and sensitivity tests. Fish eggs are sterilised by treating with iodine. Iodine concentration recommended is 100 mg/l, pH 7 for a period of 10-15 minutes at a temperature of 10-15 °C. Fish also suffer from vibriosis and yersiniosis (enteric red mouth disease).

Corynebacterial infection cause bacterial kidney disease and is of economic importance. Infected females are injected with erythromycin 11-20 mg/kg IM, 14-60 days before spawning. Outbreaks are controlled by feeding 100 mg/kg through food for 10-20 days.

Streptococcus species cause large-scale mortality. Treatment is resorted after culture and sensitivity test. Often erythromycin is found to be effective. For control, identify the source of infection and take appropriate measures like feed, infected fish, amphibians or tubiflex worms.

Other fish bacterial diseases are Tuberculosis (*Mycobacterium piscium, M. marinum, M. fortuitum.),* Pasturellosis, Ulcer Disease (*Haemophilus piscium*) and fish meningitis (Eubacterium).

Viral Diseases

Viral diseases of fish have come to prominence during recent years, when aquaculture evolved as a high economic activity. Many of the viral diseases are geographically specific and hence can be controlled. In viral diseases antibiotics are of no use but used to control secondary bacterial infection. Mostly young fish are susceptible but adults may often act as carriers. Specific testing procedures are available with designated laboratories. Vaccines have not become commercially viable.

Herpes virus infection has been identified in fishes. Rhabdovirus infection in salmonids causes Infectious Haemopoitic Necrosis. Similarly Birnavirus causes Infectious Pancreatic Necrosis. Rhabdovirus causes Pike Fry Disease, Spring Viremia in Carp and Viral Haemorrhagic Septicaemia (Egtved Disease) and other viral diseases. Icosahedral virions cause viral erythrocytic necrosis and cause blood dyscrasia. Herpes virus causes pox like lesions in carp. Many types of viruses have been isolated from the cells of many fishes that are pathogenic,

Disease Investigation and Pathology

As in higher animals, proper history, clinical signs, fresh material or necropsy and direct microscopical examination are used in the diagnosis of fish diseases. Direct microscopical examination may be of fresh tissue, smear and/or squash material. Fish in general decompose very quickly than mammals, especially in warm waters. Hence isolation of the real pathogen becomes difficult, unless the sample is fresh. Saprophytic microbes multiply in the fish tissues very rapidly.

Necropsy, biopsy of the skin, gill and fin as well as, microbial culture of the internal organs, collection of blood and histopathology are ideal. If the fish is dead ensure that the specimen is fresh, which can be looked by inspecting the eye (clear) and gills (normal colour) and texture. Dead fish is best preserved in ice after wrapping in a moist paper. A sample of water is worth collecting for analysis. A wet mount is prepared for gills, fin and skin mucus. This is examined under the light microscope with 100 X 400 magnification. Tissues are examined for the presence of parasites, fungi, lesions of bacteria and general morphological character. Blood is collected from the caudal vein. Fishes weighing more than 25 grams can be used for blood collection. This again varies with species. Haematological and serological values are compared with normal. Normal values from literature are difficult to get and hence it is advisable to have these normal parameters done in

healthy fishes and use as reference. Serological data are useful in cumulative poisoning especially of heavy metals like Mercury (Minamata disease of Japan). It will serve as an indicator of environmental quality of water from industrial pollution.

When a fish has to be sacrificed, it is euthanised and opened observing all aseptic precautions. Samples for bacterial culture are taken from the posterior aspect of the kidney or other organs as the case may be and blood agar is used as the culture medium. In marine species salt is often added although it is not a must. Cytophage media (e.g., Ordal's media) is used to isolate slime bacteria (myxobacteria). Specific lesions like abscesses are noted and culture done if necessary. Granulomatous lesions warrant acid fast staining to rule out mycobacteriosis. In cases of nervous symptoms before death (e.g., spinning), culture of brain tissue is indicated. Viral infections are not common in fresh water fishes.

Treatment

Criteria for Selection of Chemicals/Antibiotics in Aquaculture

1. Sensitivity of the pathogen to the drug/antibiotic must be known.
2. The antibiotic/chemical should reach the pathogen and kill the pathogen only, without adversely affecting shrimps/prawns/fish.
3. The treatment should not aggravate the disease.
4. The antibiotic/chemical should not adversely affect the user and natural flora and fauna.
5. The drugs should be stable at normal storage condition.

Treatment of fish diseases are limited both from the practical point of view as well as residue in the fish. Drugs used in aquaculture are Oxytetracycline, Cotrimazole (Sulphamerazine + ormetoprim, 5:1 ratio), Formalin and MS-222 (anaesthetic).

Oxytetracycline is a broad-spectrum antibiotic, which is extensively used. Oxytetracycline incorporated feeds are sinking type and hence

may not be completely eaten. It is indicated in furunculosis of Salmonids, bacterial septicaemia in catfish and lobsters with gaffkemia. Oxytetracycline is very effective against columnaris bacteria. The dose to be fed is 55-75 mg per kg for 10 days. Withdrawal period is 3 weeks. For gaffkemia in lobsters, it is fed at the rate of one gram per 0.45 kilogram of feed and the withdrawal period is 30 days.

Flavophospholipol is an antibiotic feed supplement and performance promoter used in livestock, poultry as well as in fishes and shrimps. Manufacturers claim improved survival rate in fishes and shrimp seed, increased growth and weight gain, bright colouration, better fertility and hatchability in brooder fish/prawn. It is available as Flavomycin, each gram containing 40 mg of Flavophospholipol. Mixing rate per tonne of feed for fishes and shrimps is 100-125 grams. Thorough mixing must be ensured, which can be done by making a premix. Since it is only gut active and not absorbed from the GI tract, there will not be any tissue residues and hence no withdrawal period is recommended.

Kanamycin is recommended in bacterial diseases of ornamental fishes. Dose is 20 mg/kg oral or injection. For fishes that are not feeding a bath concentration of 750 mg/l for two hours are recommended. Treatment is to be continued for a period of at least seven days, even after noticing apparent improvement in the clinical condition.

Erythromycin is recommended in bacterial kidney affections and streptococcal infection in salmonids. The usual route of administration is oral. The dose is 100 mg/kg body weight. The drug is incorporated in feed and administered for two weeks.

Metronidazole is a popular drug for protozoan infections in man and animals. This is used in fish to control pathogenic flagellates. It is usually given orally in medicated feeds. If the fish does not feed, it is given as bath. Oral dose is 50 mg/kg body weight for a period of five days. As a bath a concentration of approximately 7 mg/l can be used. Change the water after a few hours of treatment. Metronidazole may affect reproduction in some species of fish.

Sulphadimethoxime with ormetoprim is an approved drug in fish. Main indication is furunculosis, a specific disease of adult trout and at times of salmon. The causative agent is *Aeromonas salmonicida.* Symptoms are ulcers on the skin and the fin, and abscesses in the kidneys. Generalised infection leads to the death of catfish, and in the salmonids infection with *Edwardsiella ictaluri* . It is fed at the rate of 50 mg/kg for 5 days. The withdrawal period is only 3 days in catfish. In salmonids it is 42 days, because the drug binds on the skin. It is formulated in floating feed and hence easy to find out whether the drug has been consumed or not. This combination is not very effective against columnaris bacteria. Hence it is not recommended in disease outbreaks caused by these bacteria.

Fenbendazole is recommended against intestinal helminths at the rate of 25 mg/kg body weight for 3-5 days. Intestinal cestodes as well as trematodes on the gills and skin are treated with praziquantel. The recommended dose is 35-125 mg/kg orally for 3 days. As a bath a one hour treatment in a concentration of 1 mg/l can be given.

It may be noted that these doses and regimen of treatment are not widely tested in all species. Hence caution must be exercised before mass medication. In any case the treatment regime recommended is possible only in ornamental fishes or small facilities.

Formalin is an old preparation effective against protozoan parasites as well as trematodes seen on the external surface of the fish. It can be used as a bath at the rate of 15-25 mg/l it should be ensured formalin and not formaldehyde is used. In ponds and aquaria a lower concentration is recommended. This is because formalin depletes dissolved oxygen from water. It is estimated that each 5 mg/l dose removes dissolved oxygen from water at the rate of 1 mg/l. Formalin can be easily administered to aquarium fish. A dose of 2 drops for 4 litres of water will give a concentration of 25 mg/l. A high dose rate of 250 mg/l for 30 to 60 minutes can be done. If the temperature of water is high, i.e., greater than 25 °C, the dose should be decreased to approximately 170 mg/l. Fish under treatment should

be constantly monitored. If any untoward response is seen, flush with clean water immediately.

MS-222 (methane tricane sulphonate, tricane methane sulphonate) is a fish anaesthetic. General dose is 3-10 mg/100 ml of water (0.003-0.01%). Higher dose for small fishes and smaller doses for larger fishes. Longer the fish is immersed in the solution, longer is the duration of sedation. Indication is only to sedate the brood stock for handling, transport and injection of hormones for spawning. It is used in pet fish for surgery. Look for respiration. If the movements of operculum are meek and slow, transfer to clean fresh water. This is approved drug in food fish.

Salt is one of the oldest drugs ever used by man and is still found useful in fish diseases. It is for simple osmoregulation to control of unicellular and protozoan pathogens. Seawater contains 3% salt (30,000 ppm). Osmolarity can be increased or decreased depending upon whether the fish is of salt water or fresh water. Even in fresh water fish a dip in 3% salt-water acts as a good parasiticide. This is recommended before transportation. Most fresh water fish can tolerate a 3% salt solution for anything from 30 seconds to several minutes. Tolerance level is shown by stress symptoms like rolling on their sides. Recovery is quick and complete when placed in fresh water. A salt water dip is always recommended when new fish is introduced to prevent contamination by pathogens. Even fresh water fish is better transported in a salt solution of 0.5 to 1.0% salt solution and most species can tolerate this concentration for several hours and some for several days. Parasitic protozoan infections can be controlled to a very great extend by adding 0.02% salt in the recirculating water systems. This addition of salt is possible in recirculation system as well as small establishments. Lowering of salinity in marine fish facilities by reverse osmosis has not been tried extensively and not much information is available.

Copper sulphate is extensively used as an algaecide, as well as used as an effective parasiticide for several years. It must be noted that copper

sulphate is extremely toxic to fish especially if carbonates are present in water. Hence an initial test of Total Alkalinity (TA) is conducted. If the TA value is greater than 50 mg/l, it is not safe to use copper sulphate. If the value is between 50-250 mg/l, safe concentration of copper sulphate will be 1/100th of TA value (e.g., TA value = 100 mg/ml then copper sulphate can be added at the rate of 1 mg/l, e.g., TA value =250 mg/l, then copper sulphate not more than 2.5 mg/l). Apart from the direct toxicity of copper sulphate to fish, the quick and massive algicidal property can harm the fish by reducing the dissolved oxygen of water. Other oxygen reducing factors like high ambient temperature and continuous cloudy weather are to be noted. Copper sulphate is excellent against most of the protozoan parasites. Not only is it economical but it is also the chemical of choice when multiple treatments are required to control epizootic conditions caused by *Ichthyophthirius multifilis*. In salt water copper has to be applied in chelated form and concentration of active copper (Cu^{2+}) is monitored using test kits. Copper level is maintained at 0.2 mg/l for a period up to 3 weeks. It may be noted that copper is extensively toxic to invertebrates, not approved by FDA, but approved by Environmental Protection Agency (EPA).

Potassium permanganate ($KMnO_4$) is an effective parasiticide, fungicide and bactericide. It being an oxidising agent removes the organic matter on the skin of the fish and hence overuse and frequent use is harmful. Potassium permanganate is not approved by FDA. Excess dose especially repeated doses are harmful for the fish. The dose of potassium permanganate depends upon the organic matter to be oxidised. Once in a week treatment is the frequency that is often recommended unless there is a specific need. If the organic matter is more than that can be neutralized by the added quantity of potassium permanganate, the water will become brown or even colourless. A residual permanganate colour in light shade is the ideal one. Ordinary thumb rule is to add 1 g for 500 litres of water. Potassium permanganate may be added in the morning and wait for approximately eight hours to act. If the water becomes clear, add another dose. One method of adding potassium permanganate is by conducting bioassay. Keep the

water to be treated in a clean container of approximately 5 litre capacity and add potassium permanganate at the rate of 2 mg/l. See whether the light pink colour is retained, if not, add more till the pink colour is retained. This is an easy way of calculating the required quantity of potassium permanganate for the entire pond. If the quantity of potassium permanganate required is more than 6 mg/l for a period of at least 4 hours, then the organic load is very high. This points to the general sanitary conditions like water purification, over stocking, excessive destruction of algae and poor sunlight. In small facilities cleaning and purification of recycling water are easy.

