SMITHSONIAN HANDBOOKS

INSECTS

SPIDERS AND OTHER TERRESTRIAL ARTHROPODS

GEORGE C. McGAVIN

Photography by
STEVE GORTON

Editorial Consultant
LOUIS N. SORKIN
(American Museum of Natural History, New York)

COVENT GARDEN BOOKS

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Contents

AUTHOR'S INTRODUCTION

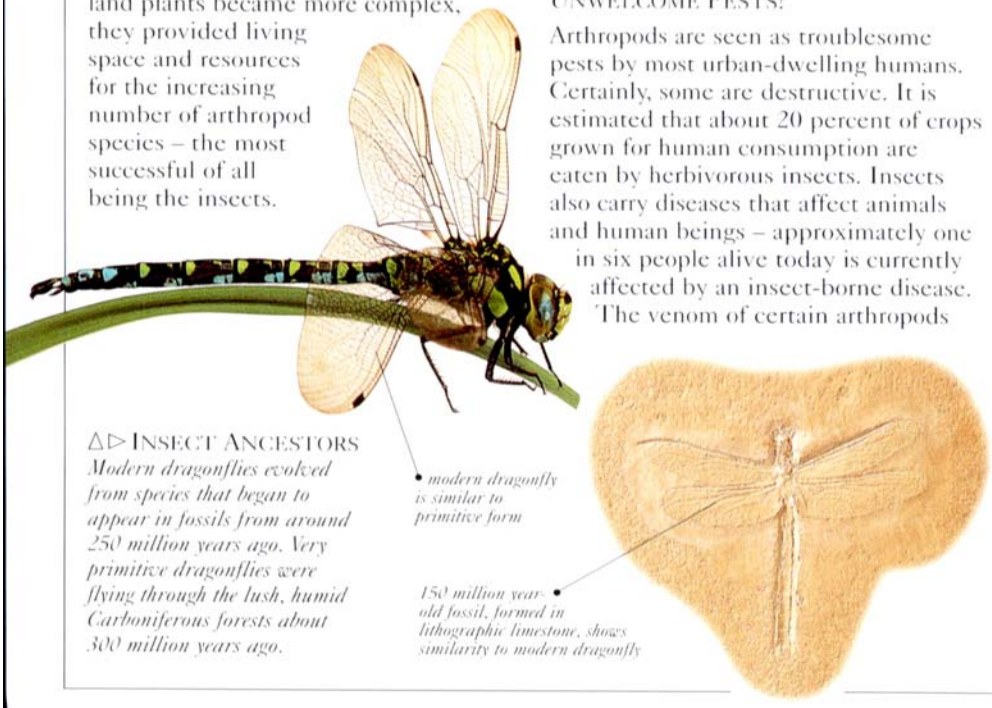
Insects are the most numerous and successful creatures on Earth. They belong to a group of invertebrates known as arthropods, which are characterized by their jointed limbs, segmented bodies, and tough outer skeletons. Arthropods play an essential role in all of the world's major ecosystems. Although they are less conspicuous than other animals, if you look closely you will uncover their incredible variety and learn something about their extraordinary lives.

THE FIRST SIGNS of life on Earth were single-celled organisms that lived in the oceans around 3,500 million years ago. Jellyfish, simple worms, and other multicellular animals later evolved in the seas, followed by creatures with hard outsides, such as shellfish and trilobites – primitive arthropods. The early sea-dwelling arthropods were later to become the very first land-living animals, emerging from the oceans as scavengers about 420 million years ago – perhaps to escape aquatic predators. As land plants became more complex, they provided living space and resources for the increasing number of arthropod species – the most successful of all being the insects.

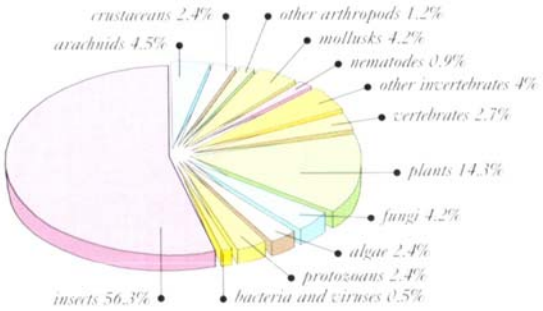
Today, invertebrate animals (those without a backbone) make up the majority of the world's known species; vertebrate animals (those with a backbone) account for less than three percent. Within the invertebrates, the huge group Arthropoda eclipses all other groups, while arthropods are, in turn, dominated by the insects. It is estimated that there are about 10 quintillion – 10,000,000,000,000,000,000 – insects alive at any time.

UNWELCOME PESTS?

Arthropods are seen as troublesome pests by most urban-dwelling humans. Certainly, some are destructive. It is estimated that about 20 percent of crops grown for human consumption are eaten by herbivorous insects. Insects also carry diseases that affect animals and human beings – approximately one in six people alive today is currently affected by an insect-borne disease. The venom of certain arthropods



△▷ INSECT ANCESTORS
Modern dragonflies evolved from species that began to appear in fossils from around 250 million years ago. Very primitive dragonflies were flying through the lush, humid Carboniferous forests about 300 million years ago.



LIFE ON EARTH
Of all the species on Earth (represented left), 73.5 percent are invertebrates, and most of these are arthropods. Insects – the most successful of all the arthropods in terms of survival and adapting to their environment – make up more than half of all species alive today. There are at least another four million insect species still to be named.

can be fatal, and many people have severe phobias about groups such as spiders and moths.

REAL BENEFITS

Most arthropods, however, are harmless. For example, less than one percent of cockroach species – a much maligned insect group – are significant pests. Many people overlook the benefits that insects bring. Useful products derived from insects range from honey and silk to waxes, oils, natural medicines, and dyes. In many countries, insects such as crickets, grasshoppers, grubs, and caterpillars still provide nutritious food for humans. Arthropods are also widely used in scientific research, helping us to understand genetics, physiology, and animal behavior. Many insects are vital plant-pollinators. Without them, many plants would die out as well as the animals that, directly or indirectly, depend on them.

PEST CONTROL
Predacious insects can help control other, harmful, species. For example, ladybirds are efficient predators of soft-bodied species such as aphids.

CHANGING THE COURSE OF HISTORY

Disease-carrying insects have made a major mark on history. Three world epidemics of plague, a flea-borne disease, killed millions and altered social structures as a result. Until the use of insecticides during World War II, twice as many people died of insect-borne diseases as from fighting. Most of Napoleon's army, which set out to conquer Russia in 1812, were killed by typhus spread by the human body louse. In the late 1800s, yellow fever carried by mosquitoes stopped the building of the Panama Canal for 15 years and killed 20,000 workers.

DEADLY MALARIA
It is estimated that malaria, a disease that is transmitted by certain mosquitoes, kills one human being every 12 seconds.

Natural Balance

The most fundamental role that the millions of arthropods play is in helping to maintain the balance of the Earth's ecosystems and food chains. These are complex networks that depend on energy from the Sun. The energy is "trapped" by green plants and converted to carbohydrate, which is then eaten by herbivores and converted into body tissue. The herbivores are then eaten by carnivores. Most food chains are dependent on insects as the majority of animals eat insects to survive and many would not exist without them. Birds, for example, are mostly insectivorous. A single swallow chick may consume about 200,000 bugs, flies, and beetles before it fledges, and even bird species that are seed-feeders as adults rear their young on a nutritious insect diet.

Animal droppings are food for certain beetles and flies, and many insects eat decomposing plant and animal matter. So insects are also helping to keep the Earth's supply of nutrients in circulation. Finally, although insects may cause serious damage to crops, they can also control it. At least one-quarter of all insect species are parasites or predators of other insects, and some are reared specially to control the numbers of agricultural pests.

Predator in Action
Food chains are highly dependent on insects. Frogs, which are largely insectivores, are, in turn, hunted by larger predators.

A World of Insects

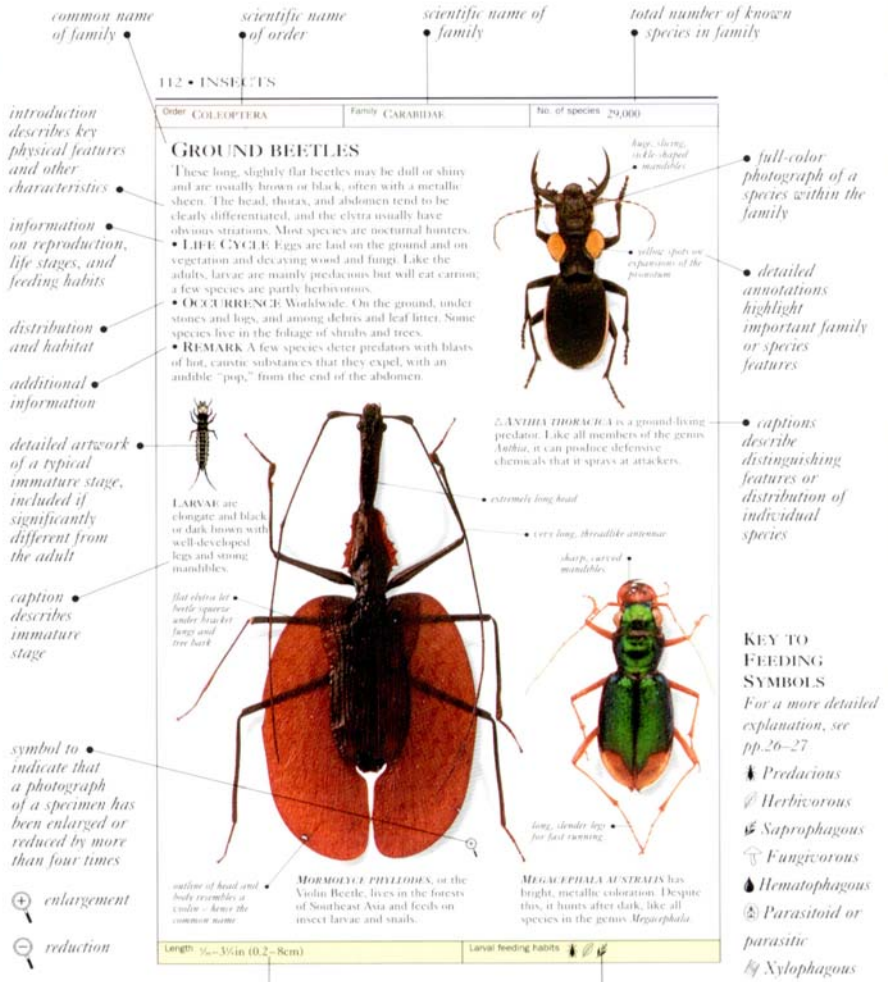
With about 1,500 families of terrestrial arthropods, it would be impossible to include them all in this book. We have chosen a broad range from around the world, including families because they are particularly important, common, or simply fascinating in some way.

▷ Pollinators
Without vital pollinators such as bees, many plants would not be able to produce fruit and seeds and so reproduce.

△▷ Insect devastation
Since humans first started to cultivate crops, insect-borne plant diseases have caused the kind of damage shown right. One swarm of Desert Locusts (above) may contain up to 50 billion individuals, who could theoretically consume up to 100,000 tons of food a day.

How This Book Works

This book is divided into 41 main sections, each covering a separate order of terrestrial arthropods. These sections are subdivided into entries that each describe the characteristics of a particular family with photographs of representative species. The family entries are arranged alphabetically by scientific name. Some of the order sections are divided into alphabetically arranged subdivisions, in which case this is explained in the introduction to the order. The sample page below shows a typical family entry.



WHAT IS AN ARTHROPOD?

LIVING THINGS ARE GROUPED by biologists into five major divisions known as kingdoms, the largest of which is the animal kingdom. The kingdoms are in turn divided into groups called phyla. Arthropods form the largest single phylum in the animal kingdom. They comprise an incredibly diverse group, ranging in size from mites a fraction of a millimeter long to the vast Japanese Island Crab, *Macrocheira kaempferi*, which can grow up to 12ft (4m) across. Arthropods are found in every habitat on Earth, from the depths of the oceans to the highest peaks, from arid deserts to the most humid rainforests, as well as in highly populated urban areas. Insects are the only winged arthropods, and are the most successful in terms of survival.

Below is a simple "tree" showing the subdivisions of the phylum Arthropoda.

Phylum
A major subdivision of a kingdom (in this case the animal kingdom, or the kingdom Animalia).

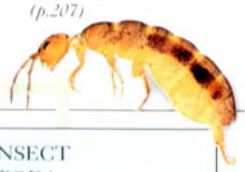
ARTHROPODA
Animals with a tough outer skeleton, segmented bodies, and jointed legs

Subphylum
A major subdivision of a phylum (in this case the phylum Arthropoda).

MANDIBULATA
Arthropods with antennae, and highly modified jaws for biting or chewing

Superclass
A subdivision of a subphylum, composed of classes of animals that share fundamental characteristics.

HEXAPODA
Mainly terrestrial, 6-legged arthropods, with 2 antennae



SPRINGTAIL
Isotoma viridis
(p.207)

Class
A group made up of orders of animals that share similar characteristics.

STINK BUG
Eurydema dominulus
(p.92)

INSECTA
The only winged arthropods

NONINSECT HEXAPODA
3 classes:
COLLEMBOLA
PROTURA
DIPLURA

Order
A group made up of closely related animal families.

INSECTA	NONINSECT HEXAPODA
29 orders	3 orders

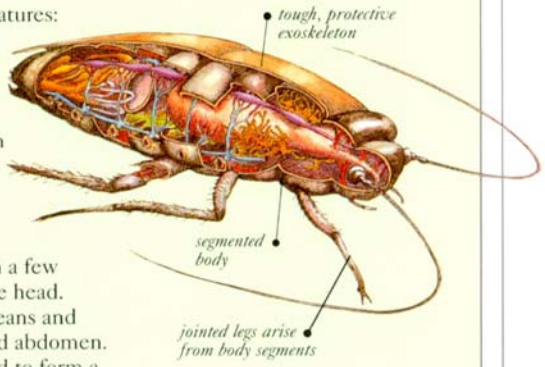
Family, genus, species
A family is made up of similar species. A genus is made up of closely related species.

INSECTA	NONINSECT HEXAPODA
949 families 1,000,000 species	31 families 7,700 species

MAIN CHARACTERISTICS OF ARTHROPODS

Arthropods share a number of common features:

- Bilaterally symmetrical bodies.
- A protective, rigid outer exoskeleton (or cuticle) made of a tough material called chitin. The muscles are attached to this exoskeleton, which is molted from time to time as the animal develops through its life stages.
- Pairs of jointed legs, which arise from the body segments.
- Body segments that are arranged to form a few main sections, the most common being the head. Myriapods have a head and trunk; crustaceans and hexapods have a separate head, thorax, and abdomen. In arachnids, the head and thorax are fused to form a single segment known as the cephalothorax.



PORCELLIONID
Porcellio scaber
(p.212)

CYLINDER MYRIAPOD
Iulus species
(p.242)

CHELICERATA
Arthropods with pincerlike mouthparts and no antennae

FUNNEL WEAVER
Tegenaria gigantica
(p.228)

CRUSTACEA	MYRIAPODA	CHELICERATA
Mainly aquatic arthropods with gills and 4 antennae	*Arthropods with 9 or more pairs of legs and 2 antennae*	*Arthropods with pincerlike mouthparts and no antennae*
6 classes: REMIPEDIA CEPHALOCARIDA BRANCHIOPODA OSTRACODA MAXILLOPODA MALACOSTRACA	*4 classes:* PAUROPODA SYMPHYLA CHILOPODA DIPLOPODA	*3 classes:* ARACHNIDA PYCNOGONIDA MEROSTOMATA
37 orders	16 orders	14 orders
540 families 40,000 species	144 families 13,700 species	470 families 76,500 species

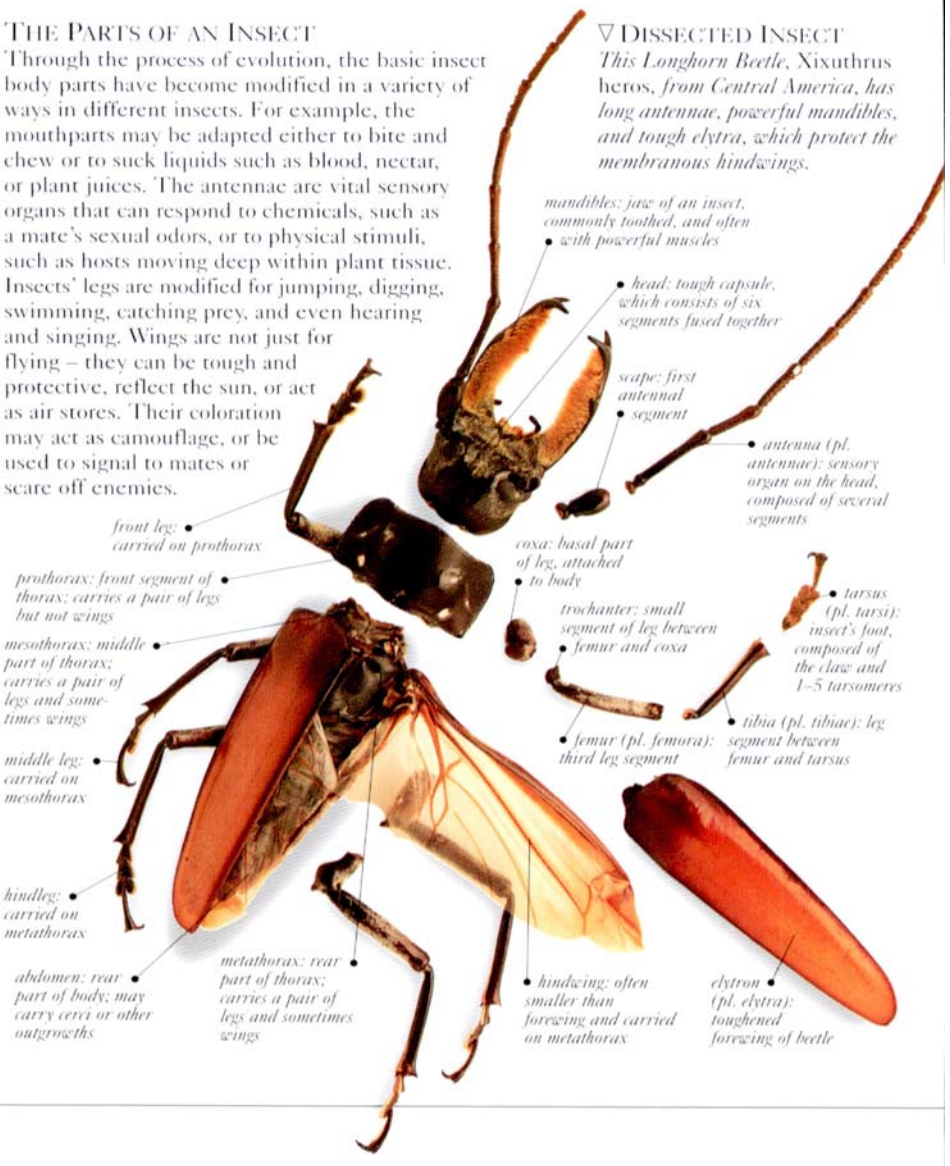
WHAT IS AN INSECT?

MANY PEOPLE CONFUSE insects and other arthropods. Insects, like all arthropods, have jointed legs and a hard cuticle, but unlike others they have only six legs and, usually, wings. The word "insect" is derived from Latin, meaning "to cut into," and refers to the separate sections that make up an insect – the head, thorax, and abdomen. The head carries the mouthparts, antennae, and eyes. The thorax has three segments, with legs and sometimes wings. The abdomen has up to 11 visible segments and may carry terminal "tails" (cerci).

THE PARTS OF AN INSECT

Through the process of evolution, the basic insect body parts have become modified in a variety of ways in different insects. For example, the mouthparts may be adapted either to bite and chew or to suck liquids such as blood, nectar, or plant juices. The antennae are vital sensory organs that can respond to chemicals, such as a mate's sexual odors, or to physical stimuli, such as hosts moving deep within plant tissue. Insects' legs are modified for jumping, digging, swimming, catching prey, and even hearing and singing. Wings are not just for flying – they can be tough and protective, reflect the sun, or act as air stores. Their coloration may act as camouflage, or be used to signal to mates or scare off enemies.

▽ DISSECTED INSECT
This Longhorn Beetle, Xixuthrus heros, *from Central America, has long antennae, powerful mandibles, and tough elytra, which protect the membranous hindwings.*



Inside an Insect

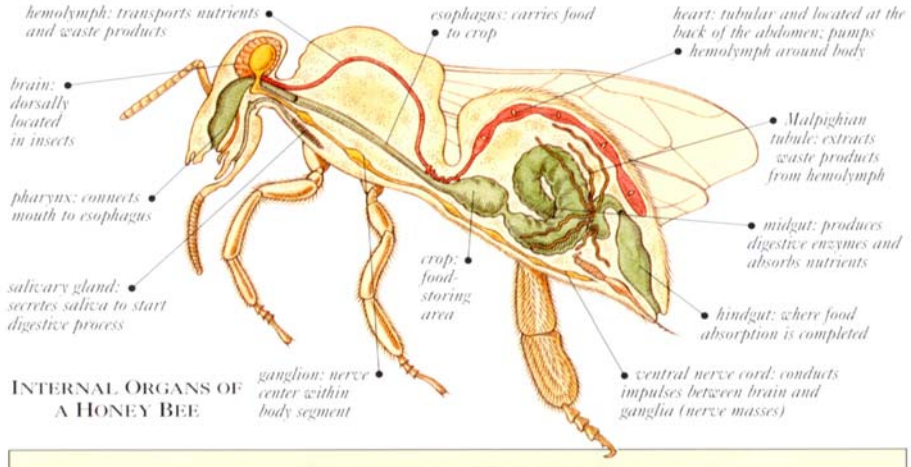
An insect's central nervous system consists of a brain connected to nerve masses called ganglia. The peripheral nervous system is composed of sensory nerves that gather information from sensory receptors and motor nerves that control the muscles.

The respiratory system consists of a network of tubes. Air is taken in through openings, called spiracles, on the abdomen or thorax. The immature stages of aquatic species take in air through gills.

The circulatory system is an open one, where the organs are bathed in a fluid called hemolymph that transports nutrients and waste around the body.

The digestive system is an open-ended tube with areas for grinding and storing food, producing enzymes, and absorbing nutrients.

To reproduce, males typically transfer sperm to the female's sperm store via a penis (aedeagus), and eggs are fertilized as they pass down the female's oviduct.



INTERNAL ORGANS OF A HONEY BEE

Noninsect Hexapods

Insects belong to a group of animals called hexapods (see pp.10–11). This group also includes three classes – collectively known as noninsect hexapods – that are generally regarded as being distinct from insects: the Diplura (diplurans), Protura (proturans), and Collembola (springtails).

Most noninsect hexapods live in soil or leaf litter. None have wings, and some even lack eyes and antennae. The major difference between these hexapods and insects, however, concerns their mouthparts. Unlike insects, the mouthparts of the noninsect hexapods are enclosed within a pouch, which is located on the underside of the head. When in use, the mouthparts are pushed out of the pouch to scrape, bite, or pierce the food.

SPRINGTAILS

These arthropods are the most abundant and widespread of the noninsect hexapod classes. They are either elongate or rounded – like the springtail shown here (See pp.207–11).

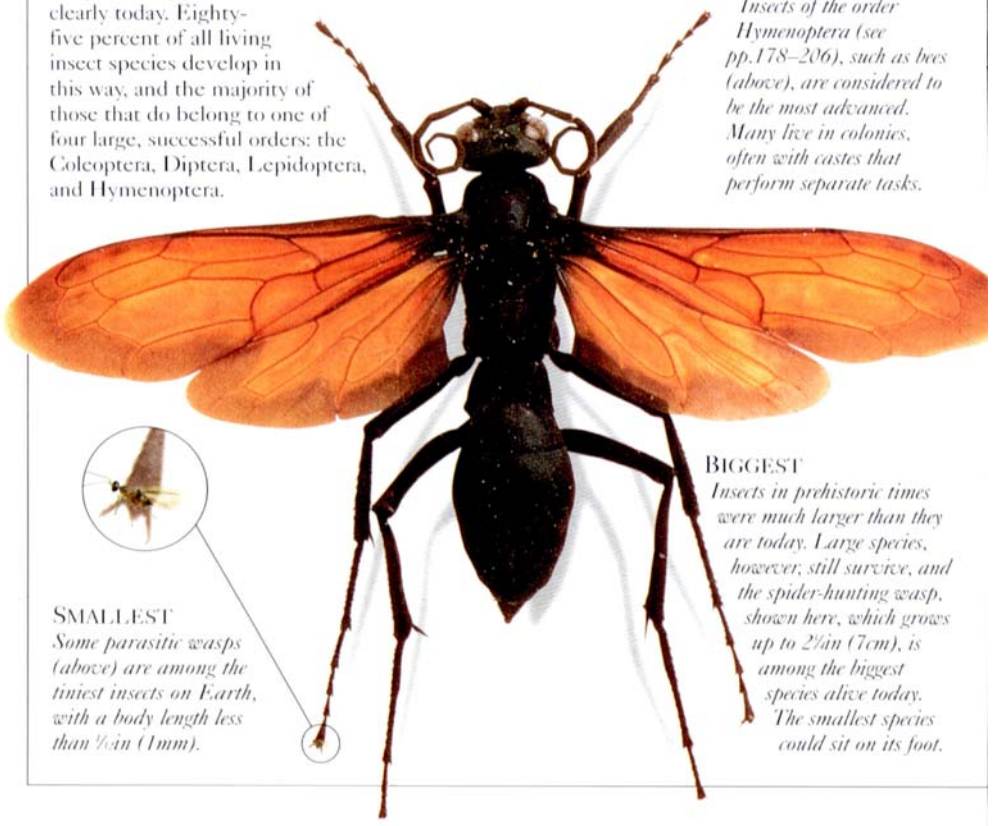
Types of Insect

Insects can be divided into three groups, depending on the way that they develop during their lifetime. Primitive, wingless insects, such as silverfish, develop to adulthood by molting periodically throughout their life. Winged insects change either by a gradual process, called incomplete metamorphosis, or undergo a more sudden transformation, called complete metamorphosis, which involves a pupal stage (see pp.20–23).

The very first winged insects developed by gradual metamorphosis. A pupal stage did not evolve until the Permian period (290–245 million years ago), perhaps in response to climatic conditions (the pupa made it possible for insects to survive a period of cold). An increasing degree of tissue reorganization within the pupa also meant that larval stages were no longer just miniature versions of adults. Larvae became "eating machines" and adults "breeding machines." The success of the pupal stage can be seen clearly today. Eighty-five percent of all living insect species develop in this way, and the majority of those that do belong to one of four large, successful orders: the Coleoptera, Diptera, Lepidoptera, and Hymenoptera.

△ **Most Primitive**
The first insects were wingless scavengers that appeared more than 400 million years ago. The most primitive insects alive today, the bristletails (above) and silverfish, are similar in function and appearance.

△ **Most Advanced**
Insects of the order Hymenoptera (see pp.178–206), such as bees (above), are considered to be the most advanced. Many live in colonies, often with castes that perform separate tasks.

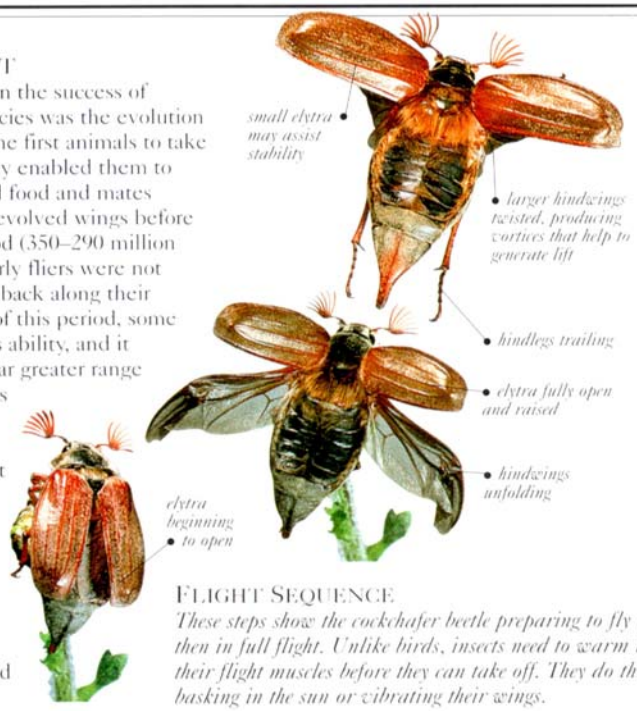


Smallest
Some parasitic wasps (above) are among the tiniest insects on Earth, with a body length less than ⅛in (1mm).

Biggest
Insects in prehistoric times were much larger than they are today. Large species, however, still survive, and the spider-hunting wasp, shown here, which grows up to 2¾in (7cm), is among the biggest species alive today. The smallest species could sit on its foot.

Wings and Flight

One of the key factors in the success of insects as terrestrial species was the evolution of flight. Insects were the first animals to take to the air, and this ability enabled them to evade enemies and find food and mates efficiently. Insects had evolved wings before the Carboniferous period (350–290 million years ago), but these early fliers were not able to fold their wings back along their bodies. By the middle of this period, some insects had evolved this ability, and it allowed them to use a far greater range of microhabitats, such as cracks and crevices in dead wood, inside leaf litter, or under stones. It also meant that they could hide from predators. The descendants of these species were highly successful, and today it is only dragonflies and mayflies that cannot fold their wings in this way.



Flight Sequence
These steps show the cockchafer beetle preparing to fly and then in full flight. Unlike birds, insects need to warm up their flight muscles before they can take off. They do this by basking in the sun or vibrating their wings.

The Secrets of Success

Throughout their evolution, several factors have combined to make insects the most successful of all species on this planet. Today, they make up over half of the species alive. There are several reasons for their success, mainly their ability to fly and reproduce quickly, their generally small size, and their protective cuticle (external exoskeleton) and their insulated central nervous system.

Factor	Effect
Cuticle (external exoskeleton)	*Tough and waterproof, the cuticle helps to protect insects from predators and also from dehydration.*
Flight	*This allows insects to escape from enemies, to find new habitats and food sources rapidly, and to establish new colonies.*
Fast reproduction	*Insects evolve at a high rate and adapt quickly to changing environmental conditions.*
Insulated central nervous system	*Insulation of the central nervous system allows nerves to work efficiently and also allows survival in hot or dry places.*
Size	*Small size allows utilization of a wide range of microhabitats – a tree, for example, may support hundreds of insect species.*

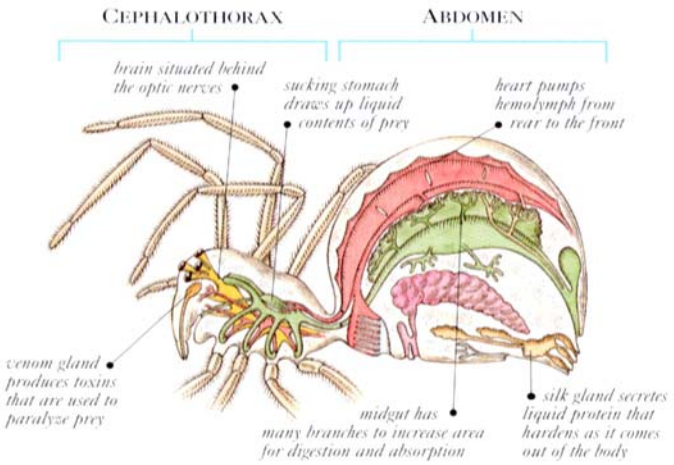
WHAT IS AN ARACHNID?

ARACHNIDS, which include spiders, scorpions, ticks, and mites, differ from insects essentially in that their bodies are divided into two rather than three segments. Their ancestors were marine, scorpion-like creatures, which flourished during the Silurian Period (435–400 million years ago); some of these were more than 39in (1m) long. The marine species died out about 250 million years ago, but their descendants have been highly successful on land.

MEXICAN RED-LEGGED TARANTULA

THE PARTS OF AN ARACHNID

An arachnid's body is divided into two parts. The head and thorax are fused together, forming a cephalothorax, or prosoma, which is joined to the abdomen, or opisthosoma. In some, the abdomen is segmented and may have a tail-like extension; spiders' abdomens contain silk glands. An arachnid's cephalothorax has six pairs of appendages. The first pair (chelicerae) may be pincer- or fanglike, and are used mainly for feeding. The second pair (pedipalps) have several functions, including capturing prey and fertilizing the female, and may be leglike or enlarged with terminal claws. The other four pairs are walking legs, although the first pair may also carry sensory organs. Gases are exchanged through the trachea or special respiratory organs called book lungs. Most arachnids digest their food outside the body using enzymes, which are pumped into or poured over food. The liquified remains are then sucked up.



▷ INSIDE AN ARACHNID
The cephalothorax houses the brain and sensory organs, as well as the sucking stomach and venom gland. The abdomen is concerned with digestion, gaseous exchange, reproduction and – in spiders (as illustrated here), pseudoscorpions, and some mites – the production of silk.

◁ HARVESTMAN
The cephalothorax and abdomen in harvestmen are joined in such a way that they look as though they have only one body section.

▷ TICK
The protruding structure at the front of a tick's body houses barbed mouthparts used to penetrate the host's skin.

TYPES OF ARACHNID

Arachnids are a large and diverse group. They are divided into 11 orders, each of which has characteristic features. Sun-spiders, for example, have massive, forward-facing chelicerae. Scorpions are recognizable by their long abdominal "tails," bearing stings, and their large, clawlike pedipalps. Whip-scorpions also have large pedipalps, but they are not clawlike, and the long, whiplike tail is without a sting. Perhaps the biggest variation in appearance is seen in the spiders and the mites. Spiders vary from tiny money spiders with turreted, eye-bearing extensions on the cephalothorax to huge, hairy species, known as tarantulas. The huge number of species that make up the mites and ticks vary from gall-forming mites, which are probably the smallest arthropods in the world at less than 1/250in (0.1mm) long, to blood-feeding ticks, which can be more than 1¼in (30mm) long. Some have slender or flattened bodies that allow them to fit inside a human hair follicle or burrow through skin layers.

SPIDERS' WEBS

Spiders produce silk to wrap their eggs in, and for lining burrows and making shelters, but the most well-known use is for capturing prey. (Not all spiders catch prey using silk; some simply rely on good eyesight and stealth.) Web-making spiders have evolved various ingenious prey-capturing techniques, several of which are shown below.

ORB WEB
Spirals of sticky silk are constructed across open spaces. Some webs can be strong enough to catch birds.

TRAP DOOR
This is a silk-lined tunnel with a hinged lid, to provide shelter and protection as the spider waits for prey.

CAST WEB
Some spiders make small webs that they hold in their legs and throw over passing prey.

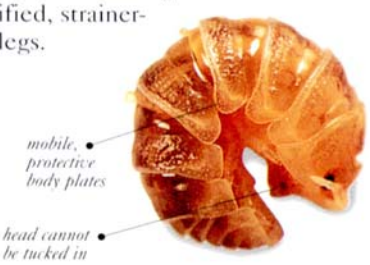
COB WEB
Tangles of silk seen in buildings may be made by daddy-long-legs. Other species make cob webs in vegetation.

PARENTAL CARE
Many arachnids, including some harvestmen and ticks, show parental care by guarding their eggs from predators. Scorpions, whip-spiders, whip-scorpions, and some spiders carry their young around on their backs for a while after they emerge from the egg sac or brood chamber.

What is a Crustacean?

Diverse in appearance, crustaceans range from waterfleas, barnacles, and sand-hoppers to shrimps, crabs, and lobsters. The group ranges in size from microscopic plankton to giant lobsters that reach lengths of more than 30in (75cm). They are primarily aquatic, and typically have a distinctive hardened carapace. They occur in freshwater and marine habitats throughout the world.

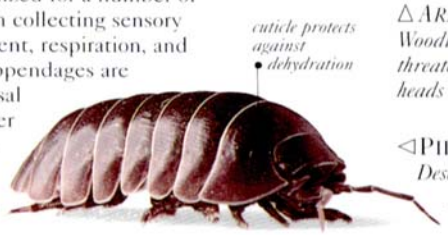
Some crustacean species have adapted to life on land; woodlice, for example, are exclusively terrestrial and are common and widespread. Most crustaceans are scavengers, but there are predatory and herbivorous species, and some, such as barnacles, filter minute particles of food from the water using modified, strainer-like legs.



△ *Armadillidium album*
Woodlice roll into a ball when threatened but cannot tuck their heads in, unlike pill millipedes.

The Parts of a Crustacean

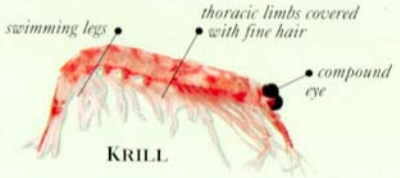
The carapace of crustaceans is similar to the exoskeleton of other arthropods, but is often strengthened with deposits of calcium carbonate. The head and thorax are often covered by a single carapace. Crustaceans have a second pair of antennae, and their appendages are specialized for a number of functions, ranging from collecting sensory information to movement, respiration, and egg brooding. Their appendages are double-branched, a basal portion bearing an inner part, which is used for walking, and an outer part, which is used for swimming.



◁ Pill Woodlouse
Descended from an aquatic species, pill woodlice still prefer damp places.

Marine Crustaceans

Most crustaceans are abundant in the sea and belong to the group Malacostraca. This includes the more familiar crab, shrimp, and lobster species. The front of the carapace often extends to form a projection, the eyes are stalked and compound, and the abdomen ends in a taillike telson. In crabs, the abdomen is short and tightly curled to fit under the broad carapace.



Krill

△ Common Lobster
In many larger species, such as the common lobster (above), the first pair of thoracic legs is enlarged, with strong claws. These are used for defense, handling food, and courtship.

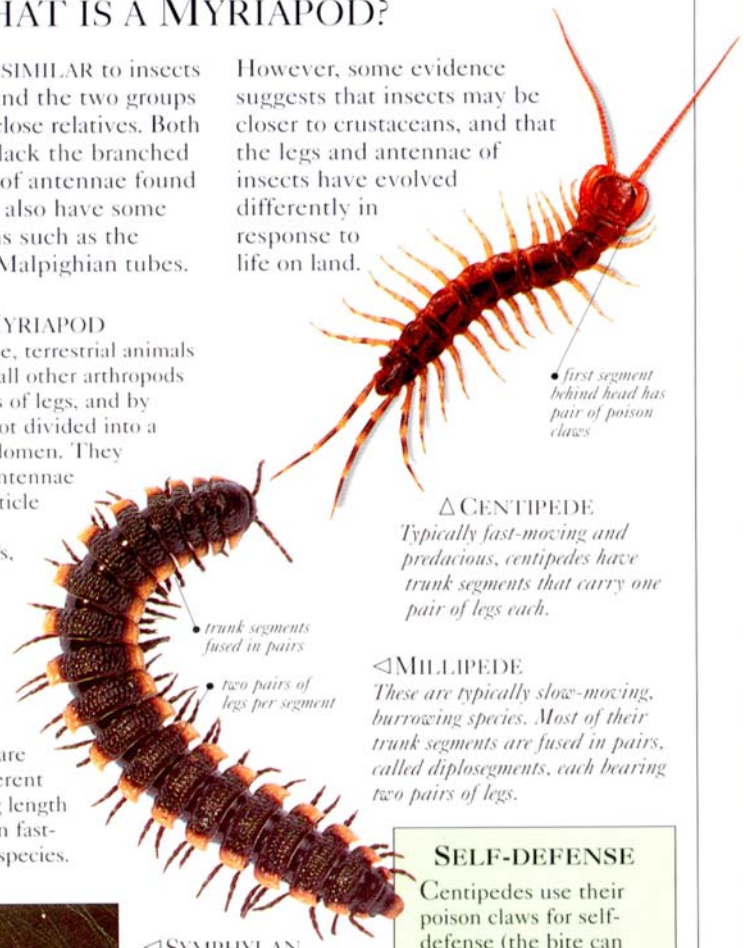
WHAT IS A MYRIAPOD?

MYRIAPODS ARE SIMILAR to insects in many ways, and the two groups are considered to be close relatives. Both have mandibles and lack the branched legs and second pair of antennae found in crustaceans. They also have some similar internal organs such as the tracheal system and Malpighian tubes.

However, some evidence suggests that insects may be closer to crustaceans, and that the legs and antennae of insects have evolved differently in response to life on land.

THE PARTS OF A MYRIAPOD

These typically elongate, terrestrial animals are distinguished from all other arthropods by their numerous pairs of legs, and by having a trunk that is not divided into a separate thorax and abdomen. They have one pair each of antennae and mandibles. The cuticle of a myriapod is not as waterproof as an insect's, and myriapods cannot close off the spiracular openings to the tracheal system; as a result, they are mostly confined to humid microhabitats, such as soil and leaf litter, and are usually nocturnal. Different gaits, determined by leg length and number, are seen in fast-running and burrowing species.



△ CENTIPEDE
Typically fast-moving and predacious, centipedes have trunk segments that carry one pair of legs each.

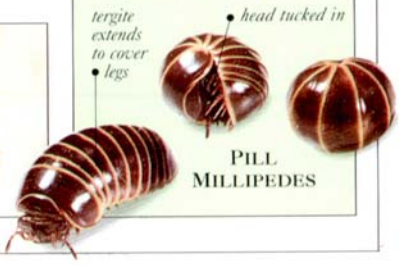
◁ MILLIPEDE
These are typically slow-moving, burrowing species. Most of their trunk segments are fused in pairs, called diplosegments, each bearing two pairs of legs.

◁ SYMPHYLAN
Closely related to the centipede, this soft-bodied creature lives in soil and leaf litter. It has fairly long antennae and 12 pairs of legs.

▷ PAUROPOD
A close relation of the millipede, this myriapod inhabits leaf litter and soil. It has a soft body, short, branched antennae, no eyes, and nine pairs of legs.

SELF-DEFENSE

Centipedes use their poison claws for self-defense (the bite can cause vomiting and fever in humans). Pill millipedes can roll into a ball with their head tucked in under the last tergite (abdominal plate).



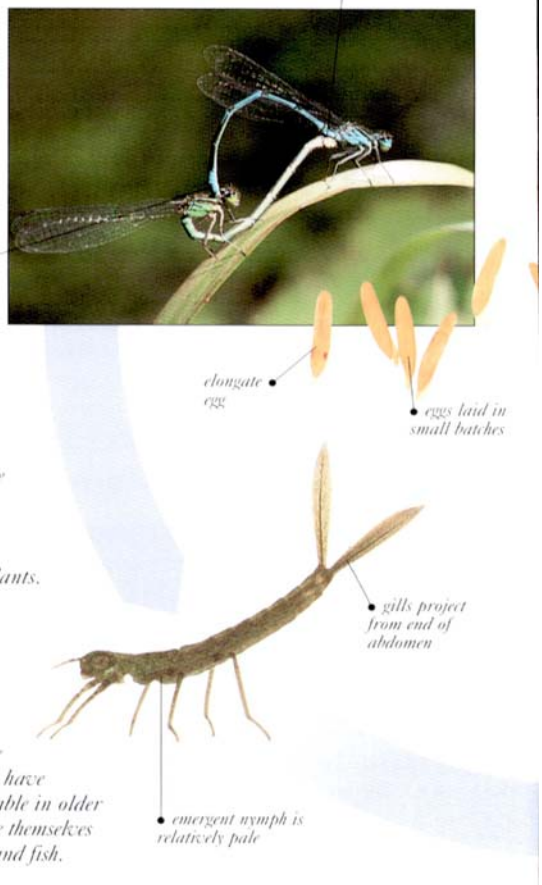
PILL MILLIPEDES

LIFE CYCLE

ALL ARTHROPODS must shed their exoskeleton at intervals in order to grow, but the development from egg to adulthood varies between the different groups. Myriapods and arachnids molt throughout their lives, and immature stages typically look like smaller versions of the adults. Insects, however, with the exception of bristletails and silverfish (see p.23), change their appearance from the immature to the adult stage. In more primitive insects, change is gradual and the metamorphosis is described as "incomplete" (see below); in advanced insects the change is often extremely dramatic and the metamorphosis is known as "complete" (see pp.22–23).

INCOMPLETE METAMORPHOSIS

In insects that undergo incomplete metamorphosis, the immature stages are called nymphs. The nymphs look very similar to adults but lack wings and reproductive structures. Wings develop gradually on the outside of the body, inside wing buds or pads. After a series of molts – the precise number varying between species – the final molt to adulthood occurs with the expansion of the wings. In aquatic orders, such as dragonflies and damselflies, the nymphs are less like the adults.

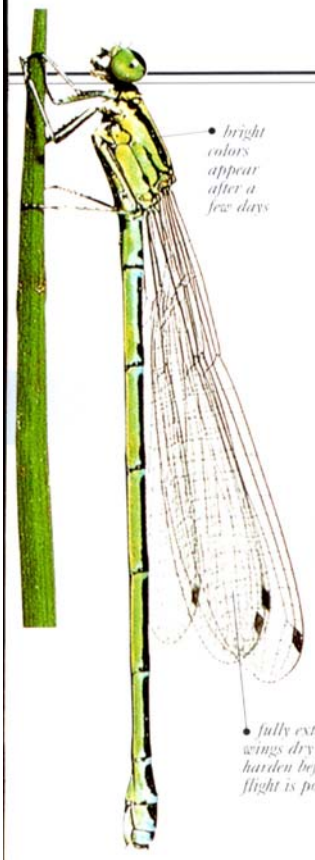


1. MATING

In the damselfly species shown here, Coenagrion puella, *the male transfers sperm from its primary genital organs on the ninth abdominal segment to secondary genitalia on the third abdominal segment. The male clasps the female behind the head, while the female bends her abdomen around to join with the secondary genitalia of the male. Sperm is transferred via the penis to the female's sperm storage organ. Eggs are laid inside aquatic plants.*

2. EMERGENT NYMPH

After the pale nymph emerges from the egg, it develops through a series of stages called instars – the number of which varies between species, and according to temperature and food supply. The first few instars do not have visible wing pads. Pads become more noticeable in older nymphs. Although predacious, the nymphs are themselves prey to many creatures, such as water beetles and fish.

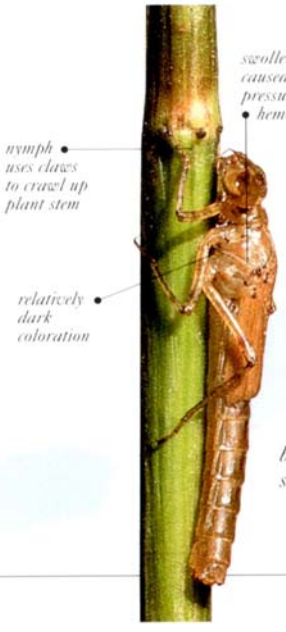


5. Adult Damselfly

Once free of the nymphal skin, the adult can expand its abdomen and wings to full size by pumping hemolymph into them. The cuticle will harden in a few hours, but it will be several days before the bright adult coloration develops. The female is not ready to mate immediately; it feeds for a week or two while its ovaries mature.

4. Emerging Adult

Anchored by the nymphal skin, the emerging adult pushes upward and takes hold of a stem using its legs. Pulling itself forward, it gently eases the wings out of the wing buds and then removes its abdomen. At this stage the thorax has not acquired its final shape, the body is soft, and the wings are crumpled and unexpanded.



3. Final Instar

When a nymph is fully grown, it begins to emerge from the water for increasingly long periods of time and eventually leaves for good. An increase in hemolymph pressure in the thorax causes a split along the back of the nymphal cuticle between the wing pads. The adult's head and thorax separate from the old skin first and emerge.

Complete Metamorphosis

In the insects that develop by complete metamorphosis, the immature stage, called the larva, looks completely different from the adult. The larvae of some flies are known as maggots; the larvae of many beetles are known as grubs; and the larvae of butterflies and moths are called caterpillars. The larvae feed continuously and go through a number of molts until the final larval stage is reached. They then stop feeding and search for a suitable place to pupate. In the pupal stage, the reorganization and transformation of the larval tissues into adult structures takes place. The tissues of the immature insect are broken down and small groups of cells called imaginal disks, which have been present since the egg first hatched, grow and develop into adult organ systems. To protect the pupa, the final larval stage often spins a cocoon or makes a cell out of soil particles or chewed wood fibers. The pupae of some species have moveable jaws and are able to defend themselves to a certain extent. The adult frees itself from the pupal skin and/or cocoon by using its jaws, legs, or by swelling parts of the body.

1. Mating

Courtship may involve the production of sexual odors, sounds, and even light displays. In the ladybird species shown here, Coccinella septempunctata, *the male clings to the back of his mate. Sperm may be transferred in a matter of minutes, but by maintaining hold for a longer time, the male makes sure that other males do not mate with the same female.*

2. Emergent Larvae

The eggs are laid in relatively small batches on the leaves of plants, and after about one week the minute first instar larvae emerge. The cuticle is soft at first but soon hardens and darkens. The larvae must find suitable soft-bodied prey, which in this species are aphids of various kinds.

3. Final Larval Stage

The dark-colored, elongate larvae have well-developed spines and projections on their bodies, and strong legs. They can be found on stems and the undersides of leaves wherever there are aphids to eat. A single ladybird larva can eat many hundreds of aphids during its larval development. Its pale spots signal that it is distasteful to potential predators.

6. Adult Ladybird

The distinctive, hemispherical adult is protected from predators, such as birds, by its bright warning colors and the ability to exude distasteful liquids from its leg joints. Like the larvae, the adults feed on aphids and other soft-bodied insects and are useful in biological control of pests. Many ladybird species overwinter in groups in sheltered places outside or in buildings, and emerge to lay their eggs in the springtime.

5. New Adult

After a week or so, pupation is complete. The pupal cuticle splits down the back, and the pale, soft adult emerges. During the hour or two after emergence, the elytra must be raised and the hindwings expanded from underneath and hardened before they can be folded away again ready for flight. The bright colors and contrasting spots of the adult beetle will take a couple of days to appear.

4. Pupation

After about four weeks, depending on conditions such as temperature and the supply of food, the fully grown larva pupates. It attaches itself to the underside of a leaf and sheds its last larval skin. The larva remains immobile and the pupal cuticle underneath hardens and becomes dark.

Ametabolous Insects

In insect species in which there is no change in shape and molting continues even after sexual maturity is reached, development is said to be ametabolous. Only two orders, bristletails and silverfish, comprising less than 0.1 percent of all insect species, develop in this way. In addition to thoracic legs, these primitive, scavenging species have short appendages on some of their abdominal segments.

Silverfish
The streamlined shape gives the silverfish its name.

THE SENSORY SYSTEM

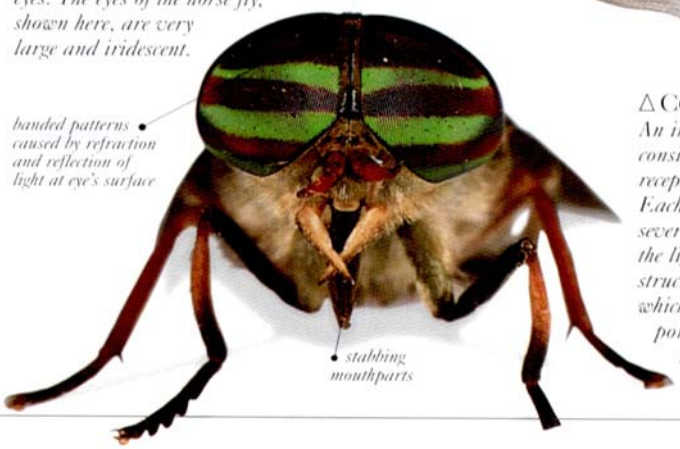
ALTHOUGH MOST ARTHROPODS are very small creatures, they possess surprisingly sophisticated sensory systems that allow them to respond appropriately to a wide range of internal and external stimuli. Arthropods are able to receive visual, chemical, and mechanical cues, many have temperature and humidity sensors, and some can detect magnetic fields and infrared radiation.

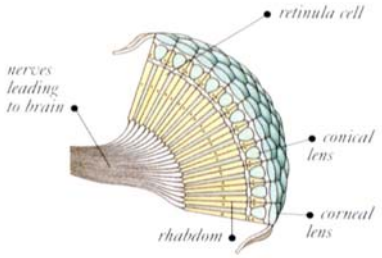
HOW INSECTS SEE

In most insects, some parasitic groups, and the worker castes of some ants and termites, the main visual organs are compound eyes (see below). Some cave-dwelling species are actually blind. In day-flying species, the image received is made up of numerous tiny spots of differing light intensity. Night- and dusk-flying insects have eyes that are adapted to dim light conditions, although the images they form are not as sharp as in day-flying species. Many adult insects and some immature ones have simple eyes, called ocelli, either instead of or as well as the compound eyes. Simple eyes respond to light or dark only and are important in determining certain behavioral rhythms, such as when to forage for food or hibernate. Color vision occurs in all orders of insects. Generally, insects see better at the blue end of the spectrum rather than the red. Some insects are sensitive to ultraviolet light.

△ A BEE'S VIEW
Flowers may have very distinctive patterns, called nectar guides, which reflect ultraviolet light and are visible only to bees and some other species. This photograph was taken with UV-sensitive film.

▽ EYES OF A HUNTER
Eyes are important for finding food and mates. Aerial predators often have larger eyes and sharper vision than other insects, sometimes with the eyes covering the entire surface of the head. Insects that mate in swarms also tend to have big eyes. The eyes of the horse fly, shown here, are very large and iridescent.





△ COMPOUND EYE
An insect's compound eyes consist of up to 20,000 light-receptive units called ommatidia. Each ommatidium comprises several clear lenses that direct the light on to a rodshaped structure called a rhabdom, which is made up of the inner portions of light-sensitive retinula cells.

Touch, Smell, and Taste

Chemical sense organs, or chemoreceptors, are present on the mouthparts, antennae, tarsi, and other parts of the body in insects. These enable the insect to detect food, find good egg-laying sites, or to follow marked trails on the ground. Insects pick up airborne odors by means of olfactory sensilla, which are located mainly on the antennae; if present in very large numbers, they can detect extremely low odor concentrations. Insects emit volatile chemicals called pheromones. These can be used for a variety of purposes, but are usually involved with sexual behavior. Attraction pheromones act at a distance to bring the two sexes together; often it is the female who emits the odors and waits for males to find her. Once together, other odors called courtship pheromones are produced.

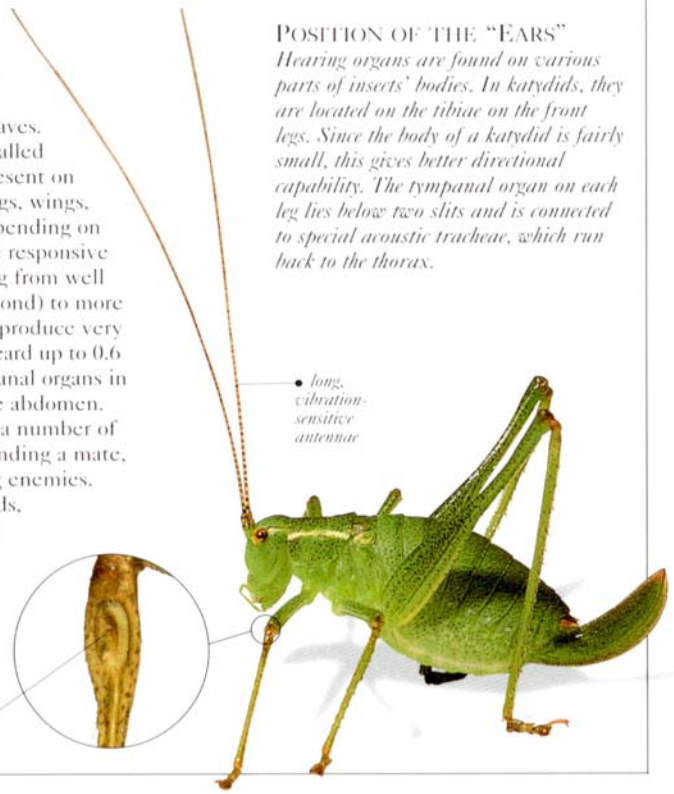
Communicating Ants
Messages are passed between insects in several ways. Some use sound or light displays, but touch and taste are more common. Here, two worker ants may be exchanging information about which colony they belong to and perhaps about new food sources.

Detecting Sound

Many insects have hairs on their cuticle surface that are responsive to vibrations, air currents, touch, and sound waves. Special hearing structures, called tympanal organs, may be present on various parts of the body (legs, wings, abdomen, or antennae). Depending on the species, these organs are responsive to sound frequencies ranging from well under 100Hz (cycles per second) to more than 200KHz. Male cicadas produce very loud sounds, which can be heard up to 0.6 miles (1km) away; the tympanal organs in both sexes are located in the abdomen.

Insects may use sound for a number of reasons: for attracting and finding a mate, detecting prey, and avoiding enemies. Many moths, praying mantids, lacewings, and several other species have ultrasonic-sensitive hearing organs, which allow them to receive the sounds of hunting bats.

Position of the "Ears"
Hearing organs are found on various parts of insects' bodies. In katydids, they are located on the tibiae on the front legs. Since the body of a katydid is fairly small, this gives better directional capability. The tympanal organ on each leg lies below two slits and is connected to special acoustic tracheae, which run back to the thorax.

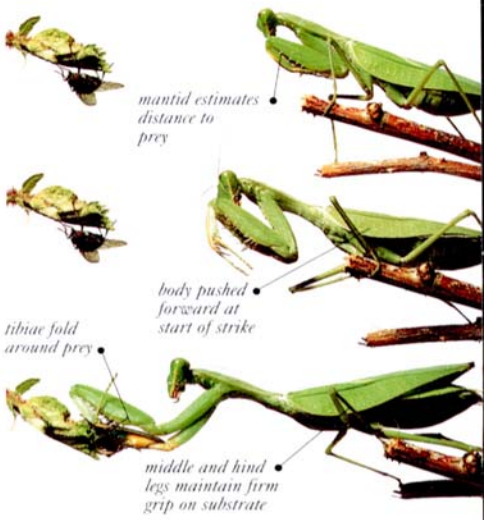


FOOD AND FEEDING

ARTHROPODS EAT a variety of foods. Sometimes the food eaten by the immature stages and the adults is the same, but often the larval stages have very different feeding habits. In some cases, adult insects may not feed at all and simply depend on reserves built up at the larval stage. The main feeding types, together with the symbols that appear in this book, are outlined below.

PREDACIOUS SPECIES

Predacious species kill and eat other animals to survive. Most predators rely on more than one type of prey, although some do specialize. Predators do not have to eat as much as herbivores, since their food is more nutritious and provides all the protein that they need. Sometimes adult arthropods catch prey and store it for their larvae to eat. As a result of attempting to avoid predators, many arthropods have evolved defense mechanisms, including spines and hairs, cryptic coloring, and toxic secretions.



PRAYING MANTID ▷
Binocular vision allows the praying mantid to calculate the exact distance to its prey. The strike itself takes less than 100 milliseconds. The tibiae extend, then the femora, while the tibiae flex around the prey.

HERBIVOROUS SPECIES

Plant-eating insects may feed on flowers, seeds, or leaves, or may eat inside the plants' tissues. A special case is that of gall-formers, which chemically induce an abnormal growth (gall) to form on a plant, inside which the insect is protected and feeds. Many insects have sucking mouthparts and feed only on plant sap or empty the contents of plant cells.

CATERPILLAR
One of the most well-known foliage-eaters, caterpillars use their thoracic legs and abdominal prolegs to grip leaves.

• *caterpillar uses mandibles to nibble foliage*

SAPROPHAGOUS SPECIES

Scavenging species that feed on dead or decaying organic matter are also called detritivores. Some of these scavengers eat primarily plant debris, while others devour mainly animal remains. In practice, it is difficult to distinguish precisely who eats what, and few species rely entirely on one type of food; for this reason, all scavenging species have been classified as saprophagous in this book.

FUNGIVOROUS SPECIES

Fungivorous species are those that are adapted to feeding on fungi (the fruiting body and the hidden hyphae). Typical examples are springtails and the larvae of many beetles and flies, which can be found inside the tissue of fungal fruiting bodies. Leaf-cutter ants and some species of termite cultivate fungal cultures for food.

Hematophagous Species

Ticks, fleas, many flies, and certain bugs need the blood of vertebrates to survive or bring their eggs to maturity. Some insects take only mammalian blood, whereas others feed on different hosts, such as birds or reptiles. Irritation from insect bites leads to scratching and sometimes to serious infections, even death. However, the main danger from bites lies in the transmission of various human and animal diseases caused by microorganisms and protozoa. Malaria, yellow fever, and river blindness affect many millions of people in tropical regions; in temperate regions, ticks are significant disease vectors.

Parasitoids and Parasites

Parasitoids are specialized predators that live in or on the body of a host animal. In its lifetime, a parasitoid colonizes only one host, which it eventually kills. Some parasitoids feed internally (endoparasitoid), while others feed externally on the host's body (ectoparasitoid). Examples of this feeding strategy are found in parasitic wasps and some flies. For the purposes of this book, the same symbol is also given to parasites, such as fleas and lice, which feed on another animal's blood, skin, or hair but do not kill their host.

Infested Tree Hopper
This tree hopper (Membracidae, see p.98) has been infested with red parasitic mites. The mites feed on the bugs' hemolymph by penetrating the cuticle with their mouthparts, especially at joints and where the cuticle is thin.

Xylophagous Species

Wood-eating species make use of an abundant resource, but it is of poor nutritional value, so many xylophages tend to be slow-growing. Some attack living or recently dead wood, while others can eat decaying wood only. Many have internal symbiotic microorganisms to help them digest the cellulose; they may augment their diet by eating fungal hyphae and other material.

Deathwatch Beetle
This pest lays its eggs in crevices on wood. The larvae burrow through the timber, and may take a few years to reach maturity.

Coprophagous Species

Some species live on the droppings of other animals. Scarab beetles eat only dung, and in Africa, where there are numerous grazing mammals, there are thousands of species of dung beetle all using the droppings of various animals in different ways to rear their young. The larvae of many flies also breed in dung.

Melliphagous Species

With the exception of wind-pollinated grasses, most flowering plants are dependent on insects for pollination. In order to attract the right species, plants offer rewards of sugar-rich nectar and protein-rich pollen. While the insects supply their larval cells with these foods, the flowers are, in turn, pollinated.

Pseudoplacental Species

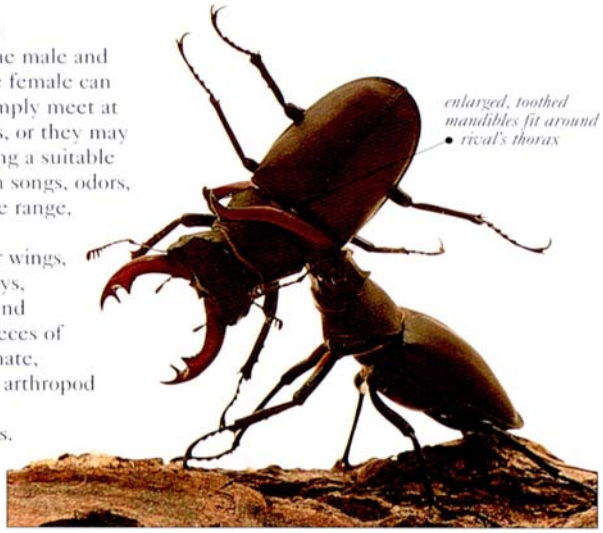
In some flies, such as the Tsetse Fly (see p.147), the larvae do not feed independently of the mother. The egg hatches and the larva is kept inside a brood chamber, where it feeds on secretions. When the larva is ready to be released, it may fill the whole of its mother's abdomen, and will usually pupate immediately.

Arthropod Behavior

THE BRAINS OF ARTHROPODS are relatively small. An adult locust, for example, has approximately one million nerve cells to serve all its sensory and motor needs. Smaller insects have far fewer nerve cells. Nevertheless, insects are capable of surprisingly sophisticated behavior, which is evident in the way that they move, avoid predators, feed, mate, and care for their offspring.

Courtship and Mating

In most species of arthropod, the male and female need to mate before the female can lay her eggs. The sexes may simply meet at good feeding or egg-laying sites, or they may take a more active part in finding a suitable mate, attracting each other with songs, odors, and even light displays. At close range, courtship can be a complicated process. Insects may move their wings, legs, and antennae in certain ways, secrete pheromones, and give and receive nuptial gifts (usually pieces of food). Not all species have to mate, however. The females of many arthropod species are able to lay viable eggs without the need for males.



△ Fighting Stag Beetles
Female arthropods are often highly selective, which leads to competition and rivalry between males. Here, male stag beetles fight for access to females. The winner may throw the opponent on to its back, and then mate with the female.

△ Light Attraction
In some beetles, such as the Glowworm, Lampyris noctiluca *(above), females attract males of the same species by emitting flashes of light. In a few cases, females lure males of other species to eat them.*

▷ Getting Together
In many arthropods, sperm is transferred to the female indirectly. However, in insects (here, soldier beetles), copulation always takes place.

CARE OF THE YOUNG

Parental care of eggs and young is common in some centipedes, arachnids, and insects. Some female spiders wrap their eggs in silk and carry them around, or stay close by until they hatch. Scorpions and some other arachnids brood their eggs and carry recently emerged young on their backs. Among insects, it is usually the female who takes responsibility for "child-care," but the males may also play a part in some families.

STANDING GUARD

Several species of bugs guard their young nymphs, and even guide them to good feeding sites. Here, a female parent bug watches over her brood resting on a birch leaf.

METHODS OF SELF-DEFENSE

An arthropod's first line of defense is its cuticle, which may be very tough or leathery. Sharp, cuticular spines and protrusions, such as warts and bumps, or the ability to roll up into a ball, may further increase the protection that the exoskeleton provides. Mandibles and limbs are effective when used to strike out at enemies – the kick from a locust's hind leg can draw blood in most predators.

Physical defenses are enhanced by producing unpleasant sounds, or repellent chemicals or odors. Many bugs, for instance, produce strong-smelling compounds from thoracic or abdominal stink glands. Sap-sucking bugs, such as aphids, often surround themselves with "bodyguards" in the form of ants: the ants are attracted to the sugar-rich honeydew (excrement) that the bugs produce, and in turn help protect the aphids from predators. Some arthropods are brightly colored, which may serve to warn predators of their toxicity; sometimes eyespots and other bright patches are flashed at predators in order to startle them.

△ POISONOUS PRICKLES

Toxic chemicals may be made inside the body or obtained from a poisonous food plant. These chemicals are often stored in outer parts of the body.

△ WARNING COLORS

Bright, contrasting warning colors advertise the presence of chemical defenses. Some species "cheat," and are not actually poisonous at all.

◁ CAMOUFLAGE

Many insects have evolved to blend into their surroundings, or to mimic dead leaves, sticks, thorns, bird droppings, stones, or even other, more dangerous, species.

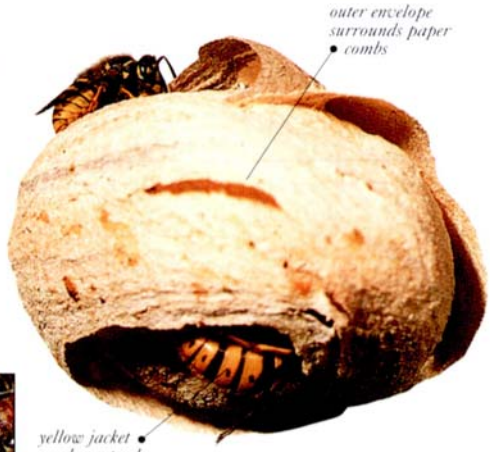
Social Insects

MOST ARTHROPODS lead solitary lives, coming together only for mating. Some might be considered gregarious, grouping together for safety or sharing a food source. However, truly "social" species (all termites and ants, some wasps and bees) are characterized by cooperation within a colony to rear young, coupled with a division of labor, and an overlap of generations.

Social Wasps and Bees

In these highly social insects, the reproductive females, or queens, found and head the colonies. The queens lay eggs, then rear a few workers (sterile females) themselves. Thereafter, the queen leaves nest-building, colony defense, and feeding and tending the young to the growing number of workers. Mated queens can determine the sex of their offspring by withholding sperm if a male is preferred (males are produced from unfertilized eggs, females from fertilized ones).

◁ HONEYCOMB
The honey bee's nest consists of vertical wax combs divided into hexagonal cells, in which young are reared and honey is stored.



△ WASPS' NEST
Yellow jackets and hornets make exposed or underground nests of paper made from chewed wood fibers. The horizontal cells contain the developing larvae.

Migrating Insects

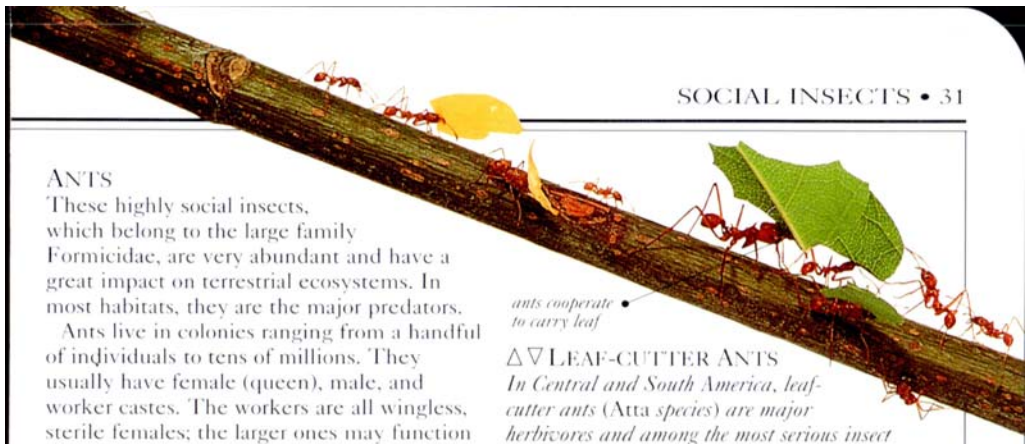
Some arthropods undertake regular migrations from one place to another to find food or egg-laying sites. Army ants (see p.184) and swarming species, such as the migratory locust *Locusta migratoria* (Acrididae, see p.64), are good examples of migratory insects. The longest insect migration is that of the Painted Lady butterfly, *Cynthia cardui* (Nymphalidae, see p.174), which can travel approximately 4,000 miles (6,440km) from North Africa to Iceland. Some spiders can be blown for hundreds of miles in wind currents.

LONG-DISTANCE TRAVELERS
The Monarch butterfly (Danaus plexippus), *a notable migrant, travels from winter roosts in Mexico to North America and Canada.*

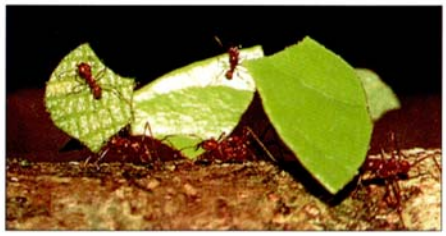
ANTS

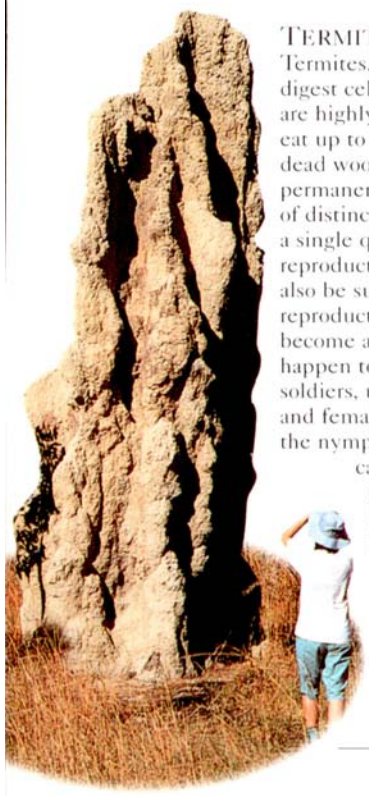
These highly social insects, which belong to the large family Formicidae, are very abundant and have a great impact on terrestrial ecosystems. In most habitats, they are the major predators.

Ants live in colonies ranging from a handful of individuals to tens of millions. They usually have female (queen), male, and worker castes. The workers are all wingless, sterile females; the larger ones may function as soldiers to defend the colony. Reproduction usually occurs between winged males and females. After mating, the males usually die and the females lose their wings. The caste is mainly determined by the food that the larvae are fed by the workers: a diet low in protein will lead to the production of another worker, whereas a diet high in protein will produce a queen. The soldier's head and jaws are often modified according to the caste and species, and may be specialized for crushing seeds or dismembering enemies.



△▽ LEAF-CUTTER ANTS
In Central and South America, leaf-cutter ants (Atta *species*) *are major herbivores and among the most serious insect pests. Their subterranean nests can be more than 15ft (5m) deep and include millions of workers.*

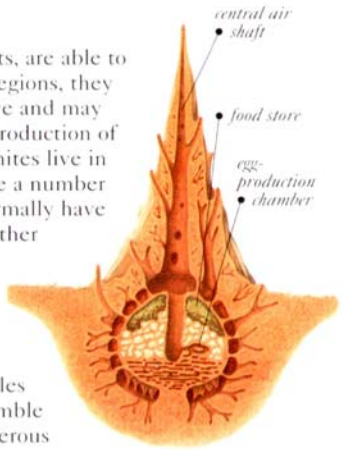




TERMITES

Termites, unlike many other insects, are able to digest cellulose. In some tropical regions, they are highly abundant and destructive and may eat up to one-third of the annual production of dead wood, leaves, and grass. Termites live in permanent social colonies and have a number of distinct castes. The colonies normally have a single queen, a king, and a few other reproductive males. There may also be supplementary reproductives, which will become active if anything should happen to the queen. Termite soldiers, unlike ants, are sterile males and females. Worker termites resemble the nymphs and are the most numerous caste. The role of the worker termites is to build and repair the nest, forage for food, and feed the young nymphs.

TERMITE NEST
Depending on the species, a termite colony can range from a tiny nest to a vast structure both below and above ground.



INSIDE THE NEST
The internal structure of many of the larger termite nests allows air to circulate so that the temperature inside the nest can be regulated to within 2°F (1°C). Stale, carbon-dioxide-rich air is vented to the outside.

HABITATS

INSECTS AND OTHER terrestrial arthropods are found all over the globe, from snow-covered mountains to hot desert valleys, but they are not evenly distributed. Apart from some species of mites and midges in the Antarctic and some blood-sucking insects, such as mosquitoes, in the Arctic, there are very few arthropods near the poles. The closer to the equator you go, the greater the number of arthropods, both in species variety and abundance.

SURVIVAL STRATEGIES

The survival and persistence of most arthropod species has much to do with their relatively small size, protective cuticle, and ability to reproduce quickly (see p.14), but many also have special strategies for survival. When conditions are too hot and dry, many species remain dormant, while other species hibernate where winters are cold. Several insects, notably some species of ants, are able to function in extremely high temperatures, in excess of 149°F (65°C). At the other end of the scale, some species are able to withstand excessively cold conditions, surviving temperatures as low as -40°F (-40°C).

CONSERVATION

Mammals and birds used to be the only animals considered worthy of conservation, but a growing awareness of the vital role that insects play in global ecosystems is changing this view. Some rare insects are now protected by international law, and many countries are beginning to implement legislation. First and foremost, we must protect their habitats from destruction – then we must educate and limit collectors.

MOUNTAINS

Species that live in mountains are adapted to cold, wet, and windy conditions. Plant life becomes sparser with increasing altitude; as a result, there are fewer species of arthropod.

COMMON STONEFLY

TROPICAL FORESTS

These lush, moist habitats cover a tiny part of the total land area of the globe (about six percent), yet they are estimated to hold approximately 50 percent of all the world's arthropod species.

PRIAM'S BIRDWING

TEMPERATE WOODLAND

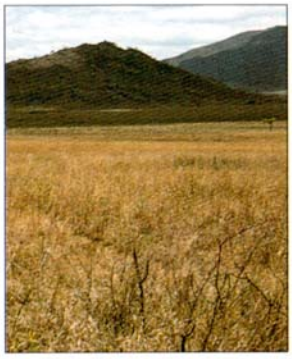
Although less lush than tropical forest, temperate woodland has a rich and varied fauna. Fertile soil, broad-leaved trees, deep leaf litter, and decaying wood all provide ideal conditions for arthropods.

FUNNEL WEAVER

TEMPERATE GRASSLAND

Numerous insect species live in temperate grassland. If heavily used for grazing or cultivation, insect diversity declines.

PLANT BUG



SAVANNA

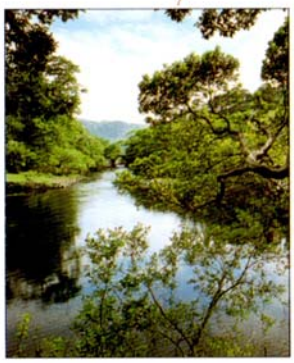
The canopies of scattered trees in tropical grassland harbor a rich, diverse arthropod fauna, particularly termites and ants. Overgrazing is endangering many species.

BRACONID WASP

CAVES AND DESERTS

Cave-dwelling species adapt to survive in total darkness and high humidity. Many are blind and wingless. Desert-dwellers adapt to temperature extremes and arid conditions.

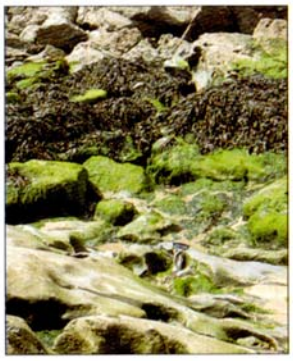
BOTHRIURID SCORPION



FRESHWATER

Freshwater habitats have a unique arthropod fauna. Only about 5 percent of insect species are aquatic for part of their life cycle, yet their abundance means they contribute greatly to aquatic food chains.

WATER BOATMAN



SEASHORES

There are many opportunities for insects among the rocks, sand plants, and decaying seaweed along coasts. Beetles and flies are very abundant. A few insects are even adapted for going underwater occasionally.

PILL WOODLOUSE

TOWNS AND GARDENS

Many arthropods thrive in towns. Some species have taken up residence inside buildings or are associated with garbage. The garden can be a refuge and home to numerous arthropod species.

BUMBLE-BEE

STUDYING INSECTS

YOU CAN LEARN a lot about insects from reference books, but if you really want to understand their world then you have to experience them at first hand. There is no substitute for patient observation: if you want to know exactly how a spider spins its web, it is best simply to sit and watch. Insects are endlessly fascinating, so take the time to observe their busy lives.

WHAT YOU WILL NEED

It is not necessary to invest in expensive equipment to study insects. Various sorts of collecting net are easy to make (see facing page). Below are a few other items that you will need, or are simply useful:

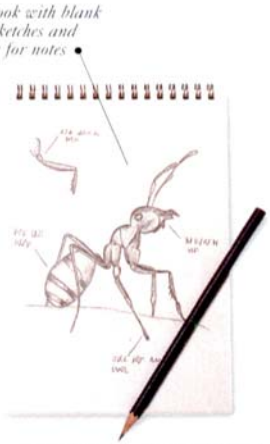
- Hand lens (x 10 magnification) and low-power lens, for viewing at close range.
- Camera, sketch book, and notebook, to record your observations.
- Measuring tape and a stopwatch, for determining running or flying speeds.
- Sieve, for sifting leaf litter.
- Pooter (see facing page), also known as an aspirator, essential for collecting small insects without harming them.
- Pond net, a pair of waterproof boots, and plastic containers for viewing aquatic species.

IDENTIFYING INSECTS

Identifying an insect to the level of order is fairly straightforward with a little practice. However, to identify the species is considerably more difficult. While some insects are very distinctive, many bear an extremely close resemblance to other species, and are distinguishable only by minute characteristics that can be observed using a hand lens.

PHOTOGRAPHY

A single lens reflex camera (SLR) with a 50mm or 100mm macro lens is ideal. Most zoom lenses with a macro setting are not good enough for photographing small insects. You may also need flash to maximize the depth of field.



SKETCHING INSECTS

Drawing is an excellent way to record what you see, and you will also learn a great deal from close observation. Remember to record details in the book of when and where you found the insect.

How to Collect Insects

Since most insects are mobile, collecting them involves intercepting them with hand nets, sweep nets, pond nets, or pooters as they fly, swim, or crawl. Trapping insects by attracting them to some kind of bait is also a good technique. In tropical regions, rotting fruit will attract many insects including butterflies, and animal dung will draw hundreds of beetles. Wherever you are, a piece of rotting fish in a plastic bottle will collect flies and some parasitic wasps.

If you want to discover how abundant a species is in a specific area compared to another site, it is important to carry out identical tests in each area for an accurate comparison. For example, make sure you cover the same surface area, use the same number of pitfall traps, or sieve the same volume of leaf litter. Remember to wash your hands after field work.

Using a Pooter

With a pooter, you can collect small insects from a beating tray by sucking them up a tube and into a container.

Beating Tray

A white tray or cloth placed under a tree is a good way to catch insects; shake the branch to dislodge leaf-inhabiting species.

Butterfly Net

These nets should be made of fine mesh and may be used to catch any flying insects. This one has an extendible handle.

Pitfall Trap

To catch ground-running insects and other arthropods, sink a plastic cup into the ground with its top flush with the surface.

Attracting Insects to Your Garden

A garden with overgrown patches will attract considerably more forms of wildlife than one that is highly manicured. Variety is another important feature of a good wildlife garden: a wide range of habitats and microhabitats will attract a diverse fauna of insects and other animals. Never use pesticides in the garden.

When tidying the garden, try not to clear too much away that could be appealing to insects. Leave wood to decay naturally, and make a compost heap with vegetable waste from your kitchen and garden. A huge number of species live in decaying plant matter, and your garden will benefit from the compost you produce. Nectar-rich flowers such as lavender attract butterflies, moths, hover flies, and bees.

Create a Wildlife Area

A pond surrounded by plants is ideal for luring wildlife to the garden and provides a home and shelter for a great range of arthropods. Dig a pond as large as you can; aquatic insects will colonize it immediately.

IDENTIFICATION KEY

THIS KEY IS INTENDED to be a guide to the identification of specimens to the taxonomic level of order. First, answer the questions in keys 1 and 2. These will lead you to the catalogue of families and species that form the main part of the book – either directly or via the galleries of orders presented in keys 3–6. In most cases, close inspection with a hand lens will be necessary.

KEY 1: TERRESTRIAL ARTHROPODS

DOES IT HAVE LEGS?
In this key, "legs" means limbs that are used mainly for walking.

NO

It might be the larva or pupa of an insect. Or it might be a worm or some other type of invertebrate not covered in this book.

YES

HOW MANY PAIRS?
Look carefully. With small specimens you may need to use a hand lens.

3 PAIRS

HEXAPODS
Go to Key 2
(p.37)

4 PAIRS

ARACHNIDS
Go to Key 6
(pp.44–45)

7 PAIRS

WOODLICE
(Isopoda)
- *1/16–1/2in (0.5–1.5cm) long*
- *flat body*
- *7 main body segments (6 smaller terminal segments)*
- *many can roll into a ball*

See p.212

8 OR MORE PAIRS

PAUROPODS
(Pauropoda)
- *less than 1/16in (2mm) long*
- *blind*
- *soft body*

See p.238

SYMPHYLANS
(Symphyla)
- *1/32–1/16in (1–8mm) long*
- *blind*
- *soft body*

See p.239

MILLIPEDES
(Diplopoda)
- *1/16–12in (0.5–30cm) long*
- *2 pairs of legs on each leg-bearing segment (after the fourth segment)*

See p.242

CENTIPEDES
(Chilopoda)
- *1/16–10in (0.5–25cm) long*
- *1 pair of legs per leg-bearing segment*
- *first pair of legs modified as poison fangs*

See p.240

KEY 2: HEXAPODS

DOES IT HAVE WINGS?
Look carefully, the wings may be very small or hidden under wing cases.

YES → **WINGED INSECT**
Go to Key 4 (pp.40–43)

NO

NONINSECT HEXAPODS
These small, 6-legged arthropods are all relatively primitive. They are distinguished from insects by their mouthparts.

IMMATURE INSECT
It might not be an adult specimen. In many orders, the immature stages are like small adults but without wings or genitalia.

WINGLESS INSECT
It may be a wingless adult insect. Go to Key 3 (pp.38–39)

SPRINGTAILS (Collembola)
- *less than ⅛in (5mm) long*
- *often have a jumping organ (furcula) that can fold under the abdomen*
- *elongate or globular body shape*

See p.207

DIPLURANS (Diplura)
- *⅛–2in (0.5–5cm) long*
- *blind*
- *pair of tail- or forceplike appendages at end of abdomen*

See p.211

PROTURANS (Protura)
- *less than ⅛in (2mm) long*
- *blind*
- *pale*
- *soft body*
- *antennae very short or absent*
- *pointed head*

See p.210

KEY 3: WINGLESS INSECTS

Some insects are always wingless, notably fleas, lice, and the primitive silverfish and bristletails. However, many orders in which most insects have fully developed wings also contain species in which the wings are very short or absent. Winglessness is common in oceanic island and cave-dwelling species. Remember that a wingless specimen may be an immature winged insect.

ALWAYS WINGLESS

FLEAS
(Siphonaptera)

- *1/12–1/8in (1–8mm) long*
- *brown with body flattened from side to side*
- *often found on animals or in nests*
- *can jump well*

See p.135

PARASITIC LICE
(Phthiraptera)

- *1/12–1/4in (0.1–1cm) long*
- *flat body*
- *found on hair or feathers of host animals*
- *eyes small or absent*
- *legs modified to grip host*

See p.83

SILVERFISH
(Thysanura)

- *1/16–1/4in (0.2–2cm) long*
- *3 tail filaments*
- *abdominal segments with small ventral projections*
- *eyes small, not touching*
- *do not jump*

See p.47

BRISTLETAILS
(Archaeognatha)

- *1/12–1/4in (0.7–1.5cm) long*
- *3 tail filaments*
- *abdominal segments with small projections*
- *eyes touching*
- *humped body*
- *can jump*

See p.46

MAINLY WINGLESS

TERMITES
(Isoptera)

- *1/8–1/4in (0.3–2cm) long*
- *pale body*
- *found in colonies*

See p.78

Occasionally Wingless

BEES, WASPS, & ANTS (Hymenoptera)

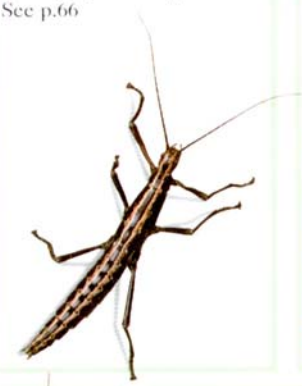
- *1/125–2½in (0.25–70mm) long*
- *often with constricted waist*
- *first abdominal segment fused to thorax*
- *many live in colonies*
- *often have sting*

See p.178

STICK INSECTS (Phasmatodea)

- *¼–12in (1–30cm) long*
- *sticklike body*
- *widely separated legs*

See p.66



BARKLICE & BOOKLICE (Psocoptera)

- *1/125–1/12in (1–9mm) long*
- *soft, squat body*
- *humped back when seen from front*
- *large head and bulbous forehead*
- *bulging or reduced eyes*

See p.81

BUGS (Hemiptera)

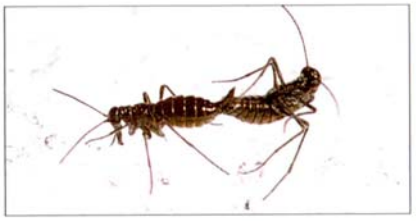
- *1/125–4in (0.1–10cm) long*
- *mouthparts form slender or short tube under head*
- *antennae have fewer than 10 segments*

See p.85

SCORPIONFLIES (Mecoptera)

- *⅛–1⅛in (0.3–3cm) long*
- *head elongated downward to form beak*

See p.133



THRIPS (Thysanoptera)

- *1/16–½in (0.5–12mm) long*
- *slender, elongate body*
- *large eyes*

See p.101

FLIES (Diptera)

- *1/16–2½in (0.5–60mm) long*
- *very small prothorax*
- *vestigial wings (halteres) often present*

See p.136

MOTHS (Lepidoptera)

- *body covered with scales*
- *proboscis usually coiled*

See p.158

KEY 4: WINGED INSECTS

The orders that appear here contain mainly winged insects although some of the groups do contain wingless species. Some beetles and bugs may not appear to have wings unless examined closely. The wings are sometimes very small or hidden. In addition to the more obvious details, such as the wing shape and color, the way in which they are held also aids identification.

COMMON IN ALL HABITATS

BUTTERFLIES AND MOTHS
(Lepidoptera)
- *wingspan ⅛–12in (0.3–30cm)*
- *body and wings covered with scales*
- *proboscis often coiled*
- *long, threadlike antennae*

See p.158

FLIES
(Diptera)
- *¼₀–2½in (0.5–60mm) long*
- *only 1 pair of wings (hindwings modified as halteres; sometimes hard to see)*
- *very small prothorax*

See p.136

NOTE
Look carefully: the forewings and hindwings might be joined by tiny hooks or hairs. If so, the specimen belongs to the Hymenoptera (see p.178).

BEETLES
(Coleoptera)
- *up to 7in (18cm) long*
- *forewings toughened to form elytra (wing cases)*
- *elytra may be short, leaving part of abdomen exposed*

See p.109

BEES, WASPS, & ANTS
(Hymenoptera)
- *⅛₀–2⅜in (0.25–70mm) long*
- *often with constricted waist*
- *forewings wider or longer than hindwings*
- *wings joined in flight by tiny hooks*
- *many live in colonies*

See p.178

BUGS
(Hemiptera)
- *½₀–4in (0.1–10cm) long*
- *mouthparts form a slender or short tube under the head*
- *front wings longer than hindwings*
- *stink glands may be present*

See p.85

NOTE
Look carefully: The mouthparts can be hard to see in some species.

