SHAPES

Coloring With Color

Learning With Colour

The Colourful World of Insects

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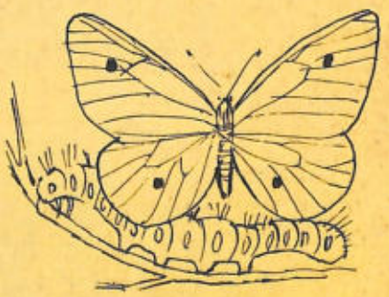

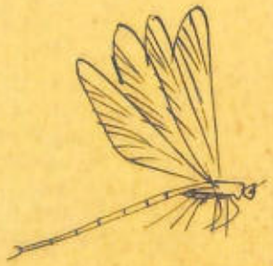

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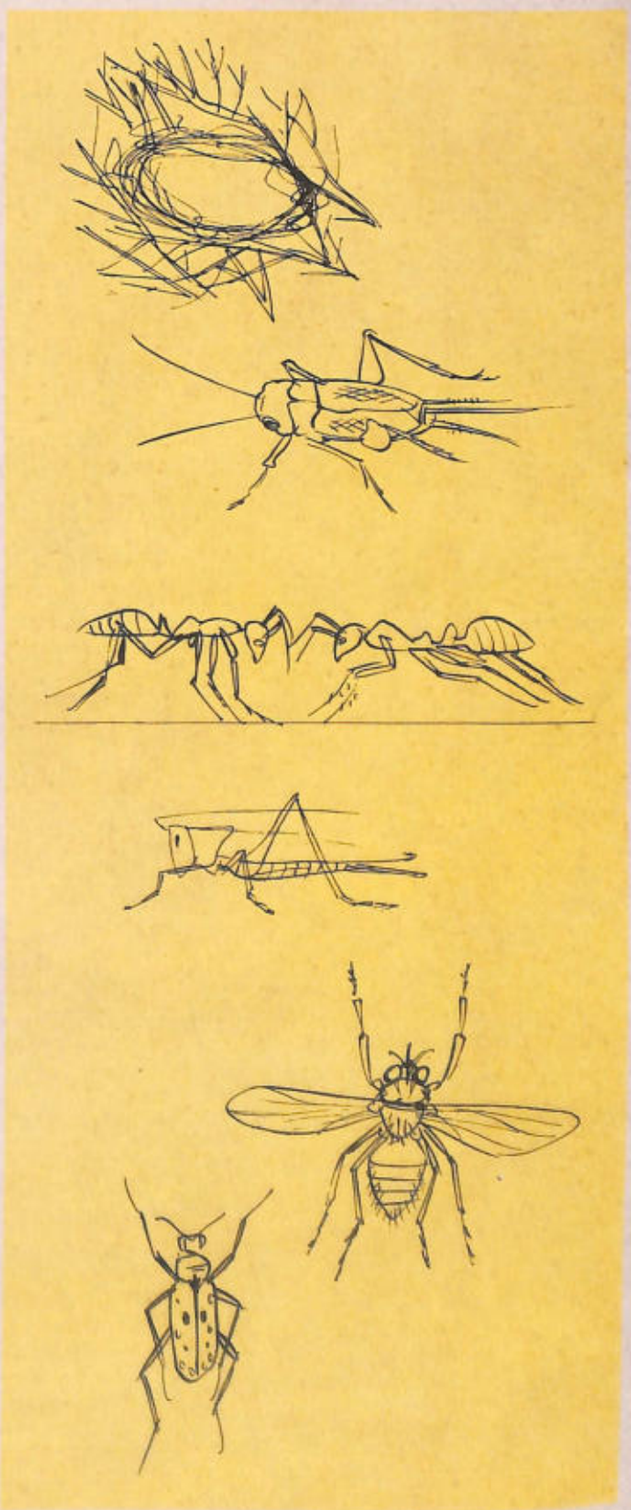



CATERPILLAR OF THE PRIVET HAWK MOTH
TWO-SPOT LADYBIRD
COLORADO BEETLE
DAMSELFLY
WASP

IO MOTH

CALOSOMA SYCOPHANTA

STAG-BEETLE

Introduction

The thrill of discovering the secrets of the insect world is something which all of us can have if we are prepared to keep our eyes open and to look. Turning the pages of this beautifully illustrated book you will see for yourself something of the wonders of insect life. That is not all. You could not possibly fail to want to know more about insects, what kinds there are, how they live and how they fit into the marvellous pattern of life in fields, woods, hedgerows, ponds, streams and, in fact, everywhere insects occur — and there are very few places where there are no insects! You will want to go out with net and note-book, and to record the places in which you find different insects and to see what they are doing and how they live. You will want to bring back some specimens and look at them at close quarters day by day and see the fascinating changes which the young insects go through.

To understand and appreciate fully something of the insect world needs not only your sharp eyes to find and watch, but also your knowledge of the kinds of things to look for, and where and when to look for them. That is just where this book will help you.

The insects here are of many countries, and they illustrate many interesting points about the natural history of insects which you can find out about for yourself if you look in your own garden or favourite bit of wood or downland. Others will be familiar, and your fun and interest will be greatly increased by the fascinating knowledge you will have got from this book.

You will be a scientist too, as you read this book. Not only will you see how scientists have made some very startling and interesting discoveries about insects, but you will realise how important insects are to human beings — and how some insects affect man and his activities. For example, the silkworm helps us by providing silk, whilst a number of insects do harm by destroying crops. You will understand, too, how other creatures, like some birds, in their turn affect insects by eating them! But I must not tell you much here. Just let me remind you that the study of insects is really an outdoor study: read this book carefully — and good hunting!

John Sankey
Juniper Hall Field Centre
Dorking
Surrey

The world of insects

Insects . . . The very word evokes the rustling of millions of wings, legs and antennae. Zoologists have counted about eight-hundred-and fifty thousand different species of insect, representing nearly three quarters of the animal kingdom.

Insects live in every environment: in the air, on land and in the water. How many are there? Only an electronic counter capable of walking, burrowing and flying would be able to assess their huge population. And yet even the biggest of them, such as the wood-eating titan longhorn beetle or the giant phasmid, are not more than ten inches long, while the smallest are microscopic.

The insects are the most highly coloured of living creatures. A thousand and one stripes, strange metallic glints and combinations of colours unknown among birds and flowers distinguish each minute subject of this vast world. A patient searcher could discover in the undergrowth scarab beetles of midnight blue or of a green more glistening than that of emeralds; and in the marshes turquoise, pale green, purple or rose-coloured dragonflies.

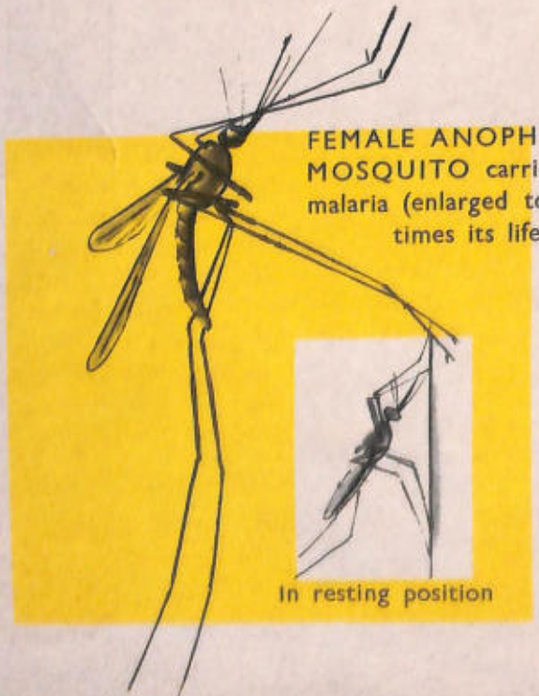
Among the winged insects there are some fragile little creatures which will die at the merest touch. There are others which on their own scale seem to have better horns than a buffalo or a rhinoceros. However, all these swaggering armour-bearers are inoffensive excavators, as is the rhinoceros beetle, who carries a trident on his forehead.

ADULT COLORADO BEETLE . . . (enlarged to three times life size)

. . . ITS LARVA (enlarged to twice its life size)

HE LARVA OF
COLORADO
BEETLE

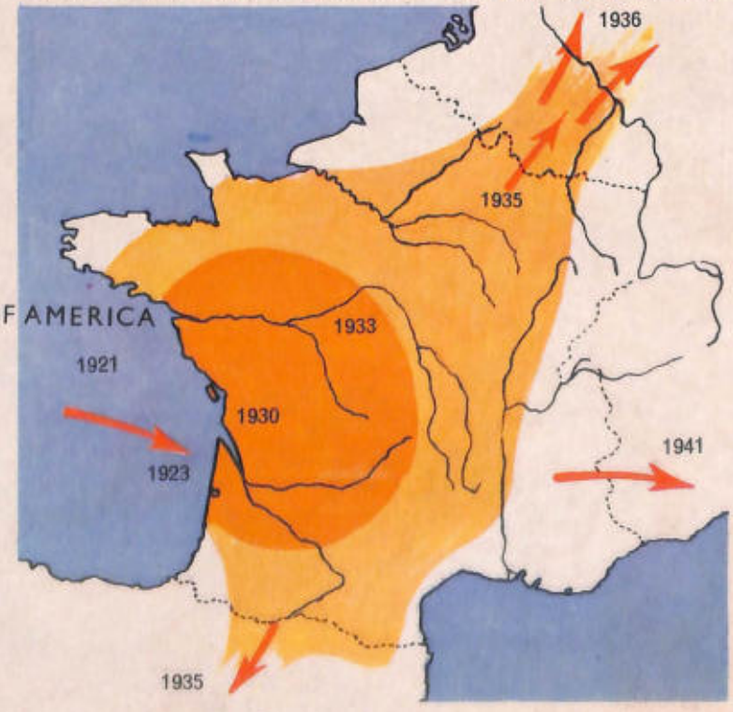
COLORADO BEETLE This comes from New Mexico and Arizona. It is a great eater of young potato shoots and can fly for several miles when helped by the wind. In Europe this insect and its larva have continued to spread despite numerous enemies such as 'insectivorous' insects, snakes, toads, birds, spiders.



FEMALE ANOPHELES MOSQUITO carrier of malaria (enlarged to five times its life size)

In resting position

STAGES IN THE COLORADO BEETLE'S INVASION



TSE-TSE FLY
(enlarged to about three times its life size)

TWO SPECIES OF TSE-TSE FLY spread the dreaded sleeping sickness among men and mammals in Equatorial Africa. One of them inhabits damp valleys, while the other prefers dry regions. Both prick men or beasts indiscriminately.

The insect world hums with the vibrating wings of flies, mosquitoes, wasps, bees and bumble-bees. The insects also have their own true musicians, such as the crooning cricket which chirps in the morning and evening, or drums a tattoo all day long. And as soon as night falls the insects fill the tropical forest with their deafening outcry.

Some insects disguise themselves: they resemble either the natural surroundings where they hunt or gather, or other insects of which they themselves are parasites, or even other animals reputed to be dangerous. The dead-leaf butterfly, the flower-mantis, and in particular the orchid-mantis, have magnificent camouflage. The craftiest insect impersonator has

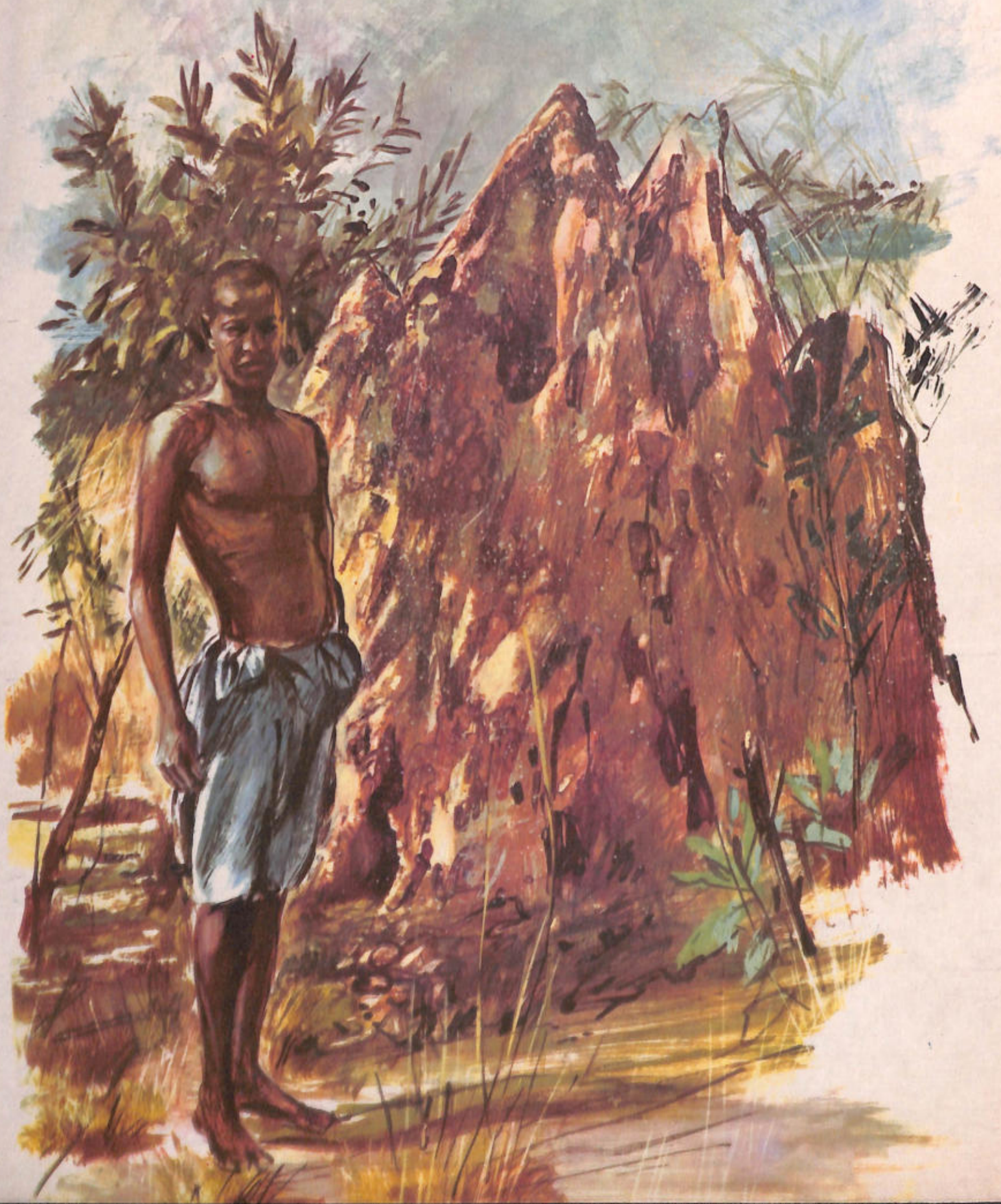
YELLOWISH GALLS
covering a vine leaf. Each one contains several hundred eggs

VINE ROOTS deformed by the pricking of Phylloxera larvae

ADULT PHYLLOXERA
(usual length: 1 millimetre)

PIMPLE
or GALL
greatly magnified

TERMITES: these social insects are the greatest builders in the animal kingdom. Some termite-mounds in Central Africa have clay walls over twenty feet high and over a foot thick, and are as striking as a three-storey house. If man wanted a building as high in proportion to his own size, he would have to build a mountainous sky-craper over nine thousand feet high.



INVASION OF NORTH AMERICA BY THE COLORADO BEETLE

Devastated areas

Areas of important damage

Territory occupied by the Colorado beetle at the moment

Mountain barriers over 5,500 feet high

A NATIVE OF NEW MEXICO and Arizona, the Colorado beetle invaded the prairies in the north of the United States from the eighteenth century onwards and then the eastern territories. In the south-west its progress has been halted by the arid lower valley of the Colorado, in the west by the Sierra Nevada and to the north-west by the Rocky Mountains.

an open invitation to meals in the homes of the ant species which it imitates. Many flies, in order to be left alone in peace, have borrowed from the most poisonous species of wasp their black and red- or yellow-stripes. Several species of butterfly in tropical forests pretend to be the head of a screech-owl by spreading out their wings. The caterpillar of the hawk-moth of Brazil adopts the shape and attitude of the head of the dreaded cobra.

Insects have extraordinary physical strength which enables them, on their own scale, to outdo the athletic performance of man and other mammals. The secret of their might is in the number and lightness of their legs as well as in the sometimes monstrous development of one pair of limbs; as, for instance, the third pair of legs on jumping insects like the grasshopper, the jaw-pincers of certain scarab beetles.

Look at some records. The flea and the grasshopper, starting from the ground, jump up to a foot in the air. If its rear legs are well supported, the louse can carry a burden two thousand times the weight of its own body. The ants are the champions at weight-lifting. Their workers cart stones or eggs three times as big as themselves. The record-holders for flying are probably the large robber flies which are capable of lifting into the air a prey twice as heavy as themselves by clasping it firmly with their legs. If the king of the strong men, the scarab of tropical America, were six feet and not six inches long, it would be much lighter and considerably stronger than the elephant,

the biggest of the land mammals. When escaping, this thick-skinned animal upturns young trees with a single blow of its shoulder.

The miniature jungle of the insects is, like the real one, strewn with traps and haunted by lions. It has its blood-suckers (the cunning larvae of the ant-lion), its cannibals (the praying mantis) and its stingers (giant wasps), with a sting as tough as a steeel needle. The most powerful carnivorous (flesh-eating) insects lie in wait in the forests of grass and the valleys of bark, or hunt in flight like the large dragonfly. They are recognisable by their clawed legs, their jagged jaws and cutting mandibles. In proportion to their size they are better equipped for tearing up and devouring their prey than the lion.

Among insects the balance between the carnivorous and the herbivorous (plant-eating) is maintained by laws much stricter than those of the full-size jungle. Whereas the Bengal tiger devours indiscriminately buffalo, deer or other large herbivorous animals, each different species of wasp pursues its own particular prey. Everything happens as though Nature had given each species the task of devouring another. Each of these killers has its own secret thrust, which is the only one it knows, and it is amazingly precise. Observe a wasp attacking a weevil. After a short struggle the wasp overturns the weevil on to its back and stings it between the first and second pair of legs. The wasp knows that by striking exactly on this spot her sting simultaneously reaches the three nerve centres of the weevil. The result is instantaneous paralysis. Another cleverer and bolder wasp hunts only the tarantula, the most poisonous of the field spiders. She keeps the spider securely on its back by means of her mandibles and legs. With a surgeon's composure she stays in this position waiting for the right moment to neutralise the terrible fangs of the tarantula with a well-aimed thrust of her sting. Once the spider has been made harmless, the wasp has all the time she wants to paralyse it completely and to carry it off still sleeping to her lair.