Other antibiotics used in fish are Kanamycin and Erythromycin.

Table 5.2 Chemicals Approved for use by US-FDA

Chemical or Drug	Use Pattern	Status
Acetic acid	Parasiticide	GRAS*
Acriflavin	Antibacterial/parasiticide	Not approved
Chloramine T	Antibacterial/parasiticide	Not approved
Copper (copper sulphate etc.)	Antimicrobial for shrimp and fish	GRAS
Di-N-butyl tin oxide	Anthelmenthic	Not approved
Diquat	Herbicide/Antimicrobial	Not approved
Erythromycin	Antibacterial	Experimental
Formalin	fungicide on eggs	Parasiticide on food fish
Iodophores	Egg disinfectant	Approved
Malachite green	Parasiticide on fish Fungicide on eggs/fish	Not approved
Nitrofuran compounds		
Furacin	Antibacterial	Not approved
Furanace	Antibacterial	Aquarium fish only
Oxytetracycline	Antibacterial	Approved for

		fish
Potassium permanganate	Antibacterial/parasiticide	Approval as oxidising agent
Quaternary Ammonium	Antibacterial	Disinfectant
Compounds		
Quinolone/Oxolinic acid	Antibacterial	Experimental
Romet 30 (Ormethoprim and sulphadimethoxin)	Antibacterial	Approved for fish
Sodium Chloride	Osmoregulator	GRAS
Sulphar drugs (Sulphamerazine)	Antibacterial	Approved for food fish
Trichlorfon	Parasiticide	Non-food fish Only

*GRAS: Generally Regarded As Safe

Health and Hygiene

It is difficult to diagnose, treat and control fish diseases. Hence the importance of prevention by adhering to strict hygienic practices is the ideal thing. Proper health of any aquaculture operation depends on water quality, proper nutrition, quarantine and sanitation.

Sanitation can be achieved by:

1. Avoid accumulation of organic matter.
2. Disinfections of nets and other equipment used.
3. Providing clean environment.
4. Effective sanitation of the holding, before sanitation of the fresh stock.

Quarantine of three weeks is recommended whenever any new fish is introduced to a facility. However, this is often neglected due to economic considerations.

Fish Food Industry

Inspite of the variations in the life cycle, physiology and environmental requirements, the production is broadly divided into two important stages.

1. Breeding and hatchery operation.
2. Grow-out operation.

Breeding and Hatchery Operation

One of the most important and the limiting factors is the availability of quality fish seed. Hatcheries are of two types. In one type reproductive cycles like breeding and spawning are controlled or regulated. In the other type the harvesting of ova and the sperm is done from the wild, e.g., shrimp and lobsters and larvae from the wild, e.g., eels.

Breeding and the spawning are controlled by regulating the environmental factors like ambient temperature (water), light, nutrition and by chemical substances. Human Chorionic Gonadotropin (HCG) or crude pituitary extracts are used. Some brood stock and some finfish species are injected to induce spawning. Handling of fertilised ova, unfertilised ova and sperms is a highly skilled job. These techniques vary with the species cultured. Optimum fertilisation of ova with the sperm in artificial fertilisation is obtained only if various parameters like ratio, dilution, timing and temperature are optimised and maintained. Each aquaculture species has different requirements. The only favourable side is the high fecundity. It is estimated that an oyster is capable of producing 110 million ova during one spawning. Similarly the finfish variety, catfish can produce approximately 9000 ova per kilogram body weight.

Unlike domesticated mammals and birds, various stages of metamorphosis take place in many aquaculture species. For example larvae of certain molluscs get attracted to rocks. This is known as settlement stage and this necessitates a settlement tank. These developmental stages are prone to affliction due to various diseases,

which may be nutritional, environmental, metabolic, infectious and congenital. Diseases spread very fast through the aquatic medium, especially when there is overcrowding. Like the high fecundity rate, mortality rate is also high especially during the larval stages.

The pumped water and feed may carry pathogens. Most common bacteria are Aeromonas, Pseudomonas and Vibrio species. Regular monitoring of water, feed and larvae are very important. Other indirect detrimental factors can be toxic materials, predators or parasites, ultimately creating an unfavourable climatic situation for the desired species to grow properly.

Grow-out Operation

The grow-out facilities depend upon the requirement of the particular species, locational needs, availability of water, feed and ultimately, resulting in economic production.

Finfish species (trout, catfish, tilapia) are raised in grow-out operation separately (tanks, ponds and wire pen in open bodies of water). Salt-water species are kept in estuaries or seawater. Homing species left to the sea and captured on return; often called sea ranching.

Promoting the vegetation growth by primary fertilisers and supplementing with commercial formulated feed that is often species specific, ensure availability of feed. Oysters, clams and mussels are called filter feeders and their natural feed is plankton blooms and algae and diatoms of seawater. Some of the molluscs like the Bivalve molluscs may at times ingest plankton that is toxic to man. (e.g., paralytic shellfish poisoning). They may ingest coliform pathogens from human excreta. Hence purification using clean water irradiated with ultraviolet rays is undertaken before consumption.

Commercial Fish Culture

Fishery is broadly classified into marine fisheries and inland fisheries (including esturine).

Marine Fisheries

The Indian coastline is specially suited for fisheries because of its wide continental shelf at the mainland, coastline coupled with the islands of Andaman Nicobar and Lakshadeep. Marine fisheries include apart from various species of fish, crustaceans also. Other minor marine resources like molluscs, seaweed and echinoderms are hardly exploited.

West coast leads in marine fish catch. Nearly 70% of the total marine fish catch is landed on the west coast. Oceanic fish dominates Indian fisheries and bulk of the fisheries comprises several species of sardines and mackerel. Wide fluctuations are noticed in the annual landing. Arabian sea contributes mainly to the total catch quality wise also. Arabian sea leads to Bay of Bengal. There are wide variations annually, the following table gives an idea between the east and west coast :

Table 5.3 Percentage of Catch of Composition of the West and East Coasts of India

Group	Percentage West Coast	Percentage East Coast
Clupeoids	20.8	26.6
Perches	3	3.3
Crustaceans	19.6	7.7
Mackerel, Seer fishes and cutlass fishes	6.1	23.6
Jacks and Mullets	1.4	3.4
Elasmobranchs	4	6.3
Flat fishes	1.2	0.7
Tuna	1.8	1.2
Miscellaneous	42.1	27.2

Major marine fisheries of Indian importance are Sardines, Mackerels, Crustaceans, Tunas, Catfish, Bombay Duck, Elasmobranchs, Molluscs, Polynemids, Sciaenids, Leiognathids or Silver Bellies, Ribbon Fish, Anchovies, Pomfrets, Perches and Carangids.

Sardines comprise nearly 15% of the total marine fish landings. There are different species. Oil Sardine (*Sardinella longiceps*) is the most

abundant species and form, bulk of the landings is in the Kerala and Karnataka coast. The season usually starts in late May (pre-monsoon season) and reaches peak in October to January. There are wide fluctuations every year. Oil sardines are generally consumed fresh, canned and even used as manure where storage facilities are poor and the catch is abundant. There is a number of allied species called as lesser sardines.

Mackerel Indian Mackerel (*Rastreliger kanagurta*) It is seen in the tropical Indo-Pacific Ocean. Again the major fishing zone is the west coast and extends from Ratnagiri to Kanyakumari. Mackerels constitute about 4.5% of the total marine fish production. Like Sardines, Mackerel landings show wide fluctuations from season to season. They thrive well in esturine water and are seen in the esturine waters of river Kali, Netravati estuary and backwaters of Kerala. A couple of other species of mackerels are seen in the neighbourhood of Andaman Islands and off the coast of Chennai.

Bombay Duck (*Harpodon nehereus*) This is mostly a local fish of Maharashtra and Gujarat coast. It is also found among the coastal regions of Bengal and Orissa. Bombay duck contributes to nearly 7.5% of the total marine fish production. It is a carnivorous fish and attain a maximum size of 33 cm. Catch begins by the end of September and lasts up to the end of January. In commercial catch nearly 80% is immature fish and a major portion is dried and used.

Crustacean fishery includes prawns, lobsters and crabs. India leads in the world production. It is estimated that there are about fifty two species of prawns and shrimps in the Indian waters. The larvae and juveniles of these species with exception of one, migrate to back waters and estuaries. They feed there and return back to the sea after some growth. In the sea they grow further to attain breeding maturity.

Lobsters are prevalent mostly in certain regions of the west and east coasts along the rocky patches. There are only few species that are of commercial importance. Crab fishing is in its infancy. It is mostly in the northern parts of Kerala, Central Maharashtra and coasts of

Southern Tamil Nadu. Backwaters and estuaries are good sources of crabs. Export of various processed (frozen and canned) prawns and lobsters is mainly to Japan and USA. Various types of tuna, elasmobranchs (cartilaginous fish comprising sharks, rays, dogfishes and skates) and molluscs (oysters, clams, mussels, squids, cuttle fish and octopus) are other fisheries that need large-scale exploitation. Pearl fishes of the Gulf of Mannar and Kutch are famous. Oysters and clams are widely cultivated. Green mussels are common along the coasts of Kerala and Southern Karnataka. Mussels are also seen off Chennai, Orissa, Tirunelvelli and Kollam coasts. Deep water trawling may bring about a sea change in the quality, quantity and variety of landings.

Table 5.4 Percentage Composition of Landings of Selected Groups of Marine Fish

Group	Percentage
Scianids	6.92
Anchovies and Whitebaits	3.65
Ribbon-fishes	5.26
Catfishes	3.27
Carangids	1.71
Pomfrets	2.98
Leiognathids	3.76

Seaweed cannot be strictly called as fishery, but they are important in certain areas as a profitable vocation. The areas popular in seaweed collection are Sunderbans, Chilka lake, deltas of Godavari and Krishna, Visakapatanam, Mahabalipuram, Gulf of Mannar, Gujarat coast, Andaman and Nicobar islands and Paek Bay. Seaweeds are consumed by human beings and also used as cattle feed and fertiliser. Some of the value added products made from the seaweed are agar-agar and algin.

Inland Fisheries

India has extensive water bodies that can sustain fisheries on a commercial level. Inland fisheries include both fresh and brackish water.

Rivers, reservoirs, backwaters, swamps, lakes, ponds and tanks are major water bodies that sustain fishery. It is estimated that the water bodies cover 9.6 million hectares and can yield a potential of 7 million tonne fish a year, currently fresh water fish landings are hardly one million tonnes.

Table 5.5 Percentage of Commercially Important Fresh Water Fishes

Group	Percentage
Carps	35.2
Catfishes	32.9
Live fishes	10
Prawns	6.5
Feather- Backs	4.8
Mullets	4.4
Eels	0.7
Herrings and Anchovies	0.6
Miscellaneous	4.9

Capture Fisheries

Major capture fisheries are catla, rohu, calbasu, mrigal, catfish, mullets, feather backs, mahseer, trout and catfish. Important fresh water prawns are *Macrobrachium* species. Indiscriminate fishing has diminished the yield. But culturing them has given important results. Main fishery is after monsoon. Construction of dams at various points in rivers and streams has affected spawning and the fish population in general.

Culture Fishes

The reservoirs and lakes offer scope both for culture and capture of fishes. Many reservoirs and ponds are stocked periodically. They may breed in the reservoir or in tributaries or in streams that drain into lakes and reservoirs. It is seen that predatory fish dominate the catches from the cultured fisheries. Exotic varieties of various fishes include varieties of carp and tilapia.

Yield from pond culture in India is only 0.6 tonne/hectare, while it is about five tonnes per hectare in southeast Asian countries. However,

experiments show that a yield of 8-9 tonnes per hectare can be achieved by adopting scientific practices.

Air breathing fishes often called as 'live fishes' are predatory, but are extremely popular in some states. Another advantage with these fishes is that they thrive well in swampy and marshy areas where scientific aquaculture is difficult to practice.