MAINLY FOUND AROUND FRESHWATER

MAYFLIES
(Ephemeroptera)

- *1/16–1½in (0.5–4cm) long*
- *forewings large, triangular, and held upright*
- *abdomen with 2 or 3 filaments (tails)*

See p.48

DAMSELFLIES & DRAGONFLIES
(Odonata)

- *1½–6in (4–15cm) long*
- *long, cylindrical abdomen*
- *large eyes*
- *wings of equal size*
- *thoracic segments slope backward*

See p.51

CADDISFLIES
(Trichoptera)

- *1/16–1½in (0.2–4cm) long*
- *slender, mothlike body, covered with hairs*
- *long, threadlike antennae*

See p.156

STONEFLIES
(Plecoptera)

- *⅛–2in (0.3–5cm) long*
- *wings folded along body*
- *conspicuous cerci*
- *bulging eyes*
- *rectangular body*

See p.56

ALDERFLIES & DOBSONFLIES
(Megaloptera)

- *⅛–6in (1–15cm) long*
- *wings held together rooflike over body at rest*
- *long wings of similar size*
- *soft abdomen*

See p.103

THIS KEY IS CONTINUED OVER THE PAGE

KEY 4: WINGED INSECTS Continued

OTHER WINGED INSECTS

TERMITES
(Isoptera)
- *⅛–¾in (0.3–2cm) long*
- *wings with longitudinal veins and weak cross-veins*
- *only reproductives have wings, and these are shed after short nuptial flight*
- *very small cerci*
- *found in colonies*

See p.78

SNAKEFLIES
(Raphidioptera)
- *¼–1¼in (0.6–3cm) long*
- *wings held together rooflike over body at rest*
- *elongated cephalothorax*

See p.104

LACEWINGS & ALLIES
(Neuroptera)
- *⅛–3½in (0.2–9cm) long*
- *wings held together rooflike over body at rest*
- *netlike wing venation, with many cross-veins*

See p.105

BARKLICE & BOOKLICE
(Psocoptera)
- *⅛–⅜in (1–9mm) long*
- *soft, squat body*
- *humped back when seen from front*
- *large head and bulbous forehead*
- *bulging or reduced eyes*

See p.81

GRASSHOPPERS & CRICKETS
(Orthoptera)
- *⅛–6in (0.5–15cm) long*
- *tough, leathery forewings*
- *hindlegs often large*
- *pronotum extended down at sides*
- *often produce sounds with wings or legs*

See p.60

COCKROACHES
(Blattodea)
- *⅛–4in (0.3–10cm) long*
- *flat, oval body*
- *shieldlike pronotum, often covering head*
- *toughened forewings*
- *membranous hindwings*

See p.74

STICK INSECTS
(Phasmatodea)
- *⅛–12in (1–30cm) long*
- *stick- or leaflike body*
- *widely separated legs*

See p.66

MANTIDS
(Mantodea)
- *⅛–6in (0.8–15cm) long*
- *front legs distinctively modified for catching prey*
- *elongate prothorax*
- *toughened forewings*
- *large, membranous hindwings*

See p.71

EARWIGS
(Dermaptera)
- *⅛–2in (0.5–5cm) long*
- *forceps at end of abdomen*
- *flat, elongate body*
- *short, tough forewings*
- *hindwings folded at rest*
- *telescopic and mobile abdomen*

See p.69

SCORPIONFLIES
(Mecoptera)
- *⅛–1⅛in (0.3–2.8cm) long*
- *head elongated downward as a beak*
- *wings of similar size*

See p.133

KEY 5: MINOR ORDERS

Some insects are very small and are unlikely to be encountered in the field. The females of certain species spend their entire lives hidden inside the body of a host insect.

WEB-SPINNERS
(Embioptera)
- *⅛–¾in (0.3–2cm) long*
- *swollen first tarsal segment of front legs*
- *live gregariously in silk tunnels*

See p.77

STREPSIPTERANS
(Strepsiptera)
- *up to 1½in (3.5cm) long*
- *females are wingless and live inside other insects*
- *males have fan-shaped hindwings and blackberry-like eyes*

See p.132

FEMALE

MALE

ANGEL INSECTS
(Zoraptera)
- *less than ⅛in (5mm) long*
- *termitelike*
- *may be winged or wingless*

See p.80

ROCK CRAWLERS
(Grylloblattodea)
- *½–1⅛in (1.2–3cm) long*
- *found in cold regions of western North America and eastern Asia*

See p.59

KEY 6: ARACHNIDS

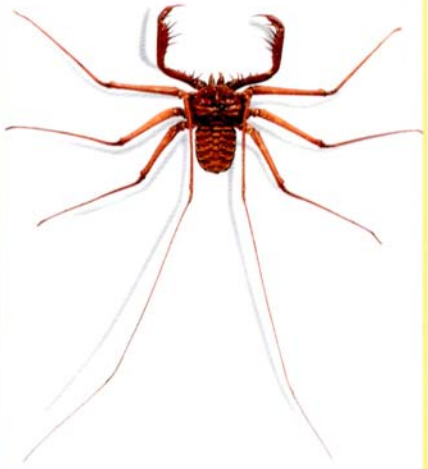
Arachnids are wingless arthropods with four pairs of legs. Despite the fact that the group as a whole is very diverse in appearance, the major groups are easily recognized. Spiders are the most familiar arachnids. All spiders have silk-spinning organs, and some can be identified by the type of web they produce. Scorpions have distinctive claws on the end of their powerful pedipalps, and mobile abdominal "tails" with a sting. Pseudoscorpions, although quite similar to

SPIDERS
(Araneae)
- *up to 3½in (9cm) long*
- *relatively short pedipalps*
- *first pair of legs similar in size to other pairs*
- *nonsegmented abdomen carries silk-spinning organ*

See p.228

WHIP-SPIDERS
(Amblypygi)
- *up to 1¾in (4.5cm) long*
- *squat body with broad cephalothorax*
- *large, spiny pedipalps*
- *first pair of legs very long*

See p.220



SUN-SPIDERS
(Solfugida)
- *up to 2¾in (7cm) long*
- *leglike pedipalps*
- *large, forward-facing chelicerae*

See p.217

HARVESTMEN
(Opiliones)
- *up to 6in (15cm) long*
- *pedipalps have 6 segments*
- *legs usually long and slender*
- *segmented abdomen (sometimes hard to see)*

See p.221

scorpions, are much smaller and lack the "tail." Whip-scorpions have a distinctive whiplike "tail," and in whip-spiders the first pair of legs is very long and whiplike. Ticks and mites are distinctively rounded. Because of the dangerous nature of certain species, avoid handling an arachnid unless you are sure that it is a harmless specimen. In fact, the vast majority of arachnids are harmless. Scorpions and other arachnids will bite or sting human beings only in self-defense.

SCORPIONS
(Scorpiones)
- *up to 7in (18cm) long*
- *flat body*
- *large pedipalps with pincers*
- *abdomen has long, jointed "tail" with a sting*

See p.213

WHIP-SCORPIONS
(Uropygi)
- *up to 3in (7.5cm) long*
- *powerful pedipalps*
- *abdomen has whiplike tail*

See p.219

TICKS & MITES
(Acari)
- *up to 1¼in (3cm) long*
- *body has no distinct divisions*
- *legs usually short*
- *nonsegmented abdomen*

See p.223

PSEUDOSCORPIONS
(Pseudoscorpiones)
- *up to ½in (1.2cm) long*
- *flat body*
- *pedipalps like small scorpion claws*
- *oval abdomen with 11 or 12 segments*

See p.215

INSECTS

BRISTLETAILS

THE ORDER ARCHAEOGNATHA contains 2 families and 350 species. These primitive, wingless insects look hump-backed when seen from the side. They have simple mouthparts, three ocelli, and large (compound) eyes that touch each other on top of the head. At the end of the abdomen are three long tails, the middle one being the longest. On the underside of the abdomen there are small projections, called styles, which help bristletails move over steep surfaces more easily.

Bristletails are ametabolous: they continue molting throughout their lives. Males deposit a sperm packet that is picked up by the female's genitalia. Small batches of eggs are laid in cracks and crevices, and the young may take up to two years to reach sexual maturity.

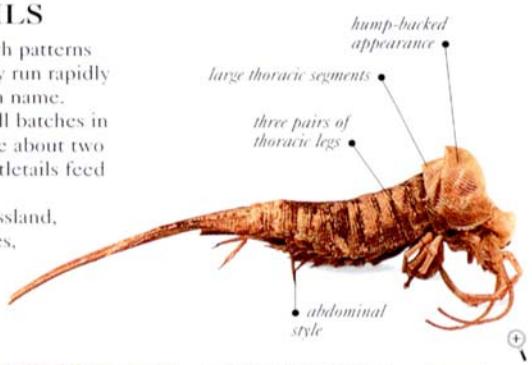
Order ARCHAEOGNATHA	Family MACHILIDAE	No. of species 250

JUMPING BRISTLETAILS

These elongate insects are covered with patterns of drab brown or dark gray scales. Many run rapidly and can also jump – hence the common name.

• **LIFE CYCLE** Eggs are laid in small batches in cracks and crevices, and the young take about two years to reach adulthood. Jumping bristletails feed on lichen, algae, and plant debris.

• **OCCURRENCE** Worldwide. In grassland, in wooded or coastal areas, under stones, and in leaf litter and decaying vegetable matter.



△ *PETROBIUS* SPECIES are found in coastal areas, mainly above the high-tide mark.

PETROBIUS MARITIMUS is a drably colored bristletail that is common along rocky shorelines in the Northern Hemisphere. When disturbed, it jumps a little way in the air by flicking its abdomen against the rock.

Length Up to ½in (1.2cm)	Nymphal feeding habits

SILVERFISH

THE 4 FAMILIES AND 370 SPECIES of silverfish that make up the order Thysanura are primitive, wingless insects with elongate, flat bodies that may have scales on the surface. They have simple mouthparts and may have small, widely separated compound eyes or no eyes at all. Most species have no ocelli. The three abdominal tails are of equal length and, as in bristletails (see opposite page), the abdominal segments have projections called styles. Silverfish vary in appearance more than bristletails and occupy a wider range of habitats.

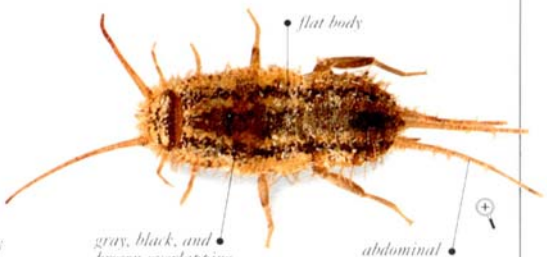
Males deposit sperm on silken threads, placed on the ground for females to pick up with their genitalia. Eggs are laid in cracks and crevices. Like bristletails, silverfish nymphs are ametabolous and develop without obvious metamorphosis.

Order THYSANURA	Family LEPISMATIDAE	No. of species 190

LEPISMATIDS

The brownish bodies of these insects are tapered, slightly flat, and usually covered with either grayish or silvery scales. They have compound eyes but no ocelli. All lepismatids are nocturnal. Some species favor cool, damp conditions, while others prefer warm, dry places.

- **LIFE CYCLE** The females lay their eggs in cracks and crevices.
- **OCCURRENCE** Worldwide, especially in warmer regions. In tree canopies, under stones, and in caves; some inhabit houses or the nests of birds, ants, or termites.
- **REMARK** Domestic species eat flour, damp textiles, book bindings, and wallpaper paste.



△ **LEPISMATIDS** in general (this specimen is an unidentified species) have brownish, scaly bodies. They reach sexual maturity after ten to twelve molts and may live for several years.

THERMOBIA DOMESTICA, or the Firebrat, is found all over the world. This species prefers warm habitats, such as areas in buildings near ovens and hot pipes. The antennae are as long as the body, and the longer hairs on the back of its body are arranged in groups on the rear margins of the body segments.

Length 1/16–1/4in (0.8–2cm)	Nymphal feeding habits

MAYFLIES

THE 23 FAMILIES and 2,500 species of the order Ephemeroptera – the mayflies – are the oldest, most primitive winged insects. They are also the only insects that molt after they have developed functional wings. Despite their common name, not all mayflies are common in May, and many species can be found at other times of the year.

Mayflies have soft bodies, long legs, and typically two pairs of wings. The forewings are large and triangular; the hindwings are small or may be absent altogether. Mayflies cannot fold their wings back along their body but instead hold them upward or downward. Adults do not feed and live for a very short time – some species survive for just one day. Mating occurs in swarms at dawn or dusk, and females drop their eggs into water. Metamorphosis is incomplete. The aquatic nymphs, which usually have lateral abdominal gills and three terminal tails, eat a wide range of submerged plant and animal matter. When fully grown, they rise to the surface and molt into a form with dull-colored wings, which is known as the sub-imago stage. They then leave the water. After a period of between one hour and several days, the final molt reveals the shiny-winged adult.

Order EPHEMEROPTERA	Family BAETIDAE	No. of species 900

SMALL MAYFLIES

These mayflies may be pale or dark brown or black with yellowish or gray markings. The forewings are elongate and rounded, and in some species the hindwings are either small or absent altogether.

• **LIFE CYCLE** Eggs are dropped into water. The nymphs are either streamlined and swim well or slightly flat and crawl. They feed by scraping algae from surfaces.

• **OCCURRENCE** Worldwide. In streams, rivers, ponds, and lakes.

• **REMARK** Small mayflies can be found in higher, colder places than members of other mayfly families.

NYMPHS are small and streamlined in shape.

△ *BAETIS RHODANI* is usually found in fast-flowing streams. The specimen shown here is the sub-imago stage, which has dull wings.

CLOEON DIPTERUM is a European species that breeds in a wide range of aquatic habitats, from ponds and ditches to water troughs and butts.

Length 1/8–5/8in (0.3–1.4cm), most 3/32–5/16in (0.4–0.8cm)	Nymphal feeding habits

Order EPHEMEROPTERA	Family EPHEMERELLIDAE	No. of species 170

CRAWLING MAYFLIES

These medium-sized mayflies have three abdominal tails and drab or dark coloration.

• **LIFE CYCLE** Many females release all their eggs in one clump, which separates out on the water's surface. The majority of nymphs feed on decaying organic matter.

• **OCCURRENCE** Worldwide, but rare in Southern Hemisphere. In rivers, streams, ponds, and lakes, among debris, weeds, and silt.

• **REMARK** Crawling mayflies are used as models for the artificial "flies" used in trout fly-fishing.

NYMPHS often have flat bodies.

***EPHEMERELLA* SPECIES** are common in and around fast-flowing rivers and streams. A newly emerged adult specimen is shown here.

Length ¼–⅝in (0.6–1.4cm)	Nymphal feeding habits

Order EPHEMEROPTERA	Family EPHEMERIDAE	No. of species 150

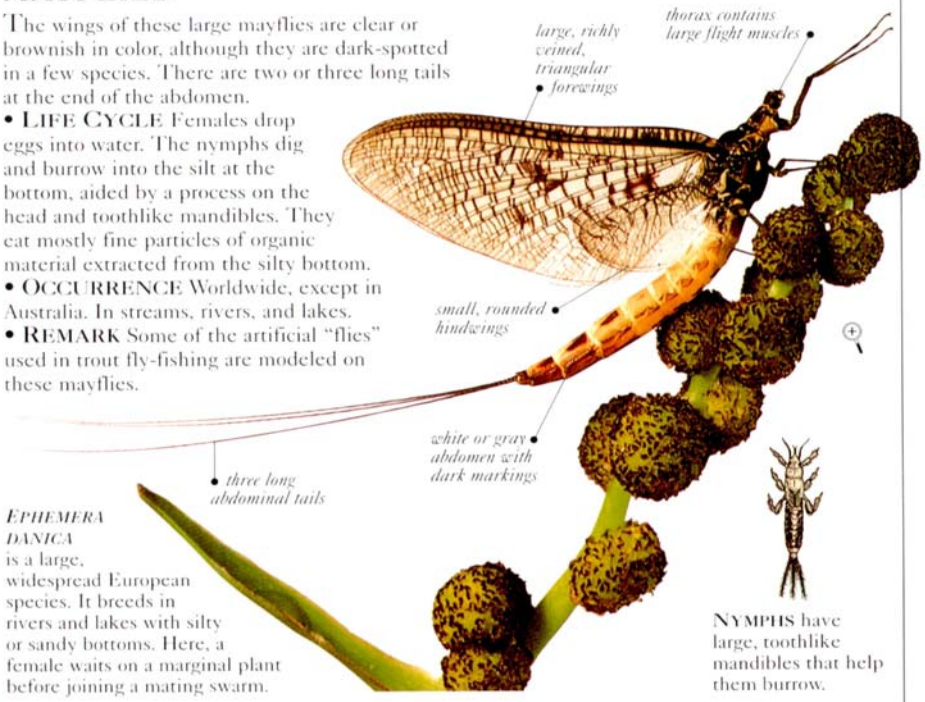
COMMON BURROWING MAYFLIES

The wings of these large mayflies are clear or brownish in color, although they are dark-spotted in a few species. There are two or three long tails at the end of the abdomen.

• **LIFE CYCLE** Females drop eggs into water. The nymphs dig and burrow into the silt at the bottom, aided by a process on the head and toothlike mandibles. They eat mostly fine particles of organic material extracted from the silty bottom.

• **OCCURRENCE** Worldwide, except in Australia. In streams, rivers, and lakes.

• **REMARK** Some of the artificial "flies" used in trout fly-fishing are modeled on these mayflies.



EPHEMERA DANICA is a large, widespread European species. It breeds in rivers and lakes with silty or sandy bottoms. Here, a female waits on a marginal plant before joining a mating swarm.

NYMPHS have large, toothlike mandibles that help them burrow.

Length ⅛–1¼in (1–3.4cm)	Nymphal feeding habits

Order EPHEMEROPTERA	Family HEPTAGENIIDAE	No. of species 500

STREAM MAYFLIES

These flat-headed mayflies are usually dark brown with clear wings and two long abdominal tails.

• **LIFE CYCLE** Eggs are laid in water. The nymphs are typically active and live under stones and vegetation or in debris. Some are poor swimmers and cling tightly to rocks and stones on the bottom of the habitat. Most scrape algae or eat fine particles of organic matter.

• **OCCURRENCE** Worldwide, except Australia and New Zealand; rare in South America. In and around ponds, lakes, and fast-flowing streams.

NYMPHS are flat and dark. They are highly mobile swimmers.

ECDYONURUS DISPAR is a common European mayfly. It prefers lake shores and stony-bottomed rivers. The dull-winged sub-imago stage is seen here.

Length 5/32–3/8in (0.4–1.5cm), most 1/8in (1cm)	Nymphal feeding habits

Order EPHEMEROPTERA	Family LEPTOPHLEBIIDAE	No. of species 600

PRONGILL MAYFLIES

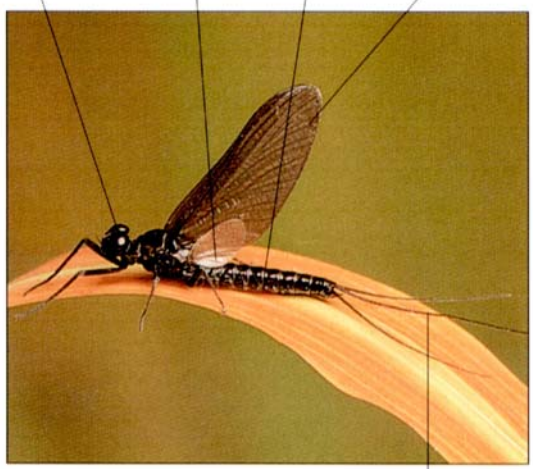
Most of these drab mayflies have dark, longitudinal veins on the wings. The males' eyes are divided into an upward-facing region with large facets and a downward-facing region with smaller facets. The abdomen carries three long tails.

• **LIFE CYCLE** Eggs are laid in water. The crawling nymphs may have a flat shape and live under stones and in debris. Most scrape algae or eat fine particles of organic debris; a few eat fish eggs.

• **OCCURRENCE** Worldwide. In streams and rivers; by the edges of ponds and lakes.

• **REMARK** The adults are used as models for artificial "flies" in trout fly-fishing.

NYMPHS look grasshopper-like from the side. The abdomen has forked gills.



LEPTOPHLEBIA VESPERTINA is widespread in Europe, near lakes and small streams. Here, a sub-imago mayfly rests on vegetation before molting into a shiny-winged adult.

Length 1/32–5/8in (0.4–1.4cm), most 1/16–1/8in (0.8–1cm)	Nymphal feeding habits

DAMSELFLIES AND DRAGONFLIES

THE 5,500 SPECIES and 30 families in the order Odonata are better known as damselflies and dragonflies. The damselflies are represented here by a selection of families, from the Calopterygidae to the Pseudostigmatidae. A selection of dragonflies follows, from the Aeshnidae to the Libellulidae.

The head of these insects has biting mouthparts, short antennae, and very large compound eyes. In damselflies, the head is broad, with widely spaced eyes, whereas dragonflies have rounded heads and eyes that are not widely separated. Both pairs of wings are more or less the same in damselflies, whereas the hindwings of dragonflies are broader than the forewings. At rest, damselflies fold their wings; dragonflies tend to hold them outstretched. Damselflies usually sit and wait for suitable prey, whereas dragonflies hunt prey in the air.

Males of both groups can curl their abdomen to transfer sperm from a genital opening on the ninth abdominal segment to a storage organ in the second or third. When mating, males may remove sperm from past matings. Eggs are laid in water and on aquatic plants. Metamorphosis is incomplete. The aquatic nymphs are predacious and have a hinged labium that can be shot forward to seize prey.

Order ODONATA	Family CALOPTERYGIDAE	No. of species 150

BROAD-WINGED DAMSELFLIES

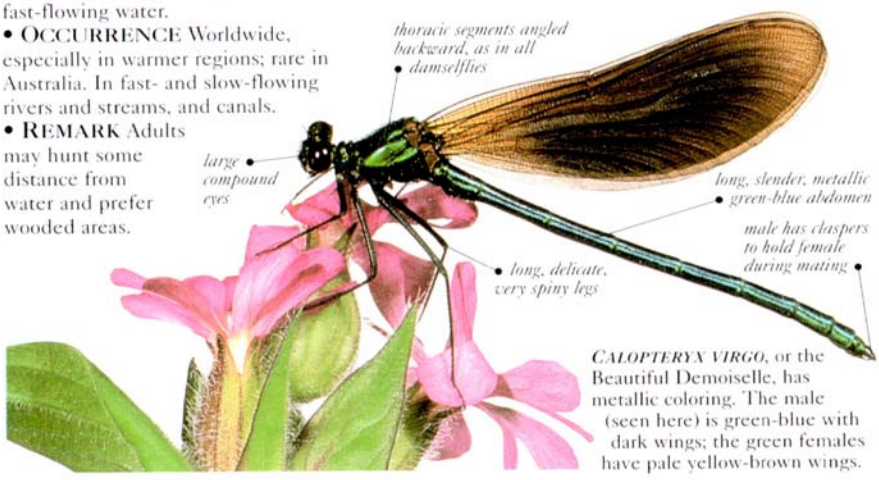
These relatively large damselflies have wings that narrow gradually and appear to be unstalked. The wings may be dark and in males can have bright red marks at the bases or distinctive dark bands elsewhere. The pterostigma is small or may be absent altogether.

• **LIFE CYCLE** Eggs are laid inside the tissues of various aquatic plants. Up to 300 eggs will be laid by a single female, and she may enter the water completely to do so. The nymphs hunt for prey in fast-flowing water.

• **OCCURRENCE** Worldwide, especially in warmer regions; rare in Australia. In fast- and slow-flowing rivers and streams, and canals.

• **REMARK** Adults may hunt some distance from water and prefer wooded areas.

NYMPHS have a small head and three prominent, flaplike gill filaments.



CALOPTERYX VIRGO, or the Beautiful Demoiselle, has metallic coloring. The male (seen here) is green-blue with dark wings; the green females have pale yellow-brown wings.

Wingspan 2–3¼in (5–8cm)	Nymphal feeding habits

Order ODONATA | Family COENAGRIONIDAE | No. of species 1,000

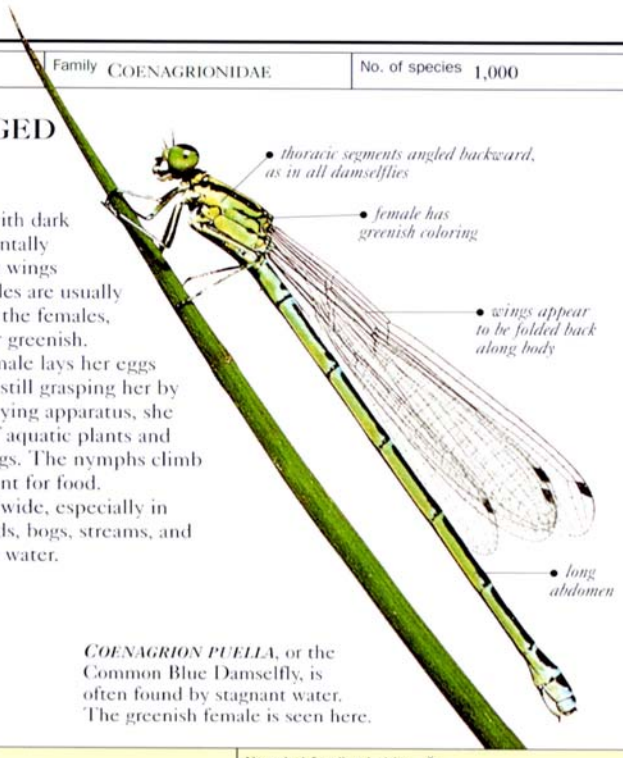
NARROW-WINGED DAMSELFLIES

Many of these slender damselflies are pale blue with dark markings. They rest horizontally with their relatively narrow wings folded above the body. Males are usually more brightly colored than the females, which tend to be grayish or greenish.

• **LIFE CYCLE** The female lays her eggs in water while the male is still grasping her by the neck. Using her egg-laying apparatus, she makes slits in the stems of aquatic plants and inserts small batches of eggs. The nymphs climb onto vegetation as they hunt for food.

• **OCCURRENCE** Worldwide, especially in temperate regions. In ponds, bogs, streams, and even brackish water.

NYMPHS are slender, with three narrow gill filaments.



COENAGRION PUELLA, or the Common Blue Damselfly, is often found by stagnant water. The greenish female is seen here.

Wingspan ¼–1¼in (2–4.5cm) | Nymphal feeding habits

Order ODONATA | Family LESTIDAE | No. of species 160

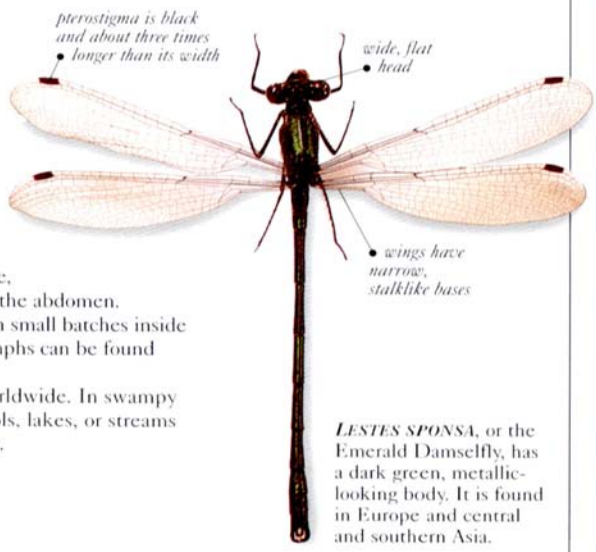
STALK-WINGED DAMSELFLIES

Also known as spread-winged damselflies, these sturdy insects are often bright blue and green with a metallic sheen. Each wing has a narrow, stalklike base and a dark, rectangular pterostigma on the front edge. At rest, they adopt a vertical pose with the head up and wings held out. Males have distinctive, forceps-shaped claspers at the end of the abdomen.

• **LIFE CYCLE** Females lay eggs in small batches inside the aerial parts of aquatic plants. Nymphs can be found clinging to vegetation in still water.

• **OCCURRENCE** Worldwide. In swampy or boggy places and pools, lakes, or streams with slow-flowing water.

NYMPHS are elongate in shape and light green to dark brown in color.



LESTES SPONSA, or the Emerald Damselfly, has a dark green, metallic-looking body. It is found in Europe and central and southern Asia.

Wingspan 1¼–3in (3–7.5cm) | Nymphal feeding habits

Order ODONATA | Family PSEUDOSTIGMATIDAE | No. of species 20

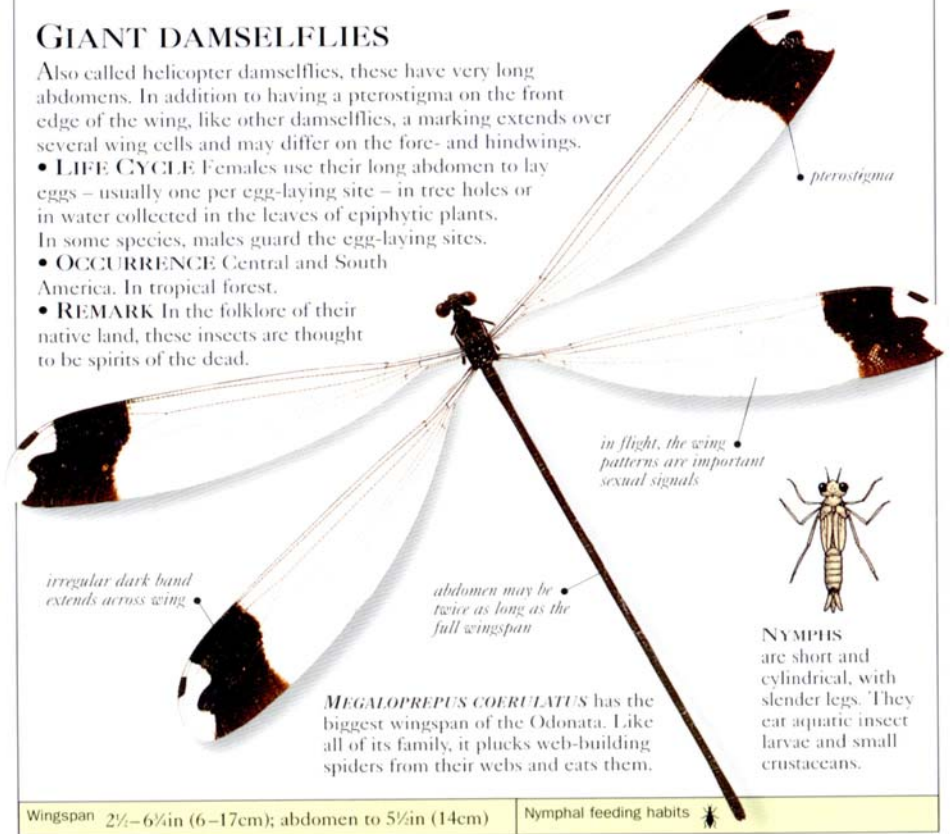
GIANT DAMSELFLIES

Also called helicopter damselflies, these have very long abdomens. In addition to having a pterostigma on the front edge of the wing, like other damselflies, a marking extends over several wing cells and may differ on the fore- and hindwings.

• **LIFE CYCLE** Females use their long abdomen to lay eggs – usually one per egg-laying site – in tree holes or in water collected in the leaves of epiphytic plants. In some species, males guard the egg-laying sites.

• **OCCURRENCE** Central and South America. In tropical forest.

• **REMARK** In the folklore of their native land, these insects are thought to be spirits of the dead.



MEGALOPREPUS COERULATUS has the biggest wingspan of the Odonata. Like all of its family, it plucks web-building spiders from their webs and eats them.

NYMPHS are short and cylindrical, with slender legs. They eat aquatic insect larvae and small crustaceans.

Wingspan 2½–6¾in (6–17cm); abdomen to 5⅛in (14cm) | Nymphal feeding habits

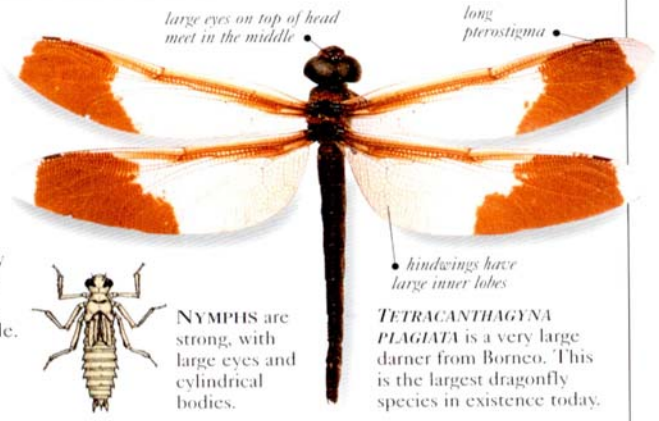
Order ODONATA | Family AESHNIDAE | No. of species 420

DARNERS

Also called hawkers, this family includes some of the biggest, most powerful dragonflies. They have large eyes and are often darkly colored, with blue or green markings. The wings have a long pterostigma.

• **LIFE CYCLE** Females lay small numbers of eggs in slits cut in dead or live vegetation.

• **OCCURRENCE** Worldwide. By still water and swampy areas; along paths and hedgerows; and in towns.



NYMPHS are strong, with large eyes and cylindrical bodies.

TETRACANTHAGYNA PLAGIATA is a very large darner from Borneo. This is the largest dragonfly species in existence today.

Wingspan 2½–5½in (6–14cm), most 2½–3½in (6.5–9cm) | Nymphal feeding habits

Order ODONATA	Family CORDULEGASTRIDAE	No. of species 50

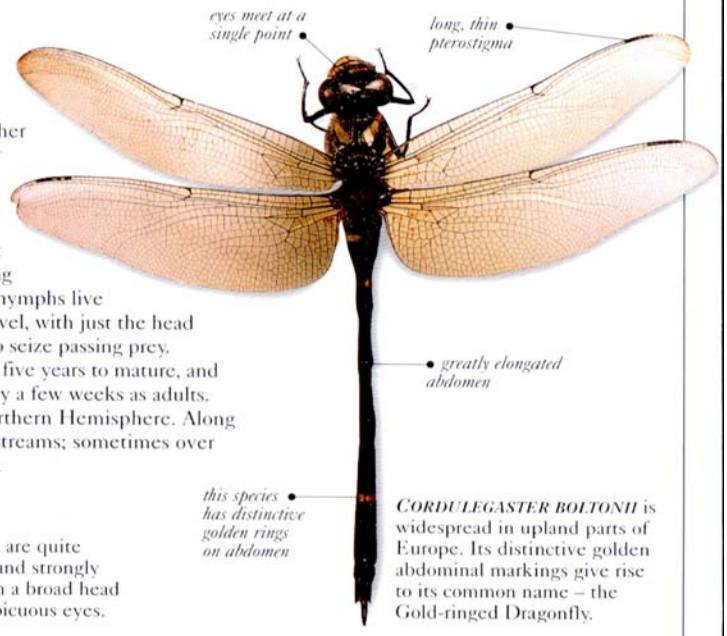
BIDDIES

These large dragonflies are brownish or black with yellow markings. The eyes touch each other at a single point. Most members of this family have a long abdomen.

• **LIFE CYCLE** Females lay their eggs at the bottom of fast-flowing streams and rivers. The nymphs live buried in the mud or gravel, with just the head and front legs exposed to seize passing prey. Nymphs may take up to five years to mature, and many species live for only a few weeks as adults.

• **OCCURRENCE** Northern Hemisphere. Along mountain or woodland streams; sometimes over open ground near pools.

NYMPHS are quite elongate and strongly built, with a broad head and conspicuous eyes.



CORDULEGASTER BOLTONII is widespread in upland parts of Europe. Its distinctive golden abdominal markings give rise to its common name – the Gold-ringed Dragonfly.

Wingspan 3¼–4¾in (8–12cm)	Nymphal feeding habits

Order ODONATA	Family CORDULIHDAE	No. of species 400

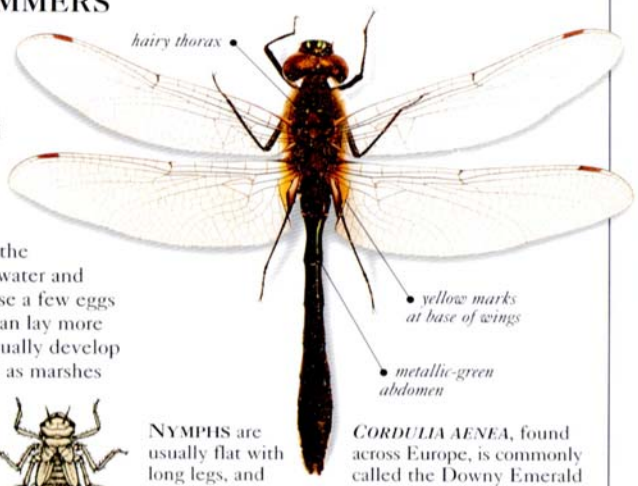
GREEN-EYED SKIMMERS

Often quite hairy, many of these skimmers are dark brown to black in color or have a green, red, or blue metallic luster. The abdomen can be either long and cylindrical or flat in shape. The eyes touch each other and have a noticeable indentation on the rear margin.

• **LIFE CYCLE** After mating, the female skimmer flies above the water and dips her abdomen down to release a few eggs into the water. Just one female can lay more than 2,000 eggs. The nymphs usually develop in bodies of stagnant water, such as marshes and peat bogs, and hunt for prey along the bottom.

• **OCCURRENCE** Worldwide. Common around stagnant water; sometimes found near streams.

NYMPHS are usually flat with long legs, and can be stout or quite elongated.



CORDULIA AENEA, found across Europe, is commonly called the Downy Emerald because of its hairy body and green abdomen.

Wingspan ¼–2in (2–5cm)	Nymphal feeding habits

Order ODONATA	Family GOMPHIDAE	No. of species 950

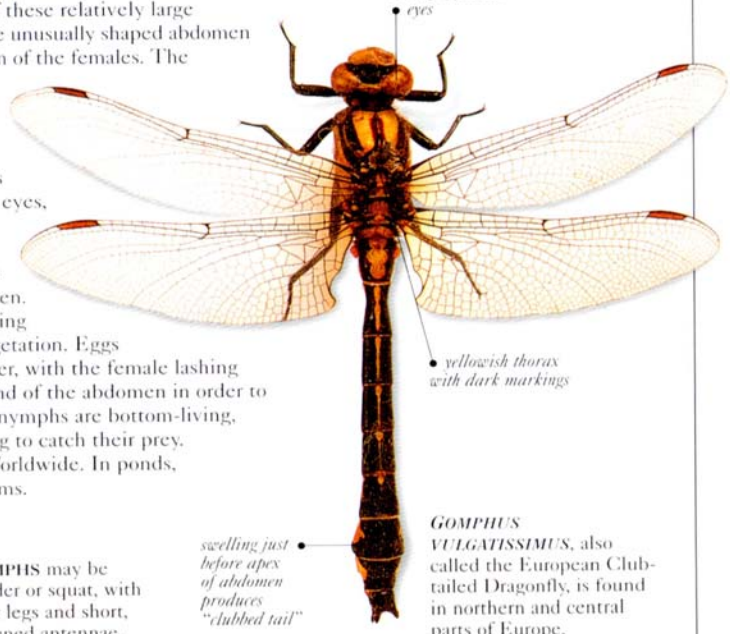
CLUB-TAILED DRAGONFLIES

The common name of these relatively large dragonflies refers to the unusually shaped abdomen of the males – and often of the females. The abdomen is swollen just in front of its apex, giving it the appearance of a club. Club-tailed dragonflies have widely separated eyes, and most species are brightly colored in differing combinations of black, yellow, or green.

• **LIFE CYCLE** Mating takes place among vegetation. Eggs are laid in shallow water, with the female lashing the surface with the end of the abdomen in order to release the eggs. The nymphs are bottom-living, crawling and burrowing to catch their prey.

• **OCCURRENCE** Worldwide. In ponds, lakes, rivers, and streams.

NYMPHS may be slender or squat, with stout legs and short, flattened antennae.



GOMPHUS VULGATISSIMUS, also called the European Club-tailed Dragonfly, is found in northern and central parts of Europe.

Wingspan 2½–4¾in (6–12cm)	Nymphal feeding habits

Order ODONATA	Family LIBELLULIDAE	No. of species 1,300

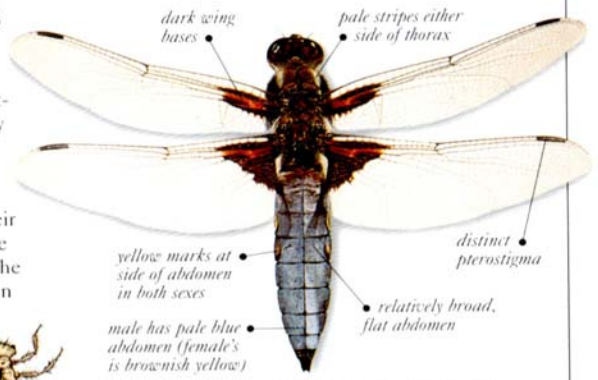
COMMON SKIMMERS

These skimmers are also called darters due to their unpredictable flight pattern. Many species are stout-bodied, and they are often extremely colorful. The wings may have dark, irregular markings.

• **LIFE CYCLE** Females usually hover over water and dip or strike their abdomen below the surface to release the eggs, which fall onto plants or to the bottom. The nymphs hunt for prey in mud and debris or on plants.

• **OCCURRENCE** Worldwide. In various habitats, including forests and mountainous areas, near slow-flowing streams, ponds, and bogs.

NYMPHS are often squat and slightly flat in shape.



LIBELLULA DEPRESSA is a European species whose adults fly in June and July. Its nymphs take up to three years to mature.

Wingspan ¼–3½in (2–9.5cm)	Nymphal feeding habits

STONEFLIES

THE 15 FAMILIES AND 2,000 species of stoneflies form the order Plecoptera. The body of a stonefly is typically soft, relatively flat, and slender. The elongate abdomen ends in a pair of tails (cerci), while the legs are sturdy. Although stoneflies have two pairs of wings, they are not strong fliers and are never found very far from water. The mouthparts are either underdeveloped or absent. In many species, the adults are short-lived and do not feed at all.

In the courting rituals of these insects, the males of many species attract females by drumming the underside of the abdomen against the ground or by trembling. In most species, the males and females "duet" – that is, they send courtship sounds back and forth between them. After mating on plant matter or on the ground, the females lay egg masses in water. Metamorphosis is incomplete. Most aquatic nymphs have gill-tufts and two terminal abdominal filaments. The nymphs pass through more than 30 molts before they finally emerge as adults.

Stoneflies occur all over the world but are most common in cool, temperate regions. However, there are five stonefly families that are found only in the Southern Hemisphere.

Order PLECOPTERA | Family CAPNIIDAE | No. of species 250

SMALL WINTER STONEFLIES

The majority of these relatively slender stoneflies are dark colored – usually brown or black. The abdominal tails and antennae may be as long as the body.

• **LIFE CYCLE** Adults emerge during winter to mate and lay eggs in water.
• **OCCURRENCE** Northern Hemisphere. By streams and lakes.

NYMPHS are yellow to brown, with short hairs and long antennae.

CAPNIA BIFRONS is a species in which the male, shown here, has no wings.

Length 1/16–1in (0.5–2.5cm) | Nymphal feeding habits

Order PLECOPTERA | Family LEUCTRIDAE | No. of species 200

ROLLED-WINGED STONEFLIES

At rest, the wings of these slender, usually dark brown stoneflies are either folded down or rolled around the sides of the body – hence the name. The cerci are very short.

• **LIFE CYCLE** Adults often emerge very early in the year to mate and lay eggs in water.
• **OCCURRENCE** Mainly Northern Hemisphere. Often by small streams, springs, or lakes.

NYMPHS are slender and yellowish in color.

***LEUCTRA* SPECIES** have dull coloring. At rest, their wings are rolled tightly around the body.

Length 1/4–1/2in (0.6–1.3cm), most under 1/4in (1cm) | Nymphal feeding habits

Order PLECOPTERA	Family NEMOURIDAE	No. of species 400

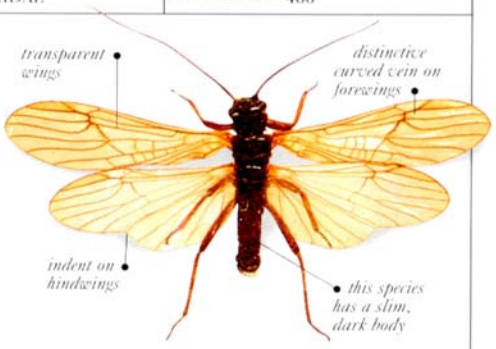
SPRING STONEFLIES

Sometimes called brown stoneflies because of their typical coloring, most species in this family are stout-bodied. Many have mottled wing patterns and extremely short cerci.

• **LIFE CYCLE** Most species emerge as adults, mate, and lay eggs in water during spring and summer. The nymphs are characteristically dull brown in color, with spines and body hairs. They mostly feed on detritus and algae, although some species feed on leaves.

• **OCCURRENCE** Northern Hemisphere. By lakes, springs, and fast-flowing streams.

NYMPHS' wing pads are not parallel to the body.



NEMOURA CAMBRICA is a slim-bodied stonefly, quite common throughout Europe. Typical of its family, it has brownish coloration and is found near streams.

Length ¼–⅝in (0.6–1.5cm)	Nymphal feeding habits

Order PLECOPTERA	Family PERLIDAE	No. of species 400

COMMON STONEFLIES

Yellow or brown in general coloring, these stoneflies have minute remains of the nymphal gill-tufts on the underside of the thorax, near the bases of the legs.

• **LIFE CYCLE** Females lay a ball of sticky eggs in the water. The nymphs take several years to reach adulthood and may be significant predators in some habitats.

• **OCCURRENCE** Worldwide, except Australia. On vegetation near running water.

• **REMARK** Unlike most stoneflies, some species in this family are very tolerant of warm conditions.

NYMPHS have branched gills on the thorax as well as on the abdomen.

NEOPERIA CLYMENE is common in North American streams. Other members of the genus favor broad rivers.

DINOCRAS CEPHALOTES is a European species whose nymphs may molt more than 30 times and take up to five years to mature.

Length ⅛–1⅛in (1–4.8cm), most under 1in (2.5cm)	Nymphal feeding habits

Order PLECOPTERA	Family PERLODIDAE	No. of species 250

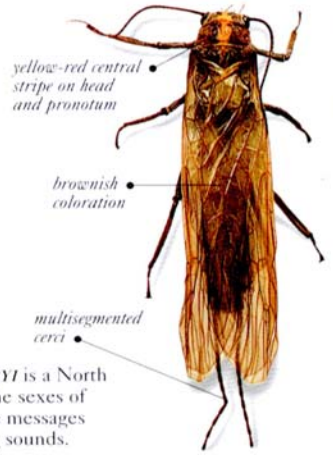
PREDATORY STONEFLIES

Species in this family range from pale yellow to dark brown. They have a square pronotum and long abdominal tails.

• **LIFE CYCLE** Eggs are generally laid in streams in spring. Fully grown nymphs crawl onto stones to emerge as adults in late spring or early summer. The adults are active during the day, rarely feed, and most die soon after laying their eggs. The nymphs are largely predacious, although they may eat plant matter or rotting material when very young.

• **OCCURRENCE** Northern Hemisphere. In and around medium- to large-sized, stony-bottomed streams.

NYMPHS are waxy-looking, with light and dark patterning and long legs.



HYDROPERLA CROSBYI is a North American species. The sexes of this species exchange messages via special drumming sounds.

Length 1/16–2in (0.8–5cm), most under 1in (2.5cm)	Nymphal feeding habits

Order PLECOPTERA	Family PTERONARCYIDAE	No. of species 12

GIANT STONEFLIES

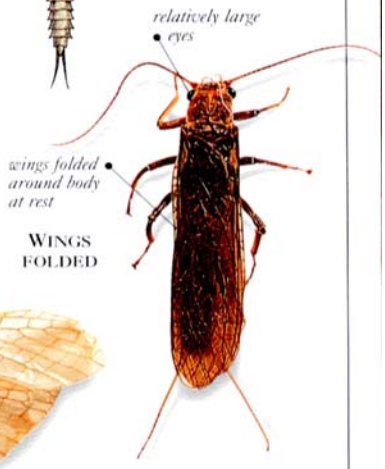
The adults of this family have broad, heavy bodies. Their coloration is either gray or brown. Giant stoneflies are active mostly after dark.

• **LIFE CYCLE** Dark, rounded eggs are laid in water. The nymphs take up to three years to develop and use their mandibles to shred aquatic plants and detritus. Adults emerge in summer and do not feed.

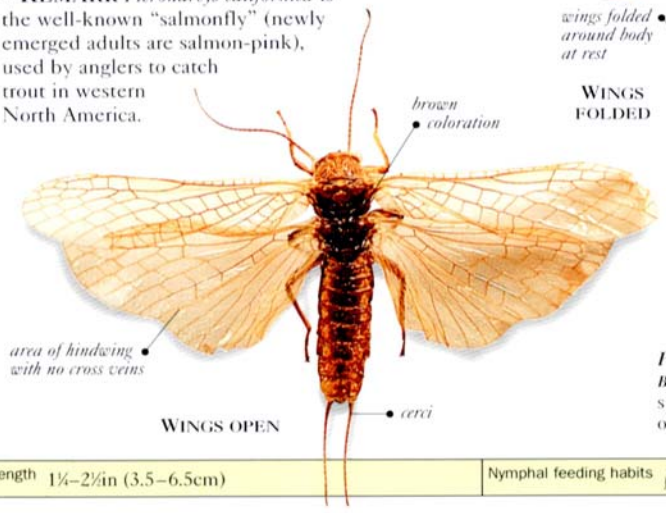
• **OCCURRENCE** Northern Hemisphere. In streams and rivers.

• **REMARK** *Pteronarcys californica* is the well-known "salmonfly" (newly emerged adults are salmon-pink), used by anglers to catch trout in western North America.

NYMPHS can be large and many have distinctive lateral expansions on the thorax and abdomen.



WINGS FOLDED



WINGS OPEN

PTERONARCELLA BADIA is a widespread species in western parts of North America.

Length 1¼–2½in (3.5–6.5cm)	Nymphal feeding habits

ROCK CRAWLERS

THE ORDER GRYLLOBLATTODEA consists of a single family, with 25 species. These small and wingless insects were first discovered in the Canadian Rockies in 1906, and were initially considered to be a primitive family belonging to the order Orthoptera (see pp.60–65).

Rock crawlers have slender cerci at the end of their abdomen. The small head bears threadlike antennae with 22 to 40 segments and simple, biting, forward-facing mandibles. Eyes may be small or totally absent. Early stages look rather like immature earwigs, and the females have a short ovipositor.

Rock crawlers are found in eastern Asia and North America. Most species belong to the genus *Grylloblatta*, which is native to western United States and Canada. The members of this genus are adapted to mountainous conditions and low temperatures and are commonly found in rotting wood or moving over rocks, snow, and ice after dark – hence the common name, ice bugs.

Rock crawlers are good daytime and nocturnal hunters, eating live, recently dead, windblown, or torpid prey items. They may also eat moss and plant matter, especially when they are young. Metamorphosis is incomplete.

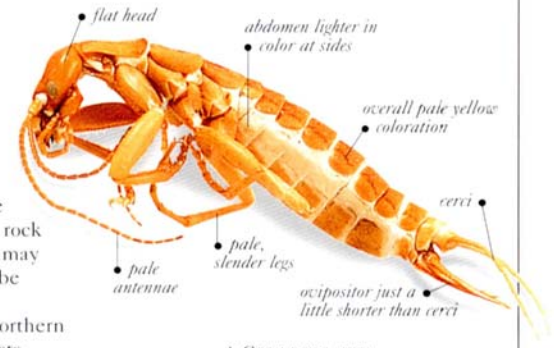
Order GRYLLOBLATTODEA	Family GRYLLOBLATTIDAE	No. of species 25

ROCK CRAWLERS

These insects are pale brown, yellow-brown, or gray. The body has a covering of short hairs, which may be dense or sparse, depending on species.

• **LIFE CYCLE** Mating may last up to four hours, and the female may not lay her eggs for several months. When she does, she lays them in rotten wood, moss, rock crevices, and soil. Nymphal development may take more than five years, and there may be as many as nine nymphal stages.

• **OCCURRENCE** Cooler parts of the Northern Hemisphere. In subalpine deciduous forests, mountainous areas, and limestone caves.



△ ***GRYLLOBLATTA CAMPODEIFORMIS***, or the Northern Rock Crawler, is found at high altitudes in North America and Canada, near glaciers and on rocks and damp scree slopes.

***GRYLLOBLATTA* SPECIES** are found under stones and on open ground in autumn and spring. They spend the short summers underground or in crevices.

Length ½–1¼in (1.2–3cm)	Feeding habits

CRICKETS AND GRASSHOPPERS

THE 28 FAMILIES AND 20,000 species of crickets, grasshoppers, and their relatives form the order Orthoptera. They have chewing mouthparts and hindlegs that are adapted for jumping. Most species have toughened forewings to protect the larger hindwings.

These insects are found in a range of terrestrial habitats. Singing is common, usually by males to attract mates, and metamorphosis is incomplete. There are two suborders: Ensifera and Caelifera. The Ensifera, typical of tropical and subtropical regions, comprise crickets and katydids (the selection here runs from Gryllacrididae to Tettigoniidae). The Caelifera, dominant in temperate areas, comprise grasshoppers and locusts (the selection of families runs from Acrididae to Tetrigidae).

Order ORTHOPTERA	Family GRYLLACRIDIDAE	No. of species 600

LEAF-ROLLING CRICKETS

True to their name, many of these crickets roll leaves into a kind of nest in which they hide during the day. The antennae are long and threadlike. In females, the ovipositor is long – often longer than the rest of the body – and has a slight upward curve.

• **LIFE CYCLE** Eggs are laid on bark, vegetation, and sometimes on the ground.

• **OCCURRENCE** Mainly tropical regions. In trees; sometimes on lower vegetation or on the ground.

HYALOGRYLLACRIS SUBDEBILIS is found in northern and southern parts of Australia.

***GRYLLACRIS* SPECIES** hunt for small insects after dark and will also eat freshly dead prey.

very long antennae

antennae are more than three times the length of the body

Length ¼–2⅓in (2–6cm)	Feeding habits

Order ORTHOPTERA	Family GRYLLIDAE	No. of species 4,000

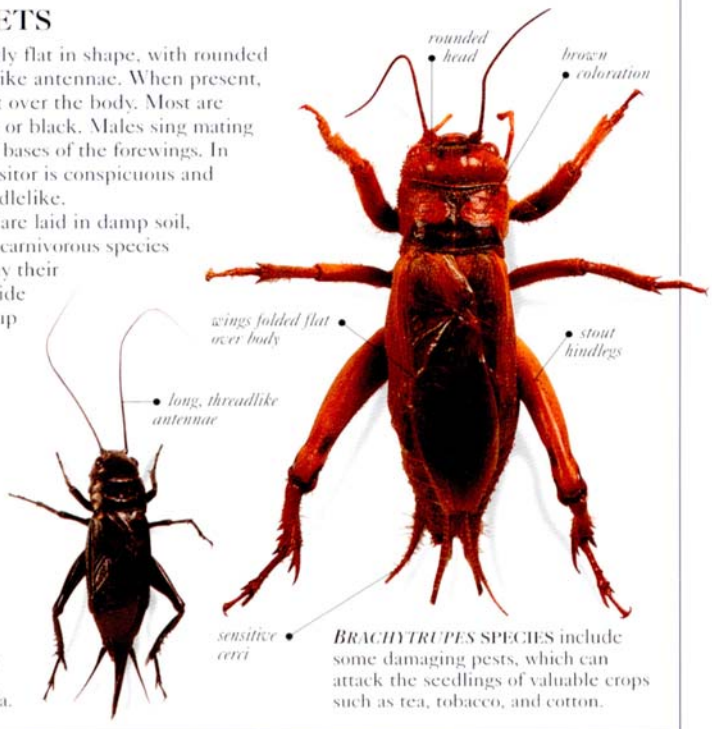
TRUE CRICKETS

These insects are slightly flat in shape, with rounded heads, and long, threadlike antennae. When present, the wings are folded flat over the body. Most are various shades of brown or black. Males sing mating songs using ridges at the bases of the forewings. In most females, the ovipositor is conspicuous and either cylindrical or needlelike.

• **LIFE CYCLE** Eggs are laid in damp soil, singly or in masses. The carnivorous species known as tree crickets lay their eggs in small groups inside plant tissue. There are up to 12 nymphal stages.

• **OCCURRENCE** Worldwide. In woods, meadows, scrub, and grassland. Most species are ground-living.

• **REMARK** Some species are renowned for their songs, and in certain countries are kept in cages, as pets.



GRYLLUS BIMACULATA, the Two-spotted Cricket, is common in Africa, southern Europe, and Asia.

***BRACHYTRUPES* SPECIES** include some damaging pests, which can attack the seedlings of valuable crops such as tea, tobacco, and cotton.

Length 1/16–2in (0.5–5cm)	Feeding habits

Order ORTHOPTERA	Family GRYLLOTALPIDAE	No. of species 60

MOLE CRICKETS

These brownish, burrowing crickets – which are covered with short, velvety hairs and have short, broad front legs adapted for digging – look remarkably like miniature moles. They are stout with short, leathery forewings.

• **LIFE CYCLE** Mating takes place on the surface, and eggs are laid in underground chambers. There are about ten nymphal stages, and the nymphs stay underground, eating plant roots and stems and small prey.

• **OCCURRENCE** Worldwide. In burrows up to 8in (20cm) long in damp sand or soil near streams, ponds, or lakes.

• **REMARK** Males produce songs by rubbing their forewings together. Their burrows may have flared tunnels that amplify and carry the song to the surface.

GRYLLOTALPA GRYLLOTALPA, commonly known as the European Mole Cricket, can be a pest of grasses, vegetables, and other crops. It is a protected species in the United Kingdom.

Length 1/4–1 1/4in (2–4.5cm)	Feeding habits

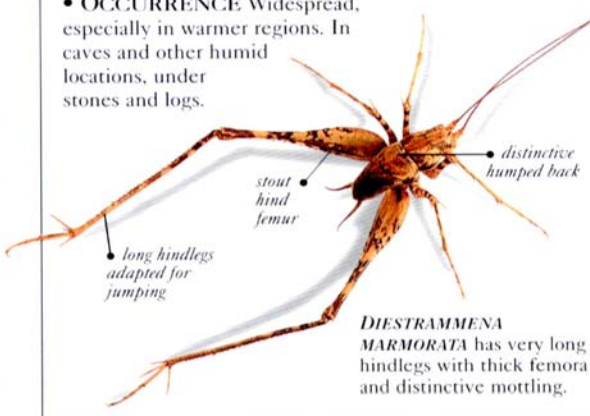
Order ORTHOPTERA	Family RHAPHIDOPHORIDAE	No. of species 500

CAVE CRICKETS

Many of these hump-backed, squat, wingless crickets have very long hindlegs and extremely long antennae, which are waved backward and forward in the dark to sense the environment and approaching predators. They are drably colored, usually brown or gray. Some highly cave-adapted species have reduced eyes and soft bodies.

• **LIFE CYCLE** Eggs are laid in the substrate of the cave, and the nymphs search for food as soon as they hatch. Nymphs of some species eat plant life at cave entrances.

• **OCCURRENCE** Widespread, especially in warmer regions. In caves and other humid locations, under stones and logs.



DIESTRAMMENA MARMORATA has very long hindlegs with thick femora and distinctive mottling.

PHOLEOGRYLLUS GEERTSI is a species that is native to northern Africa and parts of southern Europe.

Length ½–1½in (1.3–3.8cm)	Feeding habits

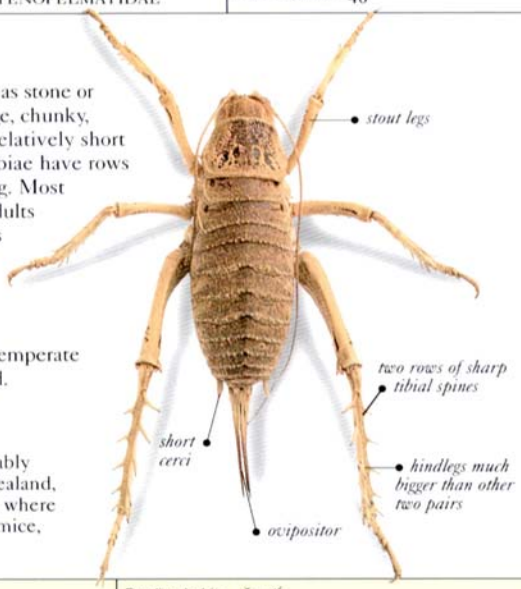
Order ORTHOPTERA	Family STENOPELMATIDAE	No. of species 40

KING CRICKETS

Some members of this family are known as stone or Jerusalem crickets or wetas. Most are large, chunky, wingless insects, with a large head and relatively short antennae. The legs are stout, and the tibiae have rows of strong spines that are used for digging. Most species are very dark brown or black. Adults emerge from their underground burrows only after darkness falls.

• **LIFE CYCLE** Eggs are laid in soil. King crickets may have nine or ten nymphal stages.

• **OCCURRENCE** Warm tropical and temperate regions. In rotten wood and underground.



DEINACRIDA RUGOSA, probably once common across New Zealand, now survives only on islands where introduced animals, such as mice, are absent or controlled.

Length 1½–3⅛in (3.8–8cm)	Feeding habits

Order ORTHOPTERA	Family TETTIGONIIDAE	No. of species 6,000

KATYDIDS

Also called bush crickets or long-horned grasshoppers, katydids are named after a species whose song sounds like the phrase "Katy did." Most are large brown or green insects with wings that slope over the sides of their bodies. Many species mimic leaves, bark, or lichen, and some flash bright hindwing colors to startle predators.

• **LIFE CYCLE** Male katydids sing to attract mates, using a file-and-scraper system at the base of the forewings. Females lay rows of eggs in plants or soil, and there may be five or six nymphal stages.

• **OCCURRENCE** Worldwide, mainly in tropical regions. On vegetation and in forests, from ground level to the canopy.

▷ ***SATHROPHYLLIA RUGOSA***, from India, mimics the appearance of bark and is very difficult to see when at rest.

▽ ***METRIOPTERA BRACHYPTERA***, also known as the Bog Bush Cricket, lives in damp meadows and is widespread across Europe.

adults of this species have short wings

creamy brown coloration to blend with bark

uneven outline of wings increases resemblance to leaves

slender, sickle-shaped ovipositor for laying eggs in plant tissue

very long, multisegmented antennae

△ ***OMMATOPTERA PICTIFOLIA*** comes from Brazil. Like many bush crickets, it mimics dead leaves and keeps very still when predators are close at hand.

▽ ***LEPTOPHYES PUNCTATISSIMA***, or the Speckled Bush Cricket, is commonly found in bushes, trees, and grassland. The female has a large, sword-like ovipositor.

very short wings in both sexes

downward-pointing mouthparts

bright green coloration

ovipositor

Length ⅛–3in (1.5–7.5cm), most 1¼–2in (3.5–5cm)	Feeding habits

Order ORTHOPTERA	Family ACRIDIDAE	No. of species 10,000

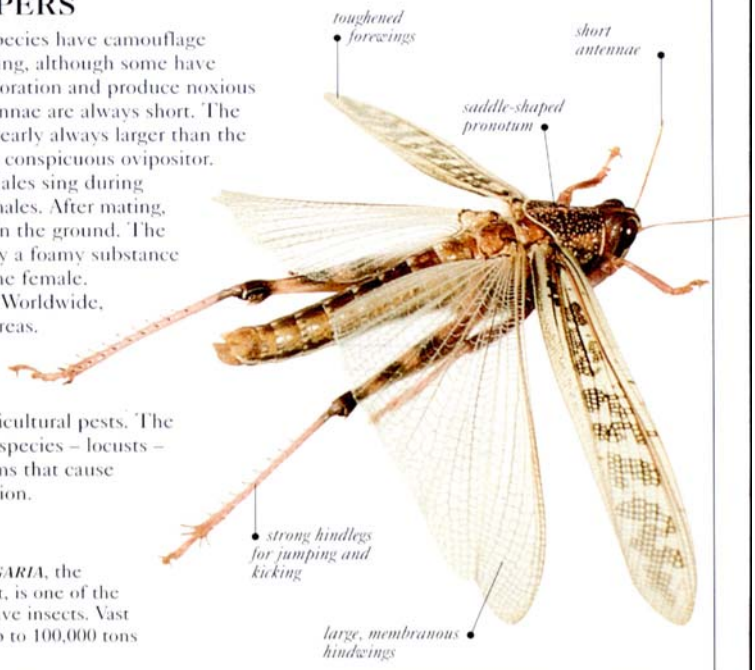
GRASSHOPPERS

Most grasshopper species have camouflage coloring and patterning, although some have bright "warning" coloration and produce noxious chemicals. The antennae are always short. The females, which are nearly always larger than the males, do not have a conspicuous ovipositor.

• **LIFE CYCLE** Males sing during the day to attract females. After mating, egg masses are laid in the ground. The eggs are protected by a foamy substance that is secreted by the female.

• **OCCURRENCE** Worldwide, especially in warm areas. On the ground and among vegetation.

• **REMARK** Many grasshoppers are agricultural pests. The most notorious pest species – locusts – can form huge swarms that cause widespread devastation.



SCHISTOCERCA GREGARIA, the African Desert Locust, is one of the world's most destructive insects. Vast swarms can devour up to 100,000 tons of food in a day.

Length ⅛–3¼in (1–8cm), most ⅛–1¼in (1.5–3cm)	Feeding habits

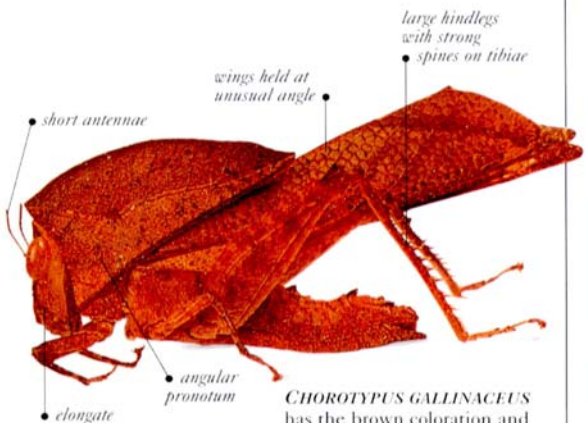
Order ORTHOPTERA	Family EUMASTACIDAE	No. of species 1,200

MONKEY-HOPPERS

The head of these slim insects is long and set at an angle to the thorax. Many are brightly colored, while some resemble leaves or sticks. The hindlegs are thin and elongate, with distinctive spines on the lower half of the tibiae. At rest, many species sit with their hindlegs splayed out sideways.

• **LIFE CYCLE** Mating involves the male on top of the female. Eggs are laid in the ground or in detritus.

• **OCCURRENCE** Southeast Asia, Africa, India, and North and South America, especially in tropical and subtropical regions. In a variety of habitats, including woodland, forests, and grassland.



CHOROTYPUS GALLINACEUS has the brown coloration and leaflike appearance that provides effective camouflage.

Length ⅛–2¼in (1.5–5.8cm)	Feeding habits

Order ORTHOPTERA	Family PYRGOMORPHIDAE	No. of species 600

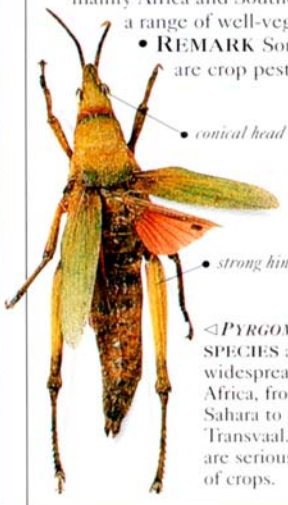
BUSH-HOPPERS

Also called bush-locusts, these insects may have camouflage coloring. Many species are brightly colored and defend themselves by producing foamy, toxic substances. The body can be slender but is more often quite robust, with thoracic bumps and blunt projections. Adults of some species travel in small swarms.

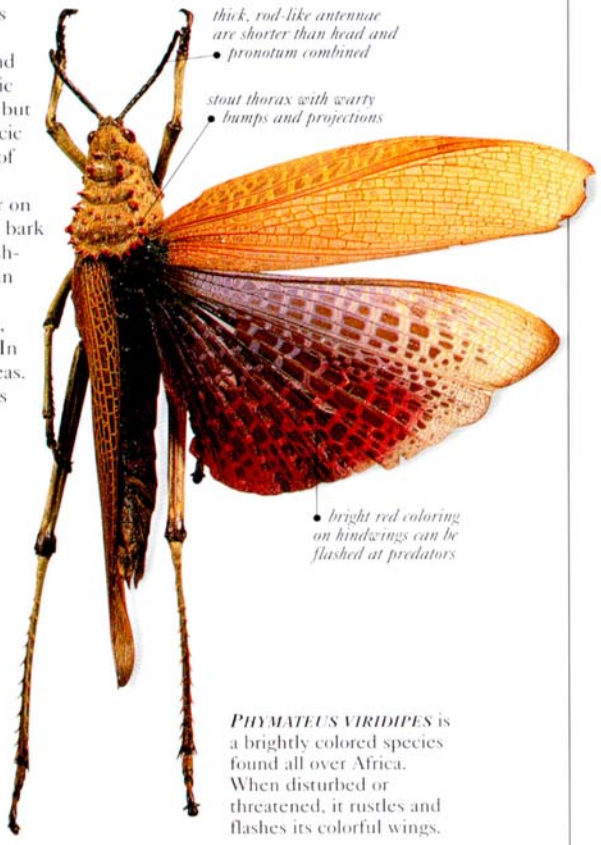
• **LIFE CYCLE** Eggs are laid in or on soil, in rotting wood, or wedged into bark crevices. The nymphs of certain bush-hopper species are gregarious and can migrate several miles.

• **OCCURRENCE** Tropical regions, mainly Africa and Southeast Asia. In a range of well-vegetated areas.

• **REMARK** Some species are crop pests.



◁ *PYRGOMORPHA* SPECIES are widespread in Africa, from the Sahara to the Transvaal. Some are serious pests of crops.



PHYMATEUS VIRIDIPES is a brightly colored species found all over Africa. When disturbed or threatened, it rustles and flashes its colorful wings.

Length ⅛–3¼in (1–8.5cm)	Feeding habits

Order ORTHOPTERA	Family TETRIGIDAE	No. of species 1,200

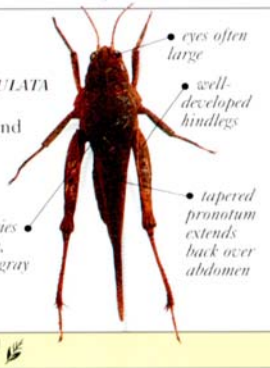
PYGMY LOCUSTS

Also called ground-hoppers or grouse locusts, these insects have a distinctive pronotum that extends back over all of the abdomen, often tapering to a point. In some species, the pronotum is enlarged and shaped to imitate leaves or stones.

• **LIFE CYCLE** Females lay eggs in damp soil. Some species have up to five nymphal stages.

• **OCCURRENCE** Worldwide, mainly in warmer regions. On bare or sparsely covered ground in moist, wooded areas and the edges of bogs and lakes.

TETRIX SUBULATA can swim underwater and is found in Asia and Europe.



Length ¼–¾in (0.6–1.8cm), most about ⅜in (1.5cm)	Feeding habits

STICK AND LEAF INSECTS

THERE ARE 3 FAMILIES and 2,500 species of stick and leaf insects in the order Phasmatodea. The largest of the three families is the Phasmatidae.

These long, slow-moving, herbivorous insects are mostly nocturnal. By day, they protect themselves from predators with their highly convincing stick- or leaflike appearance. If disturbed, many stick insects remain motionless, holding their legs tightly along their body. Males tend to be smaller than females. The males of many species are winged; females are often wingless. Most females drop, scatter, or flick their eggs from the end of the abdomen. A few lay eggs in soil or glue them to plants. Some eggs are very seedlike and attract ants, who take them to their nests, where they are protected. Metamorphosis is incomplete.

Order PHASMATODEA	Family PHASMATIDAE	No. of species 2,450

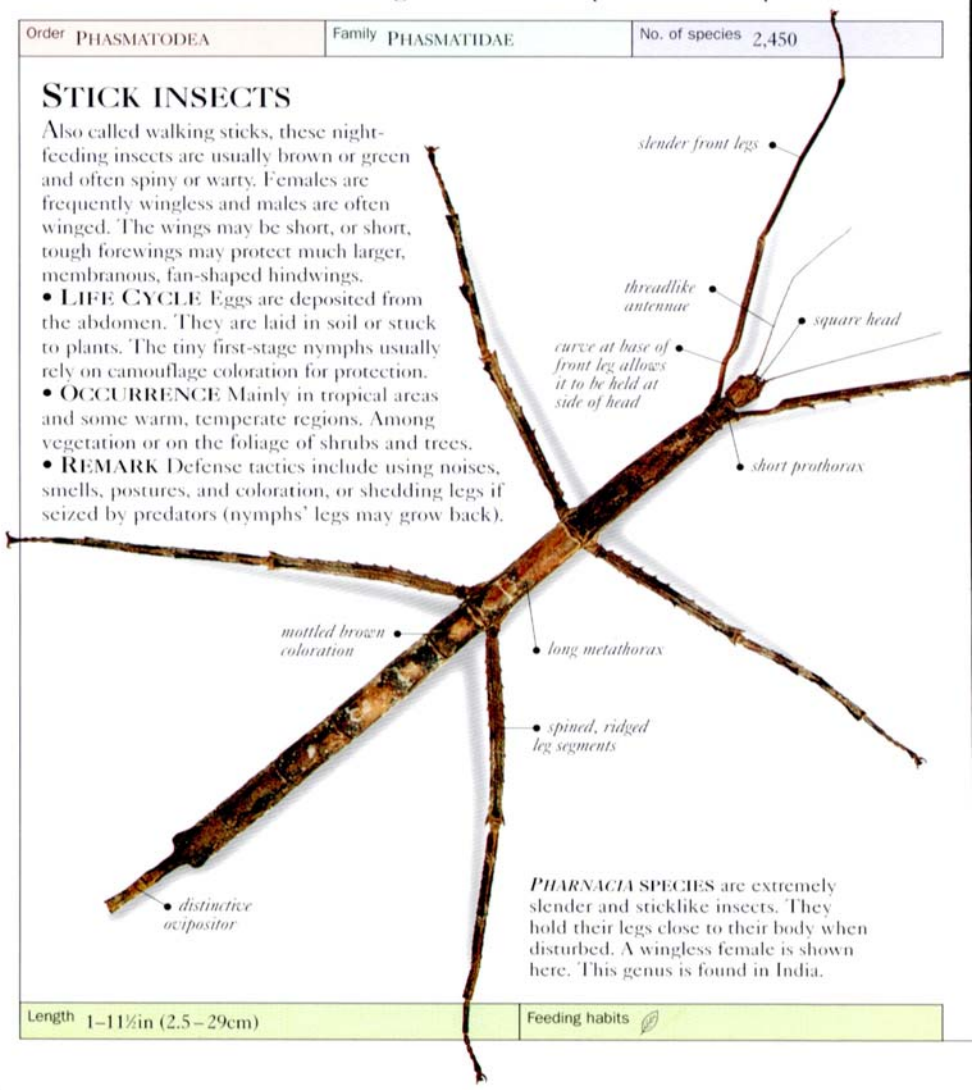
STICK INSECTS

Also called walking sticks, these night-feeding insects are usually brown or green and often spiny or warty. Females are frequently wingless and males are often winged. The wings may be short, or short, tough forewings may protect much larger, membranous, fan-shaped hindwings.

• **LIFE CYCLE** Eggs are deposited from the abdomen. They are laid in soil or stuck to plants. The tiny first-stage nymphs usually rely on camouflage coloration for protection.

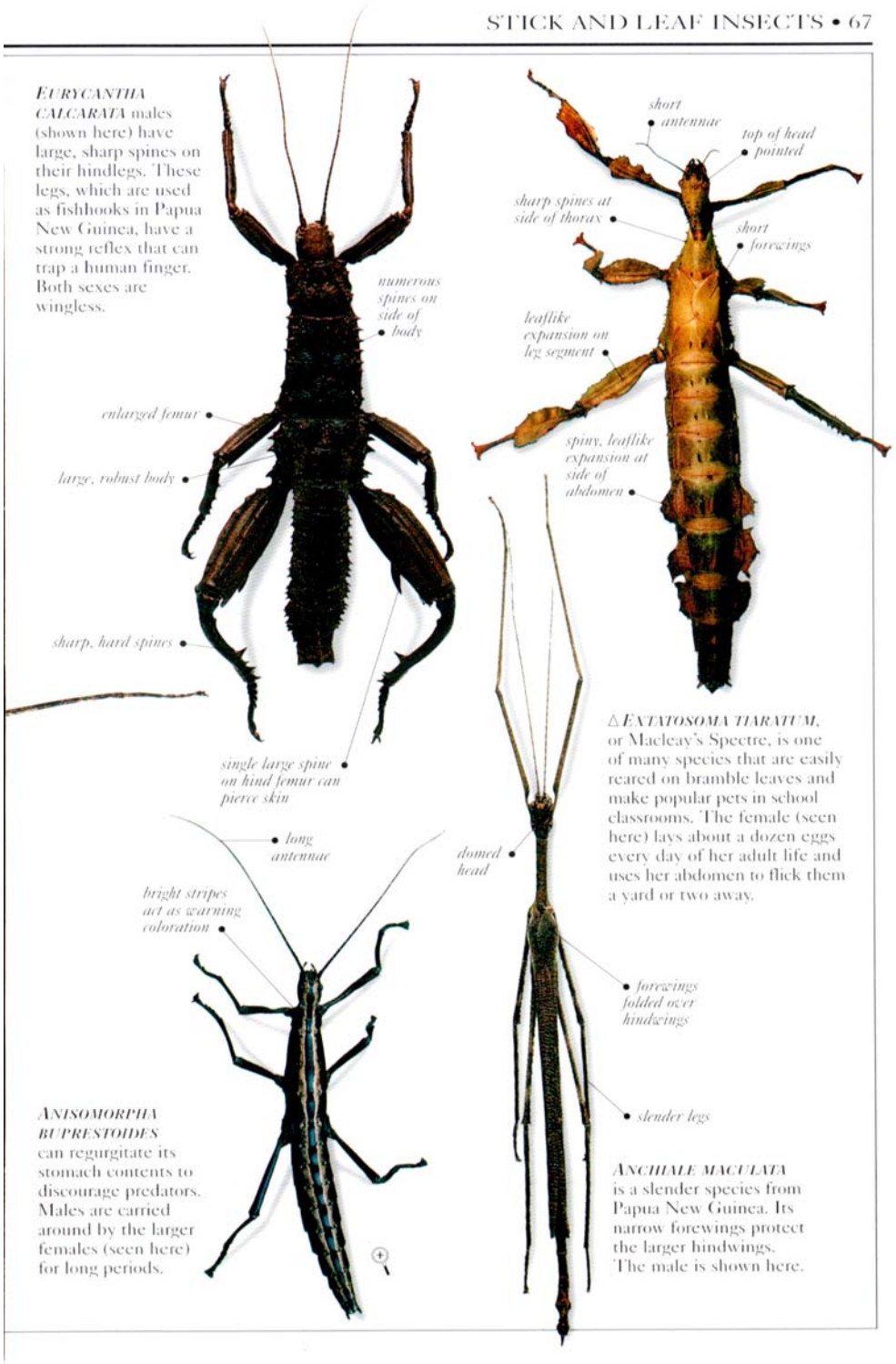
• **OCCURRENCE** Mainly in tropical areas and some warm, temperate regions. Among vegetation or on the foliage of shrubs and trees.

• **REMARK** Defense tactics include using noises, smells, postures, and coloration, or shedding legs if seized by predators (nymphs' legs may grow back).



***PHARNACIA* SPECIES** are extremely slender and sticklike insects. They hold their legs close to their body when disturbed. A wingless female is shown here. This genus is found in India.

Length 1–11½in (2.5–29cm)	Feeding habits



EURYCANTHA CALCARATA males (shown here) have large, sharp spines on their hindlegs. These legs, which are used as fishhooks in Papua New Guinea, have a strong reflex that can trap a human finger. Both sexes are wingless.

△ ***EXTATOSOMA TIARATUM***, or Macleay's Spectre, is one of many species that are easily reared on bramble leaves and make popular pets in school classrooms. The female (seen here) lays about a dozen eggs every day of her adult life and uses her abdomen to flick them a yard or two away.

ANISOMORPHA BUPRESTOIDES can regurgitate its stomach contents to discourage predators. Males are carried around by the larger females (seen here) for long periods.

ANCHIALE MACULATA is a slender species from Papua New Guinea. Its narrow forewings protect the larger hindwings. The male is shown here.

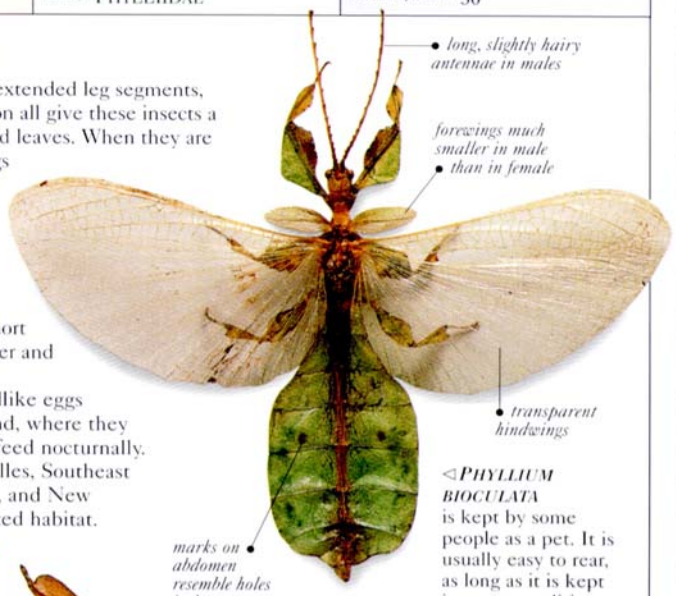
Order PHASMATODEA	Family PHYLLIIDAE	No. of species 30

LEAF INSECTS

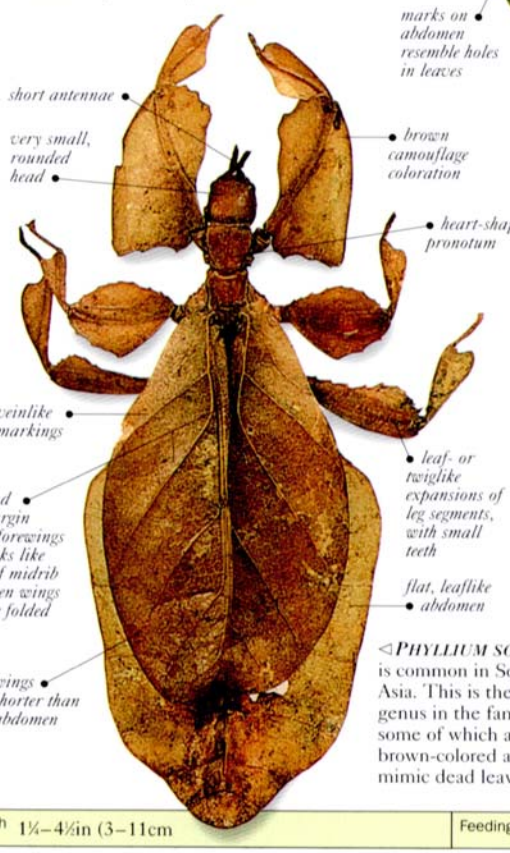
Flat, expanded abdomens, extended leg segments, and brown or green coloration all give these insects a resemblance to living or dead leaves. When they are at rest, their veined forewings may cover their transparent hindwings to complete the disguise, made even more effective by surface texturing, blotches of color, and an ability to sway in the breeze. The antennae are short and smooth in females, longer and slightly hairy in males.

• **LIFE CYCLE** The seedlike eggs are dropped on to the ground, where they hatch. The young nymphs feed nocturnally.

• **OCCURRENCE** Seychelles, Southeast Asia, Northern Queensland, and New Guinea. In any well-vegetated habitat.



◁ ***PHYLLIUM BIOCULATA*** is kept by some people as a pet. It is usually easy to rear, as long as it is kept in warm conditions.



◁ ***PHYLLIUM SCYTHE*** is common in Southeast Asia. This is the largest genus in the family, some of which are brown-colored and mimic dead leaves.

▷ ***PHYLLIUM* SPECIES** in general are well known for their gentle, side-to-side swaying motion, imitating the way in which foliage rustles in a breeze.

Length 1¼–4½in (3–11cm	Feeding habits

EARWIGS

THE ORDER DERMAPTERA is relatively small. It is divided into 10 families, containing about 1,900 species. Commonly known as earwigs, these relatively flat insects have short, veinless forewings that protect the large, fan-shaped hindwings. The abdomen is mobile and telescopic, with a pair of forcepslike appendages that are usually straight in females and curved in males.

Metamorphosis is incomplete. Females typically lay their eggs in soil, although some parasitic species give birth to live nymphs. The females show a high degree of maternal care, for example, licking fungal spores off the eggs and guarding them from predators. This care continues for some time after the eggs hatch. Females feed their nymphs by bringing food into the nest or by regurgitating part of their own meals. Eventually, the nymphs have to disperse – as they grow, the mother starts to regard them as a potential meal.

Earwigs molt up to five times. Apart from increasing in size and gaining antennal segments with each molt, they look similar to their parents.

Earwigs like confined spaces. Their name may refer to the popular belief that they enter human ears (they rarely do), or to the shape of their hindwings.

Order DERMAPTERA	Family CARCINOPHORIDAE	No. of species 400

CARCINOPHORID EARWIGS

Most of these short-legged species lack hindwings, and in some species, the short, toughened forewings are also absent. Many species are dark-colored in shades of dark brown, black, or reddish with paler yellow or red markings. The antennae have fewer than 20 segments, and the abdominal forceps, which are typically short, may not be symmetrical in males.

• **LIFE CYCLE** Eggs are laid in burrows or in leaf litter.

• **OCCURRENCE** Worldwide, especially in warmer regions. In a wide range of habitats.

• **REMARK** Some species of earwigs are significant pests of cultivated flowers and fruits.

***CARCINOPHORA* SPECIES** are found mostly in South America, with some in North America and the Far East. The species seen here has both fore- and hindwings.

▷ ***TITANOLABIS COLOSSEA*** is the largest known earwig. The genus *Titanolabis* contains four species, which are native to Australia.

Length ⅛–2in (0.7–5cm)	Feeding habits

Order DERMAPTERA | Family FORFICULIDAE | No. of species 450

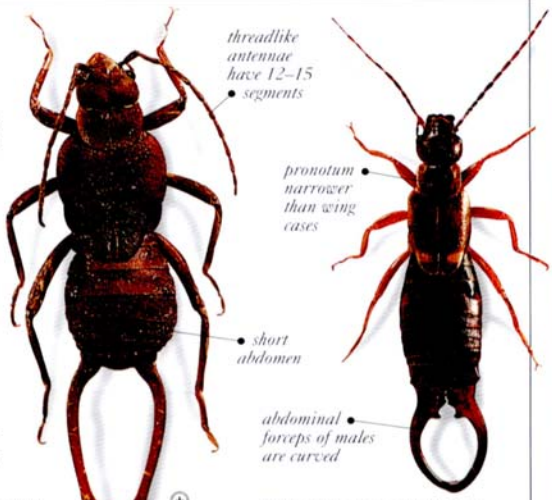
COMMON EARWIGS

These typically slender earwigs vary in appearance but are usually dark brown or blackish brown, with paler legs and threadlike antennae. The abdominal forceps of the male earwigs are highly curved, whereas those of the females are relatively straight.

• **LIFE CYCLE** Females usually lay eggs in soil under rocks or bark. They guard the eggs against predators and lick them clean to prevent any fungal growth. Apart from plant matter, the diet may include small caterpillars, aphids, and other insects.

• **OCCURRENCE** Worldwide. In leaf litter and soil, under bark, or in crevices.

• **REMARK** These insects can be pests of crops or garden plants.



***ALLODAHLIA* SPECIES** are found in India, Malaysia, and various parts of the Far East.

FORFICULA AURICULARIA, the European Earwig, is now very widespread and is a well-known pest of flowers.

Length ½–1in (1.2–2.5cm) | Feeding habits

Order DERMAPTERA | Family LABIDURIDAE | No. of species 75

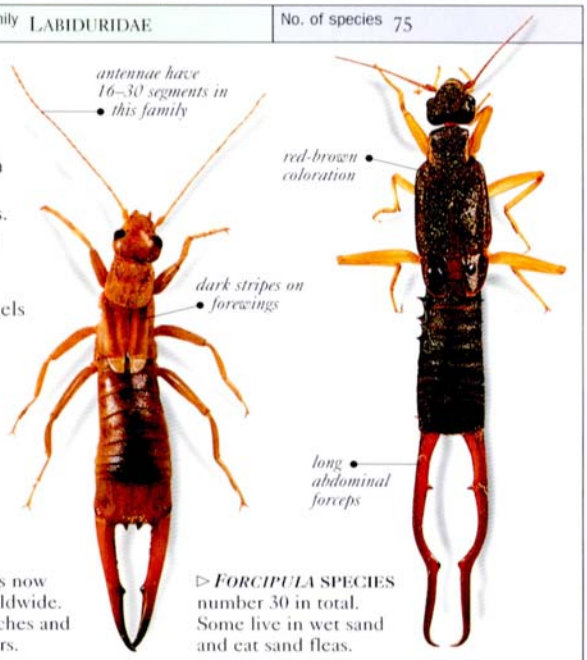
STRIPED EARWIGS

Also called long-horned earwigs due to their long antennae, these relatively robust insects are reddish brown. They are usually winged, although some species are wingless. Common species have dark stripes on the pronotum and wing cases.

• **LIFE CYCLE** Female striped earwigs lay their eggs in deep tunnels that they have dug in sandy soil.

• **OCCURRENCE** Worldwide, mainly in warmer regions. Around coastal areas, riverbanks, and mudflats; in leaf litter, sand, and debris, or under stones.

• **REMARK** Some species can discharge a foul-smelling liquid produced by abdominal glands.



LABIDURA RIPARIA is now found practically worldwide. It lives on sandy beaches and along shores and rivers.

▷ ***FORCIPULA* SPECIES** number 30 in total. Some live in wet sand and eat sand fleas.