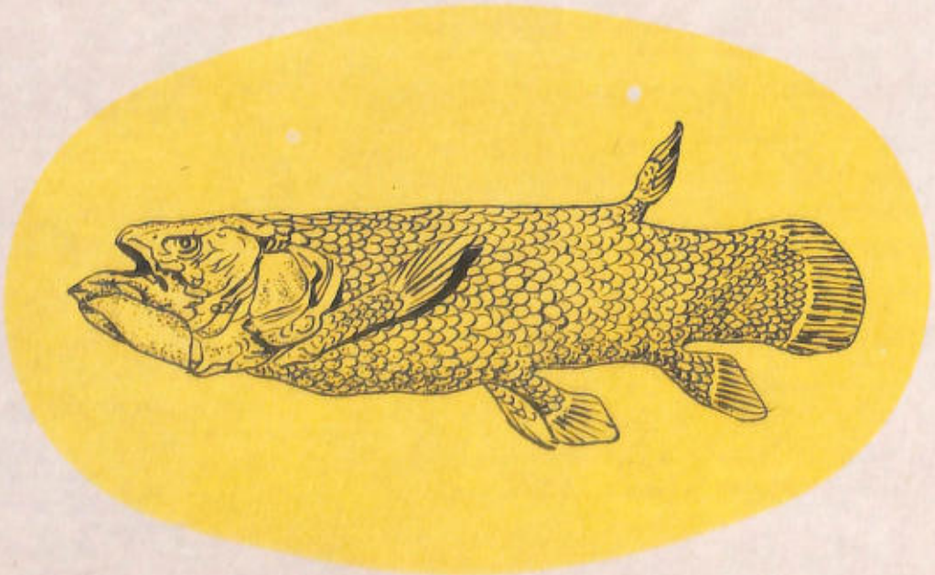
The social insects are the higher animals in the insect world. Their organisation shows a strange resemblance to human society. Among the more evolved species of ants and termites, the social structure is even more highly developed than among some primitive peoples of the present day. It is astonishing to discover within a termite mound a fortress, a city and a kingdom: a fortress defended by helmeted soldiers covered in chitin; a city whose outskirts are in perpetual expansion; a kingdom where the queen has her own devoted servants and a military bodyguard.

In the large group of social insects the ants are easily the most highly organised. They have market-gardeners, harvesters and ranchers: a complete little world of order and industry. Sometimes their underground cities and nests in the open air are devastated by the Amazon ants. These warrior species are the slave-making or merciless killer ants.

The ants, whether war-like or peaceful, are, together with man, the only inhabitants of our planet to go to war for territorial gain. Two colonies of the same species may live peacefully for several years a short way from one another, until the day when one finds itself overpopulated and so goes to war with its neighbour to increase its territory.

The first human beings appeared on the Earth less than a million years ago: the ants were already forming organised societies thirty million years ago. Luckily for man the rise of the ants was mysteriously halted, whereas human society has never stopped progressing. What would have been the destiny of the social insects if evolution had made them as big and strong as man, and what would have happened to man?

THE COELACANTH: this bony fish has probably been living in the sea for three hundred million years. Many naturalists think that, in evolution, it is the intermediate link between fish and amphibians.



THE HISTORY OF LIFE ON EARTH

THE CREATION OF THE EARTH

The solar system is thought to have come into being 6,000 million years ago. The Earth then consisted of molten rocks which gradually cooled and grew solid. Formation of the earth's crust. Powerful volcanic eruptions. Rivers of lava furrow the earth's new-born crust. Fire, rock, sea and rain are the only elements present.

THE ARCHAIC ERA (3,500 million years ago)

Nothing living. Life appeared in the oceans in the form of algae about 2,700 years ago. The earliest fossil is that of an alga.

THE PRIMARY ERA

CAMBRIAN (500 million years ago). Aquatic plants move out of the seas on to the shore. Numerous species of marine animals with shells. Evolution of the invertebrates: trilobites, the earliest forerunners of the insects?

SILURIAN (400 million years ago). The plants spread further and further into the dry land. The first fish. Rapid development of the invertebrates. Appearance of the first land animals, that is, animals with aerial respiration, like scorpions and spiders.

DEVONIAN (300 million years ago). Marine insects without wings. period of great development for fish, some of which leave the water and become amphibians. The first crabs, ferns and conifers.

CARBONIFEROUS (280 million years ago). Evolution of the amphibians. The insects are marine rather than land animals and look like cockroaches. Appearance of the reptiles. Development of giant fern and conifer species.

PERMIAN (225 million years ago). Evolution of the primitive reptiles. Great development of modern insects.

THE SECONDARY ERA (The era of the reptiles)

TRIASSIC (200 million years ago). Large numbers of bony fish. On land the reptiles (dinosaurs) and trees (cordaites) reached enormous proportions. Appearance of the first mammals.

JURASSIC (175 million years ago). Some of the reptiles begin to evolve into modern species like the crocodiles and lizards.

CRETACEOUS (150 million years ago). Disappearance of the dinosaurs. The first snakes and modern fish. Birds with teeth.

THE TERTIARY ERA (The birth of present-day flora and fauna)

EOCENE (75 million years ago). The higher mammals succeed primitive mammals. Development of the birds.

OLIGOCENE (50 million years ago). Evolution of the higher mammals.

MIOCENE (35 million years ago). Evolution of the horse. Appearance of flowering plants and flower-liking insects like bees and butterflies.

THE QUATERNARY ERA (The last million years)

PLEISTOCENE. Successive ice-ages. Some mammals become enormous like mammoths and buffalos. The first cave men.

HOLOCENE. The melting of the glaciers. Appearance of all present-day animal and vegetable species. The predominance of mankind.

THE GIANT PHASMID OR STICK INSECT inhabits Indo-Malaysia. It is a long, thin insect (about eight inches long). Many species of phasmid imitate twigs of rose-trees, ivy and exotic plants and become invisible by copying the shape and colour of the branches a lentil and leaves upon which they live.

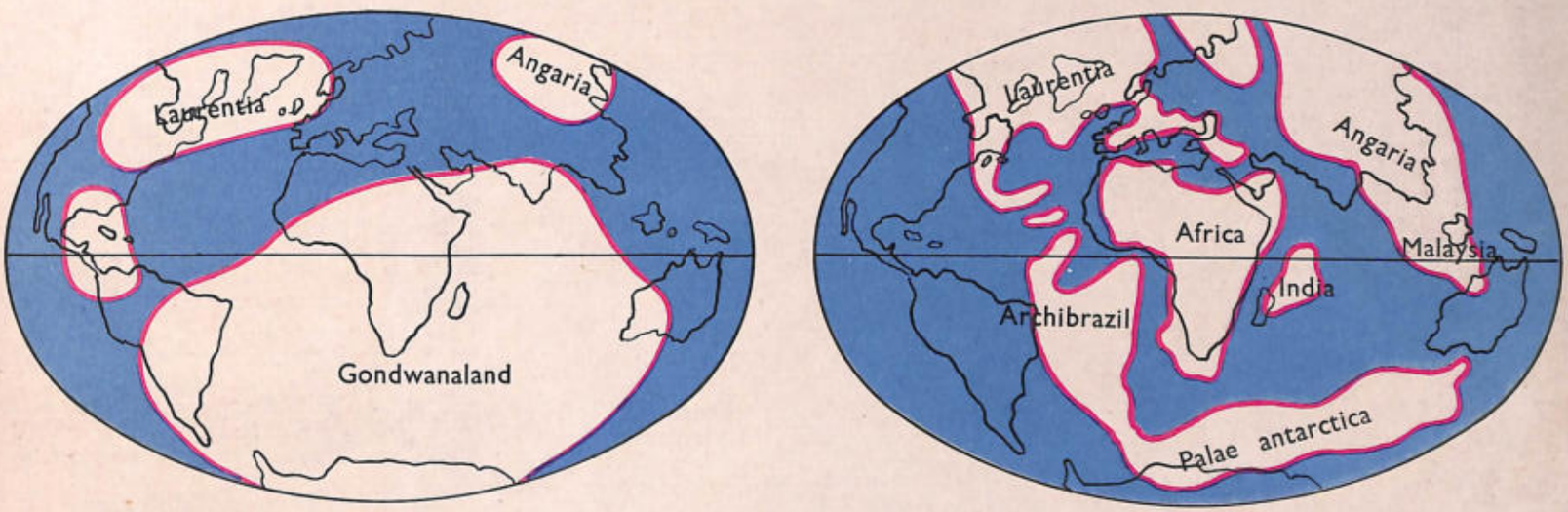
The insects' ancestors

Life appeared in the oceans during the early ages of the Earth. Scientists know practically nothing of this great beginning: they may only dream and put up theories. On their reckoning the origin of life goes back two thousand million years, when the world was completely covered by floods. At that time some simple molecules must have joined together to give birth to an organic compound, and then to the first organism. The molecules probably drew the energy necessary for their transformation from the electric discharge of the clouds. It was the sea which first sheltered the world's most simple form of life. It consisted of only one cell. Was it animal or vegetable, or some intermediate being which from the beginning bordered on both worlds? This ancestor was probably nearer to the vegetable, and almost certainly a microscopic alga. The earliest trace of life in fact is an African alga whose fossils have been found in the limestone rocks of Southern Rhodesia. This alga lived about two thousand seven hundred million years ago.

We can go no further forward in the history of the ancestry of insects without speaking of evolution.

The theory of evolution was founded by the French naturalist, Lamarck (1744—1829). According to him the changes that take place in an environment affect the behaviour of its inhabitants, whether plant or animal, and eventually lead to modifications in their organism. Thus, in the case of animals living in the darkness of caves or of ocean deeps, the eyes disappear because they become useless.

The English naturalist, Darwin (1809—1882), took up the theory of evolution again very actively. He stated specifically that evolution was the result of a process of natural selection. The only members of a species to survive are those strongest and best adap-



On the left are shown the continents which sheltered the evolution of animals and vegetables during the Carboniferous Era (according to Ardlt). On the right can been seen the fragmentation and shifting of the continents in the Cretaceous Era (according to Wegener). Then came the appearance of the present-day continents and the dispersal of the species. In many cases this explosion of the land caused the offspring of insects to be divided and evolve into different branches on both sides of the Atlantic and Indian Oceans.

ted to their environment. These superior beings in turn transmit their special qualities to a group of descendants, so that these qualities eventually spread throughout the whole species.

The theory of evolution is accepted by an ever-growing number of experts. With its help, starting from the animals of today, they have been able to go back through the ages from fossil to fossil right down to the traces of their remotest ancestors.

A new science, *radiogeology*, measures the age of rocks and of the fossils they contain. This allows the approximate evaluation of the period in the history of the Earth when the ancestors of vegetables or animals appeared.

A fossil is the impression of, or the remains of, a creature preserved in a rock.

Unfortunately there are many animals and, in particular, insects, whose geological history is interrupted at one time or another during the Primary Era. These 'missing links' have led naturalists to make guesses about what actually happened during these periods.

Five thousand years ago the trilobites appeared on the beds of the oceans. Numerous impressions of these arthropoda have been discovered, and some entomologists say that they are the remotest ancestors of the insects. Although this hypothesis is extremely controversial, the trilobites may be treated as the first citizens of the insect world.

The trilobites, five hundred million years ago

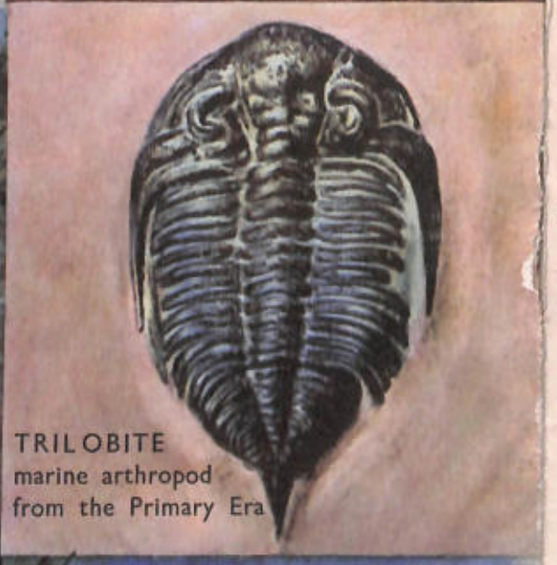
The head, thorax and abdomen of these fossil creatures are divided into three parts: one on each side and one in the middle. Because of this they were given the name of 'three-lobed sea-shell', and then of 'trilobites'.

A large number of trilobite tracks have been found on fossil sea beds. From these, zoologists have concluded that these arthropods sometimes crawled and sometimes walked, as the furrow left by their middle section disappears from time to time, leaving just the minute circular prints of their legs. At times, both the central furrow and the prints on the side disappear suddenly: doubtless these animals were also fairly good swimmers.

More than two thousand sorts of trilobite have been counted, of lengths varying from a few millimetres to about two feet. According to the species, their eyes are simple or made up of several thousands of facets. We can see how this huge variation in shape and in their organs could well give birth to a whole

500 MILLION YEARS AGO the only living things were marine animals and vegetables. The earliest trilobites were also the largest (about two feet long). The ammonites were shell molluscs, varying in size from a lentil to a motor-car wheel.

THE KING OR HORSESHOE 'CRAB' LIMULUS, an articulated marine animal descended from the trilobites which today inhabits the Caribbean Sea and the Pacific (about a foot long)



TRILOBITE
marine arthropod
from the Primary Era

AMMONITE
mollusc of the Secondary Era

range of new creatures that became increasingly different from each other. All these new species belonged, of course, to the general branch of Arthropoda (invertebrate animals with segmented bodies), but evolution had already divided them into several classes or families. The family of crustaceans adapted themselves better and better to marine life, at every level of the ocean. In this way crabs drew ahead of other walking crustaceans, which remained the ancestors to today's lobsters and crayfish. Meanwhile, other branches of arthropod preferred to live in shallow water near the shore. Among them were the marine scorpions and the early forerunners of spiders, the first shapes to herald the insects. For millions of years these arthropods lived on the border between the two environments of sea and air, and we do not know into which they first broke.

The first insects

The early insects had no wings. They first adapted themselves to life on land and in the air at the beginning of the Carboniferous Era, two hundred and eighty million years ago, or seventy million years before the appearance of the amphibians.

At that time the land which had emerged from the flood formed three continents and a few large islands.

The biggest of these, the continent of Gondwanaland, covered the whole of the world's surface that lies between the southern half of South America, the South Pole, the western half of Australia and the coastline of North Africa. The smallest continent, Angaria, lay in the north of Siberia (where the river Angara flows today) and over part of the Arctic Ocean. Finally, the third continent, called Laurentia, occupied the present-day site of Canada and Alaska, and stretched across to the British Isles and Norway.

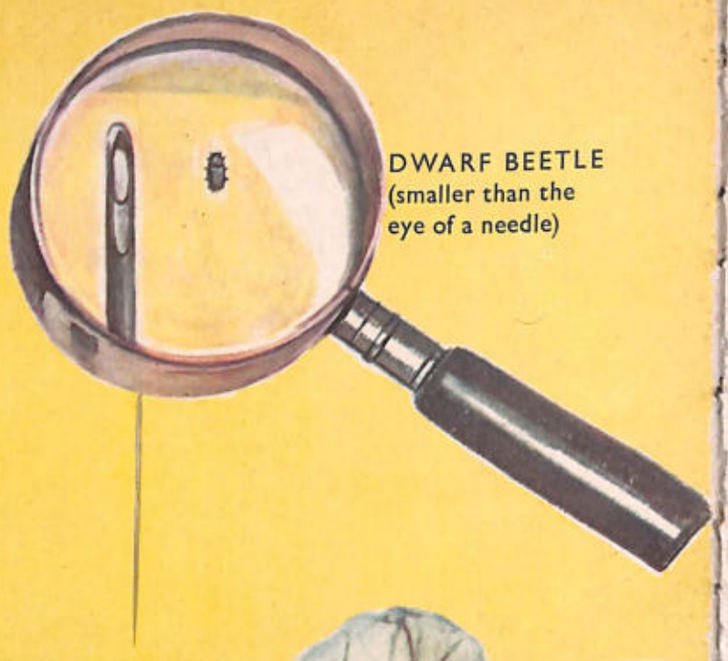
The strong tides created huge coastal marshes that altered the conditions of life, and a new world was born cradled by the powerful movement of the seas. Gradually there appeared on Gondwanaland and Laurentia new species of animal and plant life that lived only

THE MUD-SKIPPERS, fish from the warm seas, come up on to the shores. Not only are they capable of turning their eyes in every direction, but they are also equipped with buccal papillae for aerial respiraton as well as gills for breathing in the water. Already, here, they are walking on their fins and can even heave themselves on to the roots of mangrove trees. In this way marine animals became amphibians and then land animals.

MUD-SKIPPERS

in the big swamps. Here the water's surface was interspersed with a vast number of little islands and strips of land, and evolution, the directing force of life, brought about some incredible transformations. It seems probable that the swamp flora adapted itself much more quickly than the fauna. One after the other they were led to choose the sand-dunes rather than the waves. The herbivorous animals evolved parallel to the aquatic plants on which they fed, but with something of a lag, so that the plants grew stronger and more profuse. In the sunlight which bathed the new-born land their stalks sprang ever higher above the waters, and their thick, wide leaves appeared, split into delicate traceries.

GIANT GOLIATH BEETLE OF GUINEA
(life size)



DWARF BEETLE
(smaller than the eye of a needle)

BEETROOT WEEVIL
(magnified by about a third)

Modern insects

The Carboniferous Era witnessed the rise of large-scale vegetation, ferns, arborescent plants and scale-covered trees. As the wind always carried seeds further into the interior of the land, the plant-eating creatures had to adapt themselves in order to follow them. In the course of the next twenty million years all these swimming animals learnt to crawl, walk, burrow and, eventually, to fly. And the flesh-eaters, to avoid extinction, followed the plant-eaters: they too adapted themselves accordingly.

The first winged insects appeared in the hot, damp forests of Laurentia at the end of the Carboniferous Era. They were the giant ances-

THE INSECT KINGDOM has its Davids, some of them microscopic, and its Goliaths, larger than hummingbirds and longer than some small mammals. Whether vegetarians or flesh-eaters, the insects have never stopped specialising. The family of weevils alone includes more than 30,000 species which, like the beetroot weevil, ravage leaves, stalks, roots, seeds and fruit.

GIANT TITAN LONGHORN OF GUIANA
(life size)

tors of the dragonfly, the grasshopper and the mantis. In Gondwanaland during the same period the first Coleoptera (beetles) started to evolve. There was a chain reaction, a whole outburst of transformations — and from the midst of the new flora came the song of the crickets.