Integrated farming systems like fish-cum-pig and fish-cum-duck and use of domestic sewage can cut the cost of farming considerably. Three types of farms are popular in southeast Asia. A research centre on fresh water fish culture has been established in Orissa (Fresh Water Aquaculture Research and Training Centre)and several other centres established in different places.

Ideal fish culture species should have fast growth, excellent feed conversion ratio, both from natural food materials and artificial, capacity to stand high stocking density, disease resistance, good organoleptic characters and resistance to both abiotic and biotic changes in the pond.

Fish Seed

One of the most important factors in commercial fish farming is the availability and use of pure and disease free fish seed. The current production is only half of the estimated requirement. Often fish seed for stocking purpose is collected from the wild, river systems where the fish naturally breed during the monsoon months. The major defect for this system of collection is that there will be a mixture of desirable and undesirable varieties. There are various types of indigenous methods for selective spawning like collecting rainwater in the shallow waters. This is practised for major carps in Bengal. Injection of pituitary extract is a proven and scientific method. Both female (repeated injection) and males are given injections and released into covered cloth containers that are generally known as breeding hapas. Spawning takes place within 3-6 hours after introduction to the hapa. Inter species pituitary extracts including that of mammalian type are found to be effective. To

provide adequate fish seed government agencies have established hatcheries in different parts of the country.

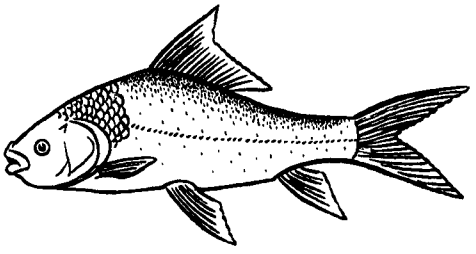
As in domestic animals variety improvement by selective breeding and hybridisation has been achieved. Selection has been aimed at better feed conversion ratio (FCR), resistance to disease and adverse environmental conditions and for organoleptic characters.

Paddy Fields for Fish Culture

Organised paddy cum fish culture has been tried in certain parts of the country. Pesticides and inorganic fertilisers are the main deterrent to this type of cultivation. In many areas fish culture is being carried out in paddy fields close to backwaters. During high tide these fields get stocked with young ones of prawns, mullets and other fishes. Sluices are provided to keep the water from draining back to the backwaters during low tide. Fishing is done using conical nets during ebb tide. In Kerala, this type of culture is done from October to March. Bulk of the catch is prawn. Fish rearing is done in Tamil Nadu in paddy fields when they get flooded from rivers and in deep water paddy fields in Bihar. Fish yield in Kerala varies between 900-1200 kg/ha and in Bihar it is 100-125 kg/ha.

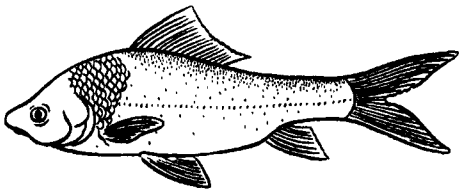
Commonly Used Fish for Commercial Farming

1. **Catla** (*Catla catla*) has a large head and upturned mouth with thick lips and deep stout body. Catla is a surface feeder and feeds mainly on zooplankton. It may reach a weight of 2.5 kg in the first year itself.



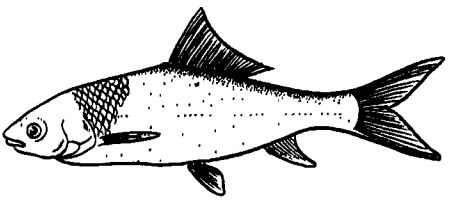
Catla

2. **Rohu** (*Labeo rohita*) is characterised by pointed head terminal mouth, fringed lips and cylindrical body with reddish tinge. It is a column feeder feeding on filamentous algae, vegetable debris and zooplankton. It attains a weight of 1.5 kg in the first year and is very much in demand as it is the best tasting of all Indian species.



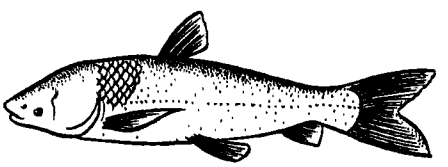
Rohu

3. **Mrigal** (*Cyrrhinus mrigala*) has a small head with non-fringed lips and cylindrical body having a silver colouration. It is a bottom feeder and feeds mainly on decaying material. It gains a weight up to 1 kg in the first year.



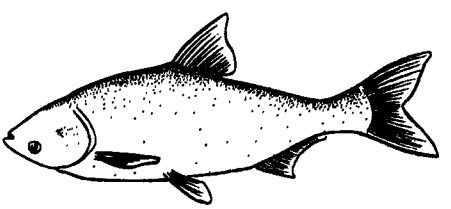
Mrigal

4. **Grass Carp** (*Ctenopharyngodon idella*) is a native to China with cylindrical body with a green colour and large scales. Head is flat with long upper jaw ending in a snout. It feeds mainly on aquatic weeds and grasses. It is a fast growing fish and may reach up to 5-8 kg in the first year itself. Since it feeds on grass and weeds, it is known as phytophagus fish.



Grass Carp

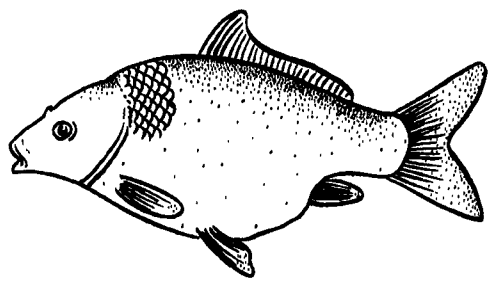
5. **Silver Carp** (*Hypophthalmichthys molitrix*) is a native of



Siver Carp

China. Body is laterally compressed with minute silvery scales. Mouth is upturned and it is a surface feeder feeding mainly on phytoplankton. It attains a weight of 2.5 kg in the first year.

6. **Murrel** (*Channa striatus* and *Channa marulius*) is a snake headed fish with a pair of air breathing organs. It feeds mainly on the frog tadpole and fish and hence known as predatory fish. It is highly cannibalistic. Stocking rate of murrel is 75-460 fry per m^3. Being an air breathing fish it can be sold as live fish and hence attracts good market price. It has good organoleptic characters and claims to have rejuvenating properties.
7. **Pearl Spot** (*Etroplus suratensis*) lives both in fresh water and brackish water. Body is compressed with spines over the dorsal pin and pearl like dots all over the body. It feeds mainly on decaying vegetation and growth rate is rather slow, reaching 300 g in the first year, but it commands good price in the market.
8. **Clarias** (*Clarias batrachus*) is the Indian catfish with two pairs of breathing organs on either side of the head. It has omnivorous feeding habits and can be fed on artificial feed also. It has a high productivity and reaches a weight of 500-700 g in the first year. Owing to its air breathing, stocking density is very high; upto 20,000 to 50,000 fish can be stocked in a hectare.
9. **Common Carp** (*Cyprinus carpio*) is a short-headed fish with barbed mouth and stout body, native to Europe. It is omnivorous and feeds on insects, worms and decaying vegetation. Unlike rohu, catla, silver carp, mrigal and grass carp, it breeds naturally in confinement.



Common carp

10. **Tilapia** (*Oreochromys mossambicus*) is native to Africa with anterior spinus and posterior soft dorsal. Feeding is omnivorous and they are very hardy showing low oxygen demand and true temperature tolerance. Maximum growth is seen in 5% seawater. Breeding starts from six months onwards and occurs in every two

month. Often excessive breeding may be a problem for the farmers.

Commercial fish foods are produced in large scale for cold water and warm water fish. Organised fish farming is extensively practised in southeast Asia. Salmons are the most important cold water fish. Besides the several species of salmon, rainbow trout are also included in this. Game fish are farmed on a commercial scale. Fish farm in homestead is more of recreational type. Tilapia is a very common cultured fish that is very hardy too. They can withstand intensive culture practices that include recirculating systems. Although they are territorial, their territoriality is lost in heavy stocking and crowding. In recirculating systems, monitoring of the water quality is very important. Rainbow trout is often raised in ponds to which water from a running stream is pumped or diverted. The quantum of water, thus, diverted should be determined depending upon the stocking rate. Salmonids start with fresh water (hatcheries), then gradually to salt water that is often called as smoltification. Grown up ones are reared in sea cages which are large net pens. These pens are usually kept in bays away from storms and waves. Exchange of water takes place during high and low tides. These pens are thus exposed to diseases from the wild.

Ornamental and Bait-fish Farming

This is a very value added aspect of fish farming. They are often pond reared and then trapped. Common ornamental fishes include gold fish, swordtail, platys, and guppies. There is a big market for all these varieties in pet trade. Baitfish is highly commercialised and traded variety. They can be pond reared or alternatively hatchery bred and harvested from grow-out facilities.

Invertebrates

Invertebrates that are called as 'fish' in the food parlance include the shrimp, lobster and the shellfish. Shrimp culture is an organised industry. Shellfishes like the clams, oysters and mussels are often done as a small-scale venture.

Frog Culture

Large-scale capturing and export of frog legs to European countries has resulted in almost the verge of extinction of the frog population (*Rana hexadactyla* and *R. tigrina*). Indiscriminate use of pesticides also has contributed to this malady. An exotic variety from USA, *Rana catesbeiana* has been tried. The attempts have not become viable, commercially.

Table 5.6 Requirement of Nutrients and Quantity Provided by 200 g of Fish Flesh

Nutrient	Require-ment	Fat Fish (%)	Lean Fish (%)	Vitamins	Require-ment	Fat Fish (%)	Lean Fish(%)
Protein	75 g	50	50	A	5000 IU	100	-
Fat	80 g	60	-	B1	1.7 mg	15	15
Calories	2,600	25	5	B2	1.8 mg	30	20
Phosphorus	1.5 g	45	40	Niacin	12 mg	75	50
Iron	12 mg	30	25	D	400 IU	100	

Table 5.7 Mineral Content in Fish Flesh (in mg per 100 g of flesh)

Element	Range	Average
Sulphur	100-300	200
Chlorine	60-250	100
Sodium	30-150	60
Potassium	250-500	400
Phosphorus	100-400	220
Calcium	5-200	30
Magnesium	10-60	30
Iron	0-475	1
Copper	0.04-0.6	0.25
Iodine	0.01-0.05	0.17
Fluorine	0.5-1.0	_
Manganese	0.01-0.05	0.025
Zinc	0.7-3.0	_
Lead	0.005-0.02	_

Types of Culture

1. Monospecies Culture. Often Giant River Prawn (*Macrobrachium rosenbergii*) is the species of choice. It attains 50 g in six months and a maximum of 850 grams. It is omnivorous and fed with compounded ration containing rice bran, groundnut cake, clam meat, tapioca, trash fish, abattoir waste etc. Since cannibalism is common in this species predation of moulted species is avoided by providing earthen pipes, tiles etc. Ordinarily a production rate of 700 kg per hectare is obtained in 6 months. Intensive culture may produce upto 4 tonnes. Repetition stocking rate of 20,000-30,000 per hectare are utilised
2. Composite Fish Culture (Polyculture) is the system wherein fishes of different species, that are fast growing, and with different feeding habits are employed. Species like Catla (surface feeder), silver carp (surface feeder-phytoplankton), rohu (column feeder), mrigal (bottom feeder), grass carp (weed eating) and common carp (omnivorous) are cultured in the same pond utilising the biomass produced at the different levels of the pond. Ideal depth of a pond is considered as one metre. Initially the pond is cleared of predator fishes by applying mahua cake at the rate of 2.5 tonnes per hectare. Optimum pH for culture is 6.5-8.5. Acidity may be reduced by adding commercial grade of lime at the rate of 600 kg per hectare. It destroys intermediate hosts, parasites and submerged weeds and algae. This is considered as synergist to fertiliser. Application of manure and fertilizer considerably increases the productivity. A boost to plankton production is achieved by application of organic manure (cow dung, pig manure) at the rate of two tonnes per hectare and synthetic fertiliser urea at the rate of 50 kg per hectare. Recommended ratio of six species of fish in composite fish culture are catla, silver carp, mrigal, rohu, grass carp and common carp in a ratio of 10:20:20:20:15:15. Stocking rate is 5000-8000 per hectare. Artificial feed can be compounded by mixing rice bran and groundnut cake in a ratio of 1:1 and fed at the rate of 2% of body weight. Feed should contain protein 30%, fat 10%, carbohydrate 50%, cellulose 5% and vitamin and mineral 5%. Floating pellets available in the market are good for certain fishes. Major

carp do not breed in confined water and hence induced breeding by hormone injection has been developed. It is estimated that artificial feeding can increase the net profit nearly three fold.