Length ½–1½in (1.2–4cm) | Feeding habits

MANTIDS

THE ORDER MANTODEA includes 8 families and 2,000 species. The common name "praying mantis" is derived from the distinctive way in which the front legs are held up and together, as if in prayer.

Variable in shape, mantids have several clearly recognizable features: a triangular head with large, forward-facing eyes, and an elongated prothorax with the front pair of legs distinctively modified for catching live prey. Mantids are excellent hunters. The head is very mobile – these are the only insects that can turn their head to "look over their shoulder." The forward-pointing eyes give true binocular vision and allow distances to be calculated accurately, while the front legs can be used to pounce and seize prey very quickly – typically in less than a tenth of a second.

Mantids are mostly daytime fliers, eating a wide range of arthropods and even vertebrates such as frogs and lizards. Many avoid attacks by bats with the aid of a special ultrasonic ear on the underside of the thorax.

Metamorphosis is incomplete. The eggs are laid inside a papery or foam-like case, which is fixed to twigs or other surfaces. The females of some species guard this egg case from predators.

Order MANTODEA | Family EMPUSIDAE | No. of species 30

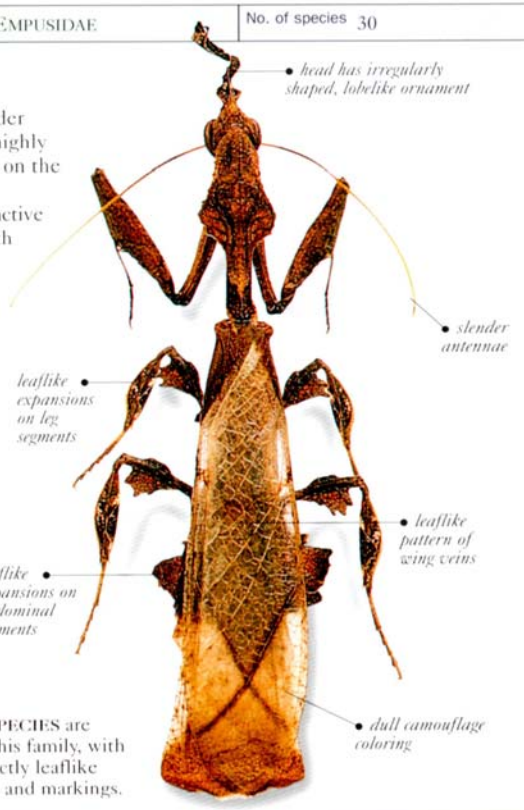
EMPUSIDS

These insects are often large and slender in shape. Most empusid species have highly distinctive leaf- or lobelike expansions on the ends of the femora and at the sides of the abdomen. The front tibiae are distinctive in having long spines that alternate with two to four short ones. The head has a lobelike outgrowth, and the antennae appear plumed in males.

• **LIFE CYCLE** Typical of mantids, the eggs are laid inside an egg case, and the first nymphs molt very soon after emerging.

• **OCCURRENCE** Africa, parts of the Mediterranean region, and Asia. On flowers, foliage, and other vegetation.

• **REMARK** As with all mantids, the size and activity of prey are carefully judged. Prey capable of fighting back are not attacked if they are more than half the size of the mantid.



***EMPUSA* SPECIES** are typical of this family, with their distinctly leaflike expansions and markings.

Length 1¼–3½in (4.5–9cm) | Feeding habits

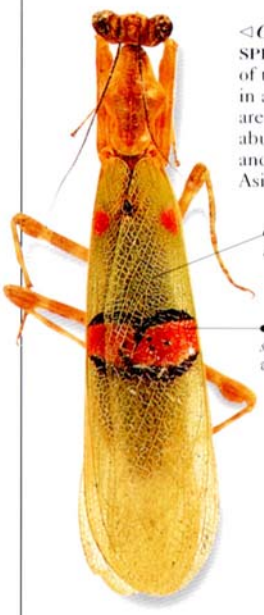
Order MANTODEA	Family HYMENOPODIDAE	No. of species 50

FLOWER MANTIDS

Vivid coloration, including bright pinks and greens, coupled with body ornamentation, allows these species to blend in perfectly with the flowers on which they rest, awaiting the arrival of prey. Some parts of the body, such as the legs, often have broad extensions that resemble leaves. The forewings may have colored bands or spirals, or conspicuous, circular marks that look rather like eye-spots. In female flower mantids, the wings are sometimes short.

• **LIFE CYCLE** Eggs are laid in a case, typically attached to vegetation. Young nymphs tackle small prey as soon as their cuticle has hardened.

• **OCCURRENCE** In tropical regions all around the world, except Australia. On a wide variety of vegetation.



◁ ***CREOBROTER*** **SPECIES** are typical of the flower mantids in appearance. They are particularly abundant in India and across Southeast Asia generally.

coloration blends in with flowers

distinctive eye-spot markings on wings

pointed ornamentation on head

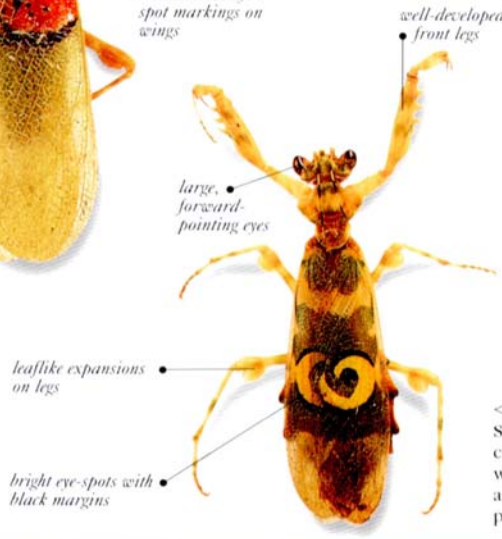
broad, leaflike extensions on legs

spots on forewings

fairly uniform overall coloration

darker wingtips

△ ***HYMENOPUS CORONATUS*** usually has camouflage coloring that mimics the flowers on which they live. Their color varies depending on the surroundings in which a nymph develops – red, for example, if a nymph spends its early life on a red bloom.



well-developed front legs

large, forward-pointing eyes

leaflike expansions on legs

bright eye-spots with black margins

◁ ***PSEUDOCREBOTRA*** **SPECIES** have vividly colored markings on their wings. These can be flashed as a warning when any potential predators threaten.

Length ¼–3¼in (2–8cm)	Feeding habits

Order MANTODEA	Family MANTIDAE	No. of species 1,400

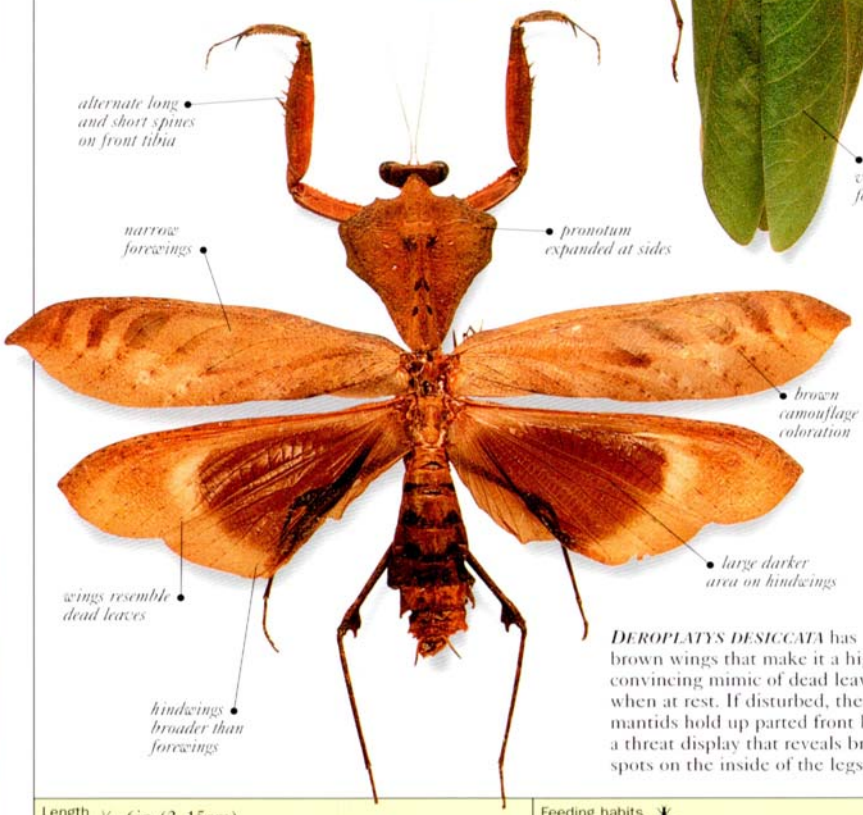
COMMON PRAYING MANTIDS

Many members of this family vary very little in appearance, and most have green or brown coloration. Unlike families such as the flower mantids (see opposite), the wings of common praying mantids are seldom patterned, although they may have wing-spots.

• **LIFE CYCLE** The female praying mantid is famed for eating the male after mating. However, although mating can be dangerous for the smaller males, they are cautious and are seldom eaten by their partners in the wild. Anything from a few dozen to a couple of hundred eggs are laid. The eggs are surrounded by a papery or foamlike egg case.

• **OCCURRENCE** Worldwide, mainly in warmer regions. On any kind of vegetation where there is a good supply of prey.

▷ ***CHOERADODIS STALII*** and other large species in this genus are capable of preying on vertebrates such as salamanders and frogs.



DEROPLATYS DESICCATA has brown wings that make it a highly convincing mimic of dead leaves when at rest. If disturbed, these mantids hold up parted front legs in a threat display that reveals bright spots on the inside of the legs.

Length ¼–6in (2–15cm)	Feeding habits

COCKROACHES

THE ORDER BLATTODEA contains 6 families and 4,000 species. These leathery insects usually have an oval, flat shape that lets them squeeze through tight spaces. The head is often covered by a shieldlike pronotum. There are generally two pairs of wings. The forewings are usually tough and cover large, membranous hindwings.

Most cockroaches live in tropical regions. Less than one percent of them are pests, adapted to human habitats, thriving in warm, unsanitary conditions, and often carrying disease. Cockroaches mostly eat dead or decaying organic matter, including bird and bat guano. Their main defense against predators is that they are highly sensitive to vibration and can run fast, but some also spray or ooze toxic chemicals.

Female cockroaches produce sexual pheromones to which males respond, and males may produce aphrodisiac secretions to encourage the female. Mating occurs back to back, and sperm is transferred in a packet. The females lay up to 40 eggs, which are surrounded by a tough case that may be dropped, stuck to the ground, or carried around, partly projecting from the end of the cockroach's abdomen. Metamorphosis in these insects is incomplete.

Order BLATTODEA	Family BLABERIDAE	No. of species 1,000

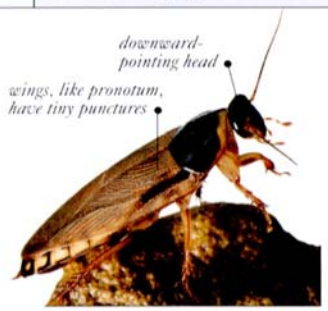
LIVE-BEARING COCKROACHES

These large insects often have well-developed, pale brown wings with dark markings. In many species of large live-bearing cockroach, however, the females are wingless and burrow under wood and stones.

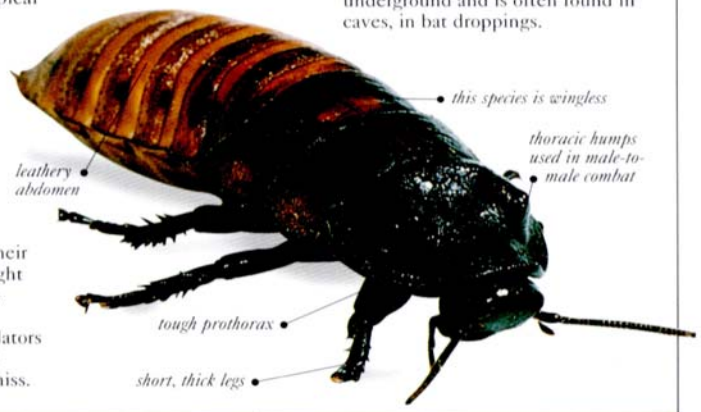
• **LIFE CYCLE** In some species, courtship rituals involve the production of sounds. Males of *Nauphoeta cinerea*, for example, make sounds by rubbing a ridged part of the forewing against the hind corners of the pronotum. Most species reproduce by producing eggs that develop inside an egg case. The egg case is fully extended from the end of the female's abdomen, rotated by 90 degrees, and then drawn back into the body to be brooded.

• **OCCURRENCE** Tropical regions. In a range of habitats including rainforests and caves.

• **REMARK** Some species are reared as laboratory animals.



PYCNOSCELIS SURINAMENSIS is a widespread tropical pest. It lives underground and is often found in caves, in bat droppings.



GROMPHADORHINA PORTENTOSA males use their large thoracic humps to fight each other. Also known as the Madagascan Hissing Cockroach, it startles predators by squeezing air out of its spiracles to create a loud hiss.

Length 1–2½in (2.5–6cm), rarely up to 3¼in (9.5cm)	Feeding habits

Order BLATTODEA	Family BLATTIDAE	No. of species 600

COMMON COCKROACHES

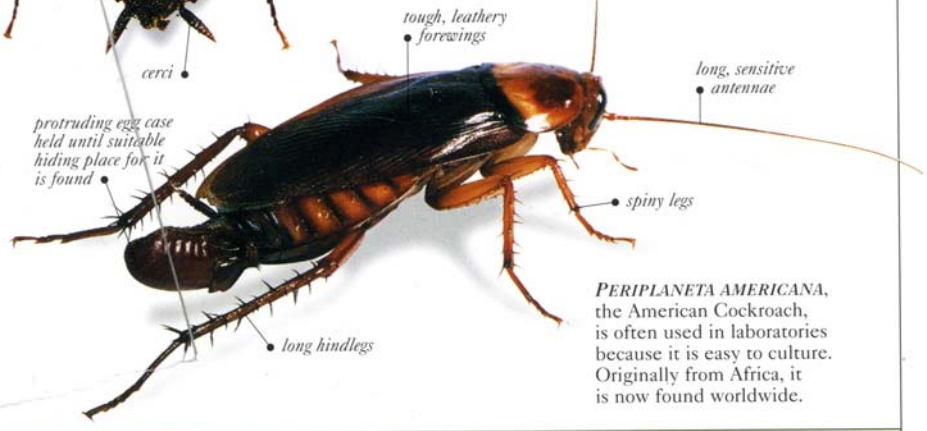
Most species in this family are brown, red-brown, or black-brown, with varied markings. They are highly active, can run very fast, and fly in hot conditions. They usually hide during the day, coming out to feed after dark. Some species produce repellent chemicals that can cause skin rashes and temporary blindness. They eat a range of organic matter and food scraps, regurgitating already digested food and leaving behind their feces and a characteristic unpleasant smell.

• **LIFE CYCLE** Males may have special glands on their back, which secrete chemicals that lure a mate into a suitable position for copulation. Females can produce up to 50 egg cases, each containing 12–14 eggs. The egg cases may be deposited on, buried in, or stuck to a variety of surfaces.

• **OCCURRENCE** Mostly in tropical and subtropical regions. Pest species are found around ports, warehouses, sewers, and garbage dumps.

△ *BLATTA ORIENTALIS*, known as the Oriental Cockroach, is a common domestic pest. Like many species, it has spread beyond its native region by traveling on ships.

◁ *NEOSTYLOPYGA RHOMBIFOLIA*, the Harlequin Cockroach, produces a sharp-smelling chemical (amyl acetate), which it uses to defend itself against predators.



PERIPLANETA AMERICANA, the American Cockroach, is often used in laboratories because it is easy to culture. Originally from Africa, it is now found worldwide.

Length ¼–1¼in (2–4.5cm)	Feeding habits

Order BLATTODEA	Family BLATTELLIDAE	No. of species 1,750

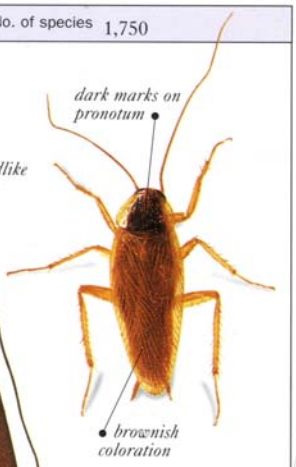
BLATTELLIDS

Many of these insects are pale brown but a few are olive-green. Darker brown markings are common, typically on the wings and pronotum. They often appear shiny. Both sexes usually have fully developed wings.

• **LIFE CYCLE** Adults and nymphs are scavengers. Females can be very fertile, breeding five to six times a year and producing about 40 eggs each time. In many species, eggs are carried in a case protruding from the abdomen, which is dropped to the ground just before they hatch.

• **OCCURRENCE** Worldwide, especially in warmer areas. In woodland litter, debris, garbage dumps, and buildings.

△ ***LOBOPTERA DECIPIENS*** is a wingless species, found in Europe. It lives in leaf litter and under stones and bark.



△ ***BLATTELLA GERMANICA***, the German Cockroach, is a common pest of houses, kitchens, and stores. Females can produce thousands of eggs in a lifetime.

MEGALOBLATTA LONGIPENNIS, from Peru, Ecuador, and Panama, is the largest winged cockroach in the world. Its wingspan can measure up to 8in (20cm).

Length 1/16–4in (0.8–10cm), most under ¾in (2cm)	Feeding habits

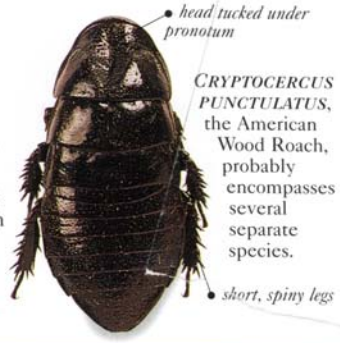
Order BLATTODEA	Family CRYPTOCERCIDAE	No. of species 4

WOOD ROACHES

The wood roaches are the most primitive cockroaches and belong to a single genus: *Cryptocercus*. They are quite elongate and are shiny dark brown to black.

• **LIFE CYCLE** Wood roaches live in small family groups comprising two adults and up to 20 nymphs. They tunnel through dead wood – sticking their eggs to the roof of the wooden chambers – and use special symbiotic protozoans in their gut to break down the wood cellulose into sugars. Each time nymphs molt, they eat some of the group's droppings, thus reinfecting themselves with the protozoans.

• **OCCURRENCE** North America and China. In dead wood in a variety of habitats.



CRYPTOCERCUS PUNCTULATUS, the American Wood Roach, probably encompasses several separate species.

Length ¼–1¼in (2–3cm)	Feeding habits

WEB-SPINNERS

A RELATIVELY SMALL GROUP, the order Embioptera contains just 8 families and 300 species. Web-spinners are gregarious insects whose common name is derived from their ability to make expansive silk tunnels in soil, in litter, and under bark. These are used for protection against predators.

Web-spinners' legs are short. Adults and young of all species have a swollen tarsal segment on their front legs, which contains silk glands. The silk is ejected through the many bristlelike structures found on the underside of the segments. As the insect moves its front feet against a surface, a silk sheet gradually forms.

Females are wingless, while the males typically have two pairs of narrow wings. The females and nymphs remain within the colony, but adult males fly off to find mates in other colonies. Metamorphosis in this order is incomplete.

Order EMBIOPTERA | Family CLOTHODIDAE | No. of species 14

CLOTHODIDS

The members of this family are typically long and cylindrical in shape, with short legs. They have simple biting mouthparts. The front legs of both adult and young clothodids have swollen tarsal segments that contain many silk glands. The eyes are small, and the antennae have 10–35 segments.

• **LIFE CYCLE** Males do not feed but use their mandibles to hold onto females during mating. There is a great deal of maternal care. The female covers her eggs with silk and bits of detritus. After the eggs hatch, the female may feed her young prechewed food.

• **OCCURRENCE** Worldwide, in tropical and subtropical regions. In a wide variety of habitats, from rainforest to desert.

CLOTHODA URICHI, seen here inside its silken web, is a native of Trinidad and is either communal or solitary. Both types live in the same silk nest as their nymphs, but communal females produce more eggs than solitary females.

Length 1/16–1/4in (0.5–2cm) | Feeding habits

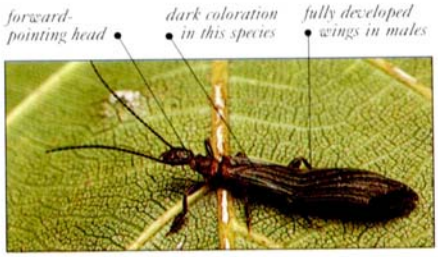
Order EMBIOPTERA | Family EMBIIDAE | No. of species 250

EMBIIDS

These colony-living web-spinners are usually quite stout. Males have two pairs of wings that bend forward, as is typical of the order. This allows them to move backward in the colony's galleries. When flying, a substance is pumped into a special wing vein to stiffen each wing.

• **LIFE CYCLE** Eggs are laid in silk-lined galleries. The female guards the eggs and young until they disperse.

• **OCCURRENCE** South America and Africa. In various habitats, in bark, tree holes, and cracks, and under stones and rocks.



***EMBIID* SPECIES** have very similar characteristics to members of the family Clothodidae (see above).

Length 1/16–1/4in (0.5–2.2cm) | Feeding habits

TERMITES

THE 7 FAMILIES AND 2,750 species in the order Isoptera are never found more than 50 degrees north or south of the Equator. A typical termite is pale, soft, and wingless, with chewing or biting mandibles and short antennae, but the different castes within a colony have varying features. The reproductives, including kings and queens, have two pairs of long wings, short cerci, and round or oval heads. The sterile soldiers have proportionately larger heads than the workers. Eyes are often reduced or absent. Metamorphosis is incomplete.

Termites live in mud nests or vast underground mazes with huge ventilation chimneys above ground. Most eat dead or rotting wood – this is the only order in which all families digest cellulose – and many attack crops or wooden buildings.

Order ISOPTERA | Family HODOTERMITIDAE | No. of species 19

HARVESTER TERMITES

These termites have eyes, and their mandibles have large, distinct teeth on the inner surfaces. They are cream or light to dark brown in color. The pronotum is saddle-shaped, extending down at the sides.

• **LIFE CYCLE** Eggs are laid in the colony's nest, which may be up to 20ft (6m) under the ground. Workers forage above ground for grass or small bits of wood to feed the young.

• **OCCURRENCE** Africa and Asia. In regions of dry savanna. In soil.

• **REMARK** These termites can be pests of open pasture. They may eat the food of larger herbivores – both wild animals and domestic cattle – and encourage soil erosion.

***HODOTERMES* SPECIES** are widespread in African savannas and always make underground nests. During the day, they can be seen running along the ground, collecting grass and pieces of twigs.

Length 1/2–3/4in (0.4–1cm) – soldiers and workers only | Feeding habits

Order ISOPTERA | Family RHINOTERMITIDAE | No. of species 345

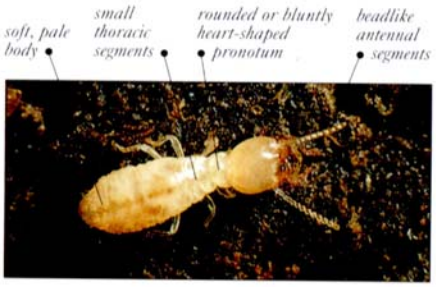
SUBTERRANEAN TERMITES

The pronotum of all castes is rounded at the back and may, in some species, appear almost heart-shaped. Soldiers have no eyes. Coloration is cream or light to dark brown.

• **LIFE CYCLE** Eggs are laid in the colonies, which are found either in soil or in damp wood that touches the ground.

• **OCCURRENCE** Worldwide, in warm regions. In various habitats, in soil and wood.

• **REMARK** Some species are timber pests. One North American species is such a serious pest that there are special building regulations to help prevent the damage it can cause.



RETICULITERMES LUCIFUGUS makes its nest under the ground, inside damp wood. These pale, soft-bodied termites, with distinctive antennae, are found throughout southern Europe.

Length 1/16–5/16in (2–8mm) – soldiers and workers only | Feeding habits

Order ISOPTERA	Family TERMITIDAE	No. of species 1,950

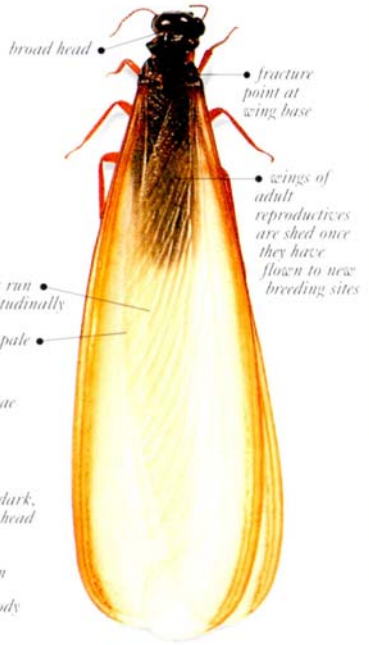
HIGHER TERMITES

This highly variable family of pale cream to dark brown termites comprises almost three-quarters of all termites. Workers and soldiers have no eyes, and soldiers often have large, biting mandibles or a snoutlike head from which sticky poisons are ejected.

• **LIFE CYCLE** Eggs are laid in nests that vary from small structures in trees and soil mounds to vast underground mazes. Some queens are enormous and may produce several thousand eggs a day.

• **OCCURRENCE** Worldwide, in tropical and subtropical areas. In varied habitats, in trees or soil.

• **REMARK** Many higher termites are pests. This family has a more complex, rigid caste system than other, "lower" termites.



TRINERVITERMES GEMINATUS, or the Snouted Harvester Termite, has soldiers that can produce a repellent secretion from a gland in their head. This is used against their main enemies – ants.

MACROTERMES **SPECIES** can attack cocoa and coconut crops. At certain times of year, reproductive adults like this one emerge from colonies in their thousands.

Length ½–⅝in (0.4–1.4cm) – soldiers and workers only	Feeding habits

Order ISOPTERA	Family TERMOPSIDAE	No. of species 20

TRUE DAMP WOOD TERMITES

These termites, pale to dark brown in color, are also called rotten wood termites. The flat pronotum is much narrower than the head.

• **LIFE CYCLE** Eggs are laid in nests in decaying wood – usually wood that is in contact with the ground.

• **OCCURRENCE** Warm regions of North and South America, Africa, Asia, and Australia. Mainly in rotting trees or fallen logs.

• **REMARK** A few species are pests of structural timbers, especially those buried in the ground, such as telegraph poles.

ZOOTERMOPSIS ANGUSTICOLLIS, the Pacific Damp Wood Termite, is native to North America, where it can become a troublesome pest of damp timber found above the ground.

Length ¼–⅛in (3–6mm) – soldiers and workers only	Feeding habits

ANGEL INSECTS

THE ORDER ZORAPTERA consists of a single family divided into 29 species. Discovered in the early twentieth century, these small, delicate, termitelike insects are light straw to dark brown or blackish in color. The adults of most species come in two forms. One form has no eyes or ocelli, and is pale and wingless like the nymphs. The other form has eyes and three ocelli, dark coloration, and two pairs of wings with minimal venation. The winged forms are responsible for dispersal to new locations when the habitat becomes unsuitable for some reason. When a new site is found, the wings are shed. Both wingless and winged angel insects have short abdominal cerci and unspecialized, downward-pointing mouthparts, which resemble those seen in crickets and grasshoppers (see pp.60–65). The tarsi are divided into two segments.

Metamorphosis is incomplete, and the nymphs vary in appearance depending on whether or not they have wings as adults. Native to North and South America, Africa, and parts of eastern Asia, these insects live gregariously under the bark of rotting trees and in wood dust and damp leaf litter. Some are associated with termite colonies.

Order ZORAPTERA	Family ZOROTYPIDAE	No. of species 29

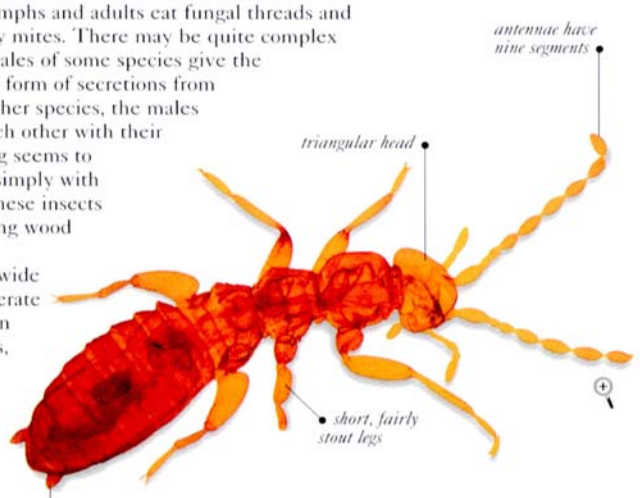
ANGEL INSECTS

These insects are pale and wingless, or darker and winged. The body has an oval abdomen, and the distinctly triangular head carries a pair of antennae with nine beadlike segments.

• **LIFE CYCLE** Both nymphs and adults eat fungal threads and small arthropods, especially mites. There may be quite complex sexual behavior, and the males of some species give the females mating gifts in the form of secretions from glands in their heads. In other species, the males fight for mates, kicking each other with their hindlegs. Success in mating seems to increase with age and not simply with size. Eggs are laid where these insects live, in places such as rotting wood or leaf litter.

• **OCCURRENCE** Worldwide in tropical and warm temperate regions, except Australia. In rotting wood, sawdust piles, and leaf litter, and under tree bark.

• **REMARK** All the known species are contained in the single genus, *Zorotypus*.



ZOROTYPUS HUBBARDI is pale to dark brown in real life – this is a slide-mounted specimen that has been stained red. Native to eastern and southern US, this species is found in sawdust and rotting logs and under dead bark.

Length 1/16–1/4in (2–3mm)	Feeding habits

BARKLICE AND BOOKLICE

COMMONLY KNOWN as barklice and booklice, the order Psocoptera contains 35 families and 3,000 species. Drab and soft-bodied, these common insects are often overlooked. The large head has a bulbous forehead, bulging eyes, and long, threadlike antennae. The thorax appears humped when seen from the side, and there are usually two pairs of membranous wings, held rooflike over the body when folded. A few species bear live young, but most lay eggs. Metamorphosis is incomplete, and there are usually five nymphal stages.

These insects are found in a range of terrestrial habitats, from soil to tree canopies, where they eat algae, lichens, molds, and fungal spores. Some eat pollen and plant tissues. Many species are solitary but some can be gregarious.

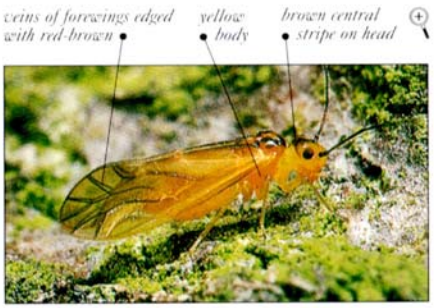
Order PSOCOPTERA	Family CAECILIDAE	No. of species 330

CAECILIIDS

Most caeciliids are brown, yellow, or green in color and either fully winged or short-winged – very few are wingless. The wings may have markings, and the front edge of the forewings and wing veins are covered in short hairs.

• **LIFE CYCLE** Typically, a batch of 12–16 eggs is laid on leaves. Where there is more than one generation each year, the autumn-laid eggs fall with the leaves on to the leaf litter and hatch out in spring.

• **OCCURRENCE** Worldwide. In a range of habitats. Commonly in the foliage of deciduous trees and in low-growing vegetation and grasses. A few are found among leaf litter.



CAECILIUS FLAVIDUS is abundant on the leaves of many deciduous trees. This species is native to Europe, including the British Isles.

Length ⅛–⅜in (1.5–4mm)	Feeding habits

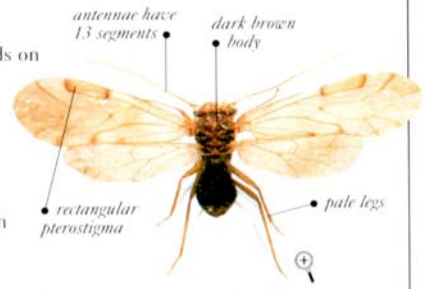
Order PSOCOPTERA	Family ECTOPSOCIDAE	No. of species 150

ECTOPSOCIDS

These pale brown species may have dark brown bands on their abdomen. The head is covered with hairs. They have fairly small eyes and 13-segmented antennae that are quite long in males but shorter in females.

• **LIFE CYCLE** Females lay batches of eggs on the veins of dead or withering leaves and cover them with silk threads produced by special glands. In good conditions – a hospitable, disease-free environment with ample food – populations can become very large. The adultlike nymphs are hairy and feed on fungal threads, rotting matter, algae, and sometimes on pollen.

• **OCCURRENCE** Worldwide. In various habitats. Among the dry leaves of various deciduous tree species or in leaf litter. Some species occur in greenhouses or in houses.



ECTOPSOCUS BRIGGSI is a European species, found on deciduous trees. Most members of this species have fully developed wings, although short-winged forms occur occasionally.

Length ⅛–⅜in (1.5–3.5mm)	Feeding habits

Order PSOCOPTERA	Family LIPOSCELIDAE	No. of species 150

LIPOSCELID BOOKLICE

These insects have flat bodies and distinctively swollen femora on their hindlegs. Most liposcelid booklice have no wings, although winged forms do occur. The head has a pair of short antennae and small eyes.

• **LIFE CYCLE** The female lice lay their eggs in places such as leaflitter, crevices in tree bark, and birds' nests. Their nymphs look much like small adults although they have shorter antennae.

• **OCCURRENCE** Worldwide. In dry leaf litter, under bark, and in nests. Some are found inside buildings and food stores.

• **REMARK** Some species can be pests. Several species in the genus *Liposcelis* will thrive in damp conditions and can attack stored flour, cereals, books, and papers. They have also been known to do considerable damage to museum collections of plants and insects.

LIPOSCELIS TERRICOLIS is a very widely distributed species of booklice. It is found in leaf litter and in a variety of stored, dry produce, where it can become a pest.

Length ¼₄–⅛in (0.5–1.5mm)	Feeding habits

Order PSOCOPTERA	Family PSOCIDAE	No. of species 500

COMMON BARKLICE

Most common barklice have dull brown, gray, or blackish coloration, and many species have pale markings. The wings are hairless and may also be mottled with spots and irregular patches.

• **LIFE CYCLE** The females lay their eggs singly or in groups, usually inside crevices in tree bark. The life cycle of a typical barklouse may take a little over two months; there are usually several generations in a year. Most species feed on fungi, pollen, algae, and lichen.

• **OCCURRENCE** Worldwide. On the bark, branches, and twigs of a wide variety of trees and shrubs. Some of the most common species in this order belong to this family, and enormous populations can be found on certain trees.

PSOCOCERASTIS GIBBOSA is native to Europe and parts of Asia. It is found on a number of tree species and is the largest member of its genus in the British Isles.

Length ½₂–¼in (1–6mm)	Feeding habits

PARASITIC LICE

THE 25 FAMILIES and 6,000 species in the order Phthiraptera are commonly called parasitic lice. These flattened-looking insects are wingless ectoparasites, living permanently on the bodies of birds and mammals without killing them. The mouthparts are used for biting skin, feather, or fur but in the sucking lice they are used exclusively for feeding on blood. The legs are short and are often modified for clinging onto either fur or feathers. Metamorphosis is incomplete in this order.

Different lice are linked with specific hosts, such as the species with distinctive mouthparts that are found only on warthogs and African elephants. Many lice are also restricted to certain areas of the body, so more than one species can inhabit a host at the same time.

Order PHTHIRAPTERA | Family MENOPONIDAE | No. of species 650

BIRD LICE

These lice have oval abdomens and short, stout legs. The large, roughly triangular head has biting mandibles.

• **LIFE CYCLE** Eggs are glued singly to feathers. The majority of species feed on feather fragments, but some also take blood and skin secretions.

• **OCCURRENCE** Worldwide. On a variety of birds.

• **REMARK** Some species, such as *Menopon gallinae* (the Shaft Louse), can be serious poultry pests.

MENACANTHUS STRAMINEUS, the Chicken Body Louse, is a widespread species. Infestation can lead to feather-loss and infection.

Length ½–¼in (1–6mm), most under ⅛in (4mm) | Feeding habits

Order PHTHIRAPTERA | Family PEDICULIDAE | No. of species 2

HUMAN LICE

These lice are small, pale, and elongate, with short, strongly clawed legs for gripping onto their hosts. The small head bears distinctively dark eyes. The human louse, *Pediculus humanus*, also occurs on some monkeys. It has two subspecies: *P. humanus* subsp. *corporis* (the Body Louse) and *P. humanus* subsp. *capitis* (the Head Louse). The other species in the family, *P. schaeffi*, is found exclusively on apes.

• **LIFE CYCLE** The Body Louse lives and lays eggs in the fibers of clothing, whereas the Head Louse lives entirely in hair and glues its eggs (nits) to hair.

• **OCCURRENCE** Worldwide. On humans, apes, and monkeys.

• **REMARK** Outbreaks of head lice are common among young children. Resistance to insecticidal shampoos is developing and regular washing and fine combing is often just as effective. Up until World War II, many more soldiers died of louse-borne epidemic typhus and relapsing fever than were ever killed in battle.

PEDICULUS HUMANUS CAPITIS, like all human lice, has mouthparts specially adapted for sucking blood.

PEDICULUS HUMANUS CORPORIS, the Body Louse, lives in people's clothing and can transmit the organism that causes typhus.

Length ½–¼in (1.5–3.5mm) | Feeding habits

Order PHTHIRAPTERA	Family PTHIRIDAE	No. of species 2

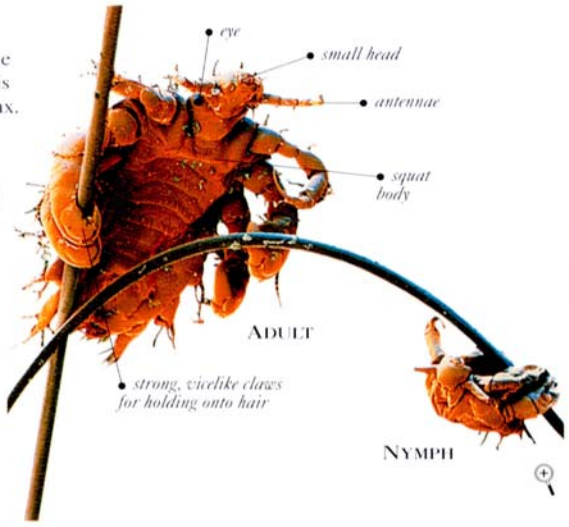
PUBIC LICE

These pale to translucent lice have a squat, flat body and a head that is very much narrower than the thorax. The middle and hindlegs are especially stout and have strong claws for gripping onto hair shafts. The family consists of the Human Pubic Louse, *Pthirus pubis*, and the Gorilla Pubic Louse, *Pthirus gorillae*.

• **LIFE CYCLE** After mating, the female uses a strong, waterproof glue to stick her eggs singly to pubic hairs. Both nymphs and adults feed on the host's blood, leaving bluish marks on the skin.

• **OCCURRENCE** Wherever their hosts live. The Human Louse is found worldwide.

• **REMARK** Contrary to popular belief, these very slow-moving lice do not jump and can transfer to new hosts only during intimate contact.



PTHIRUS PUBIS, the Human Pubic Louse, may be found in armpits and beards as well as the groin. Although unpleasant, it is not known to transmit disease.

Length 1/16–3/32in (1.5–2.5mm)	Feeding habits

Order PHTHIRAPTERA	Family TRICHODECTIDAE	No. of species 350

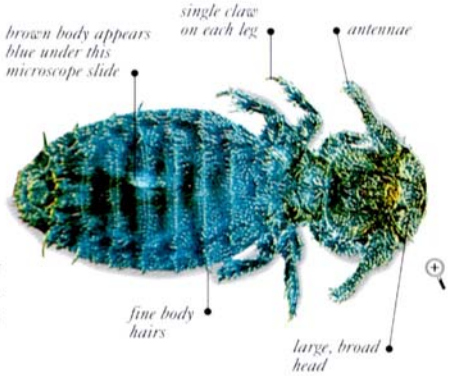
MAMMAL CHEWING LICE

Generally pale brown in color, these lice have large, square heads with conspicuous, short antennae and distinctive mandibles. The legs are short, each with a single tarsal claw. Females have blunt-ended abdomens, while those of males are slightly pointed. The name comes from the fact that these lice live on mammals such as horses, cattle, sheep, goats, dogs, and cats, as well as nondomesticated species.

• **LIFE CYCLE** Eggs are laid on the hairs or fleece of hosts. This is also where the nymphs live, eating tiny pieces of skin, hair, sebaceous gland secretions, and, sometimes, blood.

• **OCCURRENCE** Worldwide. On their mammalian hosts.

• **REMARK** The Dog Louse carries tapeworms. Infestations affect animals' health because they spend more time grooming than feeding.



DAMALINIA ORIS is a small louse found on sheep all over the world. A badly infected sheep may carry over 750,000 lice.

Length 1/32–1/8in (1–3mm)	Feeding habits

BUGS

THE ORDER HEMIPTERA consists of 134 families and 82,000 species. Bugs range from minute, wingless insects to giant water bugs that can catch fish and frogs. They are found in all terrestrial habitats, in freshwater, and even on the surface of southern oceans.

Modern classification recognizes four suborders: the Coleorrhyncha (just one family); the Heteroptera (true bugs); the Auchenorrhyncha (plant-, leaf-, and tree-hoppers, lantern bugs, and cicadas); and the Sternorrhyncha (jumping plant lice, whiteflies, aphids, and scale insects). The selection below is divided into true bugs (Acanthosomatidae to Tingidae); hoppers and relatives (Aphrophoridae to Membracidae); and aphids and relatives (Aleyrodidae to Psyllidae).

Only the true bugs include predacious and blood-sucking species; the others are herbivorous. All bugs have piercing, sucking mouthparts in the form of a long rostrum made up of slender stylets sheathed by the labium. Many bugs that suck plant sap are serious crop pests.

Metamorphosis is incomplete. Eggs are laid in and on vegetation and soil, and under bark. There are typically about five nymphal stages. Some bugs produce live young, and others reproduce without the need for males.

Order HEMIPTERA | Family ACANTHOSOMATIDAE | No. of species 250

ACANTHOSOMATID BUGS

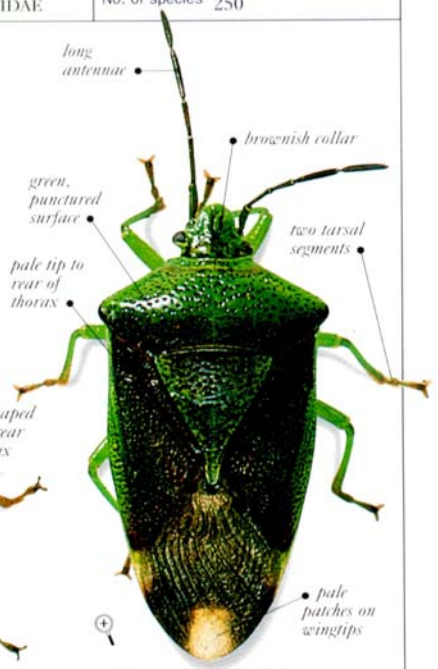
These bugs are similar to their close relations, the shield-backed bugs (see p.94). They are usually green, brown, or gray, although some are brightly colored. The head is small, and the body is oval or tapers behind the wide pronotum.

• **LIFE CYCLE** Eggs are laid on host shrubs and trees. Nymphs and adults suck sap from these plants.

• **OCCURRENCE** Worldwide, especially in warm regions. In various habitats such as woods, meadows, and scrubland, wherever their host plants are found.

• **REMARK** Some females guard the eggs until they hatch. Small nymphs may shelter under their mother's body when predators threaten.

▷ *ELASMUCHA GRISEA* is called the Parent Bug because of its advanced maternal behavior. It feeds on birch foliage.



△ *ELASMOSTHETUS INTERSTINCTUS*, the European Birch Shield Bug, favors mixed woodland and also feeds on hazel and aspen.

Length 1/16–1in (0.5–2.4cm) | Feeding habits

Order HEMIPTERA	Family ALYDIDAE	No. of species 300

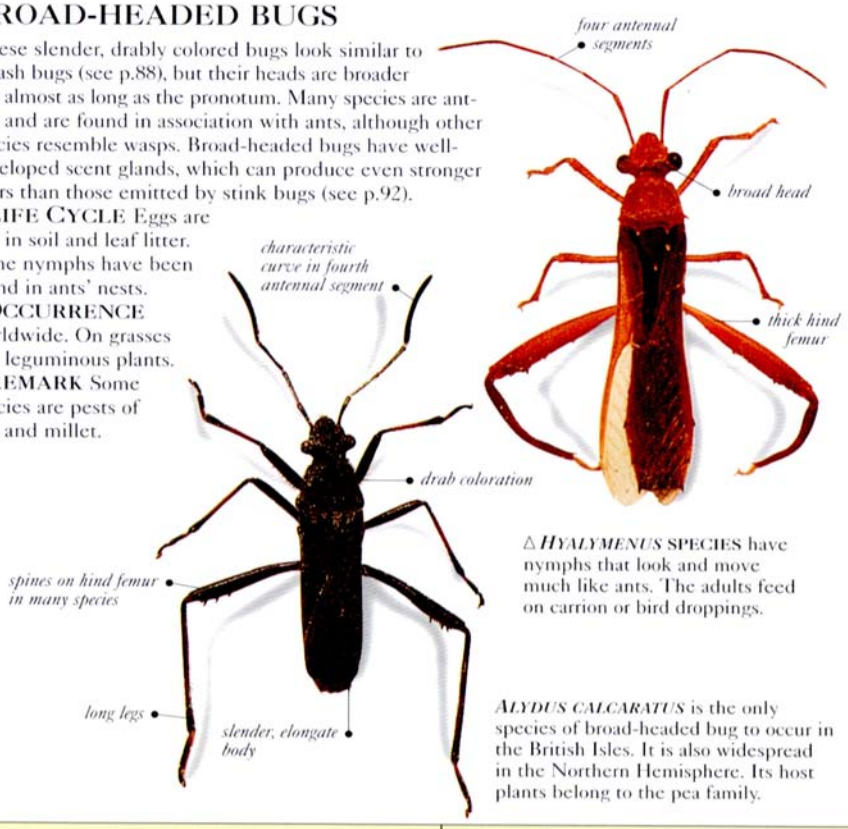
BROAD-HEADED BUGS

These slender, drably colored bugs look similar to squash bugs (see p.88), but their heads are broader and almost as long as the pronotum. Many species are ant-like and are found in association with ants, although other species resemble wasps. Broad-headed bugs have well-developed scent glands, which can produce even stronger odors than those emitted by stink bugs (see p.92).

• **LIFE CYCLE** Eggs are laid in soil and leaf litter. Some nymphs have been found in ants' nests.

• **OCCURRENCE** Worldwide. On grasses and leguminous plants.

• **REMARK** Some species are pests of rice and millet.



△ ***HYALYMENUS* SPECIES** have nymphs that look and move much like ants. The adults feed on carrion or bird droppings.

ALYDUS CALCARATUS is the only species of broad-headed bug to occur in the British Isles. It is also widespread in the Northern Hemisphere. Its host plants belong to the pea family.

Length ⅛–1in (1–2.6cm)	Feeding habits

Order HEMIPTERA	Family ANTHOCORIDAE	No. of species 500

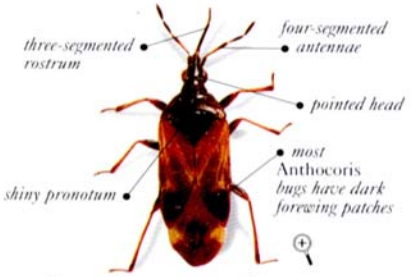
FLOWER BUGS

Also known as minute pirate bugs, species in this family have relatively flat bodies that can be elongate or oval. Most flower bugs have fully developed wings, but the wings are short in some species. The antennae have four segments.

• **LIFE CYCLE** Eggs are laid in small groups on the undersides of leaves or leaf stalks. They may also be laid in stems, bark, or debris.

• **OCCURRENCE** Worldwide. Under bark and in flowers, vegetation, leaf litter, and fungi. Some live in animal nests and burrows.

• **REMARK** These bugs are used to control aphids, thrips, scale insects, moths, and mites.



***ANTHOCORIS* SPECIES** lay eggs on leaves infested with prey such as aphids. *Anthocoris* bugs are attracted to odors given off by their prey.

Length 1/16–1/8in (2–5mm)	Feeding habits

Order HEMIPTERA | Family ARADIDAE | No. of species 1,800

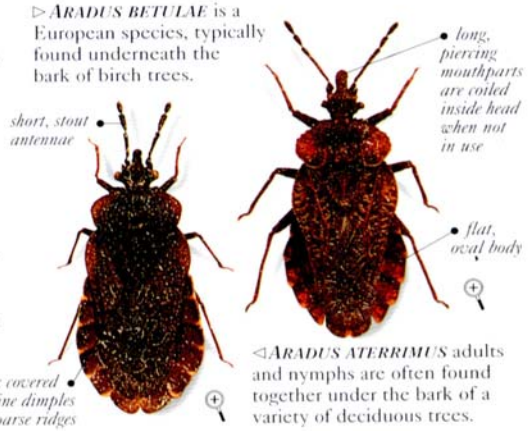
BARK BUGS

Also known as flat bugs, these insects have a flat, oval shape and many are wingless. They always have black or dark to reddish brown camouflage coloring, and the upper surface of the body is very rough or has short projections or dimples.

• **LIFE CYCLE** Eggs are laid in a small mass under bark or in leaf litter. A few species care for their young, and the male may share this role.

• **OCCURRENCE** Worldwide. Most under bark, especially of decaying trees; among plant debris and leaf litter on the forest floor; among certain fungi.

▷ ***ARADUS BETULAE*** is a European species, typically found underneath the bark of birch trees.



◁ ***ARADUS ATERRIMUS*** adults and nymphs are often found together under the bark of a variety of deciduous trees.

Length ⅛–½in (0.3–1.3cm) | Feeding habits

Order HEMIPTERA | Family BELOSTOMATIDAE | No. of species 150

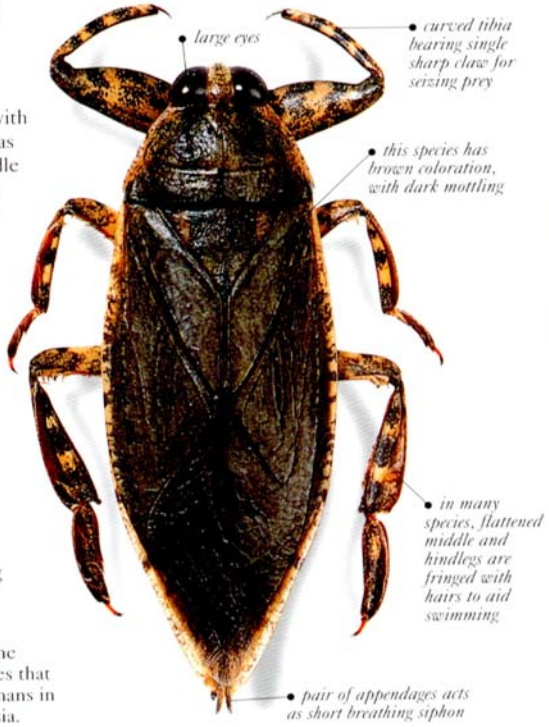
GIANT WATER BUGS

Also called electric light bugs due to their attraction to lights after dark, this family contains the largest bugs. They are oval, flat, and streamlined with enlarged front legs that are modified as prey-capturing pincers. The flat middle and hindlegs are usually fringed with hairs to aid swimming. The antennae are small and concealed.

• **LIFE CYCLE** Males can attract mates by using their bodies to send waves across the water's surface. Females may glue the eggs to the male's back or to vegetation. In back-brooding species, male giant water bugs care for the eggs and keep them moist.

• **OCCURRENCE** Worldwide, especially in subtropical and tropical regions. In slow-moving streams, pools, and ponds.

• **REMARK** Nymphs and adults are highly predacious, even catching frogs, fish, and small birds.



LETHOCERUS GRANDIS is one of the giant water bug species that are caught and eaten by humans in certain parts of Southeast Asia.

Length ⅛–4in (1.5–10cm) | Feeding habits

Order HEMIPTERA | Family CIMICIDAE | No. of species 90

BED BUGS

These flat, oval, wingless bugs are usually reddish or brown. As well as humans, many species use other mammals and birds as hosts.
• **LIFE CYCLE** Eggs are laid in crevices in the adults' resting place. Each of the five nymphal stages needs a huge meal of blood. The life cycle spans two to ten months.
• **OCCURRENCE** Worldwide. On hosts, in nests and caves, and in crevices in buildings.

CIMEX LECTULARIUS is the best-known species, long associated with humans. It feeds at night and finds hosts partly by sensing their body heat.

Length ⅛–¼in (3–6mm) | Feeding habits

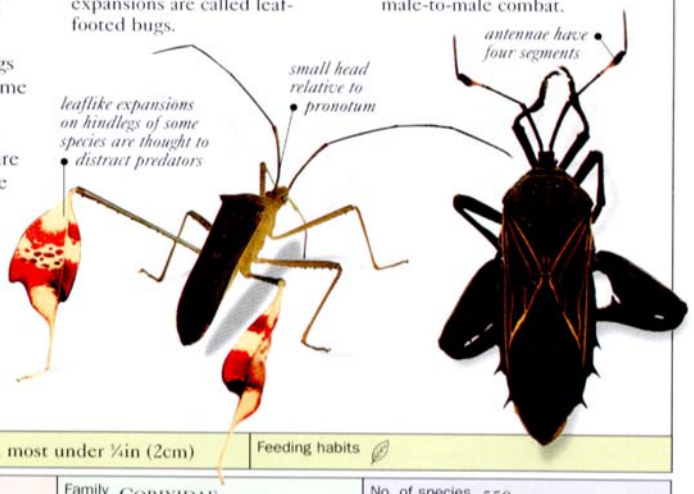
Order HEMIPTERA | Family COREIDAE | No. of species 2,000

SQUASH BUGS

The name of this family is derived from the fact that some species use squash plants as hosts. These bugs are mainly dull brown. Some are bright red, yellow, or green. A few are metallic.
• **LIFE CYCLE** Eggs are laid on host plants. There are five nymphal stages, and from hatching to adulthood can take as little as three weeks.
• **OCCURRENCE** Worldwide, especially in warmer regions. On a range of plants. Some species are crop pests.

DIACTOR SPECIES and related genera with leaflike expansions are called leaf-footed bugs.

THASUS ACUTANGULUS has very strong hindlegs, used in male-to-male combat.



Length 3/32–1½in (0.7–4.2cm), most under ¼in (2cm) | Feeding habits

Order HEMIPTERA | Family CORIXIDAE | No. of species 550

WATER BOATMEN

These swimming bugs rest under the water surface or cling to plants. Usually dark red- or yellow-brown, their short front legs form a food scoop; the slim middle legs grip plants; and the oarlike hind pair are used for swimming.
• **LIFE CYCLE** These attract mates by rubbing body parts together. Eggs are glued to submerged objects and plants.
• **OCCURRENCE** Worldwide. In pools, ponds, lakes, and slow streams.

▽ *CALLICORIXA WOLLASTONI* is probably predacious and in some areas is found in peaty upland pools.

△ *CORIXA PUNCTATA* is adapted for swimming, like its relatives, but will also fly readily.

Length ⅛–⅜in (0.3–1.5cm) | Feeding habits

Order HEMIPTERA	Family GELASTOCORIDAE	No. of species 90

TOAD BUGS

All members of this family can jump onto their prey, and many have a bumpy or warty appearance. Oval and broad in shape, with bulging, toadlike eyes, their camouflage coloring blends in with mud, sand, or shingle.

• **LIFE CYCLE** Eggs are laid in plant debris or wet soil. The nymphs have good sight.

• **OCCURRENCE** Worldwide, especially in the Southern Hemisphere. By ponds and streams; in rotten wood and leaf litter; and under stones.

NERTHRA GRANDICOLLIS is a typical toad bug in appearance. This common genus is the largest in the family.

Length 1/32–5/8in (0.7–1.4cm)	Feeding habits

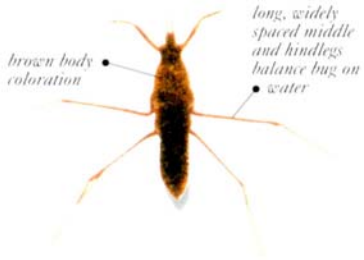
Order HEMIPTERA	Family GERRIDAE	No. of species 500

POND-SKATERS

Also known as water-striders, these very fast-moving, often wingless bugs are adapted to living on the surface of water. The body is dark brown or black and thickly covered with velvety, water-repelling hairs. Long middle and hindlegs spread the bug's weight evenly over the water surface.

• **LIFE CYCLE** "Ripple communication" is used to attract mates. Egg masses are laid on submerged plants or floating objects or inserted into plant stems.

• **OCCURRENCE** Worldwide. In water bodies ranging from small pools and ponds to streams, rivers, lakes, and warm oceans.



***GERRIS* SPECIES** are widespread and may be found living on running water. Attracted by the ripples made by prey, they move rapidly to seize their quarry on the surface.

Length 1/16–1 1/4in (0.2–3.5cm), most 1/8–5/8in (1–1.5cm)	Feeding habits

Order HEMIPTERA	Family HYDROMETRIDAE	No. of species 120

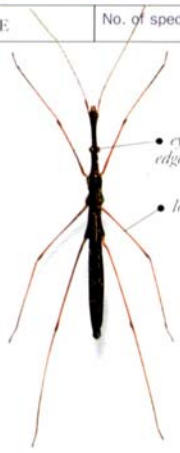
WATER-MEASURERS

Also called marsh-treaders, these delicate bugs are elongate, slender, with threadlike legs. They are reddish to dark brown in color. The head is very long, with protruding eyes about halfway along its length. Most water-measurers are wingless, but winged forms sometimes occur in certain species.

• **LIFE CYCLE** The long eggs are laid singly, glued to vegetation or pond edges, above the water.

• **OCCURRENCE** Worldwide, especially in tropical and subtropical regions. On marginal or floating plants of ponds, pools, marshes, and swamps.

• **REMARK** Nymphs and adults prefer prey that is injured or freshly dead. They are particularly fond of mosquito eggs and similar immobile food items.



HYDROMETRA STAGNORUM holds prey with its mouthparts, rather than its front legs. It sometimes sucks the body juices of dead insects.

Length 1/8–1/2in (0.3–2.2cm)	Feeding habits

Order HEMIPTERA	Family MIRIDAE	No. of species 8,000

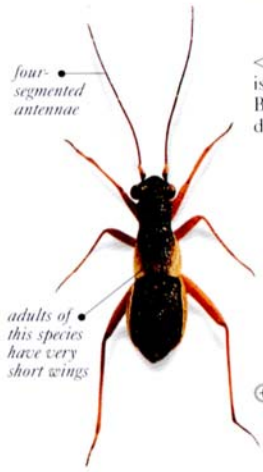
PLANT BUGS

These elongate or oval bugs are usually quite delicate and fragile. The different species display a great diversity of colors and markings.

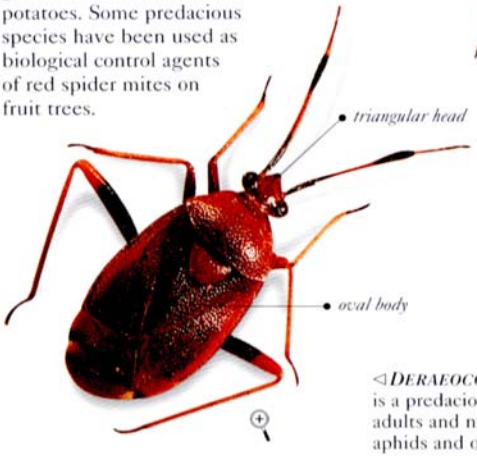
• **LIFE CYCLE** Eggs are typically inserted inside plant tissues. There are five nymphal stages. The nymphs – and adults – of most species suck plant sap, but many will attack small, soft-bodied prey such as aphids and scale insects.

• **OCCURRENCE** Worldwide. In a wide range of well-vegetated habitats.

• **REMARK** Many plant bug species are pests, damaging crops such as grasses, cotton, coffee, and potatoes. Some predacious species have been used as biological control agents of red spider mites on fruit trees.



◁ *PITHANUS MAERKELI* is found throughout the British Isles, usually in damp meadows.



◁ *DERAEOCORIS RUBER* is a predacious species. Both adults and nymphs feed on aphids and other small insects.

▷ *LYGOCORIS PABULINUS*, or the Common Green Capsid, is widespread in Europe and a serious pest of fruit crops.

Length 1/16–5/8in (0.2–1.6cm)	Feeding habits

Order HEMIPTERA	Family NAUCORIDAE	No. of species 400

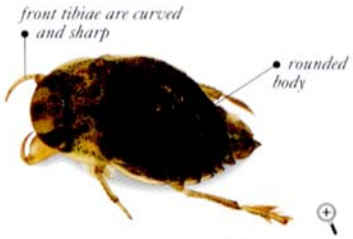
SAUCER BUGS

Also called creeping water bugs, these flat insects have a smooth oval or rounded body. Most are dark brown to black. The front legs are used to catch prey, while the hindlegs are used for swimming.

• **LIFE CYCLE** Eggs are inserted, in rows, into the stems of aquatic plants.

• **OCCURRENCE** Worldwide. In ponds, streams, and, occasionally, hot springs.

• **REMARK** Air from the surface is trapped under the folded wings, helping the bugs stay alive and making them buoyant as they feed underwater.



ILYOCORIS CIMICOIDES is found in Europe. Despite having fully developed wings, this species rarely, if ever, flies.

Length 1/4–3/4in (0.6–1.8cm)	Feeding habits

Order HEMIPTERA | Family NEPIDAE | No. of species 250

WATER SCORPIONS

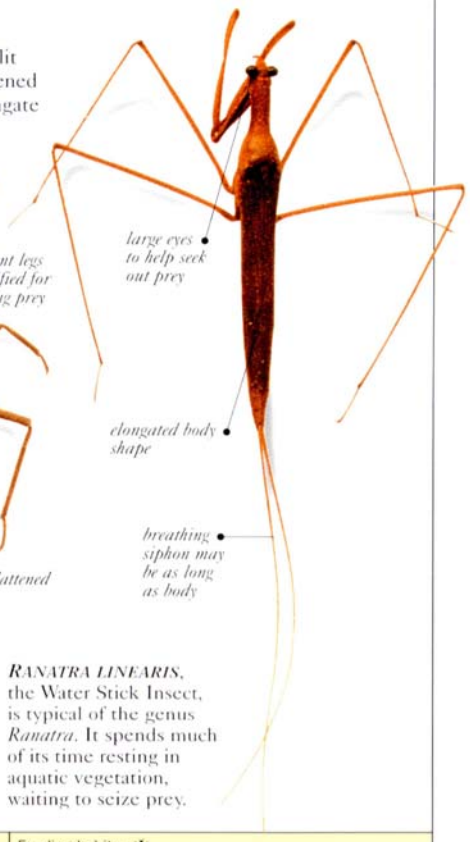
These grayish brown or reddish brown bugs are split into two main genera. *Nepa* species are oval and flattened with fairly short legs while *Ranatra* species are elongate with relatively long legs. The strong front legs are modified for catching prey while the other legs are used for walking. There is a long breathing siphon at the end of the abdomen.

• **LIFE CYCLE** Females often lay eggs inside plant tissues. Adults and nymphs may communicate by rubbing the base of their legs against their body to make sounds.

• **OCCURRENCE** Worldwide, especially in warmer regions. In slow-moving streams, ponds, pools, and bogs.

• **REMARK** Most species have wings but rarely fly.

NEPA CINERA has the fairly short legs and oval shape of the genus *Nepa*. It is found in Europe, North Africa, and parts of Asia.



RANATRA LINEARIS, the Water Stick Insect, is typical of the genus *Ranatra*. It spends much of its time resting in aquatic vegetation, waiting to seize prey.

Length ⅛–1¼in (1.5–4.8cm) | Feeding habits

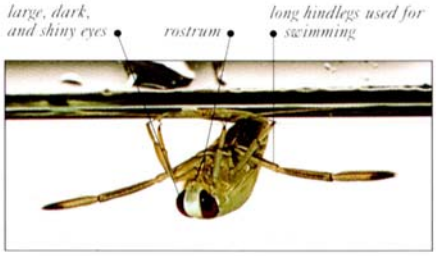
Order HEMIPTERA | Family NOTONECTIDAE | No. of species 350

BACK-SWIMMERS

The adults of these compact bugs are good fliers. Their upper body surface is typically pale and convex, with a central ridge. The underside, which faces up as they swim, is normally dark brown or black. The front and middle legs are used to catch prey, and the long, hair-fringed hindlegs are used for swimming.

• **LIFE CYCLE** Males make mate-attracting noises by rubbing part of the rostrum against the front legs. Eggs are laid in batches of less than ten at a time, inserted into aquatic plants.

• **OCCURRENCE** Worldwide. In small pools and ponds, and at the edges of lakes.



NOTONECTA GLAUCA, the Common Back-swimmer, is widespread in the ponds and ditches of the British Isles. It is sensitive to vibration and uses its large eyes to locate approaching prey.

Length 1/16–⅛in (0.2–1.7cm) | Feeding habits

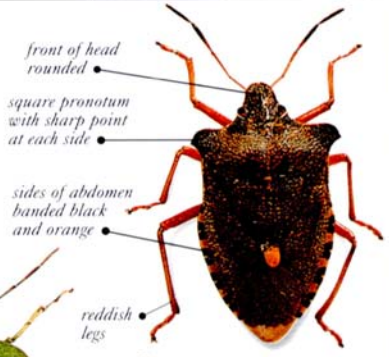
Order HEMIPTERA	Family PENTATOMIDAE	No. of species 5,500

STINK BUGS

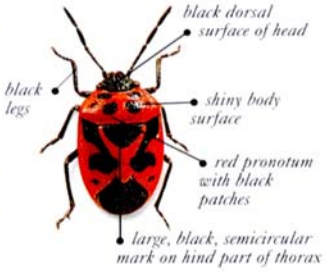
Also known as shield bugs because of their distinctive shape, these insects can produce strong defensive odors from their thoracic glands. Many species are green or brown but some are brightly colored.

• **LIFE CYCLE** Females lay clusters of barrel-shaped eggs on plants. There are five nymphal stages. Many nymphs start life as herbivores but later become predators or mixed feeders.

• **OCCURRENCE** Worldwide. On vegetation, shrubs, and trees.



PENTATOMA RUFIPES, the Forest Bug, feeds on deciduous trees, such as oak, in European woodland.



EURYDEMA DOMINULUS has bold coloration that warns predators of its distastefulness. It is found throughout Europe.

NEZARA VIRIDULA, also called the Green Vegetable Bug or Green Stink Bug, is a worldwide pest of fruit, vegetables, and cereals.

Length 1/16–1in (0.5–2.5cm)	Feeding habits

Order HEMIPTERA	Family PYRRHOCORIDAE	No. of species 400

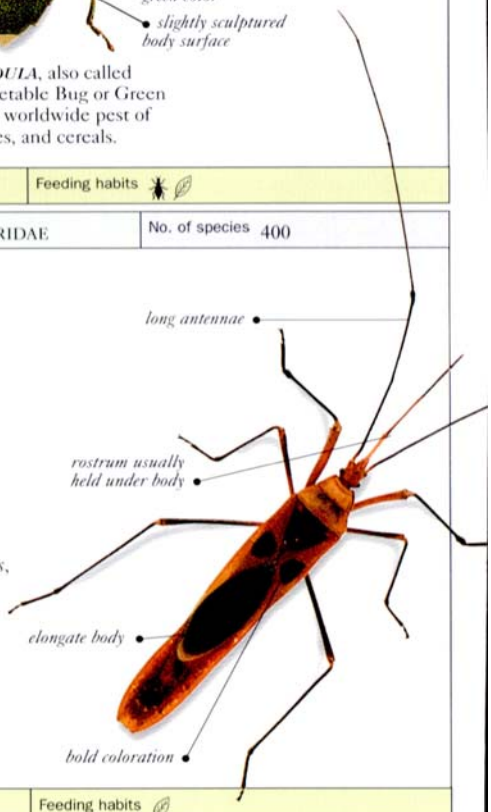
RED BUGS

Also called fire bugs due to their bright black, red, and orange coloring, these conspicuous insects often have quite elongate bodies.

• **LIFE CYCLE** Eggs are laid in damp soil or debris, or among the seeds of the host plant. Many species feed communally on the seeds and juices of their host plants.

• **OCCURRENCE** Worldwide, especially in warmer regions. On plants belonging to the family Malvaceae and others.

• **REMARK** Some species in the genus *Dysdercus*, called cotton-stainers, are pests of cotton crops. The staining of the cotton boll is caused by a fungus, introduced when the bugs feed.



LOHITA GRANDIS, the Giant Red Bug, is a pest in forested parts of northern India. It feeds on various trees, including two species that are valuable sources of timber.

Length 1/16–1/4in (0.8–2.2cm); some up to 2in (5cm)	Feeding habits

Order HEMIPTERA	Family REDUVIIDAE	No. of species 6,000

ASSASSIN BUGS

These bugs get their name from being highly predacious. They vary from being stout-bodied to very elongate with threadlike legs. Most species are dark-colored but some may have bright markings. The head has a short, curved, three-segmented rostrum. The front legs are strong and shorter than the others – ideal for gripping prey.

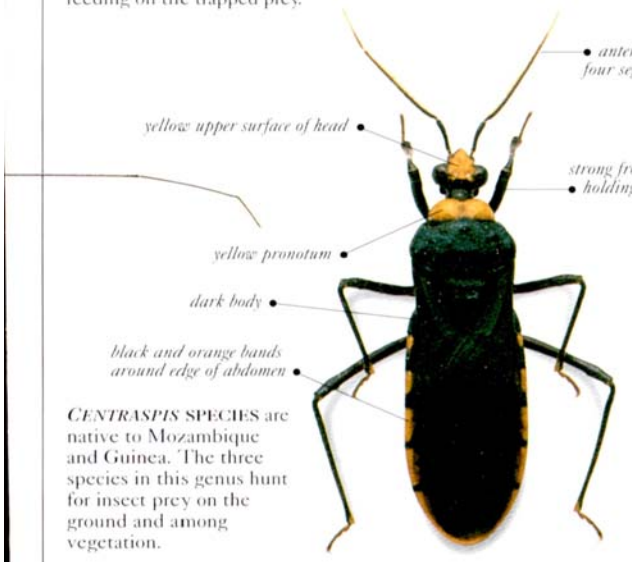
• **LIFE CYCLE** Up to 50 eggs are laid in cracks or crevices or in soil, or are glued to foliage. They may be guarded by the males.

• **OCCURRENCE** Worldwide, especially in subtropical and tropical regions. In a wide variety of habitats.

• **REMARK** Certain blood-sucking species carry Chagas' disease, which can cause heart failure.

GARDENA MELANARTHRUM belongs to a group of small, very slender species that live on plants, in leaf litter, and in caves. Some live in spider webs, feeding on the trapped prey.

PLATYMERIS BIGUTTATA is a large species that is kept in laboratories and as a pet. Its saliva is toxic, and can cause temporary blindness.



CENTRASPIS SPECIES are native to Mozambique and Guinea. The three species in this genus hunt for insect prey on the ground and among vegetation.

RHINOCORIS ALLUAUDI, like many assassin bugs, can make sounds by rasping its rostrum on a special file on the underside of the thorax.

Length 3/32–1⅓in (0.7–4cm)	Feeding habits

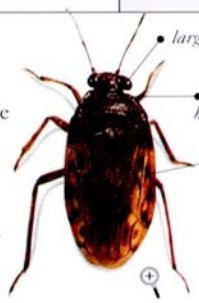
Order HEMIPTERA | Family SALDIDAE | No. of species 300

SHORE BUGS

These small, oval bugs are mostly brown or black in color. The head often has a long rostrum and large eyes with a notch in the hind margin. Shore bugs can jump to escape predators.

• **LIFE CYCLE** Females lay eggs at the base of various grasses or in moss. Some nymphs burrow.

• **OCCURRENCE** Worldwide. On muddy margins of salt marshes, streams, and ponds. On the seashore, among vegetation and seaweed.



***SALDULA* SPECIES** are found at the edges of freshwater pools. They have distinctive patches on the wings.

Length ⅛–9/32in (3–7mm) | Feeding habits

Order HEMIPTERA | Family SCUTELLERIDAE | No. of species 500

SHIELD-BACKED BUGS

These often-colorful bugs can resemble beetles. Their bodies are typically convex and either rounded or elongate and oval. The shield-shaped middle part of the thorax (scutellum) is very large, almost covering the abdomen.

• **LIFE CYCLE** Rounded eggs are laid in batches and stuck to plants. Both adults and nymphs are sap-suckers and sometimes feed in groups.

• **OCCURRENCE** Worldwide, mainly in warmer regions. On vegetation.

• **REMARK** Several species are pests of cereal crops and cotton.

***CALLIPHARA* SPECIES** have the beetlelike look typical of this family. They are found in Australia, New Guinea, Indonesia, and the Philippines.

Length ¼–¾in (0.6–2.2cm) | Feeding habits

Order HEMIPTERA | Family TINGIDAE | No. of species 2,000

LACE BUGS

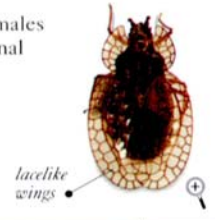
These small, grayish bugs are distinguished by lacelike patterning and sculpturing on the upper surface of the wings. The pronotum can extend, hoodlike, over the head.

• **LIFE CYCLE** Eggs are inserted into the tissue of host plants. The females of some species show complex maternal care of both their eggs and young.

• **OCCURRENCE** Worldwide. On herbaceous plants and trees.

• **REMARK** Many species are pests, but some are used as control agents to destroy weeds.

▷ ***TINGIS CARDUI*** is a British lace bug that feeds on thistles. The body sometimes looks pale gray due to a covering of light, powdery wax.



◁ ***DEREPHYSIA FOLIACEA***, with its typical lacy wings, prefers ivy as a host. It was found in North America for the first time in 1987.

Length 1/16–⅛in (2–5mm) | Feeding habits

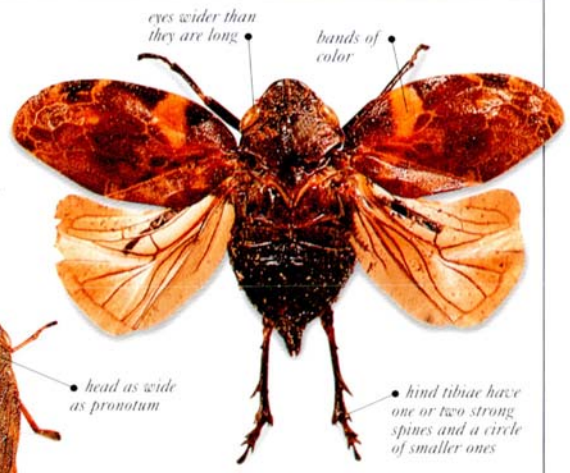
Order HEMIPTERA	Family APHROPHORIDAE	No. of species 850

SPITTLE BUGS

Similar to frog-hoppers (below), these bugs are also strong jumpers. Many species are pale to dark brown, with mottling and bands of color.

• **LIFE CYCLE** Eggs are laid in slits in plant tissue. True to their name, the pale, soft nymphs live under a frothy, protective covering that they make by mixing a special fluid with air and expelling it from their anus.

• **OCCURRENCE** Worldwide. On low-growing vegetation, shrubs, and trees.



APHROPHORA ALNI is a common species throughout Europe. It is found on various herbaceous plants.

BALSANA SUBFASCIATA comes from Brazil and has characteristic bands of color on its wings.

Length ¼–½in (0.6–1.2cm) | Feeding habits

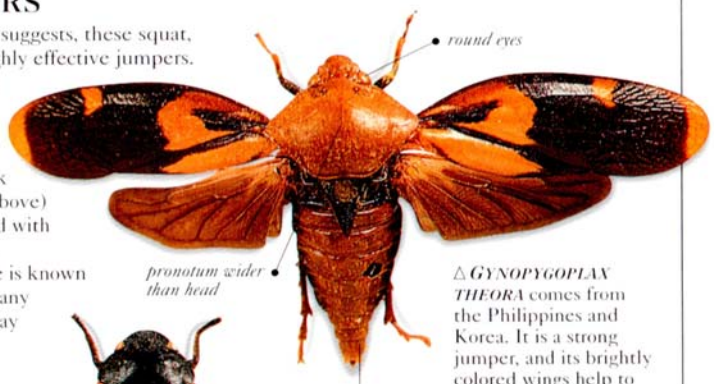
Order HEMIPTERA	Family CERCOPIDAE	No. of species 2,400

FROG-HOPPERS

As their common name suggests, these squat, round-eyed bugs are highly effective jumpers. Many species have drab coloring but some are brightly colored black and red or yellow and black. Frog-hoppers look similar to spittle bugs (above) and can also be confused with leaf-hoppers (see p.96).

• **LIFE CYCLE** Little is known about the life cycle of many species, although some lay their eggs in or on soil.

• **OCCURRENCE** Worldwide, especially in warmer regions. On a wide variety of shrubs, trees, and herbaceous plants.



△ *GYNOPYGOPLAX THEORA* comes from the Philippines and Korea. It is a strong jumper, and its brightly colored wings help to warn off predators.

◁ *CERCOPIS VULNERATA* nymphs live under the ground, surrounded by a protective frothy mass that they produce. They feed on plant roots.

Length 1/16–¾in (0.5–2cm) | Feeding habits

Order HEMIPTERA	Family CICADELLIDAE	No. of species 16,000

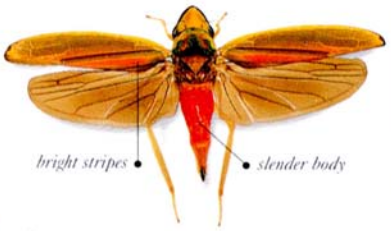
LEAF-HOPPERS

Leaf-hoppers are generally slender, with broad or triangular heads. Many species are brown or green, although some can be brightly striped or spotted. These bugs jump very well and are characterized by distinctive hind tibiae, which have an angular cross section and one or more rows of small spines running along their length.

• **LIFE CYCLE** Leaf-hoppers communicate with mates by making sounds with special abdominal organs. The sounds travel through foliage by making the leaves vibrate. Rows or clusters of eggs are laid under the epidermis of host plants.

• **OCCURRENCE** Worldwide. Almost anywhere with vegetation.

• **REMARK** Leaf-hoppers are pests of vital crops such as rice and corn.



△ *GRAPHOCEPHALA COCCINEA* is found on blackberry and ornamental plants in North America and on rhododendron species in Europe.

LEDRA AURITA is a large, flat-bodied leaf-hopper. It has mottled coloring and blends in well against lichen-covered bark.

Length ⅛–¾in (0.3–2cm), mostly under ⅜in (1.5cm)	Feeding habits

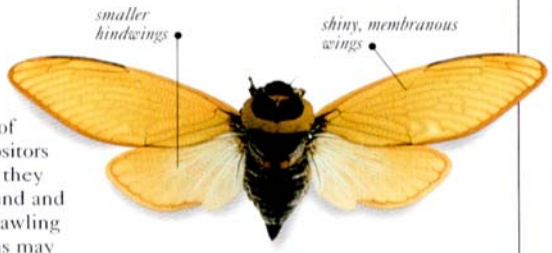
Order HEMIPTERA	Family CICADIDAE	No. of species 2,500

CICADAS

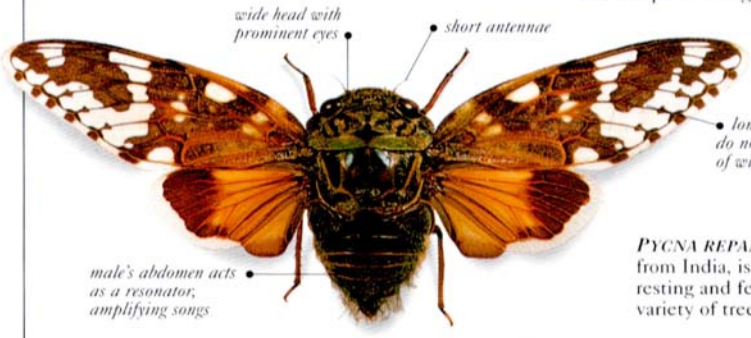
These bugs have dark brown or green camouflage coloring and a distinctive blunt-headed, tapered shape.

• **LIFE CYCLE** The males' famous, loud mating songs are produced by a pair of abdominal organs. Females use their ovipositors to cut slits in trees and shrubs, into which they lay their eggs. Hatchlings drop to the ground and burrow into the soil, later emerging and crawling up tree trunks for their final molt. Nymphs may take many years to become fully grown.

• **OCCURRENCE** Worldwide, mainly in warmer regions. On shrubs and trees.



△ *ANGAMIANA AETHEREA* comes from India. Like all cicadas, it produces a number of songs, which it uses for courtship and to signal aggression.



PYCNA REPANDA, which comes from India, is commonly found resting and feeding among a variety of tree species.

Length 1–2⅛in (2.3–5.5cm)	Feeding habits

Order HEMIPTERA	Family DERBIDAE	No. of species 800

DERBIDS

Many derbids are brightly colored yellow, brown, and pale brown. They have thin legs, a small head, large eyes, and typically long, narrow wings.

• **LIFE CYCLE** Little is known, but some species may lay eggs in wood, plant debris, or bark crevices.

• **OCCURRENCE** Worldwide, especially in tropical and subtropical regions. On trees, flowering plants, and woody fungi on rotting wood.

DERBE LONGITUDINALIS has the fragile, mothlike appearance typical of derbids. It is found in Bolivia and Ecuador.

Length 3/32–½in (0.7–1.2cm)	Feeding habits

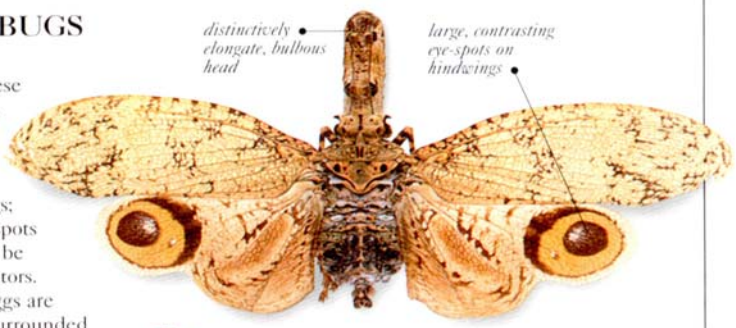
Order HEMIPTERA	Family FULGORIDAE	No. of species 800

FULGORID BUGS

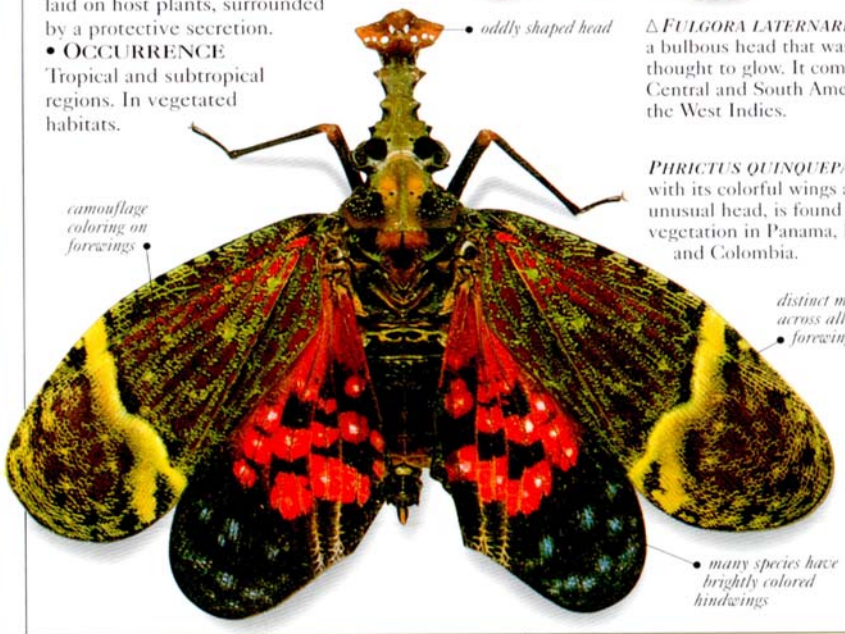
The most distinctive feature of many of these bugs is the long head, which may be very strangely shaped. At rest, fulgorids blend into their surroundings; if disturbed, the eye-spots on the hindwings can be flashed to deter predators.

• **LIFE CYCLE** Eggs are laid on host plants, surrounded by a protective secretion.

• **OCCURRENCE** Tropical and subtropical regions. In vegetated habitats.



△ *FULGORA LATERNARIA* has a bulbous head that was once thought to glow. It comes from Central and South America and the West Indies.



PHRICTUS QUINQUEPARTITUS, with its colorful wings and unusual head, is found on vegetation in Panama, Brazil, and Colombia.

Length ¼–4in (1–10cm)	Feeding habits

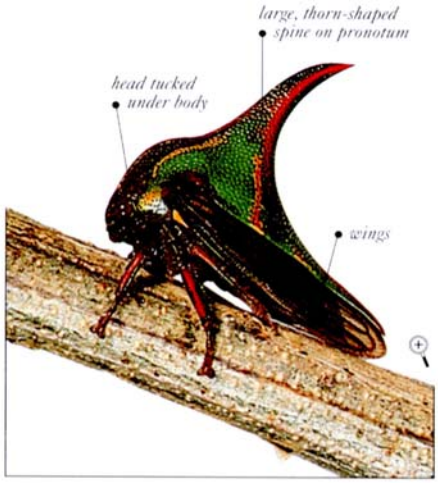
Order HEMIPTERA	Family MEMBRACIDAE	No. of species 2,500

TREEHOPPERS

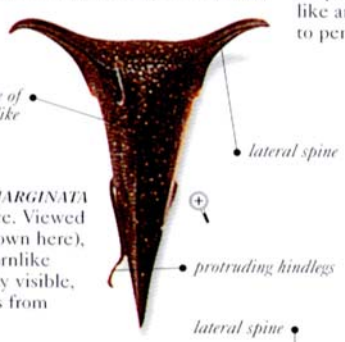
The arboreal habits of these insects is obvious from their common name. Also known as thorn bugs, these insects are mostly green, brown, or black. Some, however, are brightly colored. They are distinguished from other bugs by the shape of their pronotum. This varies from a thorn or spine, which makes them difficult for a predator to eat, to a large and complex structure that may act as an effective disguise. Nymphs do not have an enlarged pronotum, but may have dorsal spines or lateral expansions.

• **LIFE CYCLE** Treehopper eggs are deposited inside plant tissue, and the young go through five nymphal stages before reaching adulthood. Treehoppers feed in groups and suck plant sap. They are often attended by ants who "milk" the nymphs for their carbohydrate-rich excrement (honeydew). In return for the food, the ants guard the treehopper colony.

• **OCCURRENCE** Worldwide, mainly in warmer areas. On trees in a variety of habitats.

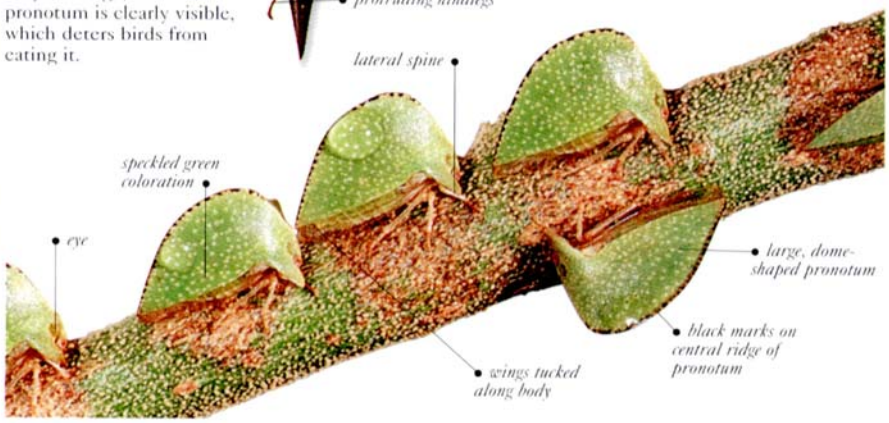


△ *UMBONIA* SPECIES are found in South America, parts of North America, and Southeast Asia. The shape of the pronotum varies but is often spine-like and very sharp – sharp enough, for example, to penetrate shoes and puncture skin.



▷ *HEMIKYPTHA MARGINATA* is a Brazilian native. Viewed from above (as shown here), only the large, thornlike pronotum is clearly visible, which deters birds from eating it.

▽ *ANTIANTHE EXPANSA*, from Guatemala, has an effective camouflage device. As seen here, rows of bugs sit feeding head to tail, so that the spines point the same way and make the bugs look like part of a plant.



Length 1/16–5/8in (0.5–1.5cm)	Feeding habits

Order HEMIPTERA | Family ALEYRODIDAE | No. of species 1,200

WHITEFLIES

These insects resemble tiny moths. The head of these bugs carries a pair of seven-segmented antennae, and the conspicuous wings are either white or mottled, with a distinctive dusting of white, powdery wax over the surface.

• LIFE CYCLE The females lay their eggs on tiny stalks on the undersides of leaves. When the nymphs first hatch out, they move around. However, they lose their legs at the first molt, and after this they become sedentary sap-suckers.

• OCCURRENCE Worldwide, especially in warmer regions. On a range of host plants.

• REMARK Many whiteflies are serious pests. Well-known examples include *Trialeurodes vaporariorum* (see picture) and *Bemisia tabaci*, which is a widespread pest of cotton and other important crops.

TRIALEURODES VAPORARIORUM, the Greenhouse Whitefly, is a widespread pest of cucumbers and tomatoes grown under glass. It may also attack field crops in warm conditions.

Length 1/32–1/8in (1–3mm) | Feeding habits

Order HEMIPTERA | Family APHIDIDAE | No. of species 2,250

COMMON APHIDS

These aphids are small, soft-bodied, and mostly green, pink, black, or brown. The abdomen usually carries a pair of short tubes, called cornicles, from which a substance is secreted to deter predators.