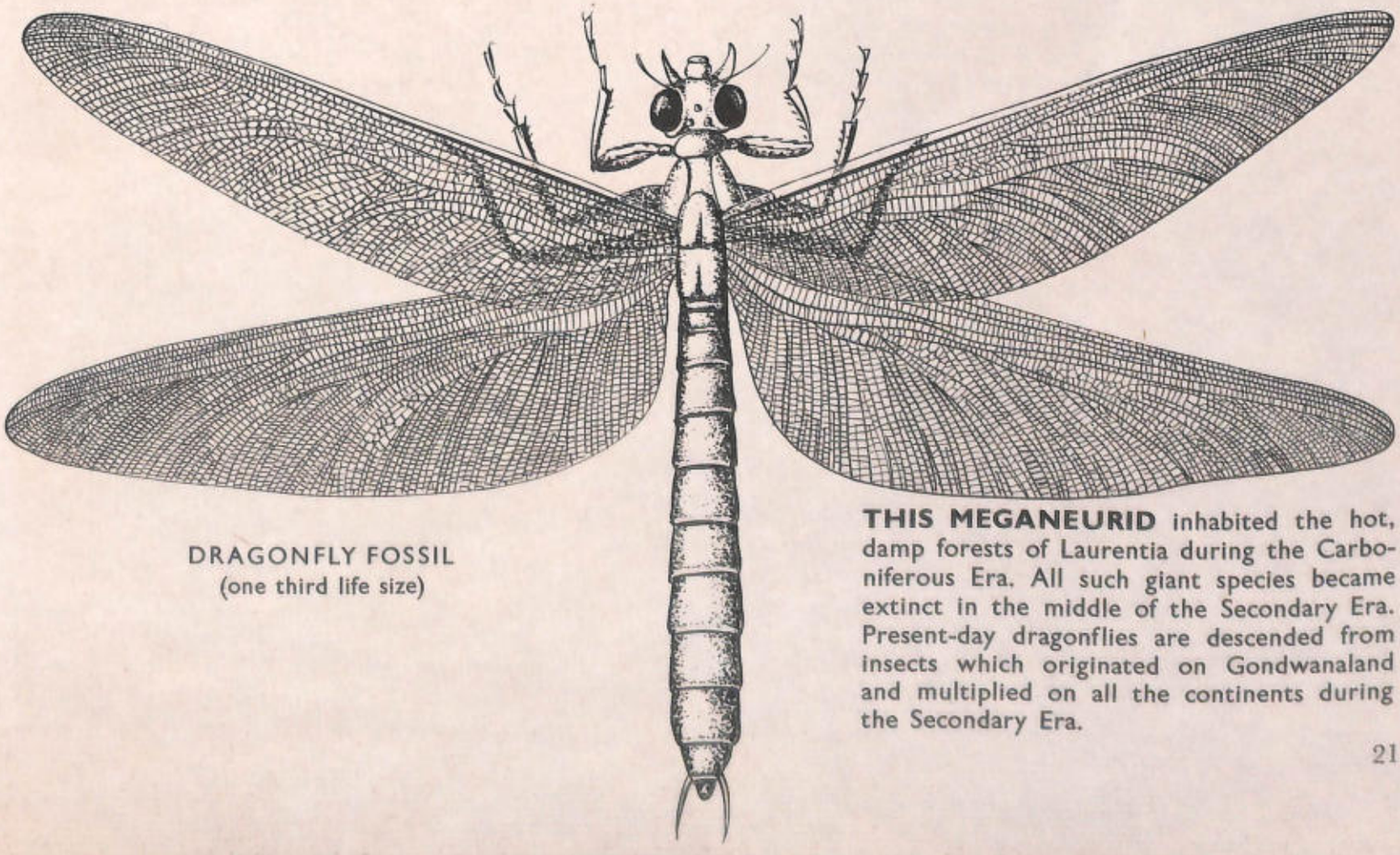
At the end of the Primary Era, with the appearance of the large reptiles, the size of the insects became smaller and the third continent of Angaria must have been colonised by insects coming from eastern Gondwanaland. It is also during this period that scientists lose track of the last species of trilobite.

In the course of the Secondary Era a tropical climate spread throughout all the land that had risen from the sea. The insects took advantage of this and invaded the three continents.

The continents began to change: they broke up, expanded, or moved away from each other, so that by the end of the Secondary Era Africa and America had begun to take on the outlines by which we know them. This breaking up of the land explains why some species of insect are today found in South America, Africa and the Far-East.

Flowering plants grew up in Angaria during the course of the Secondary Era. This in turn led to the development of the flower-loving insects (the bees and butterflies) at the beginning of the Tertiary Era, seventy five million years ago.

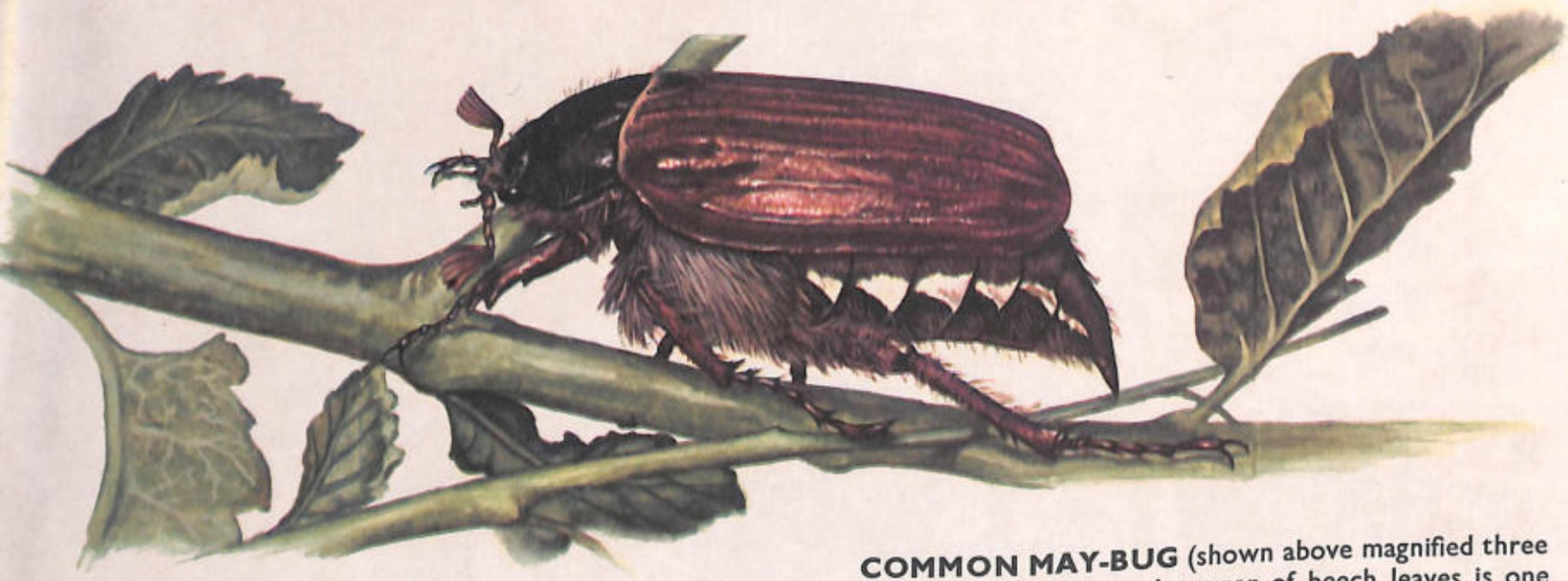
The history of the ancestors of modern insects and of their succeeding generations is told to us by the impressions which they left behind in the Earth's layers. We do not yet know, however, all the chapters of this history, and there are many insects whose geological course is more or less unknown.



DRAGONFLY FOSSIL
(one third life size)

THIS MEGANEURID inhabited the hot, damp forests of Laurentia during the Carboniferous Era. All such giant species became extinct in the middle of the Secondary Era. Present-day dragonflies are descended from insects which originated on Gondwanaland and multiplied on all the continents during the Secondary Era.

What is an insect?



COMMON MAY-BUG (shown above magnified three times). This voracious devourer of beech leaves is one of the insects best known to inhabitants of the five continents. The larva lives for three years underground eating the buried stems and roots of plants. Reproduced below are diagrams of its topside and underside showing the different parts that make up an insect's body.

The word 'insect' comes from the Latin *insectum* and means 'animal divided into sections'. The class of insects is part of the big group or phylum of Arthropoda, animals with segmented bodies.

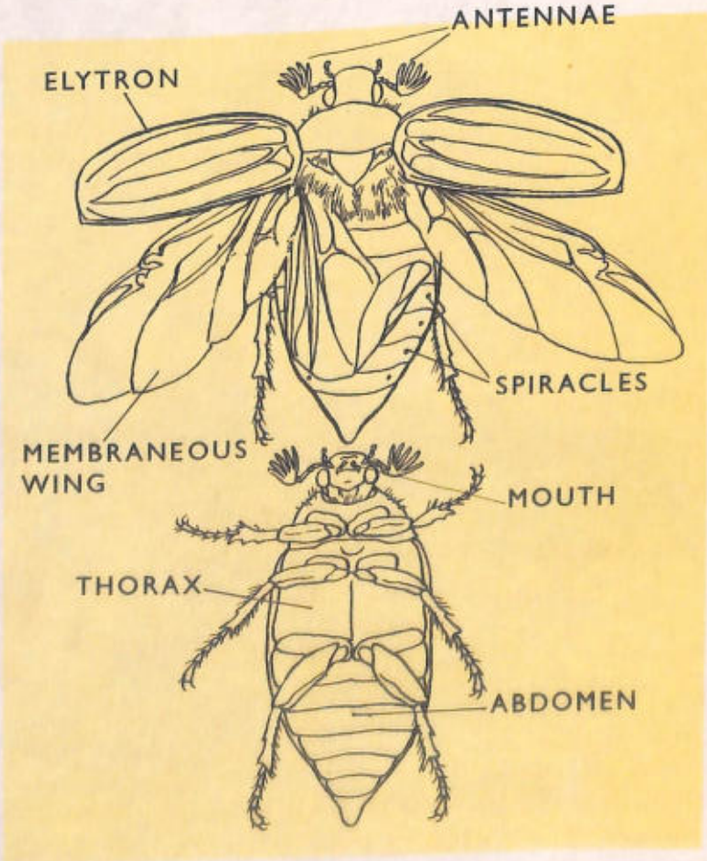
An insect has two lives: that of a larva, and then that of an insect in the true sense of the word. After its first life, or childhood, which lasts for days, weeks or longer, according to the species, the larva undergoes a change which enables it to become a perfect insect *(see: The double life of insects, page 33)*.

The perfect insect is an animal with aerial respiration. Only the larvae of some aquatic insects breathe through gills, like the fish (*see: Aquatic insects*, page 51).

The body of an insect is made up of three parts: the head, the thorax and the abdomen, all three of them protected by an external skeleton of chitin, a hard, horny substance which is often coloured *(see: The skeleton and the skin, page 23)*. Usually each section of the body has a pair of jointed appendages.

As modern insects developed, these appendages were adapted to deal with the new conditions of life and, in particular, with the ever-increasing range of plant species. To overcome the vast labyrinth of roots, stems, leaves and flowers, the insects' legs and mandibles or claws became perfect tools.

An insect has one pair of mandibles, three pairs of legs and, in most cases, two pairs of wings. It



also has complex organs of sense, which have been developed into precision instruments for feeding the insect with information on a world of many smells and colours, full of sap and nectar.

The skeleton and the skin

An insect is protected by an external skeleton composed of hard plates of chitin, joined together in the same way as the different pieces of a knight's suit of amour. It is formed by a reinforcement of the skin, which is made up of two layers. The outer covering, or cuticle, is a hard jacket of chitin, while the inner skin, or hypoderm, consists of a layer of very active cells. Some of these secrete the chitin that goes to make up the shell: others produce the black, green and red substances which give insects their colours. Some beetles and other insects also have lamellae (scales) which give the colours a sort of metallic glint by splitting up the sun's light like tiny prisms. In the same way the electric glints on butterflies are caused by the scales which cover their wings.

An insect's skin is covered by various outgrowths which may or may not be mobile. Among the beetles these outgrowths are shaped like teeth and even, sometimes, like horns: with the bees they are silky hairs, and in the case of butterflies they are scales.

The head

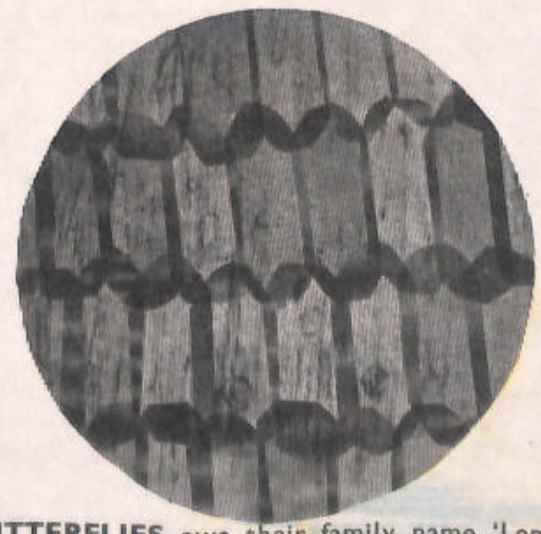
The head of an insect carries the antennae, eyes and mouth parts.

THE ANTENNAE are the highly sensitive organs of touch and smell. They take the form of two long filaments on the grasshopper, a sort of small club

MORPHO MENELAUS
at rest

MORPHO MENELAUS
in flight (life size)

BUTTERFLY WING-SCALES
seen through a microscope



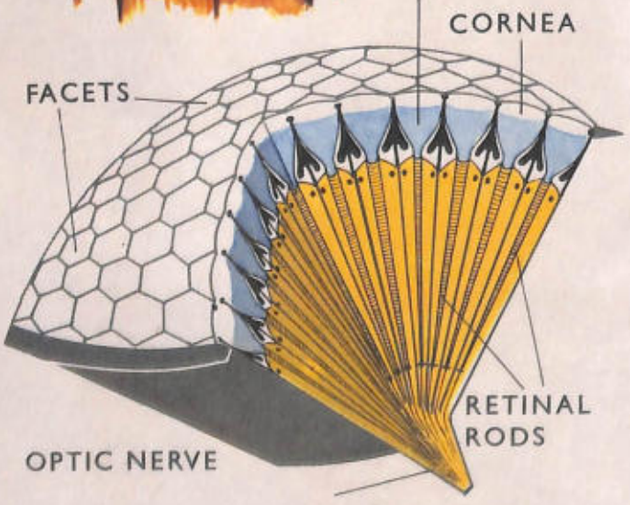
BUTTERFLIES owe their family name 'Lepidoptera' (from the Greek **lepis**, a scale, and **pteron**, a wing) to the great Swedish naturalist Karl von Linné (1707–1778). The **Morpho menelaus** is a butterfly that lives in Brazil. Its metallic blue wings are used for jewellery.

DIFFERENT ANTENNAE SHAPES

1. Club-shaped
2. Thread-shaped
3. Knotted
4. Comb-like
5. Tapering
6. Short
7. Spindle-shaped
8. Geniculate
9. Saw-toothed
10. Foliated
11. Like a string of beads
12. Feathery

ANTS' CONVERSATION (magnified seven times)

HEAD AND THORAX OF A MAY-BUG



SECTION OF A COMPOUND EYE
In a compound eye, the retina is no more than a link between the facets and the insect's brain (as in bees, dragonflies, butterflies); the facets, or lens, transmit a pattern of images to the brain which recreates the overall picture

on the flea and a delicate comb on the may-bug. Through their antennae insects can touch and feel things such as plants, leaves and stones, and make contact with other insects.

The antennae of butterflies and may-bugs are provided with thousands of small pores, pores that act as microscopic noses. May-bugs may have up to five thousand of them. The night-flying moths have a sense of smell so highly developed that it is rather like a complete radar system, sensitive even to infra-red vibrations (*see: The imitators, page 68*).

Tests show that smell rather than sight is responsible for guiding flower-liking insects. Bees have a sense of smell so highly developed that they can locate at long distances the source of a scent (the flowers to be looted) as easily as our ears allow us to fix our position in relation to sounds. Indeed, smell is the most acute of the senses in all species of insect. The inhabitants of an ant colony do not recognise each other by a password but by the smell given them once and for all by their queen. When two ants meet at the entrance to an ant-hill, they confront each other 'nose to nose' and energetically cross their antennae. If their smells differ, the meeting turns into a desperate struggle, and other ants are quick to help to kill the intruder or chase him out of the nest.

Although Nature takes great care in the positioning of the organs of sight and smell among insects, she seems less worried about the location of their ears. While ants and mosquitoes hear through their antennae, other insects such as the Orthoptera have ears on different parts of their bodies, and even on their front legs, as in the case of the cricket. Other species, as for example the American beetle, known as the passalid, have their ear and screech organ tuned to a particular wavelength — as we tune our radios to pick up a transmission.

It is with the antennae that the insects' ability to specialise is most clearly seen. The antennae of an insect parasite of the beaver are shaped like little spoons and act as storage tanks for air. (A parasite is an animal which lives on, or in close association with, another animal and benefits by this association). In the ant-hills of central Africa there has even been found a very up-to-date insect with luminous globes on the end of its antennae, which it appears to use as headlamps to find its way through the murky tunnels of the ant-hill.

THE MOUTH PARTS are adapted to an insect's eating habits. There are insects that nibble their food, lick it, lick and suck it, pierce and suck.

Browsing insects like crickets and caterpillars have

an upper lip, a lower lip, a pair of mandibles and additional jaws, also called maxillae. The mandibles of the cricket are, in proportion to its size, as powerful as the molar teeth of the large herbivorous mammals. The upper lip of the browsing insects is used only for keeping food in the mouth.

In the case of the dragonfly larva the lower lip is highly developed and forms a sort of bag, called 'the mask', which is an organ of capture. The larva flicks this rapidly in and out in front of itself, as does a fisherman with his line. The biting organs are the mandibles which enable the insect to cut things up, to gnaw and to crush. The jaws or maxillae, which masticate, contain the organs of taste. Carnivorous insects, such as the long-horned grasshopper, have fine, sharp mandibles like the canine teeth of flesh-eating mammals.

The mandibles of licking insects are less developed and in some species have even disappeared. These insects feed on liquids by means of a tongue equipped with hairs, and their lips and jaws are shaped into a trunk.

Among the insects that lick and suck juice or sap, the trunk has become the most important organ. It enables the larger butterflies to pump nectar out of flowers with long narrow corollae, into which they themselves could never penetrate. The taste buds of a butterfly are situated on the end of its legs: the uncurling of the trunk is a reflex caused by these buds, when the insect alights on a sugared petal.

The sap- and blood-sucking insects may also be prickers. In this case the mandibles are shaped like a needle and are used to pierce the skin of animals or the bark of plants. With these sting-mandibles some aquatic beetle larvae are able to inject poison into their prey. The record for the largest number of stings belongs to the female mosquito, which is equipped with six needles to help it to inject toxic saliva, and to suck the blood of its victim.

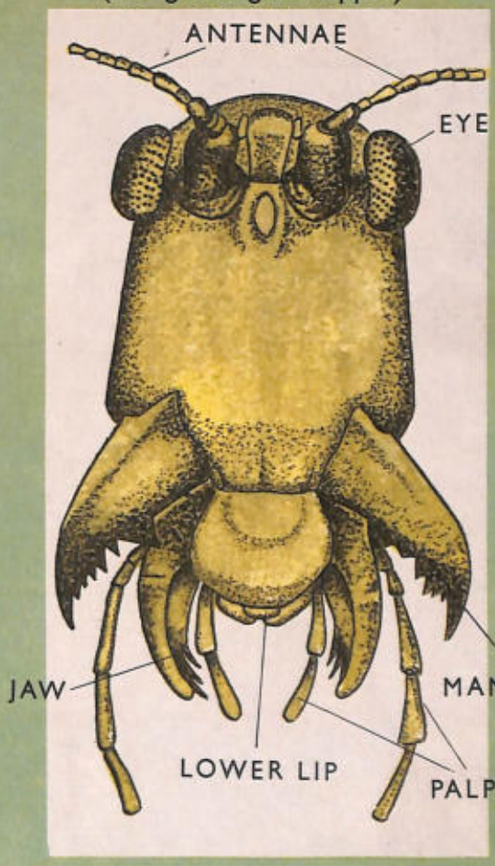
THE EYES of insects may be either simple or compound. Larvae, with very few exceptions, only have simple eyes and these disappear during transformation.