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Quantity of feed}}{\text{Increase in weight}}$$

Coastal Aquaculture

Coastal aquaculture includes brackish water fish culture as well as sea farming or mariculture. In Kerala and West Bengal extensive brackish water areas are used traditionally for prawn culture. The yield of prawn may vary from 500 to 1200 kg/ha/year. Significant progress has been made in mussel (brown and green) and edible oysters culture.

Transportation of the fish seed (spawn, fry or fingerlings) is important and various methods have been standardised. Oxygen under pressure and use of sedatives are some of them. The ponds must be cleaned before they are stocked with fresh seed. Predator fishes can be killed by poisons of plant origin like derris root powder, seeds and leave of *Milletia piscidia* , stem, root and bark powder of *Barringtonia acutangula* and oil cakes of mahua (*Bassia latifolia*). Chemical poisons like insecticides are also used.

Shrimp Farming

Shrimp farming is catching attention in several parts of the India especially in the East Coast where intensive shrimp farming is very popular. In Kerala, Karnataka, Goa and West Bengal, traditional shrimp farming is practised, where the salt content of the soil is washed away the south west monsoon from June to September and shrimp farming is done in paddy fields after paddy cultivation from January to April. During shrimp farming the salinity of the soil reaches from 0.2 to 30 per cent. Preliminary preparations like deepening of channels, strengthening of bunds, fixing of sluices and removal of aquatic weeds are carries out during December every year. Seeds of *Penaeus indicus* and *Penaeus monodon* are stocked n paddy fields at the rate of 60000 per hectare (size 14 mm and 11 mg). In scientific shrimp farming the

stocking density is 2 to 4 lakh per hectare. Ideal pH is between 6.5 to 8, salinity between 15 to 25 per cent and dissolved oxygen 3 to 5 c.c. per litre.

Intensive shrimp farming is fast developing in the East Coast while the traditional methods are practised in the West Coast for many reasons. First, labour as well as land is cheap in the East Coast and the climate is also ideal for intensive culture. Rainy season is very short in the month of October only and hence two cultures can be done before the north east monsoon. In the West Coast, occasional rains through out the year can lead to mass mortality of the shrimps. In many parts of the West Coast, sea water is pumped into the culture ponds through out the year. Production of shrimp is estimated to be 5 to 8 tons per hectare in the East Coast whereas it is only 1 ton per hectare in the West Coast.

Brackish Water Aquaculture

Indian has over 1.9 million hectares of brackish water, which includes estuaries, backwater areas, and coastal paddy fields. Brackish water species are tolerant to salinity, temperature and oxygen content variations in the water. Important brackish water aquaculture fishes are the following:

1.Mi lk fish (*Chanos chanos*)
2.Sea bass (*Lates calcarifer*)
3.G rey mullet (*Mugil cephalus*)
4.P earl spot (*Etroplus suratensis*)
5.T ilapia (*Orechromis mossambicus*)
6.T iger prawn (*Penaeus monodon*)
7.W hite prawn (*Penaeus indicus*).

Weeding

Excessive growth of weed is a serious menace for commercial fish farming. Chemicals like copper sulphate, ammonia and 2,4,D are used. Environment friendly approach is mechanical or biological. Introduction of grass eating carp has yielded good results. In addition this technique will yield a profitable crop of fish, i.e., carp itself.

Pollution as mentioned above is increasing at a tremendous pace. Effluents from fertiliser, paper pulp, textile, tannery, distillery, sugar, coal washery and vanaspathi are worth mentioning. Effluents from the thermal plants with very high temperature affect the micro and macro habitat very badly. Ib river in Orissa, Kalu river in Kalyan-Bombay section and Sindhri fertiliser factory are examples of this type of large-scale pollution. Water pollution control boards can help to alleviate these problems.

Integrated Intensive Farming System (IIFS)

The credit of integrated farming system goes to the people of ancient China. Immigrant Chinese introduced it into southeast Asian countries.

Historically fish farming was a part of peasant farming practice. Integrated intensive farming system helps in utilising farm resources to the maximum extent possible. Farm ponds are a requirement for assured water supply for farm animals and cultivated crops. Naturally these water bodies can be developed to grow fish and improve the economic status of the farmer. This can be achieved without much additional expenditure and will result in diversified farm output. Labour can be shared between farm activities and can, thus, reduce the cost of production. Farm wastes are used for fertilising fishpond as well as feeding fish. Silt from the pond provides good quality organic fertilizer for the crop. Ponds and their embankments are suitable for duck rearing.

Ponds are often constructed in a low-lying area of the farmland where other crops cannot be grown. Infact this may even prove as a means of land reclamation in certain areas. Integrated intensive farming system has been utilised as a means of reclaiming sodic soil in Eastern European country, Hungary. Besides developing countries of Asia, some in Africa (Zambia, Central African Republic, Madagascar) and South America (Panama, Brazil) have introduced this system. Some of the east European countries have improved and expanded Integrated intensive farming system including fish culture along with animal

production (Poland, Hungary and Czech and Slovak Republics). Paddy fields are often used for fish culture and are truly complimentary.

Fundamental principles involved in Integrated Intensive Farming System are the utilisation of the synergistic effects of inter-related farm activities and the conservation including the full utilisation of farm wastes. The basic idea is "there is no waste" or wealth from waste. "Waste is only a misplaced resource that can become a valuable material for another product" as is mentioned by FAO (1977). This provides certain amount of self-reliance with minimum of exogenous inputs for farming.

In integrated intensive farming system the primary crop may vary depending on the local micro-environment, resource and market demand and price of produce. In China fish is the main crop and livestock and agriculture are of secondary importance. In other countries agriculture and livestock remain as the main source of income. Area allocation in a predominant fish farm, is 60% fish culture, 14% cattle and pigs, 14% fodder and 10% rice and wheat. It may be noted that this farming system is an old practice and there is no evidence that this causes transmission of pathogens to humans through fish.

Fish farming can be integrated with husbandry of most domestic animals. Pig and duck raising are found to be most successful in this regard. In China and southeast Asian countries pigs have an important role in animal husbandry. There is a saying about pig "Costless fertiliser factories moving on hooves" and pig manure is the most common fertiliser of domestic origin. Hence pigs are reared not only for fish farming but also for crop cultivation. Pigsties are constructed on the fishpond embankments. Aquatic plants harvested from the pond and other waste bodies, along with crop wastes are used for feeding the pigs. Pig manure is used both for fertilising ponds as well as for agricultural activities. Manure can either be used directly as raw or after fermentation. Manure from cattle as well as from chicken can be used. Duck raising is another important farming practice that has proved

to be mutually beneficial. Spaces on the embankments of ponds or water bodies provide space for duck rearing and ducks in turn fertilize the pond with excreta. Ducks are useful since they feed on unwanted organisms growing in the pond like the snails, that often act as intermediate hosts for certain diseases.

Fish can be herbivorous or omnivorous. Most commonly used species are Common and Chinese Carp. In addition Catfish and Tilapia are tried in a limited scale. Manure applied in the fishponds produces microorganisms like plankton that in turn forms feed for the fish. Wider embankments of fishponds facilitate the construction of pigsties as well as planting of vegetables, other short-term crops and even fruit trees. In China, the embankments in Integrated Intensive Farming System are over ten metres wide and cultivated with vegetables, corn, groundnut, mulberry, sugar cane, banana etc. Slopes are planted with grass and can be used as fodder for grass carp as well as for other farm animals like cattle. Feeder channels and irrigation ditches associated with fish ponds are used for growing aquatic plants like azolla, water hyacinth and duck weed that in turn can be used for feeding pigs. Ordinarily management control of micro vegetation in tropical fish ponds is a major problem, but in Intensive Integrated Farming System such vegetation is not only controlled but also considered as valuable source of food. Because of the high level of biomass available in the pond, high rates of stocking as well as polyculture can be practised. The stocking may go upto 60,000 fingerlings of different species weighing 20-30 grams per hectare of the pond.

Pigsties are built either on the pond embankments or adjoining land. The number of pigs reared varies. In China, 45-75 pigs are reared per hectare. However in certain conditions, it may go even up to 90 pigs. Pigs on an average produce manure (faeces and urine) around 7.5-8 tonnes per annum, this is to say 350-600 tonnes of manure per hectare per year. In Taiwan, according to certain reports pigs ranging from 150-300 are maintained per hectare of the pond. In all these practices, considerable expertise is needed to prevent pollution of the

water body and resultant mortality arising from the large quantity of biological waste. These values are not computed based on scientific studies, but based on years of field experience. Some of the East European studies recommend 600 kg per hectare per day. This has to be considered with ambient environmental temperature. An improvement to the direct drainage of manure and washings to the ponds is the treatment of the waste. The wastes are collected in specially built tanks, where the sedimentation and fermentation of the manure take place. At periodic intervals the supernatant liquid is allowed into the ponds and the sludge is used for fertilising agriculture crops. This avoids large-scale decomposition of organic matter in the ponds. Quality and quantity of the pig manure depend on the food and water consumed by the pigs.

It is estimated that 10 tonnes of aquatic plants can be produced in one hectare of water area and is sufficient for ten pigs. Mixing with bran, bananas, oil cakes, soyabean and fishmeal increases their nutritive value. Duration of Integrated Intensive Farming System varies but generally it is about one year. The yield of fish per hectare per annum may vary from 2-12 tonnes. Pigs are sold when they attain 90-100 kg weight. The overall economics is quite variable and depends upon the local conditions as well as the expertise available. In any case it increases the productivity per area and increases the farmers income two or three folds. Ducks and fishponds act synergistically and are popular in Eastern Europe and parts of China. Recent studies in East European countries like Hungary, Czechoslovakia and Germany have further confirmed this. Barrage type of ponds by construction of check dams is considered to be most suitable for fish cum duck farming.

Chinese Carp and Indian Major Carp do not breed in confined water bodies. They usually breed in the monsoon season in their natural habitats that is, large rivers. Commercial production then needs artificial means to induce breeding. Induced breeding involves induction of final oocyte maturation and ovulation in female and sperm production in male. This is followed either by natural spawning or artificial fertilization.

Controlling the photoperiod and ambient temperature followed by hypophysation and elevation of ambient temperature to 25^0-29^0C are used. Gold fish have spawned with and without Human Chorionic Gonadotropin (HCG) treatment in the presence of plants. Injection of pituitary extract is known as hypophysation and this is a traditional method for induced breeding and is practised widely in Common Carp, Mrigal, Rohu and Catla. Recently purified piscine pituitary extract or gonadotropins like salmon gonadotropin (SG-100) have been successfully used in induced breeding for gold fish and grey mullet. Female is injected with pituitary extract in two stages. A primary dose is followed by a secondary dose after some time. Often males may not require hypophysation or given only a relatively low dose that is often equivalent to that of the primary dose of the female. This is given at the time of second injection to the female. Pituitary injection is given at the rate of 8 mg/kg for female and 4 mg/kg for male by I/M route. HCG is administered in a very minute quantity as low as 0.1 IU/g body weight and to as high as 40 IU/g and the results are variable. Corticosteroids and progesterone have given successful results in breeding gold fish. Deoxycorticosterone acetate at the rate of 50 mg/kg body weight is found to be effective in the spawning of African Cat Fish (*Clarias lazera*). Pituitary preparations like Ovaperin and Ovatide are widely used at the rate of 4-ml/kg-body weight. A carp weighing one kg may give one-lakh eggs. The fertilised eggs are kept in Happas i.e., rectangular cloths fixed in the ponds and within 20-40 hours eggs hatch out.