• LIFE CYCLE Females produce large colonies by parthenogenesis (asexual reproduction in which eggs develop without fertilization) and usually give birth to nymphs. Winged adults migrate to a host plant where sap-feeding and parthenogenetic reproduction continues. Later, more winged aphids fly back to the original host plant, where the males and females mate and lay eggs once more.

• OCCURRENCE Worldwide. Wherever host plants are found.

• REMARK With their huge reproductive potential, aphids are the most destructive of all plant-eating insects. Virtually all crop species are affected by their feeding and by the viral diseases that they transmit.

MACROSIPHUM ALBIFRONS, the American Lupin Aphid, is now also found throughout many parts of Europe. This species is a pest and carries diseases such as yellow mosaic virus.

Length 1/32–5/16in (1–8mm), most 3/16in (5mm) | Feeding habits

Order HEMIPTERA	Superfamily COCCOIDEA	No. of species 7,000

SCALE INSECTS

Members of this superfamily vary widely in coloration. The sedentary, wingless females are flat and elongate or oval. Their bodies may be covered with waxy secretions that form a soft or scalelike covering. The males, which are uncommon, look very different and may be winged or wingless.

• **LIFE CYCLE** Nymphs and adult females are sap-suckers. Reproduction can be asexual or sexual, and the reproductive potential of many species is immense. Females lay eggs, commonly on host plants, or give birth to nymphs. Newly hatched nymphs have legs and disperse. Later stages may lose their legs and become sedentary, like the females.

• **OCCURRENCE** Worldwide, especially in subtropical and tropical regions. On host plants in a wide variety of habitats.

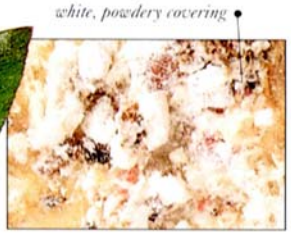
• **REMARK** Many species are significant pests of crops such as citrus trees and coffee.

△ ***SAISSETIA NIGRA*** is a widespread pest of cassava plants and trees and also attacks nutmeg, cinnamon, and teak.

△ ***MARGARODES*** **SPECIES** produce cystlike nymphs called "ground pearls," which live underground and attack the roots of grasses.

△ ***CEROCOCCUS QUERCUS*** frequently causes great damage to ornamental trees in North America.

◁ ***PLANOCOCCUS CITRI***, the common Citrus Mealy Bug, also attacks other crops, including coffee, guava, and soybeans.



DACTYLOPIUS TOMENTOSUS has been used to control cactus weed in parts of South Africa.

Length ½–1¼in (0.1–3cm), most under ⅛in (1cm)	Feeding habits

Order HEMIPTERA	Family PSYLLIDAE	No. of species 1,500

JUMPING PLANT LICE

These variously colored bugs look like small leafhoppers (see p.96), but with longer antennae. The two pairs of oval wings are held, rooflike, over the body. The head has a short, three-segmented beak.

• **LIFE CYCLE** Females lay stalked eggs on or in plants, and some may cause gall formation or rolling of leaves. The flat nymphs develop wing pads as they get older.

• **OCCURRENCE** Worldwide. On any suitable host plant, in a wide variety of habitats.

• **REMARK** Some species are significant plant pests.

CACOPSYLLA PYRICOLA, the Pear Psyllid, is a significant pest of pear trees throughout the Northern Hemisphere.

Length 1/16–⅛in (1.5–5mm)	Feeding habits

THRIPS

COMMONLY KNOWN as thrips, the order Thysanoptera contains 8 families and 5,000 species. They are small, slender insects usually with two pairs of narrow, hair-fringed wings. The head bears short antennae, conspicuous compound eyes, and distinctive sucking mouthparts, which include a pair of mandibles in which one is small and the other is needlelike. There is a sticky, inflatable structure between the tarsal claws that aids grip on smooth surfaces.

Thrips are closely related to bugs but are unusual in that they undergo neither complete nor incomplete metamorphosis. As in members of the order Hymenoptera (see pp.178–206), fertilized eggs produce females and unfertilized eggs produce males. There are also one or more pupalike stages after the two nymphal stages. The females of some species have a sawlike ovipositor and lay their eggs inside plant tissue, while others lack an ovipositor and lay their eggs in cracks and crevices or on the surface of host plants.

Thrips may be herbivorous or predacious. A few species show simple forms of social behavior, and in some there are soldiers who defend their colony. Many thrips are plant pests – especially of cereal crops.

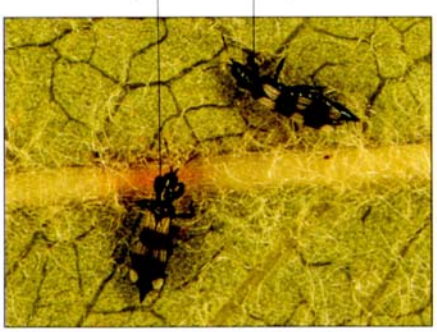
Order THYSANOPTERA	Family AEOLOTHRIPIDAE	No. of species 250

BANDED THRIPS

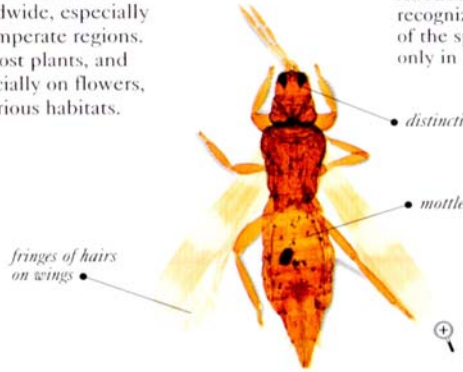
Also called predacious thrips, because of the feeding habits of some species, these thrips are yellow-brown or dark. The body is round in cross section, and the wings, which lie parallel to each other when folded, often have cross bands or stripes.

• **LIFE CYCLE** Although most banded thrips feed on other small insects, including other thrips, some species feed on pollen grains. The females of most species lay eggs inside host plants with a sawlike ovipositor. When the yellow or orange nymphs are fully grown, they form a silken cocoon underground.

• **OCCURRENCE** Worldwide, especially in temperate regions. On host plants, and especially on flowers, in various habitats.



***AEOLOTHRIPS* SPECIES** are often recognized by their banded wings. Most of the species in this genus are found only in the Northern Hemisphere.



AEDOTHRIPS TENUICORNIS is common throughout Europe, especially among the yellow flowers of legumes and composites.

Length ½–⅛in (1–2mm) (body length)	Feeding habits

Order THYSANOPTERA	Family PHLAEOTHRIPIDAE	No. of species 2,700

TUBE-TAILED THRIPS

Members of this family have larger, stouter bodies than most thrips and the abdomen has a tubular, pointed end. Most species are dark but often have light or mottled wings. When present and folded, the wings overlap each other.

• **LIFE CYCLE** Eggs are laid in cracks and crevices. Most species eat fungi, while some feed inside galls, on plants, or in decaying wood. A few eat mites and small insects. The nymphs are usually red or yellowish, feed alongside the adults in groups, and communicate by sounds.

• **OCCURRENCE** Worldwide, mainly in tropical and subtropical areas. On herbaceous plants, trees, and shrubs; in soil and leaf litter.

• **REMARK** Some species are crop pests.

***PHLAEOTHRIPIDAE* SPECIES** feed on plants. This specimen is seen resting on a bromeliad plant in South America. It will soon molt to the adult stage and develop full-sized wings.

Length 1/32–1/2in (0.1–1.2cm), most under 3/16in (5mm)	Feeding habits

Order THYSANOPTERA	Family THRIPIDAE	No. of species 1,750

COMMON THRIPS

The coloration of these flat thrips varies from pale yellow to brown or black. The hair-fringed wings are very narrow, pointed at the ends, and sometimes banded. Females have a sawlike ovipositor that bends downward.

• **LIFE CYCLE** Reproduction can occur asexually, and the females use their sawlike ovipositors to insert their eggs inside plants or flowers. The adults and nymphs of most species suck plant juices, although some species eat fungi or even suck the juices of other insects. When fully grown, the nymphs enter a pupa-like stage either on the plant or in the soil.

• **OCCURRENCE** Worldwide. On the leaves and flowers of a huge range of host plants.

• **REMARK** Many common thrips are serious pests of a wide range of crops, including tobacco, cotton, and beans.

THRIPS FUSCIPENNIS is a dark-colored species with distinctive hairs on its body. Widespread across the Northern Hemisphere, these thrips are found inside a wide range of plant species.

THRIPS SIMPLEX, the Gladiolus Thrips, originally came from South Africa. It has now spread much further afield and is found wherever gladioli flowers are grown.

Length 1/32–1/16in (0.7–2mm)	Feeding habits

ALDERFLIES AND DOBSONFLIES

THE ORDER MEGALOPTERA is relatively small. It is divided into 2 families and 300 species. They are the most primitive insects that develop by complete metamorphosis. There are two distinct families: the alderflies (Sialidae) and the dobsonflies (Corydalidae).

Both families have soft bodies and are drably colored with two pairs of large wings of almost equal size. When the wings are folded, they are held, roof-like, over the body. Weak fliers, species in this order never move far from water.

Adults may have large mandibles, but they do not feed. Their larvae, which are aquatic and have abdominal gills, are predacious and eat anything they can kill. After up to 11 larval stages, pupation occurs inside a chamber made by the larva in sand, soil, or moss.

Order MEGALOPTERA	Family CORYDALIDAE	No. of species 200

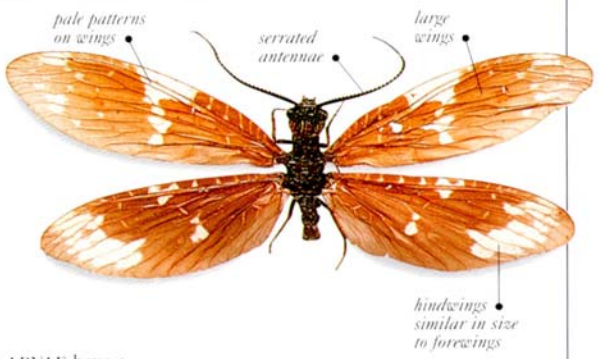
DOBSONFLIES

The wings of these usually large, soft-bodied insects are clear or have gray or brown areas. Unlike alderflies, they have three ocelli. The males may have huge mandibles, used for male-to-male combat or for holding the female.

• **LIFE CYCLE** Eggs are laid near water. The bottom-dwelling larvae have eight pairs of simple filaments with basal gill tufts and may take years to mature.

• **OCCURRENCE** Worldwide, especially in temperate regions. In running water.

LARVAE have a pair of hooklike prolegs at the end of the abdomen.



***CHAULIODES* SPECIES** may be called fish flies. They have distinct rounded hind corners on the head.

Length 1–3in (2.5–7.5cm); wingspan to 6in (15cm)	Larval feeding habits

Order MEGALOPTERA	Family SIALIDAE	No. of species 100

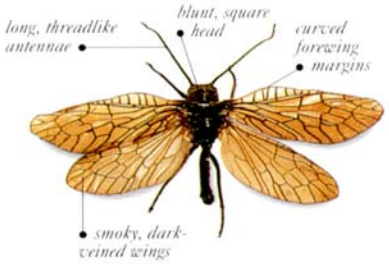
ALDERFLIES

These dark, smoky-winged species are much smaller than dobsonflies (see above) and have no ocelli. Adults are often found resting on waterside vegetation.

• **LIFE CYCLE** Females lay large egg masses near water, into which the hatched larvae drop. These aquatic larvae take one year to mature. They have seven pairs of feathery, lateral gills and a single tail filament at the end of the abdomen.

• **OCCURRENCE** Worldwide, especially in temperate regions. In ponds, canals, streams, and slow-moving water.

LARVAE have well-developed legs and are good crawlers.



***STALIS* SPECIES** are common in the Northern Hemisphere. Fully grown larvae crawl out of the water and pupate in damp soil above the water margin.

Length ⅛–¾in (1–2cm), most under ⅝in (1.5cm)	Larval feeding habits

SNAKEFLIES

RAPHIDIIDAE and Inocellidae are the two families that make up the order Raphidioptera, which contains 150 species in total. Both families have similar features. All snakeflies have two pairs of wings and a slightly flattened head with forward-pointing mouthparts that are used for chewing. The pronotum is typically elongate. Species belonging to the Inocellidae, the smaller of the two families, are distinguishable from the Raphidiidae in that they do not have ocelli and their antennae are long. Snakeflies are closely related to alderflies (see p.103), but their larvae are terrestrial and they do not have gills.

Snakeflies live in woodlands where there is a plentiful supply of vegetation. Both the adults and their larvae are predacious, but they also scavenge for a significant amount of their food.

During mating, the male is positioned underneath the female. Several hundred eggs may be laid, in groups of up to 100, either in tree bark or in rotten wood. Metamorphosis is complete.

The name snakefly refers to the snakelike way in which the adults catch their prey. They do this by raising up their head, at the end of its elongate prothorax, and moving it forward to seize the food.

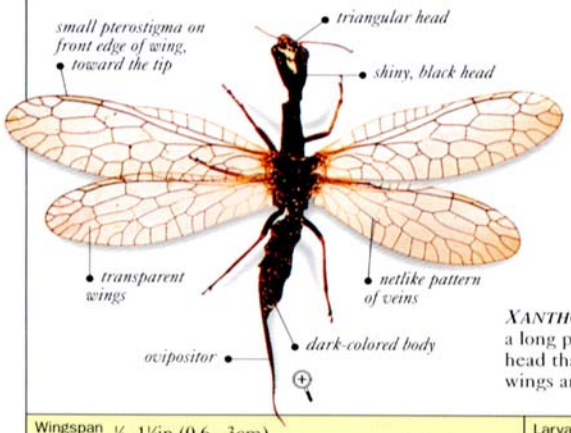
Order RAPHIDIOPTERA	Family RAPHIDIIDAE	No. of species 85

SNAKEFLIES

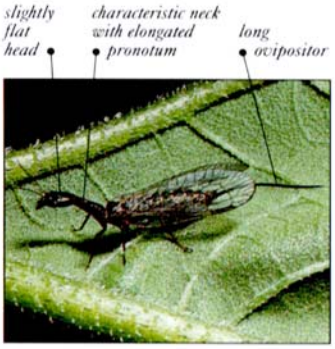
These dark-colored insects have a distinctive neck consisting of an elongated pronotum on which the head can be raised. The head is typically broad across the eyes and tapering toward the rear. Female snakeflies are slightly larger than the males.

• **LIFE CYCLE** Females use a long, slender ovipositor to lay eggs in slits in bark. The elongate larvae can be found under loose bark, in decaying tree stumps, and among leaf litter. Like their parents, the larvae feed mostly on beetle larvae and other soft-bodied insects.

• **OCCURRENCE** Primarily in the Northern Hemisphere. In woods among vegetation.



LARVAE are flat, with a square head, small eyes, short, curved mandibles, and strong legs.



△ *AGULLA* **SPECIES** are found in North America and Canada, from the Rocky Mountains west through the Great Basin to the Pacific coast.

XANTHOSTIGMA XANTHOSTIGMA has a long pronotum and a distinct, broad head that tapers to the rear. The four wings are of almost equal size.

Wingspan ¼–1¼in (0.6–3cm)	Larval feeding habits

ANTLIONS, LACEWINGS, AND THEIR RELATIVES

THE ORDER NEUROPTERA includes 17 families and 4,000 species. Its members generally have large compound eyes, chewing mouthparts, and antennae that are usually longer than the head and thorax combined. They also have two pairs of equally sized wings, which are held rooflike over the body when not in use. The major wing veins are forked or twigged near the margins.

The adults in this order are mostly predatory, but a few feed on pollen and nectar. Most species hunt either in the evening or after dark.

Metamorphosis is complete. The larvae have curved mouthparts that form a hollow tube, through which the juices of prey are sucked up. After three nymphal stages, larvae pupate inside a fragile silk cocoon.

Order NEUROPTERA	Family ASCALAPHIDAE	No. of species 450

OWLFLIES

Large, conspicuous, and sometimes with highly patterned wings, these species are active mostly after dark and are often attracted to lights. The gray, black, or red-brown body is elongate, and the antennae have clubbed ends. The wings are pale to smoky, with yellow or darker markings. Adults are agile hunters, actively chasing and seizing prey in the air.

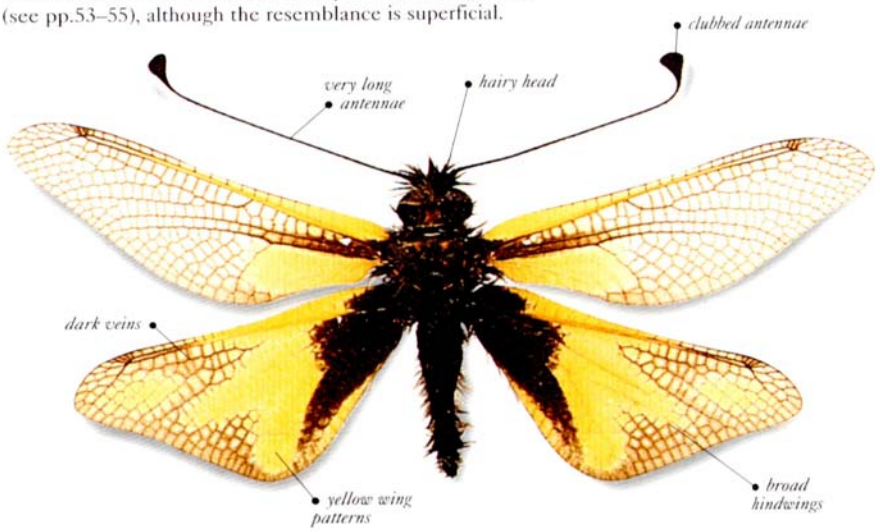
• **LIFE CYCLE** Females lay rows or spirals of up to 50 eggs on twigs or grass stems. The larvae wait on the ground, in leaf-litter, or on tree trunks for suitably sized prey to come along.

• **OCCURRENCE** Worldwide, especially in warm regions. In grassland or warm, dry woodland.

• **REMARK** Some owlflies look very similar to dragonflies (see pp.53–55), although the resemblance is superficial.

LARVAE are oval and flat, with expansions at the sides of the abdomen. Some have jaws that open very wide.

LIBELLOIDES COCCAJUS is a European species with a distinctive wing shape and a large area of black at the bases of the hindwings.



Wingspan 1¼–4¾in (3–12cm)	Larval feeding habits

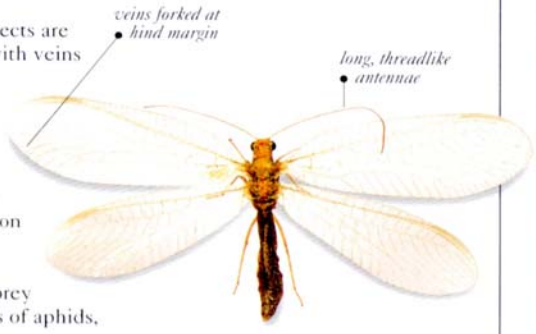
Order NEUROPTERA	Family CHRYSOPIDAE	No. of species 1,600

COMMON LACEWINGS

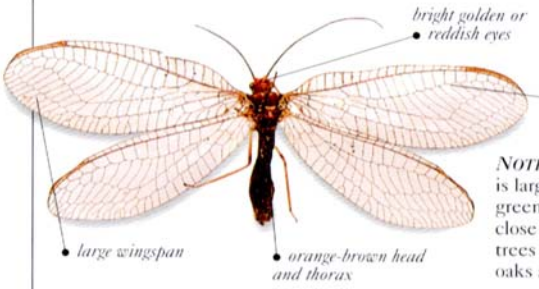
Although some species are brown, these insects are generally green. The wings are iridescent, with veins that form complex patterns and fork at the wing margins. The eyes have a bright golden or reddish shine. Adults are nocturnal and are attracted to lights, often entering houses to hibernate. Many have special bat-detecting sensors in their wings.

• **LIFE CYCLE** Females lay stalked eggs on vegetation, and the pale larvae pupate in round silk cocoons stuck to leaves. Many larvae cover themselves with the bodies of prey as a disguise. Adults and larvae are predators of aphids, thrips, scale insects, and mites.

• **OCCURRENCE** Worldwide. On vegetation in varied habitats, including arid areas, and in ants' nests.



***CHRYSOPA* SPECIES** are delicate and large-winged insects. When at rest, they hold their wings, roof-like, over their body.



NOTHOCHRYSA CAPITATA is larger and duller than the green lacewings. It is found close to the trunks of various trees and in the crowns of oaks and pines.

LARVAE have curved jaws, hairy warts, and well-developed legs.

Wingspan ⅛–2in (1–5cm)	Larval feeding habits

Order NEUROPTERA	Family MANTISPIDAE	No. of species 300

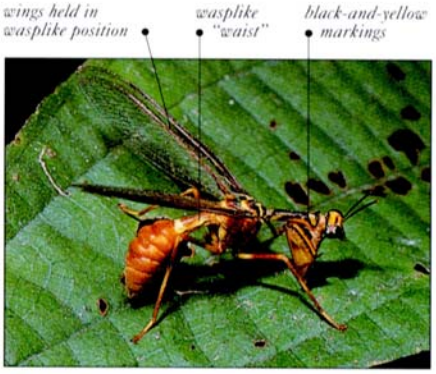
MANTISPIDS

Also called mantidflies, mantispids have front legs exactly like those of praying mantids (see p.73), which they use to seize prey. The first segment of the thorax is elongate, and the two pairs of narrow wings are of roughly equal size.

• **LIFE CYCLE** Small, white, short-stalked eggs are laid in groups of several hundred on tree bark. The young nymphs are mobile and hunt for spiders' egg sacs, inside which they feed. Some species parasitize bees.

• **OCCURRENCE** Worldwide, mainly in warm, temperate and tropical regions. In well-vegetated areas.

LARVAE have six thoracic legs and become maggotlike as they mature.



***CLIMACIELLA* SPECIES** have a distinctive body shape. The one shown here is probably protected from attack by its bright, wasplike coloration.

Wingspan ⅛–2¼in (1–5.5cm)	Larval feeding habits

Order NEUROPTERA	Family MYRMELEONTIDAE	No. of species 1,000

ANTLIONS

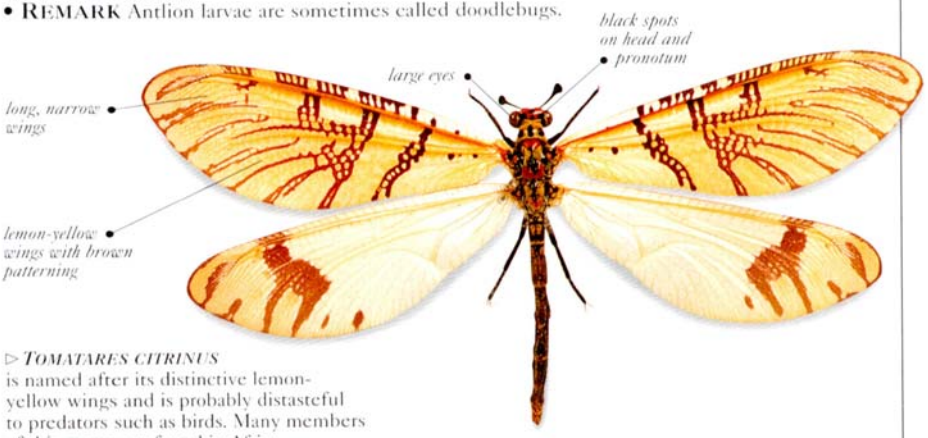
These large, soft, slender insects resemble damselflies (see pp.51–53). The head is broader than the pronotum, with large, conspicuous eyes and club-ended antennae that are about as long as the head and thorax together. The long, narrow wings may have brown or black patterns.

• **LIFE CYCLE** Eggs are laid in soil or sand, singly or in small groups. The larvae eat insects and spiders. Some antlions construct conical pits to trap prey. The larvae live in these pits, with only their sharp, spiny mandibles showing, and flick sand grains at prey to knock them into the lair. Other larvae live on tree trunks, in soil and debris, or under stones.

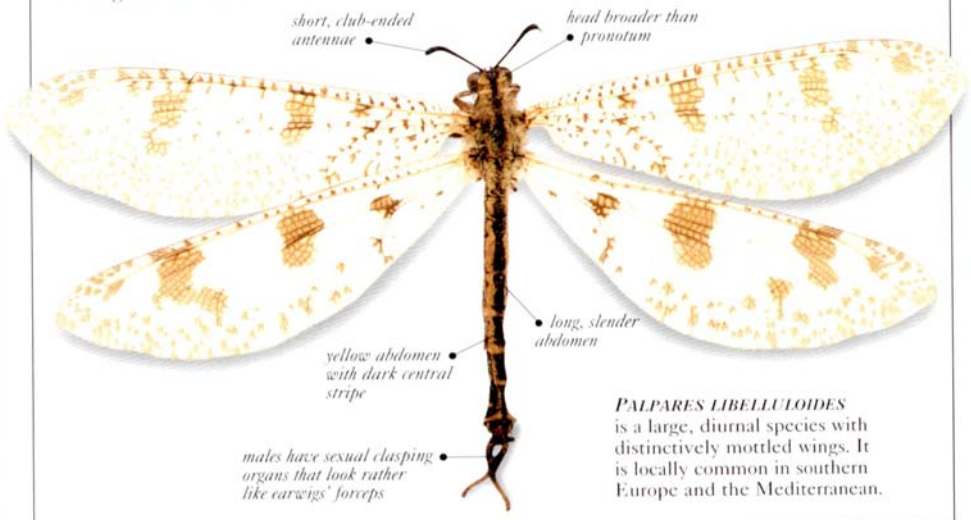
• **OCCURRENCE** Worldwide, especially in semiarid areas in subtropical and tropical regions. In open woodland, scrub grassland, and dry, sandy areas.

• **REMARK** Antlion larvae are sometimes called doodlebugs.

LARVAE have large, curved, toothed jaws and long legs. The large abdomen tapers toward the rear.



▷ ***TOMATARES CITRINUS***
is named after its distinctive lemon-yellow wings and is probably distasteful to predators such as birds. Many members of this genus are found in Africa.



PALPARES LIBELLULOIDES
is a large, diurnal species with distinctively mottled wings. It is locally common in southern Europe and the Mediterranean.

Wingspan 1¼–4¾in (3–12cm)	Larval feeding habits

Order NEUROPTERA | Family NEMOPTERIDAE | No. of species 150

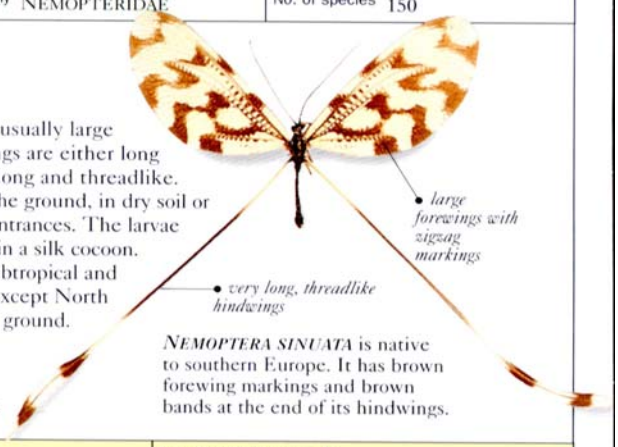
THREAD-WINGED LACEWINGS

The forewings of these species are usually large and patterned, whereas the hindwings are either long and slender, with rounded ends, or long and threadlike.

• **LIFE CYCLE** Eggs are laid on the ground, in dry soil or sand under rock outcrops and cave entrances. The larvae develop *in situ*, and pupation occurs in a silk cocoon.

• **OCCURRENCE** In subtropical and tropical areas worldwide except North America. On soil or sandy ground.

LARVAE of some species have very elongated necks.



NEMOPTERA SINUATA is native to southern Europe. It has brown forewing markings and brown bands at the end of its hindwings.

Wingspan ¼–3¼in (2–8cm) | Larval feeding habits

Order NEUROPTERA | Family OSMYLIDAE | No. of species 150

OSMYLIDS

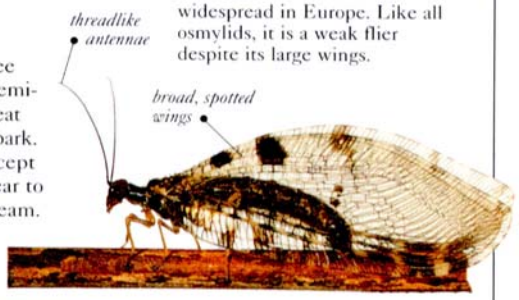
These slender lacewings have broad, patterned wings and threadlike antennae.

• **LIFE CYCLE** Rows of eggs are laid on tree trunks or foliage near water. Some larvae are semi-aquatic (living in wet moss, for example) and eat insect larvae; others live under tree bark.

• **OCCURRENCE** Worldwide, except North America. In wooded areas near to a steady flow of water, such as a stream.

LARVAE have straight, needlelike mouthparts.

OSMYLUS FULVICEPHALUS is widespread in Europe. Like all osmylids, it is a weak flier despite its large wings.



Wingspan ⅜–1¼in (1.4–3cm) | Larval feeding habits

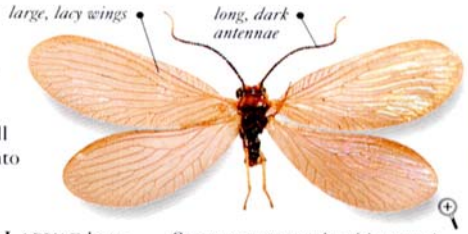
Order NEUROPTERA | Family SISYRIDAE | No. of species 50

SPONGEFLIES

Also known as spongillaflies, these small insects have slender antennae and lacy wings. Adults do not fly very far from water and are active at twilight and after dark.

• **LIFE CYCLE** Eggs are laid singly or in small groups on overhangs, and hatched larvae drop into the water. The larvae have very elongate, slender jaws for sucking out the body contents of sponges.

• **OCCURRENCE** Worldwide. Near a source of freshwater, wherever sponges occur.



LARVAE have three pairs of legs and abdominal gills.

SISYRA FUSCATA is widespread across Europe. The adults catch and feed on aphids and are often attracted to lights after dark.

Wingspan ¼–½in (0.6–1.2cm) | Larval feeding habits

BEETLES

THERE ARE 166 families and 370,000 species in the order Coleoptera. About one in three insects in existence today is a beetle, and they have successfully colonized every sort of terrestrial and freshwater habitat. They range from tiny insects less than 1/32in (1mm) in length to tropical giants measuring 7in (18cm).

Although beetles vary enormously in both their shape and their coloration, a major distinguishing feature is their toughened forewings, also known as elytra. These hard forewings protect the larger, membranous hindwings that are folded underneath. The elytra may be short, but in all species they meet down the middle of the body. The protective elytra and compact, strong body have contributed to the success of the order Coleoptera because these traits allow beetles to dig or squeeze themselves into all kinds of spaces and survive in a huge variety of habitats. In aquatic species, the space beneath the elytra provides a valuable storage area for air.

Mating usually takes place with the male clinging to the female's back. Most beetle species are herbivorous, but there are many scavengers and predators, as well as a few specialized parasitic species. Metamorphosis is complete.

Order COLEOPTERA	Family ANOBIIDAE	No. of species 1,500

WOODWORM

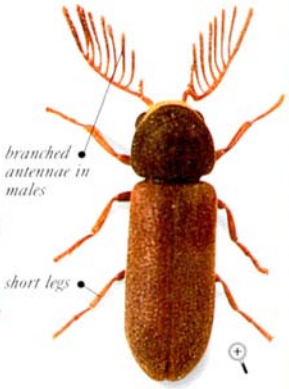
The larvae of some of these small beetles attack wood – hence the common name. They are pale brown to black and vary from elongate to oval. The head is often hooded by the pronotum, and the short legs fit into grooves on the underside of the body. The last three segments of the antennae are lengthened or expanded.

• **LIFE CYCLE** Eggs are laid on a suitable food source, and the larvae bore inside, making circular tunnels. Pupation takes place just below the surface.

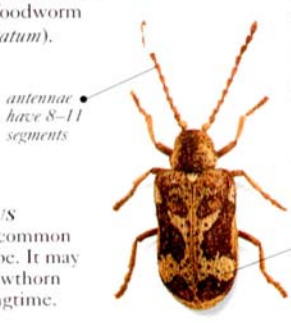
• **OCCURRENCE** Worldwide. In woods, stores, warehouses, and other buildings.

• **REMARK** This family includes the notorious Furniture Beetle or Common Woodworm (*Anobium punctatum*).

△ ***XESTOBIUM RUFOVILLOSUM***, the Deathwatch Beetle, is so named because its mating calls (head-taps against tunnels in wood) were once commonly heard in quiet rooms during wakes.



△ ***PTILINUS PECTINICORNIS*** is found all over central Europe. It sometimes becomes a pest by attacking wooden furniture.



PTINOMORPHUS IMPERIALIS is common in central Europe. It may be found on hawthorn flowers in springtime.

LARVAE that eat wood contain symbiotic yeasts that break cellulose down into sugars.

Length 1/16–11/32in (2–9mm), mostly 1/16–1/4in (2–6mm)	Larval feeding habits

Order COLEOPTERA	Family ANTHRIBIDAE	No. of species 3,000

FUNGUS WEEVILS

Most of these weevils are oblong. They are usually dark and densely covered with patterns of white or dark scales or hairs. The antennae usually have 11 segments.

• **LIFE CYCLE** Eggs are laid, and larvae develop, inside rotten wood, fungi, or plant tissue. Adults mostly eat fungi.

• **OCCURRENCE** Worldwide, especially in tropical regions. On twigs, under bark, and in fungi, wood, and seed pods.

LARVAE are pale and curved, often with short, two-segmented legs.

broad nose

very long antennae, with 11 segments

MECOCERUS GAZELLA is found in Southeast Asia. It has exceptionally long antennae.

Length 1/32–1⅛in (0.05–3.8cm), most under ¼in (2cm)	Larval feeding habits

Order COLEOPTERA	Family BOSTRICHIDAE	No. of species 700

BRANCH-BORING BEETLES

These cylindrical beetles are mostly dark brown or black in color. The head points downward.

• **LIFE CYCLE** Eggs are laid under the surface of wood. Adults and larvae may tunnel into wood, branches, or twigs. Their guts contain microorganisms that help them digest wood.

• **OCCURRENCE** Worldwide, especially in tropics and subtropics. Inside wood of host plants.

LARVAE are pale and short-haired.

BOSTRICHUS CAPUCINUS is a widespread European species.

parallel-sided, cylindrical body

Length 1/8–2in (0.3–5cm), most ¼–⅞in (0.6–2cm)	Larval feeding habits

Order COLEOPTERA	Family BRENTIDAE	No. of species 2,500

PRIMITIVE WEEVILS

These parallel-sided, elongate beetles are typically black, brown, or yellow. The long, narrow head has a distinctive rostrum, bearing thread- or beadlike antennae with 11 segments.

• **LIFE CYCLE** Using her rostrum, the female beetle bores a hole into wood, where she deposits her eggs. The larvae tunnel into the sapwood of dead or decaying trees and may feed on fungi. The adults feed on fungi and sap.

• **OCCURRENCE** Tropical regions. In forests.

***BRENTHUS* SPECIES** are usually hairless. Like all members of this family, they are closely related to weevils (see p.117).

mandibles

elongate rostrum

eyes

antennae arise partway down head

elongate body, with parallel sides

LARVAE are elongate and have short, one-segmented legs.

Length 1/8–3⅛in (0.3–8.6cm)	Larval feeding habits

Order COLEOPTERA | Family BUPRESTIDAE | No. of species 15,000

JEWEL BEETLES

Also called metallic wood-boring beetles, most jewel beetles are a brilliant, metallic green, red, or blue, with stripes, bands, and spots. Typically they are slightly flat, tapering toward the rear, with large eyes and short antennae.

• LIFE CYCLE Eggs are laid in wood. The larvae of most species chew oval tunnels into dead or dying trees. Adults feed on flowers, nectar, and pollen.

• OCCURRENCE Worldwide, primarily in tropical regions. In woods and forests.

• REMARK Some species have heat sensors at the base of the middle legs that detect freshly burned forest – good mating and egg-laying sites. Many species are timber pests.

CHRYSOCHROA CHINENSIS is native to India. Like most tropical species, it flies during the warmest part of the day.

• *head appears sunk into the pronotum*

• *bright, metallic elytras have been used in embroidery and jewelry*

• *parallel-sided body, tapering toward the rear*

• *hairy body surface is characteristic of this species*

JULODIS KLUGII, from South Africa, has distinctive hairs all over its body, although the majority of jewel beetles are smooth and shiny, with pits or striations.

LARVAE are pale, with a large, expanded prothorax and a tapering abdomen, giving rise to another common name – flat-head borers.

Length 1/16–2½in (0.2–6.5cm); most under 1¼in (3cm) | Larval feeding habits

Order COLEOPTERA | Family CANTHARIDAE | No. of species 4,500

SOLDIER BEETLES

Most soldier beetles have soft, elongate bodies with parallel sides. The head has distinctive curved mandibles and threadlike antennae. Although they are predacious, some species will also feed on pollen and nectar.

• LIFE CYCLE Eggs are scattered on the ground. Most larvae hunt for prey in soil, decaying timber, and leaf litter, and under bark. The larvae of a few species eat plant material.

• OCCURRENCE Worldwide. On flowers and other vegetation in hedgerows, meadows, and woodland margins.

• REMARK The common name comes from the red, yellow, and black coloring of many species, reminiscent of old military uniforms.

• *slender antennae*

• *square pronotum*

elongate body

LARVAE have a distinctive velvety appearance, with flat bodies and well-developed legs.

CANTHARIS LATERALIS is found mainly in wet meadows and other marshy areas.

Length 1/16–1¼in (0.3–3cm) | Larval feeding habits

Order COLEOPTERA	Family CARABIDAE	No. of species 29,000

GROUND BEETLES

These long, slightly flat beetles may be dull or shiny and are usually brown or black, often with a metallic sheen. The head, thorax, and abdomen tend to be clearly differentiated, and the elytra usually have obvious striations. Most species are nocturnal hunters.

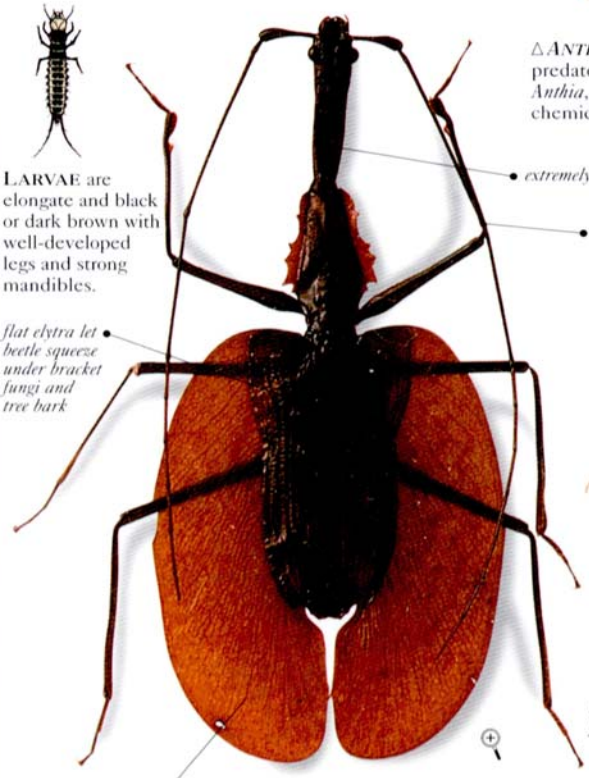
• **LIFE CYCLE** Eggs are laid on the ground and on vegetation and decaying wood and fungi. Like the adults, larvae are mainly predacious but will eat carrion; a few species are partly herbivorous.

• **OCCURRENCE** Worldwide. On the ground, under stones and logs, and among debris and leaf litter. Some species live in the foliage of shrubs and trees.

• **REMARK** A few species deter predators with blasts of hot, caustic substances that they expel, with an audible "pop," from the end of the abdomen.

△ *ANTHIA THORACICA* is a ground-living predator. Like all members of the genus *Anthia*, it can produce defensive chemicals that it sprays at attackers.

LARVAE are elongate and black or dark brown with well-developed legs and strong mandibles.



MORMOLYCE PHYLLODES, or the Violin Beetle, lives in the forests of Southeast Asia and feeds on insect larvae and snails.

MEGACEPHALA AUSTRALIS has bright, metallic coloration. Despite this, it hunts after dark, like all species in the genus *Megacephala*.

Length 1/16–3¼in (0.2–8cm)	Larval feeding habits

Order COLEOPTERA	Family CERAMBYCIDAE	No. of species 30,000

LONGHORN BEETLES

Also known as timber beetles, members of this family have elongate, parallel-sided bodies and long antennae – up to four times their body length. Their coloring is varied.

• **LIFE CYCLE** Single eggs are laid on plants and trees. Most larvae eat dead or decaying wood, aided by internal microorganisms that help them digest cellulose, but some attack live trees or bore into stems or seeds. Adults may eat pollen, nectar, leaves, or sap.

• **OCCURRENCE** Worldwide, mainly in tropical regions. In forests and woodland.

• **REMARK** Many species are serious pests of timber, fruit, and ornamental trees.

head has distinctive orange stripes

surface patterned with spots and bands

◁ ***STERNOTOMIS BOHEMANNI*** has the typical longhorn shape. The females use their mandibles to cut through bark, under which they lay eggs.

LARVAE are cylindrical in shape and may take months, or years, to develop.

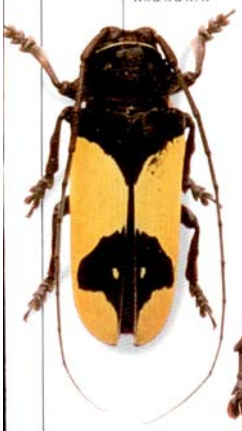
third segment of tarsus has two lobes, as with all family members

strong, toothed mandibles

eyes notched where antennae arise

pronotum has spiny margin

mandibles point downward



PHOSPHORUS JANSONI is found in Africa. It lays eggs in trees, and its larvae attack some economically important species such as the cola tree.

parallel-sided body

XIXUTHRUS HEROS males are territorial and fight with each other for control of suitable egg-laying sites.

Length ⅛–6in (0.3–15cm), most under 1¼in (4.5cm)	Larval feeding habits

Order COLEOPTERA	Family CETONIIDAE	No. of species 3,500

FLOWER CHAFERS

Also called fruit chafers, many of these robust, squarish, slightly flat beetles are brightly colored and often shiny. The head may have projections of varying lengths, which are usually more developed in males.

• **LIFE CYCLE** Eggs are laid in decaying plant matter, dry carcasses, and the ground. The larvae eat rotting plant material, dung, and wood; the adults mostly eat plant sap, pollen, and fruit.

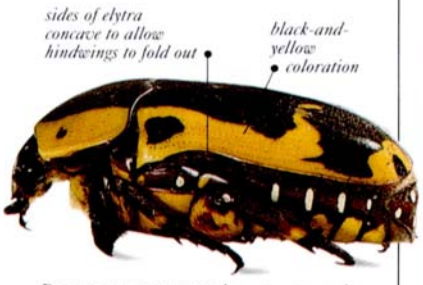
• **OCCURRENCE** Worldwide, especially in tropical and subtropical regions. In any well-vegetated habitat.

LARVAE are C-shaped, and can wriggle along on their backs when exposed.

▷ ***DICRONORHINA DERBYANA*** specimens may be less striped than the one shown here, with larger green areas.

◁ ***AGESTRATA LUZONICA*** is so called because it is found only in Luzon, in the Philippines.

△ ***IUMNOS RUCKERI*** comes from northern India and Burma. Its squarish outline, shiny surface, and slightly flat shape are characteristic of flower chafers.



PACHNODA SINUATA is a stout species from South Africa. It has several forms, in varying patterns of yellow and black. There are more species of this genus in tropical Africa than anywhere else.

Length ⅛–2¼in (1–7cm)	Larval feeding habits

Order COLEOPTERA	Family CHRYSOMELIDAE	No. of species 35,000

LEAF BEETLES

These beetles range from cylindrical and elongate to round-backed. Many species are brightly colored or metallic. The antennae are less than half the length of the body, which is typically smooth and hairless.

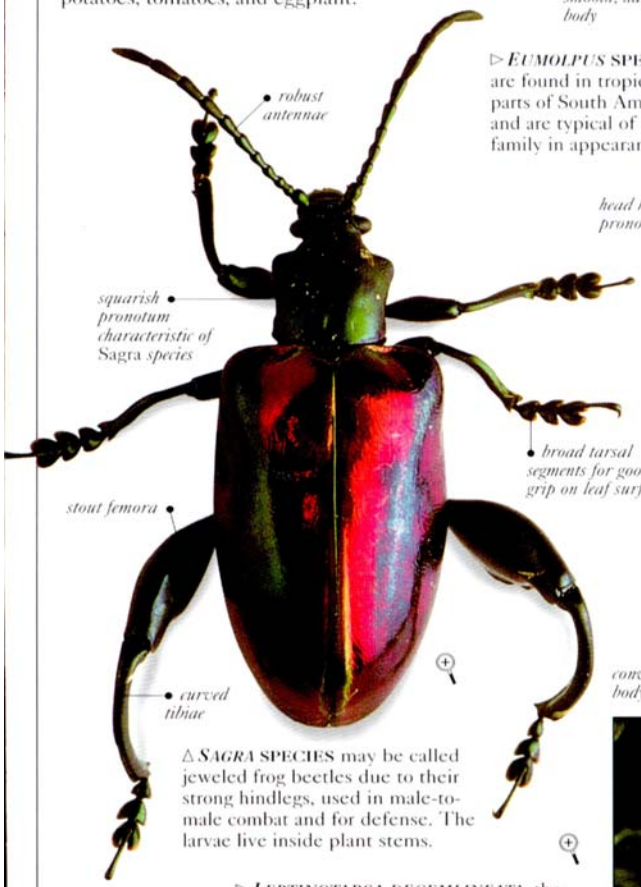
• **LIFE CYCLE** Groups of eggs are laid on host plants or in soil. The larvae usually feed externally on stems, foliage, and roots. Pupation normally occurs in the soil.

• **OCCURRENCE** Worldwide. Widespread on plants in all terrestrial habitats.

• **REMARK** Many species are pests: the brightly striped Colorado Beetle (*Leptinotarsa decemlineata*, see below) eats potatoes, tomatoes, and eggplant.

LARVAE are long and slightly curved, with well-developed legs.

▷ *EUMOLPUS* SPECIES are found in tropical parts of South America and are typical of this family in appearance.



△ *SAGRA* SPECIES may be called jeweled frog beetles due to their strong hindlegs, used in male-to-male combat and for defense. The larvae live inside plant stems.

△ *CALISPIDEA REGALIS* is native to Brazil. This very round species has red, netlike patterning and flat expansions of the elytra at the sides.

▷ *LEPTINOTARSA DECEMLINEATA*, the Colorado Beetle, is found in Asia, North America, and Europe. It is a pest of various food crops, including potatoes.

Length ½–1¾in (0.1–3cm)	Larval feeding habits

Order COLEOPTERA	Family CLERIDAE	No. of species 3,500

CHECKERED BEETLES

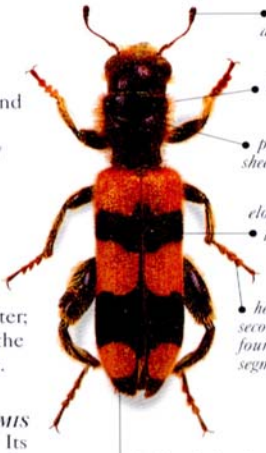
Most species in this family have soft, elongate, slightly flat bodies. They are often covered with long hairs, and many have distinctive clubbed antennae. Many species are brightly colored red, green, blue, or pink, and a few have brown or black camouflage coloring.

• **LIFE CYCLE** The larvae of these beetles typically prey on the larvae of wood-boring beetles, and eggs are frequently laid in dead wood where the hosts are burrowing. The larvae of some species in this family eat bee and wasp larvae and grasshopper eggs.

• **OCCURRENCE** Worldwide, mainly in subtropical and tropical regions. On tree trunks, flowers, and foliage; in fungi and leaf litter; and in the tunnels of wood-boring beetles and the nests of social insects such as bees and termites.

LARVAE often have projections at the end of the abdomen.

TRICHODES CRABRONIFORMIS comes from central Europe. Its larvae develop in the nests of certain bee species.



Length 1/16–2in (0.2–5cm)	Larval feeding habits

Order COLEOPTERA	Family COCCINELLIDAE	No. of species 5,000

LADYBIRDS

Also known as lady beetles or ladybugs, these rounded, short-legged beetles are either shiny and smooth or hairy. Most species are brightly colored black, red, yellow, or orange, often with distinctive spots or stripes.

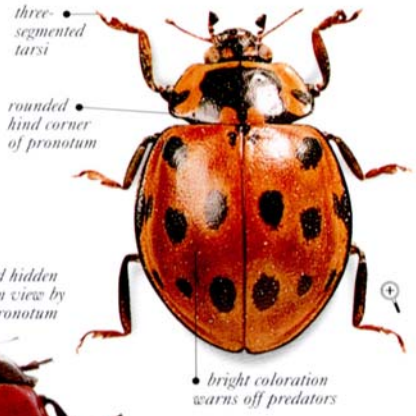
• **LIFE CYCLE** Eggs are laid singly or in small groups and glued to plants. The adults and larvae of most species eat soft-bodied insects. The larvae are dark in color, and the pupae may resemble bird droppings.

• **OCCURRENCE** Worldwide. On foliage.

• **REMARK** Ladybirds are beneficial control agents of pest insects and mites.

LARVAE are often warty or spiny.

COCCINELLA SEPTEMPUNCTATA is a common, seven-spotted European species that can ooze liquid from its leg joints to deter predators.



△ ***ANATIS OCELLATA***, or the Eyed Ladybird, is found on trees and is easily recognized by its black spots in the center of pale patches.

Length 1/32–3/16in (0.1–1.5cm)	Larval feeding habits

Order COLEOPTERA	Family CURCULIONIDAE	No. of species 48,000

WEEVILS

These insects are also called snout beetles, because of the extension of the head – the rostrum – that is present in most species, and which carries the mandibles. Many species have camouflage coloring, but others are brightly colored with metallic scales.

• **LIFE CYCLE** Females lay their eggs inside plant tissues. Many use their rostrums to bore holes in which to deposit the eggs.

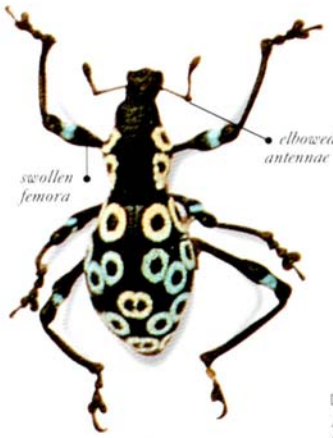
• **OCCURRENCE** Worldwide. On most terrestrial and some aquatic plant species.

• **REMARK** Many weevils are pests of crops such as cotton and rice, and of bark. Weevils form the largest family in the animal kingdom.

LARVAE are pale and grublike, with a dark, tough head and no thoracic legs.

△ ***CYRTOTRACHELUS* SPECIES** come from Southeast Asia. The males have long, hairy front tibiae, used in courtship displays.

▷ ***BRACHYCERUS FASCICULARIS*** is a strange-looking, hairy species that lives in South Africa. Its larvae feed on lilies.



***PACHYRHYNCHUS* SPECIES** have distinctive patterns of spots across their bodies. They are endemic to the Philippines.

▷ ***LAMPROCYPHUS AUGUSTUS*** is a South American species. Its green coloring may serve to hide it from predators by helping it blend in with foliage.

Length ½–3½in (0.1–9cm)	Larval feeding habits

Order COLEOPTERA	Family DERMESTIDAE	No. of species 950

LARDER BEETLES

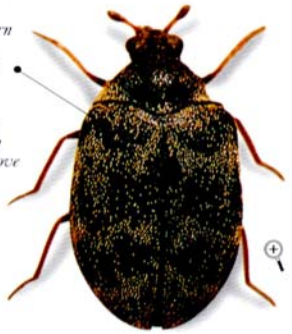
Sometimes called skin or museum beetles, members of this family are rounded or slightly elongate. They are dull-colored, brown or black, and are usually covered with patterns of colored hairs or scales. The head may be difficult to see from above as it is often hidden by the pronotum.

• **LIFE CYCLE** Eggs are usually laid on suitable foodstuff. The hairy, scavenging larvae feed at a rapid rate on a wide variety of organic matter.

• **OCCURRENCE** Worldwide. In a wide range of habitats.

• **REMARK** Many species are serious pests of foods stored in buildings, such as dried meat and spices, as well as textiles.

LARVAE are very hairy and are often referred to as "woolly bears."



△*ANTHRENUS MUSEORUM*, the Museum Beetle, is so called because its larvae can be pests of museum insect or plant collections.

DERMESTES LARDARIUS, the Larder Beetle, frequents food stores. The front half of its wing cases have white hairs and dark patches.

Length 1/16–1/2in (0.2–1.2cm)	Larval feeding habits

Order COLEOPTERA	Family DYTISCIDAE	No. of species 3,500

PREDACIOUS DIVING BEETLES

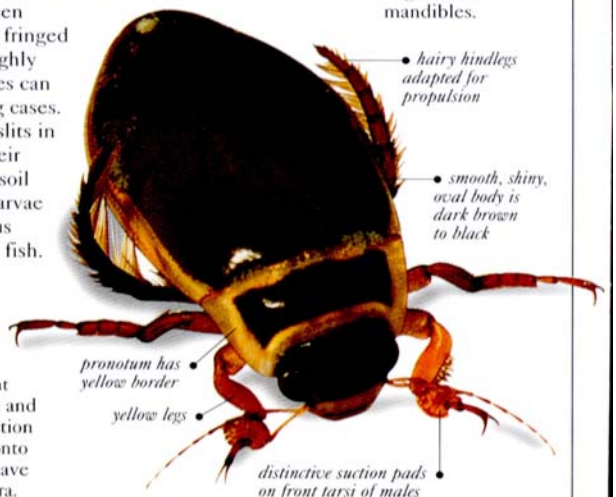
These beetles are oval and streamlined, with smooth, shiny bodies. Most species are black or dark brown but some have yellow, brown, or green markings. The hindlegs are flat and fringed with hairs to provide propulsion. Highly adapted for aquatic life, these beetles can carry air supplies beneath their wing cases.

• **LIFE CYCLE** The females cut slits in the stems of water plants and lay their eggs inside. Pupation occurs in wet soil near water. Like their parents, the larvae are fierce predators, attacking various prey, from insects to frogs and small fish.

• **OCCURRENCE** Worldwide. In streams, shallow lakes and ponds, brackish pools, and thermal springs.

DYTISCUS MARGINALIS, the Giant Diving Beetle, is found in Europe and Asia. The male has distinctive suction pads on its front legs for holding onto females during mating. Females have many more grooves along the elytra.

LARVAE are elongate, with well-developed legs and large, curved mandibles.



Length 1/16–1 1/2in (0.2–4cm)	Larval feeding habits

Order COLEOPTERA | Family ELATERIDAE | No. of species 9,000

CLICK BEETLES

Also called skip jacks, these beetles are elongate and mostly dull-colored. Their most distinctive characteristic is their ability to propel themselves into the air, making a loud click that frightens predators.

• **LIFE CYCLE** Eggs are laid in soil and plant matter. The larvae can take years to develop.

• **OCCURRENCE** Worldwide. Around plants, leaf litter, rotten wood, and soil.

LARVAE, or wireworms, are slender and cylindrical.

CHALCOLEPIDIUS LIMBATUS is found in woodland and grassland in South America.

SEMIOTUS ANGULATUS has distinctive orange markings on the thorax, which continue on the elytra.

Length 1/16–2¾in (0.2–7cm) | Larval feeding habits

Order COLEOPTERA | Family EROTYLIDAE | No. of species 2,500

GIANT FUNGUS BEETLES

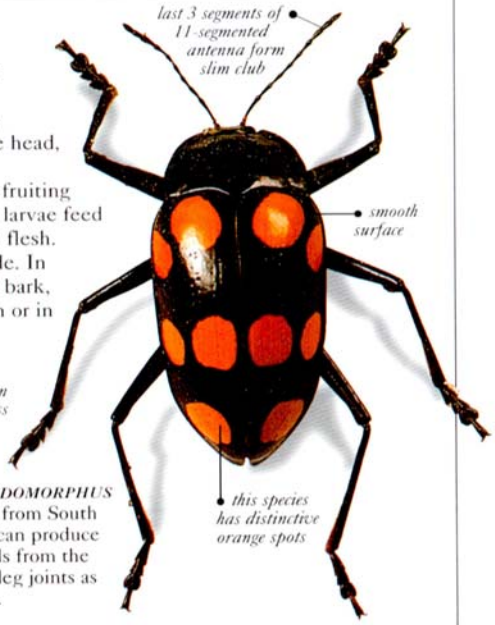
Also called pleasing fungus beetles, due to their attractive coloration, these insects are generally smooth, with an oval or elongate shape. In many species, the elytra are dark green or blue and the head, pronotum, and legs are reddish brown.

• **LIFE CYCLE** Females lay their eggs on the fruiting bodies of larger fungi or on decaying wood. The larvae feed on the surface of the fungus or tunnel inside the flesh.

• **OCCURRENCE** Worldwide. In forests and woods: under tree bark, at sources of plant-sap, and on or in fungi and rotting wood.

LARVAE are elongate and may be brightly colored.

***ZONARIUS* SPECIES** have the boldly striped elytra that are typical of some tropical members of this family.



▷ ***SCAPHIDOMORPHUS* SPECIES**, from South America, can produce toxic fluids from the anus and leg joints as a defense.

Length 1/8–1in (0.3–2.5cm) | Larval feeding habits

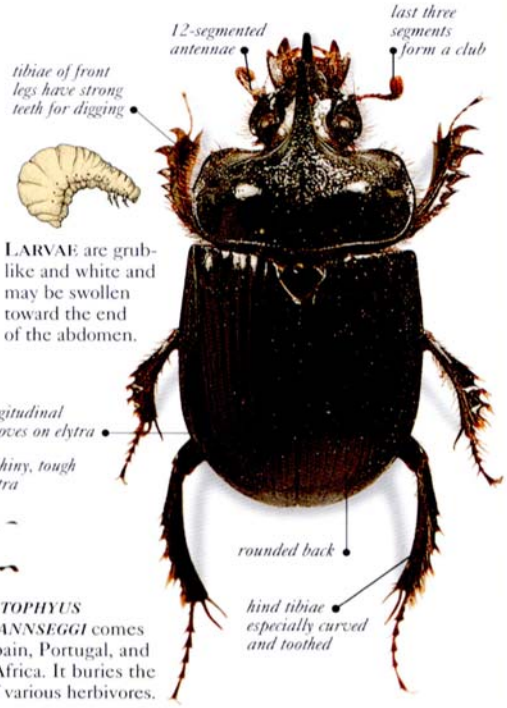
Order COLEOPTERA	Family GEOTRUPIDAE	No. of species 600

DOR BEETLES

Also called earth-boring dung beetles, these stout insects are oval and rounded. They are brown or black and shiny, often with a metallic-blue or purple sheen. The tough elytra have longitudinal grooves or striations, and the broad tibiae of the front legs have strong "teeth" for digging.

• **LIFE CYCLE** Eggs are laid in soil and dung. Adults prepare burrows and carry down dung, carrion, or decaying matter to feed their larvae.

• **OCCURRENCE** Worldwide. In dung, carrion, decaying wood, or fungi.



LARVAE are grub-like and white and may be swollen toward the end of the abdomen.

TYPHAEUS TYPHOEUS is known as the Minotaur Beetle because the males, shown here, have horns. Females make burrows, stocking the side tunnels with rabbit dung.

▷ ***CERATOPHYUS HOFFMANNSEGGI*** comes from Spain, Portugal, and North Africa. It buries the dung of various herbivores.

Length ½–1½in (0.4–4cm)	Larval feeding habits

Order COLEOPTERA	Family GYRINIDAE	No. of species 750

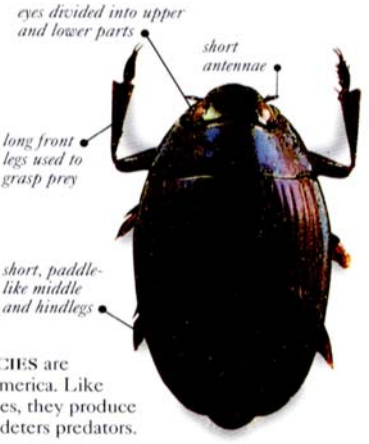
WHIRLIGIG BEETLES

These oval, streamlined beetles are mostly black, often with a bronze or steel-blue sheen. The long front legs are used to grasp prey, while the middle and hindlegs are short and paddlelike. Whirligigs occur in large numbers on the surface of water and use their ripple-sensitive antennae to locate prey.

• **LIFE CYCLE** Groups of eggs are laid on the underside of leaves. Pupation occurs on land in a cocoon or inside a mud cell.

• **OCCURRENCE** Worldwide. On the surface of ponds and slow-flowing streams.

• **REMARK** Their name derives from the fact that they swim rapidly, in circles.



LARVAE are elongate, with sharp, sucking mandibles and feathery abdominal gills.

***ENHYDRUS* SPECIES** are found in South America. Like all whirligig beetles, they produce a fruity odor that deters predators.

Length ⅛–1in (0.3–2.5cm)	Larval feeding habits

Order COLEOPTERA | Family HISTERIDAE | No. of species 3,000

HISTER BEETLES

These tough-bodied insects are rounded or oval. Many are convex in profile, although some have flat bodies that allow them to live under bark. Most species are black and have various striations and punctures on the surface of the elytra and other body parts.

• LIFE CYCLE Eggs are laid in carrion, dung, and rotting plant matter. The larvae (and adults) eat other insects, especially fly maggots and beetle grubs.

• OCCURRENCE Worldwide. In dung, carrion, or leaf litter; under bark; in tunnels of wood-boring insects; in nests of ants or birds; or inside termite colonies.

LARVAE are elongate, with square heads.

SIDE VIEW

OVERHEAD

CARCINOPS PUCILO is a black, extremely shiny beetle that breeds in rotting vegetable or animal matter and in bat dung.

△ *HOLOLEPTA* SPECIES are very flat, with an extremely hard body surface. They hunt for prey underneath the bark of various trees.

Length ½–1in (0.1–2.5cm) | Larval feeding habits

Order COLEOPTERA | Family HYDROPHILIDAE | No. of species 2,000

WATER SCAVENGER BEETLES

These beetles are oval and colored black, brown, or sometimes yellowish. The principal distinguishing feature is their antennae, which end in a four-segmented club. The last three segments of this club are hairy, whereas the first is smooth and saucer-shaped. Many adults live in water, carrying air under their wing cases and on the surface of their body.

• LIFE CYCLE Eggs are laid on water and in dung and damp places. Adults are usually scavengers; the larvae eat aquatic insect larvae, snails, and worms. The larvae may have gills or take air at the surface.

• OCCURRENCE Worldwide. Most live in water and damp habitats, although some are found in dung, decaying vegetation, and soil.

LARVAE may have warty or hairy backs.

HYDROPHILUS PICEUS, also called the Great Silver Water Beetle, uses its specially shaped antennae to channel air back, under the wings.

Length ½–1¾in (0.1–4.5cm) | Larval feeding habits

Order COLEOPTERA	Family LAMPYRIDAE	No. of species 2,000

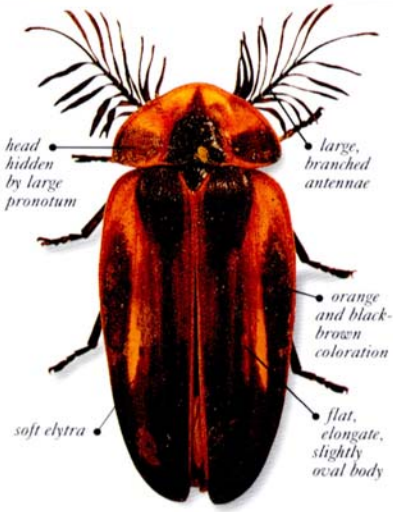
FIREFLIES

Also called lightning bugs, fireflies are neither flies nor bugs but flat, elongate, or slightly oval beetles. Most are dull-colored but may have red or yellow markings. Males usually have fully developed wings, whereas females may be wingless. Some wingless females look like larvae. The common names derive from the fact that the adults of many species communicate with mates by using species-specific flashes of cold, green light. These are made by luminous organs on the underside of the abdomen.

• **LIFE CYCLE** Eggs are laid on vegetation. The larvae, which are commonly known as glow worms, feed on invertebrates and snails.

• **OCCURRENCE** Worldwide. On vegetation in woodland and moist grassland.

• **REMARK** Females of some species imitate the flashing of closely related species, luring the males with their sexual signals and then eating them.



LARVAE are elongate and taper at both ends. The head is small and usually longer than its width.

LAMPROCERA SELAS has distinctive antennae and orange-red and black-brown coloration, which warns potential predators that this insect is distasteful.

Length 1/16–1¼in (0.5–3cm)	Larval feeding habits

Order COLEOPTERA	Family LATHRIDIIDAE	No. of species 500

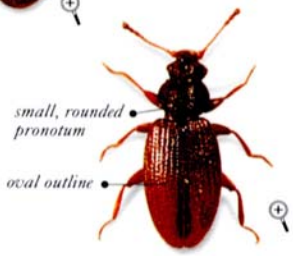
MINUTE SCAVENGER BEETLES

These tiny, oval, brown or black beetles, also called mold beetles, have a small, rounded pronotum. The wing cases have rows of ribs or puncture marks and may be slightly hairy or bristly.

• **LIFE CYCLE** Eggs are laid on substances such as decaying matter and fungi. The larvae feed on the spores of various fungi.

• **OCCURRENCE** Worldwide, especially in temperate regions. Under stones and bark; in fungi, decaying or moldy material, and birds' nests; and on flowers.

◁***ARIDIUS BIFASCIATUS*** is a fungus-feeding native of Australia, now found elsewhere. Its elytra have distinctive coarse grooves and dark markings.



LARVAE are pale, oval or elongate, and slightly flat. The upper surface has groups of hairs.

ENICMUS TRANSVERSUS has brown to black coloration, a very flat body, and distinctive grooves on its elytra.

CORTICARIA IMPRESSA is a dark brown, fungus-feeding beetle. Its wing cases are a lighter color than the head and thorax.

Length 1/32–1/8in (1–3mm)	Larval feeding habits

Order COLEOPTERA	Family LUCANIDAE	No. of species 1,300

STAG BEETLES

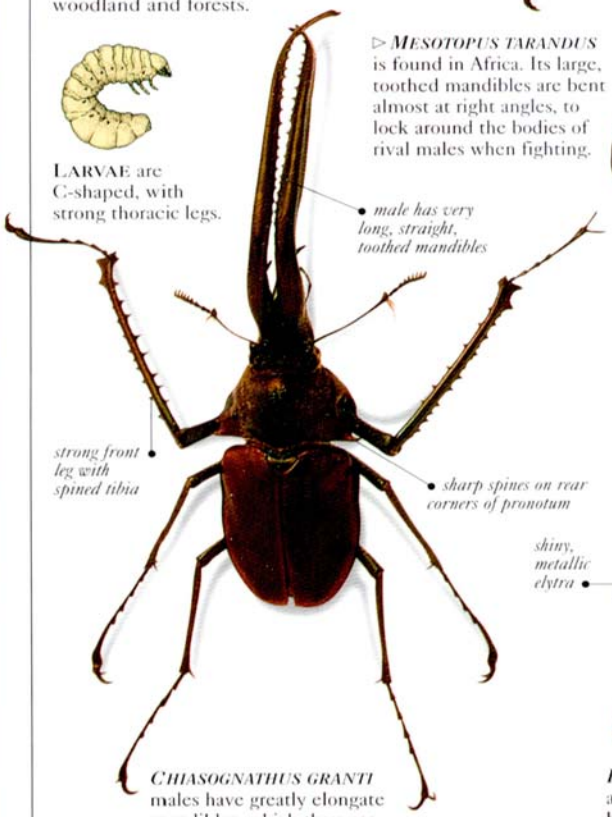
These beetles are typically large, smooth, and black or reddish brown. Males are larger than females and have greatly enlarged mandibles that may be lined with prominent teeth. These powerful mandibles are used in male-to-male combat over females and are designed to fit around the edges of a rival's pronotum, with the victor flipping its rival over. Adults are mainly nocturnal and either do not feed or take fluids (plant sap, nectar, or fruit juice).

• **LIFE CYCLE** The female lays her eggs on decaying tree stumps, roots, or logs. Stag beetle larvae may take several years to complete their development. The larvae pupate inside a cell that is composed of chewed wood fibers.

• **OCCURRENCE** Worldwide. In deciduous woodland and forests.

▷ ***MESOTOPUS TARANDUS*** is found in Africa. Its large, toothed mandibles are bent almost at right angles, to lock around the bodies of rival males when fighting.

LARVAE are C-shaped, with strong thoracic legs.



CHIASOGNATHUS GRANTI males have greatly elongate mandibles, which they use in male-to-male combat.

PHALACROGNATHUS MULLERI is a distinctively colored, metallic stag beetle that is found in the rainforests of northern Australia.

Length 1/16–3 1/8in (0.5–8cm), most 1/8–1 1/8in (1.5–4.5cm)	Larval feeding habits

Order COLEOPTERA	Family LYCIDAE	No. of species 3,500

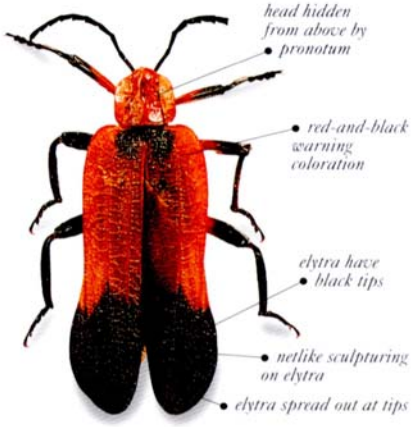
NET-WINGED BEETLES

The wings of these soft-bodied, black-and-red or yellow beetles often have a netlike pattern of cells on the elytra. Adult females of a few rainforest species look like very large larvae.

• **LIFE CYCLE** Eggs are typically laid in or on the larval feeding site – the larvae suck liquids from rotting matter or eat small arthropods. There is some debate about what these beetles eat, and little is known about the life cycle of most species. Adults probably do not feed a great deal, but some take nectar and pollen.

• **OCCURRENCE** Worldwide, except in New Zealand, mainly in warmer regions. In wooded and well-vegetated areas.

LARVAE are often wider in the middle than at the ends, and the dorsal surface may be patterned.



***LYCUS* SPECIES** are typically flat, with black-and-red warning coloration that deters predators. Males and females may have different shapes or markings.

Length ⅛–1¼in (0.3–3cm)	Larval feeding habits

Order COLEOPTERA	Family MELOIDAE	No. of species 3,000

BLISTER BEETLES

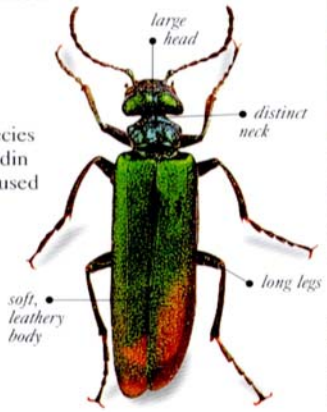
Also called oil beetles, the adults produce cantharidin, an oily fluid to deter predators that can blister human skin. Most species are soft, leathery, and black or brown with red or yellow marks. Some are metallic. Most are long and parallel-sided; a few are oval. The elytra vary in length.

• **LIFE CYCLE** Eggs are laid in soil. The mobile, first-stage larvae locate and eat the eggs of grasshoppers or bees. Adults are herbivorous.

• **OCCURRENCE** Worldwide, except in New Zealand, mainly in warm, dry areas. On flowers and foliage.

• **REMARK** Some species are crop pests. Cantharidin from *Lytta vesicatoria* is used to treat urogenital disorders.

LARVAE become increasingly grublike with each molt.



△ ***MYLABRIS* SPECIES** are all brightly colored and secrete toxic or blistering fluids from their leg joints. Some species are serious pests of millet crops in West Africa.

LYTTA VESICATORIA, the Spanish Fly, is a bright, iridescent green and produces a mouselike odor. Its larvae develop in the nests of solitary bees.

Length 1/16–1¼in (0.5–3cm), most ⅛–¾in (1–2cm)	Larval feeding habits

Order COLEOPTERA	Family MORDELLIDAE	No. of species 1,500

TUMBLING FLOWER BEETLES

These beetles, named after their habit of tumbling when disturbed, are typically humped or arched in profile but quite flat from side to side. The end of the abdomen is spinelike. Most species are brown or black with patterns of short white, red, or yellowish hairs or scales.

• **LIFE CYCLE** Eggs are laid singly in dead wood or plants. The larvae develop mostly in decaying wood or mine plant stems. Adults eat nectar.

• **OCCURRENCE** Worldwide, mainly in tropical regions. Adults gather on flowers and dead wood in the sun.

LARVAE are cylindrical and elongate, with a round head and short legs.

OVERHEAD

SIDE

◁△ *MORDELLA OCTOPUNCTATA* has bright orange spots on its elytra and a patterned pronotum.

▷ *TOMOXIA BUCEPHALA* has the parallel-sided to slightly tapering shape that is characteristic of this family.

Length 1/16–⅜in (0.2–1.5cm)	Larval feeding habits

Order COLEOPTERA	Family NITIDULIDAE	No. of species 3,000

POLLEN BEETLES

Also known as sap beetles, these small beetles are mostly oval, square, or rectangular, and are often convex in profile. Most are brown or black and can have irregular red or yellow spots. In some species the elytra are shortened, exposing the last couple of abdominal segments.

• **LIFE CYCLE** Eggs are laid around feeding sites. Adults and larvae feed on sap, nectar, and pollen, but a few prey on scale insects, and some larvae develop inside seed pods.

• **OCCURRENCE** Worldwide. On flowers, sap flows, and decaying plant and animal material; a few species live in ant and bee colonies.

LARVAE are long, slender, slightly curved, and white.

***EPURAEA* SPECIES** are mostly pale or red-brown and slightly flat, with clubbed antennae and dark eyes.

△ *MELIGETHES PLANIUSCULUS* is a European native. Both the adults and larvae feed on buds and flowers.

Length 1/32–⅛in (0.1–1.5cm)	Larval feeding habits

Order COLEOPTERA	Family PASSALIDAE	No. of species 500

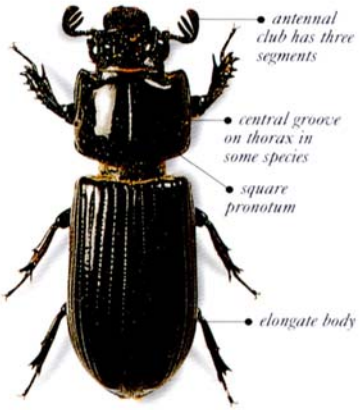
BESS BEETLES

Also called betsy or patent-leather beetles, these species are shiny black or dark brown with a parallel-sided, flattened body. The elytra have noticeable striations, and many species rarely fly.

• **LIFE CYCLE** Eggs are laid in dead wood. Adults and larvae live together in rotten tree stumps and logs. Adults chew wood into pulp for the larvae to eat; the cellulose is digested by fungi in the gut.

• **OCCURRENCE** Primarily tropical regions. Mainly in wooded areas of South America and Southeast Asia. Some are found inside leaf-cutter ant nests.

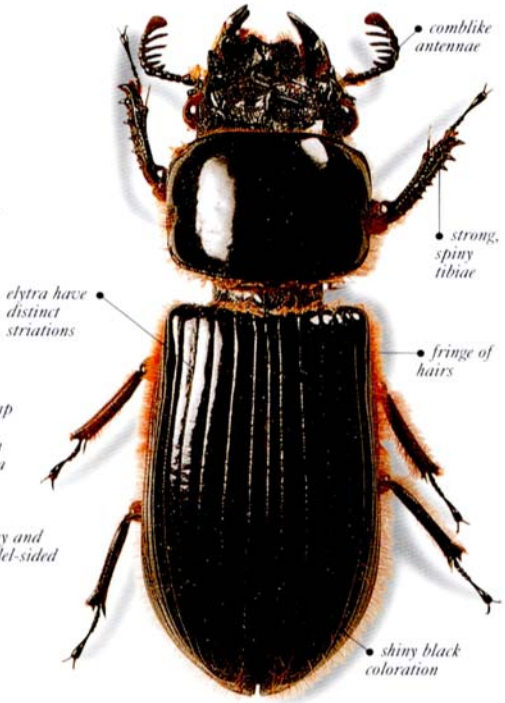
• **REMARK** Adults make sounds by rubbing their hindwings against the abdomen. These are used for aggression, mating, and keeping in touch with larvae.



AULACOCYCLUS PARRYI has a flattened body that allows it to dig through detritus and under bark.

LARVAE have short, thick hindlegs, which are scraped against ridges on the middle legs to produce sound.

***AULACOCYCLUS* SPECIES** are well represented across Southeast Asia. Individual species look very similar, and detailed examination is required for correct identification.



ACERAIUS RECTIDENS has curled, ten-segmented antennae and a short peg on the head.

Length ⅛–3¼in (1–8.5cm)	Larval feeding habits

Order COLEOPTERA | Family PSELAPHIDAE | No. of species 9,000

PSELAPHID BEETLES

The abdomen of these small brown beetles is considerably broader than the pronotum and the head. The elytra are short, which leaves most of the abdomen exposed.

• LIFE CYCLE Little is known about the life cycle of most species. Adults, and presumably larvae as well, eat mites, small insects, and other invertebrates.

• OCCURRENCE Worldwide. Under bark, in rotting vegetation and wood, and in moss, leaf litter, caves, and soil. Some species live in ant colonies.

▷ *RYBAXIS LONGICORNIS* is European and lives in moss clumps near pools and bogs.

short elytra leave abdomen exposed

last segment of antennae enlarged

◁ *BATRISODES DELAPORTI* lives in association with *Lasius brunneus* ants, in dead wood.

LARVAE are often slightly flattened in shape.

Length 1/64–1/4in (0.5–6mm), most under 1/8in (3mm) | Larval feeding habits

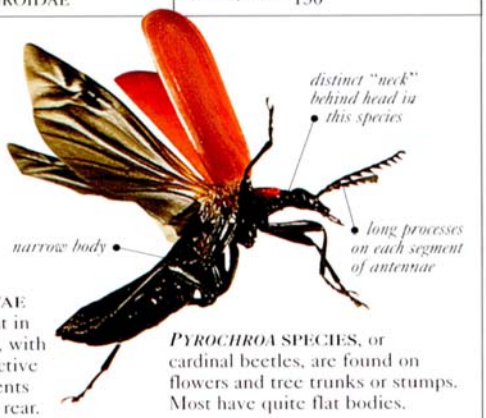
Order COLEOPTERA | Family PYROCHROIDAE | No. of species 150

PYROCHROID BEETLES

Also called fire-colored beetles because of their distinctive black, red, and yellow coloring, most species are narrow and soft-bodied. The eyes are large in relation to the head, and the segments of the antennae are serrated or have long processes.

• LIFE CYCLE Eggs are laid under the bark of dead wood, where the larvae develop, eating threads of fungi or small creatures.

• OCCURRENCE Mostly in Northern Hemisphere and Southeast Asia. In woodland and forests.



distinct "neck" behind head in this species

long processes on each segment of antennae

narrow body

LARVAE are flat in shape, with distinctive segments at the rear.

PYROCHROA SPECIES, or cardinal beetles, are found on flowers and tree trunks or stumps. Most have quite flat bodies.

Length 1/4–3/4in (0.6–1.8cm) | Larval feeding habits

Order COLEOPTERA | Family RHIPIPHORIDAE | No. of species 450

WEDGE-SHAPED BEETLES

These hump-backed, black-and-orangish beetles are described as wedge-shaped because of their extremely blunt-ended abdomens. The wings may be either full-sized or short.

• LIFE CYCLE Eggs are laid where host insects visit – the larvae are parasitic on cockroaches or wood-boring beetle, bee, and wasp larvae. Young larvae may have legs. Later stages are maggotlike.

• OCCURRENCE Worldwide. In a variety of habitats where insect hosts can be found.

LARVAE of early stages may have legs to grip the host insect.

METOECUS PARADOXUS is the only British species in this family. Its larvae are parasites of *Vespula* wasps and their larvae.

wedge-shaped body

Length 1/32–1 1/2in (0.4–3.6cm) | Larval feeding habits

Order COLEOPTERA	Family SCARABAEIDAE	No. of species 16,500

SCARABS

The huge family Scarabaeidae comprises several major subfamilies, including dung beetles or scarabs, giant hercules beetles, and leaf chafers. Extremely varied in shape and size, their colors range from black to metallic blues and greens. All species have antennae that end in a kind of club, made up of several movable plates. The males of many species have horns, which they use when fighting over females.

• **LIFE CYCLE** Eggs are laid – and larvae can be found – in soil, the dung of herbivorous mammals, rotten wood, and decaying matter. Some adult dung beetles use their hindlegs to roll fresh dung away in balls before burying the balls and laying their eggs inside. Others bury dung where it is.

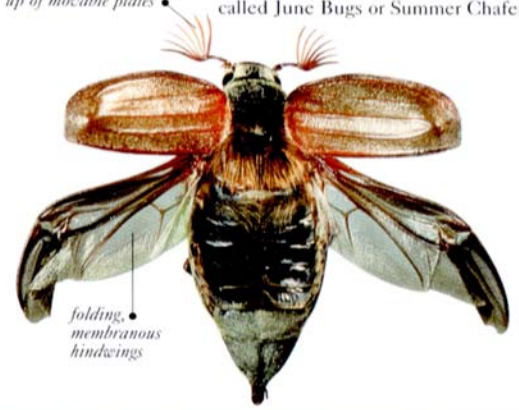
• **OCCURRENCE** Worldwide. On dung, carrion, decaying matter, fungi, and vegetation; under bark; and in the burrows of vertebrates or in ant and termite nests.

• **REMARK** The dung or scarab beetle was a major religious symbol in Ancient Egypt. Mummification may have been an imitation of its pupal stage, protecting the body during its transformation and ultimate rebirth.

△ ***PHANEUS DEMON*** is a Central American species whose larvae develop inside the dung of large herbivores.

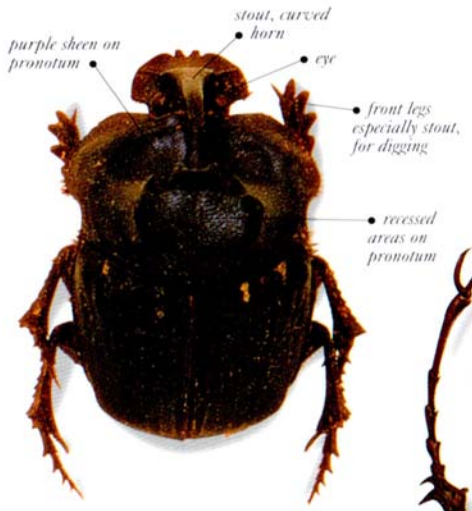
▷ ***PLUSIOTIS RESPLENDENS*** is found in Central America. Many brightly colored species such as this are much sought after by unscrupulous collectors.

▽ ***MELOLONTHA MELOLONTHA***, the Cockchafer, is nocturnal and often attracted to lights. Related species are called June Bugs or Summer Chafers.



△ ***KHEPER AEGYPTIORUM***, found in Africa, rolls dung balls as large as 2in (5cm) away from dung pats to bury. This large, colorful beetle was probably the first to be revered in Ancient Egypt.

Length 1/16–6¼in (0.2–17cm)	Larval feeding habits



△ *COPROPHANEUS LANCIFER* comes from South America. This species buries pieces of dead animals, on which it then rears its larvae.

LARVAE are white, C-shaped grubs with well-developed mandibles.

△ *CHALCOSOMA ATLAS* is one of three known species from eastern Asia. Males use their horns to grapple with each other in contests over females.

△ *SCARABAEUS CATERATUS*, found in eastern Africa, is attracted to the dung of large herbivores, such as buffalo and giraffes. Females stay in the nest to look after the young when they emerge from within the brooding dung balls.

Order COLEOPTERA	Family SILPHIDAE	No. of species 250

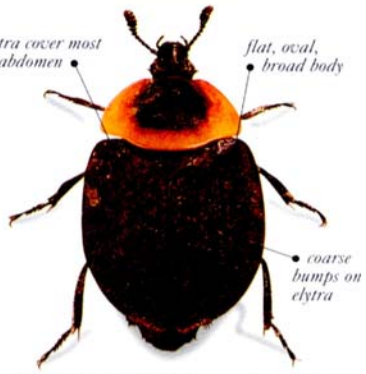
CARRION BEETLES

Many of these flat, soft-bodied species are black or brown, often with bright yellow, red, or orange markings. In some species, the elytra are shortened, exposing several abdominal segments.

• **LIFE CYCLE** Adults and larvae are mostly scavengers, eating rotting animal or plant material. Species of the genus *Nicrophorus* (sexton or burying beetles) bury corpses of small animals and lay their eggs on the buried carcass. In some species, adults may feed their larvae regurgitated carrion.

• **OCCURRENCE** Worldwide, but mainly in the Northern Hemisphere. On the ground near carcasses, dung, and rotting fungi.

LARVAE are flat and elongate, with a broad pronotum and small head.



SILPHA AMERICANA is a native of North America. It has a broad shape and fairly bright coloration. Like all carrion beetles, it is quickly attracted to carrion by the odor.

Length ⅛–1¼in (0.4–4.5cm), most under ¾in (2cm) | Larval feeding habits

Order COLEOPTERA	Family STAPHYLINIDAE	No. of species 29,000

ROVE BEETLES

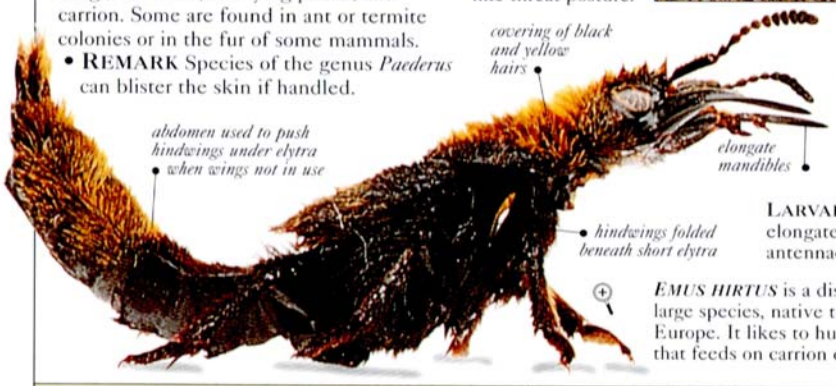
Most of these beetles are small and smooth, with elongate, parallel-sided, brown or black bodies. Some may have a sculptured body surface, bright colors, or body hairs. They all have short elytra, and a highly mobile, exposed abdomen. Small species tend to be diurnal; larger species are usually nocturnal.

• **LIFE CYCLE** Eggs are commonly laid in soil, fungi, and leaf litter. Most larvae prey on insects and other arthropods, and usually live in the same place as the adults.

• **OCCURRENCE** Worldwide. In soil, fungi, leaf-litter, decaying plants, and carrion. Some are found in ant or termite colonies or in the fur of some mammals.

• **REMARK** Species of the genus *Paederus* can blister the skin if handled.

STAPHYLINUS OLENS, or the Devil's Coach Horse, is a large, black European species. If disturbed or threatened, it curves its abdomen up in a scorpion-like threat posture.



LARVAE are elongate, with short antennae and cerci.

EMUS HIRTUS is a distinctive, large species, native to southern Europe. It likes to hunt prey that feeds on carrion or dung.

Length ⅛–1⅛in (0.1–4cm), most under ¾in (2cm) | Larval feeding habits

Order COLEOPTERA	Family TENEBRIONIDAE	No. of species 17,000

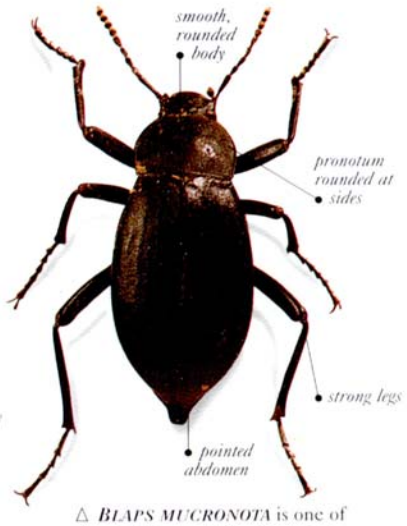
DARKLING BEETLES

These beetles are mostly black or brown in color. Some species, however, have colored markings or white elytra. There is a great variation in shape within this family, from parallel-sided and blunt-ended to large and broadly oval. The body may be smooth and shiny or dull and roughly textured.

• **LIFE CYCLE** The eggs are scattered singly or in groups in and around the larval feeding-matter. These beetles are scavengers and mostly eat decaying vegetable or animal material; some larvae will eat plant roots. Adults of many species are able to produce a foul-smelling secretion, used for defense, from special glands on the abdomen.

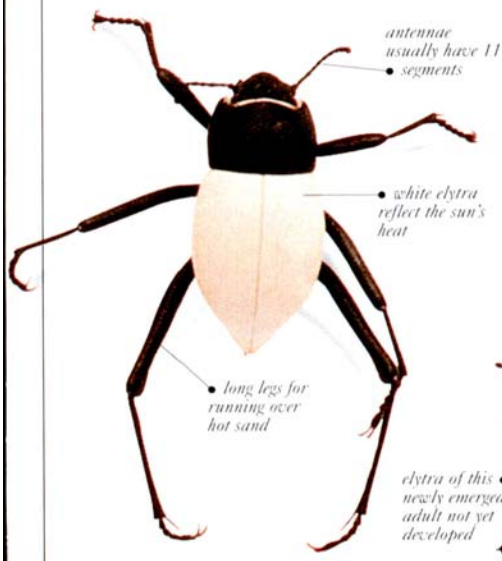
• **OCCURRENCE** Worldwide. In all terrestrial habitats, especially desert and arid regions.