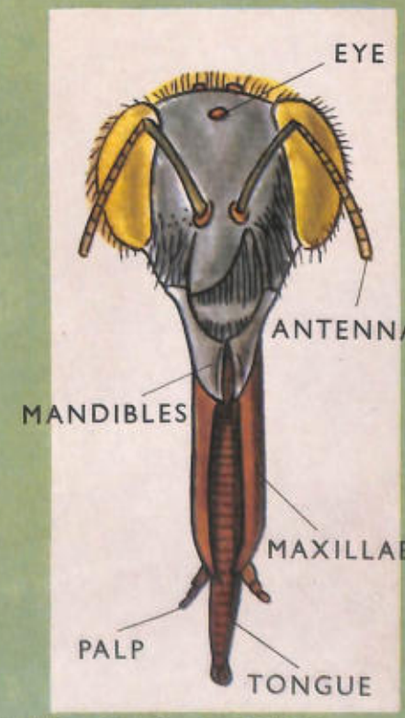
The perfect insect has two types of visual organ. The first consists of the simple eyes, or ocelli, to be found in the middle of the forehead; the second of the compound eyes. A compound eye is shaped like a half sphere: the dome is covered with facets. The number of facets varies from over twenty thousand, as in the case of bees, to a mere twenty in the ants. It is difficult for us to imagine the complicated view of the world which some beetles must get through their two sets of compound eyes.

A large number of insects spend all their life underground. Although most of them have lost their eyes, experiments have proved that these blind creatures are nonetheless sensitive to light.

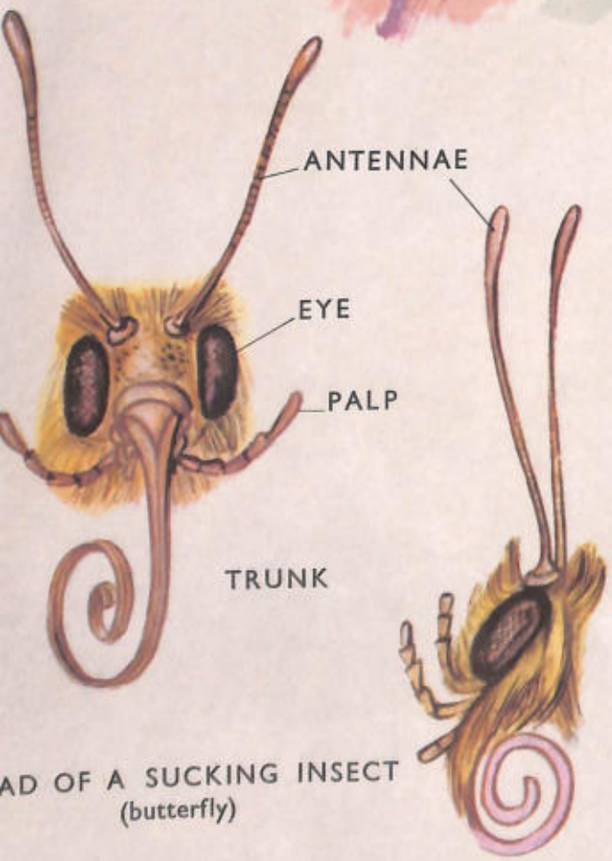
The new science of electronic or bionic biology uses high quality apparatus copied from the most highly perfected organs of sense from the animal world. Naturally, many insects have already been used as models.

HEAD OF A BITING AND GRINDING INSECT
(the green grasshopper)

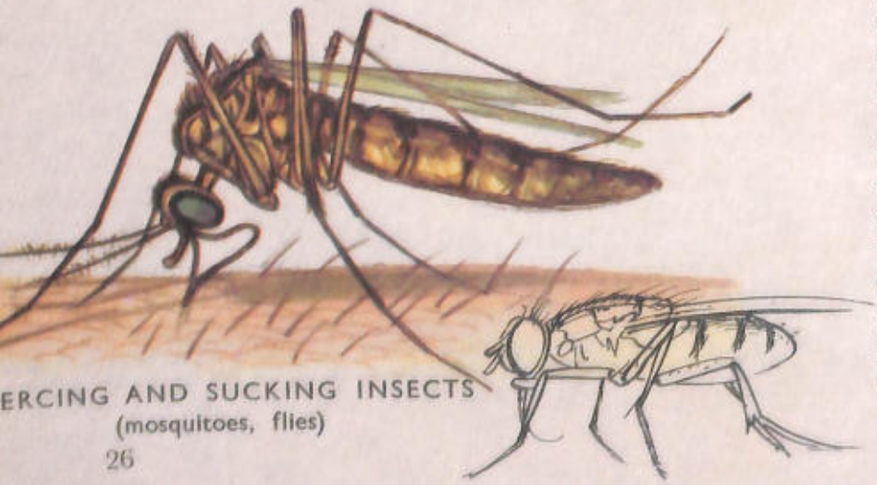




HEAD OF A LICKING INSECT
(bee)



AD OF A SUCKING INSECT
(butterfly)



ERCING AND SUCKING INSECTS
(mosquitoes, flies)

Through their globular eyes, both the fly and the dragonfly see not one image, but rather a whole series of images. Photographs have proved that the compound eye is not only an organ of sight, but also a recorder of speed. Imagine, for instance, that a swallow suddenly enters the field of vision of a bee. The insect will not see just one swallow, but a swallow reproduced several hundred times. None of these reproductions, however, will picture the same part of the sky, since the visual field of each facet varies according to its position. The bee will see the swallow cross hundreds of visual fields one after the other, and by means of this record will be able to assess the bird's speed from the picure. This performance of the compound eye inspired the invention of a computer for measuring the speed of aeroplanes.

Insects distinguish colour to different degrees. Colour-blind bees confuse red and green, but they are much more sensitive than we are to blues and greens. Butterflies, which have weak vision, come into houses and try to loot artificial flowers or even designs on paper that do not even represent flowers.

The insects which see best of all are dragonflies. Their actual sight is no more acute than that of other insects, as the 'mosaic' effect produced by eyes with many facets tends to distort their image. However, the compound eyes of the dragonfly are so big that the field of vision is almost spherical and only a very small area of space escapes the insect's attention.

The thorax and legs

The head is connected to the thorax by a very thin neck. The thorax of an insect is made up of three segments of chitin shell: the prothorax, the mesothorax and the metathorax (fore, middle and hind thorax). The thorax bears three pairs of legs, each of which is made up of five jointed segments; the haunch or coxa, the trochanter, the femur, the tibia and the tarsus.

The legs do more than just allow the insect to move around in the surroundings in which it lives. By means of its legs an insect may walk, run or jump on the ground, climb up stalks or along the bark of trees, or swim and dive. However, insects also use their legs for digging burrows (the cricket) and traps (the ant-lion) for building nests (the mason wasps), for shaping food balls (the sacred scarab), for seizing their prey (the praying mantis), and, with the elytra, for making their chirruping sound (the locust).

Among jumping insects the femora are highly developed, while the legs of the carnivorous insects are often formidable weapons as well. The femora and tibiae of the praying mantis, for instance, bristle with spines and have sharp edges placed opposite each other like the blades of shears.

The strongest tibiae are to be found on the digging insects. The tarsus, or end of the leg, of the scarab beetle often takes on the shape of a jagged pallet which

enables it to break up soil with ease. The legs of the aquatic insects resemble paddles and are fairly large with bristles on the edges.

The abdomen

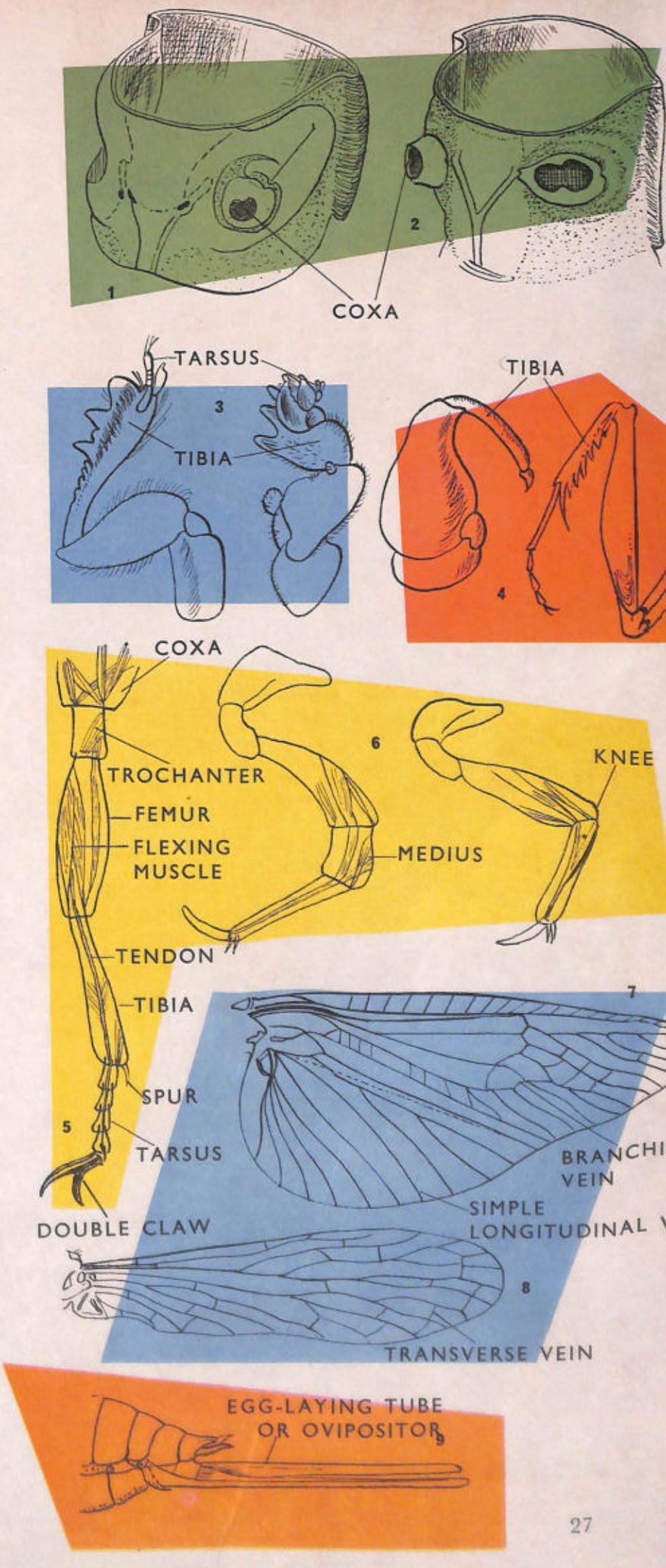
The abdomen is attached to the thorax by a waist, which is very thin (particularly among ants and wasps). The abdomen, like the thorax, is made up of rings or segments. It has no true legs, although it sometimes carries appendages or false legs (as with the caterpillar) which are used as supports for walking or jumping. The end of the abdomen sometimes holds a sting which may be either a defensive weapon (as with bees) or an offensive one (as with wasps). Finally, the abdomen holds most of the insect's digestive system.

The wings

Entomologists have divided insects into two groups: the Apterygota, or insects without wings, and the Pterygota, or insects with wings (*see: The classification of insects, page 30*). In the first group are to be found the more primitive species of insect. The second group represents by far the largest part of the insect population. Almost certainly the ancestors of winged insects once had rigid pallets of some sort that gradually got longer, larger, thinner and more supple until they became the membranous wings that we see today. The early Apterygota used to glide from branch to branch before they learnt to fly properly.

Insects' wings are membranous and shaped more or less like a triangle with the corners cut away or rounded off. The edges may be smooth, jagged or feathery.

Most insects have two pairs of wings and are able to fly throughout their adult life. Others have but one pair which some of them only use at one stage in their life. Lastly, some species of parasite (fleas and lice) have lost their wings because they became useless.



THE STRUCTURE OF INSECTS. Each segment of the thorax carries a pair of legs, on both winged (1) and wingless insects (2) alike. A leg (5) is made up by a succession of five articles each controlled by its own muscle, except for the tarsus, to the last segment of which is attached the tendon of a flexing muscle coming down from the femur. The legs of early insects had as a 'knee' a sixth article, known as the medius (6), which still survives in a small number of larvae. The tarsus and tibia of digging legs form a sort of hollow, jagged shovel (3). The tibia of grasping legs folds back on the femur to make a pincer (4). Wings may be arrow-shaped like those of an aeroplane (7) or they may, on the other hand, be wider at the end than at the base (8). The abdominal segments are devoid of legs but sometimes carry appendages that have been converted into organs for laying eggs or jumping (9).

BUMBLE-BEE
(enlarged to twice life size)

BLUEBOTTLE
(enlarged to ten times life size)

GREEN BOTTLE
(enlarged to three times life size)

HOUSEFLY
190 wing beats to the second
(enlarged to about twice life size)

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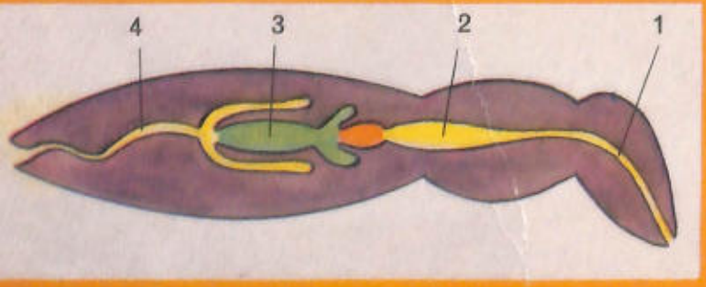


THE DIGESTIVE TUBE is usually short in the case of carnivorous insects and long in the case of vegetarians. The diagram shows: 1. oesophagus; 2. crop; 3. middle intestine; 4. rear intestine.

The dragonfly and moth squadrons are the fastest in the insect world. Some hawk-moths can fly at an average speed of thirty miles an hour. Beetles make the most noise when flying: the beating of the wings of larger specimens is like the drone of a small motor.

In a large number of species the front wings merely act as guards for the rear-wings. The front wings of beetles, for example, do not function in flight, but each forms a sort of rigid wing cover, known as the elytron. Beneath these elytra are placed the rear wings, the only active organs of flight.

How insects breathe

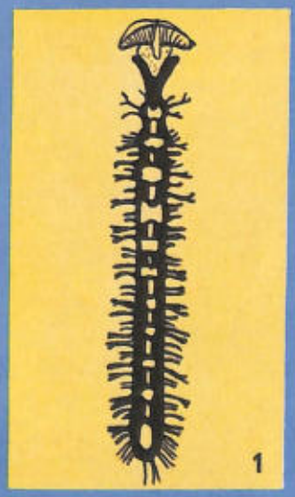
Most insects breathe through spiracles and airvessels or tracheae. Air enters the insect's body through the spiracles (little holes on the thorax and abdomen), and then flows through the air-vessels.

The number of spiracles varies from ten to twelve pairs. They consist of a minute round aperture which opens and closes on to a small cavity, or chamber, from which run the air-vessels. The air which the insect breathes is filtered by hairs that guard the opening of the spiracles, just as eyelids protect our eyes from dust.

The air-vessels, or trachea, are flexible tubes which run right through an insect's body and even into its wings: in the bee and the fly they widen in places to form 'air-sacs'. The trachea, however, are no more than ducts for carrying oxygen to all the various organs. It is the cells of these organs that act as lungs, relieving the blood of its carbon dioxide and feeding it with oxygen. Some insects do not breathe through spiracles: the air reaches their body through their extremely thin skin. This is known as cutaneous respiration.

A BEE IS a Hymenopteron with four membranous wings, but also a social insect whose slightest buzzing means work and discipline. Our domestic bees come from India. A long time ago they left their ancestral forest to share their honey with most of the peoples of the world. In India there is till to be found a giant bee as big as a hornet, and a dwarf bee as small as a housefly. In 1920 people learnt from the Austrian, Professor Karl von Frisch, that these insects also possessed a type of language.

THE NERVOUS SYSTEM of the more primitive (wingless) insects consists basically of a central chain of ganglions (1). In the case of the more evolved **Chironomus** gnat the ganglions are still very numerous (2), whereas the nervous system of the domestic fly is controlled from one main centre (3).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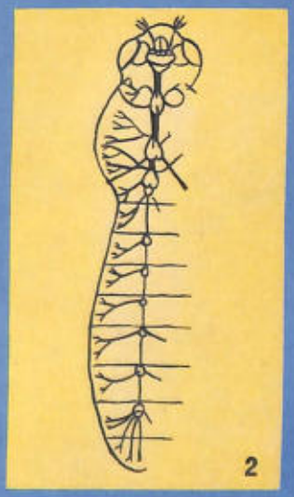
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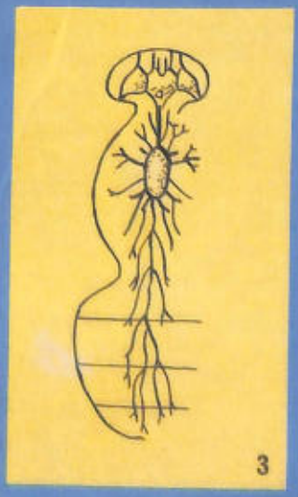
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Not all of the aquatic insects breathe in the same way. Some, when they dive, take with them a supply of air in the form of air-bubbles, kept in position on the bottom of their thorax by thin hairs. Others, such as the underwater hunting insects, are fitted with a breather, a sort of tube connecting the spiracles to fresh air. And some aquatic larvae are equipped, like fish, with gills shaped like tubes or lamellae.