Fish Preservation

Fish is a highly perishable commodity. Hence it has to be preserved properly from the time of catch till the time it reaches the consumer. In India with tropical climate this is more important. Quality degradation takes place due to microbiological, enzymatic, oxidative and hydrolytic factors. As the quality degradation starts from the time of fishing and since the catch is often unpredictable all the fish caught cannot be consumed fresh. Transportation from the coast to the interior and for export is to be considered. Several traditional /local methods have been

used for long, to preserve and keep the fish in edible form. These methods include sun drying, semi-drying, pickling, pit curing and salting or drying. Since there are no specific standards prescribed or complied, the resultant products are often not of the same quality. The consumers do not accept most of them. Unhygienic methods are prevalent to a great extend. Refrigeration and canning have made a sea change in the preservation of fish as food.

Salting: Usually small and lean varieties are preserved by salting. The fish are packed in layers in a tub or a cement tank with salt sprinkled between the layers. The ratio of the salt is 1:6 to 1:8 depending on the size of the fish. It is kept as such for 18-20 hours and washed in self-brine and then sun dried for 2-3 days.

Semi-drying: This technique is mostly done for prawn. Prawn is boiled in weak brine solution and moisture is reduced from 80 to 40%. It is then de-shelled, immersed in concentrate brine and dried.

Pickling: This is done for domestic as well as export market. Mackerels are commonly used. Mackerels are gutted, cleaned and rubbed with salt and then packed in wooden barrels in alternate layers of fish and salt as is being done in salting. Tamarind pulp is often mixed with the salt. The wooden barrel is packed to the brim and pressed. Shrinkage is noticed after 2-3 days and self-brine found at the bottom is drained off. The barrel is again filled. This is an old method used to export fish to Sri Lanka, but not currently used.

Pit Curing: This produces very inferior fish with poor acceptance by the consumer and is hardly practised now. The fish is rubbed with salt and packed in pits. Pits are lined with Palmyrah leaves. After some time it is sun dried.

Freezing and Canning: This method is often used for export. Different methods of freezing include plate freezing, blast freezing and brine freezing. Since the fish importing countries have prescribed standards for quality there is statutory control of canned and frozen marine products.

Fish By-products

The most important of all fish by-products is fishmeal. Good quality fishmeal should have at least 50% protein and is used as protein feed supplement for poultry and livestock. Nowdays there are automated fishmeal plants. Poor quality fishmeal is used as manure. High levels of nitrogen (from protein) and phosphorus (from bone) make it a good and valuable manure. Fishmeal in general contains 65% crude protein and has a digestibility of 93-95%. The digestibility comes down if the processing is not upto the mark. In general quality of fishmeal protein is good and it depends on the processing method and degree and length of heating time. The nutritional importance of fish meal is its high content of amino acids Lysine, Methionine and Tryptophan that are valuable supplements to cereal based ration. Mineral content is very high, ranging from 18-21% with high proportion of Calcium and Phosphorus. Other desirable trace minerals present are Manganese, Iron and Iodine. Fishmeal is a good source of B complex vitamins and particularly Choline, B_{12} and Riboflavin. Fishmeal has an increased nutritive value because of the presence of growth factors collectively known as Animal Growth Factor (AGF). Simple stomached animals and young ruminants greatly benefit from fishmeal due to the presence of Animal Protein Factor. Inclusion of fishmeal can be up to 15% in the diet of young animals and in old animals up to 5%. It is better to avoid fishmeal during the fattening and slaughter to avoid tainting of carcass as well as to make the ration more economic. An inclusion more than 5% in the ration may taint milk and eggs.

Table 5.8 Average Nutrient Analysis of Fishmeal

Composition	%
Dry Matter	92
Crude Protein	60.9
Crude Fibre	0.9
Ether Extract	6.9
Nitrogen Free Extract	5
Mineral Matter	18.3
Calcium	8
Phosphorus	3.5
Digestible Crude Protein	53.6
Total Digestible Nutrients	74.8

Fish oil: Body oil from sardines and liver oil from shark, cod and halibut are extracted. Commercial use of sardine body oil is used in industries like jute, leather and steel. A soap made from fish oil (Fish oil Rosin Soap) is an insecticide. Sharkliver is used as a vitamin A supplement both in humans and animals. Glue made from the skin and bone of fish, shark skin (Shagreen), fish maws, dried air bladder and shark fins are products of fishery industry used for cooking or for industrial purposes. Scales of fish yield, pearl essence from which artificial pearl is made. Chitin and chitosan are made from shells of prawns, crabs and lobsters. Fish protein concentrate (FPC), fish hydrolysate, bacteriological peptone and pet food are other by-products of fish industry.

Seaweeds yield agar-agar, algin and china grass. Molluscs are collected to make lime, carbide and white cement. In addition, fish paste, fish soup powder, fish wafer, fish pappads, fish flakes, fish sausage and fish cutlets are some of the value added products of fisheries industry.

Table 5.9 Average Composition of Sea Food (Edible parts)

Category	Water (%)	Protein (%)	Lipid (%)	Ash (%)
Fat Fish	68.6	20	10	1.4
Semi-Fat Fish	77.2	19	2.5	1.3
Lean Fish	81.8	16.4	0.5	1.3
Crustaceans	76	17.8	2.1	2.1
Molluscs	81	13	1.5	1.6

Food Poisoning from Fish and Fish Products

Some types of fish and shellfish have biotoxins or poisons. They are not often destroyed in cooking and result in poisoning. Allergy is common to some fish. *Salmonellas, Staphylococci, Clostridium botulinum, Escherichia coli* and *Streptococcus faecalis* cause bacterial food poisoning of fish food origin. Spoiled fish can produce fish

poisoning. It must be noted that more than three hundred species of marine fishes possess biotoxins that can cause illness in human beings. Pharmacologists are trying to make use of these principles for therapeutic purposes.

Based on the nature of the intoxication they are classified into three types :

1. Ichthyosarcotoxism.
2. Ichthyootoxism.
3. Ichthyohaemotoxism.

Ichthyosarcotoxism arises out of poisoning caused by eating flesh that is poisonous. These poisons are not specifically confined to any part or organ of the fish, but may be found in various parts of the body.

Ichthyootoxism as the name indicates it is caused by eating roe (mass of fish eggs) of fishes. The poison is usually restricted to the gonads only.

Ichthyohaemotoxism. This is caused by the ingestion of fish blood and is very rarely seen in India.

In addition, biotoxins are noticed in fish and shellfish as a result of the toxic organism consumed by these fishes. Dinoflagellates are examples for this. They are plant like flagellate of the sub-class Phytomastigophora, some species of which (e.g., *Gonyaulax cantanella*) produce potent neurotoxin. This can cause severe food poisoning by ingesting parasitised shellfish. Strict quarantine measures can prevent this to some extent. Skin diseases are common in fishermen. Injuries from handling of fishes with spines or fishing gear are common. Fish spine injuries may cause severe inflammatory reactions in some individuals. Severe allergic and anaphylactic reactions to bites and stings of various fishes are also common. Anaphylactic reactions shown by some individuals to jelly fish is very severe and the patient may succumb to the illness. Tuna group of fishes often causes dermatitis.

Fisheries — Indian Scenario

India ranks eighth among the fishing nations, but with regard to the consumption of the fishes we are the lowest. It is estimated that nearly 70% of the Indian population would not mind eating fish although people by and large are vegetarians. India with its peninsular coastline of 6100 km holds a good potential for fish farming. In addition we have several rivers, lakes, both fresh water and brackish water, reservoirs, tanks, swamps, ponds and backwaters. It is estimated that 1.62 million hectares of area is available for fresh water fish culture. Similarly nearly 2.02 million hectares are available for fish farming and only less than one third of the full potential being utilised.

Fish export can be a major foreign exchange earner for India. This is expected to boost India's foreign exchange earnings in the coming years. China is the largest producer of fish, as well as number one consumer of fish in the world. India being a land of vegetarians will have fish to spare. There is a forecast that the prices of seafood can rise as the world population growth strips the supplies. In India domestic consumption is not going to increase that fast. India is likely to post a net export of 400,000 tonnes annually by 2020, slightly less than China's expected export of 500,000 tonnes. Globally fish production is expected to grow around 0.4% while the world population is expected to reach 8.5 billion by 2025 compared with 6 billion of today. The world consumed 130 million tonnes of fish in 2000 accounting for 7% of the global food supplies. This has provided people with their primary source of animal protein, calcium and vitamin A. As the prices rise, the gap between urban and rural income widens, and poorer people in Asia and Africa may lose out. Taking five per cent of the global production, India has been ranked second in global aquaculture production after China.

Marketing

Processing and marketing of fish for export are often advanced and is state of the art, but domestic marketing is very primitive. Most of

the government undertakings and cooperatives are inefficiently and poorly managed. Often fish is marketed as fresh. Later they are salted, dried and converted to fishmeal for feed or fertiliser. Value added products from fish are next to nothing.

Marine Products Export Promotion Council (1961), which gained a statutory power by an act of Parliament (1972), is now renamed as Marine Products Export Development Authority (MPEDA).

It is estimated that nearly 1.6 million people are engaged in fishing and related activities, whose socio-economic backgrounds are very poor. The whole community is mostly conservative and often illiterate. Hence they use very primitive methods. Unless good extension work is carried out this class is likely to remain poor, as the return per unit of effort is relatively small. Various state governments have come out with development projects for fishermen community. Indo-Norwegian project of Kerala is worth mentioning.

Major research, development, education and extension are being done by Central Marine Fisheries Research Institute, Central Inland Fisheries Research Institute, Central Institute of Fisheries Technology, Central Institute of Fishery Education, Fisheries Extension Training Centre, Central Institute of Fisheries Nautical and Engineering Training, Various Agricultural Universities and conventional universities.

Improved methods of fishing, processing and marketing can contribute greatly to the economy of the country and to the well being of the fishermen community.

Trade and Commerce

Export of seafood from India has grown substantially from rupees 2.46 crores in the early fifties to 6444 crores in 2000-01. This is equivalent to US $ 1416 million. Although various varieties of fishes are available, only products like Shrimp, Squid, Cuttlefish, Crab, Lobster and a few varieties of Finfishes are processed and exported, in bulk form. In the early fifties, the products exported were mainly dried type

and countries to which exports were made only to neighbouring countries like Sri Lanka, Myanmar, Singapore and Hong Kong. Currently the trend is from frozen blocks to individually quick frozen and value added products. Now the major markets are Japan, USA, EU and China.

Indian coastline extends over 7500 km which includes peninsular coastline as well as other major islands and two million square km of EEZ and 0.5 million sq. km of continental shelf. The expected potential is 3.9 million MT of which, only a fraction is presently exploited, (3.32MT). Another 1.2 million of potential brackish water area suitable for shrimp farming is available. Presently only 12% is utilised yielding 1,10,000 tonnes of shrimp for export. India's total fishery production is 5.36 million tonnes from both capture and culture sources. Our rank among the fish producing countries is fourth, but only 17th position among fish exporting countries.

The world market for seafood is around US$ 58 billion and in that our share is only 2.31%. We can hope to achieve the maximum potential by adopting the following programmes.

1. Increase production and productivity in a sustainable manner,
2. Develop infrastructure and increase hygienic standards,
3. Promote value added products and marketing techniques,
4. Encourage exporters and provide them with the knowledge of value added products,
5. Improve packing standards,
6. Build brand image in major consuming countries,
7. Arrange buyer seller meets and
8. Encouraging buyers to visit our processing units and convince the good manufacturing practices (GMP) that we are adopting.