• **REMARK** Some species can be pests. The family includes flour beetles – which may damage stored, dried foods such as flour, grain, and cereals – and others that damage coffee or mushroom crops.

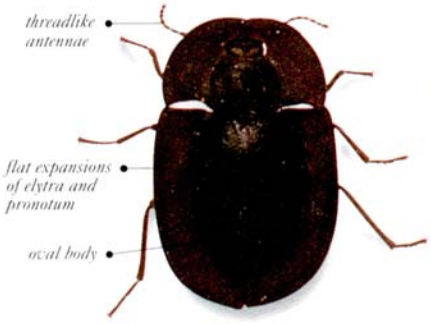


△ *BLAPS MUCRONOTA* is one of six similar, nonflying European species. Called cellar or churchyard beetles, they favor dark places.

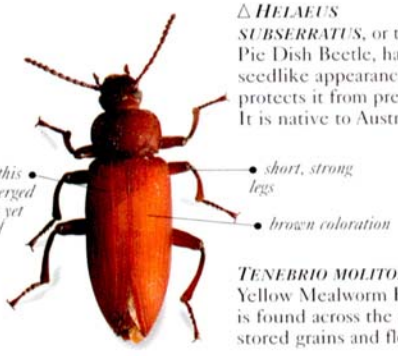
LARVAE are elongate and cylindrical with tough bodies and short legs.



ONYMACRIS CANDIDIPENNIS has elytra with no pigmentation. Combined with its long legs, this allows it to be active during the day in its native Namib Desert.



△ ***HELAEUS SUBSERRATUS***, or the Pie Dish Beetle, has a seedlike appearance that protects it from predators. It is native to Australia.



TENEBRIO MOLITOR, or the Yellow Mealworm Beetle, is found across the world in stored grains and flour.

Length 1/16–2in (0.2–5cm), most under 1/4in (2cm)	Larval feeding habits

STREPSIPTERANS

THERE ARE 8 FAMILIES and 560 species in the order Strepsiptera. Male strepsipterans have large, fan-shaped hindwings and tiny, straplike forewings. The hindwings have a twisted appearance, giving rise to the other common name for this order – twisted-winged parasites. The grublike females are wingless and, typically, legless. They usually live as endoparasites, inside the bodies of other insects. Strepsipterans use species from many different orders as hosts but favor bugs, wasps, and bees.

Males detect mates by the sexual pheromones that females emit and then cling to the host's body and mate with the female inside. Metamorphosis is complete. Eggs hatch inside the female. Hundreds or thousands of tiny, six-legged larvae (triungulins) emerge from the host, and each goes in search of its own host. Once a host is found, the larva uses an enzyme to get inside and molts to become a legless endoparasite, feeding on the host's body fluids and tissues. Pupation occurs inside the host. Males emerge and fly off, killing the host in the process, but females remain inside the live host.

Some species of strepsipterans are useful control agents of pests such as crickets and planthoppers.

Order STREPSIPTERA	Family STYLOPIDAE	No. of species 260

STYLOPIDS

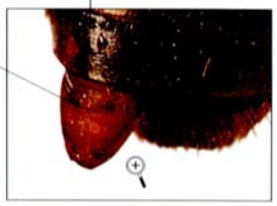
Males of this family are small and dark, with bulging, berrylike eyes. The forewings are tiny and straplike; the hindwings large and fanlike. Females are wingless and legless and never leave the body of their host.

• **LIFE CYCLE** Most stylopid species parasitize mining or sweat bees or solitary or vespid wasps (see pp.178–93). After mating, eggs hatch inside the female stylopid. The active triungulin larvae then leave the female through a special brood passage and crawl onto flowers to wait for the next host.

• **OCCURRENCE** Worldwide. In various well-vegetated habitats, wherever hosts are found. Males are free-living, whereas the females of the species live in the bodies of certain bees and wasps.

• **REMARK** The sexual organs of the parasitized hosts degenerate and, in some cases, there may be a reversal of secondary sexual characters, so that males look like females and vice versa.

HOST BEE



female stylopid inside host bee projects partly from between segments of the bee's abdomen

FEMALE IN ABDOMEN OF HOST BEE

LARVAE are very small, with a pair of bristles at the end of the abdomen that they use to jump.

branched antennae

berrylike eyes

hindwings have slightly twisted appearance

MALE

***STYLOPS* SPECIES** have a highly distinctive shape. They have an interesting biology that has led to them being used as the emblem of a major entomological society.

Length ¼–½in (0.5–4mm)	Larval feeding habits

SCORPIONFLIES

THE ORDER MECOPTERA includes 9 families and 550 species. The common name refers to the scorpion-like abdomen seen in the males of certain species – slender and upturned, with swollen genitalia. Scorpionflies have an elongated body, and most species have two pairs of narrow wings. The head is typically lengthened downward to form a beak, called the rostrum, which bears the mandibles.

Scorpionflies feed on dead or dying insects and will also feed on carrion, nectar, or various other fluids. Mating often occurs after dark. It may involve the presentation of nuptial gifts by the males, usually in the form of a dead insect or a mass of saliva that the male produces. Females will reject males who offer small or poor gifts, but a male may then simply take a mate by force, seizing the female with its genital claspers. Sexual pheromones may also be involved in the courtship rituals, being produced either by the males only or by both sexes.

Scorpionflies lay their eggs in soil. Metamorphosis is complete and the larvae are either highly caterpillar-like, with abdominal prolegs, or grublike. Pupation takes place in an underground cell or in vegetation.

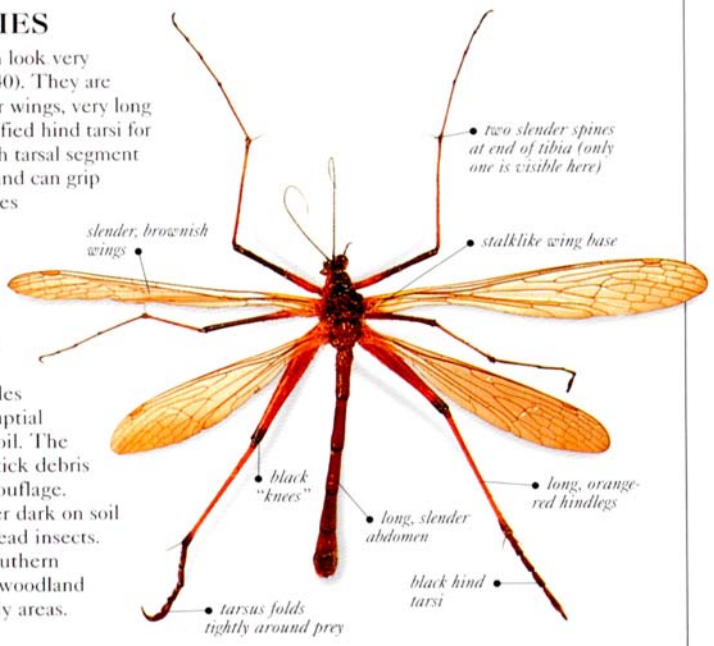
Order MECOPTERA	Family BITTACIDAE	No. of species 170

HANGINGFLIES

These scorpionflies can look very like crane flies (see p.140). They are characterized by slender wings, very long legs, and specially modified hind tarsi for capturing prey. The fifth tarsal segment of the hindleg is sharp and can grip prey tightly. Hangingflies typically hang from vegetation by their front legs and trail their long hindlegs to catch passing prey.

• **LIFE CYCLE** The mating process can be complicated by the males stealing each other's nuptial gifts. Eggs are laid in soil. The caterpillar-like larvae stick debris to their bodies for camouflage. They crawl around after dark on soil and leaf litter, eating dead insects.

• **OCCURRENCE** Southern Hemisphere. In damp woodland or well-vegetated, shady areas.



LARVAE are caterpillar-like, with three pairs of short thoracic legs, short abdominal prolegs, and hair-bearing warts.

HARPOBITTACUS AUSTRALIS is an Australian species with brownish wings and orange-red, banded legs.

Length ⅛–1½in (1.5–4cm)	Larval feeding habits

Order MECOPTERA	Family BOREIDAE	No. of species 26

SNOW SCORPIONFLIES

These dark brown or black insects do not fly, although their long middle and hindlegs allow them to jump short distances. The wings are reduced and hooklike in the males, and scalelike in the females.

• **LIFE CYCLE** Eggs are laid in moss. The adults and larvae of this family mainly feed on mosses and lichens.

• **OCCURRENCE** Northern Hemisphere, in cold, mountainous areas. They occur on snow, in mosses, and under stones, but are quite rare.

LARVAE are cylindrical and caterpillar-like, with well-developed thoracic legs.

BOREUS BRUMALIS is seen here mating on the surface of snow. This is the most common snow scorpionfly in the northeastern US.

Length 1/16–3/16in (2–5mm), most 1/8–1/6in (3–5mm) | Larval feeding habits

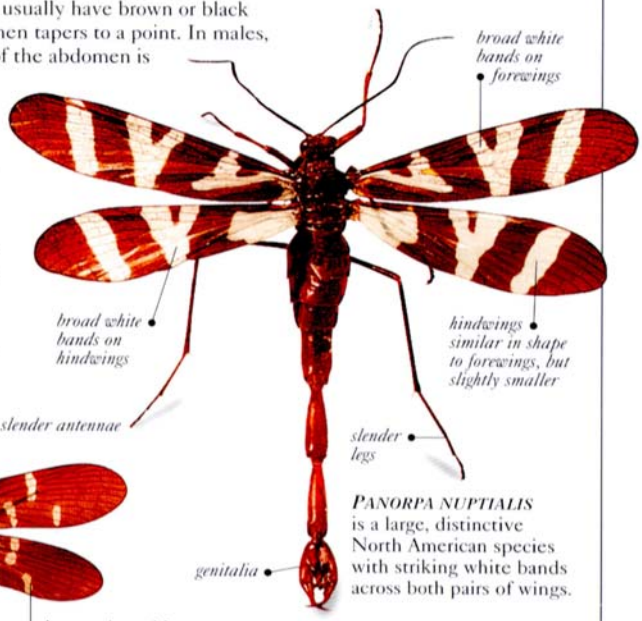
Order MECOPTERA	Family PANORPIDAE	No. of species 360

COMMON SCORPIONFLIES

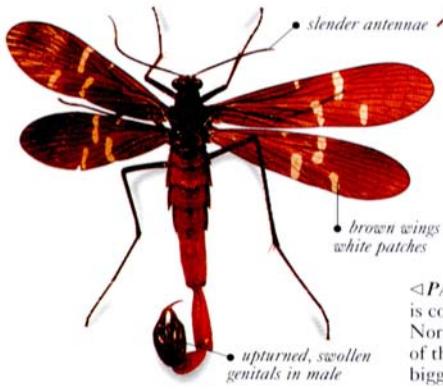
The wings of these scorpionflies usually have brown or black patterning. In females, the abdomen tapers to a point. In males, the genital apparatus at the end of the abdomen is swollen and upturned.

• **LIFE CYCLE** Some males steal prey from spiders' webs to feed the female during mating. Eggs are laid in soil or damp leaf litter, and the larvae resemble caterpillars. Pupation takes place inside a cell underground. Adults eat dead insects, nectar, and fruit.

• **OCCURRENCE** Worldwide, but mostly in the Northern Hemisphere. Among vegetation in a variety of shady habitats.



PANORPA NUPTIALIS is a large, distinctive North American species with striking white bands across both pairs of wings.



◁ *PANORPA LUGUBRIS* is common in parts of North America. The males of this large species are bigger than the females.

LARVAE have three pairs of thoracic legs and eight pairs of short, abdominal prolegs.

Length 11/32–1in (0.9–2.5cm), most 3/8–5/8in (1–1.5cm) | Larval feeding habits

FLEAS

THE ORDER SIPHONAPTERA is divided into 18 families and 2,000 species of flea. These brown, shiny, and wingless insects have tough, laterally flattened bodies covered with backward-pointing spines and bristles. The enlarged hindlegs are part of a unique jumping mechanism involving energy storage in rubberlike pads of protein. Fleas have specialized mouthparts for sucking blood. They are ectoparasites, living on the outside of a host animal and feeding on it without killing it.

Less host-specific than parasitic lice (see pp.83–84), some fleas are found on over 30 host species – mostly terrestrial mammals but also birds. Metamorphosis is complete. The larvae do not suck blood, but scavenge on the excrement of adult fleas, detritus, and dried blood.

Order SIPHONAPTERA | Family HYSTRICHOPSYLLIDAE | No. of species 80

RODENT FLEAS

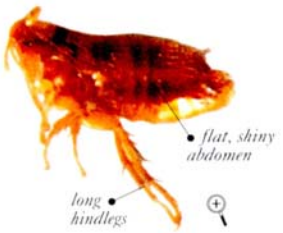
These species of fleas have a comb of stout, dark bristles at the rear edge of the pronotum. Most are ectoparasites of small rodents such as mice and wood rats.

• **LIFE CYCLE** Sticky eggs are laid in the host's burrow, lair, or nest. There are three larval stages, and pupation takes place within a silken cocoon.

• **OCCURRENCE** Worldwide, mainly in the Northern Hemisphere. In hosts' nests.

• **REMARK** Pest species include *Ceratophyllus gallinae*, the European Chicken Flea.

LARVAE are slender, pale, relatively hairless, and without legs.



***EPITEDIA* SPECIES** are found only in North America. Their favored hosts are rats, mice, and shrews.

Length 1/32–3/8in (1–4mm) | Larval feeding habits

Order SIPHONAPTERA | Family PULICIDAE | No. of species 200

COMMON FLEAS

This family looks typical of its order and may have bristle-combs on its pronotum and cheeks. Common fleas are ectoparasitic on humans and a wide range of other mammals, including dogs, cats, and rabbits.

• **LIFE CYCLE** Eggs are dropped in hosts' nests or burrows. Adults can survive for a long time without a blood meal. Emergent fleas remain in their cocoon until they sense a host's presence.

• **OCCURRENCE** Worldwide. On mammalian hosts in a wide range of habitats.

• **REMARK** Many species spread disease. The Dog Flea carries a tapeworm that affects dogs, cats, and humans. The bacterium that caused bubonic plague in medieval Europe was carried by various types of rat flea.

LARVAE are slender, pale, and wormlike.

▷ ***SPILOPSYLLUS CUNICULI*** is widespread in the Northern Hemisphere and carries the rabbit disease myxomatosis.

CEDISPSYLLA SIMPLEX is found on cottontail rabbits in North America.

Length 1/32–5/16in (1–8mm) | Larval feeding habits

TWO-WINGED FLIES

THE ORDER DIPTERA contains 130 families and 122,000 species. These insects have just one pair of wings; the hindwings are reduced to small, club-shaped balancing organs called halteres. Some are wingless. There are two suborders. The delicate and slender Nematocera (Bibionidae to Tipulidae below) have slim antennae. The Brachycera, divided into Orthorrhapha and Cyclorrhapha (and represented here by the families Acroceridae to Tephritidae) are more robust, with short, stout antennae that have fewer than six segments. Metamorphosis is complete.

Two-winged flies are vital pollinators, parasites, predators, and decomposers in all kinds of habitats. Many, however, damage crops or carry diseases that have a huge impact on animals and humans.

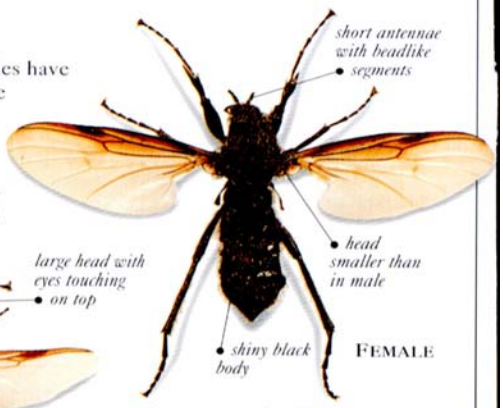
Order DIPTERA | Family BIBIONIDAE | No. of species 780

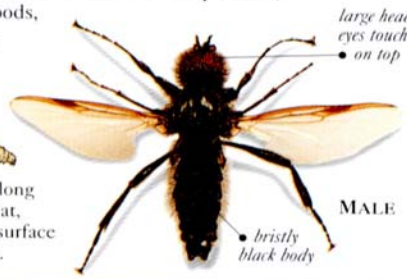
MARCH FLIES

These hairy flies are black or dark brown. Males have large heads with eyes that touch. Females have smaller heads and separated eyes. Despite the common name, few fly before April.

• **LIFE CYCLE** Females dig into soil, where they lay batches of eggs. The larvae can be found in soil, compost, dung, and leaf litter.

• **OCCURRENCE** Worldwide. In pastures, meadows, woods, and gardens.





LARVAE are long and slightly flat, with a rough surface or projections.

BIBIO MARCI is a European species. Adults emerge in early spring, when mating swarms are seen flying clumsily with their legs hanging down.

Length 3/16–3/8in (0.5–1.1cm) | Larval feeding habits

Order DIPTERA | Family CECIDOMYIIDAE | No. of species 5,000

GALL MIDGES

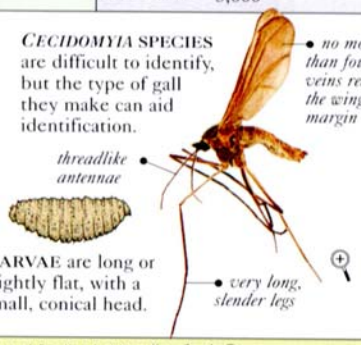
The delicate gall midge has long, slender legs. It may be white, pale yellow to green, or brown. The wings have only a few unbranched, longitudinal veins.

• **LIFE CYCLE** Most species lay eggs inside plants, producing galls in which the larvae grow. Some lay eggs on decaying matter, moist soil, or host plants. Their larvae eat mites, rotting plant matter, or fungi.

• **OCCURRENCE** Worldwide. Anywhere near decaying matter, fungi, or their host plants.

• **REMARK** Many gall midges harm vital crops.

***CECIDOMYIA* SPECIES** are difficult to identify, but the type of gall they make can aid identification.



LARVAE are long or slightly flat, with a small, conical head.

Length 1/32–5/16in (1–8mm), most under 5/32in (4mm) | Larval feeding habits

Order DIPTERA	Family CERATOPOGONIDAE	No. of species 4,000

BITING MIDGES

The common name of these pests comes from their habit of biting vertebrates or other insects. Slender or stocky, with short, strong legs, these flies are dull gray or brown, usually with dark wing mottling. The head is very rounded, and the male's feathery antennae are sensitive to the female's wingbeats.

• **LIFE CYCLE** Males and females mate while flying in a swarm. Eggs are laid in groups or strings in wet soil, rotting matter, bogs, and water. Adults do not fly very far from the boggy larval breeding areas and suck blood from a wide range of vertebrates. Some species suck body fluids from larger insects, while others catch and eat very small insects or eat a variety of other matter.

• **OCCURRENCE** Worldwide, but mainly in the Northern Hemisphere. Common by margins of ponds, rivers, and lakes, in bogs, and near seashores.

• **REMARK** The bites of these insects can produce severe irritation, making working outside almost impossible in some regions. In warmer areas, some biting midges transmit worm parasites to humans and some carry animal diseases such as African horse sickness and Bluetongue. These midges are also, however, important crop pollinators.

LARVAE are worm-like, with a distinct head. They may have hairs on the body.

CULICOIDES IMPUNCTATUS is notorious around Scottish lochs, streams, and boggy areas. The female's bite is extremely itchy and painful.

Length 1/32–5/16in (1–5mm), most about 1/8in (3mm)	Larval feeding habits

Order DIPTERA	Family CHIRONOMIDAE	No. of species 5,000

NONBITING MIDGES

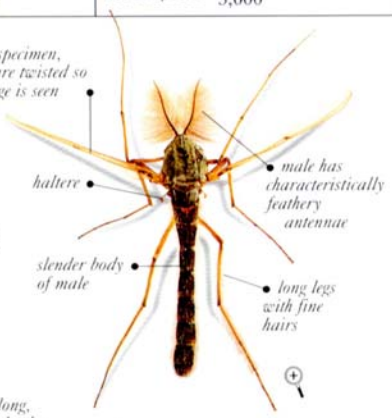
These humpbacked flies can be robust or delicate, with long, slender legs, and are pale brown or slightly green in color. They look like mosquitoes but lack functional mouthparts.

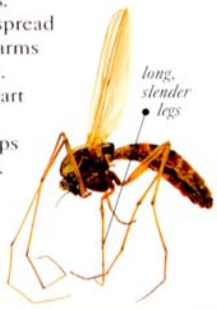
• **LIFE CYCLE** Most of the two- to three-year life cycle is lived as larvae; adults live no longer than a couple of weeks. Mating occurs on the wing in a mating swarm, and eggs are laid in a mass of sticky jelly on water or plants. The larvae eat decayed organic matter, algae, and tiny plants or aquatic animals, but some are predacious or burrow into aquatic plants.

• **OCCURRENCE** Worldwide. Widespread in many habitats and often seen in swarms at dusk near ponds, lakes, and streams.

• **REMARK** The larvae form a vital part of aquatic food webs. Some have hemoglobin in their bodies, which helps them to live in stagnant, muddy water.

LARVAE are elongate and often have a pair of prolegs on the prothorax and the last abdominal segment.





△ ***CHIRONOMUS RIPARIUS*** is a European species whose larvae live in stagnant ponds and backwaters.

CHIRONOMUS **SPECIES** are fragile flies. The adults are short-lived – mostly just for a few days – but can be present in very large numbers.

Length 1/32–11/32in (1–9mm)	Larval feeding habits

Order DIPTERA	Family CULICIDAE	No. of species 3,100

MOSQUITOES

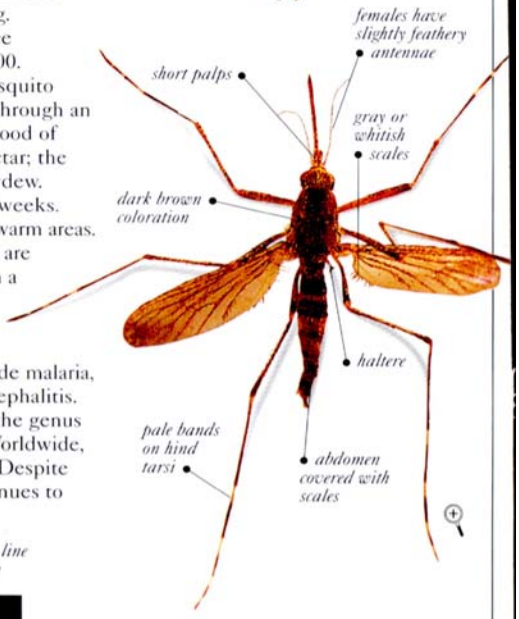
The body of these delicate, slender flies is covered with patterns of white, gray, brown, and black scales. Some tropical species are brightly colored. The long, narrow wings have scales along the veins and edges, and the mouthparts are very long, slender, and piercing.

• **LIFE CYCLE** Eggs are laid on the surface of water, either singly or in groups of 30 to 300. The larvae are saprophagous or eat other mosquito larvae and obtain air from the water surface through an abdominal siphon. Adult females suck the blood of vertebrates but also take plant fluids and nectar; the males feed on plant fluids, nectar, and honeydew. The life cycle usually lasts fewer than three weeks.

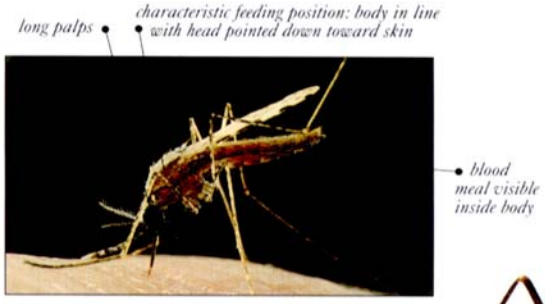
• **OCCURRENCE** Worldwide, especially in warm areas. Adults are common near woodland, and larvae are found in virtually any body of freshwater, from a rain-filled treehole or water-butt to a lake.

• **REMARK** The females of many species carry organisms that cause serious diseases in animals and humans. These diseases include malaria, yellow fever, dengue fever, filariasis, and encephalitis. Malaria is caused by protozoa that belong to the genus *Plasmodium* and that are parasites of blood. Worldwide, one person dies of malaria every 12 seconds. Despite massive efforts to control the disease, it continues to be a serious, and growing, problem.

LARVAE are elongate, with tufts of hair on the large thoracic segments.



△ *AEDES CANTANS* is a European species that breeds in temporary pools of water and bites humans.



△ *ANOPHELES GAMBIAE* belongs to the main malaria-carrying genus of mosquitoes and is a widespread vector of the disease in Africa. It usually bites humans rather than animals.

CULEX SPECIES rest with their head and abdomen pointing down toward the surface. Various species carry diseases, including filariasis.

Length ⅛–¼in (0.3–2cm), most under ⅜in (1cm)	Larval feeding habits

Order DIPTERA	Family MYCETOPHILIDAE	No. of species 3,300

FUNGUS GNATS

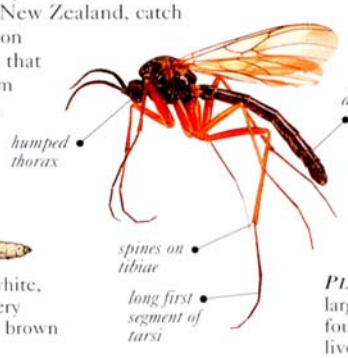
Small and mosquito-like, these flies are generally brown, black, or yellowish. However, some species may be brightly colored. The thorax is characteristically humped, and the legs are long and slender.

• **LIFE CYCLE** Eggs are usually laid in fungi, on or under bark, on cave walls, and in nests. The larvae mostly eat fungi and are found inside fungi, in dead wood and decaying vegetation, or under bark. Some larvae eat tiny insects and worms. Pupation occurs inside larval food or in a silk cocoon.

• **OCCURRENCE** Worldwide. In damp, dark places such as woods and caves, and near rotting vegetation and fungi.

• **REMARK** The cave-dwelling, luminescent larvae of *Arachnocampa* species, which live in Australia and New Zealand, catch flying insects on sticky threads that they hang from the cave rock.

△ *MACROCERA STIGMA* is a widespread western European species with hairs on its wings.



LARVAE are white, smooth, and very slender, with a brown or black head.

PLATYURA MARGINATA is a fairly large, dark-colored species that is found in western Europe. Its larvae live underneath decaying wood.

Length 1/16–3/8in (0.2–1.5cm)	Larval feeding habits

Order DIPTERA	Family PSYCHODIDAE	No. of species 2,000

SAND FLIES AND MOTH FLIES

Small and mothlike, these gray to brown flies are covered with hairs or scales. The wings, usually broad with pointed tips, are held together over the body in sand flies and are tentlike or partly spread in moth flies. Most species are nocturnal.

• **LIFE CYCLE** Sand flies feed on vertebrate blood, including that of humans, but the eggs are laid, and larvae develop, in wet soil. Moth flies lay eggs, and live, near wet, decaying matter.

• **OCCURRENCE** Worldwide, especially in warm areas. Sand flies favor warm, dry habitats; moth flies prefer woods near streams and bogs.

• **REMARK** Some sand flies spread disease, especially leishmaniasis in humans.

LARVAE are elongate, and some taper to the rear.

PERICOMA FULIGINOSA is a dark, widely distributed moth fly. Its larvae develop in shallow water and in tree rot holes.

Length 1/32–1/16in (1–5mm)	Larval feeding habits

Order DIPTERA	Family SIMULIIDAE	No. of species 1,500

BLACK FLIES

Usually black or dark brown, these flies have a stout, hump-backed appearance. The antennae and legs are short.

• **LIFE CYCLE** Eggs are laid in running water. Larvae stick to stones and plants by means of a holdfast organ at their rear and pupate in submerged cases. When the adults emerge, they rise to the surface of the water and fly off.

• **OCCURRENCE** Worldwide. Near flowing water.

• **REMARK** *Simulium* species carry the roundworm that causes river blindness in tropical regions.

LARVAE use their posterior sucker to anchor themselves.

***SIMULIUM* SPECIES** are also known as black flies, although some are not entirely black. Many species carry disease.

Length 1/32–3/16in (1–5mm), most under 5/32in (4mm)	Larval feeding habits

Order DIPTERA	Family TIPULIDAE	No. of species 15,000

CRANE FLIES

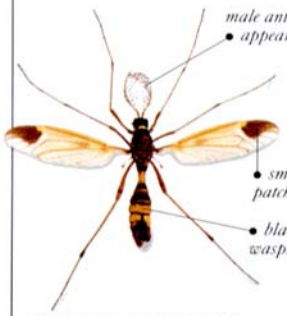
Also called daddy-long-legs, these fragile flies are well known for shedding their very long legs easily if caught. They are mostly brown, black, or gray with yellow or pale brown markings. The end of the abdomen is blunt and expanded in males, while females have a pointed ovipositor.

• **LIFE CYCLE** Eggs are typically laid in soil. The larvae live in soil, rotting wood, birds' nests, and bogs, where they eat roots, decaying organic material, fungal threads, and mosses. Some aquatic crane flies may be carnivorous. Many adults are short-lived, fly at twilight, and may feed on nectar.

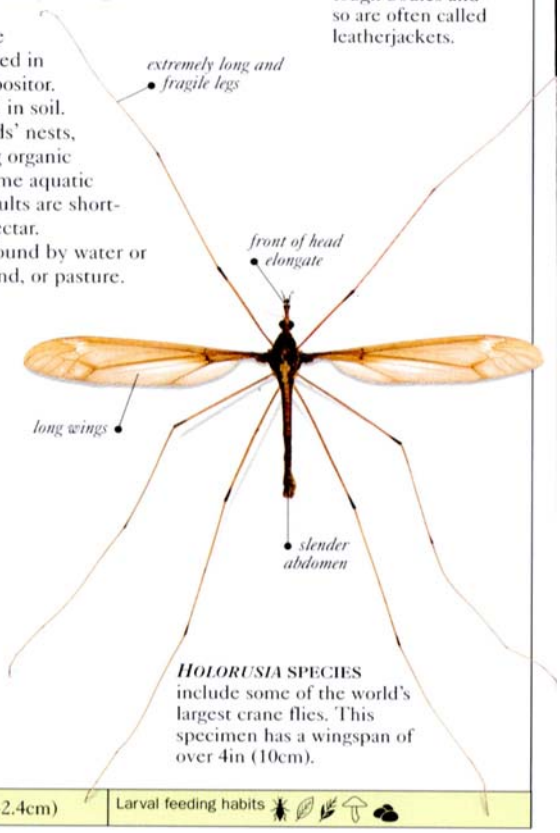
• **OCCURRENCE** Worldwide. Often found by water or among damp vegetation, shaded woodland, or pasture.

• **REMARK** The larvae of many crane flies are pests of crops, garden plants, and lawns.

LARVAE have tough bodies and so are often called leatherjackets.



CTENOPHORA ORNATA is a distinctive European species whose larvae develop in well-decayed wood.



***HOLORUSIA* SPECIES** include some of the world's largest crane flies. This specimen has a wingspan of over 4in (10cm).

Length 1/4–2 1/2in (0.6–6cm), most 1/2–1in (1.2–2.4cm)	Larval feeding habits

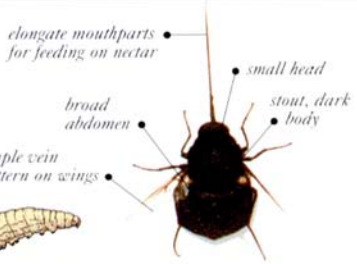
Order DIPTERA	Family ACROCERIDAE	No. of species 500

SMALL-HEADED FLIES

True to their name, the head of these flies is small and the eyes cover most of its area. The body is stout, and the thorax has a humped appearance.

• **LIFE CYCLE** Eggs are laid on grass or twigs or dropped in flight. Hatched larvae seek out and parasitize young spiders. Once inside a spider's body, the larva does not develop further until the spider reaches its last molt. The larva itself then molts, eats the spider's internal organs, and leaves the spider's body in order to pupate.

• **OCCURRENCE** Worldwide. Various habitats, wherever spiders are found.



LARVAE become fat and grublike once inside a spider's body.

***LASIA* SPECIES** larvae develop inside the bodies of tarantula spiders in South America.

Length ⅛–⅜in (0.3–2.2cm) | Larval feeding habits

Order DIPTERA	Family AGROMYZIDAE	No. of species 2,500

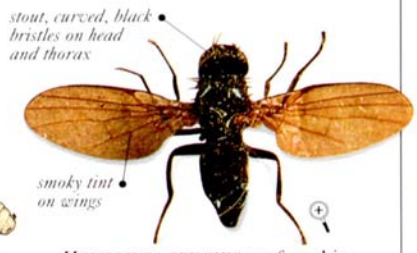
LEAF-MINING FLIES

These flies are gray, black, or greenish yellow and may have patterned wings. The abdomen tapers, and females have a pointed ovipositor.

• **LIFE CYCLE** Eggs are laid in plant tissue. Larvae chew "mines" (channels) through leaves or feed inside stems, seeds, or roots. Some form galls. Pupation occurs in the mine or in soil.

• **OCCURRENCE** Worldwide. Wherever their host plants occur.

• **REMARK** These flies are crop pests. A few species are used to control weeds.



LARVAE are white or pale yellow and slightly flat.

***HEXOMYZA* SPECIES** are found in the UK, US, Japan, and South Africa. Its larvae make galls on the twigs of trees such as poplars.

Length 1/32–¼in (1–6mm) | Larval feeding habits

Order DIPTERA	Family ANTHOMYIIDAE	No. of species 1,500

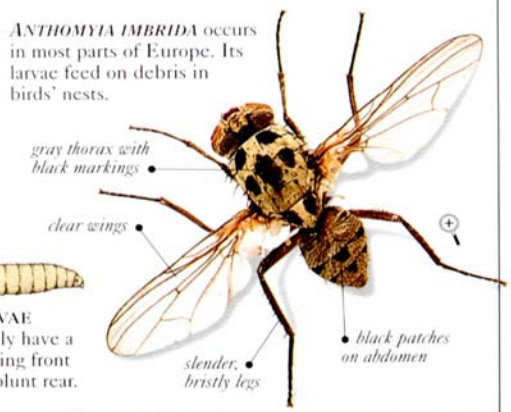
ANTHOMYIID FLIES

Many anthomyiids look like yellowish, dull brown, gray, or black house flies (see p.148).

• **LIFE CYCLE** Eggs are laid in or on plant tissue, and the larvae are found boring into stems, mining leaves, or inside galls on a huge range of host plants. Some develop in rotting seaweed or dung, and a few species live as parasites inside the nests of solitary bees and wasps.

• **OCCURRENCE** Worldwide, mainly in the Northern Hemisphere. In a wide range of wooded, damp habitats or near seashores.

ANTHOMYIA IMBRIDA occurs in most parts of Europe. Its larvae feed on debris in birds' nests.



LARVAE usually have a tapering front and blunt rear.

Length 1/16–½in (0.2–1.2cm), most 9/32–11/32in (0.7–0.9cm) | Larval feeding habits

Order DIPTERA	Family ASILIDAE	No. of species 5,000

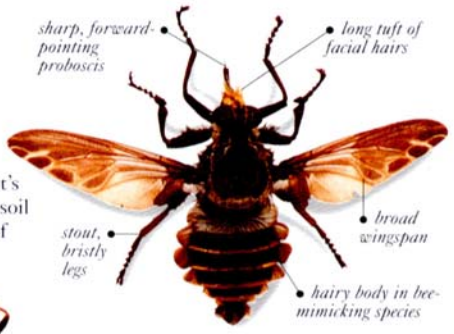
ROBBER FLIES

The head of these slender or beelike flies is characteristically slightly hollow between the eyes, with a long tuft of hairs on the face.

• **LIFE CYCLE** Robber flies stab insect prey through a weak point, such as the neck, and inject saliva. The contents of the paralyzed insect's body are then sucked up. Eggs are laid either in soil or on or inside plants. Most larvae live in soil, leaf litter, or rotting wood, where they eat the eggs, larvae, and pupae of other insects.

• **OCCURRENCE** Worldwide. In a variety of habitats, especially dry or semiarid grasslands.

LARVAE are long, cylindrical, and often pointed at both ends.



△ ***BLEPHAROTES SPLENDIDISSIMUS*** is found in Australia. This large species has platelike tufts of hair at the sides of its flat abdomen.

PAGIDOLAPHRIA FLAMMIPENNIS has a long, sideways-flattened proboscis. Some of the facial hairs are as long as the proboscis.

Length ⅛–2¼in (0.3–7cm), most ⅛–¾in (0.8–1.5cm)	Larval feeding habits

Order DIPTERA	Family BOMBYLIIDAE	No. of species 5,000

BEE FLIES

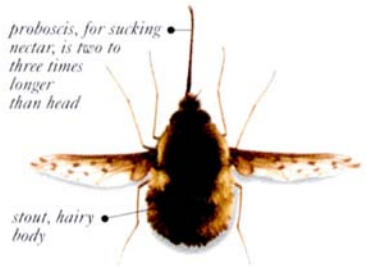
Although some can be small, most bee flies tend to be stout and hairy, hence their common name. Many species are brown, red, and yellow in coloration, and some have bright markings.

• **LIFE CYCLE** The larvae of most known bee flies parasitize the larvae of various other insects, although a few eat grasshopper eggs. Females produce many small eggs, which may, for example, be laid near the nest of a host bee. The active first-stage larvae of the bee fly will then locate the host bee larvae in their nest, eat them, and pupate inside the bee's cell. Adult bee flies feed on nectar.

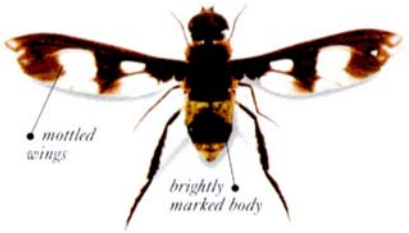
• **OCCURRENCE** Worldwide, especially in open and semiarid regions. Around flowers or resting on the ground.

LARVAE are curved and narrow toward both ends.

SYSTROPUS SPECIES are slim-bodied, extremely wasp-like insects from tropical and subtropical regions.



△ ***BOMBYLIUS DISCOLOR*** is a European species. With its broad abdomen and furry body, it looks very much like a bumblebee.



LIGYRA VENUS is a distinctively patterned species from Tanzania. Its larvae develop inside the nests of certain wasps.

Length ⅛–1¼in (0.2–3cm), most under ¾in (2cm)	Larval feeding habits

Order DIPTERA	Family CALLIPHORIDAE	No. of species 1,200

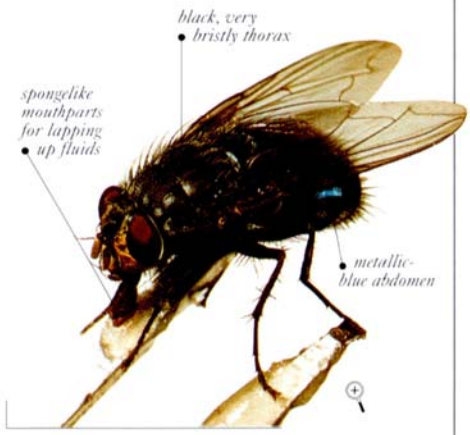
BLOW FLIES

These flies are typically stout and may be metallic green or blue, shiny black, or dull. In some species, the sexes are of different colors. This family includes the familiar bluebottles and greenbottles.

• **LIFE CYCLE** Blow flies lay eggs on carrion, dung, and flesh. The larvae of certain species are predators of ants, termites, and other insect larvae and eggs, and a few suck the blood of nestlings. Some blow flies lay larvae rather than eggs.

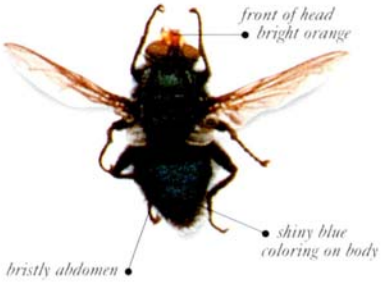
• **OCCURRENCE** Worldwide. On flowers, vegetation, and carcasses. Also attracted to cooked and raw food.

• **REMARK** Many blow flies lay their eggs on livestock and humans and carry disease. The sheep maggot fly, *Lucilia sericata*, for example, lays eggs on the wool of sheep, and its larvae burrow into the flesh. A few blow-fly species burrow into human flesh and have been used in surgery as a way of removing dead tissue.



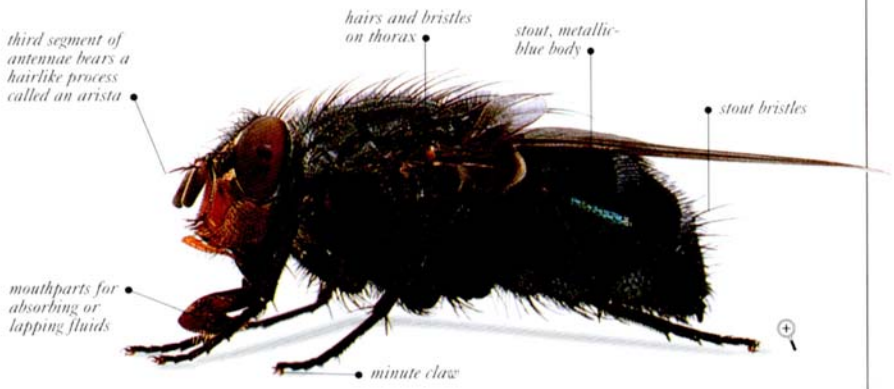
CALLIPHORA VOMITORIA is a bluebottle species that is extremely common in the countryside. The females may lay many hundreds of eggs during their lifetime.

LARVAE are white or pale. They taper at the front and are blunt at the rear. Bands of tiny spines encircle the body.



◁ ***CYNOMYIA MORTUORUM*** is a common bluebottle whose larvae develop in rotten meat, corpses, and human excrement.

▽ ***CALLIPHORA VICINA*** is more common in towns and cities, where the maggots develop inside the corpses of dead animals such as pigeons, rats, and mice.



Length ½–⅝in (0.4–1.5cm)	Larval feeding habits

Order DIPTERA	Family CELYPHIDAE	No. of species 100

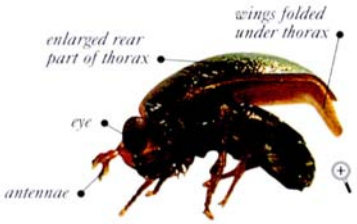
BEETLE FLIES

These flies owe their common name to the beetle-like hind part of the thorax (the scutellum). Hugely enlarged and often metallic-colored, this covers the abdomen and the folded wings.

• **LIFE CYCLE** Eggs are laid, and the larvae develop, in decaying vegetation.

• **OCCURRENCE** Tropical regions, except Central and South America. In damp habitats near water and in grasslands.

LARVAE are small, pale, and maggotlike. They taper at both ends.



***CHAEMAECELYPHUS* SPECIES** look like small beetles. They push their wings out from under the rear of the thorax to fly.

Length 1/8–5/16in (3–8mm)	Larval feeding habits

Order DIPTERA	Family CHLOROPIDAE	No. of species 2,000

GRASS FLIES

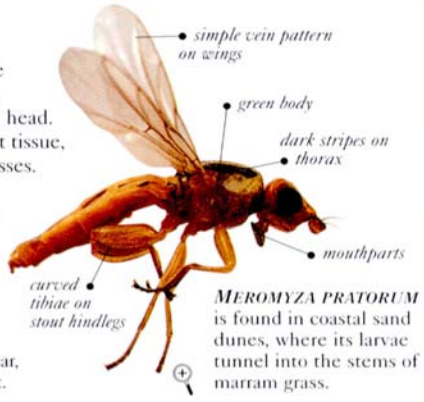
Also known as stem flies, these common insects are blackish gray, green, or black with yellow markings. There is a distinct triangular mark on the top of the head.

• **LIFE CYCLE** Eggs are laid mostly on or in plant tissue, or whatever the larvae eat. Most larvae bore into grasses. Others form galls or eat decaying plant matter, root aphids, or the eggs of spiders and other insects.

• **OCCURRENCE** Worldwide. Widespread in a range of habitats, from grasslands to rainforests.

• **REMARK** Several species attack cereal crops and some cause blindness in humans and animals.

LARVAE are usually slender, blunt at the rear, and narrow at the front.



MEROMYZA PRATORUM is found in coastal sand dunes, where its larvae tunnel into the stems of marram grass.

Length 1/32–1/4in (1–6mm), most under 5/32in (4mm)	Larval feeding habits

Order DIPTERA	Family CONOPIDAE	No. of species 1,000

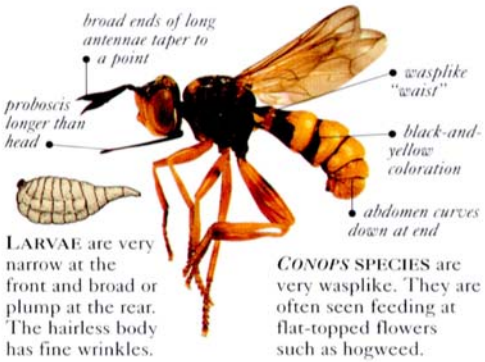
THICK-HEADED FLIES

These flies have broad heads and an abdomen that narrows where it joins the thorax. Many resemble bees or wasps in shape and coloration.

• **LIFE CYCLE** Eggs are laid on the bodies of hosts such as other flies, crickets, cockroaches, wasps, or bees. Larvae burrow inside and feed on body fluids.

• **OCCURRENCE** Worldwide. In varied habitats, usually feeding at flowers.

• **REMARK** Some larvae may cause bee hosts to burrow into the soil before they die, giving the flies a safe place to pupate.



LARVAE are very narrow at the front and broad or plump at the rear. The hairless body has fine wrinkles.

***CONOPS* SPECIES** are very wasplike. They are often seen feeding at flat-topped flowers such as hogweed.

Length 1/8–1in (0.3–2.6cm)	Larval feeding habits

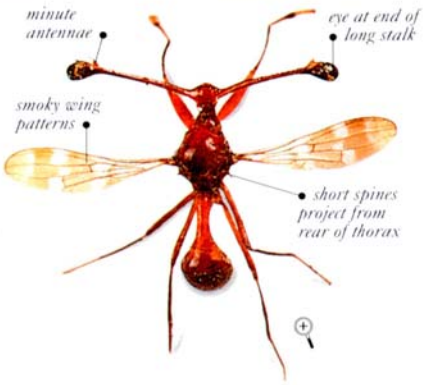
Order DIPTERA | Family DIOPSIDAE | No. of species 180

STALK-EYED FLIES

The most recognizable feature of these small flies is the head. This is extended on both sides into stalks that bear the eyes and the antennae. The eye stalks are larger in the males and may be absent in the females.

• **LIFE CYCLE** Eggs are stuck onto young foliage or rotting vegetation. Males engage in combat over territories and females. Those with more widely spaced eyes tend to have more success in finding mates.

• **OCCURRENCE** Tropical regions, especially Africa. Absent from South America, and only one very short-stalked species occurs in North America. Often found near or on vegetation or close to running water.



LARVAE taper at both ends and have smooth, hairless bodies.

CYRTODIOPSIS DALMANNI is found in parts of Southeast Asia. Its larvae bore into the stems of various grass species.

Length 1/8–3/4in (0.3–1.8cm) | Larval feeding habits

Order DIPTERA | Family DOLICHOPODIDAE | No. of species 5,500

LONG-LEGGED FLIES

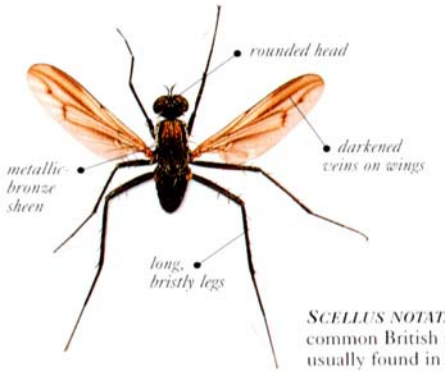
These small, bristly flies are metallic-bronze, -green, or -blue. The rounded head has a short, fleshy proboscis, and the legs are distinctively long and slender.

• **LIFE CYCLE** Usually, eggs are laid, and the larvae are found, under bark and in wet soil, water, mud, leaf litter, and seaweed. The larvae mostly eat other insects, while the adults eat soft-bodied insects or feed on nectar.

• **OCCURRENCE** Worldwide. In damp meadows, woods, and streams and at lakesides and seashores.

• **REMARK** Some larvae are predators of pests such as the larvae of bark beetles or mosquitoes.

△ *POECILOBOTHRUS NOBILITATUS* males are often found on patches of bare mud, in the sun. They wave their wings to display them to females.



SCELLUS NOTATA is a fairly common British species. It is usually found in grassy areas.

LARVAE are pale and taper slightly to the front. The rear of the abdomen often has four lobes.

Length 1/32–1/5in (0.1–1cm), most under 1/8in (4mm) | Larval feeding habits

Order DIPTERA	Family DROSOPHILIDAE	No. of species 2,900

POMACE FLIES

Also called lesser fruit flies or vinegar flies, these small yellow, brown, or black species usually have light or bright red eyes. The thorax and the abdomen may be striped or spotted.

• **LIFE CYCLE** Eggs are laid in or near a food supply: usually bacteria and other micro-organisms, but also fungi, carrion, or dung. A few species burrow inside leaves or eat spittlebug nymphs (see p.95) or aquatic fly larvae.

• **OCCURRENCE** Worldwide. On rotting vegetation and fruit, or near fungi or fermenting liquids.

• **REMARK** Half of all pomace flies are in the genus *Drosophila*.

LARVAE have hooked spines all around each segment.

◁ ***DROSOPHILA MELANOGASTER*** is the best known pomace fly. It is often used for genetics studies since it breeds quickly and has large chromosomes in its salivary glands.

△ ***DROSOPHILA*** **SPECIES** are often attracted to rotting fruit. The one shown here is feeding on a piece of apple.

Length ½–¼in (1–6mm)	Larval feeding habits

Order DIPTERA	Family EMPIDIDAE	No. of species 3,500

DANCE FLIES

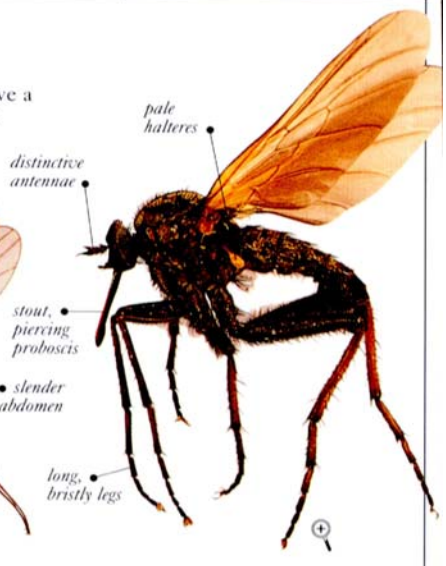
The common name of this family derives from the dancing motions of mating swarms. Most species have a stout thorax and a tapering, elongate abdomen. The rounded head has large eyes and usually a sharp, downward-pointing proboscis.

• **LIFE CYCLE** Courtship and mating may involve males offering prey as food to females. Eggs are usually laid on soil, dung, rotting wood or plant matter, leaf litter, and water. The larvae develop in these places and feed on small insect prey. Adults eat small flies and drink nectar.

• **OCCURRENCE** Worldwide, mainly in the Northern Hemisphere. On vegetation in damp habitats; above water.

LARVAE are slender and aquatic species have prolegs.

WIEDEMANNIA STAGNALIS adults are predacious and sit on wet moss waiting for suitable prey. The larvae probably develop inside clumps of wet moss.



EMPIS **SPECIES** have a large, downward-pointing proboscis. This enables the fly to "stab" its prey and extract the fluids on which it feeds.

Length ½–½in (0.15–1.1cm)	Larval feeding habits

Order DIPTERA | Family GASTEROPHILIDAE | No. of species 50

HORSE BOT FLIES

These stout flies resemble honeybees (see pp.180–81). They have nonfunctional mouthparts and do not feed. All horse bot species are internal parasites of large mammals such as horses, rhinoceroses, and elephants. Some species may parasitize humans.

• LIFE CYCLE The short-lived adults lay eggs on grass or near the host's mouth. The larvae burrow into the host or are swallowed. They live in the host's gut and, when mature, are passed out with the excrement to pupate in the soil.

• OCCURRENCE Worldwide, especially in Asia and Africa. Near host animals.

LARVAE are thick-bodied, with distinct bands of backward-pointing spines.

GASTEROPHILUS INTESTINALIS is a parasite of horses. It flies around the horse and darts in to lay eggs on the skin, which are swallowed when the host grooms itself.

Length ⅛–1in (1–2.5cm) | Larval feeding habits

Order DIPTERA | Family GLOSSINIDAE | No. of species 22

TSETSE FLIES

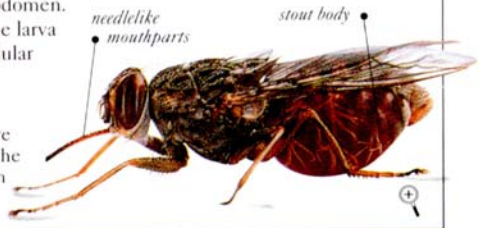
These brown or gray flies feed on animal or human blood and cause sleeping sickness in humans and nagana in animals. At rest, they cross their wings over their abdomen.

• LIFE CYCLE Females produce eggs singly. The larva hatches inside the female's body and feeds on glandular secretions. Once deposited on the ground, it pupates immediately and the adult emerges after four weeks.

• OCCURRENCE Africa. In wooded savanna and bush.

LARVAE are as large as the adults when mature.

GLOSSINA MORSITANS is one of the species that transmits the trypanosome parasite – the cause of sleeping sickness.



Length ¼–⅝in (0.6–1.4cm) | Larval feeding habits

Order DIPTERA | Family HIPPOBOSCIDAE | No. of species 200

LOUSE FLIES

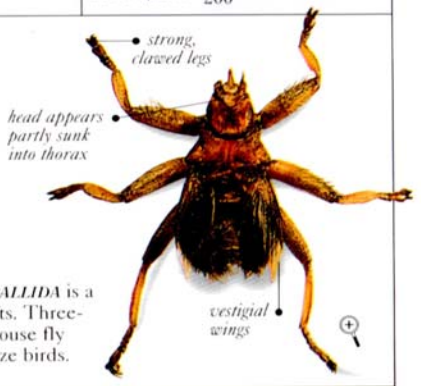
These stout, flat flies have a short proboscis and strong, clawed legs for gripping hair or feathers. They are parasites, feeding on the blood of mammals and birds.

• LIFE CYCLE Larvae develop inside the female. Laid when mature, the larvae pupate on their hosts.

• OCCURRENCE Worldwide. On host animals, including cattle, sheep, horses, deer, and birds.

LARVAE are white or yellow. When fully grown, they are fat and round.

CRATAERINA PALLIDA is a parasite of swifts. Three-quarters of all louse fly species parasitize birds.



Length 1/32–½in (0.15–1.2cm) | Larval feeding habits

Order DIPTERA | Family MUSCIDAE | No. of species 3,500

HOUSE FLIES

Most house flies are drably colored, with dark bristles and long, slender legs. The mouthparts are spongelike, for lapping fluids, or piercing, for sucking blood.

• **LIFE CYCLE** Masses of eggs are laid in excrement, rotting matter, fungi, birds' nests, water, or plants. The larvae (maggots) grow fast and can pupate in just over a week.

• **OCCURRENCE** Worldwide. On flowers, excrement, and rotting matter; blood-sucking species are found near their hosts.

• **REMARK** House flies may carry infections, including typhoid and cholera.

LARVAE mostly taper at the head and are blunt at the rear.

MUSCA DOMESTICA breeds in fermenting organic matter and spreads a variety of diseases, including cholera, typhoid, dysentery, and gastroenteritis.

Length 1/16–1/2in (0.2–1.2cm) | Larval feeding habits

Order DIPTERA | Family MYDIDAE | No. of species 350

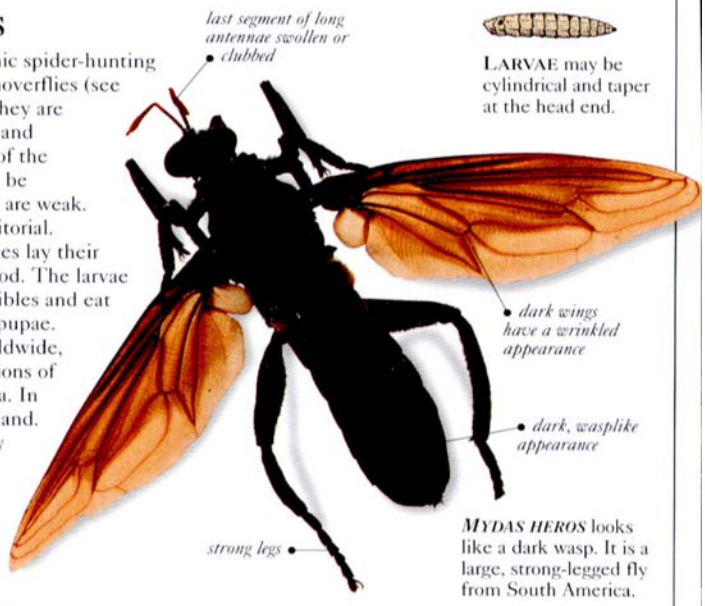
MYDAS FLIES

Many of these flies mimic spider-hunting wasps and some mimic hoverflies (see p.153 and pp.188–89). They are typically smooth-bodied and black, although the tips of the wings and antennae may be orange. Adult mouthparts are weak. The males are often territorial.

• **LIFE CYCLE** Females lay their eggs in soil or rotting wood. The larvae have large, curved mandibles and eat beetle larvae and insect pupae.

• **OCCURRENCE** Worldwide, especially in warmer regions of Africa and South America. In sandy, dry areas or woodland.

• **REMARK** This family contains the world's largest flies. The larvae of *Mydas heros* live inside the nests of leaf-cutter ants, where they eat scarab beetle larvae.



LARVAE may be cylindrical and taper at the head end.

MYDAS HEROS looks like a dark wasp. It is a large, strong-legged fly from South America.

Length 1/4–2 1/2in (2–6cm) | Larval feeding habits

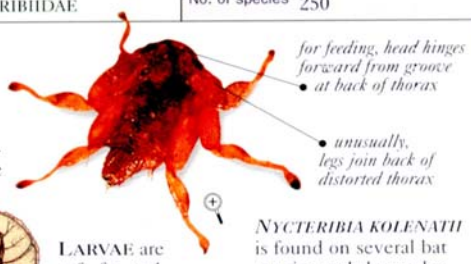
Order DIPTERA | Family NYCTERIBIIDAE | No. of species 250

BAT FLIES

These small, spidery, wingless flies prey on the blood of bats. They have a narrow head, and the eyes are either tiny or totally lacking.

• **LIFE CYCLE** The eggs hatch, and larvae develop, inside the mother's abdomen, fed by special internal glands. Pupae are laid in the bat roost. Adults emerge when they sense a bat nearby.

• **OCCURRENCE** Worldwide. In or near bat roosts.



LARVAE are soft, fat, and white and darken as they mature.

NYCTERIBIA KOLENATII is found on several bat species and shows the distorted thorax that is typical of bat flies.

Length 1/16–1/2in (2–4mm) | Larval feeding habits

Order DIPTERA | Family OESTRIDAE | No. of species 80

BOT AND WARBLE FLIES

Many of these heavy, large-headed, hairy flies look like stout-legged bees. The short-lived adults do not feed.

• **LIFE CYCLE** The larvae are all internal parasites of mammals such as sheep and cattle. Bot flies lay larvae directly into the nostrils of their hosts. Warble flies lay eggs on the hair of the host, and the larvae burrow under the skin. Fully grown larvae emerge and pupate in the soil.

• **OCCURRENCE** Worldwide, especially in the Northern Hemisphere and Africa. Near their hosts.

LARVAE are fat, taper at the head, and have bands of spines.

HYPODERMA BOVIS, or the Ox Warble Fly, is a widespread species. It may look like a bee, but cattle recognize it and twist, jump, or run to get out of its way.

Length 1/16–1in (0.8–2.5cm) | Larval feeding habits

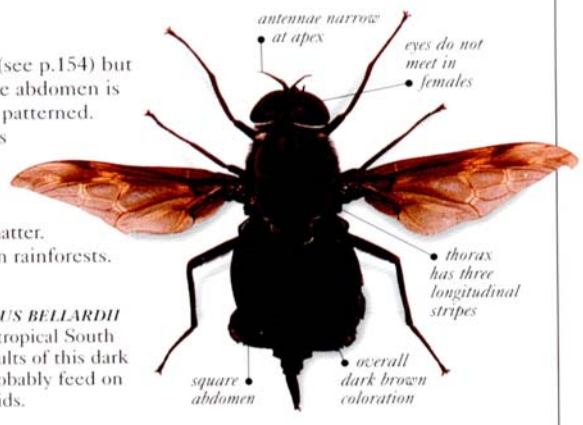
Order DIPTERA | Family PANTOPHTHALMIDAE | No. of species 25

TIMBER FLIES

These flies look like large horseflies (see p.154) but with small, nonbiting mouthparts. The abdomen is typically square and the wings darkly patterned.

• **LIFE CYCLE** Small groups of eggs are laid in cracks in tree bark, and the larvae burrow into the wood. It is uncertain whether they digest the wood or eat sap, fungi, and decaying matter.

• **OCCURRENCE** South America, in rainforests.



LARVAE are stout and may take up to two years to mature.

PANTOPHTHALMUS BELLARDII is widespread in tropical South America. The adults of this dark brown species probably feed on sap and other fluids.

Length 1/8–2in (0.3–5cm) | Larval feeding habits

Order DIPTERA | Family PHORIDAE | No. of species 3,000

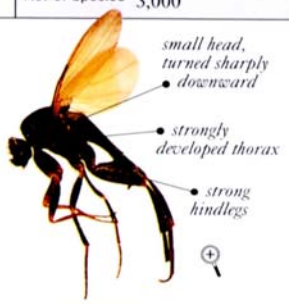
SCUTTLE FLIES

These small brown, black, or yellowish flies are also known as hump-backed flies because of their distinctive appearance. They have a small, strongly down-turned head and hind femora that are often flat and highly enlarged. The body bristles look feathery under magnification.

• **LIFE CYCLE** Eggs are laid, and larvae develop, in a wide range of microhabitats. Some larvae feed on fungi, carrion, or decaying matter; others are scavengers or parasitic on other insects, snails, millipedes, or worms.

• **OCCURRENCE** Worldwide. In a wide variety of habitats.

LARVAE are fattest in the middle, often with spiny projections.



ANEVRINA THORACICA is native to the Northern Hemisphere. Its larvae prefer soil, the corpses of small animals, and moles' nests.

Length ¼–⅛in (0.6–6mm) | Larval feeding habits

Order DIPTERA | Family PLATYSTOMATIDAE | No. of species 1,200

SIGNAL FLIES

Many of these flies have bright coloration and patterned wings. Their antennae lie within grooves on the head, and the males' eyes may be on stalks.

• **LIFE CYCLE** Eggs are laid on all kinds of decaying matter. Adults mate around trees and foliage, and males use their wings to display.

• **OCCURRENCE** Worldwide, especially in warm, humid parts of Europe, Asia, and Africa. In a wide range of habitats.

LARVAE are cylindrical and blunt at the rear. Short spines under the abdomen help with locomotion.

CLITODOCA FENESTRALIS is a large African species with a wingspan of 1⅛in (4.5cm). Its bright coloration is probably important in courtship.

Length ½–¼in (0.4–2cm) | Larval feeding habits

Order DIPTERA | Family PSILIDAE | No. of species 250

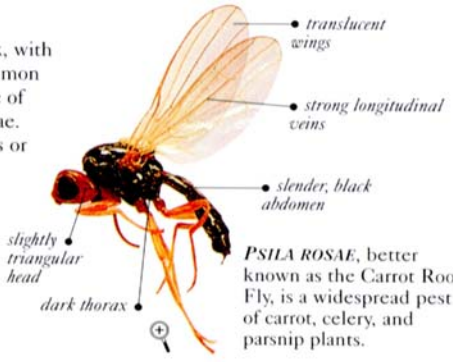
RUST FLIES

These slender flies are reddish brown to black, with a slightly triangular or rounded head. The common name refers to the rust-red, flaking appearance of plant roots that have been affected by the larvae.

• **LIFE CYCLE** Eggs are laid on host plants or in soil near the roots. The larvae of most rust flies bore through plant stems or roots and under bark; some form galls.

• **OCCURRENCE** Mainly in the Northern Hemisphere. In woodland and damp areas.

LARVAE are pale, smooth, slender, and cylindrical.



PSILA ROSAE, better known as the Carrot Root Fly, is a widespread pest of carrot, celery, and parsnip plants.

Length ⅛–1½in (3–9mm) | Larval feeding habits

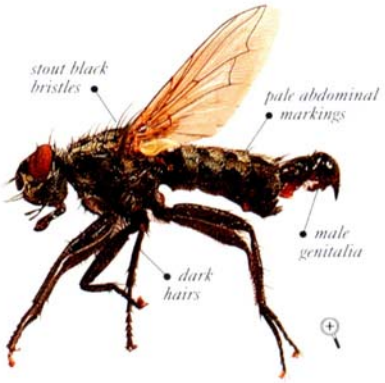
Order DIPTERA	Family SARCOPHAGIDAE	No. of species 2,500

FLESH FLIES

These flies are mostly a dull, silvery gray or black. The thorax is longitudinally striped, and the abdomen looks checkered or marbled.

• **LIFE CYCLE** The common name refers to the fact that some flesh flies lay their larvae in body cavities and on wounds in vertebrates, including man. Most females give birth to live first-stage larvae. They either lay these larvae or drop them in flight and retain the egg shell within their body. Some larvae feed on carrion, while others are parasitic on other insects, snails, worms, or other invertebrates.

• **OCCURRENCE** Worldwide, especially in the Northern Hemisphere. In varied habitats.



LARVAE have pointed heads, blunt rears, and bands of fine spines.

SARCOPHAGA MELANURA is a British species, found near coastal areas. Its larvae are found in rotting matter and may parasitize snails or insects.

Length 1/16–¼in (0.2–2cm), most ¼–⅜in (0.6–1cm)	Larval feeding habits

Order DIPTERA	Family SCATHOPHAGIDAE	No. of species 350

DUNG FLIES

These flies are generally dull gray, brown, or yellow-brown but may be black or yellow and black. Their slender legs may have strong, dark bristles. The most common dung flies are very hairy. The common name is misleading since it refers only to flies of the genus *Scathophaga*.

• **LIFE CYCLE** Typically, eggs are laid, and the larvae develop, in plants, where the young eat foliage and may be leaf-miners, or in dung, where they eat other larvae. Some larvae are found in damp soil and water, where they prey on small invertebrates. Adults catch and eat smaller insects.

• **OCCURRENCE** Northern Hemisphere. In various habitats, including all kinds of plants and fresh dung.

LARVAE are pale and cylindrical. Some taper to a point at the head end.

SCATHOPHAGA STERCORARIA, also called the Yellow Dung Fly, is widespread across the Northern Hemisphere. Common on sheep and cow dung, it also breeds on the dung of poultry, horses, and humans.

Length 1/8–½in (0.3–1.2cm)	Larval feeding habits

Order DIPTERA | Family SEPSIDAE | No. of species 250

BLACK SCAVENGER FLIES

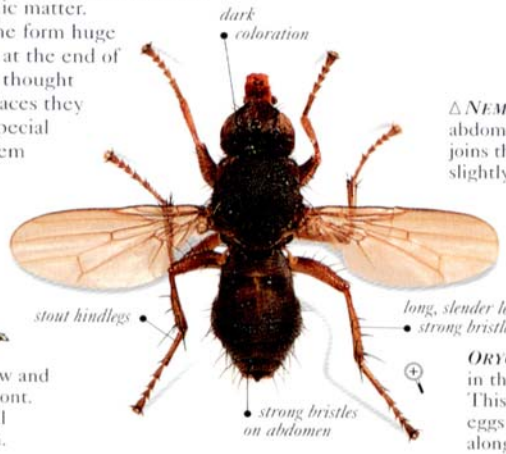
Also known as ensign flies due to the fact that males signal to females by waving their wings, most of these flies are shiny black or brownish, and males often have dark wingtips. Some small species are antlike. The front legs of males are modified with bristles and spines so that they can grip the wings of females before and during mating.

• **LIFE CYCLE** Eggs are laid – and the slim larvae are found – in mammals' dung, compost, and rotting meat on carcasses. Larvae may occur in huge numbers.

• **OCCURRENCE** Worldwide. In a wide range of habitats, on flowers and around dung or decaying organic matter.

• **REMARK** Some form huge swarms on plants at the end of the summer. It is thought that they mark places they have been with special odors and find them again after hibernation, when mating occurs.

△ *NEMOPODA NITIDULA* has an abdomen that narrows where it joins the thorax, giving a slightly wasplike appearance.



LARVAE are narrow and taper toward the front. The last abdominal segment is swollen.

ORYGMA LUCTUOSA is found in the Northern Hemisphere. This large species lays its eggs on rotting seaweed along shorelines.

Length 1/16–1/4in (2–6mm) | Larval feeding habits

Order DIPTERA | Family STRATIOMYIDAE | No. of species 2,000

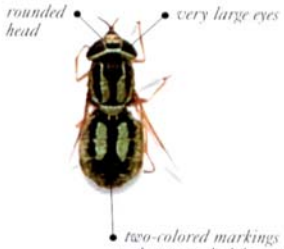
SOLDIER FLIES

Most of these flies are quite stout and slightly flat, with bright or metallic markings. Some are fairly large and wasp-like. The broad abdomen is typically banded yellow, black, or green, while the head is very rounded. In males, the head is largely covered by the eyes. Certain species are aquatic.

• **LIFE CYCLE** Eggs are laid on the surface of water, on plants, or in dung, leaf litter, soil, or rotten wood. Most larvae eat rotting matter or the larvae of flies and bark beetles.

• **OCCURRENCE** Worldwide. In a wide variety of habitats, often at flowers. Some aquatic species can even survive in hot springs or very salty water.

LARVAE are toughened and flat, with many short bristles.



HEDRIODISCUS PULCHER is a native of South America. It has green coloration and distinctive markings.

Length 1/8–1/4in (0.3–2cm) | Larval feeding habits

Order DIPTERA	Family SYRPHIDAE	No. of species 6,000

HOVER FLIES

Also called flower flies, these flies are highly distinctive because they hover and dart between flowers. Many species are quite slender and wasplike, with yellow stripes, spots, or bands; others are stout, hairy, and beelike. Some are black, blue, or metallic. A false vein runs down the center of the wings, which also have false margins.

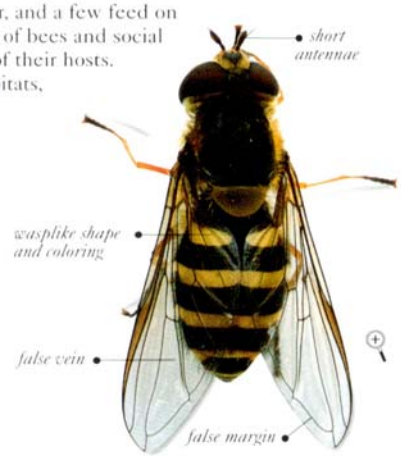
• **LIFE CYCLE** Eggs are laid where the larvae feed (see below). Adults feed on pollen and nectar but the larvae have diverse feeding habits. The larvae of many hover flies eat huge numbers of aphids during the course of their development. Other predatory species attack scale insects, sawfly larvae, and soft-bodied insects. Some larvae feed in or on decaying wood, dung, mud, or stagnant water, and a few feed on plants or fungi. Certain larvae live inside the nests of bees and social wasps, where they eat the dead larvae and pupae of their hosts.

• **OCCURRENCE** Worldwide. In a variety of habitats, usually on flat-topped flowers.

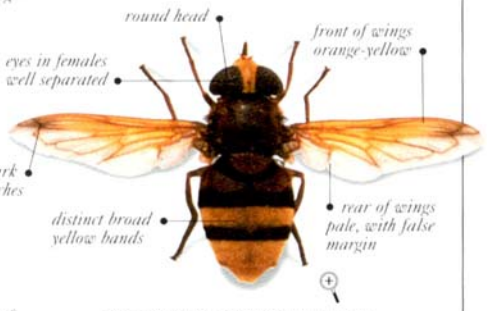
• **REMARK** Although a few herbivorous species are pests in bulbs, most are important plant pollinators.

LARVAE are variable in form. Those that live in water or liquid manure typically have a breathing tube at the rear.

SERICOMYIA SILENTIS is found on acid heathland. The larvae of this species live in boggy pools such as those that form after cutting peat.



△ ***SYRPHUS RIBESII*** is a common, wasplike species found in Europe. It often gathers in large numbers, and its larvae eat greenflies.



VOLUCELLA ZONARIA is a stout, distinctively banded hover fly. It is a native of Europe and is migratory. The larvae of this species scavenge inside wasps' nests.

Length 1/8–1¼in (0.3–3.4cm), most 1/8–¼in (1–2cm)	Larval feeding habits

Order DIPTERA	Family TABANIDAE	No. of species 4,000

HORSE FLIES

Also called deer flies, clegs, and gad flies, these stout, hairless insects have colorful, patterned eyes in flat, round heads. Most are black, gray, or brown with broad abdomens that often have bright bands or markings. The females' bladelike mouthparts are adapted for cutting skin. Male horse flies do not have biting mouthparts and drink at pools and flowers.

• **LIFE CYCLE** Eggs are laid in places such as soil and rotting wood. Larvae typically live in wet soil or mud near ponds and streams, where they eat worms, crustaceans, and insect larvae. Some live in rotting tree-holes or decaying wood. Adults feed on pollen and nectar. Females also take blood from mammals and birds.

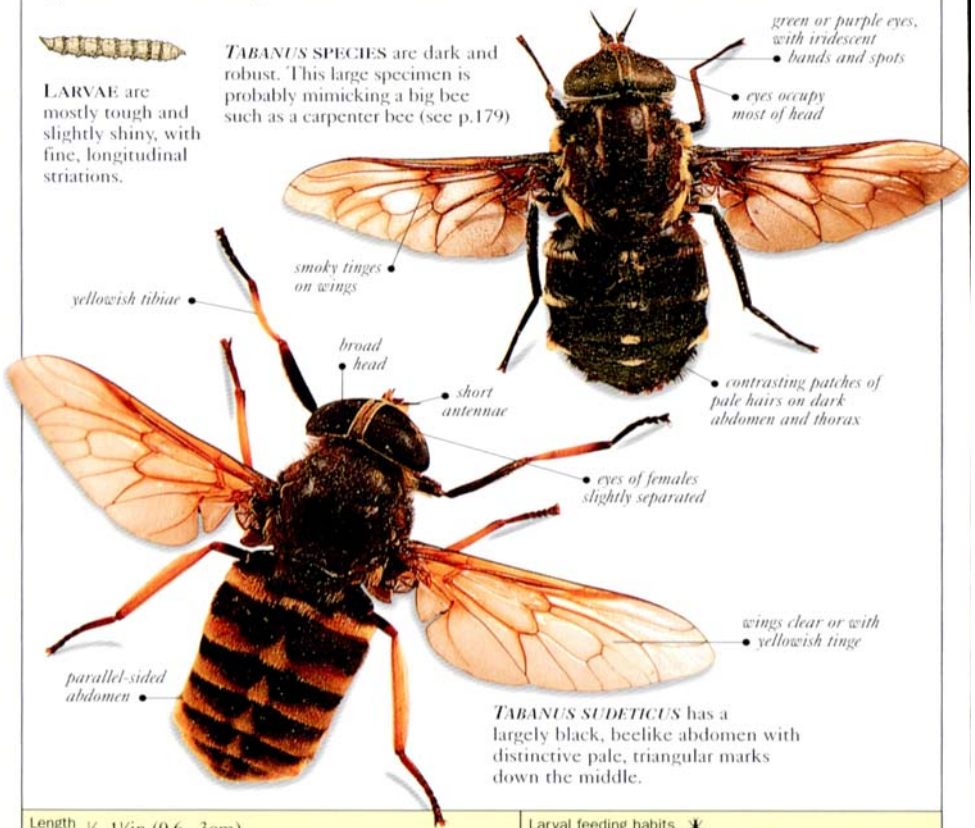
• **OCCURRENCE** Worldwide. In a very wide range of habitats, near mammals.

• **REMARK** In warm regions, horse flies can spread diseases affecting animals and humans.

TABANUS ATRATUS is a black horse fly found throughout the US. This and other species bite cattle and can damage beef production. They may also transmit viruses to livestock.

LARVAE are mostly tough and slightly shiny, with fine, longitudinal striations.

TABANUS SPECIES are dark and robust. This large specimen is probably mimicking a big bee such as a carpenter bee (see p.179)



TABANUS SUDETICUS has a largely black, beelike abdomen with distinctive pale, triangular marks down the middle.

Length ¼–1⅛in (0.6–3cm)	Larval feeding habits

Order DIPTERA	Family TACHINIDAE	No. of species 8,000

PARASITIC FLIES

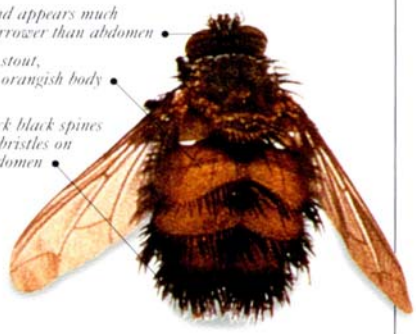
These stout flies are very variable in appearance. Many species look like bristly house flies (see p.148), while some larger species can look almost beelike. The abdomen is especially bristly, particularly toward the rear end.

• **LIFE CYCLE** The larvae are mostly parasitic on insects. Eggs are laid either on the host, with the hatched larvae burrowing inside, or inside the host. Females of some species lay their eggs directly into the mouths of feeding insects or on plants that the hosts will eat.

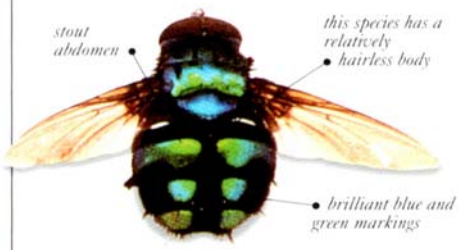
• **OCCURRENCE** Worldwide. In a wide variety of habitats, wherever their hosts are found.

• **REMARK** Many species are used as biological control agents.

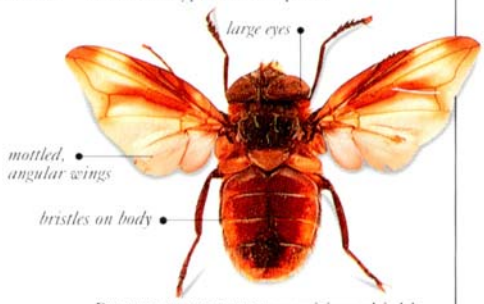
LARVAE are white or yellowish, perhaps with spines or hairs.



△ *PARADEJEANIA RUTILOIDES* is found in northwestern parts of the US. It attacks and parasitizes several different types of caterpillar.



FORMOSIA MONETA is a stout fly with highly distinctive coloration. It attacks and parasitizes the larvae of scarab beetles (see pp.128–29).



PHASIA HEMIPTERA parasitizes shield bugs (see p.92). It is found in meadows and woodlands in parts of Europe, including the British Isles.

Length 1/16–3/4in (0.5–1.5cm)	Larval feeding habits

Order DIPTERA	Family TEPHRITIDAE	No. of species 4,500

FRUIT FLIES

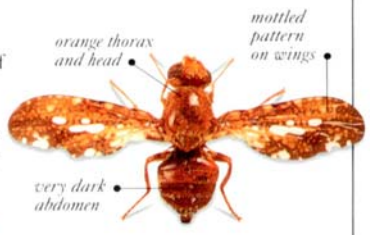
Most fruit flies have distinctive wing patterns, which can be used to identify individual species. These can take the form of bands, patches, and zigzag markings. Females have a pointed ovipositor that may be longer than the rest of the body.

• **LIFE CYCLE** Eggs are laid on and in plants. The larvae of some species feed inside soft fruits or flowerheads, while others are leaf-miners or gall-formers.

• **OCCURRENCE** Worldwide. In a wide variety of habitats.

• **REMARK** Many species are crop and fruit pests, for example *Ceratitis capitata*, the Mediterranean Fruit Fly, which damages citrus and other soft fruits.

LARVAE vary in shape. The body may be smooth or slightly spiny.



ICTERICA WESTERMANNI is a European species of fruit fly that feeds on the flowerheads of ragworts.

Length 1/16–3/4in (0.2–2cm), most under 3/4in (1.5cm)	Larval feeding habits

CADDISFLIES

MEMBERS of the order Trichoptera, containing 43 families and 8,000 species, are found almost anywhere there is freshwater. The slender, dull adults look very mothlike, but unlike moths their body and wings are covered with hairs, not scales. The long, thin antennae are multisegmented, and the weakly developed mouthparts may be used to take liquid, although the adults of many species do not feed. Caddisflies have compound eyes, sometimes accompanied by ocelli. In flight, the hindwings and forewings are coupled by curved hairs.

Females typically lay masses or strings of jelly-encased eggs below the surface of water, attached to plants. Metamorphosis is complete. The aquatic larvae usually pupate inside cases that they make from materials such as sand grains and twigs.

Order TRICHOPTERA	Family HYDROPSYCHIDAE	No. of species 1,000

NET-SPINNING CADDISFLIES

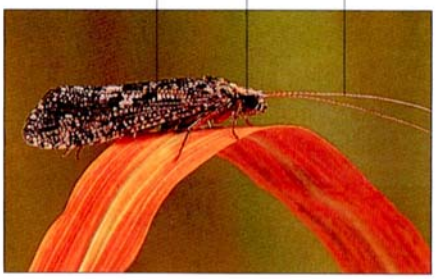
These caddisflies are drably colored with either hairy or clear wings. There are wartlike projections on the pronotum.

• LIFE CYCLE Eggs are laid in water. The stout larvae live near a cup-shaped net that they spin between stones or other objects. The net catches small organisms, algae, and debris, which the larvae eat. Some larvae are predacious.

• OCCURRENCE Worldwide. Common along streams and rivers.

• REMARK Different species make nets with varying mesh sizes to suit their preferred food.

LARVAE have well-branched gills on the thorax and abdomen.



HYDROPSYCHE CONTUBERNALIS is native to various parts of western Europe. It is found in running rather than still water. This species has the drab coloration typical of caddisflies.

Length ¼–⅝in (0.6–1.8cm)	Larval feeding habits

Order TRICHOPTERA	Family HYDROPTILIDAE	No. of species 1,000

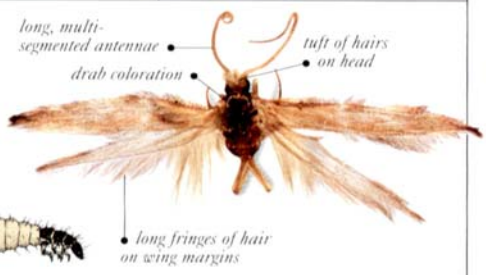
MICRO-CADDISFLIES

Also known as purse case-makers, these caddisflies have black, white, or gray speckled coloration. They are densely covered with hair.

• LIFE CYCLE Eggs are laid in jellylike masses, either on water or on water plants. The first four larval stages are active and suck the juices of water plants. The last larval stage makes an open-ended purse or barrel-shaped case out of silk from its salivary glands.

• OCCURRENCE Worldwide. Near streams, rivers, ponds, and lakes.

LARVAE are small and free-living in the early stages.



HYDROPTILA SPECIES are found all over the world – this is the largest, most widespread genus in the family, containing 150 species.

Length 1/16–¼in (2–6mm)	Larval feeding habits

Order TRICHOPTERA	Family LIMNEPHILIDAE	No. of species 1,500

NORTHERN CADDISFLIES

These species are dark brown or slightly red or yellow. The wings have dark markings, a straight front margin, and appear to be "cut-off" at the rear. The front legs each have a tibial spur.

• **LIFE CYCLE** Eggs are laid in water. The larvae make cases that often look like tiny, irregular log cabins. Most larvae eat organic detritus, algae, and other small organisms.

• **OCCURRENCE** Mainly in the Northern Hemisphere. Around ponds, lakes, streams, ditches, temporary pools, and marshes.

LARVAE have a round head and may be quite large.

LIMNEPHILUS LUNATUS is a widespread species. Its larvae are found in a wide variety of freshwater habitats. Coloration is variable, but is generally in drab shades of black and brown.

Length ½–1¾in (0.7–3.0cm), most under 1in (2.4cm)	Larval feeding habits

Order TRICHOPTERA	Family PHILOPOTAMIDAE	No. of species 500

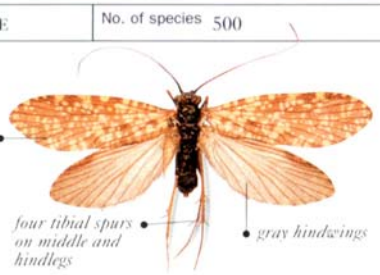
FINGER-NET CADDISFLIES

These are small and darkly colored species with oval wings. They have fairly flat heads with ocelli.

• **LIFE CYCLE** Eggs are laid in water. The larvae live inside finger-shaped, fine-meshed nets that they attach to rocks. The mouthparts are used to brush up filtered organic particles.

• **OCCURRENCE** Worldwide. Especially common near fast-flowing streams.

LARVAE have a red-tinged head and pronotum.



PHILOPOTAMUS MONTANUS, as the name suggests, is usually found around fast-flowing streams in hilly or mountainous parts of Europe.

Length ½–⅝in (4–8mm)	Larval feeding habits

Order TRICHOPTERA	Family PHRYGANEIDAE	No. of species 450

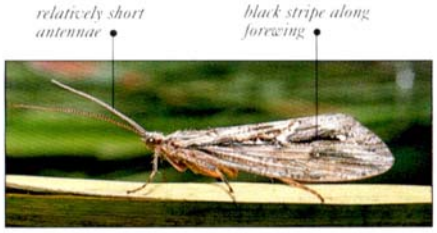
LARGE CADDISFLIES

Members of this family have light brown or gray markings and may look mottled. Ocelli are present. There are at least two tibial spurs on the front legs and four on the middle and hindlegs.

• **LIFE CYCLE** Eggs are laid in water. The larvae make light cases of spirally arranged plant fragments and fibers, adding material as they grow.

• **OCCURRENCE** Mainly Northern Hemisphere. Near ponds, lakes, bogs, and slow-flowing streams and rivers.

LARVAE are slim and flat. The head may have dark bands.



PHRYGANEA GRANDIS is the largest caddisfly found in the British Isles. The male is smaller than the female (shown here) and lacks the distinctive dark stripe along the forewing.

Length ½–1in (1.2–2.6cm)	Larval feeding habits

MOTHS AND BUTTERFLIES

THE 127 FAMILIES AND 165,000 species of moths and butterflies make up the order Lepidoptera. There is no scientific difference between moths and butterflies. Moths, however, usually fly at night and butterflies during the day, while butterflies have club-ended antennae, which moths usually lack. Both groups have tiny, overlapping scales on the body and wings and multisegmented antennae. The mouthparts usually form a proboscis for taking nectar and other liquids. The selection below places moths first (Arctiidae–Zygaenidae) and butterflies second (Lycaenidae–Pieridae).

Courtship involves displays and odors. Either sex releases a scent that is carried downwind and picked up by the mate's antennae. Eggs are scattered or laid on the larval food plants. Metamorphosis is complete. The cylindrical larvae (caterpillars), the majority of which are herbivorous, have chewing mouthparts, three pairs of thoracic legs, and a variable number of abdominal prolegs with tiny hooks to grip food plants. There are four to nine larval stages. The pupa (chrysalis) may be: underground in a silk-lined cell; surrounded by a silk cocoon produced by the mature larva; or naked and attached to the food plant.

Order LEPIDOPTERA	Family ARCTIIDAE	No. of species 2,500

TIGER AND ERMINE MOTHS

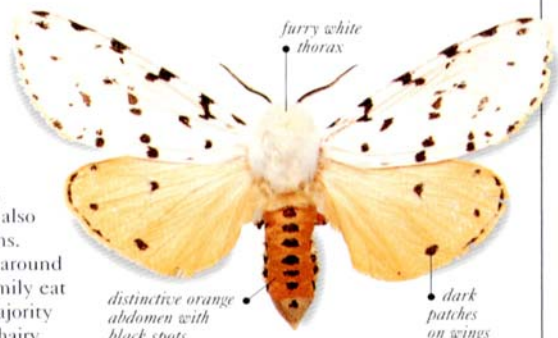
Most tiger moths are heavy-bodied and hairy, often brightly colored in various combinations of black, red, yellow, and orange, which warns off predators. Ermine moths tend to be pale or white, with small black markings. This family also includes the slender, dull footmen moths.

• **LIFE CYCLE** Eggs are laid on and around host plants. Many caterpillars in this family eat a wide range of plant matter and the majority of species feed at night. They are very hairy, and many species are poisonous because they eat the leaves of plants such as potato and laburnum, which contain toxic substances. Footmen species feed by day, and their smooth caterpillars eat lichens.

• **OCCURRENCE** Worldwide. In well-vegetated areas where host plants occur.

• **REMARK** Some are significant forest and orchard pests.

CATERPILLARS pupate inside a silken cocoon, into which they weave some of their long hairs.



ESTIGMENE ACREA is an ermine moth that is found in southeastern Canada and eastern parts of the US.

ARCTIA CAJA, the Garden Tiger Moth, is a colorful species from Europe, North America, and Asia.

Wingspan ¼–2¾in (2–7cm), most 1–1⅗in (2.5–4cm)	Larval feeding habits

Order LEPIDOPTERA	Family BOMBYCIDAE	No. of species 100

SILK MOTHS

These stout, hairy moths are pale cream, gray, or brown. They have no working mouthparts and do not feed.
• LIFE CYCLE Eggs are laid on host plants. Pupation occurs in a silk cocoon. *Bombyx mori* caterpillars eat mulberry leaves; other species eat a variety of plants.
• OCCURRENCE Southeast Asia. In well-vegetated areas wherever their host plants proliferate.

CATERPILLARS are smooth, with prolegs on some abdominal segments.