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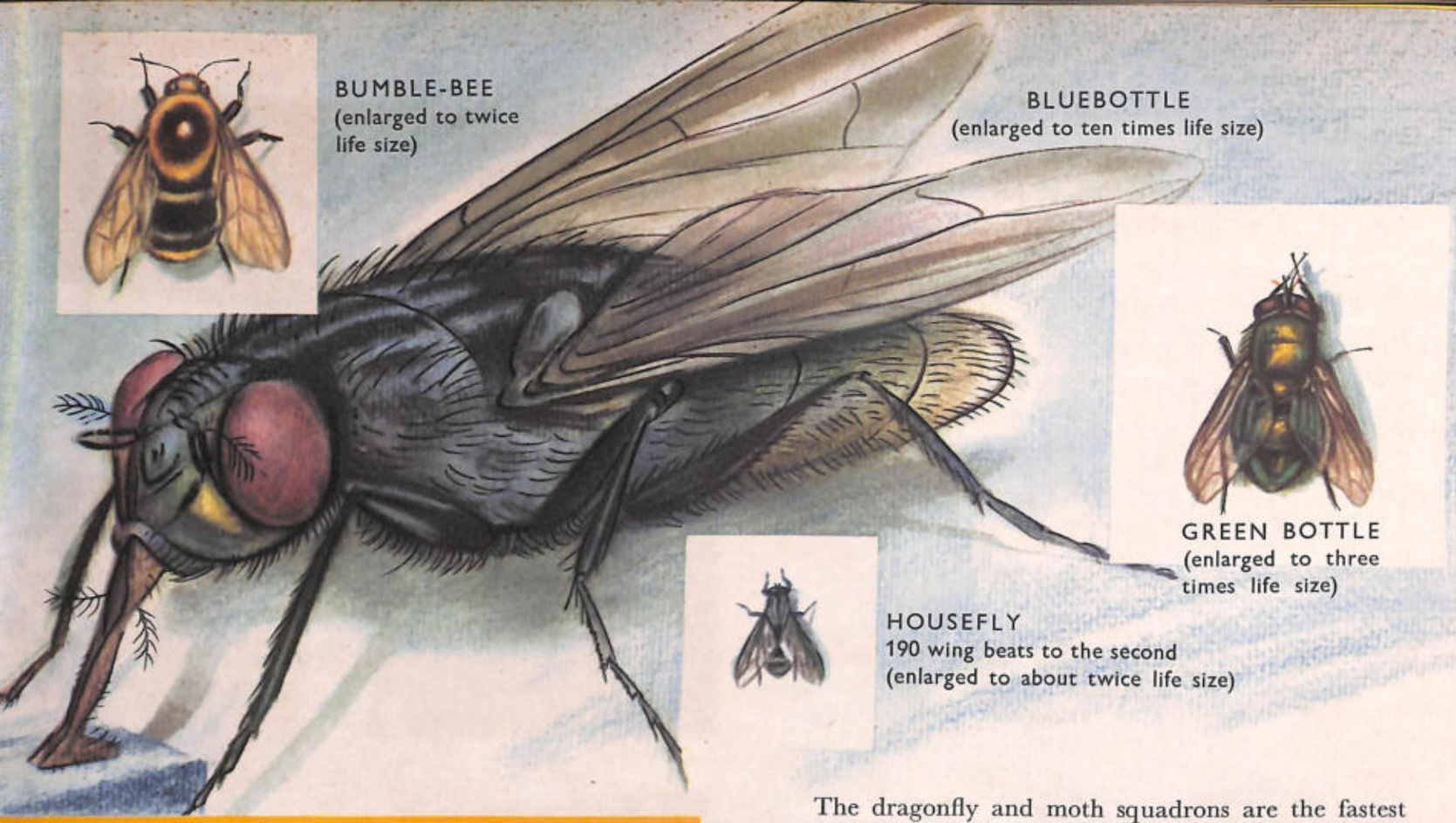

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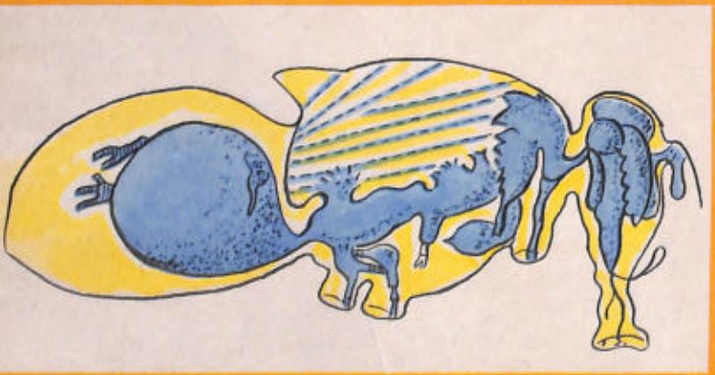

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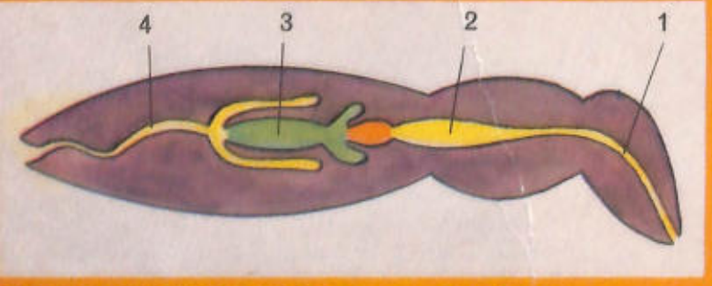

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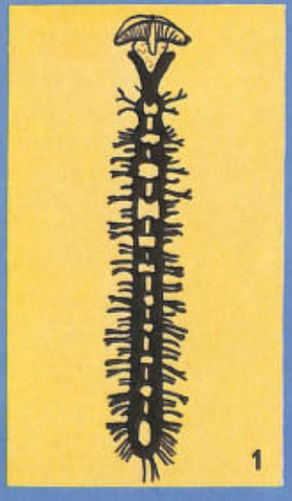
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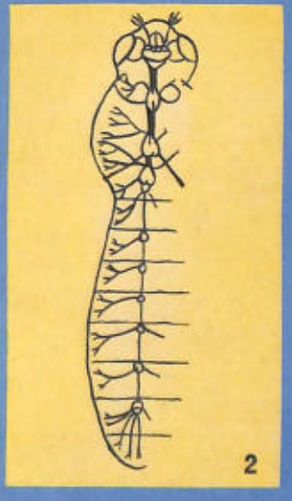
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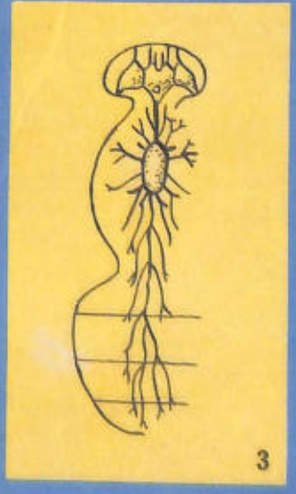
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The classification of insects

Insects are one of the eleven classes or subdivisions of the Arthropoda, or articulated animals, which are in turn one of the four main branches of the animal kingdom.

Until the end of the eighteenth century naturalists used to classify as insects all animals that did not have four legs and were not birds or fish. They considered that the snail, the slug and the starfish were insects. The famous Swedish expert Linné said of the crocodile that it was a 'monstrous insect'. In 1758 he established a classification of insects based on the shape and structure of these animals' wings.

In 1882 the German naturalist Brehm made a classification of insects based on the specialisation of their mouth parts. He distinguished between biting and grinding insects equipped with powerful mandibles to allow mastication; licking insects with an elongated lower lip; sucking insects with their jaws turned into a trunk, among which he also placed the stinging and sucking insects with jaws turned into needles.

In 1815 Brauer established a classification according to the different sorts of metamorphosis or life-cycle. Imms improved this system, which was further added to in 1951 by the work of the zoologists Martynov and Grassé.

SUB-CLASS APTERYGOTA
(4 orders grouped into two sections)
These are the insects closest to the insects' ancestors. They are wingless biting and grinding insects. Metamorphosis slight or absent.

ENTOTROPA SECTION
(3 orders)
Apterygota with internal mouthparts.
Example: the spring-tail.

ECTOTROPA SECTION
(1 order)
Apterygota with visible external mouthparts.
Example: the bristle-tail or silver fish.

SUB-CLASS PTERYGOTA
(25 orders grouped into 4 sections)
Winged insects or insects that were winged once and have gradually lost them (the flea, for example). Very varied mouthparts. Both complete and incomplete metamorphosis.

PALEOPTERA SECTION
(2 orders)
Pterygota with independent wings. Incomplete metamorphosis. Biting and grinding mouthparts. Example: dragonfly.

POLYNEOPTERA SECTION
(6 orders)
Pterygota with forewings covering the rear-wings. Incomplete metamorphosis. Biting and grinding mouthparts.
Example: the grasshopper.

OLIGONEOPTERA SECTION
(11 orders)
Pterygota with wings supported by one unramified sinew. Complete metamorphosis. Varied mouthparts.
Example: the scarab beetle.

PARANEOPTERA SECTION
(6 orders)
Pterygota with wings suported by one branching sinew. Incomplete metamorphosis. Varied mouthparts.
Example: the cicada.

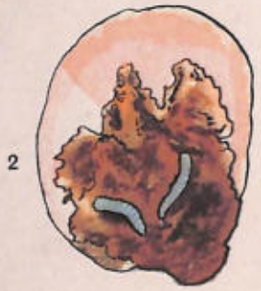
Larvae

Larvae are the children of the insects — the cleverest and most active children in the world. Imprisoned in an egg, they first of all have to make a hole in this in order to escape and be born. For creatures of such small size, breaking this often highly-resistant shell is an arduous ordeal. The only larvae to be helped and fed by their parents are the offspring of the social insects (bees, ants, termites . . .). All the rest are born as orphans.

It is impossible for us to imagine a baby hewing out a bow and arrow and waylaying birds a few hours after coming into the world. Yet this is exactly the sort of thing many larvae do just after their birth. It is true, however, that in many cases they are provided with the weapon and the instinct to defend and attack at the same time as they receive legs, mandibles and, sometimes, poison glands. Larvae are almost always able to move, although they never have wings. The majority of larvae have simple eyes.

The shape of larvae varies less according to the species than it does to the environment in which they live (water, land, fruit, seeds, living tissue . . .). For this reason naturalists thought it better to base the classification of larvae on their different shapes.


1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7

ERUCIFORM LARVAE (1) have a long cylindrical body, three pairs of legs on the thorax and sometimes false legs on the abdomen. Great walkers, they are vegetarians with large appetites. This particular larva (that of the Spurge hawk-moth) is one of the most elegant caterpillars in the cypress forests.

VERMIFORM LARVAE (2 and 3) are the most common (they include flies' maggots). (2) is *Sterandus colar* in a kola nut. (3) is a weevil. All larvae of this type have a cylindrical body devoid of legs. The head may either be very small or highly developed (3).

SCARABEIFORM LARVAE have an enormous abdomen and very small legs in relation to their size. They live on vegetable tissues. The larva of the palm *Oryctus* lives in the soil which surrounds the roots of this tree.

ONISCIFORM LARVAE are so called because their shape is similar to that of the woodlouse *(Oniscus)*. Like the larva of the Silphid beetle (5), they have a large body and each segment is protected by a small, hard dorsal plate. The three pairs of legs on their thorax are hardly visible beneath the dorsal shell. They are usually carnivorous.

CAMPODEIFORM LARVAE have an elongated body and three pairs of relatively long legs on their thorax. They are extremely agile, and usually carnivorous. (6), *Staphylinus*, is an example of a long campodeiform larva. When walking it uses the end of its abdomen as a support, but lifts it up in order to run. The aquatic campodeiform larva (7) (of the *Dytiscus*) is recognisable by its tapering body and its jaw duct.

The double life of insects

In the insect world Nature uncovers a sort of secret drawer, in which are to be found the most astonishing shapes of animal life.

Insects appear to be born twice. The young insect is a larva which, on emerging from the egg, may or may not resemble its parent. Its shape, organs and habits continue to change as long as it keeps growing. In the first case (incomplete metamorphosis) the *nymph* gradually becomes an insect identical to its parents. In the second case the larva shuts itself up in a cocoon to undergo complete metamorphosis; this is the beginning of its life as a *pupa*. Out of the pupa eventually emerges the perfect insect.

Insects lay eggs

Insects lay different quantities of eggs according to the species to which they belong. Sometimes, a species will follow a mysterious cycle in its laying habits. In the case of the locust, for instance, the eggs are extremely sensitive to the variations in heat and humidity which precede their hatching. Indeed, it is these climatic variations which help to decide the lot of the unhatched locust: if it will emerge from the egg as the nymph of a migratory locust or as the nymph of a solitary locust. This remarkable fact was revealed by the Russian entomologist Uvarov in 1921. He also proved that the solitary locust lays a thousand eggs, or about three times as many eggs as the migratory locust.

Whereas some insects in the course of their life lay only one egg, there are others, like the flies, that may produce up to seven hundred thousand.

Insects' eggs may be round, cylindrical, ovoid or

THE MAY-BUG undergoes a complete metamorphosis. One month after the eggs are laid (1), a larva (2) is hatched which looks like a white worm. This reaches its largest size (about two inches) after three years of life underground (3). In the summer of the fourth year, the larva excavates a cell in which it turns itself into a pupa (4). In the autumn, the perfect insect leaves its pupa, but does not move from its lair until spring (5). Then the cycle starts again.

THE CABBAGE WHITE (1) is also an insect with complete metamorphosis, but this butterfly lays its eggs (2) on the inside surface of cabbage leaves, and the caterpillar (3) lives in the open air.

flattish, and they are often very large in relation to the size of the insect which lays them. The eggs contain such large reserves of food that, in many cases, hatching does not take place until a long time after laying. The female woolly aphis lays only one egg and this is almost as big as herself; the eggs of the dragonfly, on the other hand, may be very minute in proportion to the size of the layer.

The most beautiful eggs are those of the butterflies. A species of butterfly in Japan lays eggs shaped like parasols! The eggs, however, though their larvae are sometimes provided with weapons, are always defenceless. Thus it is not surprising that mother butterflies lay their eggs only shortly before they hatch.

Among insects the unrelenting struggle for life begins well before the hatching of the eggs. The instinct for survival leads the parent insects to place their eggs in small bunches or one by one, either in carefully chosen sites or in nests skilfully built by the parents. Most frequently the larva, when it is born, finds itself in a solid underground shelter that is also a storehouse of food. Sometimes insects lay their eggs inside some plant or fruit, or even in the body of another insect, depending on whether they are plant-eating, fruit-eating or flesh-eating. The robber wasps, nine times out of ten, paralyse their victims to make them into a store of fresh meat on which their offspring can feed. In this way fruit and prey are devoured alive, from the inside, by larvae enlarging their holes or boring tunnels, and feeding themselves at the same time.

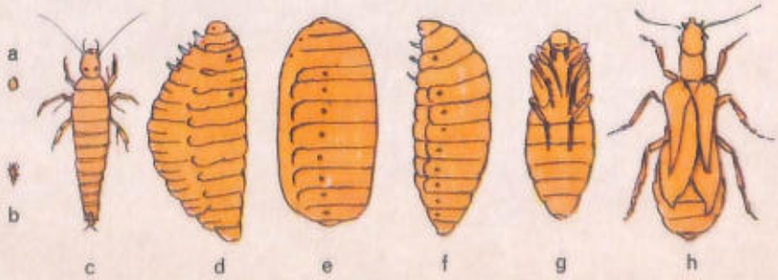
The eggs of all insects are covered by a protective shell, the thickness of which varies from species to species. Sometimes the shell is, in turn, protected from light or isolated from water by a sort of jacket. With many aquatic species it is a coating of jelly. This enables dragonflies to stick their eggs, sometimes several hundred of them, along the stems of reeds or rushes, and mosquitoes to bind theirs together into little rafts that float on stagnant water.

Among all insect species some mysterious radar system guides the mother, when she is about to lay, towards the stem, leaf, fruit, seed or living insect that is necessary for the survival of the larva.

Insects make nests

Unlike birds and mammals, the social insects are not fond parents. In the strictly divided compartments of their towns a sort of military discipline takes the place of motherly instinct. In the robot-nurses of the ants

HYPERMETAMORPHOSIS is the complicated name which the great French naturalist Henri Fabre gave to the strange growth of some beetles. One beetle, the *Sitaris muralis*, changes shape six times between the egg and the perfect insect: egg (a); lst larva (b); the same, seen through a magnifying glass (c); 2nd larva (d); 1st chrysalis (e); 3rd larva (f); 2nd chrysalis (g); perfect insect (h).



and termites we find none of that feeling of affection which gives the lion and the polar bear purrs and velvet paws.

Among the insects that are not social, the 'maternal instinct' is shown in the feverish activity of building nests. They often use ingenious and efficient methods.

There are very few species of insect where this professional concern reaches the level of family feeling. But one insect at least, through its great devotion, redeems the hard-heartedness of the insect world: this is the rhinoceros beetle, so called because it carries on its corselet three low, forward-pointing horns. This black, very peaceful beetle is a mighty worker: it bores, vertically into the ground, a hole one and a half yards deep. Right through their lives the two future parents prepare for the arrival of their children into the world — children they will only just have time to get to know. In turn they act as tunnel-diggers, food-collectors, millers and pastry-makers until they have made their nest into a great store of supplies. They devote none of their time to themselves.

Any material is good for insects to build their nests and houses with: earth, leaves, stalks, wood, cardboard, wax or resin. Termites are even starting to line their tunnels with the nylon covering of electric wires! Some insects will use anything that happens to be lying near their legs or mandibles, whereas others are more selective and will search till they find the particular material that suits their purposes. Building techniques, too, differ according to species and depend on the shape of the insects' legs and on the environment in which they live.

The miners and excavators

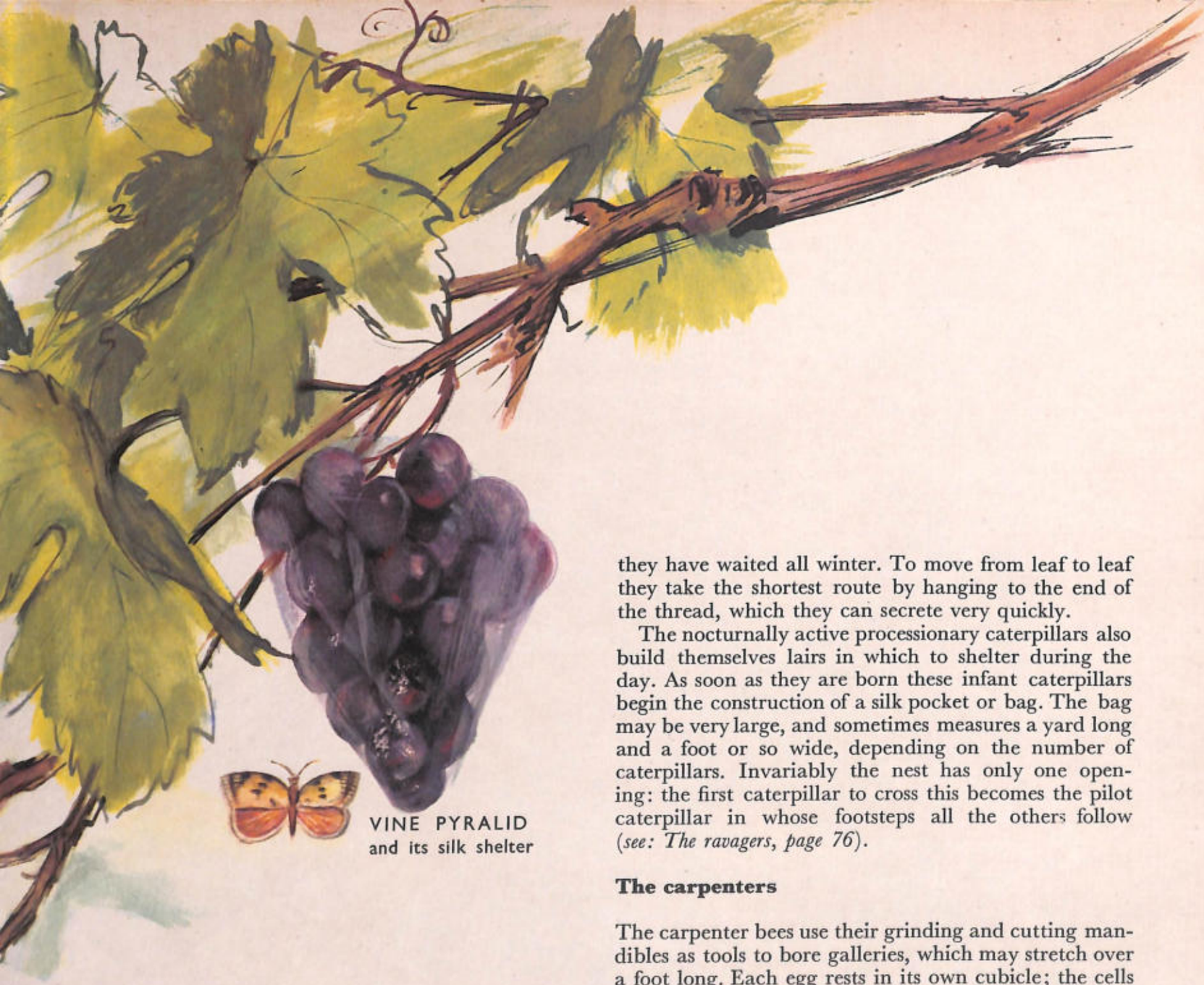
With their powerful, thick-set legs these insects can excavate horizontal or vertical tunnels. Their length or depth varies from an inch or so with the cricket to over a yard in the case of the minotaur beetle, *Geotrupes typhaeus*. The may-bug places its eggs at the bottom of a narrow shaft, then covers its nest-hole with some earth. The locust, on the other hand, shows

SECTION OF ITS UNDER-GROUND NEST

BURROWING BEE
(enlarged to about twice life size)

NEST OF THE HALICTUS BEE

THE MINERS. The solitary bees dig vertical tunnels into the ground, wherever the earth in Europe is loose or lightly sanded. Off the central shaft open several horizontal cells. Each one of these cradles first the egg and then the chrysalis.