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Appendix

LIST OF ANIMALS (MAMMALS, BIRDS, REPTILES AND AMPHIBIANS) UNDER SCHEDULE - I & SCHEDULE - II OF THE WILDLIFE (PROTECTION) ACT, 1972

SCHEDULE I

Part I

Mammals

1. Andaman Wild Pig (*Sus andamanensis*)
1A. Bharal (*Ovis nahura*)
1B. Binturong (*Arctictis binturong*)
2. Blackbuck (*Antilope cervicapra*)
3A. Brow Antlered Deer or Thamin (*Cervus eldi*)
3B. Capped Langur (*Trachypithecus pileatus*, Old name *Presbytis pileatus*)
4. Caracal (*Felis caracal*)
4A. Catacean specils
5. Cheetah (*Acinonyx jubatus*)
5A. Chinese Pangolin (*Manis pentadactyla*)
5B. Chikara or Indian Gazelle (*Gazella gazella bennetti*)
6. Clouded Leopard (*Neofelis nebulosa*)
6A. Crab-eating macaque (*Macaca irus umbrosa*)
6B. Desert Cat (*Felis libyca*)
6C. Desert Fox (*Vulpes bucopus*)
7. Dugong (*Dugong dugong*)
7A. Ermine (*Mustela ermina*)
8. Fishing Cat (*Felis viverrina*)
8A. Four Horned Antelope (*Tetraceros quadricornis*)
8B. ***
8C. ***

8D. Gangetic Dolphin (*Platinista gangetica*)
8E. Gaur or Indian Bison (*Bos gaurus*)
9. Golden Cat (*Felis temmincki*)
10. Golden Langur (*Trachypethicus geei*, Old name *Presbytis geei*)
10A. Giant Squirrel (*Ratufa macroura*)
10B Himalayan Ibex (*Capra ibex*)
10C. Himalayan Tahr (*Hemitragus jemlahicus*)
11. Hispid Hare (*Caprolagus hispidus*)
11A. Hog Badger (*Arctonyx collaris*)
12. Hoolock Gibbon (*Bunopithecus hoolock*)
12A. ***
12B. Indian Elephant (*Elephas maximus*)
13. Indian Lion (*Panthera leo persica*)
14. Indian Wild Ass (*Equus hemionus khur*)
15. Indian Wolf (*Canis lupus pallipes*)
16. Kashmir Stag (*Cervus elaphus hanglu*)
17. Leopard Cat (*Felis bengalensis*)
18. Lesser or Red Panda (*Ailurus fulgens*)
19. Lion Tailed Macaque (*Macaca silenus*)
20. Loris (*Loris tardigradus*)
20A. Little Indian Porpoise (*Neomeris phocaenoides*)
21. Lynx (*Felis lynx isabellinus*)
22. Malabar Civet (*Viverra megaspila*)
22A. Malay or Sun Bear (*Helarctos malayanus*)
23. Marbled Cat (*Felis marmorata*)
24. Markhor (*Capra falconeri*)
25. Musk Deer (*Moschus moschiferus*)
25A. Nilgiri Langur (*Trachypithecus johni*)
25B. Nilgiri Tahr (*Hemitragus hylocrius*)
26. Nayan or Great Tibetian sheep (*Ovis ammon hodgsoni*)
27. Pallas Cat (*Felis manul*)

28. Pangolin (*Manis crassicaudata*)
29. Pygmy Hog (*Sus salvanius*)
29A. Ratel (*Mellivora capensis*)
30. Rhinoceros (*Rhinoceros unicornis*)
31. Rusty Spotted Cat (*Felis rubiginosa*)
31A. Serow (*Capricornis sumatrensis*)
31B. Clawless Otter (*Aonyx cinerea*)
31C. Sloth Bear (*Melursus ursinus*)
32. Slow Loris (*Nyeticebus coveang*)
32A. Small Travancore Flying squirrel (*Petinomys fuscopapillus*)
33. Snow Leopard (*Panthera uncia*)
34. Spotted Linsang (*Prionodon pardicolor*)
35. Swamp Deer (all sub-species of *Cervus duvaucelli*)
36. Takin or Mishmi takin (*Budorcas taxicolor*)
36A. Tibetan Antelope or Chiru (*Panthelops hodgsoni*)
36B. Tibetan Fox (*Vulpus ferrilatus*)
37. Tibetan Gazelle (*Procapra picticaudata*)
38. Tibetan Wild Ass (*Equs hemionus kiang*)
39. Tiger (*Panthera tigris*)
40. Urial or Shapu (*Ovis vignei*)
41. Wild Buffalo (*Bubalis bubalis*)
41A. Wild Yak (*Bos grunniens*)
41B. Tibetan Wolf (*Canis lupus chanco*)

Part II

Amphibians and Reptiles

1. Agra Monitor Lizard (*Varanus griseus* (daudin))
1A. ***
1B. Audithia Turtle (*Pelochelys bibroni*)
1C. Barred, Oval or Yellow Monitor Lizard (*Varanus flavescens*)
1D. Crocodile including estuarine or Salt Water Crocodile (*Crocodilus porosus* and *Crocodilus palustris*)
1E. Terrapin (*Batagur baska*)
1F. Eastern Hill Terrapin (*Melanochelys tricarinata*)
2. Gharial (*Gavialis gangeticus*)
3. Ganges Soft-shelled Turtle (*Trionyx gangeticus*)
3A. Golden Gecko (*Caloductyloides aureus*)
4. Green Sea Turtle (*Trionyx gangeticus*)
5. Hawqksbill turtle (*Eretmochelys imbricata imbricata*)
6. ***
7. Indian Egg Eating Snake (*Elachistodon westermanni*)
8. Indian Soft-shelled Turtle (*Lissemys punctata*)
9. Indian Tent Turtle (*Kachuga tecta tecta*)
9A. Kerala Forest Terrapin (*Hoesemys sylratiea*)
11. Leathery Turtle (*Dermochelys coriscea*)
12. Loggerhead Turtle (*Caretta caretta*)
13. Oliveback Loggerhead Turtle (*Lepidochelys olivacea*)
14. Peacock marked Soft-shelled Turtle (*Trionyx hurum*)
14A Pythons (*Genus python*)
14B. Sail Terrapin (*Kachuga kachuga*)
14C. Spotted Black Terrapin (*Geoclemys hamiltoni*)

* * *

17A. Water Lizard (*Varanus salvator*)

Part III

Birds

1. Andaman Teal (*Anas gibberifrons albogularis*)
1A. Assam Bamboo Patridge (*Bambusicola fytchii*)
1B. Bazas (*Aviceda jerdoni* and *Aviceda leuphotes*)
1C. Bengal Florican (*Eupodotis bengalensis*)
1D. Black Necked Crane (*Grus nigricollis*)
1E. Blood Pheasents (*Ithaginis cruentus tibetanus, Ithagnus cruentus kuseri*)
2. Cheer Pheasent (*Catreus wallachi*)
2A. Eastern White Stork (*Ciconia ciconia boyciana*)
2B. Forest Spotted Owlet (*Athene blewiti*)
2C. Frogmouths (Genus *Batrachostomus*)
3. Great Indian Bustard (*Choriotis nigricerps*)
4. Great Indian Hornbill (*Buceros bicornis*)
4A. Hawks (Family Accipitridae)
4B. Hooded Crane (*Grus monacha*)
4C. Hornbills (*Ptiloaemus tickelli austeni, Aceros nipalensis, Rhyticeros undulatus tichehursti*)
4D. Houbara Bustard (*Chlamydotis undulata*)
4E. Humes Bar-backed Pheasent (*Symraticus humiae*)
4F. Indian Pied Hornbill (*Anthraceros malabaricus*)
5. Jerdon's Courser (*Cursorius biorquatus*)
6. Lammergeier (*Gypaetus barbatus*)
7. Large Falcons (*Falco perigrinus, Falco biarmicus, Falco chicquera*)
7A. Large Whistling teal (*Anatidae*)
7B. Lesser Florican (*Sypheotides indica*)

7C. Monal Pheasents (*Lophophorus impejanus, Lophophorus sclateri*)

8. Mountail Quail (*Ophrisya superciliosa*)

9. Narcondam Hornbill (*Rhyticeros (undulatus) narcodami*)

10. Nicobar Megapode (*Megapodius freycinet*)

10A. Nicobar Pigeon (*Caloenas nicobarica pelewensis*)

10B. Osprey or Fish Eating Eagle (*Pandion haeliatus*)

10C. Peacock Pheasents (*Polyplectron bicalcaratum*)

11. Peafowl (*Pavo cristatus*)

12. Pink-headed Huck (*Rhodonessa caryophyllacea*)

13. Scalater's Sonal (*Lophophorus sclateri*)

14. Siberian White Crane (*Grus leucogeranus*)

14A. ***

14B. Tibetan Snow Cock (*Tetraogallus tibetanus*)

15. Tragopan Pheasents (*Tragopan melanocephalus, Tragopan blythii, Tragopan satyra, Tragopan temminckii*)

16. White-bellied Sea Eagle (*Haliaetus leucogaster*)

17. White-eared Pheasent (*Crossoptilon crossoptilon*)

17A. White Spoon Bill (*Platalea leucododia*)

18. White Winged Wood Duck (*Cairina scutalata*)

SCHEDULE II

Part I

1. ***

1A. Assamese Macaque (*Macaca assamensis*)

2. Bengal Porcupine (*Altherurus mecrourus assamensis*)

3. ***

3A. Bonnet Macaque (*Macaca radiata*)

3B. ***

3C.	Cetatean species (other than listed in Sch. I and Sch. II, part II)
4.	***
4A.	Common Langur (*Semnopethicus entellus*, Old name *Presbytis entellus*)
5.	***
6.	***
7.	Ferret Badgers (*Melogale moschata, Melogale personata*)
8.	***
9.	***
10.	***
11.	Himalyan Crestless Porcupine (*Hyrstrix hodgsoni*)
11A.	Himalayan Newtor Salamander (*Tyletotrition verrucosus*)
12.	***
13.	***
14.	***
15.	***
16.	Pig Tailed Macaque (*Macaca nemestrina*)
17.	***
17A.	Rhesus Macaque (*Macaca mulatta*)
18.	***
19.	Stump Tailed Macaque (*Macaca speciosa*)
20.	***
21.	***
22.	Wild Dog or Dhole (*Cuon alpinus*)
23.	***
24.	Cameleon (*Chameleon calcaratus*)
25.	Spiny-tailed Lizard or Sanda (*Uromastix hardwickii*)

PART II

1A. Civets (All species of *Viveridae* except Malabar civet)

1B. Common Fox (*Vulpes bengalensis*)

1C. Flying Squirrels (All species of the genera *Bulopetes*, *Petaurista*, *Pelomys* and *Eupetaurus*)

1D. Giant Squirrels (*Ratufa indica* and *Ratufa bicolor*)

2. Himalayan Brown Bear (*Ursus arctos*)

2A. Himalayan Black Bear (*Selenarctos thibetanus*)

2B. Jackal (*Canis aureus*)

2C. Jungle Cat (*Felis chaus*)

2D. Marmots (*Marmota bobak himalayana, Mamota caudata*)

2E. Martens (*Martes foina intermedia, Martes flavigula, Martes watkinsii*)

3. ***

4. Otters (*Lutra perspicillata*)

4A. Pole Cats (*Vormela peregusna, Mustlea putorius*)

4B. Red Fox (*Vulpes vulpes, Vulpus montana, Vulpes griffithi*)

5. Sloth Bear (*Melurses ursinus*)

5A. Sperm Whale (*Physeter macrocephalus*)

6. ****

7. Weasels (*Mustela sibrica, Mustela kathian, Mustela altaica*)

8. Checkered Keelback Snake (*Xeno chorpis piscator*)

9. Dhaman or Rat Snake (*Ptyas musosus*)

10. Dog-faced Water Snake (*Cerberus rhynchopi*)

11. Indian Cobras (all species of the genus *Naja*)

12. King Cobra (*Ophiphagus hannah*)

13. Olivecerous Keel Back Snake (*Artretium schistosum*)

14. Russel's Viper (*Viper ruselli*)

15. Varanus species (excluding yellow monitor lizard)

(*** Denotes periodical deletion, this list has been since revised with effect from 1/4/2003)

2. MINIMUM PRESCRIBED SIZE FOR FEEDING/ RETIRING CUBICLE/ENCLOSURES FOR IMPORTANT MAMMALIAN SPECIES OF CAPTIVE ANIMALS

Name of the Species	Size of the Cubicle/Enclosures in Metres		
	Length	Breadth	Height
Family - Felidae			
Tiger and Lion	2.75	1.80	3.00
Panther	2.00	1.50	2.00
Clouded Leopard/Snow Leopard	2.00	1.50	2.00
Small Cats	1.80	1.50	1.50
Family Elephantidae			
Elephant	8.0	6.0	5.5
Family Rhinocerotidae			
One Horned India Rhinoceros	5.0	3.0	2.5
Family Cervidae			
Brow Antlered Deer	3.0	3.0	2.5
Hangul	3.0	2.0	2.5
Swamp Deer	3.0	2.0	2.5
Musk Deer	2.5	1.5	2.0
Mouse Deer	1.5	1.0	1.5
Family Bovidae			
Nilgiri Tahr	2.5	1.5	2.0
Chinkara	2.5	1.5	2.0
Four Horned Antelope	2.5	1.5	2.0
Wild Buffalo	3.0	1.5	2.0
Indian Bison	3.0	2.0	2.5