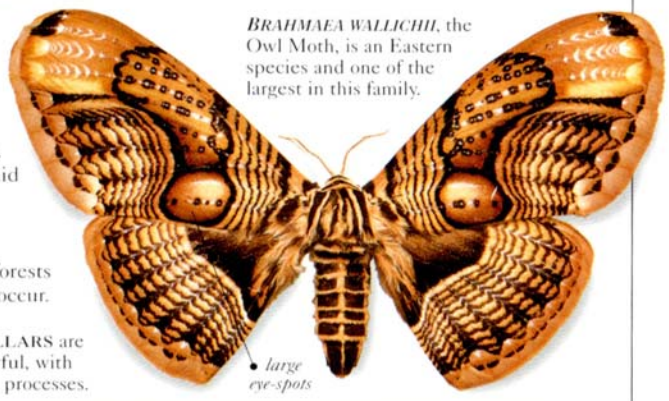
BOMBYX MORI, the Commercial Silk Moth, originated in Asia. It is now found in silk farms worldwide.

Wingspan ¼–2½in (2–6cm)	Larval feeding habits

Order LEPIDOPTERA	Family BRAHMAEIDAE	No. of species 20

BRAHMAEID MOTHS

These large moths have wavy wing patterns. The forewings may have eye-spots.
• LIFE CYCLE Eggs are laid on host plants, and pupation takes place on the ground.
• OCCURRENCE Eastern Europe, Asia, and Africa. In forests and woods, where host trees occur.



BRAHMAEA WALLICHII, the Owl Moth, is an Eastern species and one of the largest in this family.

CATERPILLARS are often colorful, with abdominal processes.

Wingspan 2–6½in (5–16.5cm)	Larval feeding habits

Order LEPIDOPTERA	Family CASTNIIDAE	No. of species 180

CASTNIID MOTHS

These day-flying, very butterfly-like moths have distinctive, broad wings. Their forewings are usually colored for camouflage but the hindwings can be either brightly colored or metallic, with white or orange spots or bands.
• LIFE CYCLE Eggs are laid on host plants. The caterpillars are stem-borers or feed on roots.
• OCCURRENCE Central and South America, Southeast Asia, and Australia. In well-vegetated areas, wherever their host plants occur.

CATERPILLARS are pale, hairless, and grublike.

CASTNIA LICUS, the Giant Sugarcane Borer, is also a significant pest of bananas.

Wingspan 1¼–4¼in (3–11cm)	Larval feeding habits

Order LEPIDOPTERA	Family COSSIDAE	No. of species 700

CARPENTER MOTHS

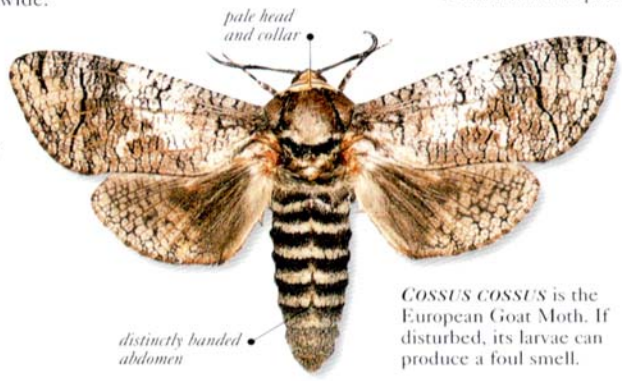
These heavy-bodied species usually have spotted, drab wings, irregularly patterned brown, white, and cream. Some are called leopard moths because they have black-spotted white wings.

• **LIFE CYCLE** Females lay eggs on bark or in the tunnels from which the moths emerge as adults. The caterpillars mainly tunnel and eat woody tissue. Carpenter moths take from one to four years to reach adulthood. When fully grown, caterpillars pupate in their tunnels or in soil, inside a cocoon of silk and chewed wood fibers.

• **OCCURRENCE** Worldwide. In woodland areas.

• **REMARK** Some species are pests of oak, maple, pine, and other trees. "Witchety" grubs, eaten by aboriginal people, are carpenter moth larvae.

ZEUZERA PYRINA, the Leopard Moth, is found across the Northern Hemisphere.



COSSUS COSSUS is the European Goat Moth. If disturbed, its larvae can produce a foul smell.

CATERPILLARS are fat-bodied and are commonly known as carpenter worms.

Wingspan ¼–8¼in (2–22.5cm)	Larval feeding habits

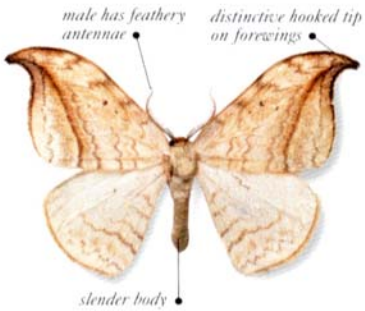
Order LEPIDOPTERA	Family DREPANIDAE	No. of species 1,000

HOOK-TIP MOTHS

These moths are so called because many have hooked tips on their forewings. Most species have slender bodies, with drably colored wings.

• **LIFE CYCLE** Female hook-tip moths lay flat eggs on host plants – the caterpillars feed on the foliage of shrubs and trees. In the caterpillars of many species, the clasping prolegs at the end of the abdomen are extremely reduced, and the tail-end may appear either tapered or pointed.

• **OCCURRENCE** Tropical regions except South America. In woodland and well-vegetated areas.



DREPANA ARCUATA, also known as the Arched Hook-tip, occurs in North America. Its caterpillars feed on the foliage of birch and alder trees.

CATERPILLARS of some species rest with the head and tail raised or the front of the body curved around.

Wingspan ¼–2in (2–5cm)	Larval feeding habits

Order LEPIDOPTERA	Family GEOMETRIDAE	No. of species 20,000

GEOMETER MOTHS

The wings of these slender-bodied moths are rather large and rounded with complex patterns of fine markings. They are generally nocturnal and usually have brown or green camouflage coloring. Some tropical species are brightly colored day-fliers.

• **LIFE CYCLE** Eggs are laid singly or in groups on the bark, twigs, or stems of host plants, and hatch in spring. When disturbed, the caterpillars of many species remain still and look twiglike. When fully grown, caterpillars spin a fragile cocoon between leaves or in litter.

• **OCCURRENCE** Worldwide. Almost anywhere vegetation is found.

• **REMARK** Many species are agricultural and forestry pests; they can cause severe damage or defoliation.

CATERPILLARS are commonly called inchworms or loopers because of their distinctive looping motion.

GEOMETRA PAPILIONARIA, or Large Emerald, caterpillars feed on the foliage of beech, alder, and hazel trees.

RHEUMAPTRA HASTATA, known as the Argent and Sable Moth, is found across the Northern Hemisphere.

Wingspan ½–3in (1.4–7.4cm)	Larval feeding habits

Order LEPIDOPTERA	Family HEPIALIDAE	No. of species 300

GHOST MOTHS

Also called swift moths due to their fast flight, most species have similarly shaped fore- and hindwings. Many have drab general coloration, while some have patterns of bright silver spots. The wings are not joined in flight, as in other moths, but simply overlap.

• **LIFE CYCLE** Females drop eggs singly on the ground by host plants, and can produce several hundred eggs. The caterpillars mainly bore into plant stems, trunks, and roots, but a few eat leaves or moss.

• **OCCURRENCE** Worldwide, especially in Southeast Asia and Australia. In open woodland and grassland.

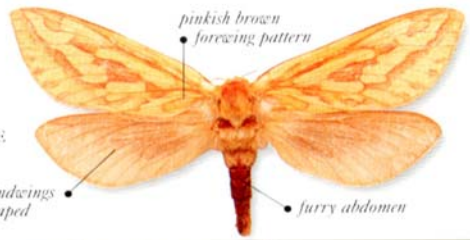
• **REMARK** Many species eat a range of plant matter and can become pests of grasses, vegetables, shrubs, and trees.

CATERPILLARS of this family are white with a brown head.

MALE

HEPIALUS HUMULI caterpillars are yellow-white with small, dark spots. They can become harmful pests of potato, lettuce, and strawberry crops.

FEMALE



Wingspan 1¼–9½in (3–24cm)	Larval feeding habits

Order LEPIDOPTERA	Family HESPERIIDAE	No. of species 3,000

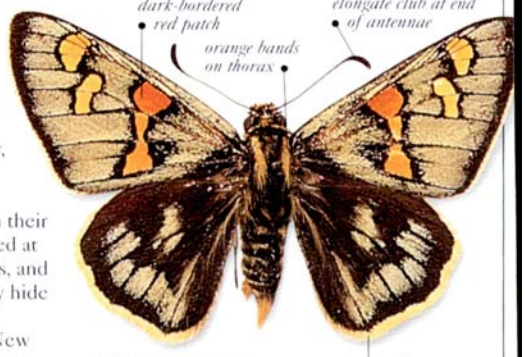
SKIPPERS

Although closely related to butterflies, these day-flyers are typically mothlike and heavy-bodied. The antennae end in a club, which is long, curved, and pointed. While the forewings are usually short and triangular, the hindwings may be tailed. The common name refers to their rapid, darting flight.

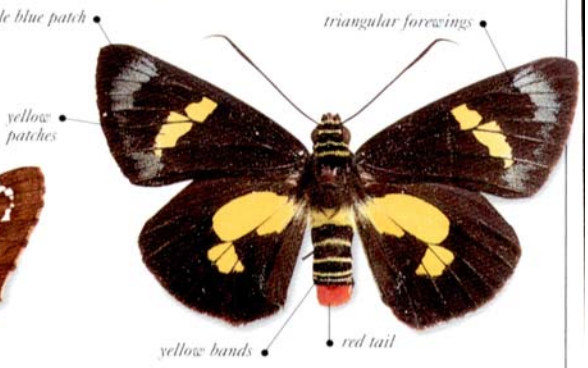
• **LIFE CYCLE** Females lay single eggs on their host plant. The caterpillars of most species feed at night on grasses and sedges, herbaceous plants, and the foliage of some trees. During the day, they hide inside a shelter of rolled or folded leaves.

• **OCCURRENCE** Worldwide, except in New Zealand. In a variety of open habitats, such as cultivated fields and grassland.

CATERPILLARS are green, brown, or white. They usually have a large head with a distinct neck and taper toward the rear.



△ *AMENIS BARONI* is a brightly colored species from Peru, with highly distinctive orange-red forewing markings.



△ *EUSCHEMON RAFFLESIA*, the vivid Regent Skipper, lives in the rainforests of Australia and is seen feeding during the day at nectar-rich flowers.

△ *URBANUS PROTEUS* is a common species in North and South America. Its long, tailed hindwings make it highly recognizable.

▷ *CALPODES ETHLIUS*, the Brazilian Skipper, is widespread in South America and the West Indies. This large and robust skipper often flies great distances.

Wingspan ¼–3½in (2–8cm), most under 1¼in (4.5cm)	Larval feeding habits

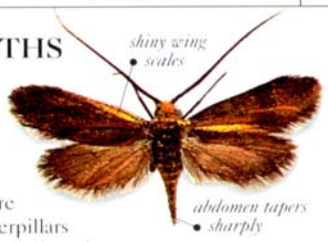
Order LEPIDOPTERA | Family INCURVARIIDAE | No. of species 300

INCURVARIID MOTHS

Most of these small moths have camouflage coloring. A few are a metallic gold or bronze. Some species with long antennae are called fairy moths.

• **LIFE CYCLE** Single eggs are laid inside plant tissue. The caterpillars are seed-borers or leaf-miners in their early stages and make a case out of plant material, inside which they live and eventually pupate.

• **OCCURRENCE** Worldwide, except in New Zealand. In woods, wherever their host plants grow.



CATERPILLARS are small, with tiny abdominal prolegs.

NEMOPHORA CUPRIACELLA has metallic wing scales, an orange tuft of hair on its head, and white antennal tips.

▽ *NEMOPHORA SCABIOSELLA*, from Asia and Europe, has dark wing fringes.

Wingspan 1/16–1in (0.8–2.5cm) | Larval feeding habits

Order LEPIDOPTERA | Family LASIOCAMPIDAE | No. of species 2,000

LAPPET AND EGGAR MOTHS

Most of these very hairy, heavy-bodied moths are yellowish brown, brown, or gray in color. Females are bigger than males and generally have large abdomens.

• **LIFE CYCLE** Eggs are laid on host plants. The caterpillars live communally in silk tents or webs, spun across the foliage of various trees, grasses, and plants. Pupation occurs inside tough, papery, egglike cocoons.

• **OCCURRENCE** Worldwide, except in New Zealand. Anywhere their host trees and plants occur.

CATERPILLARS are stout with tufts of hairs on both their back and sides.

MALACOSOMA AMERICANUM, the Eastern Tent Moth, is a troublesome pest of apple and wild cherry trees.

Wingspan 1–3⅛in (2.5–9.5cm) | Larval feeding habits

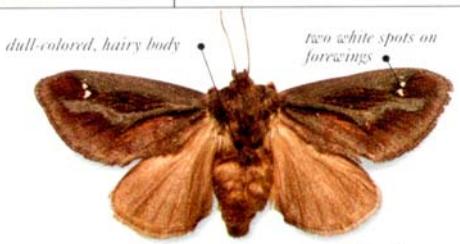
Order LEPIDOPTERA | Family LIMACODIDAE | No. of species 1,000

LIMACODID MOTHS

Most limacodids have broad, rounded wings, hairy bodies, and dull coloring. The name means "slug-like" and refers to the shape and locomotion of the caterpillars.

• **LIFE CYCLE** Flat eggs are laid on the leaves of host plants. The caterpillars are often poisonous or are armed with stinging hairs.

• **OCCURRENCE** Worldwide, especially in tropical regions. On a wide range of shrubs and trees.



CATERPILLARS are often brightly colored. They have no prolegs.

SIBINE STIMULEA, the Saddleback Moth of North America, is named after the saddle-shaped mark on the back of its caterpillars.

Wingspan ¼–1¾in (2–4.5cm) | Larval feeding habits

Order LEPIDOPTERA	Family LYMANTRIIDAE	No. of species 2,600

TUSSOCK MOTHS

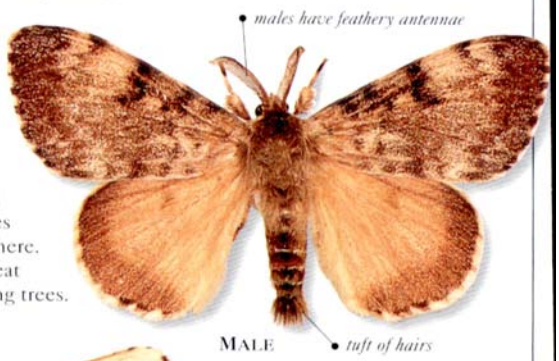
These moths look similar to noctuid moths (see p.165), but they are more hairy. Most are dull-colored, but the tropical species can be colorful. Males are slightly smaller than the females, which are sometimes wingless. Adults lack a proboscis, and do not feed.

• **LIFE CYCLE** Females lay their eggs in batches on the bark of host trees and shrubs, often incorporating some of the irritant hairs from the end of the abdomen as a protective device against predators. The caterpillars, which may be brightly colored, feed in groups on foliage.

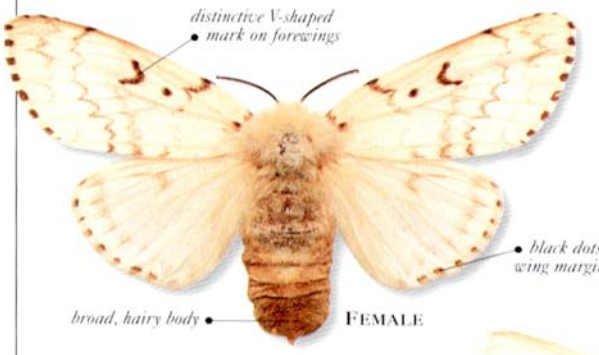
• **OCCURRENCE** Worldwide. In many habitats, including hedgerows and coniferous or deciduous woods.

• **REMARK** The Gypsy and Brown-tail moths are serious pests of a range of trees and shrubs across the Northern Hemisphere. Outbreaks of these species can cause great damage, defoliating large areas and killing trees.

CATERPILLARS are very hairy – commonly with brushlike tufts of hairs on their back and sides.

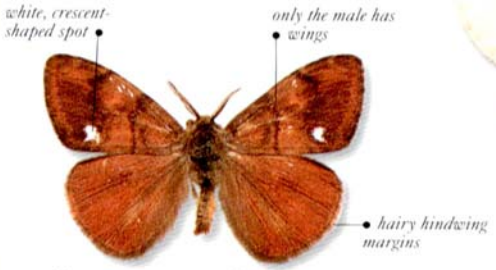


MALE

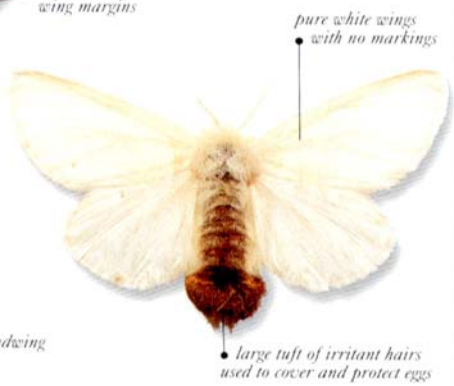


FEMALE

LYMANTRIA DISPAR, the Gypsy Moth, is a native of Europe and Asia but was introduced to North America to produce inexpensive silk. However, the moth escaped and became a serious pest.



ORGYIA ANTIQUA, otherwise known as the Vapourer Moth, is found in the Northern Hemisphere. The females are wingless.



EUPROCTIS CHRYSORRHOEA, the Brown-tail Moth, has hairy, brown caterpillars that live in a communal silk nest.

Wingspan ¼–2½in (2–6cm)	Larval feeding habits

Order LEPIDOPTERA	Family NOCTUIDAE	No. of species 22,000

NOCTUID MOTHS

These medium-sized nocturnal moths have fairly narrow forewings and broad hindwings. Noctuid moths have basically dull coloring, although the hindwings of some species are brightly colored and patterned.

• **LIFE CYCLE** Females lay eggs singly or in groups, at the base of host plants or in the soil. Caterpillars feed after dark and most attack their host plants, chewing or boring their way inside.

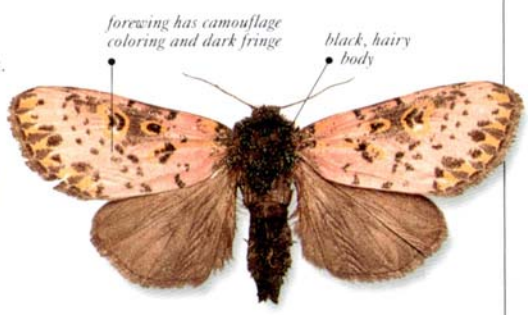
• **OCCURRENCE** Worldwide. In most habitats.

• **REMARK** These nocturnal moths have thoracic hearing organs for detecting bats. Many species are serious pests, between them damaging almost all the world's important crops. One species (see right), evolved from a fruit-piercing moth, sucks blood.

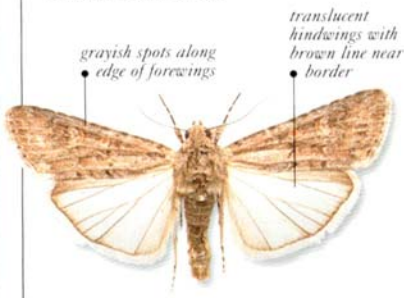
CALYPTRA EUSTRIGATA, or the Vampire Moth, sucks blood and has barbed mouthparts that it uses to pierce the skin of mammals. It is found in India and Southeast Asia.

CATERPILLARS of most species feed on their host plants at night.

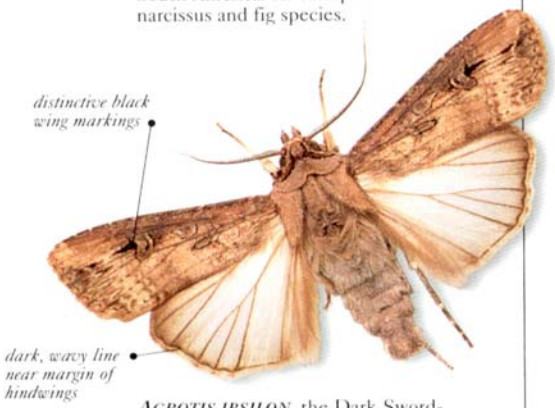
HELIOTHIS ARMIGERA, or the Old World Bollworm, is a serious pest of cotton, corn, and tomatoes. It is found across the Eastern Hemisphere.



XANTHOPASTIS TIMAIS, the Spanish Moth, is found in tropical North and South America. Its caterpillars feed on narcissus and fig species.



SPODOPTERA EXIGUA is also known as the Small Mottled Willow Moth. It has a worldwide distribution and is a serious pest of cotton, corn, and rice.



AGROTIS IPSILON, the Dark Sword-grass Moth, is found throughout the world. Its caterpillars attack cotton, potatoes, tomatoes, and other crops.

Wingspan ⅛–6in (1.5–16cm), most under 3¼in (8cm)	Larval feeding habits

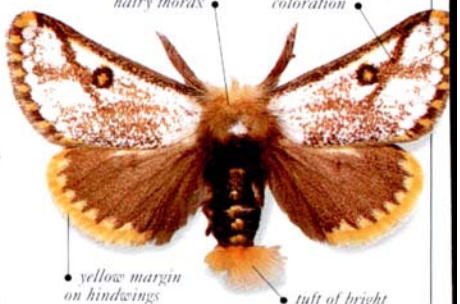
Order LEPIDOPTERA	Family NOTODONTIDAE	No. of species 3,000

PROMINENTS

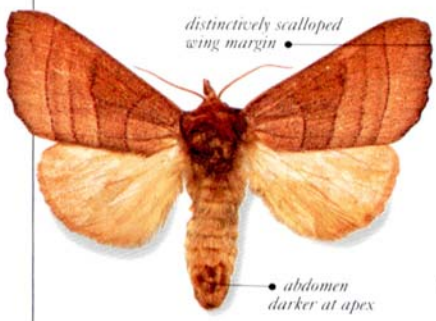
Most prominents are drably colored, with camouflage patterning. The common name refers to tufts of scales that, in some species, stick up prominently from the rear margins of the forewings when folded. A few species, such as the Buff-tip (*Phalera bucephala*), mimic broken twigs.

• **LIFE CYCLE** Eggs are laid on the leaves of host plants. The caterpillars eat foliage and feed in groups to protect themselves from attacks by birds. Some produce chemicals and adopt threatening postures. Certain prominent caterpillars are described as "processionary" due to their nighttime habit of moving in a long, head-to-tail line when seeking food. During the day, these species often shelter *en masse*, sometimes in a loose, silk nest.

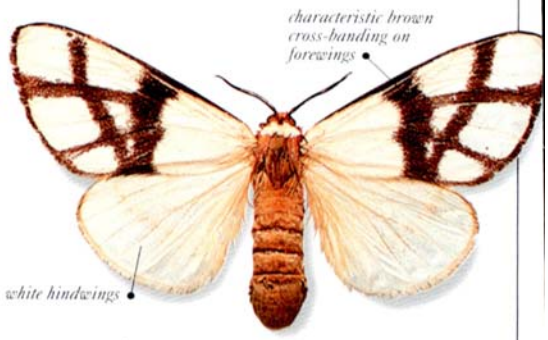
• **OCCURRENCE** Worldwide. In a variety of habitats on their host plants – most commonly shrubs, trees, and leguminous plants.



EPICOMA MELANOSTICA is an Australian species whose caterpillars feed on the leaves of *Leptospermum* species, common in southern and eastern parts of Australia.



DATANA MINISTRA is a rather drably colored species, found in North America. Its caterpillars have black and yellow stripes and feed on a variety of deciduous tree foliage.



ANAPHE PANDA, the Banded Bagnest, lives in Africa and is named after the silk shelters spun by its caterpillars during the day. Some genus members defoliate their host trees.

CERURA VINULA, the Puss Moth, is common in Europe and parts of Asia and has highly distinctive patterning.

CATERPILLARS are brightly colored, hairy, or striped, with fleshy bumps on their back.

Wingspan 1¼–3¼in (3–8cm)	Larval feeding habits

Order LEPIDOPTERA	Family PYRALIDAE	No. of species 24,000

SNOUT MOTHS

These moths are typically drably colored. In some species, the front of the head appears to have a short "snout" formed by the long, sensory palps, held out straight. The forewings are broad or narrow, while the hindwings are broad and rounded. The legs are usually long.

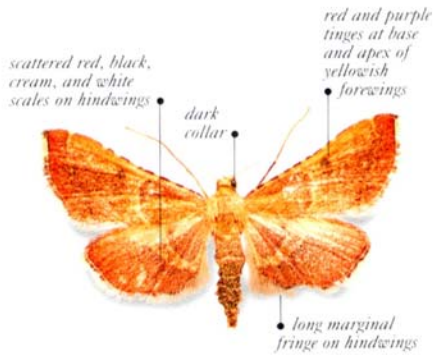
• **LIFE CYCLE** Eggs are laid near or on host plants, other host material, or prey. The larval feeding habits are diverse, but caterpillars typically burrow inside, and feed on, the leaves, stems, and roots of host plants. Some family members are scavengers, while a few prey on small insects and some even breed in sloth droppings or animal horn.

• **OCCURRENCE** Worldwide. In a wide range of habitats on their host plants.

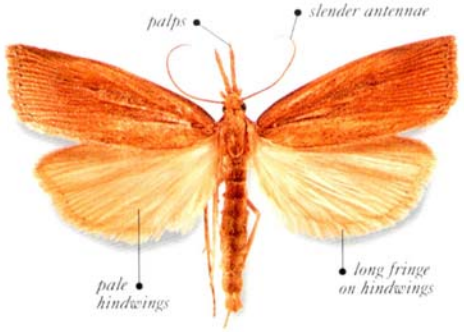
• **REMARK** A large number of snout moths are pests of crops and dried fruit.

CATERPILLARS are either slender and cylindrical or quite stout. There are prolegs on some of the abdominal segments.

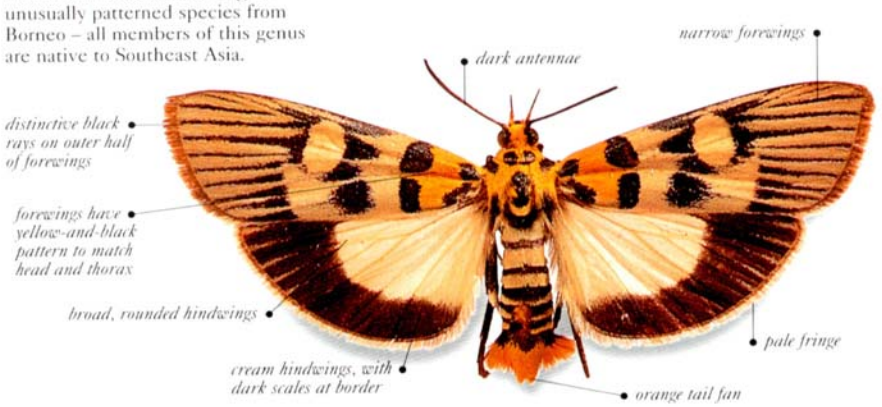
▷ ***CHILO PHRAGMITELLA*** is found in reedbeds, where its caterpillars feed on the stems of reeds belonging to the genus *Phragmites* – hence this moth's scientific name.



△ ***ENDOTRICHA FLAMMEALIS*** is a nocturnal species. It is native to the British Isles and various parts of western Europe.



VITESSA SURADEVA is a bright, unusually patterned species from Borneo – all members of this genus are native to Southeast Asia.



Wingspan ⅛–1⅛in (1–4.5cm)	Larval feeding habits

Order LEPIDOPTERA	Family SATURNIIDAE	No. of species 1,200

SATURNIID MOTHS

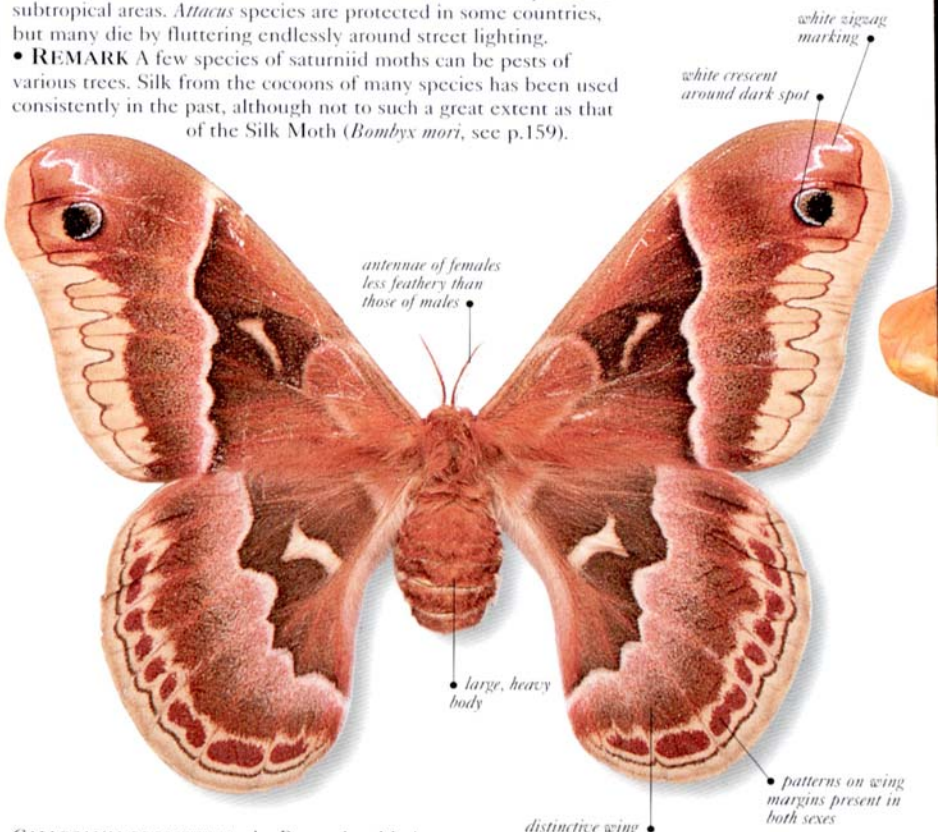
Also known as emperor, moon, royal, and atlas moths, these large, heavy-bodied species have broad, often conspicuously marked wings. The mouthparts are entirely nonfunctional, and the adults do not feed. Antennae are feathery in the males and usually threadlike in the females. Species of the genus *Attacus*, found in Southeast Asia, are the largest moths in the world in terms of wing area, although the biggest moth wingspan is that of the Giant Agrippa Moth (*Thysania agrippina*), which belongs to the family Noctuidae (see p.165).

• **LIFE CYCLE** Eggs are laid on a wide range of trees and shrubs, and the caterpillars feed on the foliage. Fully grown caterpillars make dense cocoons attached to the twigs of their host plants.

• **OCCURRENCE** Worldwide. Especially in wooded tropical and subtropical areas. *Attacus* species are protected in some countries, but many die by fluttering endlessly around street lighting.

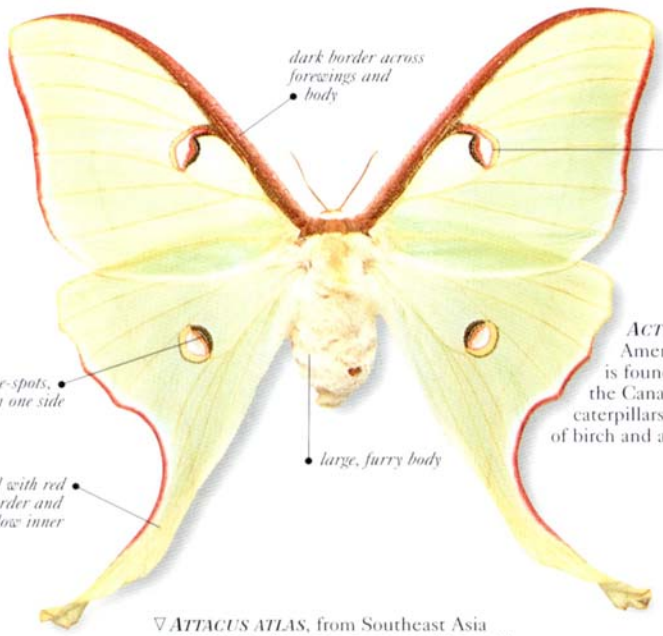
• **REMARK** A few species of saturniid moths can be pests of various trees. Silk from the cocoons of many species has been used consistently in the past, although not to such a great extent as that of the Silk Moth (*Bombyx mori*, see p.159).

CATERPILLARS can grow very large and have fleshy outgrowths (scoli) with spines and long hairs.



CALLOSAMIA PROMETHEA, the Promethea Moth, is found in North America. The caterpillars feed on a range of foliage, including that of various fruit trees. Males are mostly black-brown with a pale border; females are a bright red-brown or dark brown and have pale wing markings.

Wingspan 2–12in (5–30cm)	Larval feeding habits



ACTIAS LUNA, the American Moon Moth, is found from Mexico to the Canadian border. The caterpillars feed on the foliage of birch and alder trees.

▽ *ATTACUS ATLAS*, from Southeast Asia and India, is the largest moth in the world in terms of overall size. Its yellow-green, fleshy-spined caterpillars grow up to 4in (10cm) long. They eat a range of plants but can be reared on privet in captivity.

Order LEPIDOPTERA	Family SESIIDAE	No. of species 1,000

CLEAR-WINGED MOTHS

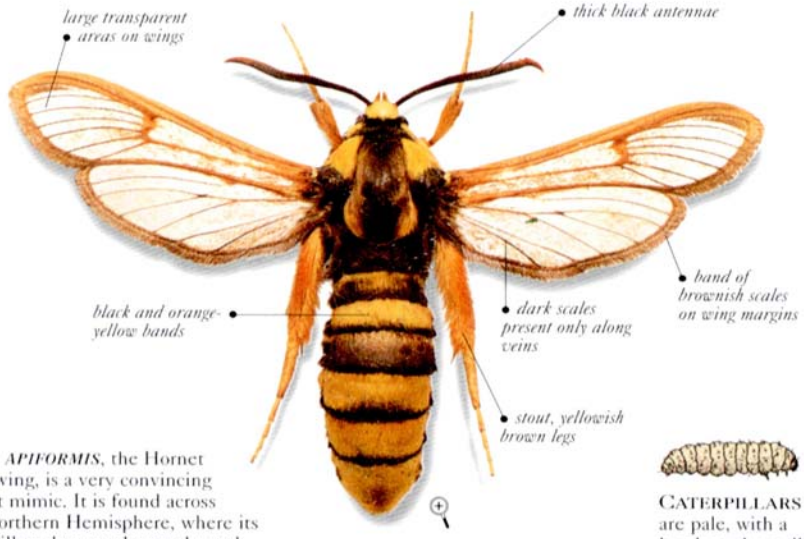
Some of these moths closely resemble wasps or bees. Their bodies are mainly black, bluish, or dark brown with yellow and orange markings, and their abdomens are often banded. They produce a buzzing sound during flight, which further emphasizes the mimicry. Some species even pretend to sting. Large areas of the wings are transparent, dark scales being present only along the veins. The end of the abdomen may have a fan-shaped tuft of long scales, and the antennae often have expanded or clubbed ends.

• **LIFE CYCLE** Female clear-winged moths typically lay eggs on the trunks, stems, or roots of trees and shrubs, and the caterpillars burrow inside. When the moths first emerge from their pupae, their wings are fully covered in scales; the bare patches appear during the first flight.

• **OCCURRENCE** Worldwide. Around flowers or near their host plants.

• **REMARK** Many species, such as the Peach Tree Borer (*Synanthedon exitiosa*), are pests of fruit and other trees and shrubs.

△ *ALBUNA OBERTHURI* is a large moth from Australia's Northern Territory. It has distinctive hindwings – clear but with a noticeable yellow bar at the front – and an obvious abdominal tuft.



SESIA APIFORMIS, the Hornet Clearwing, is a very convincing hornet mimic. It is found across the Northern Hemisphere, where its caterpillars damage the trunks and roots of poplar and willow trees.

CATERPILLARS are pale, with a head much smaller than the thorax.

Wingspan ⅛–1½in (1.5–4cm)	Larval feeding habits

Order LEPIDOPTERA	Family SPHINGIDAE	No. of species 1,100

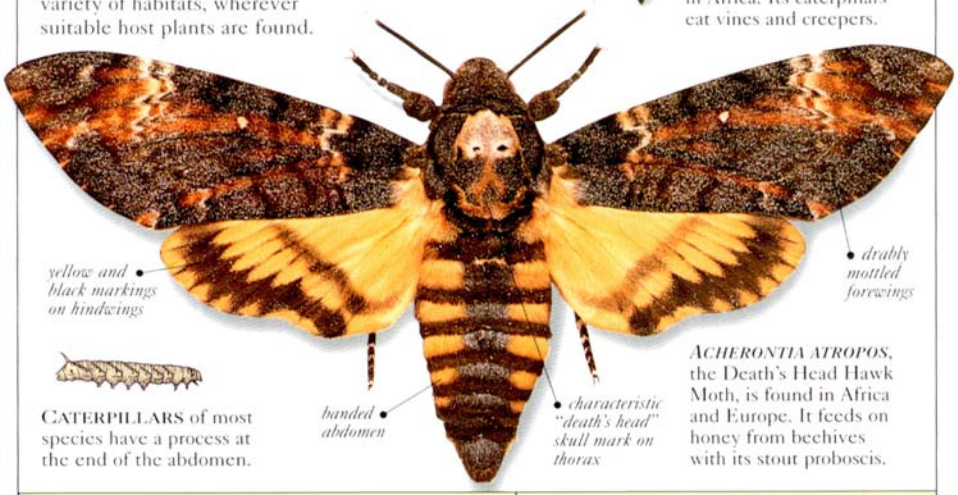
HAWK MOTHS

These moths have an elongate, robust body and long, relatively narrow forewings. The long or very long proboscis is curled under the head when not in use. At rest, the wings are held back at a distinctive angle. Adults are strong fliers and most suck flower nectar. Some hover above flowers like hummingbirds.

• **LIFE CYCLE** Single eggs are laid on plants, and the caterpillars eat their foliage.

• **OCCURRENCE** Worldwide, especially in tropical and subtropical regions. In a wide variety of habitats, wherever suitable host plants are found.

△ *EUCHLORON MEGAERA*, the Verdant Sphinx, lives in Africa. Its caterpillars eat vines and creepers.



CATERPILLARS of most species have a process at the end of the abdomen.

ACHERONTIA ATROPOS, the Death's Head Hawk Moth, is found in Africa and Europe. It feeds on honey from beehives with its stout proboscis.

Wingspan 1¼–6in (3–15cm), most under 4in (10cm)	Larval feeding habits

Order LEPIDOPTERA	Family TORTRICIDAE	No. of species 5,000

TORTRICID MOTHS

These small moths are mostly brown, green, or gray, blending in with bark, lichen, and leaves. Some species are brightly colored. The forewings are broadly rectangular.

• **LIFE CYCLE** Eggs are laid on host plants, including certain grasses, on which the caterpillars feed and pupate.

• **OCCURRENCE** Worldwide. In a wide range of habitats.

• **REMARK** Mexican "jumping beans" are the seeds of certain plants containing the wriggling larvae of a particular tortricid species.

CATERPILLARS may be slender or stout, and are relatively hairless.

CLEPSIS RURINANA is found in Europe and Asia. Its caterpillars may be found inside the rolled-up leaves of deciduous trees.

Wingspan 1/16–1⅛in (0.8–3cm)	Larval feeding habits

Order LEPIDOPTERA	Family URANIIDAE	No. of species 100

URANIID MOTHS

This family includes both large, long-tailed, colorful, day-flying moths with iridescent wing scales, and nocturnal species with dull coloration and without tails.

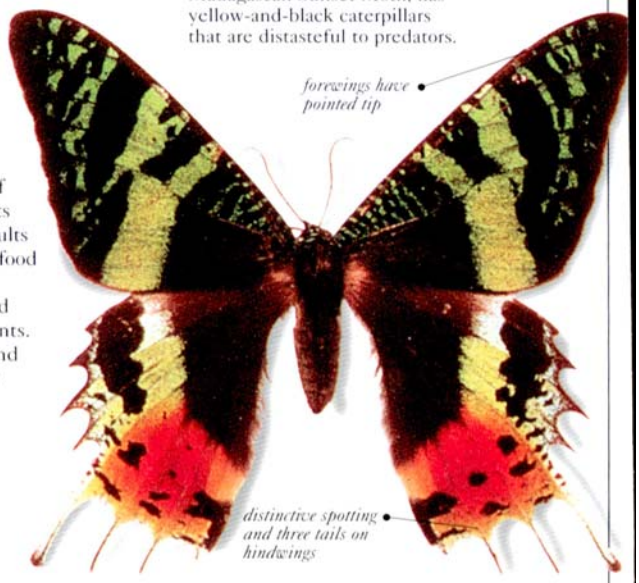
• **LIFE CYCLE** Eggs are laid on host plants. The caterpillars of many species eat poisonous plants in the family Euphorbiaceae. Adults often migrate in search of better food for their larvae.

• **OCCURRENCE** Tropical and subtropical regions. On host plants.

• **REMARK** South American and Madagascan species are so large and colorful that they are often mistaken for butterflies.

CATERPILLARS of some species live together in a silk web when young.

CHRYSIRIDIA RIPHEARIA, the Madagascan Sunset Moth, has yellow-and-black caterpillars that are distasteful to predators.



Wingspan 2½–4in (6–10cm)	Larval feeding habits

Order LEPIDOPTERA	Family ZYGAENIDAE	No. of species 800

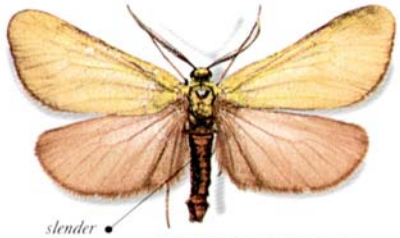
BURNET MOTHS

Also called foresters, many of these moths are black with bright or metallic red, green, or blue coloring. Some look wasplike. The antennae are thickened, and the head has a pair of hairy protuberances above the eyes. Most species produce hydrogen cyanide – a feature advertised by warning coloration.

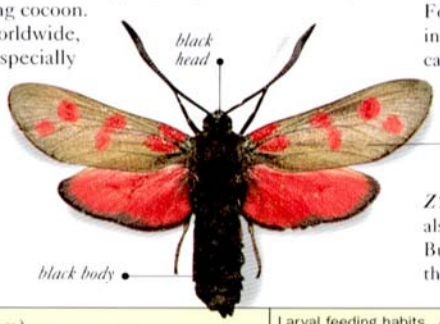
• **LIFE CYCLE** Eggs are laid on herbaceous host plants, and larvae feed externally on their leaves. The adults fly and feed at flowers by day. Pupation takes place within a long cocoon.

• **OCCURRENCE** Worldwide, except New Zealand; especially tropics and subtropics. On host plants.

CATERPILLARS have small warts, from which tufts of hairs protrude.



△ ***ADSCITA STATICES***, the Forester Moth, is found in Europe and Asia. The caterpillars feed on sorrel.



ZYGAENA FILIPENDULAE, also known as the Six-spot Burnet, is common throughout Europe.

Wingspan 1–1¼in (2.5–3.5cm)	Larval feeding habits

Order LEPIDOPTERA	Family LYCAENIDAE	No. of species 6,000

BLUES, COPPERS, AND HAIRSTREAKS

The males and females are differently colored in many of these small, slender-bodied butterflies. The upper wings of males can be iridescent blue, coppery, or purplish but some are brown or orange. The undersides of both sexes are dull, with small, dark-centered spots.

• **LIFE CYCLE** Eggs are laid on host plants. The caterpillars feed on plants or on aphids, coccids, and other small insects. The larvae of many species secrete a special fluid that is eaten by ants. In return, the ants guard them from enemies and allow them to eat the ants' larvae. Pupation occurs on the host plant, in debris, or underground.

• **OCCURRENCE** Worldwide, especially in warmer regions. In association with ants' nests or with host plants.

△ *THECLA CORONATA*, the Hewitson's Blue Hairstreak, is found in tropical regions of South America. This is one of the largest and most brilliantly colored members of the family.

CATERPILLARS are slug-like, with a squat, tapering shape, and are green or brown.

△ *POLYOMMATUS ICARUS*, known as the Common Blue, is one of the most widespread European natives.

△ *LYCAENA PHLAEAS*, the Small Copper, is a colorful and very common little butterfly, found across the Northern Hemisphere.

THECLA BETULAE, the Brown Hairstreak Butterfly, is a woodland species found in Europe and temperate regions of Asia.

Wingspan ⅛–2in (1.5–5cm)	Larval feeding habits

Order LEPIDOPTERA	Family NYMPHALIDAE	No. of species 5,000

NYMPHALIDS

Also called brush-foots due to the greatly reduced front pair of legs, species of this huge family fly by day and vary enormously in size and color. The upper surfaces of the wings are usually brightly colored, but the undersides have camouflage coloring to protect the butterfly at rest.

• **LIFE CYCLE** Females lay groups of round, ribbed eggs on the foliage of trees, shrubs, and herbaceous plants. Caterpillars may feed communally when very young. Nymphalid pupae, which often have warty bumps, hang head down from host plants by a small group of terminal hooks (a cremaster).

• **OCCURRENCE** Worldwide. Usually in flower-filled meadows and woodland clearings.

• **REMARK** A very small number of nymphalid species can be pests, causing damage to crops such as sweet potato and soybean.

CATERPILLARS are generally spiny with branched bumps and projections.

△ *HELICONIUS ERATO*, the Small Postman, is native to Central and South America.

▷ *NYMPHALIS ANTIOPA* is often called the Camberwell Beauty, referring to the part of south London where the first recorded specimen was found.

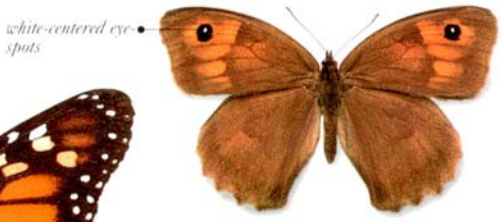
VANESSA ATALANTA, or the Red Admiral, is a widespread species. The caterpillars, usually black with white and yellow spots, feed on nettles and related plants.

Wingspan 1¼–6in (3–15cm)	Larval feeding habits

▽ *MORPHO MENELAUS* lives in South America. The female is shown here. Males are almost entirely metallic blue.

DANAUS PLEXIPPUS, or the Monarch Butterfly, is famous for its long-distance migrations, the longest of which extends from Mexico to Canada.

▽ UPPERSIDE



▽ UNDERSIDE

MANIOLA JURTINA, the Meadow Brown, is a very common species in the pastures and meadows of Europe. Its caterpillars feed on grasses.

Order LEPIDOPTERA	Family PAPILIONIDAE	No. of species 600

SWALLOWTAILS

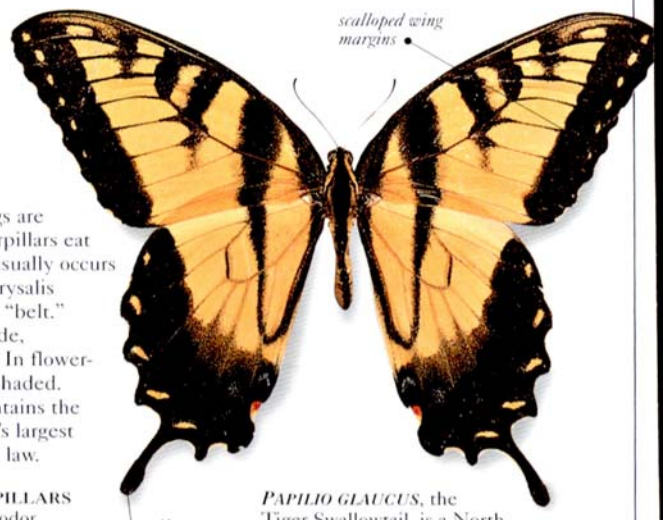
The wings of these butterflies are typically dark, with bands, spots, or patches of white, yellow, orange, red, green, or blue. True to their name, many species have tails on their hindwings.

• **LIFE CYCLE** Round eggs are laid on host plants – the caterpillars eat a range of foliage. Pupation usually occurs on the host plant with the chrysalis upright and held on by a silk "belt."

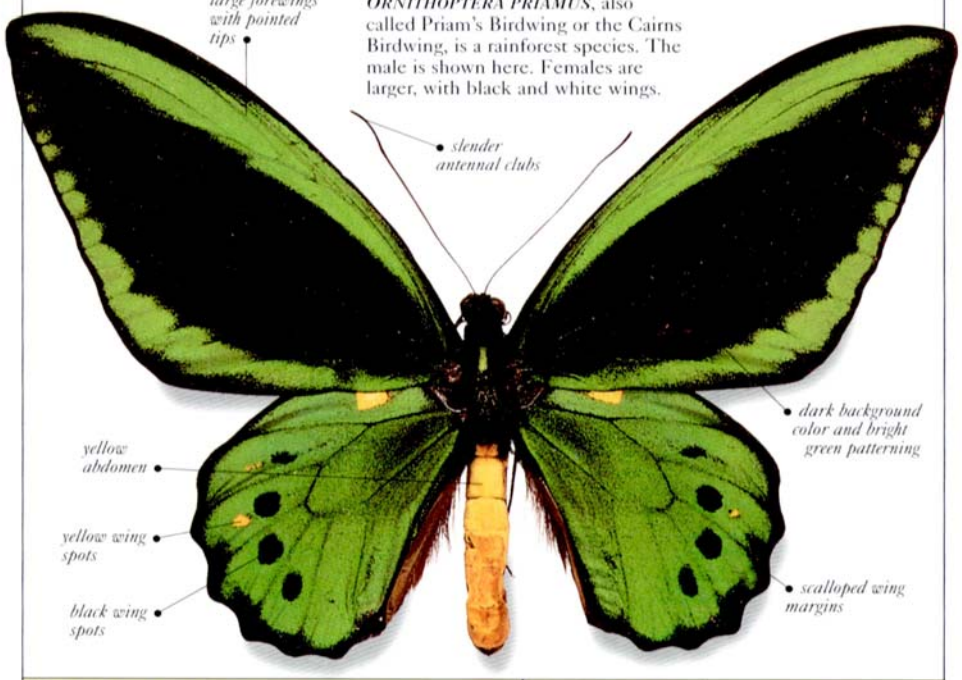
• **OCCURRENCE** Worldwide, especially in warmer regions. In flower-rich habitats, either open or shaded.

• **REMARK** This family contains the birdwing species – the world's largest butterflies, now protected by law.

CATERPILLARS emit an odor from a thoracic scent gland that deters predators.



PAPILIO GLAUCUS, the Tiger Swallowtail, is a North American species. The common name refers to its forewing markings.



ORNITHOPTERA PRIAMUS, also called Priam's Birdwing or the Cairns Birdwing, is a rainforest species. The male is shown here. Females are larger, with black and white wings.

Wingspan 1¼–11in (4.5–28cm)	Larval feeding habits

Order LEPIDOPTERA	Family PIERIDAE	No. of species 1,200

WHITES AND SULPHURS

The wings of these very common butterflies are usually white, yellow, or orange with black or dark gray markings. The pigmentation of the wing scales comes from by-products of food eaten by the caterpillars.

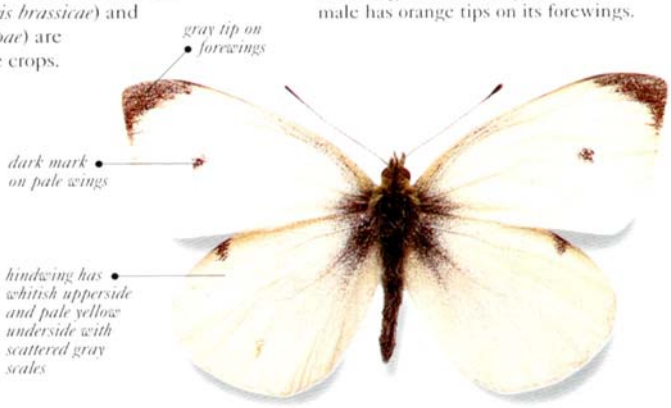
• **LIFE CYCLE** Females typically lay single, elongate, ribbed eggs on a wide range of host plants. The caterpillars have no spines or projections, but the pupae have a distinctive spiny projection that arises from the head end, and are held upright on the host plant by a silk "belt."

• **OCCURRENCE** Worldwide. In a wide range of habitats. They are often seen in groups around bird droppings, urine, or puddles in sunshine. Some species migrate in large numbers.

• **REMARK** Many species are crop pests. The Large White (*Pieris brassicae*) and the Small White (*P. rapae*) are serious pests of cabbage crops.

△ *ANTHOCHARIS CARDAMINES* occurs across Europe and Asia. In both sexes, the undersides of the hindwings are mottled green. The male has orange tips on its forewings.

CATERPILLARS may have camouflage coloring – green with pale stripes or bands. Many have spinelike hairs.



△ *PIERIS RAPAE*, the Small White, is an unremarkable-looking species that is found all over the world. The male is shown here; the female is yellowish in color.

COLIAS EURYTHEME, the Orange Sulphur, is widespread in North America. The male, shown here, is slightly smaller than the female.

Wingspan ¼–2¾in (2–7cm)	Larval feeding habits

BEES, WASPS, ANTS, AND SAWFLIES

THE ORDER Hymenoptera contains 91 families and 198,000 species. These are further divided into two suborders: primitive, plant-eating insects called sawflies (Symphyta) and wasps, ants, and bees (Apocrita). The families shown here are arranged in three groups: social wasps and bees and ants (families Andrenidae to Vespidae), parasitic wasps (Agaonidae to Trichogrammatidae), and sawflies (Argidae to Siricidae).

Most members of the order have two pairs of membranous wings, joined in flight by tiny hooks. In all species except the sawflies, the first abdominal segment is fused to the thorax, while the second and sometimes the third segments are narrow and form a waist. Sawfly females have a sawlike ovipositor while female parasitic wasps often have a long, slender ovipositor, which may also be internal. The ovipositor of female bees, ants, and social wasps has evolved into a sting. Eggs issue from an opening at its base. Metamorphosis is complete. Gender is determined by haplodiploidy, a process in which fertilized eggs produce females and males arise from unfertilized eggs.

Many species show advanced forms of social behavior and play a vital role in various types of ecosystems as predators, parasites, and plant pollinators.

Order HYMENOPTERA	Family ANDRENIDAE	No. of species 2,500

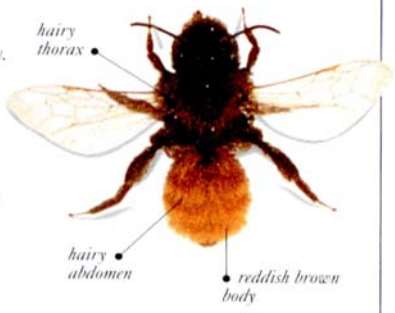
MINING BEES

These honeybee-like species are typically red-brown or brown-black, although some are yellow or white. The thorax and abdomen may be hairy. Most species are solitary.

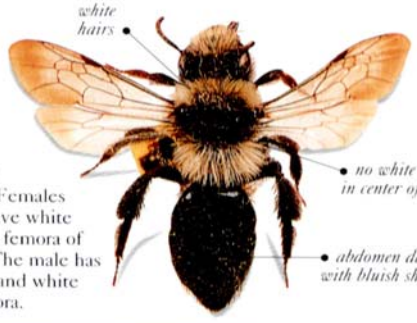
• **LIFE CYCLE** Females make nests in soil burrows and lay eggs in specially prepared cells, where the larvae develop. These cells are usually coated with a protective waterproof substance secreted by an abdominal gland and are supplied with pollen and honey – food for the larvae. Pollen is collected and taken back to the nest on the bees' hindlegs.

• **OCCURRENCE** Worldwide, except Australia. In flower-rich habitats, especially during spring.

• **REMARK** Mining bees are vital pollinators of spring flowers.



ANDRENA FULVA, the Tawny Mining Bee, appears in early spring. It often nests in lawns, making a little mound of earth at the opening.



ANDRENA CINERARIA is a European bee. Females (shown here) have white hair only on the femora of the front legs. The male has a hairier thorax and white hairs on all femora.

LARVAE can be quite slender or stout. There are protruberances on the abdominal segments.

Length ½–¾in (0.4–2cm), most ¾–⅝in (1–1.5cm)	Larval feeding habits

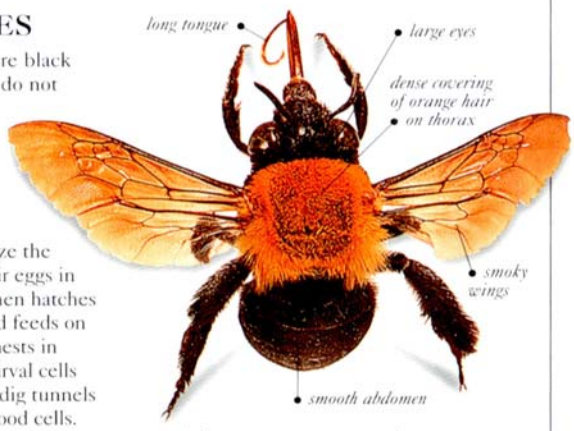
Order HYMENOPTERA	Family ANTHOPHORIDAE	No. of species 4,000

CUCKOO, DIGGER, AND CARPENTER BEES

Cuckoo bees are often wasplike and are black and yellow or brown and white. They do not have a pollen-carrying region on their hindlegs. Digger bees are generally stout and hairy, while carpenter bees are either very large and black or bluish or small and dark blue-green. Most species are solitary.

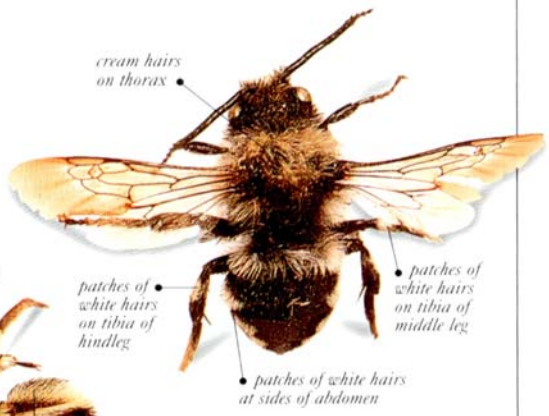
• **LIFE CYCLE** Cuckoo bees parasitize the nests of soil-nesting bees. They lay their eggs in these nests, and the cuckoo bee larva then hatches out, kills the occupying egg or larva, and feeds on its provisions. Digger bees make their nests in ground burrows and supply the nest's larval cells with pollen and honey. Carpenter bees dig tunnels in solid wood, in which they prepare brood cells. Each cell is supplied with a mass of sticky pollen, on which the female lays a single large egg before sealing the cell with chewed wood fibers.

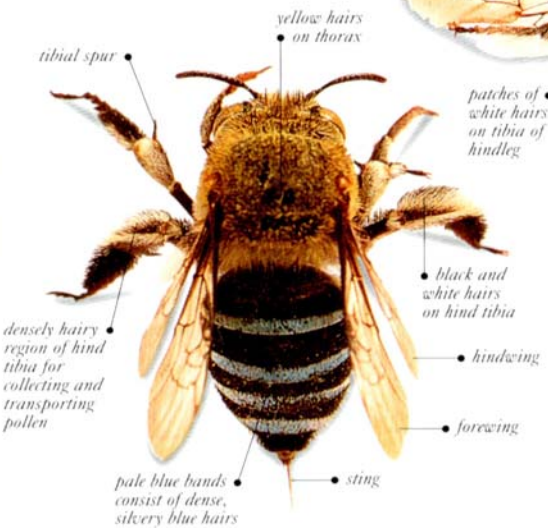
• **OCCURRENCE** Worldwide. In a wide variety of flower-rich habitats.



△ *AMEGILLA ACRAENSIS* is common in sub-Saharan Africa. This fast-flying digger bee travels long distances in order to feed on high-quality nectar from long-tubed flowers.

LARVAE are variable – either slender or stout and pale or yellow.





△ *MELECTA LUCTUOSA* is a cuckoo bee that breeds in the nests of bees that belong to the genus *Anthophora*. It is found in Europe and Asia.

◁ *AMEGILLA COMBERI* is a very common, fast-flying Indian digger bee. A ground-nester, it has an extremely long tongue for feeding at long-tubed flowers.

Length ⅛–1¼in (0.3–3cm)	Larval feeding habits

Order HYMENOPTERA	Family APIDAE	No. of species 1,000

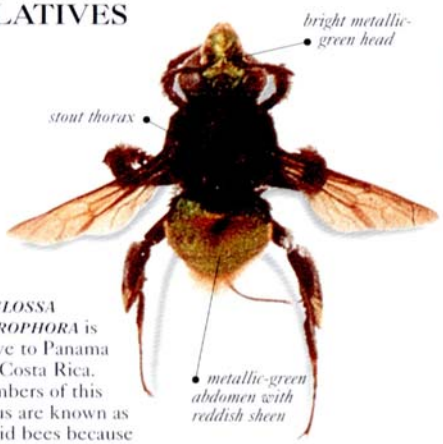
HONEYBEES AND THEIR RELATIVES

The most familiar members of this family are the stout, very hairy bumblebees and the smaller, more slender honeybees. Most females have a special pollen basket (corbiculum) on the outside of the hind tibiae. Coloration is highly varied.

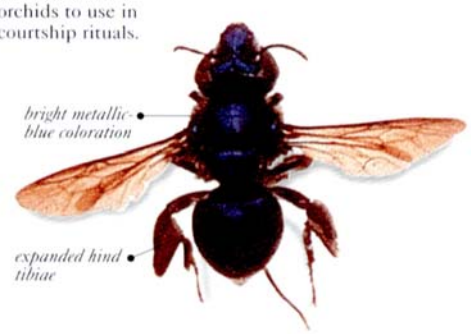
• **LIFE CYCLE** These bees are social and live in colonies consisting of an egg-laying queen, males (drones), and sterile worker females who find food and look after the young. Bumblebees form small colonies under or on the ground. The nests in which they lay their eggs are made of grass with wax brood cells. Honeybee colonies comprise a queen, up to 2,000 males, and thousands of workers. The nest is an array of double-sided wax combs divided into hexagonal cells for rearing young and storing pollen and honey. Workers use a dance language to convey the distance, quality, and direction of food.

• **OCCURRENCE** Worldwide, except in sub-Saharan Africa. Bumblebees are very common in northern temperate regions. In well-vegetated, flower-rich habitats.

• **REMARK** In addition to providing honey, wax, and other products, these bees pollinate most of the world's plants.



EUGLOSSA ASAROPHORA is native to Panama and Costa Rica. Members of this genus are known as orchid bees because the males collect oils and resins from orchids to use in courtship rituals.



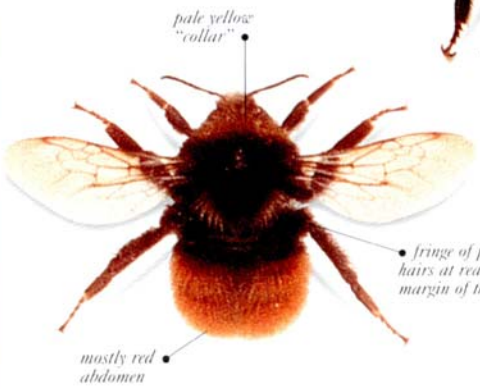
LARVAE are pale and grublike. Bumblebee larvae are fatter than honeybee larvae.

△ *EUGLOSSA INTERSECTA* is native to Surinam, Guyana, and parts of northern Brazil. Like most *Euglossa* species, it has bright, metallic coloration.

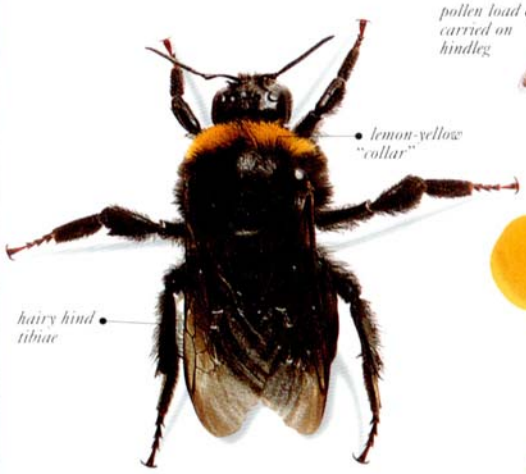
◁ *APIS MELLIFERA*, the Western Honeybee, is now found worldwide and is the best known member of the honeybee genus *Apis*. Millions of trips between flowers and the hive are required to make one jarful of honey.

Length ⅛–1¼in (0.3–3cm)	Larval feeding habits

▷ ***PSITHYRUS* SPECIES** are closely associated with bumblebees. They are cuckoo bees that lay their eggs in the nests of *Bombus* species. Many *Psithyrus* bees closely resemble bumblebees, especially the species that they parasitize.



◁ ***BOMBUS MONTICOLA*** is a relatively small, distinctive bumblebee. As its name implies, it is common in upland and mountainous areas. It makes a nest in underground burrows, often close to bilberry plants.



△ ***BOMBUS LUCORUM*** is an extremely common bumblebee species. It makes its nest under the ground and is one of the first bees to be seen in early summer in Europe.

△ ***BOMBUS TERRESTRIS*** is known as the Buff-tailed Bumblebee because the workers and males always have a whitish abdominal tail. Here, a sterile female worker bee feeds at a flower.

Order HYMENOPTERA | Family BETHYLIDAE | No. of species 2,000

BETHYLIDS

Usually black or brownish, these wasps have quite elongate heads. Some females look antlike; certain others have a pitted surface and look similar to velvet ants (see p.187). Wings may be present in both sexes but females are often wingless.

• **LIFE CYCLE** Females lay eggs on the outside of hosts such as beetle larvae or moth caterpillars – either a host she has found in a sheltered spot, or one that she has paralyzed and dragged to such a place. She may stay with the larvae as they develop.

• **OCCURRENCE** Worldwide, especially in warm regions. In varied habitats, where hosts are found.

***BETHYLUS* SPECIES** have very potent stings for their small size. Hosts are either paralyzed or killed.

LARVAE are pale and fatter toward the rear.

Length 5/32–3/4in (0.4–2cm), most under 3/8in (1cm) | Larval feeding habits

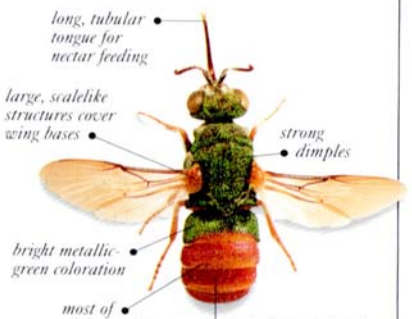
Order HYMENOPTERA | Family CHRYSIDIDAE | No. of species 3,000

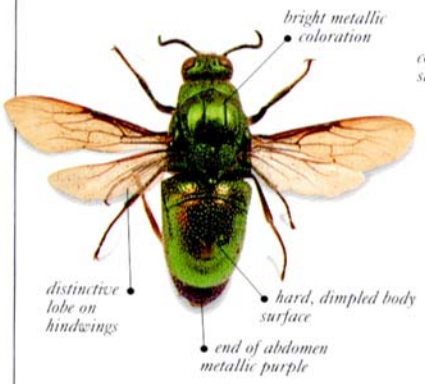
JEWEL WASPS

Also called cuckoo wasps because they steal their host larvae's provisions, or ruby-tailed wasps due to their coloring, most species of jewel wasps are bright metallic blue, green, red, or combinations of these colors. Their hard, dimpled body protects them from bee and wasp stings.

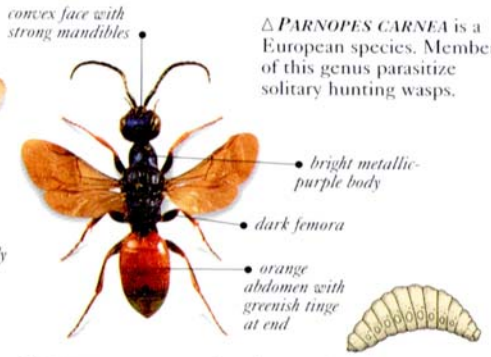
• **LIFE CYCLE** Typically, the female finds a nest containing the larva of a solitary bee or wasp and lays an egg. The jewel wasp larva eats the host larva from the outside, plus the host's provisions.

• **OCCURRENCE** Worldwide. In a variety of habitats, wherever their hosts are found.





STILBUM SPLENDIDUM is a large species native to northern Australia. It parasitizes solitary mud-nesting wasps.



△ ***PARNOPES CARNEA*** is a European species. Members of this genus parasitize solitary hunting wasps.

***CLEPTES* SPECIES** are found mostly in the Northern Hemisphere. The body is often not entirely metallic.

LARVAE are smooth and stout. The middle of the body is the broadest part.

Length 1/16–3/4in (0.2–2cm), most under 1/2in (1.2cm) | Larval feeding habits

Order HYMENOPTERA	Family COLLETIDAE	No. of species 2,000

PLASTERER AND YELLOW-FACED BEES

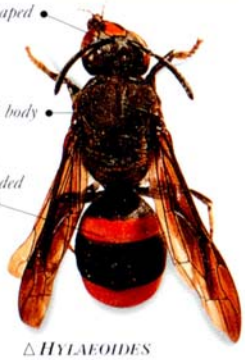
These solitary bees are slender to fairly robust, and most are very dark or black. The body hairs are pale golden or white, and the abdominal hairs often form bands.

• **LIFE CYCLE** Plasterer bees dig burrows in soil, waterproofing the cells with a special abdominal secretion. Yellow-faced bees nest in hollow plant stems and the burrows of wood-boring insects. Each larval cell is supplied with regurgitated pollen and nectar.

• **OCCURRENCE** Worldwide, especially in the Southern Hemisphere. Often on flowers.

• **REMARK** Plasterer bees carry pollen on their hindlegs, while yellow-faced bees carry it in a special pouch known as a crop.

LARVAE are variable but are generally curved and maggotlike.



△ *HYLAEOIDES CONCINNA* is a yellow-faced bee with a distinct, but reddish, facial mark.

◁ *COLLETES DAVIESANUS* is a plasterer bee, native to Europe. It makes its nest in the vertical faces of sandy cliffs.

Length 1/8–3/4in (0.3–1.8cm), most under 1/2in (1.3cm) | Larval feeding habits

Order HYMENOPTERA	Family DRYINIDAE	No. of species 1,000

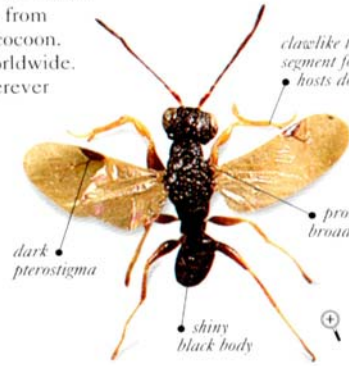
DRYINID WASPS

The males of these mainly brown or black wasps are winged. Females may be wingless or antlike, and their front tarsus often forms a kind of claw.

• **LIFE CYCLE** Females hunt down the nymphs or adults of certain bugs, sting them, and lay an egg inside them. The wasp larva feeds on the host's fluids, developing in a larval sac that protrudes from the host's body and then emerges from this to pupate inside a cocoon.

• **OCCURRENCE** Worldwide. In various habitats, wherever hosts are found.

LARVAE are usually pale, have large heads, and are strongly curved or U-shaped.



GONATOPUS SEPSOIDES is a British wasp. Like many members of this genus, the female looks very antlike.

◁ *CHELOGYNUS SCAPULARIS* is a European wasp. Its distinctive legs are yellowish with much darker femora.

Length 1/16–1/2in (0.2–1.2cm), most under 5/16in (0.8cm) | Larval feeding habits

Order HYMENOPTERA	Family FORMICIDAE	No. of species 9,000

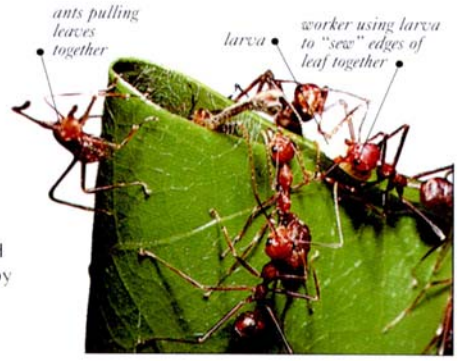
ANTS

These highly social insects live in colonies that consist of a dozen to several million individuals. The most commonly seen ants are the sterile, wingless, female workers. Reproductive queens and males usually have wings. The second, or second and third, segments of the abdomen are constricted to form a distinct "waist." This waist may have either bumps or spiny processes. Most ants are red-brown or black in color, but yellow and green species also occur. Ants protect themselves by biting or stinging, or by spraying formic acid.

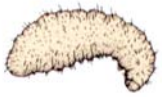
• **LIFE CYCLE** After mating, males die and queens shed their wings. Typically, a single queen lays all of a colony's eggs. As the colony grows, workers take away and protect the eggs, and then care for and feed the hatched young. If a protein diet is fed to female larvae, they become reproductives.

• **OCCURRENCE** Worldwide. In all habitats.

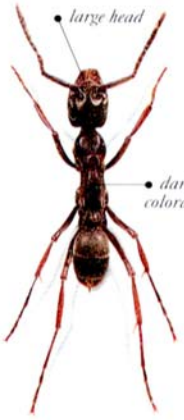
• **REMARK** Ants are significant predators or herbivores in most habitats. Much more animal flesh, for example, is eaten by ants in African savannas than by lions, hyenas, and other carnivores. Some species, such as the leaf-cutter ants (*Atta* species) and the Fire Ant (*Solenopsis invicta*), can be serious crop pests.



OECOPHYLLA SMARAGDINA, the Green Tree or Weaver Ant, builds shelters out of leaves. Workers pull the edges of leaves together while other workers use silk produced by the larvae to stick the edges together. The larva is held in the worker's mandibles and used like a shuttle.



LARVAE are white, grublike, and slightly curved. There may be hairs on the body.



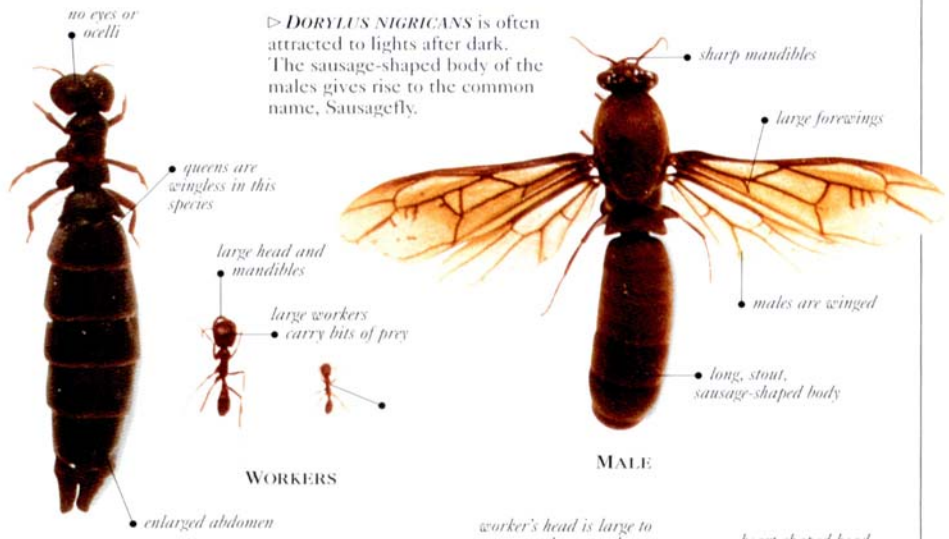
MEGAPONERA FOETENS is found in Africa and is a predator of termites. Once a termite has been found, the ants lay trails of pheromones back to the nest to recruit more workers.

▽ ***MYRMECIA*** **SPECIES**, the Australian bulldog ants, can be fairly large. Workers have a powerful sting.

DINOPONERA GRANDIS is native to parts of South America. The large workers are solitary hunters, and the colonies are small.

Length ½–¼in (0.1–2cm)	Larval feeding habits

▷ ***DORYLUS NIGRICANS*** is often attracted to lights after dark. The sausage-shaped body of the males gives rise to the common name, Sausagefly.



WORKERS

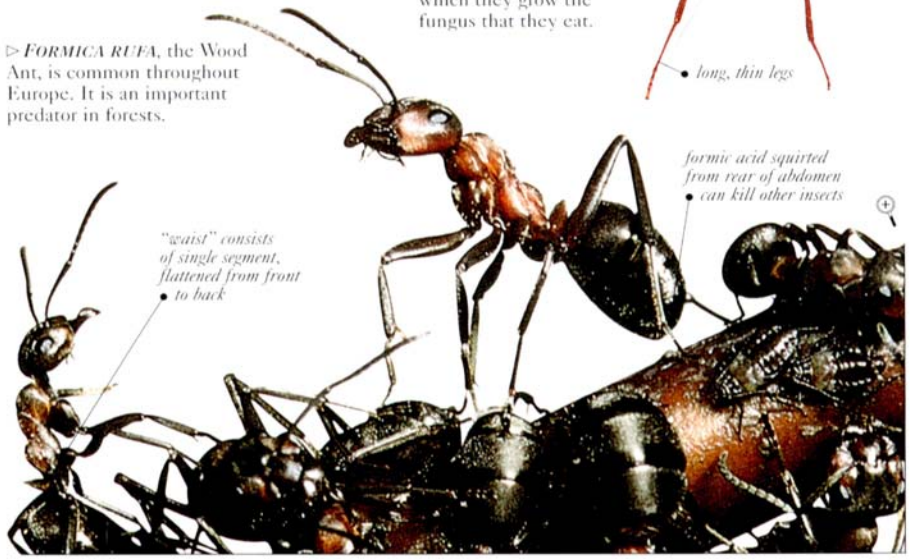
QUEEN

MALE

△ ***DORYLUS NIGRICANS*** colonies may contain millions of ants – all produced by a single queen. When these ants are in a nomadic phase, workers transport the queen's brood in their mandibles.

▷ ***ATTA LAEVIGATA*** is one of about 200 species of leaf-cutter ant found in tropical South America. Long trails of workers return to the huge underground nest with bits of foliage on which they grow the fungus that they eat.

▷ ***FORMICA RUFA***, the Wood Ant, is common throughout Europe. It is an important predator in forests.



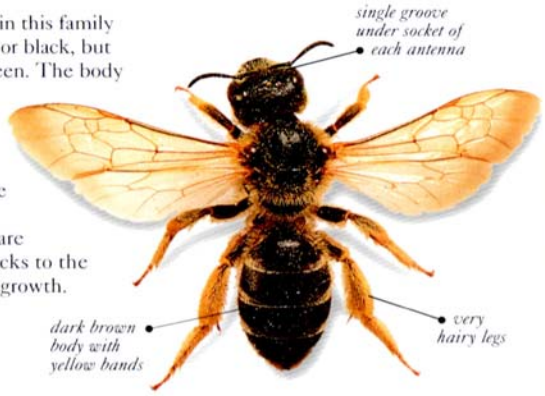
Order HYMENOPTERA	Family HALICTIDAE	No. of species 3,500

SWEAT BEES

Despite the name, only a few species in this family are attracted to sweat. Most are brown or black, but some have a metallic-blue or green sheen. The body may be pitted or dimpled with only a sparse covering of hairs. Many species are solitary, while others are social to various degrees.

• **LIFE CYCLE** Eggs are laid inside nests made in soil or in rotten wood. The cells in which eggs are brooded are waterproofed with a secretion that sticks to the surrounding soil and prevents fungal growth.

• **OCCURRENCE** Worldwide. Widespread, especially in flower-rich areas and woodland margins.



LARVAE may have bumps on the upper surface, as well as tiny spines.

HALICTUS QUADRICINCTUS is found across southern Europe and the Mediterranean. It is one of the largest European species in its genus.

Length ½–⅜in (4–15mm), most under ⅜in (10mm)	Larval feeding habits

Order HYMENOPTERA	Family MEGACHILIDAE	No. of species 3,000

LEAF-CUTTER AND MASON BEES

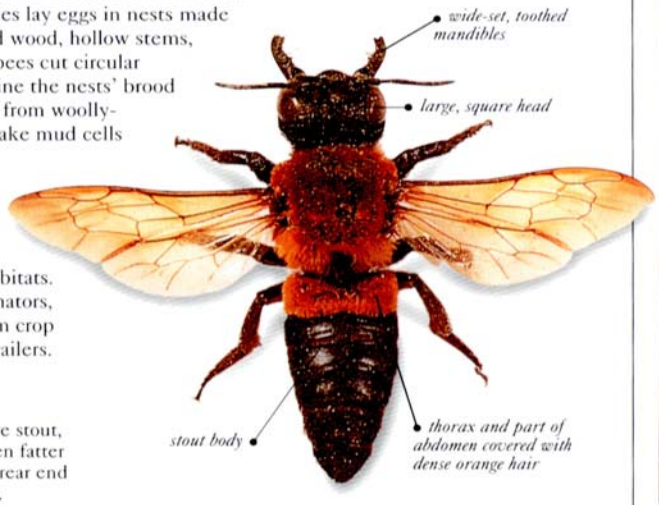
Most of these bees are solitary. Many have stout, dark brown to black bodies and may have yellow or pale markings; some are metallic blue or green. Pollen-collecting species carry their loads in a brush of hairs found underneath the abdomen.

• **LIFE CYCLE** Most species lay eggs in nests made in the natural cavities of dead wood, hollow stems, and snail shells. Leaf-cutter bees cut circular pieces of leaves or petals to line the nests' brood cells. Other species use hairs from woolly-leaved plants. Mason bees make mud cells under stones and in burrows. Some species use the nests of other bees rather than making their own.

• **OCCURRENCE** Worldwide. In a variety of habitats.

• **REMARK** Vital crop-pollinators, these bees may be taken from crop to crop by farmers on huge trailers.

CHALICODOMA MONTICOLA nests in hollow plant stems, such as bamboo canes, and builds cell partitions out of mud or from a mud and resin mixture.



LARVAE are stout, and are often fatter toward the rear end of the body.

Length ½–⅜in (0.7–2cm)	Larval feeding habits

Order HYMENOPTERA	Family MUTILLIDAE	No. of species 5,000

VELVET ANTS

These wasps are referred to as velvet ants because the females are covered with soft, velvety hairs and are wingless and antlike. The males have fully developed wings. Velvet ants are black or red-brown, with spots or bands of short hairs that are red, yellow, or silver. The body surface has coarse dimples.

• **LIFE CYCLE** Velvet ants use the larvae and pupae of other wasps and bees – those that make soil, wood, or paper nests – as food for their larvae. On finding a suitable host brood cell, the female bites it open. She will reseal any cell where the larva inside is too young. If there is a fully grown larva or pre-pupa inside, however, she will lay an egg on it, before resealing the cell. The hatched velvet ant larva then eats the host larva and pupates inside the cell.

• **OCCURRENCE** Worldwide, especially in subtropical and tropical regions. Females are often seen on the ground in dry habitats.

• **REMARK** Female velvet ants have very powerful stings.

MALE

FEMALE

◁△ *MUTILLA EUROPEA* is widespread across Europe. It parasitizes species of bumblebee (see pp.180–81).

LARVAE have very rounded abdominal segments (on the upperside) when seen in profile.

MALE

FEMALE

◁△ *SPHAEROPHTHALMA MELANCHOLICA* comes from South America. It lays its eggs in the nests of certain bees and wasps – in the ground and in plant stems respectively.

Length ⅛–1in (0.3–2.5cm)	Larval feeding habits

Order HYMENOPTERA	Family POMPILIDAE	No. of species 4,000

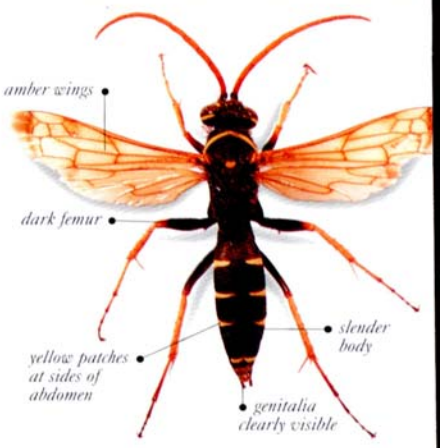
SPIDER-HUNTING WASPS

Most spider-hunting wasps are dark blue or black with wings in shades of dark yellow, blue, or black. The body is slender, and the hindlegs are long and spiny. Males are smaller and more slender than the females. Some species can be very large.

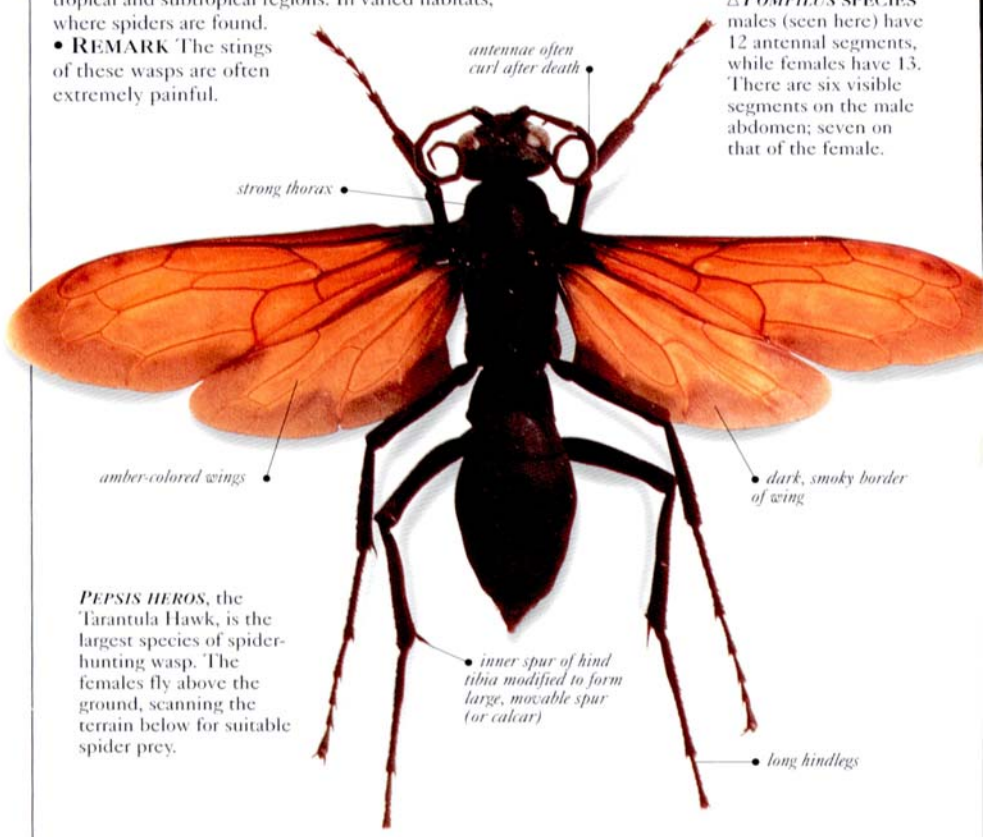
• **LIFE CYCLE** Females fly or run along the ground in search of spiders. The wasps have to wrestle with their prey, but their strong venom can cripple even very large specimens. The female drags the paralyzed spider to a prepared mud nest in a crevice or under the ground, although some will attack a spider in its own burrow. Before sealing the nest, the female lays a single egg, usually on the spider's abdomen. Some lay their eggs on a spider caught by another wasp before it is sealed in; others open already sealed nests.

• **OCCURRENCE** Worldwide, especially in tropical and subtropical regions. In varied habitats, where spiders are found.

• **REMARK** The stings of these wasps are often extremely painful.

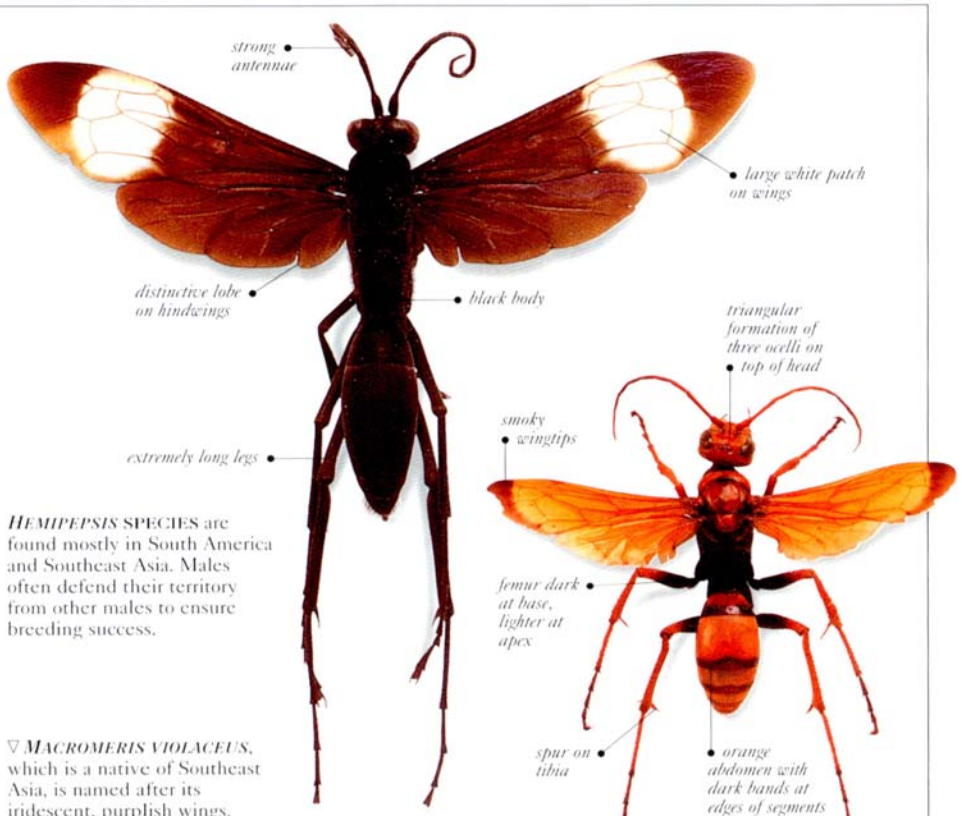


△ ***POMPILUS* SPECIES** males (seen here) have 12 antennal segments, while females have 13. There are six visible segments on the male abdomen; seven on that of the female.