VINE PYRALID
and its silk shelter

itself to be wiser and less trustful by burying its eggs inside a sort of roughly cylindrical tube, formed by a cement mixture of earth and a gluey substance.

The silk spinners

There are many caterpillars that do not use their silk glands exclusively for making themselves a cocoon. Some silk-spinners excel in the art of using their thread to protect themselves from lizards, birds and other caterpillar-hunters.

The pyralid moth caterpillars, for instance, weave a fine, silky net round the grape bunch of their choice. As soon as the buds come out, these minute green caterpillars emerge from beneath the bark where they have waited all winter. To move from leaf to leaf they take the shortest route by hanging to the end of the thread, which they can secrete very quickly.

The nocturnally active processionary caterpillars also build themselves lairs in which to shelter during the day. As soon as they are born these infant caterpillars begin the construction of a silk pocket or bag. The bag may be very large, and sometimes measures a yard long and a foot or so wide, depending on the number of caterpillars. Invariably the nest has only one opening: the first caterpillar to cross this becomes the pilot caterpillar in whose footsteps all the others follow (*see: The ravagers, page 76*).

The carpenters

The carpenter bees use their grinding and cutting mandibles as tools to bore galleries, which may stretch over a foot long. Each egg rests in its own cubicle; the cells are separated from each other by a thin partition of sawdust held together by a thread of saliva.

The masons and potters

Swarms of wasps and wild bees include potters and masons in their ranks. Once the galleries for their nurseries have been dug in some sunny slope, the mason wasps build strange, curved tunnels which extend the entry to their nest. The mouth of these tubes always points downwards to prevent rainwater flooding in. The wasps wet the sand with little drops of water, then shape it into bricks with their legs. In this way they can build a curved tube four or five millimetres in diameter and an inch or so long. One bee makes the walls of its nest like our own full-size walls: it manufactures a sort of mortar by mixing grains of clay and fine gravel with its saliva. The potter wasps fashion beautiful clay cups which are turned over, like cupolas, on to the wall, stone or stem which acts

THE PAPERMAKERS. Well before mankind the social wasps of the Old and the New World discovered the art of turning wood-pulp into paper. These forest wasps give their open-air dwellings three-layered paper walls, in order to provide the necessary insulation to maintain a constant temperature inside the nest. The nest contains several storeys of cells for housing larvae and pupae as well as stores of food.

as their support. Each one of these clay cells contains several small green caterpillars and an egg suspended from the ceiling by a thread. This clever arrangement eventually allows the larva to pick at its leisure from the store of living food and to escape towards the roof if its larder becomes too lively.
Another wasp, in escaping from the cold, readily goes into houses and sometimes even into chimneys. Here on the walls it builds superb little clay pots hardly bigger than a pea. In each of these cells there is an egg and a supply of food for the future larva.

The dung-beetles

The beauty and elegance of the sacred scarab beetle are not the only reasons for its fame. In ancient Egypt, over two thousand years ago this black beetle was looked upon as the symbol of the miraculous birth of a perfect being: for the Egyptian priests knew nothing of the metamorphosis. The scarab very soon became a charm to ward off all manner of evil, including death. A century before our time the Phoenicians, who inhabited Heliopolis, considered the beetle to be an envoy from the God-creator, Kepri, the Rising Sun.

Although a great lover of dung and manure, the scarab is no careless glutton but rather a far-sighted and economic epicure. First of all he rolls his favourite food into a ball which he then pushes with his rear legs, while retreating head down, to a hole prepared beforehand. He stays in the hole to enjoy the meal at his leisure. The female scarab uses the same technique, but with even greater care, to make a sort of pear-shaped mass which acts both as a cradle and as a supply of food for her offspring. The cell for housing the egg is accommodated in the narrow end of the pear: the larva, as it gets larger, devours its nest. Other dung-beetles manufacture a sort of sausage which can be almost a foot long and yet contain only one egg.

The paper manufacturers

Wasps and hornets specialise in making paper, and build nests of cells made out of paper instead of wax. These insects use their saliva to moisten wood fibres, then grind and knead them with their mandibles

TREE WASP
(magnified twice)

until they have a paste. Using their legs as a trowel they spread and mould this cement, which hardens as it dries. Depending on the species of insect and the type of fibre used, the cells may be made out of porous or coated paper, or of strong cardboard, sometimes corrugated. One of these nests may contain several racks, each one carrying a row of cells.

Some species construct in this way complete pear-shaped nests of varying sizes. Their shells are made up of several thicknesses of cardboard, each one separated from the other by a layer of air which insulates the larvae from big variations in temperature. This sort of nest hangs on trees with its narrow end pointing downwards. Other species build their nests in the shape of champagne glasses, to be found attached to shrubs or stones. And the lazier species just lay their paper shelves in natural shelters.

The carpet-makers

The carpet-makers are just as ingenious, but are content to work on already existing holes to make them comfortable. First of all they choose a tunnel abandoned by some insect or small mammal, a hollow stem, a hole in a rock or even an empty snail-shell. Then they collect all sorts of leaves and downy wool to make an air-tight lining. The carpet-making bee or megachilid bee, for instance, often chooses to overhaul a cricket's abandoned tunnel or a worm-hole: sometimes it will even enlarge the hole. The bee then cuts out bits of leaf with its mandibles, rolls them up and takes them into the hole. Once the piece of leaf is inside the hole, it automatically sticks to the walls. Each cell is shaped like a thimble and lined by about twenty pieces of leaf: the pieces forming the lid are sometimes almost perfectly circular. A bee can furnish ten or so such thimbles in its tunnel.

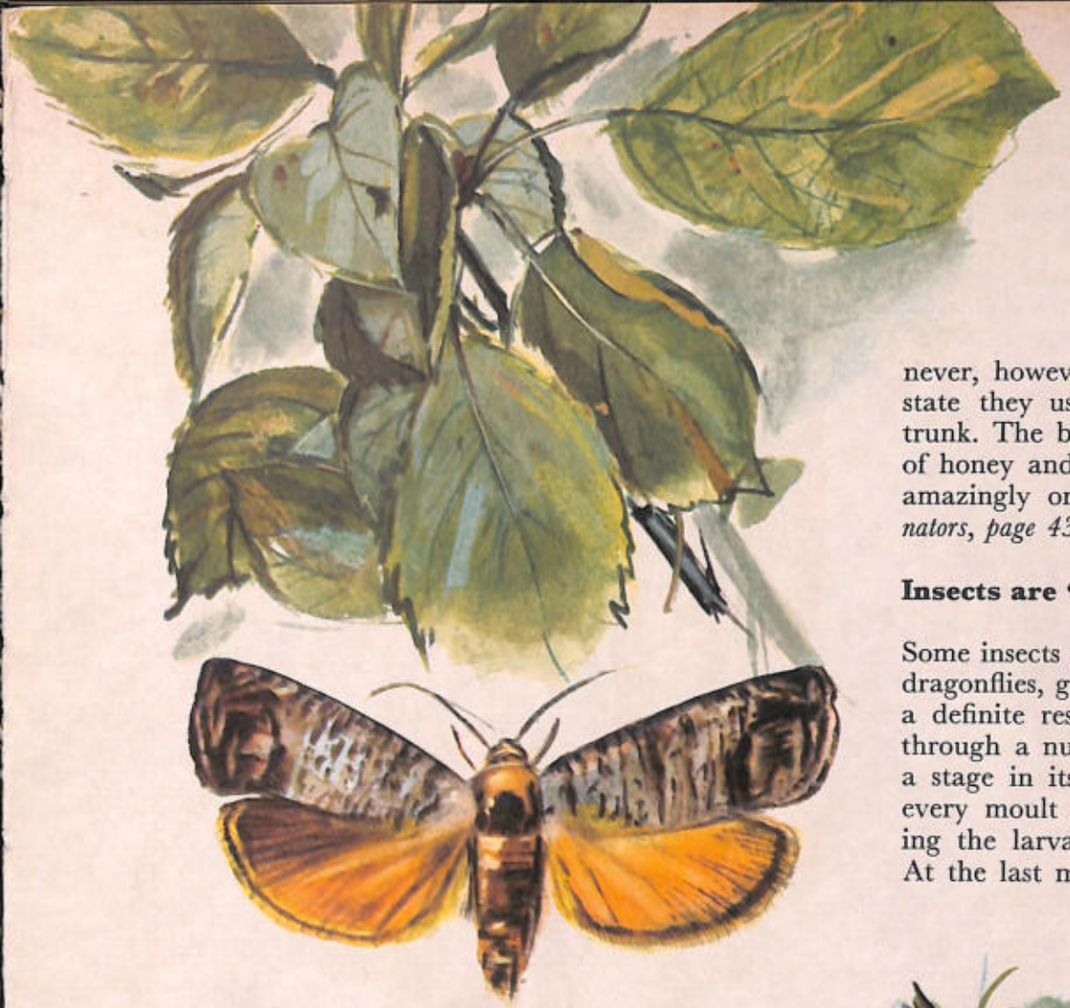
The caterpillar of the brown-tail moth uses hairs from its body to line the crevices in the bark of trees where it makes its nest. Brown-tail eggs are usually covered with 'fur' derived from the abdomen of the female moth.

Another species of solitary bee will live only in empty snail shells. This bee collects the resin from fir-cones, then kneads it into a sort of moulding paste which it uses to construct cubicles in its nest.

The cigar-rollers

Some of the weevils build their nests in the way cigar-makers roll tobacco leaves to make cigars. Without removing them from the tree, these insects

THE LEAF-CUTTER BEE is one of the most skilful of the carpet-making insects. It makes its nest in a hollow tree trunk or in the ground and furnishes six or eight thimble-shaped cells. Using its jaws as shears, it methodically cuts out of leaves oval pieces for the walls and circular pieces for the ceiling of each cell.



CODLING MOTH
(about six times life size)

roll the leaves up lengthwise and arrange their eggs between the different layers of the roll. For creatures so small this is an immense task, and so sometimes several of them get together to roll the same leaf: the cigar then becomes the nest for the whole team.

The wax-makers

Bees are the only insects that produce wax and know how to use it to build cells for their larvae and racks to store their supplies of pollen and honey. They never, however, make their own hives. In their wild state they usually choose to inhabit a hollow tree-trunk. The building of a honeycomb and the storing of honey and pollen in its cells is the result of some amazingly organised team-work (*see: The great pollinators, page 43*).

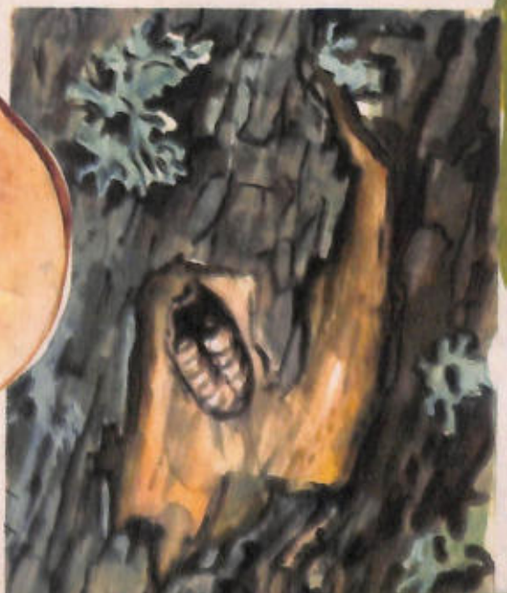
Insects are 'born' two or more times

Some insects have incomplete metamorphosis (such as dragonflies, grasshoppers, locusts...): the nymph bears a definite resemblance to the perfect insect. It goes through a number of 'moultings', each of which is a stage in its development into the adult insect. At every moult the old, hardened skin splits open allowing the larva to grow a new skin and so get bigger. At the last moult the larva becomes a perfect insect.

ADULT INSECT
on leaving
its cocoon

CHRYSALIS beneath the bark

TUNNEL made by the caterpillar of the codling moth or 'apple worm'



The majority of insects, however, undergo complete metamorphosis (beetles, may-bugs, ant-lions, flies, wasps, bees, butterflies). It all happens while the larva is in retirement within its case or cocoon, which is made of silk or substances glued together. The larva lies motionless and seems to be sleeping. By then the exterior jacket of the larva is just a box within which everything develops according to some infallible plan. Some cells change, but there are also others which, at the right moment and in the right place, are newly created.

In this living laboratory are to be found leg-cells, antenna-cells, trunk-cells — cells of all sorts.

One day the completed insect is ready to be born and the lid of the box cracks open. The mummy breaks its ribbons and tears off its mask, and the masterpiece is at last displayed. After this rebirth the insect has still not reached its normal size: it now grows longer and larger so quickly that it can practically be seen happening in the case of some species. During this final stage, as the almost perfect specimen grows bigger, its new and fragile skin hardens and the external skeleton turns into the armoured shell of chitin which protects the full-grown insect.

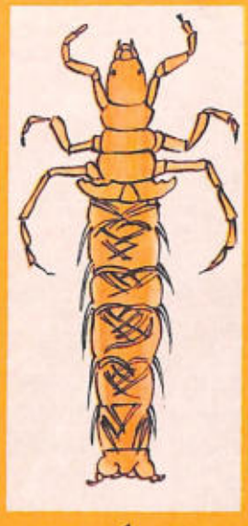
These complete metamorphoses are more interesting to follow than the incomplete type. It may be said that in the complete metamorphosis we are witnessing the transformation of living matter into another sort of living matter. Really the insect that undergoes complete metamorphosis succeeds where man has often failed. After repeated experiments the alchemists of the Middle Ages had to give up trying to change iron into gold.

Nature was the first to take up the theme of the beauty and the beast. In the case of insects that undergo complete metamorphosis, the beast and the beauty are one and the same: the beast turns into the beauty as if by magic. It is astounding how a flabby, whitish animal like a caterpillar can give birth to the butterfly, a creature of beauty.

Among the insects with complete metamorphosis there is such an enormous difference in appearance between the larva and the insect that we could compare the first to a snake and the second to a parrot. When one thinks of a snake being able to turn itself into a parrot, one realises how amazing it all is. It is not so long ago, of course, when one thinks of the

THE PINE PROCESSIONARY MOTH lays its eggs on pine needles and surrounds them with a sort of silky spindle. After hatching, the caterpillars make themselves a larger home by connecting up with threads of silk, the leaves, and sometimes also the branches, near their cradle.

CADDIS-FLY LARVAE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Earth's history, that the marine vegetation learnt how to breathe air and evolution led to amphibians from fish and birds from reptiles. Yet this outsize conjuring trick lasted several hundred million years. So perhaps we may compare evolution to an endless succession of transformations in which imperfect beings eventually acquired some dominating quality. Thus, for instance, fish are best adapted to swimming and birds to flying.

Starting from a few basic animals evolution ended with the higher mammals: in between there were several transitory species which we may compare to sloughs. The great and never-ending troubles of the animal and vegetable world have always been caused by important changes in the conditions of life. And evolution has not always been successful in finding the right track to follow. Sometimes she has been too slow and has been out-distanced. Millions of species have disappeared because of their inability to follow a new trend. The evolution of the mammals up to the animals of today is a success. The evolution of

CADDIS-FLIES are aquatic insects whose larvae (see above) (1) are much sought after by water birds and fish. To escape the attention of enemies these larvae use the little hooks which cover their bodies to construct sheathes round themselves. They choose a variety of materials so as to resemble a collection of little shells (2), a freshwater crustacean in its shell (3), a bundle of little sticks (4), a sausage made up of small stones (5), or the tip of a reed (6). The only parts of the larva to emerge from the case are its head and legs. They may be vegetarian or carnivorous, and whereas some live in stagnant water others prefer running water and even torrents. They are all campodeiform (see page 32).

SOME CADDIS-FLY LARVAE weave nets, then stretch them out under the water to filter plankton, microscopic animals which float in the water. They make different types of bow-nets, some designed for slow currents and others for fast currents. The mouth of the trap always faces into the currents, while the larva lives at the bottom of the net. The winged insect only flies about in the evening. Its life does not exceed three weeks.

the reptiles, however, is less so. The biggest of them were so heavy that they had to spend three quarters of their life in deep-water lakes and were quite unable to survive the drying up of the pools.

Incomplete metamorphosis may well be compared to the long stages of transition which preceded the modern horse. The horse's ancestor is the eohippus, a low, four-legged animal about the size of a wolf, which looked like a small horse. After the eohippus several other versions followed one after the other, among which were the mesohippus and merychippus. At the last mutation appeared a mammal perfectly adapted to running — the horse. Has evolution stopped or will it continue to surprise us in every field, including that of the insects? One day the larval stage of insects may disappear once and for ever . . . one day in, possibly, ten or twenty million years time?