Yak	4.0	2.0	2.5
Bharal, Goral, Wild Sheep and Markhor	2.5	1.5	2.0
Family Equidae			
Wild Ass	4.0	2.0	2.5
Family Ursidae			
All types of Indian Bears	2.5	1.8	2.0
Family Canidae			
Jackal, Wolf and Wild Dog	2.0	1.5	1.5
Family Vivirridae			
Palm Civet	2.0	1.0	1.0
Large Indian Civet & Binturong	2.0	1.5	1.0
Family Mustelidae			
Otters all types	2.5	1.5	1.0
Rate/Hogbadger	2.5	1.5	1.0
Martens	2.0	1.5	1.0
Family Procyonidae			
Red Panda	3.0	1.5	1.0
Family Lorisidae			
Slow Loris and Slender Loris	1.0	1.0	1.5
Family Cercopithecidae			
Monkeys and Langurs	2.0	1.0	1.5

(CZA)

3. MINIMUM PRESCRIBED SIZE FOR OUTDOOR OPEN ENCLOSURE FOR IMPORTANT MAMMALIAN SPECIES OF CAPTIVE ANIMALS

	Minimum size of the Outdoor Additional Enclosure	**Minimum area** per extra Animal (per pair)
	Square metre	
Family Felidae		
Tiger and Lion	1000	250
Panther	500	60
Clouded Leopard	400	40
Snow Leopard	450	50
Family Rhinocerotidae		
One Horned Indian Rhinoceros	2000	375
Family Cervidae		
Brow Antlered Deer	1500	125
Hangul	1500	125
Swamp Deer	1500	125
Family Bovidae		
Wild Buffalo	1500	200
Indian Bison	1500	200
Bharal, Goral, Wild Sheep and Serow	350	75
Family Equidae		
Wild Ass	1500	200
Family Ursidae		
All types of Indian Bears	1000	100
Family Canidae		
Jackal, Wolf and Wild Dog	400	50
Family Procyonidae		
Red Panda	300	30
Family Cercopithecidae		
Monkeys and Langurs	500	20

4. Threat Categories of Species

International Unior for Conservation of Nature and Natural Resources (IUCN), The world conservation union is the world's largest conservation network. It has developed a red data book aimed at categorising species according to the severity of the threats facing them and estimating the imminence of their extinction. The IUCN threat categories used in the Red Data List along with their definitions are listed below.

Extinct (EX): A taxon is extinct when there is no reasonable doubt that the last individual has died. In India the Cheetah, the Pink Headed Duck and the Himalayan Quail are now extinct.

Extinct in the Wild (EW): A taxon is extinct in the wild when it is known to survive only in cultivation, in captivity or as a naturalised population well outside the past range.

Critically Endangered (CR): A taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

Endangered (EN): A taxon is endangered when it is not critically endangered, but is facing a very high risk of extinction in the near future. Some taxa in this list include Elephant, Tiger, and Snow Leopard.

Vulnerable (VU): A taxon is vulnerable when it is most critically endangered or endangered but is facing a high risk of extinction in the wild in the medium term future. Nilgiri Leaf Monkey, Dhole are some of the taxa in this category.

Lower Risk (LR): A taxon is classified as lower risk when it has been evaluated, and does not satisfy the criteria for any of the categories. - CR, EN, VU. Taxa in this category are further classified into three sub categories. Conservation Dependent, Near Threatened and Least Concern.

Data Deficient (DD): A taxon is data deficient when there is inadequate information to make a direct or indirect assessment of its

risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied and its biology well known, but the appropriate data on the abundance/distribution could be lacking. Data deficient is, therefore, not a category of threat or lower risk. It indicates that more information is required and acknowledges that future may show that threatened classification is appropriate. Indian Black Turtle, Bengal Fox are some of the taxa in this category.

Not Evaluated (NE): A taxon is not evaluated when it has not yet been assessed against the criteria.

5. Mammalian Species of Conservation Significance

New Protected Area Proposals for 8 Species are as follows:

Crab Eating Macaque	A large Wildlife Sanctuary in Nicobars.
Golden Langur	Extend Manas Wildlife Sanctuary.
Hispid Hare	Extend Barnadi Wildlife Sanctuary.
Ibex	New Wildlife Sanctuary in Ladakh.
Phayre's Leaf Monkey	National Park and New Wildlife Sanctuary in Tripura.
Pigmy Hog	Project Tiger Management Status for whole Manas area.
Rhinoceros	Jaldapara to National Park status, plus Wildlife Sanctuary in Assam.
Tibetan Ass	Rupshu National park and enlarged Khangchendzonga National Park.

For seven species there is only one natural population, conservation therefore needs translocation to Protected Areas within their past range. Species are:

Asiatic Lion	To Kuno Wildlife Sanctuary and proposed Kuno National Park in Madhya Pradesh.
Dryland Swamp Deer	To Satpura, Indravati, Amarkantak, Bori,

	Bandhavgarh National Parks and Wildlife Sanctuaries.
Hangul	To neighbouring Protected Areas, to HP.
Indian Wild Ass	To Great Rann of Kutch Wildlife Sanctuary (restock to boost the tiny surviving population) and Kanodwala Rann.
Markhor	To protect the tiny population in JK and then translocate.
Sangai	To wetlands in Mizoram and Assam, and to drier forests in Manipur.
Urial	To Hemis National Park and Siachen-Shyok.

For nine species there is a need for field research to identify remaining populations. These are: Rusty spotted Cat, Malabar Civet, Argali/Nayan, Tibetan Antelope, Stump-tailed Macaque, Malay Sun Bear, Palla's Cat, Tibetan Gazelle, Pig-tailed Macaque. The review contains proposals for protected areas that will increase the conservation coverage for:

Bengal Florician

Dolphins

Dugong

Fresh water Turtle

Gharial

Great Indian Bustard

Jerdon's Courser

Lesser Florician

Marine Turtle

Megapode

Mugger Crocodile

Pheasants

Saltwater Crocodile

6. World Association of Zoos and Aquariums

WAZA is the acronym of the World Association of Zoos and Aquariums, which unites at a global level, zoological gardens, aquaria, national and regional associations, like minded organisations and individuals willing to abide by its Bylaws and all other rules and regulations set by the association, including its code of ethics. The World Association of Zoo and Aquariums was founded in 1946 as the International Union of Directors of Zoological Gardens (IUDZG).

The objectives of the association are:

1. To promote cooperation between zoological gardens and aquaria with regard to the conservation, management and breeding of animals in captivity.
2. To promote and coordinate cooperation between national and regional associations and their constituents.
3. To assist in representing zoological gardens and aquaria in other international organisations or assemblies.
4. To promote environmental education, wildlife conservation and environmental research.

WAZA unifies close to 200 zoological parks and aquaria, a small number of affiliate members, which support the vision, mission and interests of the association and 16 regional or national associations with another 800 member institutions. The 1000 zoos and aquaria organised in the WAZA network and about 200 institutions organised in the national associations not yet members to WAZA receive annually at least 600 million visitors, more than any group of public, conservation-oriented institutions. The headquarters of WAZA are located at BERNE, Switzerland.

WAZA Executive Office,
P. O. Box 23,
CH-3097 Liebefeld-Berne
Email: WAZA.Secretariat@bluewin.ch

The Association Members of WAZA are:

AIZA	Iberian Association of Zoos and Aquaria.
AMACZOOA	Mesoamerican and Caribbean Zoo and Aquaria Association.
ARAZPA	Australian Regional Association of Zoological Parks and Aquaria.
AZA	American Zoo and Aquarium Association.
CAZA	Canadian Association of Zoological Parks and Aquariums.
DAZA	Danish Association of Zoological Gardens.
EAZA	European Association of Zoos and Aquaria.
FUNPZA	National Foundation of Zoological Parks and Aquaria, Venezuela.
JAZGA	Japanese Association of Zoological Gardens and Aquariums.
FZG	Federation of Zoological Gardens of Great Britain and Ireland.
PAAZAB	Pan African Association of Zoological Gardens, Aquaria and Botanical Gardens.
SEAZBA	Southeast Asian Zoo Association.
SAZA	Swedish Association of Zoological Parks and Aquaria.
VDZ	German Federation of Zoo Directors.

Conservation Strategy

In 1993, WAZA published the World Zoo Conservation Strategy, which defines the role of zoos and aquaria of the world shall play in global conservation. The strategy was developed in cooperation with IUCN's Conservation Breeding Specialist Group and received input from many individuals, institutions and associations belonging to the global zoo and aquarium network. The aim of the World Zoo Conservation Strategy is to help conserve Earth's fast disappearing

wildlife and biodiversity.

1. To identify the areas in which zoos and aquaria can make a contribution and determine how zoos and aquaria can support and consolidate the process leading to nature conservation and sustainable use of natural resources.
2. To develop understanding and support for the conservation potential of zoos and aquaria from national, supranational and global authorities, as well as other social and political bodies and organisations.
3. To assist zoos and Aquaria in the formulation of policies wherein priorities relating to conservation are incorporated.
4. To indicate how extending and intensifying of contacts in the global zoo and aquarium network and other conservation can augment contributions by the individual zoo and aquarium networks.

The World Zoo Conservation Strategy stipulates that zoos and aquaria should—

1. Actively support through, coordinated programmes, the conservation of populations of the endangered species *in situ* and *ex situ* and through these, contributes to the conservation of natural habitats, biotopes and ecosystems.
2. Offer support and facilities in order to increase scientific knowledge that will benefit conservation, and lend support to conservation community by making available relevant knowledge and experience.
3. Promote an increase of the public and political awareness of the necessity for conservation, natural resources sustainability and the creation of a new equilibrium between people and nature.

The World Zoo Conservation Strategy emphasises that the growing global zoo network seeks to further intensify the integration that is crucial to successful conservation. Each individual zoo can contribute by stimulating individual zoos, by providing them with direction and integrating the efforts of their network with those of other nature conservation oriented networks, such as IUCN. This great mustering

of all available powers will be necessary to give our earth's biosphere and its living elements the best possible chance for survival.

Animal Welfare — Code of Ethics

The continued existence of zoological parks and aquaria depends upon the recognition that their operation is based on the respect for the dignity of the animals in their care. Whilst recognising that cultural differences exist in different parts of the world, and that each region may have formulated its own code of ethics, WAZA strives to develop an ethical tradition which is strong and which forms the basis of a standard of conduct for the zoo profession.

To this effect, WAZA has adopted, in 1999, a Code of Ethics setting the basic principles for the guidance of all its members. The code stipulates that achieving the conservation and survival of the species must be the aim of all members of the profession. Any action taken in relation to an individual animal, e.g., euthanasia or contraception must be undertaken with this higher ideal of species survival in mind. Among other things the code requests the members to:

1. Promote the interest of wildlife conservation, biodiversity and animal welfare to colleagues and society at large.
2. Cooperate with wider conservation community including wildlife agencies, conservation organisations and research institutions to assist in maintaining global biodiversity.
3. Cooperate with government and appropriate bodies to improve standards of animal welfare and ensure the welfare of all animals in our care.
4. Act, at all times in accordance with local, national and international law and to strive for the highest standards of operation in all areas and in particular regarding animal welfare.
5. Acquire preferably captive bred animals by direct zoo-to-zoo contact. This does not preclude the receipt of animals resulting from confiscation of rescues. If animals have to be obtained from the wild, members must be confident that such acquisitions will not have a deleterious effect upon the wild population.
6. Ensure that institutions receiving animals have appropriate facili-

ties to hold the animals and the skilled staff who are capable of maintaining high standard of husbandry and welfare. Appropriate detailed records allowing the receiving institution to make appropriate detailed records regarding the future management of the animal must accompany all animals being transferred. All animal transfers should conform to international standards and laws applying to the particular species and, where appropriate, should be accompanied by qualified staff.

7. Consider the possible physiological side effects, as well as negative effect on behaviour, before a final decision to implement contraception is made.
8. Follow the IUCN/SSC/Reintroduction Specialist group guidelines for reintroduction when participating in release to the wild life programmes.
9. Euthanise the animal only after all other options have been evaluated, and ensure that euthanasia is carried out in a manner that ensures quick death without suffering.
10. Prevent mutilation of any animal for cosmetic purpose, or to change the physical appearance, and to restrict pinioning of birds as much as possible.