PEPSIS HEROS, the Tarantula Hawk, is the largest species of spider-hunting wasp. The females fly above the ground, scanning the terrain below for suitable spider prey.

Length 1/16–2¾in (0.5–7cm), most under 1in (2.5cm)	Larval feeding habits



***HEMIPEPSIS* SPECIES** are found mostly in South America and Southeast Asia. Males often defend their territory from other males to ensure breeding success.

▽ ***MACROMERIS VIOLACEUS***, which is a native of Southeast Asia, is named after its iridescent, purplish wings.

△ ***PRIOCNEMIS* SPECIES** are found mostly in the Northern Hemisphere. This specimen has the slender abdomen and long, spiny legs typical of spider-hunting wasps.

LARVAE are pale and grublike. The body is widest in the middle.

Order HYMENOPTERA	Family SCOLIIDAE	No. of species 350

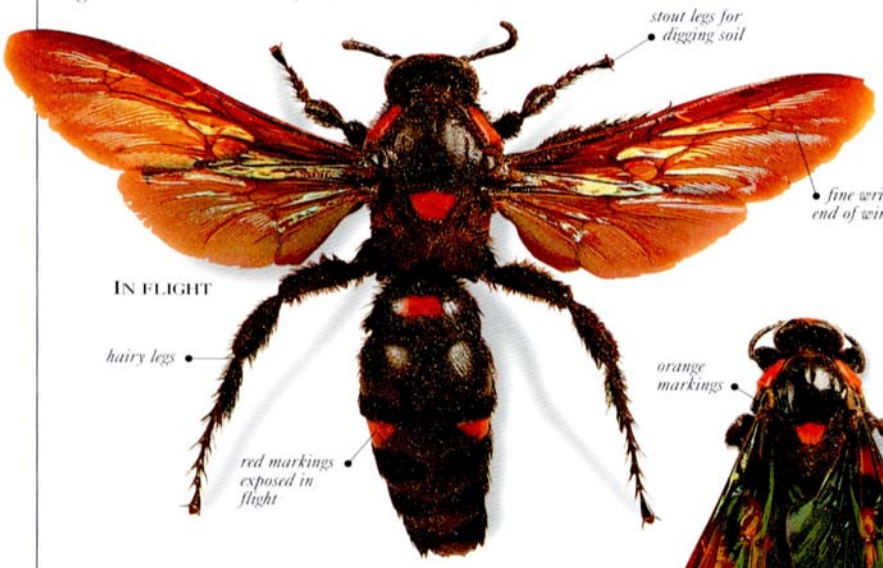
MAMMOTH WASPS

True to their name, these are very large wasps, with stout bodies. They have dark coloration: bluish black with reddish brown markings. The ends of the wings, which may be clear, smoky, metallic blue, or orangish, appear finely wrinkled. The body is densely covered with dark or gold-colored hair. Male mammoth wasps are smaller and slimmer than the females and have longer, thicker antennae. In both sexes, there is a noticeable notch on the inside margin of the eye.

• **LIFE CYCLE** After mating, females hunt through leaf litter or dig under the ground in search of the larvae of scarab beetles to use as hosts. Once found, the female wasp stings and paralyzes a beetle larva and lays a single egg on the outside. When the wasp larva emerges, it consumes the beetle larva and pupates inside a tough cocoon that it spins alongside the host's remains.

• **OCCURRENCE** Worldwide, mainly in tropical regions. In various habitats, where scarab hosts occur.

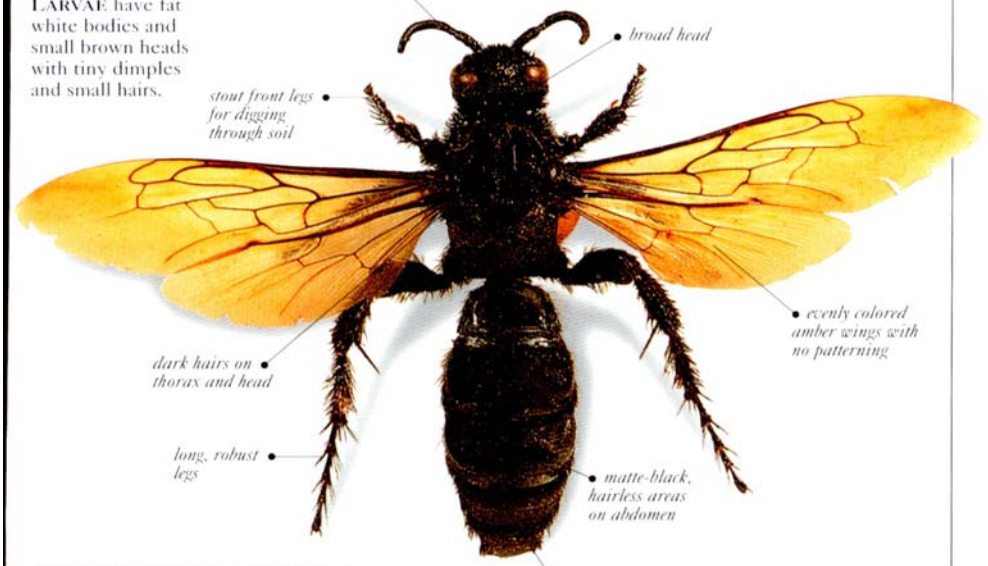
SCOLIA VARIEGATA is found in parts of South America. It has distinctive black-and-yellow coloring to warn off predators.



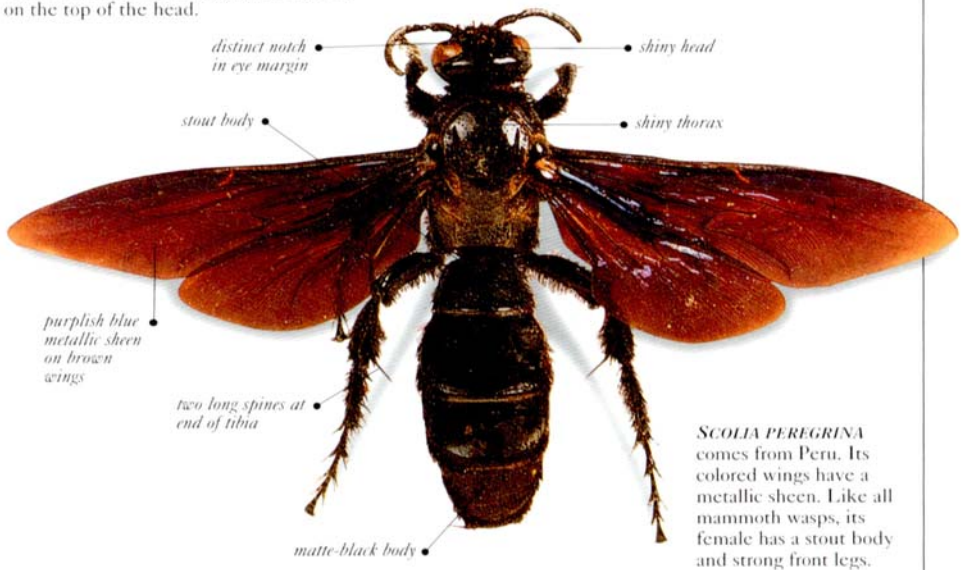
SCOLIA PROCER comes from Java, Borneo, and Sumatra. Members of this genus are not especially aggressive but may sting painfully if handled carelessly.

Length ⅛–2¼in (1–5.6cm)	Larval feeding habits

LARVAE have fat white bodies and small brown heads with tiny dimples and small hairs.



△ ***SCOLIA HYALINA***, found in Brazil, is typical of its family and has a distinctive notch on the inside edge of its eye. The ocelli are characteristic of the order – three simple eyes in a triangular formation on the top of the head.



SCOLIA PEREGRINA comes from Peru. Its colored wings have a metallic sheen. Like all mammoth wasps, its female has a stout body and strong front legs.

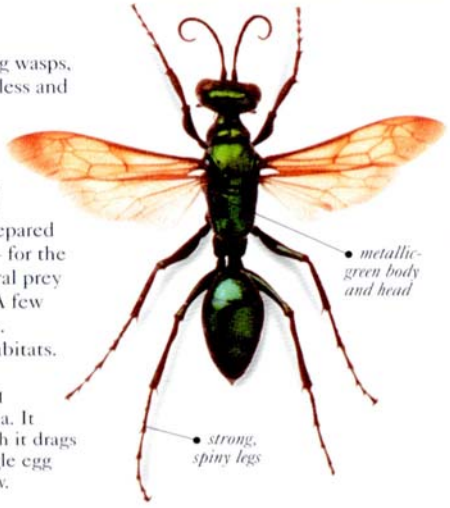
Order HYMENOPTERA	Family SPHECIDAE	No. of species 8,000

DIGGER WASPS

Some digger species are known as solitary hunting wasps, sand wasps, or mud dauber wasps. Relatively hairless and often brightly colored, they are found in many forms. They are all solitary and nest in plant stems, soil, or rotten wood. Some nest inside insect burrows. Not all species actually dig a nest.

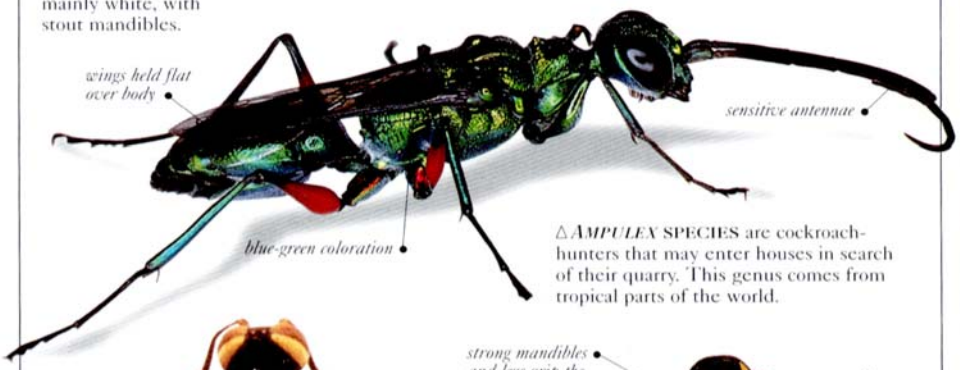
• **LIFE CYCLE** Typically, a female catches an insect or a spider, paralyzes it, and takes it to a prepared nest, where it is buried – along with a wasp egg – for the emerging larva to eat. There may be one or several prey items, or prey may be added as the larvae grow. A few species lay eggs in the nest of other digger wasps.

• **OCCURRENCE** Worldwide. In a range of habitats.



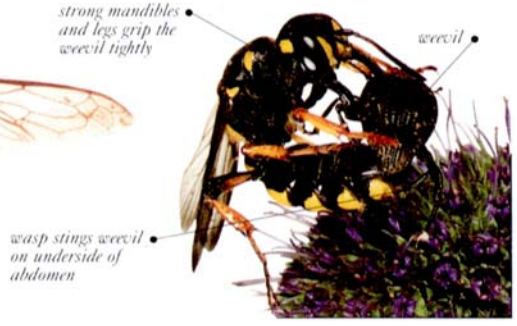
LARVAE taper at both ends and are mainly white, with stout mandibles.

▷ **CHLORION LOBATUM** is found in Southeast Asia. It parasitizes crickets, which it drags to a burrow. It lays a single egg before sealing the burrow.



△ ***AMPULEX*** **SPECIES** are cockroach-hunters that may enter houses in search of their quarry. This genus comes from tropical parts of the world.

EDITHA MAGNIFICA, from Brazil, is a very brightly marked insect that specializes in catching butterflies, mainly of the family Pieridae (see p.177)



CERCERIS ARENARIA, the Weevil-hunting Wasp, catches weevils and paralyzes them with its sting. The weevils are buried in wasp burrows, in which the wasp then lays its eggs.

Length ⅛–2in (0.4–4.8cm)	Larval feeding habits

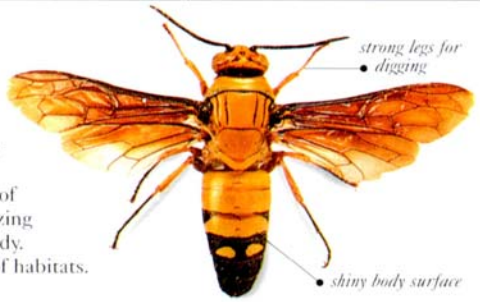
Order HYMENOPTERA	Family TIPHIIDAE	No. of species 1,600

TIPHIID WASPS

Tiphiids are shiny and vary from quite slender to stout. Some species have wingless females that look like ants.

• **LIFE CYCLE** During mating, the female may be carried aloft by the male. She then hunts out hosts for her larvae – usually larvae of scarab, longhorn, or tiger beetles. After paralyzing a host with her sting, she lays an egg on its body.

• **OCCURRENCE** Worldwide. In a range of habitats.



LARVAE are long and white, with bumps on the upper abdominal surface.

THYNNUS VENTRALIS comes from Australia. Its females are wingless, and its larvae parasitize scarab-beetle larvae (see p.128).

Length ⅛–1¼in (0.5–2.8cm)	Larval feeding habits

Order HYMENOPTERA	Family VESPIDAE	No. of species 4,000

SOCIAL WASPS

These wasps roll or fold their wings longitudinally, rather than hold them flat over the body. Nearly all have warning coloration in shades of brown or black and orange or yellow. The most familiar species are paper wasps and yellow jackets, whose nests are made of chewed fibers. However, the family also includes mason wasps, which make mud-lined, underground nests in stems and crevices.

• **LIFE CYCLE** Paper wasps and yellow jackets have queens and workers, cooperate in caring for the brood, and have overlapping generations. A typical queen overwinters, makes a nest in spring, and rears the first small brood herself. Inside the nest, larvae develop within the cells of horizontal "combs" and are fed chewed-up insects by sterile female workers. As the colony grows, so does the nest.

• **OCCURRENCE** Worldwide. In a wide range of habitats.

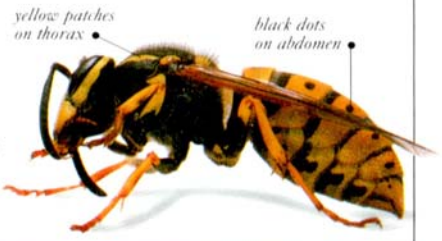
• **REMARK** Like several insects in the order Hymenoptera, a social wasp can deliver a painful sting.

LARVAE have bodies that are widest about a third back from the head.

△ *VESPA CRABRO*, the Hornet, makes its nest in hollow trees. Its colonies tend to consist of only a few hundred workers.

VESPULA VULGARIS is very helpful in the garden as it removes caterpillars and other pests. It makes its nest from wood fibers.

▷ *VESPULA GERMANICA* is found in warmer parts of the world. Colonies of this species may be perennial, with more than one queen.



Length ⅛–1¼in (0.4–3.6cm)	Larval feeding habits

Order HYMENOPTERA	Family AGAONIDAE	No. of species 650

FIG WASPS

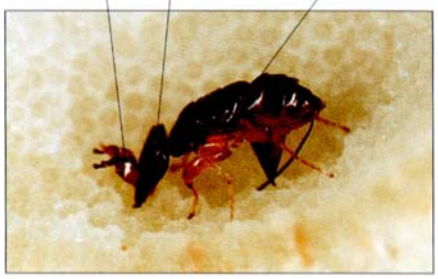
The males and females of this family look very different. The tiny, flat-bodied females have wings. Males hardly resemble wasps at all – most are wingless with odd-shaped heads, weak middle legs, and their abdomen folded underneath their body. The common name of this family is derived from the fact that these wasps and fig trees are totally dependent on each other. The trees can be pollinated only by these wasps, which in turn are able to reproduce only inside figs. Each wasp species pollinates a particular fig species.

• **LIFE CYCLE** Life cycles can be complex. Typically, a female enters a young fig through a hole. The inside of the fig is lined with female flowers and the wasp pollinates these and lays eggs in some of the ovules. The larvae develop here and feed on galls produced during the egg-laying process. Males usually emerge first and mate with the females before they emerge, biting through the female's gall wall to reach her. By this time, the male flowers inside the fig have produced pollen, which the departing females pick up and take to the next fig tree.

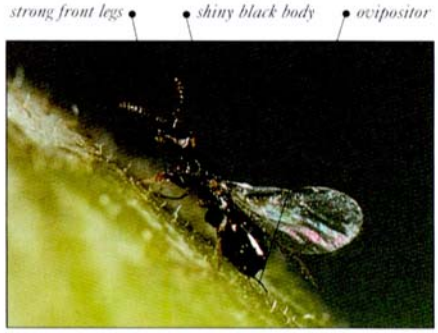
• **OCCURRENCE** Worldwide, in tropical, subtropical, and warm temperate regions. Wherever fig trees grow.

• **REMARK** Some species are parasites, laying eggs inside the larvae of other pollinating fig wasps. Recent research, however, puts some of these parasites in other families.

LARVAE are small, pale, and grublike. They develop inside figs.



CERATOSOLEN MEGACEPHALUS is an African fig wasp. The female is shown here, in the process of laying her eggs inside a fig. She has lost her wings and the ends of her antennae in the struggle to enter the fig.



BLASTOPHAGA PSENES is found all over the world. It pollinates *Ficus carica*, the common fig. A female is shown here, sitting on the outside of a fig. There are ten times more females than males.

***SYCOSCAPTER* SPECIES** are parasitic fig wasps, found in Africa. Recent DNA analysis suggests that these wasps might actually belong to the family Pteromalidae (see p.201).

Length 1/32–1/8in (1–3mm)	Larval feeding habits

Order HYMENOPTERA	Family BRACONIDAE	No. of species 25,000

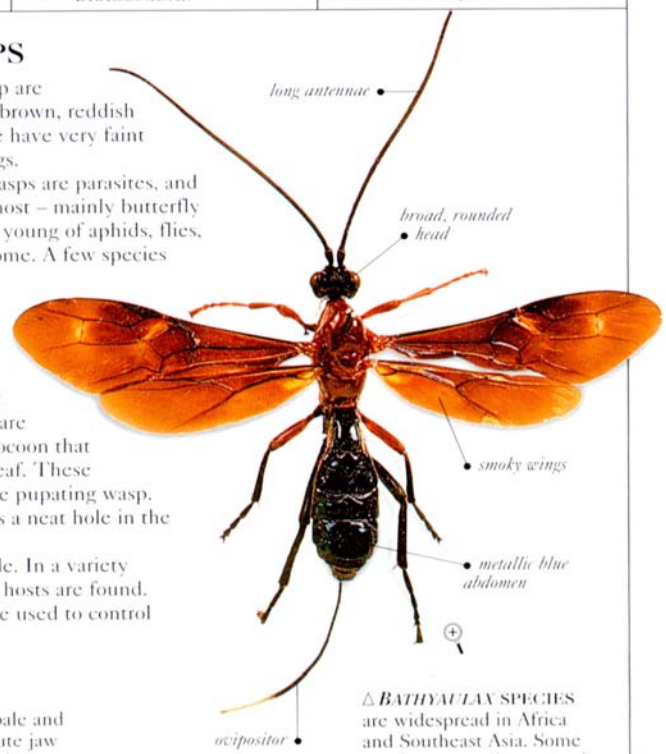
BRACONID WASPS

Most species of braconid wasp are small and inconspicuous, and brown, reddish brown, or black in color. Some have very faint patterns of veins on their wings.

• **LIFE CYCLE** Braconid wasps are parasites, and each species uses a different host – mainly butterfly and moth caterpillars, but the young of aphids, flies, or other insects are used by some. A few species are hyperparasitoids. Females lay eggs on or inside the host. If the host is large, there may be enough food for hundreds of wasp larvae to develop inside. Larvae that develop inside aphids, which are found on foliage, spin a silk cocoon that sticks the host's body to the leaf. These mummified aphids contain the pupating wasp. The emerging adult wasp cuts a neat hole in the corpse and flies off.

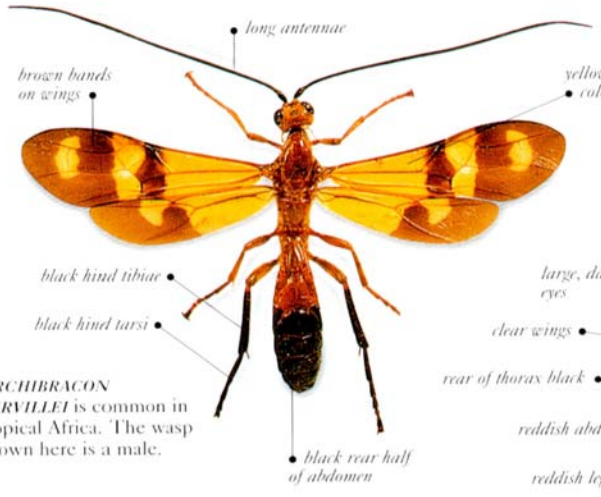
• **OCCURRENCE** Worldwide. In a variety of habitats, wherever suitable hosts are found.

• **REMARK** Many species are used to control populations of insect pests.



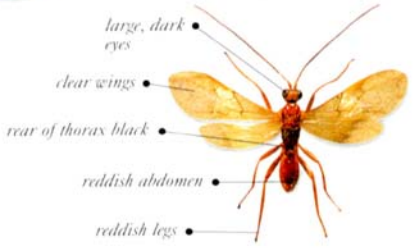
△ *BATHYAULAX* SPECIES are widespread in Africa and Southeast Asia. Some species are used to control caterpillars that attack cereal crops.

LARVAE are pale and grublike. Minute jaw details are used to distinguish species.



ARCHIBRACON SERVILLEI is common in tropical Africa. The wasp shown here is a male.

▽ *PYGOSTOLUS STICTICUS* is one of five similar species in the genus found in the Northern Hemisphere, where they attack weevils.



Length 1/16–5/8in (0.2–1.6cm), most under 9/32in (0.7cm)	Larval feeding habits

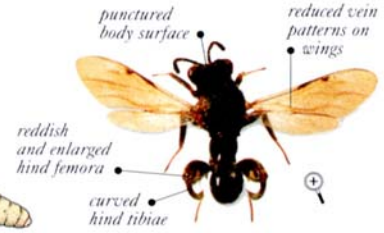
Order HYMENOPTERA	Family CHALCIDIDAE	No. of species 1,800

CHALCID WASPS

Most chalcid wasps are dark brown, black, red, or yellow. The body may have sculpturing or pits and occasionally has a metallic sheen. The first hindleg segment is large, and the hind femora are greatly enlarged and toothed underneath. Females have a short, inconspicuous ovipositor.

• **LIFE CYCLE** Eggs are laid inside the larvae and pupae of other insects. Some species are hyperparasitoids.

• **OCCURRENCE** Worldwide. In various habitats, wherever suitable hosts are found.



LARVAE are white and grub-like and have small heads.

CHALCIS SISPES is native to parts of Europe and Asia. Its larvae parasitize the larvae of soldier flies (see p.152).

Length 1/16–5/8in (0.2–1.5cm), most under 5/16in (0.8cm) | Larval feeding habits

Order HYMENOPTERA	Family CYNIPIDAE	No. of species 1,250

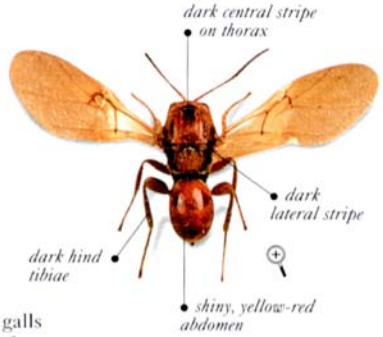
GALL WASPS

These wasps are shiny red-brown or black and usually have fully developed wings. The thorax has a humped appearance, and the abdomen of the female is flat.

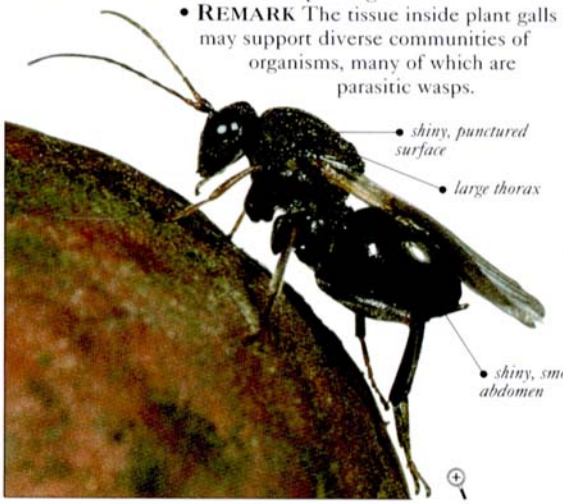
• **LIFE CYCLE** The female lays her eggs inside the tissue of oak species or other woody plants. This induces the host plant to develop a swollen gall that protects and nourishes the developing larvae. Galls vary enormously in size, color, texture, and location and may contain one or more developing larvae.

• **OCCURRENCE** Worldwide, mostly in the Northern Hemisphere. In a variety of habitats, wherever suitable host trees and plants grow.

• **REMARK** The tissue inside plant galls may support diverse communities of organisms, many of which are parasitic wasps.



ANDRICUS QUERCUSRADICIS is a widespread European wasp that uses many different oak species as its hosts.



◁ ***ANDRICUS* SPECIES** are widespread in Europe. Many are very similar to each other in appearance.

LARVAE are pale, grub-like, smooth, and often taper toward the rear.

Length 1/32–11/32in (1–9mm) | Larval feeding habits

Order HYMENOPTERA | Family ENCYRTIDAE | No. of species 3,800

ENCYRTID WASPS

This large family is quite variable, especially in the appearance of the head and antennae. Most of these small species are robust, slender, or slightly flat. They can be orange, red, or brown, often with a metallic sheen. The thorax is convex, and the middle legs, which are used for jumping, have a large, curved tibial spur.

• **LIFE CYCLE** The females of most species locate and lay eggs in the nymphs and adults of other insects – generally scale insects, mealybugs, aphids, and whiteflies. Some, however, specialize in parasitizing caterpillars or weevil grubs. A few are hyperparasitoids. Sometimes the eggs divide repeatedly to produce anything from 10 to 2,000 larvae, depending on the size of the host. Pupation occurs inside the host's body.

• **OCCURRENCE** Worldwide. In a wide variety of habitats, wherever hosts are found.

• **REMARK** These wasps are among the most important biological control agents, and many species have been used against serious crop pests. *Copidosoma koehleri*, for example, is used to control the Potato Tuber Moth in India.

***COPIDOSOMA* SPECIES** is found in parts of Europe and Asia. Their hosts are various moth species, including those belonging to the family Noctuidae (see p.165).

LARVAE vary, but may be pale and taper evenly toward the rear.

Length 1/64–5/32in (0.5–4.5mm), most 1/32–1/16in (1–2mm) | Larval feeding habits

Order HYMENOPTERA | Family EULOPHIDAE | No. of species 3,400

EULOPHID WASPS

These small wasps vary from elongate to stout. The body is soft, and the antennae have fewer than ten segments. They may be yellow, brown, or black, sometimes with a metallic sheen.

• **LIFE CYCLE** The females of most species hunt for the larvae of leaf-miners and gall-formers in which to lay their eggs, but some attack the larvae or pupae of moths, beetles, flies, and bugs. Certain small species even use the eggs of insects as hosts, and a few are hyperparasitoids. The developing wasp larva consumes the host and pupates.

• **OCCURRENCE** Worldwide. In a wide variety of habitats, wherever hosts are found.

• **REMARK** Eulophid wasps destroy various insect pests, and many are used for specific biological control programs.

LARVAE are often pale and grublike with small heads and stout bodies.

TETRASTICUS GALACTOPUS is a hyperparasitoid. It attacks the larvae of the parasitic wasp *Cotesia glomeratus*, which itself is found inside the body of its own host – the Cabbage White Butterfly.

Length 1/64–1/16in (0.5–5mm), most 1/32–1/8in (1–3mm) | Larval feeding habits

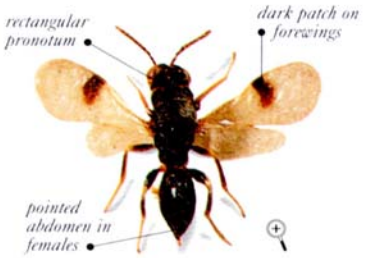
Order HYMENOPTERA	Family EURYTOMIDAE	No. of species 1,400

EURYTOMID WASPS

These wasps are yellow, reddish, or dull black. A few have a metallic sheen. They look similar to chalcid wasps (see p.196), but the hind coxae are never very enlarged and the femora do not have projections.

• **LIFE CYCLE** Many of these wasps lay eggs inside seeds, where their larvae develop. Some are leaf-miners or gall-formers. Others develop as parasitoids inside beetle, wasp, or fly larvae, and the smaller species attack the eggs of grasshoppers or certain bugs. A few species have a mixed feeding strategy, parasitizing gall-forming insects initially and then, as the larvae grow bigger, eating the gall tissue.

• **OCCURRENCE** Worldwide. In a variety of habitats.



SYCOPHILA BIGUTTATA develops inside galls made by gall wasps on oak trees. The larvae of this species are parasitic on the gall-former.

EURYTOMA BRUNNIVENTRIS is linked with certain gall-forming wasps. Its larvae may parasitize the wasps or other insects inside the gall. They may also eat gall tissue.

LARVAE are tiny, white, and grub-like. Some have quite long hairs.

Length 1/16–1/4in (2–6mm)	Larval feeding habits

Order HYMENOPTERA	Family GASTERUPTIIDAE	No. of species 500

GASTERUPTIID WASPS

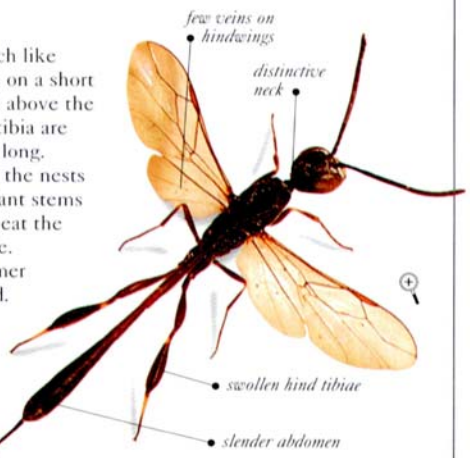
These slender, dark-colored wasps look very much like ichneumons (see opposite), but the head is borne on a short neck, and the slim abdomen joins the thorax well above the hind coxae. The hindlegs are long, and the hind tibia are swollen at their ends. The ovipositor can be very long.

• **LIFE CYCLE** After mating, females seek out the nests of solitary bees or wasps in sandy soil or inside plant stems or wood. Eggs are laid in the nest, and the larvae eat the eggs and the food store left for the host bee larvae.

• **OCCURRENCE** Worldwide, especially in warmer areas. In various habitats, wherever hosts are found.

• **REMARK** Gasteruptiids have a distinctive hovering flight, with their hindlegs dangling below the body.

LARVAE can be quite hairy, and the mandibles have three teeth.



GASTERUPTION **SPECIES** are often seen feeding at flowers in the sunshine.

Length 1/2–1 1/4in (1.2–2.8cm)	Larval feeding habits

Order HYMENOPTERA	Family ICHNEUMONIDAE	No. of species 60,000

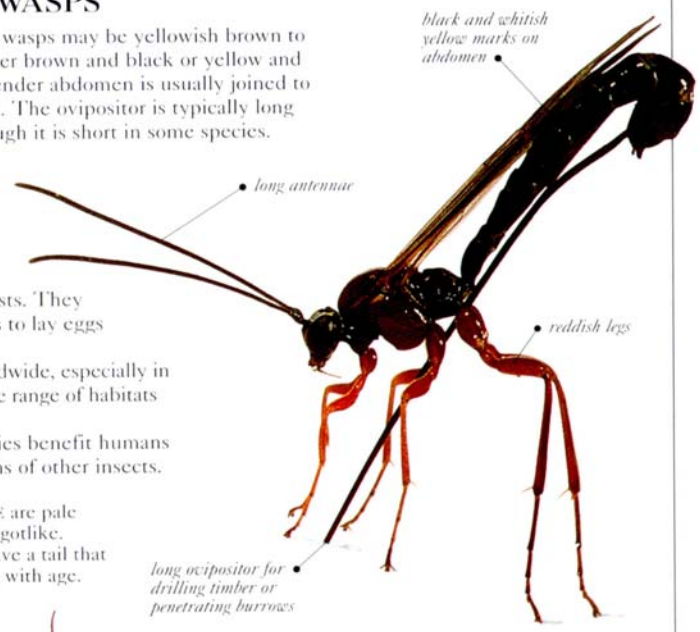
ICHNEUMON WASPS

These generally slender wasps may be yellowish brown to black, and may have either brown and black or yellow and black patterning. The slender abdomen is usually joined to the thorax by a thin stalk. The ovipositor is typically long and clearly visible, although it is short in some species.

• **LIFE CYCLE** Females mainly attack the larvae and pupae of insects such as beetles, flies, moths, sawflies, and other wasps. Some species use spiders as hosts. They use their long ovipositors to lay eggs on or inside the host.

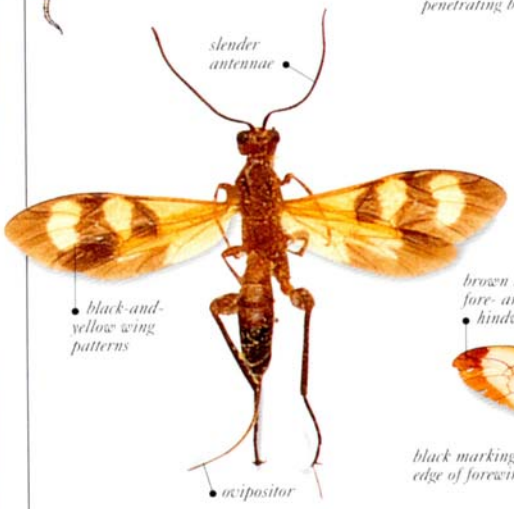
• **OCCURRENCE** Worldwide, especially in temperate areas. In a wide range of habitats where hosts occur.

• **REMARK** Many species benefit humans by controlling populations of other insects.

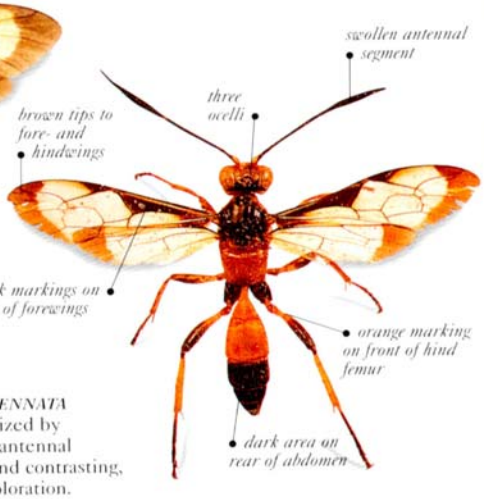


LARVAE are pale and maggotlike. Some have a tail that shortens with age.

△ ***RHYSSA PERSUASORIA*** is a large ichneumon wasp that parasitizes the larvae of horntail wasps (see p.205) as they feed inside timber.



PARACOLLYRIA **SPECIES** are native to Africa. Their bright, waspike coloring is a warning to predators and is mimicked by other insects.



JOPPA ANTENNATA is characterized by its swollen antennal segments and contrasting, wasplike coloration.

Length 1/8–1½in (0.3–4.2cm)	Larval feeding habits

Order HYMENOPTERA	Family MYMARIDAE	No. of species 1,400

FAIRYFLIES

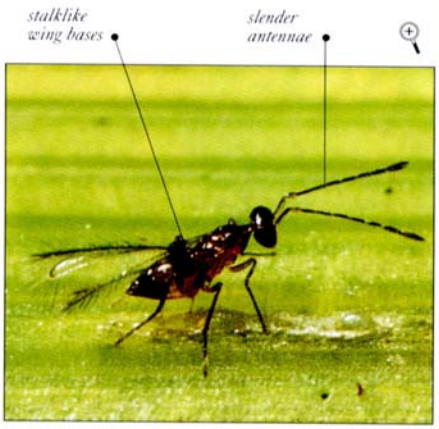
This family includes the world's smallest flying insects. They are dark brown, black, or yellow in coloration, but are never metallic. The narrow forewings lack any conspicuous vein pattern but have a distinctive fringe of hairs. The stalked and straplike hindwings are also fringed with minute hairs.

• **LIFE CYCLE** The females of all species parasitize the eggs of other insects. Most specialize on the eggs of plant-hoppers and other bug families, but the eggs of a range of other insects are also used as hosts.

• **OCCURRENCE** Worldwide. In a wide variety of habitats, wherever hosts are found.

• **REMARK** Several species have been used to control insect pests.

LARVAE are tiny and tailed at first, and grublike at a later stage.



ANAGRUS OPTABILIS is a specialist parasitoid of the eggs of certain plant-hoppers (the family Delphacidae). Related species have been used to control plant-hoppers that attack rice crops.

Length 1/128–3/16in (0.2–5mm), most 1/64–1/16in (0.5–1.5mm)	Larval feeding habits

Order HYMENOPTERA	Family PROCTOTRUPIDAE	No. of species 500

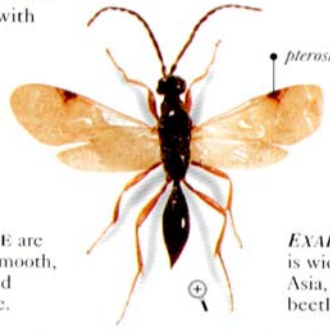
PROCTOTRUPIDS

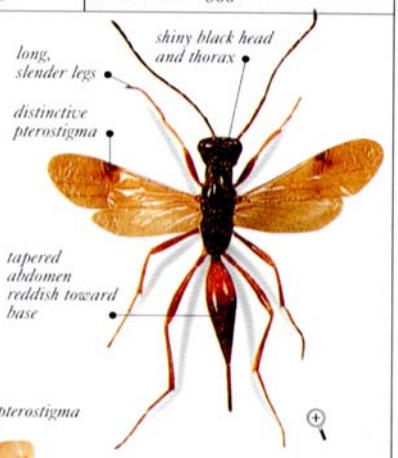
Most of the species in this family are either very dark or black in color and smooth-surfaced. The abdomen tapers at both ends and is often paler than the thorax and head. There is a conspicuous pterostigma on the relatively large forewings.

• **LIFE CYCLE** Females seek out the larvae of beetles, and sometimes of gall midges, that live in leaf litter or decaying wood and lay eggs inside them. When fully grown, the larva chews a hole through the membrane between two abdominal segments of its host and emerges almost completely. It pupates with its rear end still in contact with the host's remains.

• **OCCURRENCE** Worldwide. In woodland and a range of moist habitats.

LARVAE are small, smooth, pale, and grublike.





△ *PROCTOTRUPES GRAVIDATOR* occurs throughout the Northern Hemisphere and in parts of Southeast Asia. It parasitizes ground-beetle larvae (see p.112).

EXALLONYX LONGICORNIS is widespread in Europe and Asia, where it parasitizes rove-beetle larvae (see p.130).

Length 1/8–3/8in (0.3–1cm), most under 5/16in (0.8cm)	Larval feeding habits

Order HYMENOPTERA	Family PTEROMALIDAE	No. of species 4,000

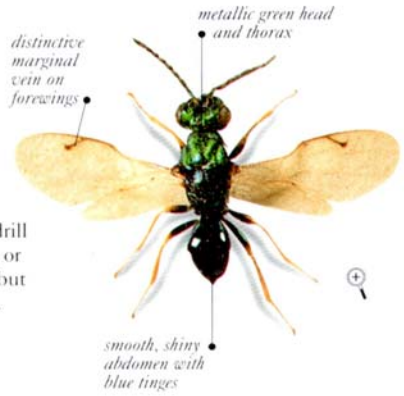
PTEROMALID WASPS

Most of these slim to quite robust wasps are black, metallic blue, metallic green, or green- or yellow-brown. The thorax is often dimpled. Viewed from the side, the smooth abdomen is frequently triangular in females and oblong in males.

• **LIFE CYCLE** Pteromalids have quite varied life cycles. The larvae may be endo- or ectoparasitoids or hyperparasitoids. Most species use the larvae or pupae of flies, beetles, wasps, fleas, butterflies, and moths as hosts. Females may have to drill through plant tissue to reach gall-forming, leaf-mining, or stem-boring hosts. Some species lay just a single egg, but others lay hundreds of eggs if the host is large enough.

• **OCCURRENCE** Worldwide. In a wide variety of habitats, wherever hosts are found.

• **REMARK** Some species are used to control populations of harmful crop pests.



LARVAE are pale and grublike, with a small head. Some have small bumps on the upper or lower body surface.

***PTEROMALUS* SPECIES** are common parasitoids. Their larvae develop inside the larvae and pupae of a wide range of insects.

Length 1/32–1/16in (1–8mm), most under 1/16in (5mm)	Larval feeding habits

Order HYMENOPTERA	Family SCELIONIDAE	No. of species 3,000

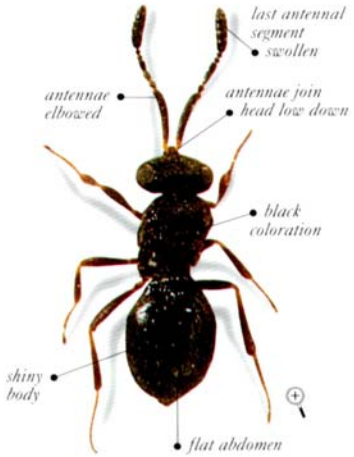
SCELIONID WASPS

These wasps are typically black, although they may be yellow or brown. The body shape varies from quite slender to quite robust, and the abdomen is generally flat, with sharply angled side margins.

• **LIFE CYCLE** The females of most species lay eggs in the eggs of other insects, especially those belonging to the orders Lepidoptera, Hemiptera, Coleoptera, and Orthoptera. Some species hang on to a host insect until it lays its eggs. To prevent another wasp laying eggs in an egg that they have parasitized, females mark a host's egg with an odor. The hatched scelionid larva feeds on the tissues of the host's eggs and pupates inside.

• **OCCURRENCE** Worldwide. Widespread in many habitats, but especially common in open grassland. Some are specialist parasites of mantids and grasshoppers in semiarid areas and deserts.

• **REMARK** These wasps are parasitic on some crop pests, and several species have been used in pest-control programs.



LARVAE are pale and grublike, with a flat rear. The head is often withdrawn into the thorax.

TRIMORUS PEDESTRE is found in Europe and Asia. Both sexes are wingless. This species has no reason to fly because it parasitizes the eggs of ground-living beetles.

Length 1/64–3/8in (0.05–1cm), most under 1/8in (3mm)	Larval feeding habits

Order HYMENOPTERA | Family TORYMIDAE | No. of species 1,250

TORYMID WASPS

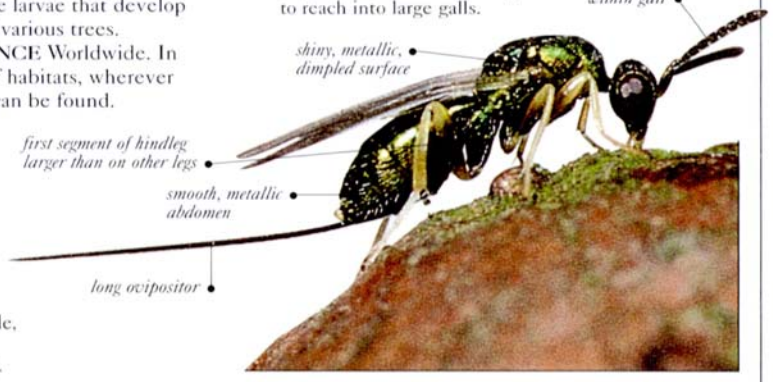
These wasps are usually elongate in shape, with metallic blue or green coloration. The thorax has dimples, while the abdomen is smooth.

• **LIFE CYCLE** Most species parasitize gall-forming flies and gall-wasps. In some cases, females use their ovipositors to drill through gall tissue and lay eggs on the host larvae inside. Other species parasitize caterpillars, mantid egg cases, and the larvae of some bees and wasps. Herbivorous species produce larvae that develop in the seeds of various trees.

• **OCCURRENCE** Worldwide. In a wide range of habitats, wherever suitable hosts can be found.

MEGASTIGMUS DORSALIS is closely related to species whose larvae develop inside seeds but is itself a parasite of gall-forming insects.

▽ ***TORYMUS* SPECIES** include many wasps that seek out larvae inside gall tissue. The ovipositor is often very long, to reach into large galls.



LARVAE are pale, grublike, and frequently hairy.

Length ⅛₂–⅜in (0.1–1.4cm), most under ⅛in (0.5cm) | Larval feeding habits

Order HYMENOPTERA | Family TRICHOGRAMMATIDAE | No. of species 600

TRICHOGRAMMATID WASPS

Because they are so small, these wasps are often overlooked. Most species are pale and fairly stout bodied. The veinless wings have small hairs forming distinctive lines across the surface and a fringe around the edge.

• **LIFE CYCLE** Eggs are laid inside the eggs of many other insects. Larval development and pupation can take as little as three days.

• **OCCURRENCE** Worldwide. In a wide range of habitats, anywhere that insect eggs can be found – usually exposed, on foliage.

LARVAE are pale, featureless, minute grubs, found inside host eggs.

TRICHOGRAMMA SEMBLIDIS, like other related species, has been used to control many butterfly and moth pests worldwide. Here, the eggs being parasitized are those of the alderfly (*Sialis lutaria*).

Length ¹/₂₅–½in (0.3–1.2mm) | Larval feeding habits

Order HYMENOPTERA | Family ARGIDAE | No. of species 800

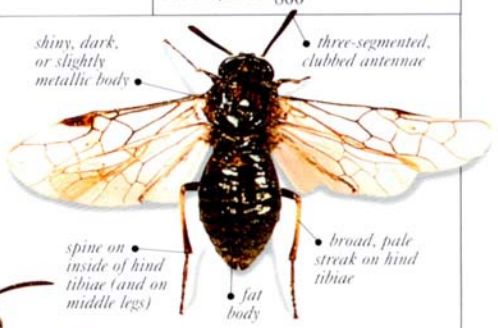
ARGIDS

These stout sawflies (rose sawflies) are typically black and red or yellow. Some have a metallic sheen. The last of the three antennal segments is long and in some males is V- or Y-shaped.

• **LIFE CYCLE** Eggs are laid in the tissue of trees and shrubs, and most larvae feed externally on the foliage. Pupation occurs in a silk cocoon.

• **OCCURRENCE** Worldwide, especially in tropical and warm, temperate regions. Wherever suitable host plants and trees occur.

• **REMARK** A few species are pests of roses and apple trees.



△ *ARGE CILIARIS*, a European sawfly, is one of about 200 species in its genus worldwide. Its larvae eat the leaves of meadowsweet plants.

ARGE PAGANA is also known as the Rose Sawfly, as these plants are its favored hosts. It is common across Europe and Asia, as far as Japan.

LARVAE look very similar to caterpillars.

Length ½–⅝in (0.4–1.6cm) | Larval feeding habits

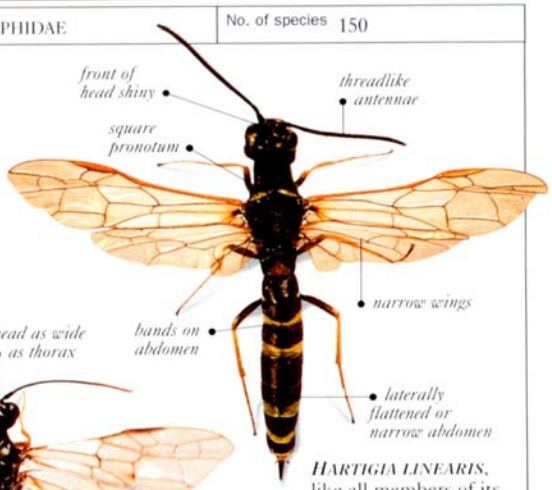
Order HYMENOPTERA | Family CEPHIDAE | No. of species 150

STEM SAWFLIES

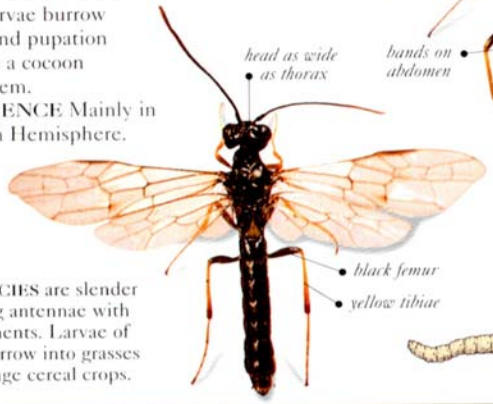
These sawflies are slim and elongate. Many species are black in color, with yellowish thoracic markings and abdominal bands.

• **LIFE CYCLE** Typically, single eggs are deposited inside the stems of host grasses, shrubs, and trees. The larvae burrow downward, and pupation occurs inside a cocoon within the stem.

• **OCCURRENCE** Mainly in the Northern Hemisphere. In pastures, meadows, and cereal crops.



HARTIGIA LINEARIS, like all members of its genus, bores into the stems of rose plants.



***CEPHUS* SPECIES** are slender and have long antennae with 16 to 30 segments. Larvae of all species burrow into grasses and can damage cereal crops.

LARVAE are slender grubs with rudimentary thoracic legs and no abdominal prolegs.

Length ½–1in (0.4–2.6cm), most under ⅜in (1.4cm) | Larval feeding habits

Order HYMENOPTERA | Family CIMBICIDAE | No. of species 150

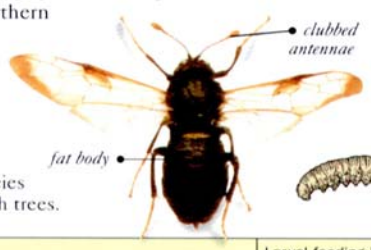
CIMBICID SAWFLIES

These large sawflies may resemble hairless bees. Many are fat-bodied, with slightly flat abdomens. Most are black or yellowish and black. The antennae have fewer than seven segments, and the last one is swollen.

• **LIFE CYCLE** Eggs are laid in host plants. Larvae feed externally on foliage, and pupation takes place in a cocoon.

• **OCCURRENCE** Northern Hemisphere, South America, and eastern Asia. Wherever host plants are found.

△ ***PACHYLOSTICA VIOLA*** is found only in South America, where its larvae probably eat tree foliage.



CIMBEX FEMORATUS is a heavy-bodied British species whose larvae feed on birch trees.

LARVAE are slightly curved, with thoracic legs and abdominal prolegs.

Length ¼–1¼in (2–3cm) | Larval feeding habits

Order HYMENOPTERA | Family PAMPHILIIDAE | No. of species 200

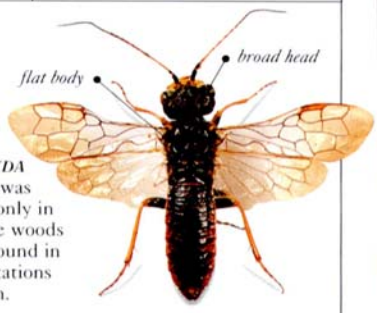
LEAF-ROLLING SAWFLIES

These sawflies have a broad head and a flat body. Most species are strongly built and are black with yellow markings.

• **LIFE CYCLE** Eggs are laid in plant tissue. The larvae feed under silk webs or in foliage, singly or in groups.

• **OCCURRENCE** Northern Hemisphere. In trees and shrubs in a variety of habitats.

LARVAE do not have abdominal prolegs.



ACANTHOLYDA POSTICALIS was once found only in Scottish pine woods but is now found in conifer plantations further south.

Length ⅛–⅜in (1–1.5cm) | Larval feeding habits

Order HYMENOPTERA | Family PERGIDAE | No. of species 350

PERGID SAWFLIES

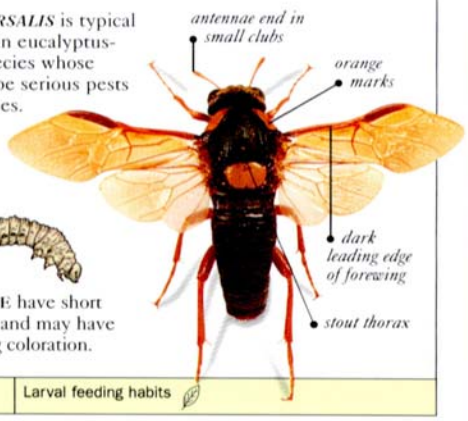
These fairly robust species have a rounded abdomen. The antennae may be simple, branched, or sawlike.

• **LIFE CYCLE** Eggs are laid in plant tissue. The larvae typically feed in groups on foliage. They can produce chemicals to repel predators.

• **OCCURRENCE** Southern Hemisphere, except Africa. Wherever host trees, especially eucalyptus, occur.

• **REMARK** Several species in Australia are pests in eucalyptus forests and can cause total defoliation.

PERGA DORSALIS is typical of Australian eucalyptus-feeding species whose larvae can be serious pests of these trees.



LARVAE have short prolegs and may have warning coloration.

Length 1/32–1in (0.4–2.5cm) | Larval feeding habits

Order HYMENOPTERA	Family SIRICIDAE	No. of species 100

HORNTAILS

Also known as wood wasps, these large sawflies are reddish brown, black and yellow, or metallic blue-purple. The common name refers to a spine at the end of the abdomen.

• **LIFE CYCLE** The females drill into the wood of live or fallen trees to lay one egg at a time and infect the tree with a rot-producing fungus. The larvae burrow into heartwood and eat the fungus and the wood. Pupation occurs in a cocoon of silk and chewed wood.

• **OCCURRENCE** Worldwide. In coniferous and deciduous woodland.

△ ***TREMEX COLUMBA*** is a widespread North American species. Its larvae usually burrow into the wood of maple and oak trees.

LARVAE are slow to develop. They have very short thoracic legs and no prolegs on the abdomen.

△ ***SIREX NOCTILIO*** is found in the Northern Hemisphere. Its larvae burrow into coniferous trees. The female is shown here – males are less metallic and have an orange-red abdomen.

▽ ***UROCERUS GIGAS***, the Common Horntail or Giant Woodwasp, may look dangerous but is actually harmless. Females are often seen, but males are more elusive.

Length ¼–1½in (2–4cm)	Larval feeding habits

Order HYMENOPTERA	Family TENTHREDINIDAE	No. of species 6,000

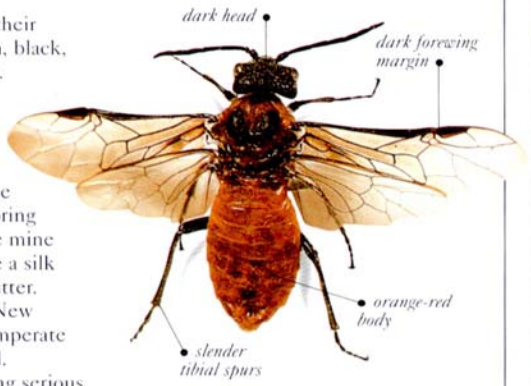
COMMON SAWFLIES

These sawflies are highly variable in both their appearance and habits. They may be brown, black, or green, brightly colored, or even wasplike. The sexes may be differently colored.

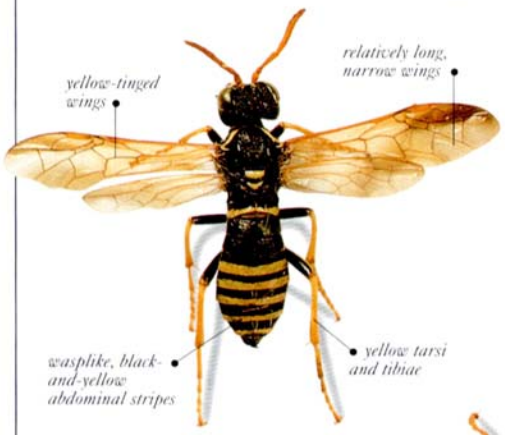
• **LIFE CYCLE** Females use their ovipositor to cut slits in the leaves, twigs, and shoots of host plants and lay eggs inside. The larvae feed on the outside of the plants and are solitary with camouflage coloring or gregarious with warning coloration. Some mine leaves or make galls. Pupation occurs inside a silk cocoon, either under the ground or in leaf litter.

• **OCCURRENCE** Worldwide, except in New Zealand, especially in northern and cool temperate regions. In gardens, pastures, and woodland.

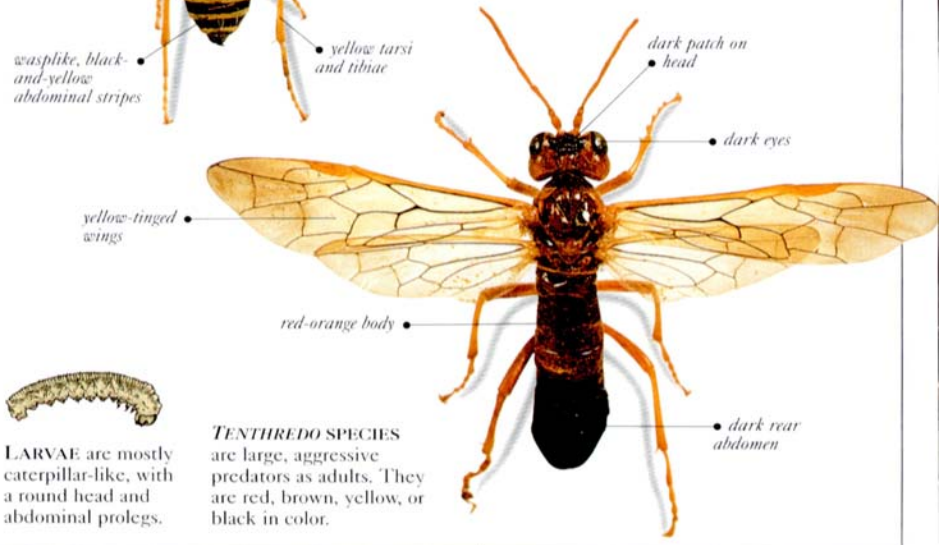
• **REMARK** Many species are pests, causing serious damage to fruit and vegetable crops and forest trees.



△ ***DOLERUS TRIPLICATUS*** is a European species. Its larvae feed on the foliage of rushes that belong to the genus *Juncus*.



◁ ***TENTHREDO SCROPHULARIAE*** is a wasp-mimicking species, found in Europe and Asia. Its larvae feed on mullein and figwort plants.



LARVAE are mostly caterpillar-like, with a round head and abdominal prolegs.

***TENTHREDO* SPECIES** are large, aggressive predators as adults. They are red, brown, yellow, or black in color.

Length ⅛–⅞in (0.3–2.2cm), most under ⅝in (1.6cm)	Larval feeding habits

NONINSECT HEXAPODS

SPRINGTAILS

COMMONLY KNOWN as springtails, the order Collembola contains 18 families and 6,500 species. These small hexapods have a structure called a ventral tube on the underside of the abdomen. This is important in maintaining a salt and water balance and, in some species, for gripping smooth surfaces. Another feature is the jumping organ (furcula), which can be folded under the abdomen, where it engages with a catch. Muscular action releasing the furcula can throw the springtail well out of the way of predators.

Males deposit sperm on the ground or place it into the female's genital opening. Adulthood is reached after 5 to 13 molts, but adults continue to molt until they die. Springtails are vital in leaf litter and soil chains, where hundreds of thousands may be found in one square meter.

Order COLLEMBOLA	Family ENTOMOBRYIDAE	No. of species 1,400

ENTOMOBRYIDS

These hexapods are pale to yellow, brown, or black in coloration. Some are patterned or mottled. They are elongate with a small pronotum, and in many the fourth abdominal segment is larger than the third segment. The antennae may be more than twice the body length.

• **LIFE CYCLE** Females lay their eggs either in soil or in leaf litter. All stages eat fungal threads or decaying plant matter.

• **OCCURRENCE** Worldwide. In leaf litter, soil, and fungi in a variety of habitats. Some are found in caves.

***ENTOMOBRYA* SPECIES** are commonly found on tree bark and rocks. Some species in this genus spend the whole of the winter on tree bark.

Length 1/32–3/16in (1–8mm), most under 1/4in (5mm)	Feeding habits

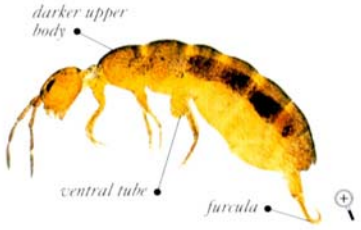
Order COLLEMBOLA	Family ISOTOMIDAE	No. of species 1,000

ISOTOMIDS

These springtails may be white, yellow, green, or brown in color, and the upper surface is usually darker than the underside. The segments of the abdomen are equal in size.

• **LIFE CYCLE** As in all springtails, males deposit rounded spermatophores on the ground, which the females take into their genital opening. A few isotomids are parthenogenetic.

• **OCCURRENCE** Worldwide. In soil in various habitats, but also around ponds and streams. A few species are abundant in harsh environments such as deserts, polar regions, and mountains.



ISOTOMA VIRIDIS is often abundant among damp leaf litter and moss clumps. The ventral tube and curved jumping organ are clearly visible on this specimen.

Length 1/32–3/16in (1–8mm), most under 1/4in (5mm)	Feeding habits

Order COLLEMBOLA	Family NEANURIDAE	No. of species 1,000

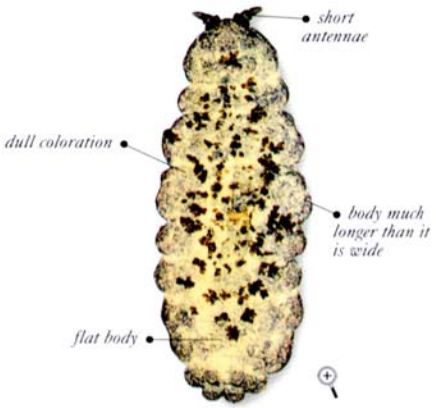
NEANURID SPRINGTAILS

The body of most species in this family is longer than it is wide, but some may be squat or even flat. Many species are blue, gray, or red in color, and a few have bands of contrasting colors. The body surface may be smooth or have blunt hairs or brightly colored, hairlike projections.

• **LIFE CYCLE** The eggs are laid in or under soil, leaf litter, dung, stones, rotting wood, and bark. The young look much like small adults, and molting continues after they have reached sexual maturity.

• **OCCURRENCE** Worldwide. In a variety of habitats, under stones and bark, in leaf litter, soil, dung, and decaying wood.

• **REMARK** The dark blue species *Anurida maritima* is extremely common on seashores in the Northern Hemisphere, where it eats the remains of dead arthropods and snails. It survives by hiding inside air pockets that form between rocks during high tide.



NEANURA MUSCORUM is found worldwide, especially in woodland, under rotting wood and in soil. It is also found in caves. This species is able to produce chemicals to deter predatory spiders.

Length 1/16–3/8in (0.2–1cm)	Feeding habits

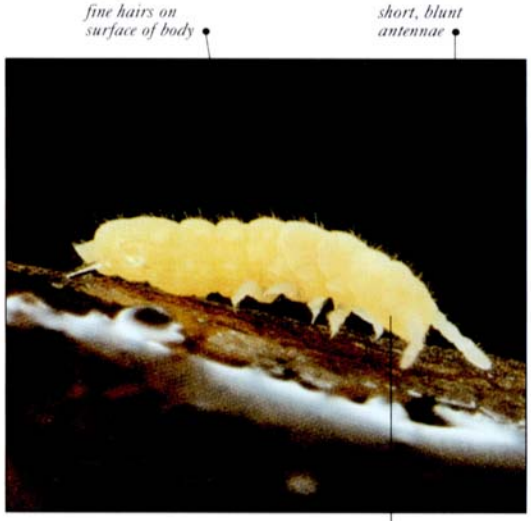
Order COLLEMBOLA	Family ONYCHIURIDAE	No. of species 600

BLIND SPRINGTAILS

Most members of this family are slender and pale or white. A few species have either blue-gray or slightly red coloration. As their common name suggests, the vast majority of blind springtails have no eyes. They do not have a furcula, although some species may have the vestigal remains of one. The body has a small number of thin-walled spots, or pores, on the cuticle of most segments, through which a noxious liquid can be secreted in order to deter predators.

• **LIFE CYCLE** Eggs are laid in soil, leaf litter, decaying wood, and fungi. The nymphs look like small adults, and molting continues after they become sexually mature.

• **OCCURRENCE** Worldwide. In forests and pastures, and in caves, alpine areas, and even the Arctic. In soil, leaf litter, rotting wood, and the fruiting bodies of fungi.



***ONYCHIURUS* SPECIES** are typical of the soil-dwelling springtails. Some species in this genus may be found in seashore habitats.

Length 1/16–1 1/2 (2–9mm), most under 1/2 (4mm)	Feeding habits

Order COLLEMBOLA	Family PODURIDAE	No. of species 1

THE WATER SPRINGTAIL

The single species in this family – *Podura aquatica* – is a very minute and common springtail. It varies in color from brown or red-brown to dark blue or black. Its furcula is extremely well adapted for life on the water. It is quite flat and long, reaching the abdominal ventral tube (which helps the springtail to grip the water surface).

• **LIFE CYCLE** This species spends much of its life scavenging on the surface of water. Its eggs are laid among vegetation found in and around bodies of water.

• **OCCURRENCE** Northern Hemisphere. On the surface of fresh water in ditches, ponds, canals, and boggy areas.

• **REMARK** The furcula is particularly long in this species because a large area of it must be in contact with the elastic film that exists on the surface of water for the Water Springtail to jump effectively.

PODURA AQUATICA is well adapted to life on water. It is even found in puddles, especially in summer, and may gather in such large numbers that the puddle appears dark in color, as if covered in soot.

Length Up to 1/16in (2mm)	Feeding habits

Order COLLEMBOLA	Family SMINTHURIDAE	No. of species 900

GLOBULAR SPRINGTAILS

Also known as garden springtails, these species are pale to dark brown or green in coloration, with spherical bodies. The segmentation on the abdomen is indistinct, and the antennae are noticeably long and elbowed. The males are often different in appearance to the females.

• **LIFE CYCLE** In many males, the antennae are designed to hold the female during mating. Eggs are laid in small batches in soil, and development to sexual maturity may take as little as one month. There is some evidence of maternal care.

• **OCCURRENCE** Worldwide. In a wide variety of habitats, on trees, in leaf litter, on the fruiting bodies of fungi, and on the surface of freshwater in ditches, bogs, and ponds. Also in damp places such as caves.

• **REMARK** Several species are significant pests of crop seedlings. *Sminthurus viridis*, which is commonly known as the Lucerne Flea, is a widespread pest of alfalfa and some vegetables – as many as 70,000 globular springtails have been recorded in just one square meter of pasture.

SMINTHURIDES AQUATICUS is widespread on the surface of ponds and stagnant water but does not gather in such large numbers as the Water Springtail (see above).

Length 1/32–1/8in (1–3mm)	Feeding habits

PROTURANS

MEMBERS OF THE ORDER Protura, which contains 4 families and 400 species, are soil-dwelling hexapods. The first specimens were discovered in 1907.

These tiny creatures have neither eyes nor antennae, although there is a pair of tiny patches on either side of the head that may be the vestiges of antennae. In place of antennae, the front pair of legs are used as sensory organs. The middle and hind pairs are used for walking. Like springtails (see pp.207–209) and diplurans (see p.211), proturans have piercing-sucking mouthparts that are contained inside a pouch and pushed out whenever the animal is feeding. The jaws are sharp and rodlike in appearance. The first three abdominal segments may have minute vestiges of leglike structures. There are no cerci.

During mating, sperm is transferred indirectly, with the male depositing a spermatophore on the ground that is picked up by the female's genitalia. When the larvae hatch out from the eggs, the abdomen has eight segments and a tail segment (telson). By the time they have molted three times, proturans have the full complement of eleven abdominal segments plus the telson. Another two molts are required before they become sexually mature.

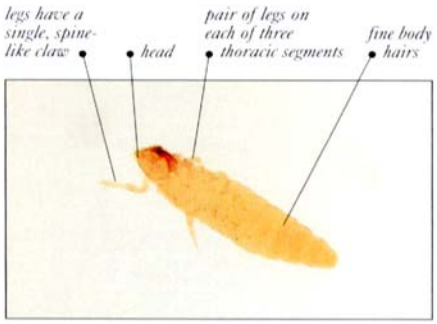
Order PROTURA	Family EOSENTOMIDAE	No. of species 90

EOSENTOMIDS

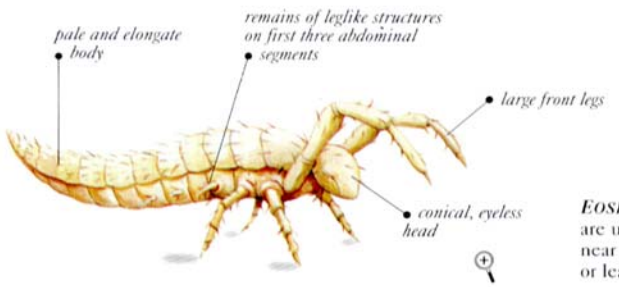
Pale and soft-bodied, these hexapods have a conical head and elongate body. The legs do not project far from the body, which allows easy passage through tiny cracks and crevices. The front legs are stouter than the middle and hindlegs and have numerous hairs and other sensory organs. Spiracles are visible on the middle and hind segments of the thorax.

• **LIFE CYCLE** The eggs are round and patterned or have raised warts, and are usually laid in soil or leaf litter. The larvae look much like small adults.

• **OCCURRENCE** Worldwide. In a variety of habitats, preferably in damp, cool conditions. Eosentomids occur in great numbers in soil, leaf litter, moss, humus, and decaying wood.



EOSENTOMON DELICATUM is native to Europe, and the genus as a whole is found all over the world. This species lives in soil, especially chalky soils.



***EOSENTOMON* SPECIES** are usually found living near the surface of soil or leaf litter.

Length ¼–⅛in (0.5–2mm)	Feeding habits

DIPLURANS

THERE ARE 9 FAMILIES AND 800 species in the order Diplura. Pale in color, these elongate, soft-bodied hexapods do not have eyes. They are sometimes called two-tailed bristletails, a name that refers to the two abdominal cerci, which may be long or pincerlike. They should not, however, be confused with the true bristletails (see p.46). The large head has long antennae and biting mouthparts contained within a pouch. Males deposit stalked spermatophores, which females take into their genital opening. Eggs are often laid in clumps, and females may guard their brood.

Diplurans live in rotting vegetation, compost heaps, and soil, and under stones and wood. With their slender, flexible bodies and strong legs, they can move through soil very easily.

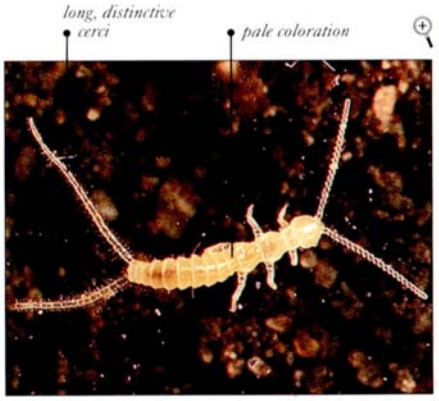
Order DIPLURA	Family CAMPODEIDAE	No. of species 200

CAMPODEIDS

These white or yellow-tinged diplurans have long, multisegmented cerci and supporting projections on the underside of their abdomen. Air is taken in through spiracles on the thorax.

• **LIFE CYCLE** Eggs are usually laid in soil. Initially immobile, larvae become progressively more active and look like small adults.

• **OCCURRENCE** Worldwide. Widespread in various habitats, including caves. They are very common deep in soil, but are also found under tree bark and in decaying wood and vegetation.



CAMPODEA FRAGILIS is a common European and Asian species, found in rotting vegetation.

Length 1/12–1/2in (0.4–1.2cm)	Feeding habits

Order DIPLURA	Family JAPYGIDAE	No. of species 200

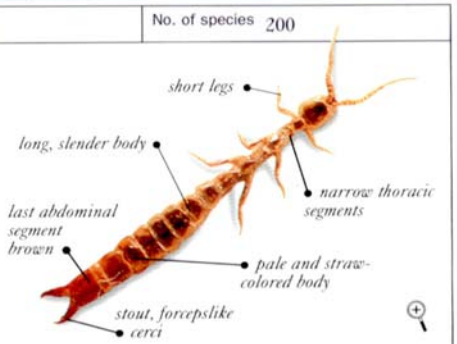
JAPYGIDS

These species are pale, slender, and flexible, with telescopic antennae that can be shortened as they make their way through soil. The cerci are dark, tough, and forceplike, similar to those of earwigs (see pp.69–70). Air is taken in through spiracles on the thorax and abdomen.

• **LIFE CYCLE** Eggs are usually laid in soil. The young become more like the adults at successive molts. The abdominal cerci are used to catch small arthropod prey.

• **OCCURRENCE** Worldwide. In various habitats, in crevices in soil.

• **REMARK** Japygids can be distinguished from young earwigs by their lack of eyes.



HOLJAPYX DIVERSIUNGUIS, or the Slender Dipluran, is native to North America. It is a common soil-dwelling species, approximately 1/16–3/8in (0.8–1cm) in length.

Length 1/4–1 1/4in (0.6–3cm)	Feeding habits

CRUSTACEANS

ISOPODS

THE ORDER ISOPODA consists of 100 families and 10,000 species of crustaceans. Most isopods are marine. However, 32 families (3,800 species) belong to a suborder called Oniscoidea and are amphibious or live in terrestrial habitats. They are known collectively as woodlice. Woodlice have a segmented, flat body with seven pairs of similarly shaped and sized legs. The female carries the eggs inside a brood pouch, which is located beneath the abdomen. The young are kept in this pouch for a while after they hatch out.

Most woodlice favor damp and cool conditions, although some have become adapted to a wide range of habitats, including extremely dry regions. Some woodlice have camouflage coloring that blends with their background.

Order ISOPODA	Family ARMADILLIDIIDAE	No. of species 250

PILL WOODLICE

Also called pill bugs, these woodlice are convex in cross section, with a rounded hind margin. Many can roll up into a ball for protection.

• **LIFE CYCLE** The eggs are carried in a brood pouch until they hatch. As in many woodlice, the newly hatched young have one less pair of legs than the adults. The mother may provide her young with some protection.

• **OCCURRENCE** Europe and the Mediterranean. In places such as leaf litter and debris.

ARMADILLIDIUM ALBUM is pale with dark markings and lives in salt marshes and coastal areas. It does not form as tight a ball as the pill millipede (see p.242) when it rolls up.

Length 1/16–1in (0.5–2.5cm)	Feeding habits

Order ISOPODA	Family PORCELLIONIDAE	No. of species 500

PORCELLIONIDS

The smooth or warty body surface of these woodlice is usually either gray or grayish brown, with various other markings. Some species of porcellionid have narrower bodies and are able to run quickly.

• **LIFE CYCLE** The females carry the eggs in their brood pouch until they hatch.

• **OCCURRENCE** Worldwide, but mainly in temperate regions. Found mostly in leaf litter and debris.

• **REMARK** As with all woodlice, nitrogenous wastes are excreted as ammonia gas – not as urine. This gives large colonies of woodlice a characteristic smell.

PORCELLIO SCABER is a widespread species. It is usually a grayish color, but orange and cream forms are often found in coastal regions.

Length 1/2–3/4in (0.9–2cm)	Feeding habits

ARACHNIDS

SCORPIONS

THE 9 FAMILIES AND 1,400 species of the order Scorpiones make up the most ancient group of all arachnids.

The cephalothorax carries four pairs of walking legs and large pedipalps with a pincerlike claw. There is a main pair of eyes situated centrally on the head and a variable number of pairs on the sides. The last segment of the mobile "tail" (telson) bears the sting and its poison gland, used to paralyze prey and for defense. The sting of some scorpions can be fatal to humans. Reproduction starts with complex courtship. After this, males deposit sperm on the ground that is picked up by the females' genitalia. Females bear live young that are carried on the mother's back until their first molt. Scorpions favor warm areas and hunt at night, hiding under stones by day.

Order SCORPIONES | Family BOTHRIURIDAE | No. of species 90

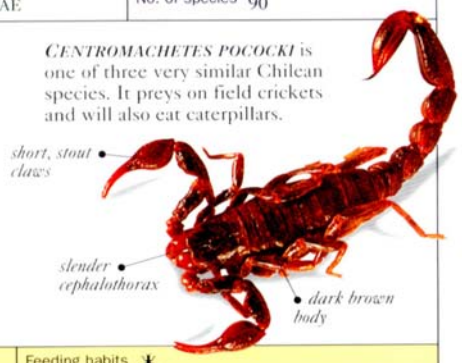
BOTHRIURIDS

These scorpions have a narrow cephalothorax. Unlike the members of some other scorpion families, their tibiae do not have spurs.

• **LIFE CYCLE** Courtship can be lengthy and may involve stinging. As in all scorpions, eggs hatch out inside the female's body. The young are born live and climb on to their mother's back.

• **OCCURRENCE** South America, Australia, Africa, and the Himalayas. In dry and humid areas, often in burrows dug under stones and boulders.

CENTROMACHETES POCOCKI is one of three very similar Chilean species. It preys on field crickets and will also eat caterpillars.



Length 1–4⅓in (2.5–12cm) | Feeding habits

Order SCORPIONES | Family BUTHIDAE | No. of species 520

BUTHIDS

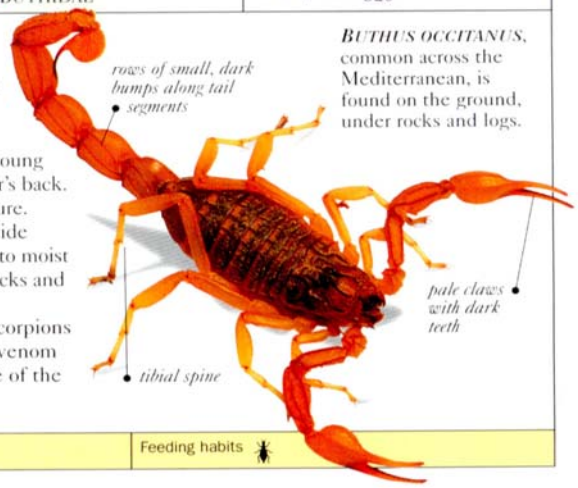
In these scorpions, the sternum of the cephalothorax is roughly triangular. Some legs have spines on the tibiae.

• **LIFE CYCLE** As in all scorpions, young are born live and climb onto the mother's back. Nymphs may take several years to mature.

• **OCCURRENCE** Worldwide. In a wide variety of habitats, ranging from desert to moist forest, where they are found in rock cracks and underneath stones, logs, and bark.

• **REMARK** Most of the dangerous scorpions belong to this family. Their powerful venom paralyzes the muscles, including those of the respiratory system and the heart.

BUTHUS OCCITANUS, common across the Mediterranean, is found on the ground, under rocks and logs.



Length 1/16–4⅓in (0.8–12cm) | Feeding habits

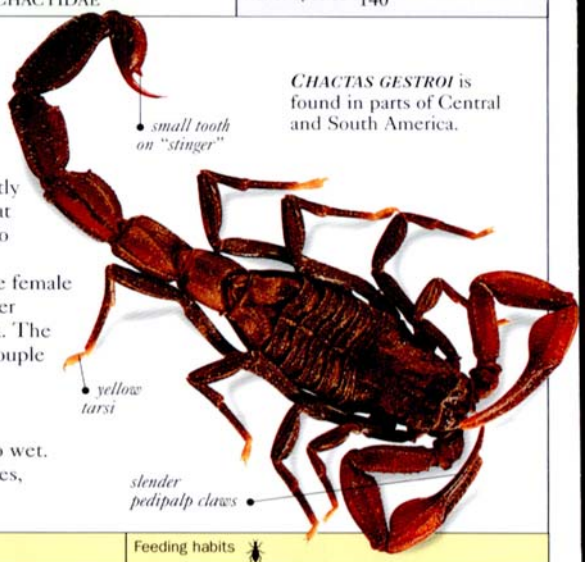
Order SCORPIONES	Family CHACTIDAE	No. of species 140

CHACTIDS

These species are not very robust and can be quite slender. The sternal plate on the underside may be five-sided and wider than it is long or long and narrow. Coloration is pale to dark brown or slightly yellow. Chactids are not generally good at digging but some burrow underground to avoid summer heat and drought.

• **LIFE CYCLE** As in all scorpions, the female produces live young that emerge from her genital opening and climb onto her back. The first stage of development lasts from a couple of days to two weeks.

• **OCCURRENCE** North and South America, Europe, and North Africa. In habitats that are neither too dry nor too wet. Among vegetation or under rocks, stones, and logs. Some species live in caves.



CHACTAS GESTROI is found in parts of Central and South America.

Length ⅛–3½in (1.5–9cm)	Feeding habits

Order SCORPIONES	Family SCORPIONIDAE	No. of species 130

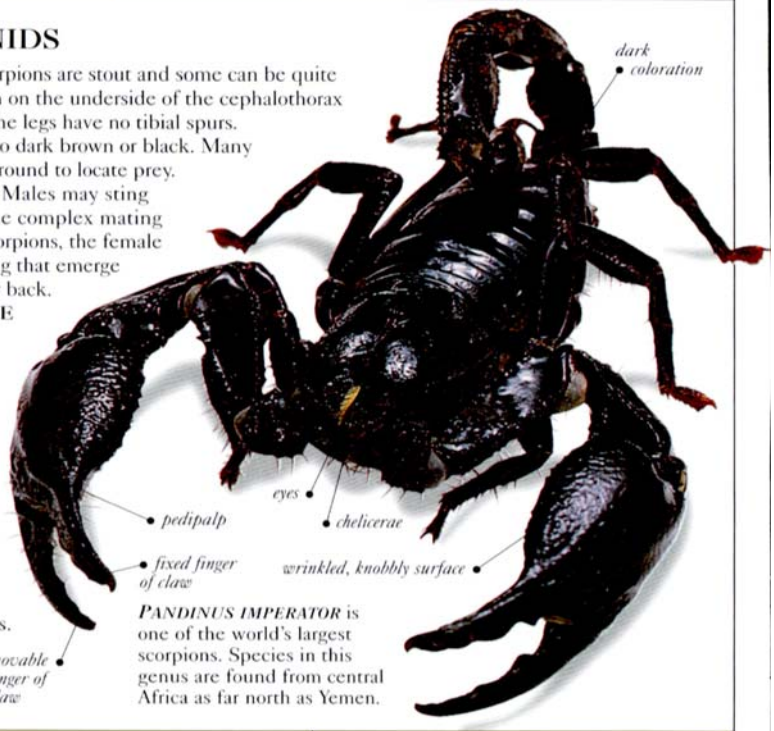
SCORPIONIDS

Many of these scorpions are stout and some can be quite large. The sternum on the underside of the cephalothorax is five-sided, and the legs have no tibial spurs. Coloration is pale to dark brown or black. Many species dig underground to locate prey.

• **LIFE CYCLE** Males may sting mates as part of the complex mating rituals. As in all scorpions, the female produces live young that emerge and climb onto her back.

• **OCCURRENCE** Africa, Asia, the Middle East, and Australia. In cracks, under stones and logs, and in caves and tree holes.

• **REMARK** Like all scorpions, they will sting only to subdue prey or to defend themselves.



PANDINUS IMPERATOR is one of the world's largest scorpions. Species in this genus are found from central Africa as far north as Yemen.

Length 2½–8¼in (6–21cm)	Feeding habits

PSEUDOSCORPIONS

THE ORDER Pseudoscorpiones is divided into 23 families and 3,300 species. Also called false scorpions, they are similar in general shape to true scorpions, but are very small and lack the abdominal tail and stinger of their larger relatives. The cephalothorax has a dorsal carapace, and the abdomen has 11 or 12 segments. Large, pincerlike pedipalps, which may be toothed, are used to catch prey and for defense, and the swollen parts of the pincers contain poison glands.

Males deposit sperm packets on the ground that are picked up by the females' genitalia. Eggs are laid into a pouch under the female's body. Pseudoscorpions make silk nests in which they molt, brood young, and hibernate. Most prefer moist or humid habitats – among leaf litter or under stones, for example.

Order PSEUDOSCORPIONES	Family CHELIFERIDAE	No. of species 300

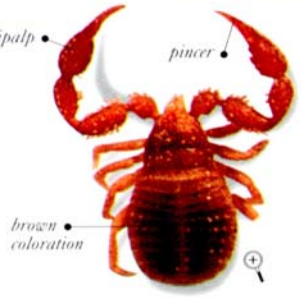
CHELIFERIDS

These pseudoscorpions have venom glands in both fingers of the pincers, and there are no teeth on the inner surfaces. They usually have two eyes. Coloration varies from pale to dark brown and black, in some cases tinged with red or olive, and with dark markings.

• **LIFE CYCLE** Mating can be complex and may involve males and females dancing together, holding each other's pedipalps. As in all species, eggs are kept in a sac beneath the female and there are three nymphal stages. Some first-stage nymphs stay with the mother.

• **OCCURRENCE** Worldwide, especially in warmer regions. In leaf litter and on tree bark.

• **REMARK** The species *Chelifer cancroides* is often found inside buildings.



***DACTYLOCHELIFER* SPECIES** are found in parts of the Northern Hemisphere. Some species are confined to coastal habitats.

Length 1/16–3/16in (1.5–5mm)	Feeding habits

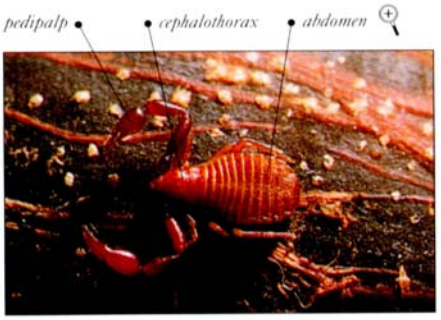
Order PSEUDOSCORPIONES	Family CHERNETIDAE	No. of species 600

CHERNETIDS

In this family, the fingers of the pincers have teeth, and a poison gland is present only in the movable finger. The eyes are either weakly developed or absent. Males may be different in appearance from the females. Chernetids are shiny and colored a variety of shades of brown.

• **LIFE CYCLE** Males and females engage in a courtship dance, gripping each other with their pedipalps. As in all other species, the eggs are kept inside a sac under the female. Newly hatched nymphs may cling to the sides of their mother. There are three nymphal stages.

• **OCCURRENCE** Worldwide. In leaf litter, debris, caves, and the nests and burrows of birds and small mammals.



***CHERNETID* SPECIES** are found in the Northern Hemisphere and in tropical regions of South America. The specimen shown here lives in caves in parts of Venezuela.

Length 1/16–3/16in (1.5–5mm)	Feeding habits

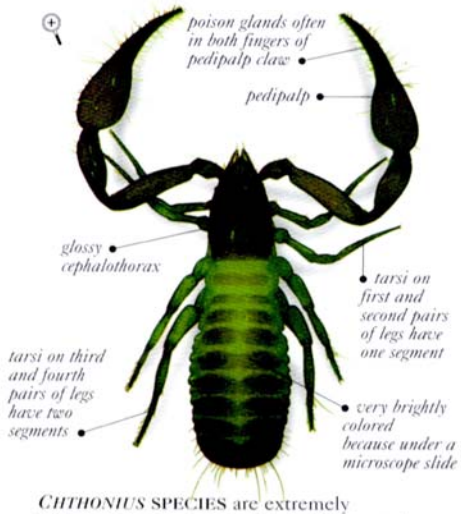
Order PSEUDOSCORPIONES	Family CHTHONIIDAE	No. of species 570

CHTHONIIDS

In these arachnids, the abdomen is typically much longer than the carapace, which in turn covers the dorsal surface of the rest of the body and may be broader at the front than at the rear. Most species have four eyes and large chelicerae. On the first two pairs of legs, the tarsi have a single segment, whereas those on the third and fourth pairs of legs have two segments. The overall coloration varies from shades of brown to olive-green, and the legs are tinged with pink.

• **LIFE CYCLE** Eggs are brooded inside the female's sac. The live young are usually released on to soil, leaf litter, or bark. There are three nymphal stages, as in all pseudoscorpions.

• **OCCURRENCE** Worldwide, except in the extreme north or south. In various sheltered places, among soil and leaf litter, and under tree bark. Others are found among seashore debris, in or near buildings, on wasteland, in caves, and in gardens and greenhouses.



***CHTHONIUS* SPECIES** are extremely widespread and are found in leaf litter, at the base of grasses, under stones, and in the nests of birds and small mammals.

Length 1/32–1/16in (1–2mm)	Feeding habits

Order PSEUDOSCORPIONES	Family NEOBISIIDAE	No. of species 500

NEOBISIIDS

The carapace of these pseudoscorpions is quite angular or square when seen from above, and the chelicerae are large. In all the pairs of walking legs, the tarsi are made up of two segments, and the claw of the pedipalp has a poison gland only in the fixed finger. There are usually four eyes, but there may be fewer, or none at all, in cave-living species. The overall coloring varies from olive shades to dark brown, perhaps with red, yellow, or cream tinges. The legs are often slightly green in color. Small items of prey are held and paralyzed with venom and are then shredded by the large chelicerae.

• **LIFE CYCLE** Eggs are carried by the female in her brood sac, and the live young are typically released onto soil, leaf litter, or bark. There are three nymphal stages.

• **OCCURRENCE** Worldwide, especially in the Northern Hemisphere. Many – typically smaller species – live in leaf litter and soil, and some are found in caves.

NEOBISIUM MARITIMUM is native to coastal areas of Ireland, England, and France. It is found in cracks in rocks and under stones, from the upper shore to the splash zone.

Length 1/32–1/16in (1–5mm)	Feeding habits

SUN-SPIDERS

DESPITE RESEMBLING SPIDERS and scorpions, the 12 families and 1,000 species of Solifugae form a separate order. Also called wind-scorpions, sun-spiders have a flexible abdomen that narrows where it joins the three-sectioned cephalothorax and a head that bears a pair of small eyes. All sun-spiders are predatory. They use huge, pincerlike chelicerae to kill and macerate their prey. The clawless, leglike pedipalps have suction pads that enable them to grasp small vertebrates and arthropods. Sun-spiders are equipped with many sensitive body hairs and organs at the bases of the last pair of walking legs.

Most species are found in Southeast Asia, Africa, and North America. Males push sperm into the female's genital opening, and eggs are laid in a burrow.

Order SOLIFUGAE | Family AMMOTRECHIDAE | No. of species 72

AMMOTRECHIDS

These relatively slender species are quite variable and may be colored in a range of shades of brown. The tarsi of the first pair of legs have no claws, and the front margin of the head is rounded. Many species are nocturnal, but some are active during the day. Nocturnal species typically dig into soil during the day, but some of the smaller species hide inside termite colonies or the tunnels of wood-boring insects.