ADULT CADDIS-FLY
(magnified five times)

FUNNEL-TRAPS

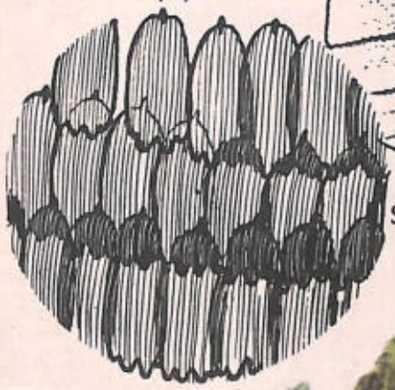
TRUMPET-SHAPED TRAP

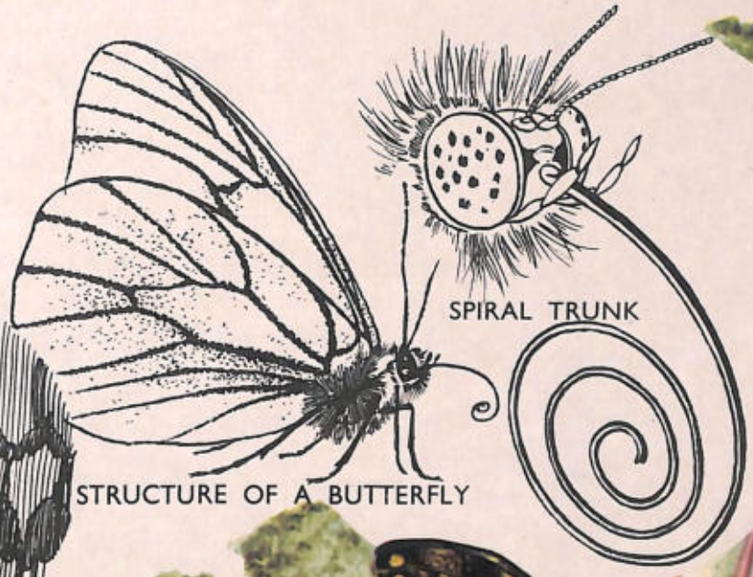
TUNNEL-TRAP

The great pollinators

BUTTERFLIES AND MOTHS

WING SCALES
(seen through a microscope)





STRUCTURE OF A BUTTERFLY

BLACK-VEINED WHITE
(life size)

FRITILLARY BUTTERFLY
(life size)

HOLLY BLUE
(life size)

SWALLOW-TAIL
(enlarged to twice li
size)

AMERICAN MONARCH
(enlarged to twice life-size)

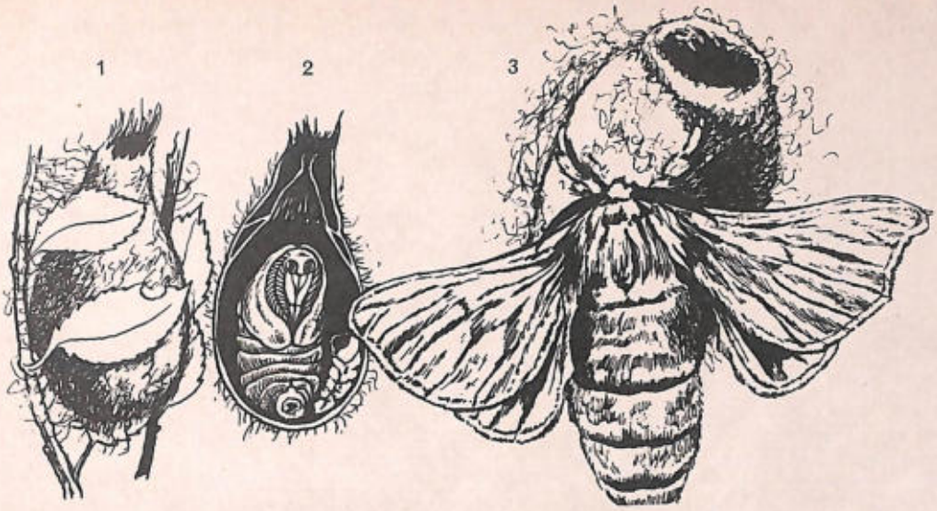
After the wind plundering insects are Nature's greatest pollinators. If all the butterflies, bees and bumble-bees were to disappear overnight, our orchards would bear much less fruit than they did the summer before. These insects carry pollen from flower to flower. Pollen is the yellow dust which is essential if fruit is to grow, and flower-plundering insects have been good friends to fruit-bearing plants ever since their appearance on the Earth in the middle of the secondary era. This partnership has never ceased to grow through the ages, so that now they can no longer dispense with one another.

The great naturalist Darwin stated that flowers made themselves beautiful and scented in order to attract insects into their corollae: their colours, smell and shape were call-signals for the flower-loving (anthophile) insects.

What is pollination?

Pollination is the fertilisation of a flower's pistil, either by pollen from its own stamen or by pollen from another flower of the same species. The second method, cross pollination, is more favourable to the growth of fruit. Insects are the unwitting agents of fertilisation. There are even some plants that may be fertilised only by certain species of insect. On many occasions man has transplanted vegetables from

THE PRETTIEST CATERPILLARS do not always give birth to the prettiest moths and butterflies. The caterpillars of the puss moth are not only richly adorned, but are also among the most interesting to watch alive. They move about very slowly on the leaves of willow and beech trees. Should a tit arrive to swallow one up, the little creature will suddenly lower its head and arch up its abdomen rather like a scorpion, while two strange little shoots emerge from the ends of its cloven tail. The waving motion of these tentacles puts the bird to instant flight.



1. Silk cocoon of the Emperor moth (actual size)
2. Section: the chrysalis with its antennae folded
3. The moth, its wings still damp, leaving its cocoon

THE AMERICAN MONARCH, a native of North America, is in the process of colonising the whole planet. It is a great traveller and succesively invaded Central America, the Wests Indies and South America. It has also crossed the Atlantic to colonize West Africa. And one or two have even reached the south of France. Moving in the other direction it has crossed the Pacific, overwhelmed Australia and invaded China. This insect probably makes use of high-level currents to sail over such vast distances, although it is also thought that it has been an unseen stowaway on many ships. The monarch also migrates annually between the north of America and the Atlantic seaboard.

LEPIDOPTERA EGGS (very much enlarged)

one continent to another. And although the plants were usually well suited to the climate, nevertheless some of them remained sterile when the new countries did not provide the particular species of insect which alone could fertilise them. The vanilla plant, for instance, is a Mexican orchid that is pollinated in its native forests by a special plundering insect (the melipona bee). The vanilla plant easily became acclimatised to its adoptive countries, yet wherever the precious bee was missing man himself had to act as the fertilising agent.

Butterflies and moths

Butterflies and moths are the most graceful of insects and at the same time very active pollinators. There are at least two hundred thousand species throughout the world. Their distinguishing features are their often large and sometimes richly-coloured wings. The most beautiful colouring effects are produced by a mass of tiny scales which cover the wings, overlapping each other like tiles on a roof. Each scale acts as a prism, splitting up the light so that the wings appear to be covered with some dazzling, glinting powder.

BRAZILIAN MORF
BUTTERFLY
(reduced by a quar

ROBIN MOTH
(life size)

AMERICAN MONARCH
(life size)

The long jaws of the butterfly are formed into a trunk, which rolls itself up like a watch-spring when the insect is resting; whenever it visits the heart of a flower the trunk unwinds.

The mother butterflies know exactly which of all the different plants to choose as right for their larvae. These larvae are caterpillars and they differ from most other larvae in the large number of legs they carry on the thorax and abdomen: the ends of the legs are equipped with little hooks or suckers that enable the caterpillar to move around quite safely on plants. Like butterflies, caterpillars are often dappled with multicoloured spots. A great number of them have bodies bristling with long hairs which sometimes sting as badly as nettle-leaves. They grow bigger by a series of moults, the last of which turns them into a chrysalis or a pupa, from which eventually emerges the adult butterfly. Most moth caterpillars spin themselves a cocoon of some kind before pupating. (*see: The silk-producers, Building the cocoon, page 58*).

The family of Lepidoptera includes both butterflies and moths. Butterflies have antennae shaped like little clubs: moths' antennae are more usually feather-like.

The smallest species of Lepidoptera have a wing-span of only a quarter of an inch or so. Nevertheless, the caterpillars of these tiny insects are dangerous ravagers of forest and fruit trees.

One of the largest butterflies lives in Brazil. Its metallic blue wings sometimes have a span of six inches. The champion of European Lepidoptera for size is *Saturnia pyri*, with a wing-span similar to that of the Brazilian butterfly species: its wings, however, are grey and shaggy. The fastest of all Lepidoptera must be the hawk-moth. Almost as big as a humming-bird, it flies at up to thirty miles an hour and must be the record-holder for speed among flying insects.

Some moths and buterflies are migratory. Others, such as the danaid butterflies from the United States, are real emigrants, capable of flying over vast distances. Swarms of them, over several million strong, have emigrated and colonised the Hawaiian Isles in the South Pacific and the Canary Islands in the North Atlantic.

WORKER QUEEN DRONE
(enlarged to two and a half times life size)

The bees' life of harmony

Bees belong to the order of Hymenoptera, among which the maternal instinct is particularly strong. Inside a bees' hive, be it natural or artificial, the maternal instinct can be seen at work in the intelligent organisation of the work. Bees feed their larvae on pollen and honey. There are three types of bee: the social bee, the solitary bee and the parasitic bee.

The most highly evolved social bees are those of

WORKER BEE
imbibing nectar
in a flower cup

NECTAR lies in the hollow of petals or at the bottom of the corollae. In the latter case only those insects equipped with a sufficiently long trunk (bees, butterflies, bumble-bees) can suck up the sugary liquid. The droplets of nectar fill the worker bee's crop; it loads up with its supply after first feeding itself directly from the flower. On its return to the hive it regurgitates most of the contents of its crop. This nectar is then in turn swallowed and regurgitated several times by honey-making bees. Finally the honey, still fluid, is put into cells where it gradually thickens.

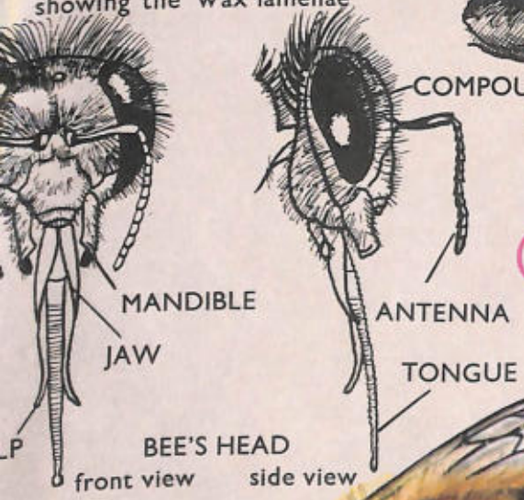
BEE-HIVES: in the middle of the nineteenth century man had the idea of putting his bees in a wooden box, the roof of which could be removed like a lid. Inside each hive the bee-keeper puts a small or large number of removable frames, according to the size of the colony. The most modern frames are artificial ranks of hexagonal wax cell foundation, which allow the bees to devote more time to making honey instead of constructing the whole of the wax honeycombs. A good bee-keeper must look after the health of his bees; he must place the hive so that its inhabitants are neither too cold nor too hot, and he must become their friend and avoid upsetting them. When the time comes to harvest the honey the bee-keeper must leave his bees with a supply of honey sufficient to feed them during the winter. Harvesting consists in withdrawing a certain number of honey-filled frames and replacing them with empty ones.

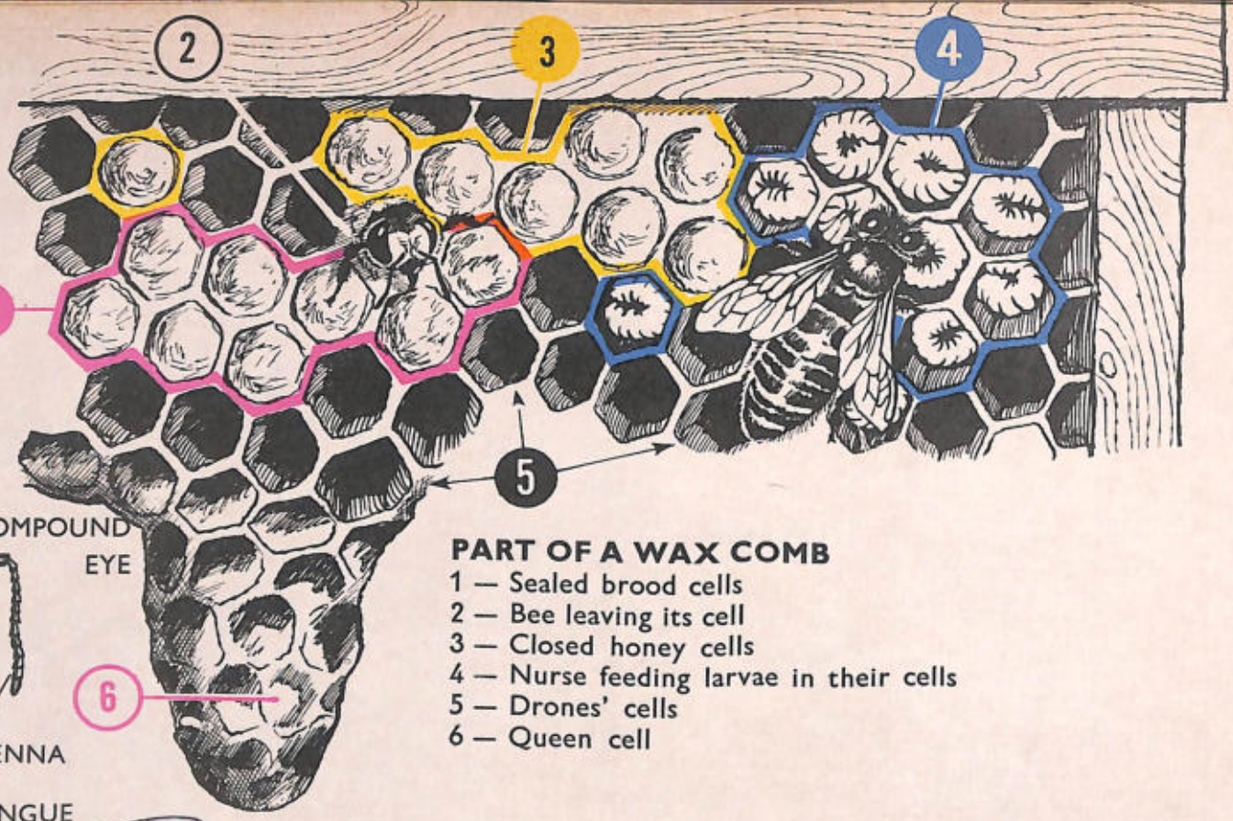
the apis family, wild or domestic, who are the most conscientious workers in the animal world. Early on they were domesticated by man so that their honey could be gathered.

All a bee's activities are subordinated to the life of the queen, the administration of the hive, the care of the honeycomb and the feeding of the queen and the young.

The population of a hive may reach 80,000 bees. The queen bee lays between 1,000 and 3,000 eggs a day, and there comes a time when the hive is over-crowded. The workers are then, in some mysterious way, warned of the danger and start to build some large cells. Into these they put some ordinary larvae, which have a special diet of royal jelly and are destined to become young queens. Then, one day at the start of the hot season, a sort of frenzy takes hold of the bees and they rush in their thousands towards the stores of honey. They gorge themselves with honey: it is the departure feast. Suddenly the old queen leaves the hive surrounded by her most faithful subjects, and a powerful and well-organised formation of about 30,000 bees builds up in the air. The swarm rolls itself up, then expands again like a live flame of golden dots. Then the waving ribbon grows bigger

NDERSIDE OF A WAX-WORKER
showing the wax lamellae

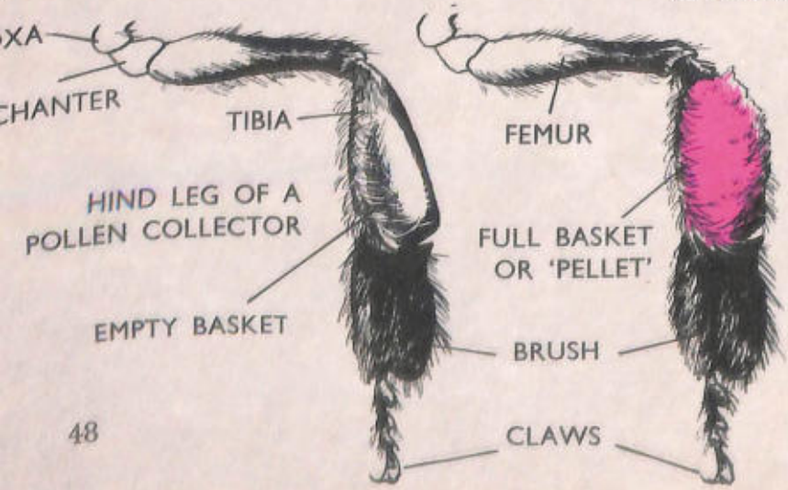




PART OF A WAX COMB

1 — Sealed brood cells
2 — Bee leaving its cell
3 — Closed honey cells
4 — Nurse feeding larvae in their cells
5 — Drones' cells
6 — Queen cell

POLLEN COLLECTOR on top of the cells after returning from its mission



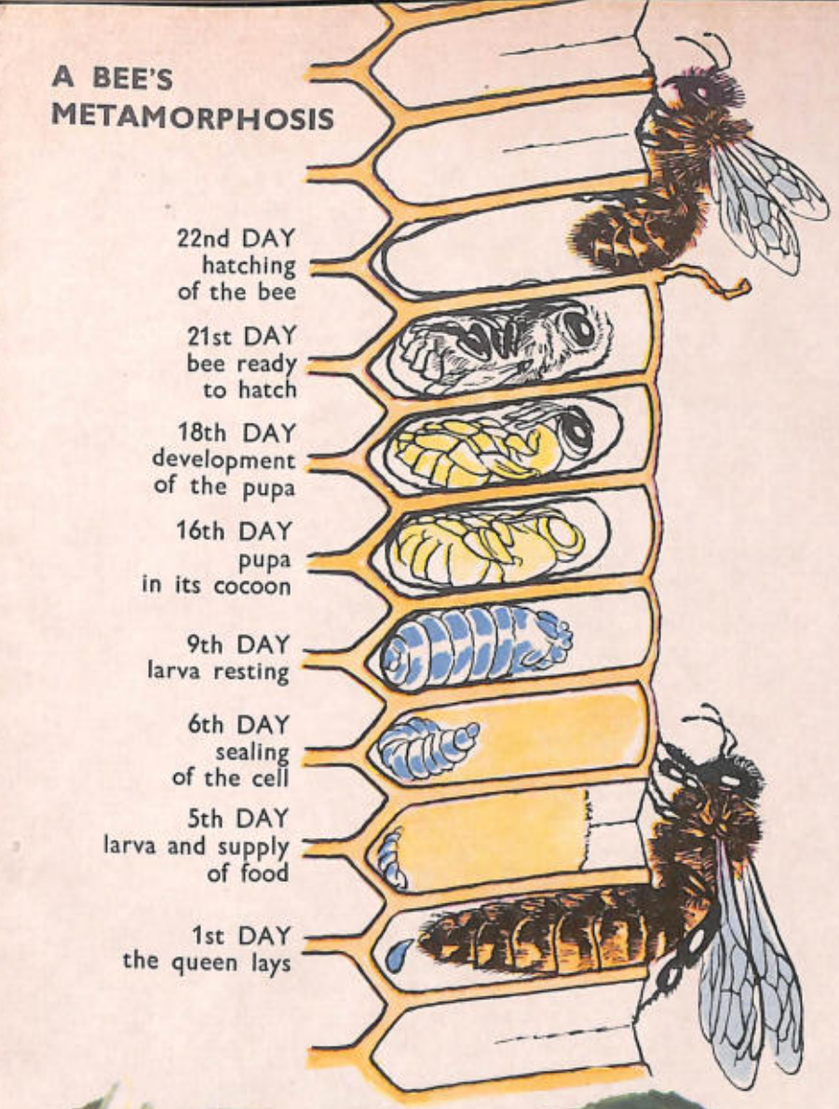
and becomes a sort of sail, until finally the bees form an enormous cluster fixed to a tree. Several scouts have already gone off to search for a new home. The moment has come for the bee-keeper to recapture the swarm and install it in a previously prepared hive. If the exodus escapes the bee-keeper's attention, the swarm remains free and, guided by its scouts, will sometimes fly quite far from the hive.

In this way domestic bees may revert to their wild state and found a new colony in a hollow tree trunk or in an old wall. Such natural hives, however, provide the bees with no more than a roof, beneath which the workers build their wax shelves.

Most of the population of a bee-hive is made up of the workers. They are the untiring purveyors of nectar and pollen, the queen's servants, the nurses of the larvae and the pupae, the fanners and, lastly, the guardians of the entrance to the hive.

The bee is a licking and sucking insect. The trunk of the workers is made up of two tubes inserted one into the other: the external tube is formed by the jaws, while the internal tube is the tongue. Watch a worker bee as it slips into the corolla of a flower. It is a nectar-carrier and so forces itself inside until it has reached the sugary droplets in the middle of the petals. These are then sucked up by means of the trunk. To fill its stomach the bee will have to visit about a thousand flowers. When it returns to the hive the honey workers seize its supply of nectar and the bee flies off again immediately. The nectar changes stomachs: the digestive system of the specialised honey workers will turn it into honey.