Work towards *in situ* Conservation

Conservation is not just a question of keeping the last surviving specimens of a species in zoos, nor is it a question of fencing in specific areas to protect specific species. Conservation is a question of saving species from extinction through developments that secure the viability of the population in an environment that is politically, socially and biologically stable enough to support them far into future. Recognising this principle, the conservation activities of zoos are continuously shifting from simple *ex situ* breeding towards a more holistic approach with *in situ* conservation becoming increasingly important.

Ex situ zoo populations can directly support the *in situ* survival of some species by providing the nuclei for the re-establishment or reinforcement of wild population in nature. The World Zoo Conservation

strategy emphasises that such reintroduction and restocking projects, when properly applied can bring great benefits to natural biological systems.

Reintroduction and restocking projects have been undertaken for more than 120 species. Typically such projects are carried out by a consortium of zoos in cooperation with the coordinators of relevant regional *ex situ* programmes and taxon advisory groups. Examples of reintroduction projects each involving several tens of zoos, include the Golden lion tamarin, the Przewalski's horse, the European bison, the Arabian and the Scimitar-horned oryx, the Addax antelope, the Alpine ibex, the bearded vulture, the White stork etc.

In addition to the *ex situ* breeding programmes, the subsequent reintroduction of captive bred animals to the wild, the zoos *in situ* activities also include educational programmes aimed at politicians, biological programmes (research and monitoring), socio-economic projects, and social workers, PR activities and much more on national and international scale — all in order to secure the conservation efforts far into the future.

Provide Class Rooms for Environmental Education

Zoos reach hundreds of millions of people all over the world, most of them living in urban areas and having little or no contact with nature. They come to the zoo because in one way or another they have an interest in animals. Consequently, living animals form the basis for education in the zoos, however important the manner of exhibition and the addition of other collection components — such as plants and non-living materials — may be. Education in zoos focuses increasingly on conservation issues.

The total zoo public, not only children, forms the target group for informal education in or by zoos. In addition, target groups outside of the zoo can be reached through outreach programmes and through media presentation. Formal zoo education comprises programmes that are educational and is conducted within the framework of the

educational curriculum of the schools, colleges etc., within or in relation with the zoo. Most if not all, zoos are regularly visited by numerous students from the kindergarten up to university level. These classes receive structured educational tours and lessons focusing around selected themes as part of their formal teaching programme at the zoo. Many zoos have developed professional programmes and facilities for this type of zoo education.

The array of educational possibilities offered by the zoo animals is inexhaustible, and certainly does not stop with topics in classical biology. Special emphasis is laid on conservation education. In this context, the zoo conservation strategy recommends that, in addition to approaching conservation issues from the view of biological sciences, zoos should also develop educational programmes that elucidate the socio-economic backgrounds of threat to nature. Through this they should play an active role in increasing the public and political awareness of the connection between consumption and lifestyle and survival of the species and biological systems.

It is of great value that zoos worldwide are carrying the same message and have a network that is demonstrating the importance of nature conservation on a global scale. Zoo educators worldwide are organised in Zoo Educators Association. Their global umbrella is the International Zoo Educators Association, an affiliate member of WAZA that organises international meetings on a regular basis, publishes a Journal and maintains a website under www.izea.net

7. Protected Areas in India

Biosphere Reserves in India

Government of India has established 14 Biosphere Reserves which protect larger areas of natural habitat, than a National Park or Animal Sanctuary, and often include one or more National Parks and/or other protected areas, along the buffer zones. The list of Biospere Reserves in India are given below:

1. Achaanak maar-Amarkantak Biosphere Reserve
2. Agasthyamalai Biosphere Reserve
3. Dehang-Debang Biosphere Reserve
4. Dibru-Saikhowa Biosphere Reserve
5. Great Nicobar Biosphere Reserve
6. Gulf of Mannar Biosphere Reserve
7. Khangchendzonga Biosphere Reserve
8. Manas Biospere Reserve
9. Nanda Devi Biosphere Reserve
10. Nilgiri Biosphere Reserve
11. Nokrek Biosphere Reserve
12. Pachmarhi Biosphere Reserve
13. Simlipal Biosphere Reserve
14. Sundarbans Biosphere Reserve.

National Parks in India

Andaman & Nicobar Islands: Campbell Bay, Galathea, Mahatma Gandhi, Mt. Harriet Island, Middle Button Island, North Button Island,Rani Jhansi, Saddle Peak, South Button Island

Andhra Pradesh: Kasu Brahmananda Ready, Mahavir Ilarina Vanasthali, Mrugavani, Sri Venkateswara

Arunachal Pradesh: Mouling, Namdapha

Assam: Dibru-Saikhowa, Kaziranga, Manas, Nameri, Orang

Bihar: Valmiki

Chhattisgarh: Indravati, Kanger Ghati, Sanjay

Goa: Mollem

Gujarat: Blackbuck, Gir, Marine, Vansda
Harvana: Kalesar, Sultanpur
Himachal Pradesh: Great Himalayan, Pin Valley
Jammu & Kashmir: Dachigam, Hemis, Kishtwar, Salim Ali
Jharkhand: Betla
Karnataka: Anshi, Bandipur, Bannerghatta, Kudremukh, Nagarhole
Kerala: Eravikulam, Mathikettan Shola, Periyar, Silent Valley
Madhya Pradesh: Bandhavgarh, Fossil, Kanha, Madhav, Panna, Pench, Sanjay, Satpura, Van Vihar
Maharastra: Gugamal, Navegaon, Pench, Sanjay Gandhi, Tadoba
Manipur: Keibul Lamjao, Sirohi
Meghalaya: Balphakram, Nokrek
Mizoram: Murlen, Phavvngpui
Nagaland: Intanki
Orissa: Bhitarkanika, Simlipal
Rajasthan: Desert, Keoladeo, Ranthambhore, Rajiv Gandhi, Sariska
Sikkim: Khangchendzonga
Tamil Nadu: Guindy, Gull'of Mannar, Indira Gandhi, Mudumalai, Mukurthi
Uttar Pradesh: Dudhwa
Uttaranchal: Corbett, Gangotn, Govind, Nanda Devi, Rajaji, Valley of Flowers
West Bengal: Buxa, Gorumara, Neora Valley, Singalila, Sundarbans.

Wildlife Sanctuaries

India has over 500 animal sanctuaries, referred to as Wildlife Sanctuaries (IUCN Category IV Protected Area). Some wildlife sanctuaries are specifically named Bird Sanctuary, e.g., Keoladeo National Park before it attained National Park status. Many National Parks were initially Wildlife Sanctuaries. Wildlife sanctuaries of national importance to conservation are named National Wildlife Sanctuaries like the National Chambal (Gharial) Wildlife Sanctuary for conserving the Gharial established in 1978.

Reserve Forest

In reserve forest areas, human activities like logging, hunting and fishing can be undertaken only with special permission.

Project Elephant Reserves in India (2004)

Elephant Range	Elephant Reserve	State	Elephant numbers
1.Eastern India	1. Mayurjharna	W. Bengal	56
	2. Singhbhum	Jharkhand	300
	3. Mayurbhanj ER	Orissa	512
	4. Mahanadi ER	Orissa	204
	5. Sambalpur ER	Orissa	284
		Total	**1,356**
2.North Brahmaputra	6. Kameng ER	Arunachal	377
	7. Sonitpur ER	Assam	577
		Total	**954**
3.South Brahmaputra	8. Dihing-Patkai ER	Assam	457
	9. Deomali ER	Arunachal	150+
		Total	**600+**
4.Kaziranga	10. Kaziranga–Karbi Anglong ER	Assam	1,000
	11. Dhansiri-Lungding ER	Assam	430
	12. Intanki ER	Nagaland	28
		Total	**1,458**
5.Eastern Dooars	13. Chirang-Ripu ER	Assam	807
	14. Eastern Dooars ER	W. Bengal	165
		Total	**972**
6.Garo Hills	15. Garo Hills ER	Meghalaya	**878**
7.Nilgiri–Eastern Ghat	16. Mysore ER	Karnataka,	5,838
	17. Wayanad ER	Kerala	961
	18. Nilgiri ER	Tamilnadu	1,938
	19. Rayala ER	Andhra	74
		Total	**8,811**
8.South Nilgiri	20. Nilambur ER	Kerala	886
	21. Coimbatore ER	Tamilnadu	132
		Total	**1,018**
9.Western Ghat	22. Anamalai ER	Tamilnadu	680
	23. Anamudi ER	Kerala	750
		Total	**1,430**
10.Periyar	24. Periyar	Kerala	1,268
	25. Srivilliputtur	Tamilnadu	223
		Total	**1,491**
11.Northern India	26. Shivalik ER	Uttaranchal	**1,391**
		Grand Total	**20,150+**

Project Tiger Reserves in India

1. Bandipur Tiger Reserve
2. Bandhavgarh Tiger Reserve
3. Bhadra Tiger Reserve
4. Buxa Tiger Reserve
5. Corbett Tiger Reserve
6. Dampa Tiger Reserve
7. Dudhwa Tiger Reserve
8. Indrawati Tiger Reserve
9. Kanha Tiger Reserve
10. Kalakad Mundanthurai Tiger Reserve
11. Manas Tiger Reserve
12. Melghat Tiger Reserve
13. Nagarjunsagar Tiger Reserve
14. Namdapha Tiger Reserve
15. Palamau Tiger Reserve
16. Panna Tiger Reserve
17. Pench Madhya Pradesh Tiger Reserve
18. Pench Maharashtra Tiger Reserve
19. Periyar Tiger Reserve
20. Ranthambore Tiger Reserve
21. Sariska Tiger Reserve
22. Similipal Tiger Reserve
23. Sunderbans Tiger Reserve
24. Tadoba Tiger Reserve
25. Valmiki Tiger Reserve

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Zoo-Instrument for Conservation, Central Zoo Authority.

Wild and Zoo Animal Health Care and Management/ Fish Production

LPM-312 Cr. Hrs. 1+1=2

(As given in 'Curricula and Course Catalogue - B. V. Sc. & A. H. degree programme, V.C.I. pattern effective from the academic year 1994-1995)

Note: This course is not independently developed in most of the veterinary colleges. With the world wildlife act coming into effect, the importance of the management and health care of the wild animals especially in the sprawling zoos, national parks, mini-zoos and deer parks are becoming an added responsibility of the veterinarians.

It is suggested that where personnel are not available as yet, teachers be trained for this purpose providing them orientation in zoological parks, I.V.R.I. etc. These institutions are requested to organise exclusive training for the teachers of wildlife medicine and management. Meanwhile guest lectures by wildlife experts can be organised and zoo vets are requested to organise demonstrations of care and management, restraint and examination, administration of medicines etc. Visits to the zoo and wildlife animal centres be organised. As apart of the internship, training in the zoos can also be arranged. Experienced persons from wild animal centres, zoo enthusiasts and activists as well as environmentalists can be called for guest lectures, panel discussions etc. This will not only provide a fill up but would also provide for interactions between wild animal personnel and veterinary scientists.

For training in wild animals, efforts from various disciplines like vet. medicine, vet. surgery, vet. pathology, vet. parasitology, epidemiology, livestock management, nutrition etc. be combined to provide a composite training programme.

Objectives of the Wild and Zoo Animal Health Care and Management

1. To provide the taxonomy of the various genera of wild animals of India and Indian zoos along with their description.
2. To apprise the students on the basic principles of habitat and housing of various classes of zoo animals (with hints on do's and don'ts).
3. To demonstrate/familiarise restraint, capture, handling, physical examination and transport of zoo animals.
4. To provide an awareness/information regarding feeding habits, feeds and feeding schedules of zoo animals.
5. To apprise the students on the principles of zoo hygiene, public health problems arising from the zoos and prevention and control of diseases in the zoos.
6. To provide an awareness of the commonly encountered nutritional and metabolic diseases in the zoos.
7. To provide awareness on other diseases (microbial infections, endo-parasites, ecto-parasites and faecal pseudo-parasites).

   (Course suggested above be developed by the institutions on the basis of the objectives laid above).

Fish Production

Fishery as a method of recycling animal and poultry wastes and feed surplus. Types of common fresh water fish, their collection. Care and breeding. Egg and spawn management. Economic production, pond and nursery management, fish preservation, inspection, utilisation of fish in animal feed.

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