• **LIFE CYCLE** The female lays her eggs, perhaps in several batches, in a burrow.

• **OCCURRENCE** Warmer regions of Central America, South America (as far as southern Argentina), and North America. In dry areas, semideserts, and deserts.

AMMOTRECHELLA STIMPSONI is native to Florida. This species is found underneath the bark of rotten trees and feeds on a variety of prey, including termites.

Length 1/32–1/4in (0.4–2cm) | Feeding habits

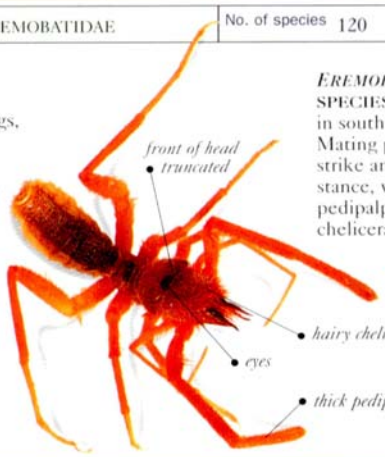
Order SOLIFUGAE | Family EREMOBATIDAE | No. of species 120

EREMOBATIDS

These species can be robust with short legs, or slender with long legs. The tarsi of the first three pairs of legs have one segment, whereas those of the fourth pair may have one to three segments. The front of the head looks square-cut. Coloration varies between light and dark brown.

• **LIFE CYCLE** Eggs are laid in burrows. The young are especially fond of termite prey.

• **OCCURRENCE** Warm, dry parts of Central America and southern North America. In dry areas, semideserts and deserts, and mountainous regions.



EREMOBATES SPECIES are common in southwestern US. Mating pairs initially strike an aggressive stance, with raised pedipalps and open chelicerae.

Length 1/16–1 1/2in (0.8–4cm) | Feeding habits

Order SOLIFUGAE	Family GALEODIDAE	No. of species 180

GALEODIDS

Members of this family have yellow, pale brown, red-tinged, or dark bodies. The tarsi on the first pair of legs have one segment, those on the second and third pairs have two segments, and those on the fourth pair have three segments. The claws on the last three pairs of legs are hairy. Galeodids hunt after dark, hiding away from the heat of the day in burrows that they have dug into sandy soil.

• **LIFE CYCLE** Mating may involve the male carrying the female. Like all sun spiders, males place a spermatophore into the female's genital opening. Eggs are laid in a pit or burrow.

• **OCCURRENCE** Asia and northern Africa. In semiarid and desert regions.

• **REMARK** Large species kill and eat lizards.

GALEODES CITRINUS frequently has yellow overall coloration. Here, the female is seen making a shallow pit in the ground, in which she will then lay her eggs.

GALEODES ARABS is a common North African species. It typically jumps on passing prey and then retires into its burrow to rest and digest its food.

Length 3/8–2¼in (1–7.2cm)	Feeding habits

Order SOLIFUGAE	Family SOLPUGIDAE	No. of species 200

SOLPUGIDS

These sun spiders are pale straw-colored, brown, or slightly yellow, and some have bright markings. The tarsi on the first pair of legs have one segment, those on the second and third pairs have four segments, and those on the last pair have six or seven segments. All but the first pair of legs have smooth-surfaced claws. Some species are active by day; others hide in burrows dug in sandy soil, in cracks, or under stones.

• **LIFE CYCLE** The females lay their eggs inside pits in the ground. Small solpugids and nymphs feed on termites.

• **OCCURRENCE** Africa and parts of the Middle East. In woodland, dry savanna, and semiarid and desert regions.

METASOLPUGA PICTA is found in the Namib desert in southern Africa. Like all solpugids, it will bite if handled carelessly, but does not have poison glands.

Length ¼–2½in (0.6–6cm)	Feeding habits

WHIP-SCORPIONS

THE ORDER UROPYGI consists of just two families comprising 99 species. These flattened arachnids are also known as vinegaroons because of their ability to defend themselves by spraying formic and acetic acids from a pair of glands at the end of their abdomen. The cephalothorax is longer than it is wide. It is covered by a carapace that carries a pair of eyes at the front edge and several eyes on each side. The chelicerae are more like spider fangs than pincers and the abdomen has 12 segments and ends in a whiplike "tail" section that is quite different from that of true scorpions. The robust pedipalps are used to catch, hold, and crush prey. Reproduction is similar to that of true scorpions, and females carry hatched young on their backs.

Order UROPYGI	Family THELYPHONIDAE	No. of species 75

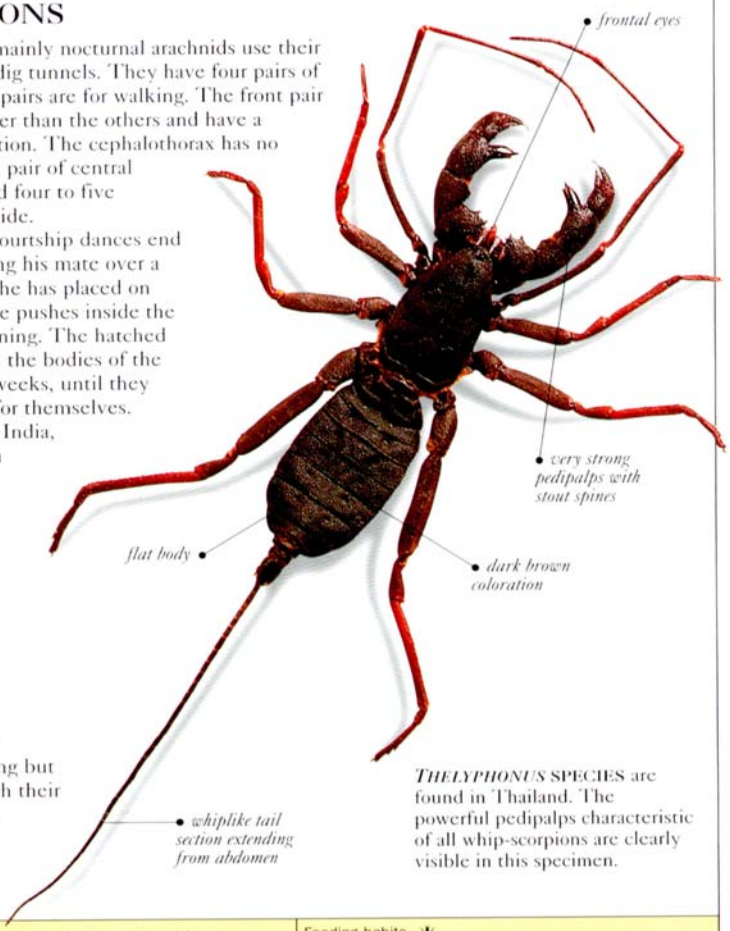
VINEGAROONS

These flat, brown, mainly nocturnal arachnids use their strong pedipalps to dig tunnels. They have four pairs of legs. The rear three pairs are for walking. The front pair are thinner and longer than the others and have a mainly sensory function. The cephalothorax has no divisions. It carries a pair of central eyes at the front, and four to five pairs of eyes at the side.

• **LIFE CYCLE** Courtship dances end with the male guiding his mate over a spermatophore that he has placed on the ground, which he pushes inside the female's genital opening. The hatched young are carried on the bodies of the females for several weeks, until they can leave and fend for themselves.

• **OCCURRENCE** India, Malaysia, and Papua New Guinea; northeastern parts of South America; and tropical and subtropical regions of North America. In soil, leaf litter, and rotten wood, under stones, and in caves. Some are found in deserts.

• **REMARK** These arachnids do not sting but can give a pinch with their powerful pedipalps.



THELYPHONUS **SPECIES** are found in Thailand. The powerful pedipalps characteristic of all whip-scorpions are clearly visible in this specimen.

Length 1/8–2¼in (1–7.2cm), excluding the whip	Feeding habits

WHIP-SPIDERS

THE ORDER AMBLYPYGI is divided into 3 families and 130 species. Also called tailless whip-scorpions, these arachnids have squat bodies, which are flat in profile, and a broad cephalothorax. The first segment of the rounded abdomen is stalklike. Whip-spiders have eight eyes: a middle pair and three lateral pairs. The large pedipalps may be long and slender or short and stout. Spiny, sharp-tipped, and six-segmented, they seize and hold prey, while the two-segmented, fanglike chelicerae tear pieces off. The much-segmented, very long first pair of legs are used as feelers.

Whip-spiders are nocturnal, do not sting or bite, and prey on insects and other arthropods. Eggs hatch out inside a sac under the female's abdomen, and the young then climb on to her back.

Order AMBLYPYGI	Family PHRYNIDAE	No. of species 52

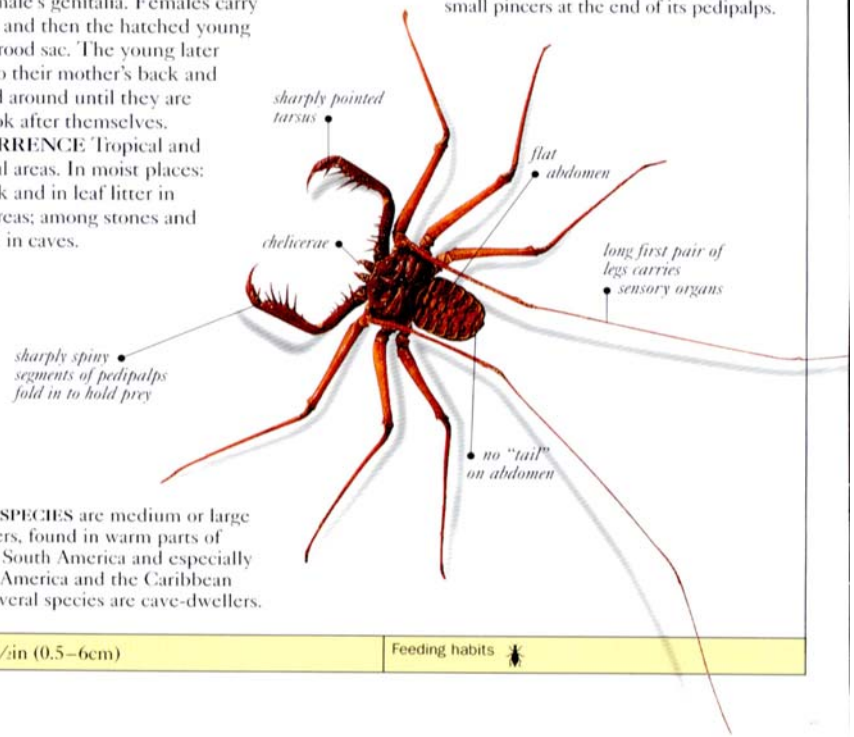
PHRYNIDS

These whip-spiders are generally colored various shades of brown, with darker markings. The tibia of the fourth pair of legs is divided into three or four segments. In some species, the pedipalps of the males are proportionately longer than those of the females.

• **LIFE CYCLE** As with all members of this order, males deposit a spermatophore on the ground, from where it is taken up by the female's genitalia. Females carry their eggs and then the hatched young inside a brood sac. The young later climb onto their mother's back and are carried around until they are able to look after themselves.

• **OCCURRENCE** Tropical and subtropical areas. In moist places: under bark and in leaf litter in wooded areas; among stones and rocks; and in caves.

PHRYNUS ASPERATIPES is found in southwestern parts of the US. It has small pincers at the end of its pedipalps.



PHRYNUS **SPECIES** are medium or large whip-spiders, found in warm parts of North and South America and especially in Central America and the Caribbean islands. Several species are cave-dwellers.

Length 1/16–2 1/2in (0.5–6cm)	Feeding habits

HARVESTMEN

COMMONLY known as harvestmen, the order Opiliones contains 40 families and 5,000 species. They lack a slender waist between their cephalothorax and their abdomen. They have a pair of eyes at the front of the cephalothorax, often carried on a raised structure. The pincerlike chelicerae have three segments, and the pedipalps have six. Their legs can be short or long. The four pairs of walking legs have seven segments and usually one or two simple claws. Special glands in the cephalothorax produce smelly secretions, which are used as a defence.

Harvestmen are unusual among arachnids in that fertilization is direct – males have a penis for transferring sperm. Females may have an ovipositor with which they lay eggs in cracks in the soil.

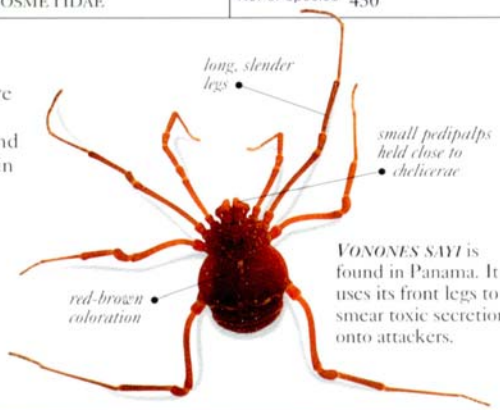
Order OPILIONES	Family COSMETIDAE	No. of species 450

COSMETIDS

Like most harvestmen, these species are generally dull-colored. Some tropical species, however, are green or yellow, and a few are able to change color to blend in with their background.

• **LIFE CYCLE** As for the whole order, fertilization is direct. Eggs are deposited in soil or other damp, sheltered spots.

• **OCCURRENCE** Mainly tropical regions of North and South America. Under stones and among debris in grassland, forest, and semidesert.



VONONES SAYI is found in Panama. It uses its front legs to smear toxic secretions onto attackers.

Length 1/16–1/2in (0.5–1.1cm)	Feeding habits

Order OPILIONES	Family GONYLEPTIDAE	No. of species 750

GONYLEPTIDS

Members of this family typically have stout bodies with a broad, sometimes flat-ended, rear. Many are brightly colored. The first part of the hindleg is enlarged and may have long, sharp spines. The eyes are close together and borne on a small protuberance. Males tend to have smaller bodies, and often much spinier legs, than females. Most species are active after dark and may produce chemicals to deter attackers.

• **LIFE CYCLE** Eggs are laid in damp, sheltered spots. Generally, the females do not look after their eggs, although there is one species that builds a protective mud wall around both herself and her eggs.

• **OCCURRENCE** Mainly in South American tropical forests. Under logs and stones.

***DISCOCYRTUS* SPECIES** are natives of the Brazilian rainforests. With their distinctive triangular bodies and enlarged hindlegs, their appearance is typical of this family.

Length 1/16–1/8in (0.5–1.4cm)	Feeding habits

Order OPILIONES	Family LEIOBUNIDAE	No. of species 450

LEIOBUNIDS

The bodies of these harvestmen vary. Most have very long, slender legs, with two rows of small "teeth" on the first segment. The second pair of walking legs may be 15 times as long as the body.

• **LIFE CYCLE** Little is known about courtship and egg-laying. In some species, mating involves large gatherings of males and females on tree stumps or mossy knolls, where males fight each other, often biting off each other's legs. Larger males usually win the contests and mate with the waiting females.

• **OCCURRENCE** Temperate parts of the Northern Hemisphere, especially North America and Europe, and in some tropical regions but absent from Africa. In moist places in woodland and cave entrances.

• **REMARK** Leiobunids use their eyes to distinguish light and dark, but they are not able to perceive images.

LEIOBUNUM ROTUNDUM is active at night, descending from trees to hunt for food at ground level. Its long, flexible tarsi can be wrapped tightly around grass blades for a strong grip.

Length 1/16–1/2in (0.2–1.2cm), body only	Feeding habits

Order OPILIONES	Family PHALANGIIDAE	No. of species 200

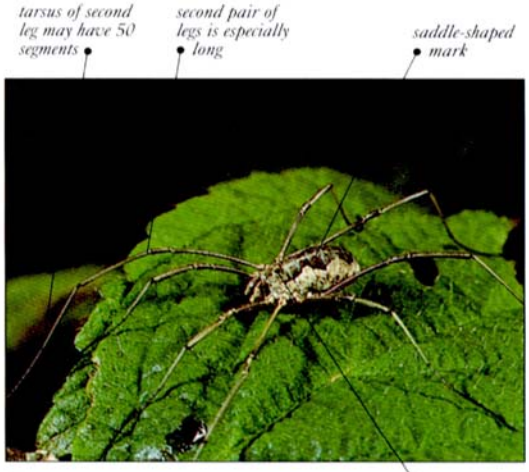
PHALANGIIDS

These arachnids usually have soft bodies and may have many spiny projections. The first leg segment is smooth, but the other segments may have longitudinal, sometimes spined, ridges. Males and females may differ, the male's enlarged chelicerae being especially distinct. Many species are nocturnal, but some are also active during the day.

• **LIFE CYCLE** Females use their telescopic, flexible ovipositor to lay eggs under bark or in soil crevices. The young stay in low vegetation at first, climbing into bushes and trees when older.

• **OCCURRENCE** Worldwide, mainly in temperate regions. Under stones and among leaf litter in wooded and grassy areas.

• **REMARK** Several species are now adapted to living in houses.



PHALANGIUM OPILIO is a white-gray to yellow species with a saddle-shaped mark on its back. It is found in the woods, gardens, and grasslands of the Northern Hemisphere.

Length 1/16–1/2in (0.2–1.2cm), body only	Feeding habits

TICKS AND MITES

TICKS AND MITES form the order Acari, a huge, diverse group of about 300 families and 30,000 species. They are found in every habitat, including aquatic ones, and have a wide range of lifestyles. Many are significant pests of crops and stored produce or parasitize humans and other animals.

Most species are less than 1/25in (1mm) long, although ticks can be much larger, especially following a blood meal. The body has no distinctive divisions, and the short abdomen has no segments. The mouthparts are carried on a special extension. The chelicerae are two- or three-segmented pincers or are adapted for piercing and sucking. Both the adults and nymphs have four pairs of six-segmented walking legs, although the first-stage larvae have only three pairs.

Order ACARI	Family ACARIDAE	No. of species 550

ACARIDS

Also called storage mites, most acarids are pale in coloration. The abdomen has long hairs. The legs of these mites can be long but in some species are extremely short.

• **LIFE CYCLE** Eggs are laid wherever the mites feed. As with most mites, there are three nymphal stages. Many live in association with certain arthropods, and some are found in rotting matter.

• **OCCURRENCE** Worldwide. In fresh or dried stored products, cheese, fungi, beehives, organic detritus, and inside mattresses.

• **REMARK** A few acarids are pests of dried, stored food. Some eat mammalian skin or bite humans and can cause skin conditions such as dermatitis or trigger allergies such as asthma.

ACARUS SIRO, the Flour Mite, is found all over the world in flour, grain, and various seeds in stores and mills. If conditions are suitable, huge populations can build up.

Length Under 1/25in (1mm)	Feeding habits

Order ACARI	Family ARGASIDAE	No. of species 150

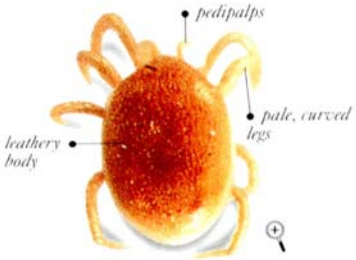
SOFT TICKS

These ticks usually have a rounded, berrylike body, although some are flat dorsoventrally. The tough, leathery body can be either wrinkled or folded, and the chelicerae are adapted for cutting through the skin of their hosts – mammals (including bats), birds, and snakes. They are ectoparasitic and feed mostly at night.

• **LIFE CYCLE** Eggs are typically laid in the nests and burrows of their hosts, and both adults and nymphs live mainly in association with these animals.

• **OCCURRENCE** Worldwide, especially in warm, dry regions. Typically in hosts' nests and burrows.

• **REMARK** Many soft ticks are carriers of disease and are pests of various domestic animals, especially poultry.



ARGAS PERSICUS is a pest of domestic chickens and other poultry in many parts of the world. It transmits a disease called fowl relapsing fever.

Length 1/16–1/8in (0.2–1cm), most under 1/4in (0.6cm)	Feeding habits

Order ACARI	Family DERMANYSSIDAE	No. of species 25

DERMANYSSIDS

These mites use their needlelike chelicerae to feed on the blood of birds and mammals. After a blood meal, their color changes from pale gray to red. Many females have a single dorsal plate with short hairs.

• **LIFE CYCLE** Males use their chelicerae to transfer sperm to the female. Eggs are laid in places such as nests, burrows, and poultry houses. The first-stage larva does not feed, although subsequent nymphal stages do.

• **OCCURRENCE** Worldwide. In association with bird and mammal hosts.

• **REMARK** Certain species are significant pests of poultry, and some carry diseases that can kill animals and also affect humans.

DERMANYSSUS GALLINAE, the Red Poultry Mite, is found all over the world on a wide range of birds. These mites feed at night and hide in crevices during the day.

Length less than 1/32in (0.2–0.8mm)	Feeding habits

Order ACARI	Family IXODIDAE	No. of species 650

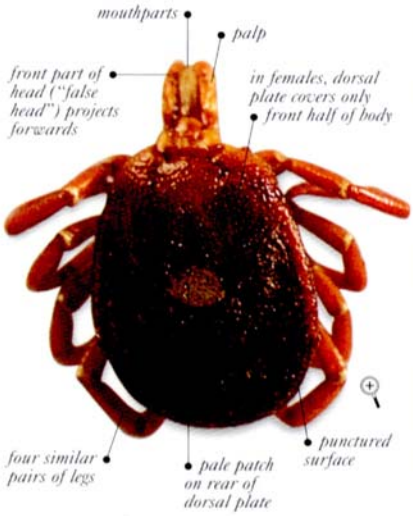
HARD TICKS

These flat ticks have a very tough, sometimes patterned plate on their back. In males, it covers the whole body; in females and immature ticks, it covers only the front half. The soft, flexible abdomen allows large blood meals to be taken from the animal hosts on which these ticks are found. Coloring varies from yellow to red- or black-brown, and some species are highly marked.

• **LIFE CYCLE** After mating, a female gorges herself on blood and then drops off the host to lay a batch of eggs among vegetation. Six-legged larvae emerge, crawl up grass blades, and attach themselves to a passing host. A larva feeds for a few days and then drops off the host to molt into an eight-legged nymph. The nymph attaches itself to a host and feeds for several days before once again dropping off to molt into an adult.

• **OCCURRENCE** Worldwide. In association with bird, mammal, and some reptile hosts.

• **REMARK** Many hard ticks transmit disease and are serious pests of domestic animals such as cattle, sheep, horses, and poultry. Some also carry viral diseases that affect humans, including encephalitis, Lyme disease, tick typhus, and Rocky Mountain Spotted Fever.



AMBLYOMMA AMERICANUM, the Lone Star Tick, attacks a range of mammals and will also bite humans. It is found in the central states of the US.

Length 1/16–3/8in (0.2–1cm); larger when engorged	Feeding habits

Order ACARI	Family LAELAPIDAE	No. of species 650

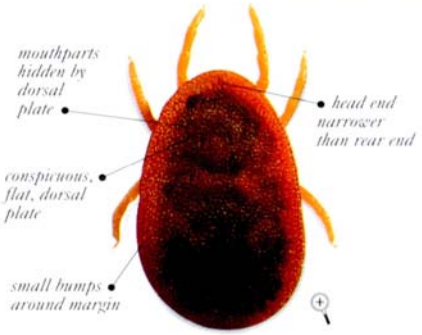
LAELAPID MITES

These brown mites are ectoparasites of insects or mammals. The former have weak, hairlike structures on the body. In the latter, these are spinier, helping the mites cling to their hosts. The dorsal plate is not divided in two, as it is in some mites.

• **LIFE CYCLE** Males transfer sperm to females with their chelicerae. Many species feed on the lymph or blood of mammals and lay eggs in the host's nest or burrow. Some produce live larvae.

• **OCCURRENCE** Worldwide. In a wide variety of habitats: in poultry houses, the nests of small animals, and ant colonies, and in dung, tidal debris, and stored produce.

• **REMARK** Many species transmit disease.



HAEMOLAELAPS GLASGOWI is widespread on rats. It can transmit the virus that causes epidemic hemorrhagic fever between rats and other rodents and possibly also humans.

Length ¼₄–¼₆in (0.5–5mm), most under ¼₆in (2mm)	Feeding habits

Order ACARI	Family MICROTROMBIDIIDAE	No. of species 500

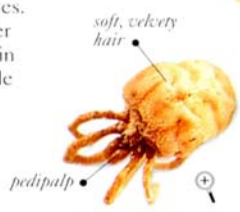
MICROTROMBIDIIDS

Microtrombidiids are usually brown and densely hairy. The legs have six segments and the front of the dorsal plate always carries two pairs of eyes.

• **LIFE CYCLE** These mites parasitize other arthropods. The females lay up to 4,000 eggs in soil, and their hatched larvae feed off a suitable host. The larvae then molt into nymphs, eat insect eggs that they find in the soil, and develop into adults.

• **OCCURRENCE** Worldwide. In various habitats, especially dry, sandy, or semiarid areas.

UNDERSIDE



UPPERSIDE

EUTROMBIDIUM **SPECIES**, like the one shown here, are usually found on the body surface of praying mantids, crickets, grasshoppers, and locusts.

Length ¼₄–¼₆in (0.5–2mm)	Feeding habits

Order ACARI	Family PARASITIDAE	No. of species 375

PARASITID MITES

Most of these mites are slightly pear-shaped and yellow-brown, with one or two visible plates on the dorsal surface. In males, the second pair of legs may be stouter and adapted to grasp females when mating.

• **LIFE CYCLE** Eggs are laid in organic debris. Nymphs are often found on insects, and many eat small insects, their larvae, and other mites.

• **OCCURRENCE** Worldwide. In dung, wood, and plant debris, on other mites in stored produce, and in mammal, bee, and wasp nests.

PARASITUS **SPECIES** are common and can be found inside the nests of wasps and bees, as well as among decaying wood and leaf litter.

Length ¼₄–¼₆in (0.75–2mm)	Feeding habits

Order ACARI	Family SARCOPTIDAE	No. of species 120

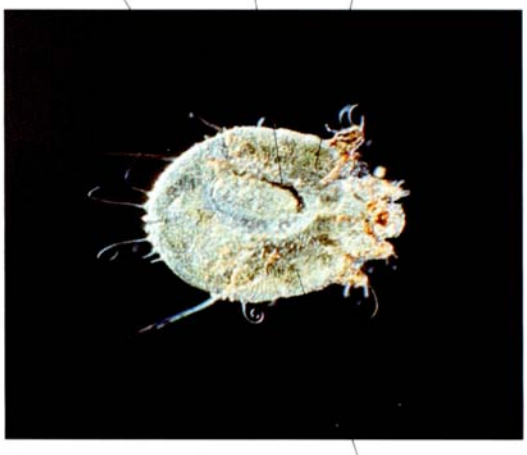
SCABIES MITES

These small mites, also known as mange mites, are a pale, translucent brown. They have short, compact legs and almost spherical bodies that are slightly flat in profile. Their chelicerae are adapted for cutting the skin of their animal and human hosts (causing mange in animals and scabies in humans).

• **LIFE CYCLE** Most species feed on the host's epidermis and lymph, leaving tunnels in the skin. Mating occurs on the skin, and females lay up to 50 eggs in the tunnels during their lifetime. The hatched young find shelter and food in hair follicles.

• **OCCURRENCE** Worldwide. In the skin or hair follicles of mammals, including humans.

• **REMARK** Infestation causes extreme itching. Scratching leads to hair loss, and serious secondary infections can follow.



SARCOPTES SCABEI mites are the most common cause of mange. There are many varieties within this species, each linked with a particular host.

Length 1/125–1/64in (0.2–0.4mm)	Feeding habits

Order ACARI	Family TETRANYCHIDAE	No. of species 650

SPIDER MITES

These mites are orange, red, green, or yellow in color, with spiderlike bodies. Large numbers feed on and infest host plants, which may then wither and develop pale blotches. Spider mites produce silk from glands at the front of their body and often cover affected plant parts with a fine webbing.

• **LIFE CYCLE** Red, rounded, quite large eggs are laid on the leaves, twigs, or bark of host plants. The mites live under the leaves, protected from harm by their silk webs.

• **OCCURRENCE** Worldwide. On a range of plants, trees, and shrubs.

• **REMARK** Many spider mites are significant pests of grasses and other plants. Affected crops include wheat, citrus and other fruit trees, clover, cotton, and coffee. Infestation can seriously affect crop yields.

TETRANYCHUS **SPECIES** feed on a wide range of plants and spend the winter deep in leaf litter, emerging in the spring to locate host plants.

Length 1/125–1/30in (0.2–0.8mm)	Feeding habits

Order ACARI	Family TROMBICULIDAE	No. of species 3,000

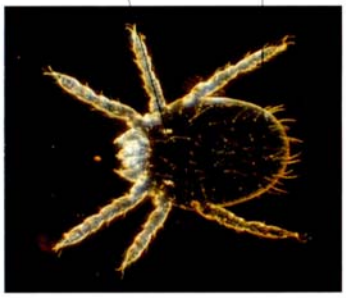
CHIGGER MITES

These mites are pale to mid brown or sometimes red. They are oval or slightly constricted in the middle, and the body and legs may have quite long hairs, although some have a velvety surface. Chigger mites parasitize mammals (including humans), reptiles, and birds.

• **LIFE CYCLE** Eggs are laid in damp soil and larvae climb grass blades to find passing hosts. First-stage larvae feed on the outside of mammals, birds, snakes, and lizards, penetrating the skin with sawlike chelicerae to eat lymph and tissue. A few species feed in the tracheal system. When fully fed, the larva drops off, molts, and preys on small arthropods such as springtails (see pp.207–209).

• **OCCURRENCE** Worldwide. In soil, leaf litter, and animals' burrows, or on hosts.

• **REMARK** Species that attack humans cause severe itching, dermatitis, and allergic reactions. A few carry scrub typhus from rodents to humans.



NEOTROMBICULA AUTUMNALIS lives in soil and emerges on to the surface when it is warm and wet. Immature stages bite birds and mammals (including humans).

Length 1/32–1/8in (1–3mm) | Feeding habits

Order ACARI	Family TROMBIDIDAE	No. of species 250

VELVET MITES

Many velvet mites have red or orange bodies that are extremely hairy, giving them a dense, velvety appearance. The body is not constricted in the middle.

• **LIFE CYCLE** At certain times of year, often after rain, adults emerge from the soil to mate and lay eggs. Some larvae are parasites on insects, such as grasshoppers, and other arthropods.

• **OCCURRENCE** Worldwide, especially numerous in tropical regions. In various terrestrial habitats, from savanna to forests, mostly in or on soil. Some species are associated with freshwater.

***TROMBIDIUM* SPECIES** are often seen walking over bare ground, especially after heavy rain, when they are forced from the soil in large numbers.

Length 1/50–3/8in (0.2–1cm), most under 1/4in (0.5cm) | Feeding habits

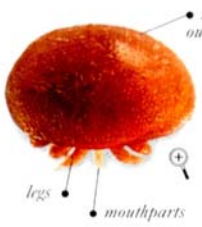
Order ACARI	Family VARROIDAE	No. of species 5

VARROA MITES

Typically, varroa mites are pale tan in color and broader than they are long, with smooth, oval, slightly convex bodies. They parasitize bees.

• **LIFE CYCLE** Eggs are laid in bees' brood cells and the nymphs feed off the bee larvae. Adult mites attach themselves to adult bees, in order to feed off them and as a way of dispersing.

• **OCCURRENCE** Worldwide. Where hosts occur.



VARROA PERSICUS attaches itself to the bodies of both wild and domestic honeybees.

Length 1/32–1/28in (1–1.75mm) | Feeding habits

SPIDERS

MEMBERS OF THE 101 families and 40,000 species in the order Araneae are distinguished by their general appearance and their ability to spin silk thread and make webs.

The cephalothorax is covered by a carapace and is joined to the abdomen by a stalk. The front part of the carapace carries the eyes. Most species have eight simple eyes, but some have six, four, or two eyes, or none at all. The chelicerae have a hinged fang at the tip, and almost all species have venom glands. A spider's pedipalps are six-segmented and have a sensory function. In males, they are also used to transfer sperm. There are four pairs of seven-segmented walking legs. The abdomen is not segmented and carries silk-spinning organs (known as spinnerets) and a genital opening called the epigyne. When a spider feeds, the body tissues of its prey are dissolved by enzymes in the spider's digestive juices, producing a liquid that it then sucks up. Typically, the round spider eggs are laid inside a silk sac, which some species carry until the young hatch.

Spiders are found in almost every terrestrial habitat, from deserts to mountain peaks. They cannot fly, but many are able to travel long distances by "ballooning" on silk threads.

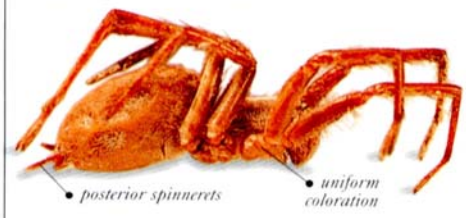
Order ARANEAE	Family AGELENIDAE	No. of species 700

FUNNEL WEAVERS

These spiders have hairy bodies and often have long legs. The narrow front of the cephalothorax bears eight eyes and the oval, quite slender abdomen may have dark bars, chevrons, or spots. The two posterior spinnerets have two segments and are longer than the anterior ones. Typically, these spiders make a funnel-shaped retreat at the margin of a flat web.

• **LIFE CYCLE** After mating, males and females may stay together until the male dies. The egg sac is covered with silk and debris and is kept in the web. The young may be fed with regurgitated food.

• **OCCURRENCE** Worldwide. In various habitats, including grassland, meadows, and gardens. Webs are made in bushes, among stones, on rocks and walls, under logs, and inside houses.



***AGELENOPSIS* SPECIES**, or grass spiders, do not have distinct abdominal markings. Some larger species have been known to bite humans.

TEGENARIA GIGANTEA is common in houses and gardens in parts of Europe. The large house spiders often found in domestic baths belong to this genus.

Length ¼–⅞in (0.6–2cm)	Feeding habits

Order ARANEAE	Family ARANEIDAE	No. of species 4,000

ORB WEB SPIDERS

These spiders often have very large abdomens, which can be brightly colored and patterned. In some species, the abdomen may have a strange, angular shape. The legs have three claws and can be very spiny. They have eight eyes – the middle four often forming a square. Males are often smaller than females. The webs often have a central hub with radiating lines and spirals. Certain species do not make webs at all. Instead, they ensnare moths after dark using a single thread with a bead of glue at the end.

• **LIFE CYCLE** Mating involves complex courtship. Silk egg sacs are kept camouflaged inside the web, stuck to vegetation or bark, or buried in leaf-litter.

• **OCCURRENCE** Worldwide. In a wide variety of different habitats, including grassland, meadows, forests, and gardens.

• **REMARK** Some tropical species make huge, strong webs and have been known to catch and eat birds. The enormous webs of *Nephila* species are used as fishing nets in Papua New Guinea.

MICRATHENA GRACILIS, the spiny orb-weaving spider, is found in North American deciduous forests. The genus has odd, spiny protrusions on the abdomen.

Length 1/16–1 1/4in (0.2–4.6cm)	Feeding habits

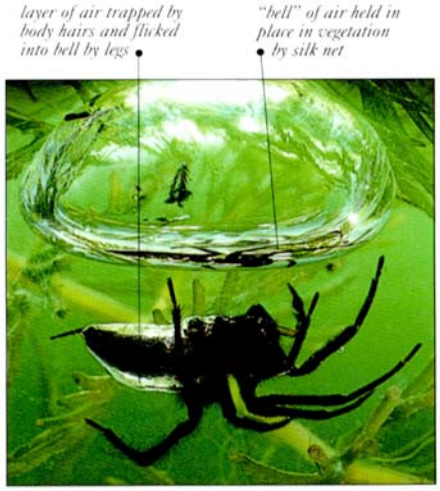
Order ARANEAE	Family ARGYRONETIDAE	No. of species 1

THE WATER SPIDER

There is just one species in this family – *Argyroneta aquatica*. It is aptly named, since it lives more or less permanently underwater. This spider has a distinctive, dense pile of short hairs on its gray abdomen. The legs are yellow-brown, and the third and fourth pairs have extensive tufts of longer hairs, which help to trap air. The Water Spider makes a dome-shaped "diving bell" out of a sheet of silk, which it attaches to submerged vegetation and fills with air. Bubbles of air are carried from the surface using the abdomen and hindlegs, and the air is 'brushed" off by the legs to fill the bell. The spider stays inside the bell with its long legs hanging down below to sense passing prey. Prey items include small fish fry and tadpoles, which are dragged into the bell to be eaten.

• **LIFE CYCLE** After mating has taken place, the eggs are wrapped in silk and are then placed in the top of the diving bell.

• **OCCURRENCE** Europe and parts of Asia. In either slow-flowing or still water.



ARGYRONETA AQUATICA, the European Water Spider, even spends the winter in its bell-shaped tent. It adds extra silk to reinforce the structure and stays there until spring.

Length 3/32–3/8in (0.7–1.5cm)	Feeding habits

Order ARANEAE | Family CTENIDAE | No. of species 600

WANDERING SPIDERS

These spiders are usually either gray or brown in general coloration. The rear portion of their carapace has a distinctive groove, running lengthwise. Most species are aggressive, nocturnal hunters. They search for suitable prey on the ground and then return to their dark hiding places at dawn.

• **LIFE CYCLE** Eggs are often laid in a silk sac that the female carries under her body.

• **OCCURRENCE** Tropical and subtropical regions. On the ground or on low-growing plants.

• **REMARK** The bites of some wandering spiders can be dangerous to humans.

***CTENUS* SPECIES** are similar in appearance to wolf spiders (see p.233). This drably colored, mottled specimen is from Africa.

Length ⅛–2in (1.5–5cm) | Feeding habits

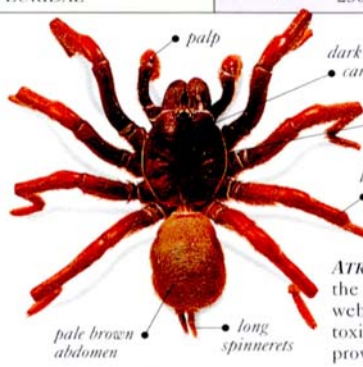
Order ARANEAE | Family DIPLURIDAE | No. of species 250

FUNNEL-WEB SPIDERS

Mostly dark brown, these spiders have six or eight eyes arranged in two groups and a flat carapace. Their flat webs have a funnel-shaped retreat that leads into crevices in tree stumps, stones, and rocks.

• **LIFE CYCLE** Females produce tough, disk-shaped egg sacs that they keep at the bottom of the retreat.

• **OCCURRENCE** Tropical and subtropical regions of North America, Africa, Asia, and Australia. In various habitats, on the ground and in trees.



ATRAX ROBUSTUS, the Sydney Funnel-web, has a highly toxic bite that may prove fatal.

Length ¼–1⅛in (0.6–2.8cm) | Feeding habits

Order ARANEAE | Family DYSDERIDAE | No. of species 250

DYSDERID SPIDERS

Most of these spiders have six eyes, arranged roughly in a circle. The chelicerae are often large, and the long fangs are sharp enough to pierce tough cuticle. The abdomen may be pinkish gray or patterned. Most are nocturnal and hunt on the ground or make tubular silk nests in cavities in bark or wood or among stones. In tube-nesting species, threads radiating from the nest entrance trip up passing prey.

• **LIFE CYCLE** Females may wrap their eggs in silk, and the eggs are always kept inside a silk-lined retreat.

• **OCCURRENCE** Worldwide. In varied habitats, in natural cracks and crevices in bark and wood and among stones.

• **REMARK** Tube-nesting species in the genus *Segestria* are sometimes placed in a separate family.

DYSDERA CROCATA is common worldwide. Species in this genus are known as woodlice-eating spiders as these crustaceans form the largest part of their diet.

Length ¼–1in (0.6–2.4cm) | Feeding habits

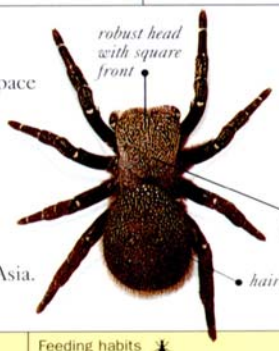
Order ARANEAE	Family ERESIDAE	No. of species 120

ERESID SPIDERS

These robust, quite hairy spiders have a large carapace and a square-fronted cephalothorax with eight eyes. Males may be brightly colored. Some species make tubular webs in holes in the ground connected to funnel-shaped webs on the surface. Others make a web in shrubs.

• **LIFE CYCLE** Females keep the egg sacs inside the retreat or carry them under their body.

• **OCCURRENCE** Parts of Africa, Europe, and Asia. In various habitats, in shrubs, and on the ground.



ERESUS CINNABERINUS is found in Europe and favors sunny spots on dry, sandy heathland.

Length ⅛–⅛in (1–2cm)	Feeding habits

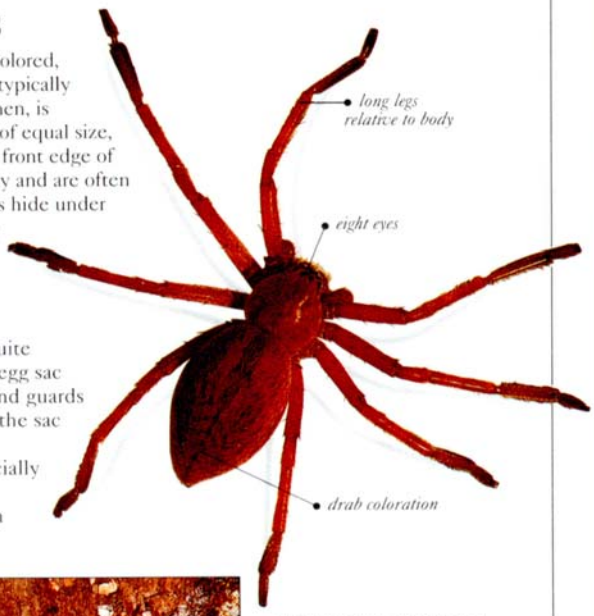
Order ARANEAE	Family HETEROPODIDAE	No. of species 1,000

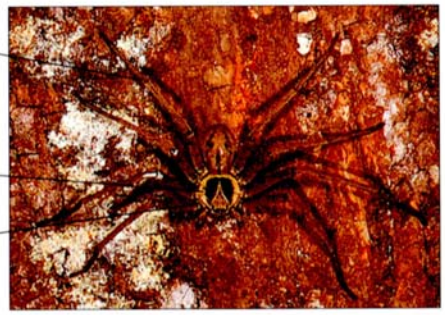
HUNTSMAN SPIDERS

Most species in this family are drably colored, with mottled patterns. The carapace is typically as wide as it is long and, like the abdomen, is flattened in profile. The eight eyes are of equal size, four of them pointing forward from the front edge of the carapace. The legs can be very spiny and are often held out to the sides. Huntsman spiders hide under bark and stones or in vegetation during the day, or may be seen on tree trunks, and they hunt for prey at night. They are able to move sideways with great agility.

• **LIFE CYCLE** Courtship can be quite complex. The female produces a silk egg sac that she hides under a stone or bark and guards until the eggs hatch, when she opens the sac to release the spiderlings.

• **OCCURRENCE** Worldwide, especially in tropical and subtropical regions. In various habitats, on the ground and on tree trunks.





△ ***HETEROPODA* SPECIES** are often imported in crates of bananas. They have been known to bite warehouse workers but are not dangerous.

◁ ***HETEROPODA VENATORIA*** is a widespread species that is helpful to humans in tropical regions as it eats small scorpions and cockroaches.

Length ⅛–2in (1–5cm)	Feeding habits

Order ARANEAE	Family LINYPHIIDAE	No. of species 4,200

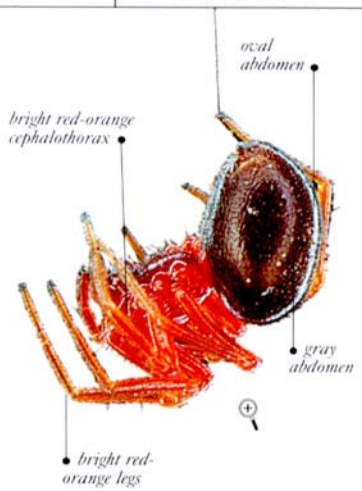
DWARF SPIDERS

As the common name implies, many of these spiders are small. The chelicerae are relatively large, with sharp teeth, and the legs have strong bristles. Males may have odd projections on the carapace, which may carry the eyes. Coloration varies from pale yellow to black and some have pale patches or banded legs. Many species attach nonsticky sheet webs to vegetation. Passing insects are knocked down on to the web, where the spider bites them from below with its chelicera and drags them under the sheet.

• **LIFE CYCLE** Females grip the male during mating. They attach egg sacs of various designs to plants, stones, and other surfaces.

• **OCCURRENCE** Worldwide, mostly in temperate areas. Among vegetation and stones in various habitats, such as woods, grassland, scrubland, and swamps. Dwarf spiders can travel vast distances by "ballooning" on silk threads.

• **REMARK** Another common name – "money spider" – comes from the myth that if a dwarf spider lands on you and is twirled around the head three times, good fortune will result.



***GONATIUM* SPECIES** are extremely common and several are widespread throughout the Northern Hemisphere. They are found in low vegetation or shrubs and prefer shady spots.

Length 1/32–3/8in (0.1–1cm), most under 1/16in (0.5cm)	Feeding habits

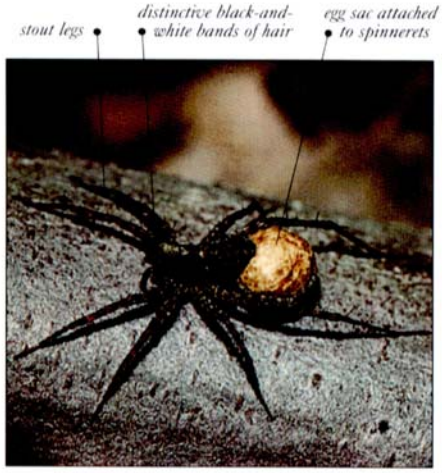
Order ARANEAE	Family LYCOSIDAE	No. of species 3,000

WOLF SPIDERS

These spiders vary from pale gray to dark brown with markings such as bands, stripes, white hairs, and black dots. The "head" area is often narrow, and the front two pairs of legs have many strong spines. Wolf spiders have four large eyes: the rear two face sideways and the two adjacent eyes face forward. They also have four small eyes. These spiders have the excellent eyesight necessary for effective hunting, and most search for prey along the ground or among leaf litter, usually at night.

• **LIFE CYCLE** Courtship can be complex. Females of ground-active species carry egg sacs around with them, attached to their spinnerets. Burrowing species keep their egg sacs in a silk burrow. When the spiderlings hatch out, the mother may carry them around on her back.

• **OCCURRENCE** Worldwide, even in the Arctic. Widespread in varied habitats. Many are vital predators in fields, eating pests such as aphids, and some live in swamps, on plants, and on the surface of water.



PARDOSA AMENTATA is common in Europe, where it prefers open habitats. This species can be quite variable in appearance – the abdomen may be either brown or gray, for example.

Length 5/32–1½in (0.4–4cm)	Feeding habits

Order ARANEAE	Family OONOPIDAE	No. of species 250

OONOPIDS

These spiders are often brightly colored red, pink, orange, or pale yellow. The abdomen may have toughened plates on both dorsal and lateral surfaces. Most species have six eyes, grouped closely together, but some have only two or four eyes, or none at all. They do not spin webs but move about in leaf litter after dark, preying on small insects. A few eat the remains of prey that they find in the webs of other spiders.

• **LIFE CYCLE** The female produces very few eggs, enclosed in a silk sac inside her daytime retreat.

• **OCCURRENCE** Worldwide, mostly in forested, tropical regions. Some are found in houses.

OONOPS DOMESTICUS is found in European houses. In southerly areas, it can also be found out of doors. It moves in a highly distinctive way, interspersing short dashes with slow walking.

Length 1/32–1/8in (1–3mm)	Feeding habits

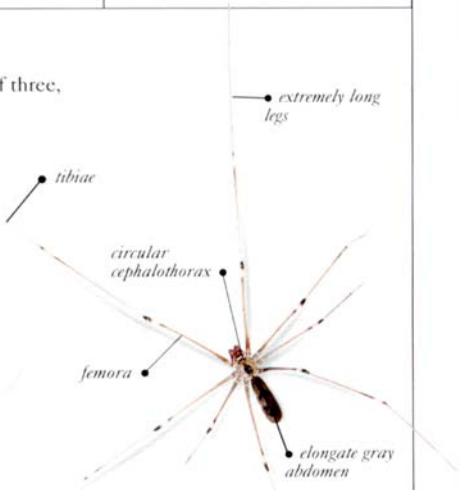
Order ARANEAE	Family PHOLCIDAE	No. of species 350

DADDY-LONG-LEGS SPIDERS

The eyes of these spiders are arranged in two groups of three, with another pair in between. Typically, the carapace is very round. The legs are much longer than the body, giving a spindly appearance like that of harvestmen (see p.221). Coloration is gray, green, or brown, with pale legs. The tarsi are very long and flexible. These spiders make tangled, irregular webs and quickly wrap trapped prey in silk before biting it.

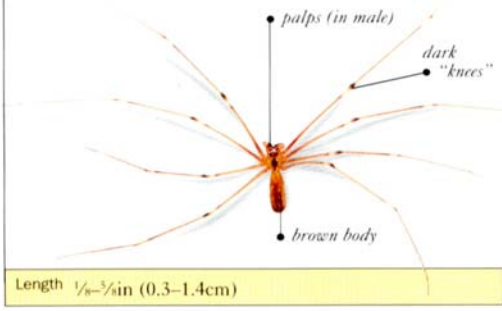
• **LIFE CYCLE** Females produce about 15 to 20 eggs, which they wrap in a silk bundle and carry in their mandibles until they hatch.

• **OCCURRENCE** Worldwide. Many tropical species occur in caves or leaf litter. In temperate regions, many species live in the dark corners of buildings.



PHOLCUS **SPECIES** are common inhabitants of caves and rock crevices, especially in warmer regions.

PHOLCUS PHALANGIOIDES is now very common in buildings all over the world, but does not like cold temperatures.



Length 1/8–3/8in (0.3–1.4cm)	Feeding habits

Order ARANEAE	Family PISAURIDAE	No. of species 550

NURSERY-WEB SPIDERS

These large, long-legged spiders are very similar to wolf spiders (see p.233), except that their eyes are smaller. Their body coloring varies from pale gray to dark brown, while the legs can be brown or white and may have yellow bands. Rather than catch prey with webs, they run on the ground to hunt prey. The carapace is oval, with longitudinal markings. The common name refers to the protective web spun by the females for her young.

• **LIFE CYCLE** The female carries her egg sac in her chelicerae. When the young are about to hatch out, many females spins a tent-like nursery web around the sac, among vegetation. She then guards her spiderlings.

• **OCCURRENCE** Worldwide. Widespread in various habitats on the ground and on the surface of still water or on aquatic plants.

***DOLOMEDES* SPECIES** are large, semiaquatic spiders that catch tadpoles and fish fry as well as insects. Common across the Northern Hemisphere, they are able to jump on and off the water's surface.

Length ⅜–1in (1–2.6cm)	Feeding habits

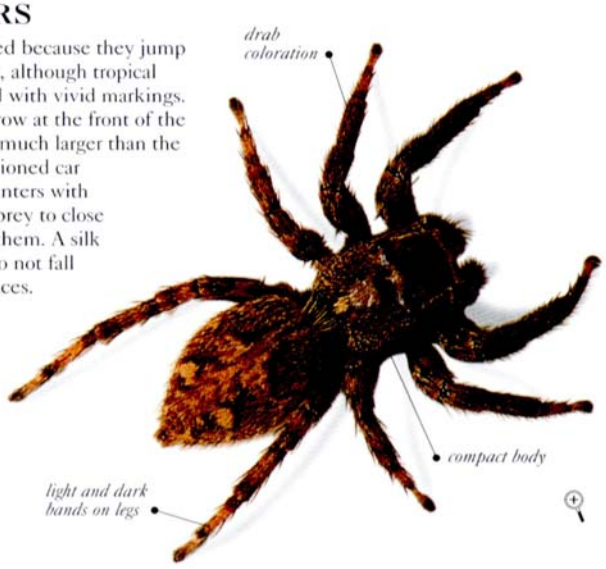
Order ARANEAE	Family SALTICIDAE	No. of species 5,000

JUMPING SPIDERS

Most jumping spiders, so called because they jump at prey, are drab in appearance, although tropical species can be brightly colored with vivid markings. Four of the eight eyes form a row at the front of the carapace. The middle two are much larger than the rest, often resembling old-fashioned car headlights. Mostly daytime hunters with excellent eyesight, they stalk prey to close range and then jump to seize them. A silk safety line ensures that they do not fall when stalking on vertical surfaces.

• **LIFE CYCLE** Females usually lay eggs among vegetation, moss, bark, and stones, inside a large silk cell that they spin. They then guard the eggs until they hatch.

• **OCCURRENCE** Worldwide, especially in warm regions. In a variety of habitats, including woods, grassland, heaths, and gardens. On walls, on the ground, in bushes, and often seen in sunny spots.



***EUOPHRYS* SPECIES** are usually found under stones or near the ground on low-growing plants. Some specialize in hunting ants.

Length 1/16–⅜in (0.2–1.6cm)	Feeding habits

Order ARANEAE	Family SCYTODIDAE	No. of species 180

SPITTING SPIDERS

Typically cream- or yellow-brown with black markings, and with black-banded legs, the spitting spider has only six eyes, and the first pair of slender legs are usually longer than the others. At first glance, the carapace of the cephalothorax looks almost the same size as the abdomen. Seen in side view, the carapace is characteristically domed toward the rear, and the dome houses large glands that produce a sticky glue. This spider's common name comes from its unique prey-capturing technique. It does not spin webs, but uses a rapid, side-to-side movement of the chelicerae to "spit" two zigzag streams of its glue at prey from close range, literally sticking it down.

• **LIFE CYCLE** The female carries a pale and knobbly egg sac around underneath her body until the young emerge.

• **OCCURRENCE** Worldwide, except in Australia and New Zealand. Mostly in warm regions. Under rocks and in buildings.

• **REMARK** All the species in this family belong to the genus *Scytodes*.

SCYTODES THORACICA, native to North America and Europe, is a darkly marked spider that is often found inside buildings. The male is slightly smaller than the female.

Length 1/32–1/2in (0.4–1.2cm)	Feeding habits

Order ARANEAE	Family SICARIIDAE	No. of species 100

SIX-EYED CRAB SPIDERS

Also known as brown spiders, because of their general body color, most species have a violin-shaped mark on their carapace and a distinctive longitudinal groove. There are six eyes, arranged in three pairs. Both the body and legs have distinct hairs. These spiders make irregular, sticky, sheetlike webs.

• **LIFE CYCLE** The females produce between 30 and 300 eggs per sac and keep the sacs out of the way, at the rear of the web. Some species live for several years, adding to their webs as they grow.

• **OCCURRENCE** Warm regions of North and South America, and also in Europe and Africa. In a wide variety of habitats, including woods, scrubland, citrus groves, gardens, and houses. In shady locations among rocks and bark, and sometimes in human dwellings.

• **REMARK** The bite of six-eyed crab spiders can be extremely dangerous, causing tissue degeneration.

LOXOSCELES RUFESCENS, a fiddle-back spider, may bite humans and produce unpleasant lesions that are slow to heal. It is common in Europe and has been introduced to Australia.

Length 1/4–3/4in (0.6–1.8cm)	Feeding habits

Order ARANEAE	Family THERAPHOSIDAE	No. of species 800

TARANTULAS

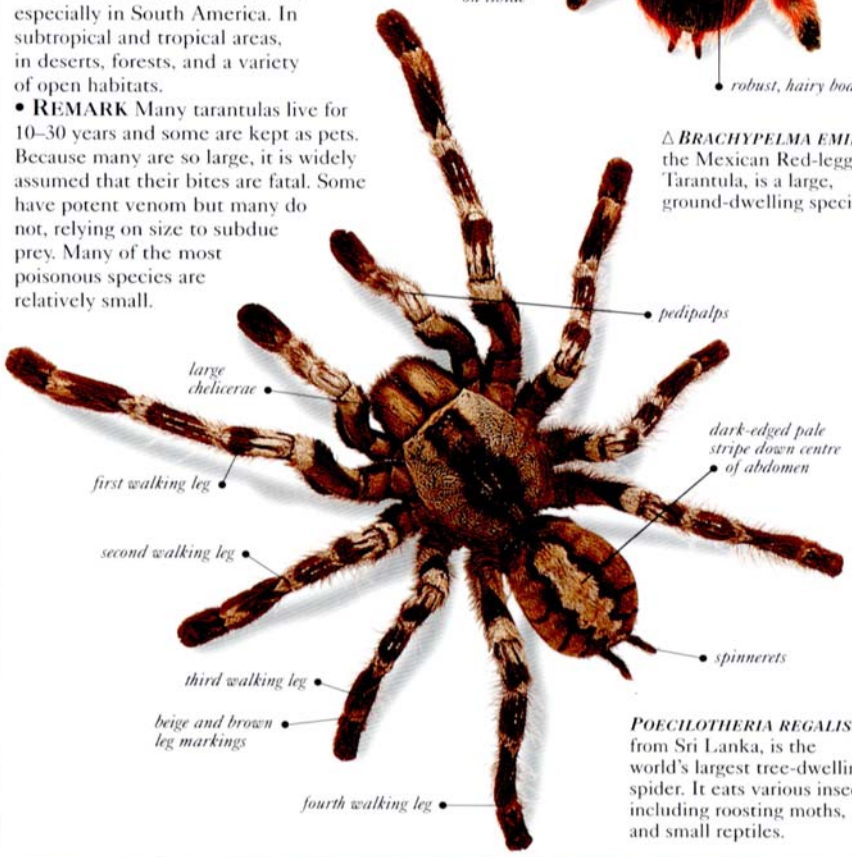
Some larger tarantulas are also called bird-eating spiders. These large, hairy spiders are usually pale brown to black, with markings in shades of pink, red, brown, or black. The fangs bite vertically, not horizontally. They have eight small eyes, grouped together at the front of the carapace. Most tarantulas hunt on the ground by night for arthropods and small vertebrates such as frogs and mice. They use their large chelicerae to crush their prey, pour digestive juices over the body, and then suck up the resulting liquid.

• **LIFE CYCLE** Some species live in trees, whereas others make burrows in the ground. Females lay a batch of eggs in the burrow. An egg sac can be the size of a golf ball and contain 1,000 eggs. The spiderlings stay in the burrow until their first molt, after which they disperse to find food and to make their own burrows.

• **OCCURRENCE** Worldwide, especially in South America. In subtropical and tropical areas, in deserts, forests, and a variety of open habitats.

• **REMARK** Many tarantulas live for 10–30 years and some are kept as pets. Because many are so large, it is widely assumed that their bites are fatal. Some have potent venom but many do not, relying on size to subdue prey. Many of the most poisonous species are relatively small.

△ ***BRACHYPELMA EMILIA***, the Mexican Red-legged Tarantula, is a large, ground-dwelling species.



POECILOTHERIA REGALIS, from Sri Lanka, is the world's largest tree-dwelling spider. It eats various insects, including roosting moths, and small reptiles.

Length 1¼–4¾in (3–12cm)	Feeding habits

Order ARANEAE | Family THERIDIIDAE | No. of species 2,200

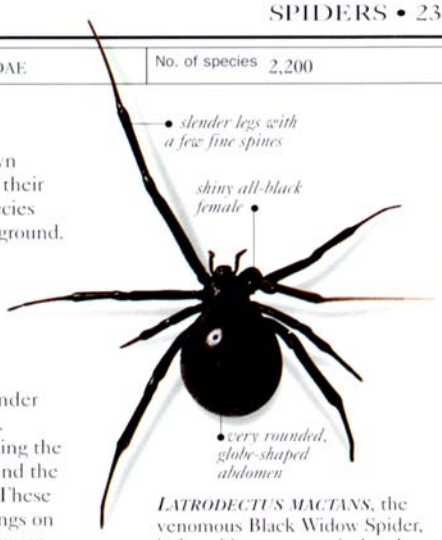
COMB-FOOTED SPIDERS

Also called cobweb spiders, these species are brown to black, often with markings and stout bristles on their hindlegs. The abdomen is very rounded. Most species are active at night, and some hunt for prey on the ground. They make irregular webs in foliage, cracks, crevices, and debris, or under buildings.

• **LIFE CYCLE** Females produce about 200–250 eggs, attached to the web in a sac. After their first molt, the spiderlings make their own webs.

• **OCCURRENCE** Worldwide. In vegetation, under stones, in leaf litter, and in and around buildings.

• **REMARK** The infamous widow spiders (including the notorious female American Black Widow Spider) and the Australian Red-back Spider belong to this family. These pea-sized black spiders have bright crimson markings on the underside of the abdomen. Their strong venom can kill, but a fast-acting antivenin can be given by injection.



LATRODECTUS MACTANS, the venomous Black Widow Spider, is found in many tropical and subtropical countries.

Length 1/16–⅝in (0.2–1.5cm), most under ⅛in (1cm) | Feeding habits

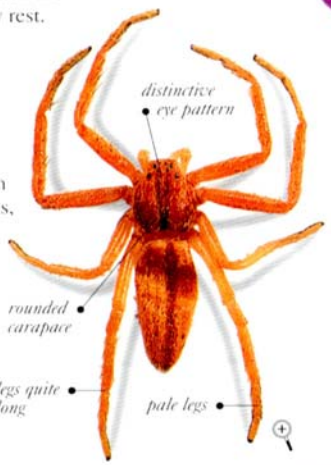
Order ARANEAE | Family THOMISIDAE | No. of species 2,500

CRAB SPIDERS

These spiders are named after their scuttling, sideways movements and squat shape, although some are elongate. The carapace is almost circular, and the short, often blunt-ended abdomen is frequently patterned. The first two pairs of legs, used to seize insect prey, are larger and spinier than the other two pairs. Many species are pink, yellow, or white to match the flowers on which they rest.

• **LIFE CYCLE** Females keep their eggs in a flat sac, attached to plants, which they guard.

• **OCCURRENCE** Worldwide. Mainly in meadows and gardens, especially on flowers but also on plants and tree bark.



△ *MISUMENA VATIA* is common throughout Europe and North America. The females are often found sitting on white or yellow flowers and can change from one color to the other to blend in.

TIBELLUS OBLONGUS lies along grass blades with its head pointing downward and seizes passing insects. It is widespread in damp meadows throughout Europe.

Length 1/32–⅝in (0.4–1.4cm) | Feeding habits

MYRIAPODS

PAUROPODS

THERE ARE 5 families and 500 species in the order Pauropoda. These small, soft-bodied myriapods are typically pale in color and have no eyes. The head carries a pair of branched antennae and weakly developed mouthparts. Located behind the head is a trunk, usually made up of between 9 and 11 segments. Hairs protrude from the upper surface of the head and trunk. The dorsal surfaces of the trunk segments (tergites) are fused together in pairs. Adult pauropods normally have 9 to 11 pairs of legs.

Pauropods live in soil or leaf litter, where they are scavengers and eat fungal threads. A few species may be predacious. Reproduction begins with the male depositing a spermatophore that is picked up by the female.

Order PAUROPODA	Family PAUROPODIDAE	No. of species 450

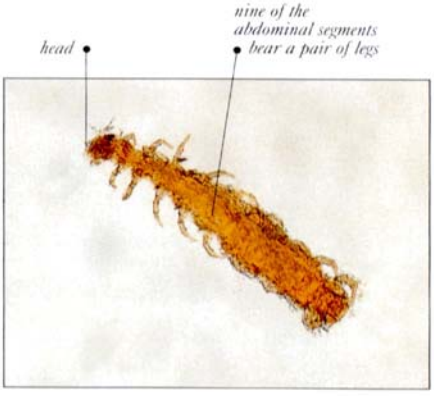
PAUROPODS

These small myriapods have very pale, slender bodies and relatively long legs. The upper surface of the head and trunk carry long, pale, slender hairs, which have a sensory function. The antennae have four segments, and the last segment is divided into two branches. Despite their small size, pauropods can move quite quickly through soil crevices.

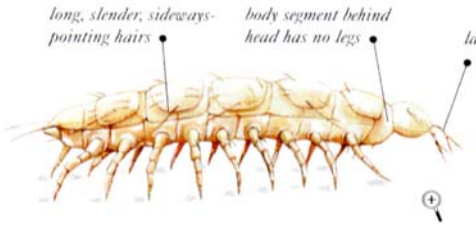
• **LIFE CYCLE** In most species, the females deposit their eggs, either singly or in small batches, in the soil or among rotting plant matter. The complete life cycle, from egg to adulthood, takes about three or four months.

• **OCCURRENCE** Worldwide. In various habitats, especially woodland, in soil, leaf litter, and rotting logs, in damp, draft-free places. Some species are very widespread.

• **REMARK** This family contains most of the known species of pauropod.



ALLOPAUROPUS DANICUS is found throughout the Northern Hemisphere. It has long, fine body hairs that are not visible on this slide-mounted specimen.



***PAUROPUS* SPECIES** may resemble very small, grublike centipedes (see pp.240–41) in general appearance. They can be very abundant in forest humus and leaf litter.

Length ¼–⅛in (0.5–2mm)	Feeding habits

SYMPHYLANS

A RELATIVELY SMALL GROUP, the order Symphyla contains just 2 families and 175 species. These small, soft-bodied myriapods are usually white or pale brown or gray. The head bears a pair of long and threadlike antennae and three pairs of mouthparts. There are no eyes. Behind the head is a trunk, made up of 14 segments. In adults, the first 12 segments typically have a pair of six-segmented legs. The last trunk segment has a pair of short spinnerets, similar in appearance to the cerci found in insects, but whose function is to produce fine silk. Unlike pauropods (see p.238), symphylans have trunk segments with tergites that are not fused together in pairs. Some of the tergites are also doubled in most species. This higher number of unfused tergites gives symphylans a great deal of flexibility.

Symphylans live in soil or in leaf litter, often in vast numbers, where they feed on plant material. Fertilization is indirect, with the female of the species picking up a spermatophore that has been deposited by the male. It is not clear whether symphylans are more closely related to centipedes (see pp.240–41) or to pauropods (see p.238) and millipedes (see pp.242–43); they have characteristics that are suggestive of both groups.

Order SYMPHYLA	Family SCUTIGERELLIDAE	No. of species 100

SCUTIGERELLIDS

These are short and stout symphylans with tough tergites. They are typically pale gray, straw-colored, or white. Scutigerellids are highly flexible and are also able to run very rapidly, twisting and turning their way through tiny crevices to escape predators.

• LIFE CYCLE The females use their mouths to pick up the stalked spermatophore deposited on the ground by the males, keeping the sperm in special pouches in their mouth. The females also use their mouthparts to remove eggs from their genital opening and then smear the eggs with sperm and stick them to a plant or position them in a crevice in the soil. A cluster of about 30 eggs may be laid at one time. When they hatch out, the first-stage young have six pairs of legs. They gain additional body segments and legs with each successive molt. Some species of symphylan can live for three or four years.

• OCCURRENCE Worldwide. In varied habitats, in soil and leaf litter.

• REMARK Many species are root-feeders and can cause losses in seedling and tuber crops.

SCUTIGERELLA IMMACULATA is commonly found in gardens and so is popularly known as the Garden Symphylan. Like several other symphylan species, it may become a minor pest in greenhouses.

Length ⅛–⅜in (3–8mm)	Feeding habits

CENTIPEDES

THE 4 ORDERS, 22 FAMILIES, and 3,000 species in the class Chilopoda – the centipedes – are predacious and hunt mostly at night. They use poison claws to kill prey, which in some cases is as large as mice. Centipedes are long and usually flat, with a head that bears mouthparts and segmented antennae. The trunk has at least 16 segments, most of which carry a pair of legs, the last being the longest. Usually yellow or brown, the body may be green- or red-tinged and is covered with fine sensory hairs.

Courtship is common. Males drop sperm on the ground that the female picks up. Eggs are laid singly or brooded underground in batches. Common in a range of habitats, many centipedes are found in temperate regions but most are native to subtropical and tropical areas.

Order GEOPHILIDA	Family GEOPHILIDAE	No. of species 200

GEOPHILIDS

The body of these straw-colored to brown centipedes is long, slender, and made up of at least 35 segments. The legs are short.

• **LIFE CYCLE** Females typically lay eggs in soil, but some lay eggs under bark and use their poison claws to position and turn them. The young have most of their legs before they hatch.

• **OCCURRENCE** Worldwide. In most habitats, forming burrows in soil, leaf litter, and debris.

• **REMARK** Their name means "earth-loving."

***GEOPHILUS* SPECIES** females brood egg masses underground, coiling their bodies around them. There are up to 181 pairs of legs, depending on the species.

Length ⅜–2in (1–5cm)	Feeding habits

Order LITHOBIIDA	Family LITHOBIIDAE	No. of species 1,500

LITHOBIIDS

Most lithobiids are red-brown, but some are brightly colored. The tough, flat body has 15 pairs of legs, the last two pairs being the longest. Some species have eyes consisting of up to 34 ocelli.

• **LIFE CYCLE** Females lay round eggs singly, one or two days apart and push them into the soil. Newly hatched young have seven pairs of legs and gain a leg-bearing trunk segment at each molt.

• **OCCURRENCE** Worldwide, especially in temperate parts of the Northern Hemisphere. In most habitats, in cracks and crevices.

▷ ***LITHOBIUS VARIEGATUS*** is common among the litter of deciduous woods. It climbs trees in search of food.

◁ ***LITHOBIUS FORFICATUS*** is found under stones and bark throughout the Northern Hemisphere.

Length ¼–1½in (0.6–3.8cm)	Feeding habits

Order SCOLOPENDRIDA	Family SCOLOPENDRIDAE	No. of species 400

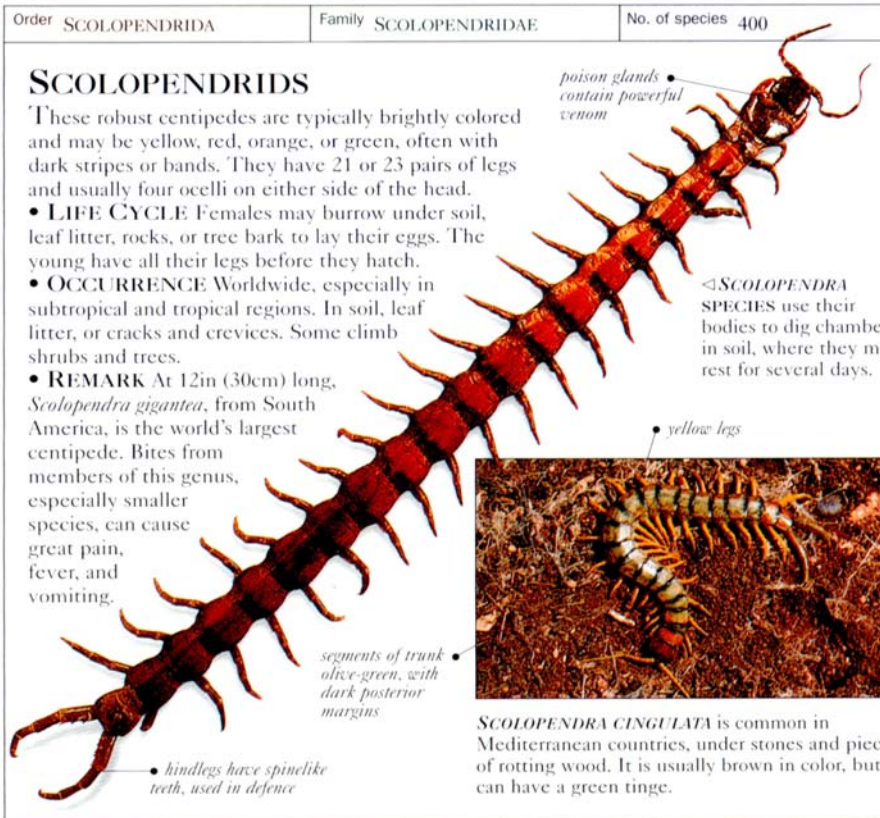
SCOLOPENDRIDS

These robust centipedes are typically brightly colored and may be yellow, red, orange, or green, often with dark stripes or bands. They have 21 or 23 pairs of legs and usually four ocelli on either side of the head.

• **LIFE CYCLE** Females may burrow under soil, leaf litter, rocks, or tree bark to lay their eggs. The young have all their legs before they hatch.

• **OCCURRENCE** Worldwide, especially in subtropical and tropical regions. In soil, leaf litter, or cracks and crevices. Some climb shrubs and trees.

• **REMARK** At 12in (30cm) long, *Scolopendra gigantea*, from South America, is the world's largest centipede. Bites from members of this genus, especially smaller species, can cause great pain, fever, and vomiting.



◁ ***SCOLOPENDRA* SPECIES** use their bodies to dig chambers in soil, where they may rest for several days.

SCOLOPENDRA CINGULATA is common in Mediterranean countries, under stones and pieces of rotting wood. It is usually brown in color, but it can have a green tinge.

Length 1¼–12in (3–30cm)	Feeding habits

Order SCUTIGERIDA	Family SCUTIGERIDAE	No. of species 150

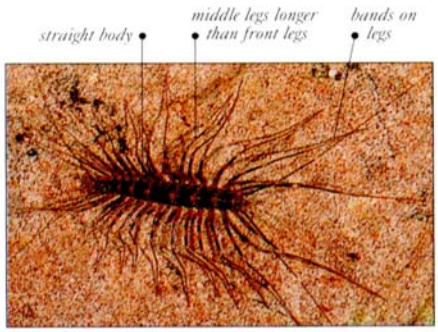
SCUTIGERIDS

These fairly short centipedes are brown with paler markings. They have 15 pairs of very long legs. Those at the rear are much longer than those at the front. The body is kept straight by rigid, overlapping "plates" (tergites). The round head bears large compound eyes.

• **LIFE CYCLE** Females lay one egg at a time – on the ground, in crevices, and among debris – and show no brooding behavior. Newly hatched young have seven pairs of legs and gain a leg-bearing trunk segment at each molt.

• **OCCURRENCE** Worldwide, but mainly in warm regions. In various habitats, including buildings and caves.

• **REMARK** *Scutigera coleoptrata*, the House Centipede, can run at 16in (40cm) per second.



***SCUTIGERA* SPECIES** are fast-running insectivores. A few species are commonly found inside buildings all year round and also in the open during summer.

Length ⅜–2in (1–5cm)	Feeding habits

MILLIPEDES

WITHIN THE CLASS DIPLOPODA, there are 13 orders, 115 families, and 10,000 species. The majority of millipedes are dull in color and are slow-moving, with tough, cylindrical bodies, strong mandibles, and seven-segmented antennae. The first four trunk segments have no legs; the other segments bear two pairs of legs. Although the common name implies that they have 1,000 legs, most have far fewer and none has more than 750. Males twist their bodies around the females to transfer sperm. A female lays her eggs inside soil nests, and most young hatch out with six legs, gaining legs and body segments as they molt.

Most millipedes live in soil, leaf litter, or debris, eating mainly rotting organic matter or fungi. To protect themselves, they roll up or produce toxic chemicals.

Order GLOMERIDA	Family GLOMERIDAE	No. of species 200

PILL MILLIPEDES

The trunk of this millipede is made up of 13 segments. The shape of the dorsal plates covering each of these segments allows it to roll up into a tight ball with its head tucked in. The small species are drably colored, but large species can be brightly marked. Adults have 15 pairs of legs.

• **LIFE CYCLE** As with all millipedes, the females typically lay their eggs in nests that they have made in the soil.

• **OCCURRENCE** Widespread throughout both warm and cool temperate regions of the Northern Hemisphere. In soil and caves.

GLOMERIS MARGINATA can easily be confused with pill woodlice (see p.212) when completely rolled up, although it has a shinier body.

Length 1/16–3/4in (0.2–2cm)	Feeding habits

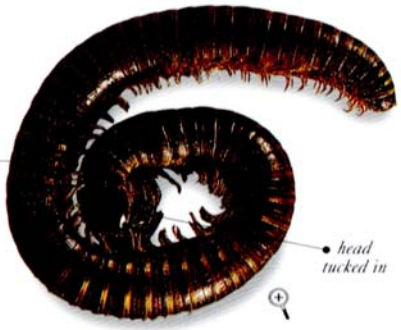
Order JULIDA	Family JULIDAE	No. of species 450

CYLINDER MILLIPEDES

As their common name implies, these millipedes have very rounded bodies. They are usually dull in color, although a few species may have either red or pale cream or brown spots.

• **LIFE CYCLE** Like all millipedes, the females of this family typically lay their eggs in nests in soil. There are usually seven nymphal stages.

• **OCCURRENCE** Mainly in the Northern Hemisphere, especially Europe and Asia. In a variety of habitats, in soil and leaf litter and underneath stones and rotting wood. Some species may be found in caves and at high altitudes.



***JULUS* SPECIES** are typical of millipedes in using their strong, stiff, body segments and many legs to push themselves through soil and leaf litter.

Length 5/16–3 1/4in (0.8–8cm)	Feeding habits

Order POLYDESMIDA	Family POLYDESMIDAE	No. of species 200

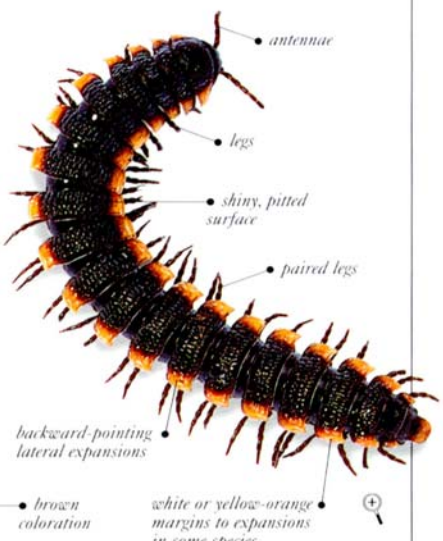
FLAT-BACKED MILLIPEDES

Also known as plated millipedes, members of this family are less rounded than other millipedes. They have no eyes and are generally dull-colored, with expansions on the top part of their body segments that project horizontally. In most species, many of the body segments contain glands that can produce toxic chemicals to deter predators.

• **LIFE CYCLE** Like other millipedes, the females lay eggs in nests made in soil. Young stages live in the soil, whereas older stages and adults forage for food on the surface.

• **OCCURRENCE** Northern Hemisphere. In woodland leaf litter. Some species are found in caves.

• **REMARK** Some Californian species in the genus *Motyxia* are luminescent. There are other species of flat-backed millipede that can live under water.



***POLYDESMUS* SPECIES** may be mistaken for centipedes because of their flat shape. However, members of this genus can easily be distinguished by their paired legs – obvious in the right-hand specimen.

Length 3/16–1¼in (0.5–3.2cm)	Feeding habits

Order SPIROSTREPTIDA	Family SPIROSTREPTIDAE	No. of species 800

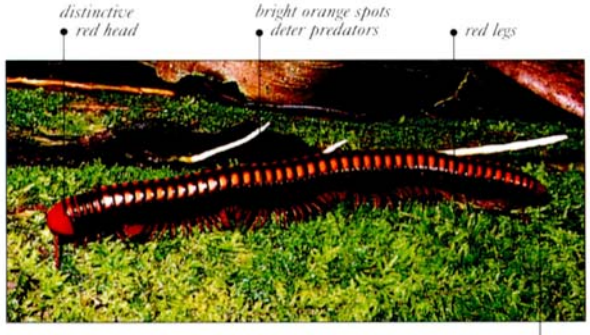
SPIROSTREPTIDS

Some of these millipedes are brightly colored, although most are dull. The body segments are typically smooth, but they may be pitted.

• **LIFE CYCLE** Eggs are laid in soil nests.

• **OCCURRENCE** Mostly Southern Hemisphere, in subtropical and tropical regions. In forests but also in semiarid areas. Some are found in trees.

• **REMARK** This family contains the world's largest millipede, the African species *Graphidostreptus gigas*.



***SPIROSTREPTUS* SPECIES** are giant, brightly colored tropical millipedes. The bright coloration warns predators that they can secrete toxic chemicals from their body segments.

Length 1/2–11in (1.2–28cm)	Feeding habits

GLOSSARY

Many of the terms described here are illustrated in the introduction (see pp.6–45). Words in **bold** type are defined elsewhere in the glossary.

• **ABDOMEN**
The rearmost of the three main segments of a typical **insect**. The head and **thorax** are the other two main segments.
• **AMETABOLOUS**
Developing without obvious **metamorphosis**.
• **ANTENNA (*pl.* ANTENNAE)**
One of a pair of mobile appendages on the heads of insects and certain other invertebrates; they respond to taste and touch.
• **ARACHNID**
An **arthropod** with a body that is divided into two main parts (the **cephalothorax** and **abdomen**), and has **chelicerae**, four pairs of **walking legs, pedipalps**, and **simple eyes**.
• **ARTHROPOD**
A member of the phylum Arthropoda. Arthropods have segmented bodies with jointed limbs and a tough **exoskeleton**.
• **CARAPACE**
The toughened protective **dorsal** plate covering the **cephalothorax** of some **arthropods**.
• **CASTE**
A physically or behaviorally specialized group within an insect colony.
• **CEPHALOTHORAX**
The body section in **arachnids** and **crustaceans** made up of the fused head and **thorax**.
• **CERCUS (*pl.* CERCI)**
One of a pair of "tails" extending from the end of the **abdomen** in some **insects**, often with a sensory function.
• **CHELICERA (*pl.* CHELICERAE)**
The first of six pairs of appendages on the **cephalothorax** in **arachnids**. Chelicerae are pincer- or fanglike and used mainly for handling prey.
• **CHRYSALIS**
The **pupa** of a butterfly.
• **COCOON**
A protective case made by the fully grown **larva** of many **insects** just before **pupation**. It is composed partly or completely of silk.
• **COMPLETE METAMORPHOSIS**
See **Metamorphosis**.
• **COMPOUND EYE**
The large eye, made of numerous separate facets (called ommatidia) found in many insects.
• **CREMASTER**
The hooked appendage on the rear end of a **chrysalis**.
• **CRUSTACEAN**
An **arthropod** with jaws and gills. Crustaceans are typically marine; the main terrestrial examples are species of woodlice (see p.212).
• **CUCKOO**
An insect that uses the food stored by another to rear its own young.
• **CUTICLE**
See **Exoskeleton**.
• **DORSAL**
Relating to the upper surface, or "back," of a structure or organism. *See also* **Ventral**.
• **DORSO-VENTRALLY FLATTENED**
Flattened from top to bottom (rather than side to side).
• **DRONE**
A male honeybee, whose sole function is to mate with the queen.
• **ECOSYSTEM**
A web or linked network of relationships and interactions between living things and their environment.
• **ECTOPARASITE**
A **parasite** that lives on the outside of its **host**, feeding on it without killing it. Notable examples include lice (see p.83) and fleas (see p.135).
• **ECTOPARASITOID**
A **parasitoid** that lives on the outside of a **host**, feeding on it and killing it in the process.
• **ELYTRON (*pl.* ELYTRA)**
The rigid forewing of a beetle, which protects the hindwing.
• **ENDOPARASITE**
A **parasite** that lives on the inside of a **host**, feeding on the host but not necessarily killing it.
• **ENDOPARASITOID**
A **parasitoid** that lives on the inside of a **host**, feeding on it and killing it in the process.
• **EXOSKELETON**
The protective or supporting structure (cuticle) covering the body of an arthropod.
• **EYESPOT**
An eyelike marking, as on the wings of certain butterflies and mantids.
• **FEMUR (*pl.* FEMORA)**
The third segment of the leg (away from the body), situated just above the **tibia**. The femur is often the largest segment of the leg.
• **FURCULA**
The forked, **abdominal** jumping organ of springtails (see p.207).
• **GALL**
An abnormal outgrowth on various parts of a plant, caused by an insect or other organism (the gall-former). Aphids (see p.99) and gall wasps (see p.196) are some of the major gall-forming insects.
• **GILL**
The respiratory organ in many aquatic animals, including some insect **nymphs**.
• **GRUB**
The short, legless larva of certain insects, especially beetles.
• **HALTERE**
One of a pair of small, club-shaped organs that help two-winged flies (see p.136) to maintain balance while flying. Halteres have evolved from what were once hindwings.
• **HAPLODIPLOIDY (*adj.* HAPLOID)**
A fertilization process in some insects, in which fertilized eggs produce females and unfertilized eggs produce males.
• **HEMIMETABOLOUS**
Having **incomplete metamorphosis**.
• **HEXAPOD**
An **arthropod** with six legs.
• **HOLOMETABOLOUS**
Having **complete metamorphosis**.
• **HONEYDEW**
The carbohydrate-rich liquid excrement of sap-feeding species such as aphids (see p.99).
• **HOST**
An organism that is attacked by a **parasite** or **parasitoid**.
• **HYPERPARASITOID**
A **parasitoid** that uses another parasitoid as a **host**.
• **INCOMPLETE METAMORPHOSIS**
See **Metamorphosis**.
• **INSECT**
An **arthropod** and **hexapod**, typically with a segmented body that is divided into three segments. Most insects also have antennae and one or two pairs of wings.

• **INSTAR**
The stage in an insect's life cycle between any two molts. The adult stage is the final instar.
• **LARVA (*pl.* LARVAE)**
The immature stage of an **insect** that undergoes **complete metamorphosis**.
• **LEAF-LITTER**
The layer of fallen leaves that is home to many **arthropods**.
• **LEAF-MINER**
A **larva** that burrows inside leaves, often leaving distinctively shaped tunnels, known as mines.
• **MANDIBLES**
The jaws of an insect. They may be toothed and used for biting, or they may be modified for piercing, as in mosquitoes (see p.138).
• **METAMORPHOSIS**
The transformation in a series of stages from an immature insect into an adult. In many insects, these stages form a **complete metamorphosis**, where the young look very different to the adults – as in beetles (see p.109) or moths and butterflies (see p.158). In complete metamorphosis, the immature stages are called **larvae**. The scientific name for complete metamorphosis is holometaboly. In other insects, there is an **incomplete metamorphosis**, where the young look like smaller versions of the adults – for example in mayflies (see p.48) and bugs (see p.85). The young of insects that develop by incomplete metamorphosis are called **nymphs**. The scientific name for incomplete metamorphosis is hemimetaboly.
• **MOLT**
To shed the outer covering of the body (the **exoskeleton**).
• **NAIAD**
The aquatic nymph of certain insects, especially dragonflies.
• **NYMPH**
The immature stages of those **insects** that develop by incomplete or gradual **metamorphosis**.
• **OCELLUS (*pl.* OCELLI)**
A simple, light-receptive organ on the head of many **insects**. Three ocelli are often arranged in a triangular formation on the top of the head. Also called a simple eye.
• **OVIPOSITOR**
The egg-laying tube of many female **insects**. It may be hidden or highly conspicuous.
• **PALPS**
A pair of fingerlike sensory organs that arise from the mouthparts of **arthropods**.
• **PARASITE (*adj.* PARASITIC)**
A species that lives off the body or tissues of another species – the **host** – without causing the host's death. *See also* **Ectoparasite** and **Endoparasite**.
• **PARASITOID**
A species that lives off the body or tissues of another species – the **host** – and causes the host's death. *See also* **Ectoparasitoid**, **Endoparasitoid**, and **Hyperparasitoid**.
• **PARTHENOGENESIS (*adj.* PARTHENOGENETIC)**
Reproduction without fertilization.
• **PEDIPALPS**
The second of six pairs of appendages on the **cephalothorax** of some **arachnids**. They may be used by males to transfer sperm but in some groups they are large and used for killing and handling prey.
• **PHEROMONE**
A chemical produced by animals in order to affect the behavior of other animals – for example, to attract a mate or deter predators.
• **PREDATOR (*adj.* PREDACIOUS)**
An animal that eats other animals.
• **PROBOSCIS**
The elongate mouthparts of certain insects, adapted for sucking food.
• **PROLEG**
A short, fleshy leg on a **larval insect** – for example, one of the short legs on a caterpillar's **abdomen**.
• **PRONOTUM**
The **dorsal** covering over the first segment of the **thorax**.
• **PROTHORAX**
The first of three segments forming an insect's thorax. The other two segments are the mesothorax and the metathorax.
• **PTEROSTIGMA**
A toughened, often darkened, area on the front margins of the wings of many **insects**, notably dragonflies (see p.51). Also called a stigma.
• **PUPA**
The stage during which the tissues are rearranged to form an adult body in **insects** that develop by complete **metamorphosis**. A pupa does not feed and is usually immobile.
• **PUPATE**
To turn into a **pupa**.
• **ROSTRUM**
The slender, sucking mouthparts of bugs (see p.85) or the elongate part of the head of weevils (see p.117) or scorpionflies (see p.133).
• **SIMPLE EYE**
See **Ocellus**.
• **SOLITARY**
Not occurring in gregarious or social groups.
• **SPERMATOPHORE**
A structure or "packet" produced by some **arthropods** to contain and transfer sperm to the female.
• **SPINNERET**
A moveable, conical structure at the end of a spider's **abdomen**, through which silk is extruded. There are typically three pairs of spinnerets.
• **SPIRACLE**
The breathing holes of insects, leading to the internal respiratory system.
• **STERNUM**
The **ventral** surface of an **arthropod** body segment – for example, the "breastplate" of a scorpion.
• **STIGMA**
See **Pterostigma**.
• **STING**
The modified **ovipositor** of some insects in the order Hymenoptera (see p.178), used for defense.
• **TARSUS (*pl.* TARSI)**
The "foot" (or last leg segment) of an **insect**, which is made up of a variable number of segments called tarsomeres.
• **TELSON**
The "tail" or final segment of the **abdomen** of some **arachnids** and **crustaceans**.
• **THORAX**
The middle segment of the three segments that make up an insect's body (the other two being the head and the **abdomen**). The wings and legs are attached to the thorax.
• **TIBIA (*pl.* TIBIAE)**
The leg segment that is located between the **femur** and the **tarsus**.
• **VENTRAL**
Relating to the underside or lower surface of a structure or organism.
• **VESTIGIAL**
Having attained a simple structure and reduced size and function during the evolution of the species.
• **WALKING LEGS**
Legs used for walking as opposed to other purposes, such as killing and handling prey or transferring sperm to a mate.

INDEX

C

D

E

F

G

H

I

J, K

L

M

R

S

T

U, V

W

X, Y, Z

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