There is another bee which deals exclusively with the harvesting of pollen. This bee, too, goes into the



corolla, but once inside behaves much more energetically than the nectar-carrier. It collects pollen from the stamen and soon two white, yellow or pale red pellets appear on its hind legs. Then the worker returns to the hive loaded with its heavy cargo.

Pollen is the bees' chief food during the summer. When winter comes they feed on the reserves of honey that have been accumulated in the hive.

The building workers secrete and work into putty the wax which is needed for the construction of the cells. The frames contain rows of cells, designed, made and maintained by the builder bee. Each has a hexagonal-shaped entrance and a floor in which the hexagon is divided into three diamond-shaped walls.

The highest storeys of the honeycomb contain liquid honey: the cells here are not sealed. Other cells are little granaries of pollen, and most of those on the lower storeys are sealed up by the mason bees. In the centre of the frames are to be found the breeding cells, complete nurseries around which foster-mothers busy themselves: each one shelters an egg, a larva or a pupa.

The queen is enormous in comparison with her fellow bees and may be over half an inch long. She spends her life in the nursery, going from cell to cell and laying an egg every thirty seconds. Her servants follow her every movement and stand by to see that she has everything she needs.

At the entrance to the hive stand ruthless guards who chase away or kill bees that do not belong to the hive.

Inside the hive there is a continual buzzing from the wings of the ventilator bees, whose task it is to maintain the temperature of the hive at a steady 35° centigrade.

Each year hundreds of drones are born in a hive; these drones take no share in the work. One day the workers get tired of feeding these lazy creatures and chase them out. Left to themselves they die of hunger.

Do bees have some sort of mysterious language? It is certainly true that plundering bees communicate with one another in a very interesting way. When one of them discovers a field of flowers, it alights at the entrance of the hive, but instead of going in it jumps around energetically, doing a kind of dance. Then a lot of bees come out of the hive and crowd round their dancing companion, who seems to be wanting to say to them: 'I've found a supply of nectar

FORMATION OF A SWARM: a week before the birth of a new queen, the old sovereign leaves the hive escorted by about half the colony. Before flying off, the emigrating workers gorge themselves with honey. Led by the old queen, the cloud of bees builds up round about the hive. Finally the queen settles in the hollow of a tree fork, and the accompanying workers crowd round her, forming a cluster or swarm of bees.

and pollen'. This 'bee dance' is continued by the forager after it enters the hive.

It is now believed that, by means of this dance, the bee can tell them the place and distance of its find, because immediately, hundreds of bees fly off to the source of the nectar or pollen.

There are also other social bees — the bumble-bee is one. The population of their colonies is less than that of the apis family or honey-bees. Bumble-bees have not just one sovereign, but several minor queens. They live underground in the hollow of a rock or in some deserted tunnel. They are large black insects with yellow and white rings, and are clothed in a fur which enables them to travel right up to Lapland.

There are several species of parasitic bee which, by force or surprise, make their way into the nests of other bees. Then they replace the other bees' eggs with their own. The parastic bumble-bees, too, act in this manner and choose their victims from among those species which they most resemble.

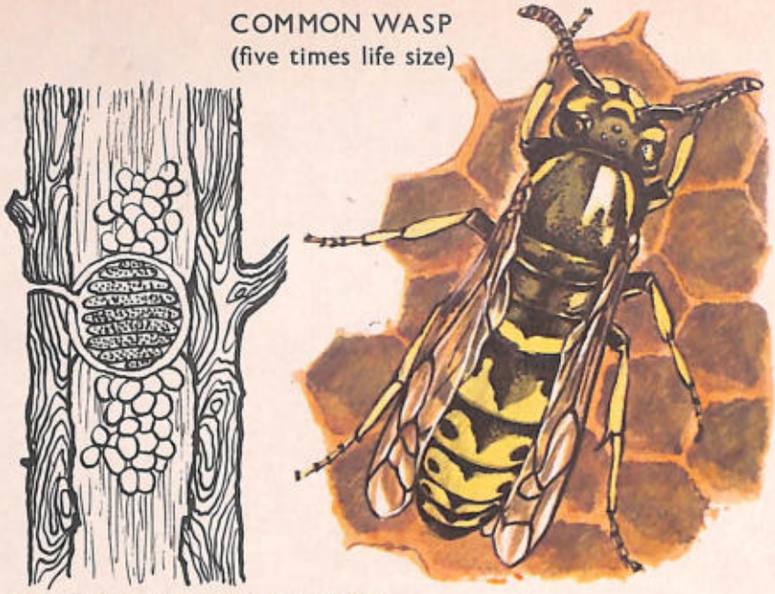
Among the solitary bees members of the same species sometimes build their individual nests quite near each other. They are not, however, founding a colony but merely a selfish little village community, where every bee lives its own life without contact with its neighbours.

Bees that do not sting

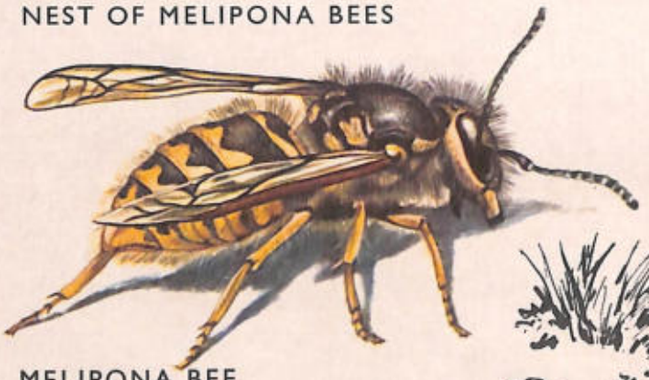
The stingless bees represent another branch of evolution in the thronging world of the bees. They live in the tropics of both the Old and the New Worlds and are more primitive than our domestic bees. In particular they are not such good mothers: they limit their motherly care to making a cake of honey and pollen for their future larvae. And even the honey-comb is of inferior quality, as they mix their wax with earth or wood.

Nevertheless, many species of these primitive bees have learnt the art of building hexagonal cells. Others, by jerking their bodies about, can inform the other bees about flower scent, but they are still unable to tell them the direction of the source of nectar or its distance away. In fact, the feverish movements they make are nowhere near the perfection of the dance-language of our domestic bees. According to Karl von Frisch, there also other species where the worker, once it has had the good fortune to find a supply of pollen, acts as a guide to a swarm of plunderers.

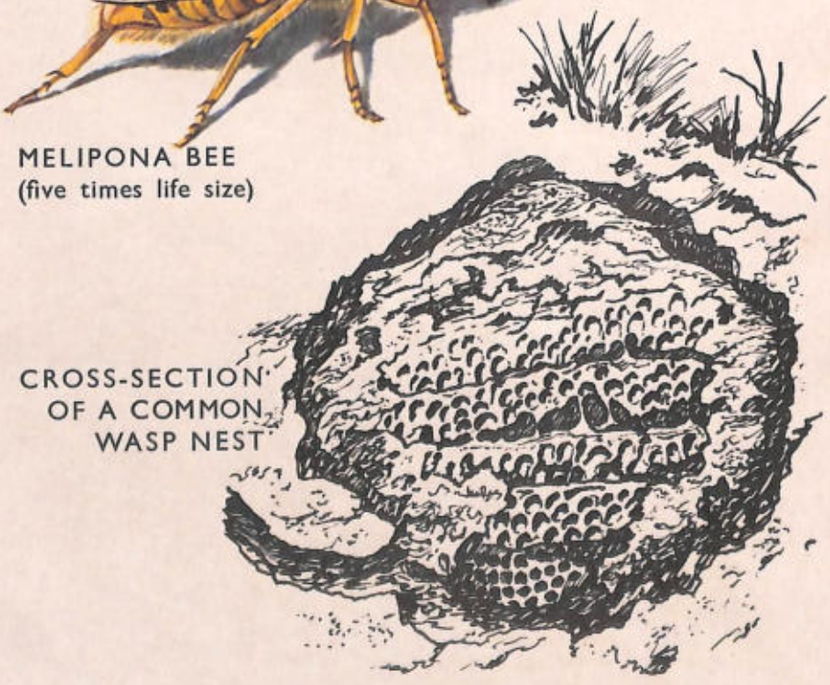
COMMON WASP
(five times life size)



NEST OF MELIPONA BEES



MELIPONA BEE
(five times life size)



CROSS-SECTION OF A COMMON WASP NEST

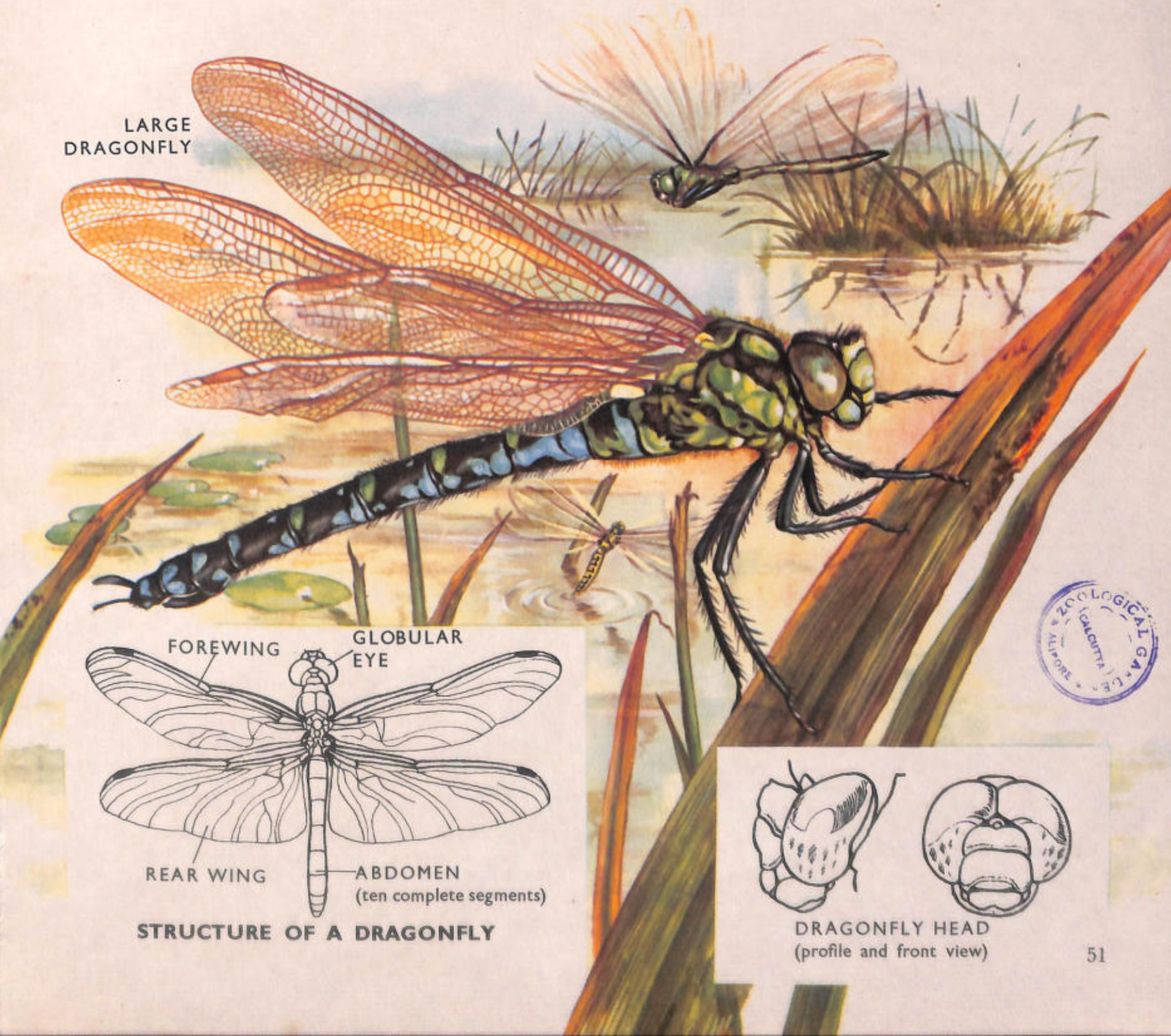
BUMBLE-BEE
(five times life size)

THE MELIPONA is a South American wild bee. It builds its nest in hollow trees. The brood cells are located horizontally inside the nest, while the supplies of honey and pollen are kept in tubs outside. Unlike our domestic bees, it is the old queen which stays in the hive and the young one that goes off to look for other quarters.

Aquatic insects

All large areas of marshland are similar, whether they are in America, like the Amazon labyrinth and the swamps of Florida, or in Europe or Asia, like the deltas of the Rhone and the Danube and the mouth of the Mekong. They are vast uncultivated tracts where rustling forests of reed and bamboo cover the water in tangled confusion, together with the roots and twisted trunks of mangrove or willow trees. All these swamps, whether in Brazil, Florida or the Camargue are one single, strange territory. Midway between land and water, they always contain similar plants and animals, similar stifled cries and furtive noises.

Occasionally across the sky and the mirror-like surface of the water flies a heron with wings as big and almost as slow-moving as palm leaves; or a panting



DRAGONFLIES AND DAMSELFLIES catch their prey in flight, often skimming over the water's surface. They are insects with biting mandibles, and each of their six legs is armed with two claws. The kings of the water, the *Anax imperator* and the *Anax parthenope* are two fearful insect hunters, capable of flying at nearly twenty miles an hour.

ANAX PARTHENOPE laying (enlarged to twice life size)

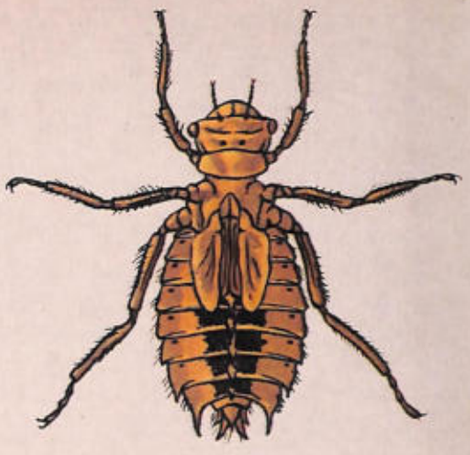
DRAGONFLY AT REST
its four wings
stretched out horizontally

flight of wild duck; or perhaps the majestic shadow and sudden glimmer of a large dragonfly. It is off to hunt, and has just caught sight of its prey, some moth or wasp, or a dragonfly smaller than itself. Immediately it soars off in pursuit. These waters and banks, so quiet in appearance, are swarming with living creatures, swimming, flying, slithering, diving, and sometimes even walking on the surface of the water. Fish, birds, reptiles, amphibians, insects — hunters or fishers — all know that, in this world of water and vegetation, silence and immobility can often help them avoid death at the hands of one of the others. A sudden stir — is that something jumping out of the water, or something diving? Is it a kingfisher after a young pike? Or a cat-fish trying to snap up a tadpole? Or is it just a branch being broken by the wind? No. It is a big, green, black-spotted frog that has been sleeping with its eyes half closed just above the surface of the water: in one quick movement it gobbles up an over-confident water measurer walking across the dark water.

The frog now heaves itself on to the leaf of a water-lily. The troop of water-measurers have scattered in panic. Content with its fresh feast the frog is not prepared to repeat the effort. Then a midge settles just nearby . . . not for long, however, for along comes a small blue dragonfly, a damselfly very fond of midges. The damselfly is getting ready to pounce on its prey when it suddenly sees the frog and quickly regains height. The midge has noticed nothing and goes on with its toilet. One after the other it passes its forelegs over its head and antennae. Still sitting on its leaf the frog remains as motionless as a Buddha and, opening its fine golden eyes, cautiously inspects its near surroundings. The frog has good reason to be suspicious: around it the silence is heavy with life and menace. A long way away in the rushes it hears the trumpeting cry of a frightened bird, then, nearer at hand, on the bank, the crackling of twigs beneath the boot of a hunter on the watch. Then suddenly, splash! — in a lightning instant, a large carp jumps out of the water and snaps at the empty air. The frog just has time to execute a crash dive and escape from the fish's huge, round, gaping mouth. The midge falls into the water, to the great pleasure of a passing water-measurer.

The big swamps, flooded plains, ponds, rivers . . . all fresh water is part of the immense world of the aquatic insects. Not all species, though, prefer semi-stagnant, calm water, or completely stagnant water.

EPITHECUS BIMACULATUS
carrying its eggs on the end
of its abdomen
(three times life size)



DRAGONFLY LARVA
with embryonic wings
(twice life size)

Some look for rapid currents and highly oxygenated torrents.

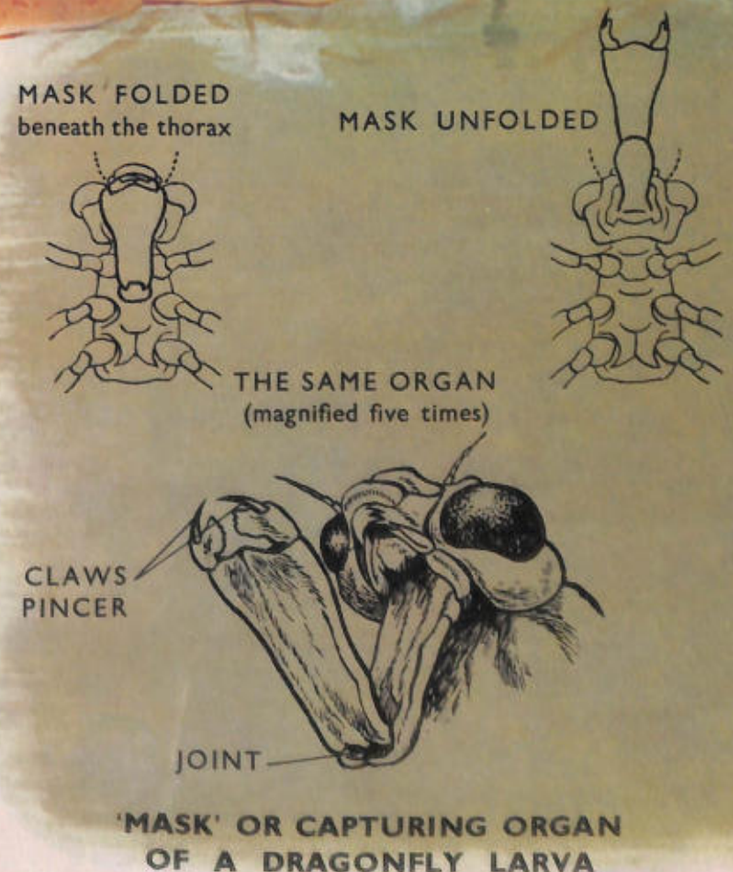
The good swimmers among these insects can move about very quickly by means of their legs which are designed like paddles for this particular purpose. And the flying insects like the large and small dragonflies have no reason to be jealous of the birds. The long, stiff wings of the large dragonflies enable them to perform fantastic zigzags on top of the water.

One of the most original features of the aquatic insects is that they never get wet. Their chitin covering secretes a film of grease which acts in the same way as the insulating substance with which the feathers form of water-birds are impregnated.

Dragonflies

The big dragonflies are, together with the ants, the praying mantis and the wasps, the most dangerous of the carnivorous insects. Their life is one long hunting flight — their favourite prey is little dragonflies or damselflies, flies, butterflies, mosquitoes and even wasps.

The big dragonflies are in turn terrorised by a majestic blue and green dragonfly known as the



'MASK' OR CAPTURING ORGAN
OF A DRAGONFLY LARVA

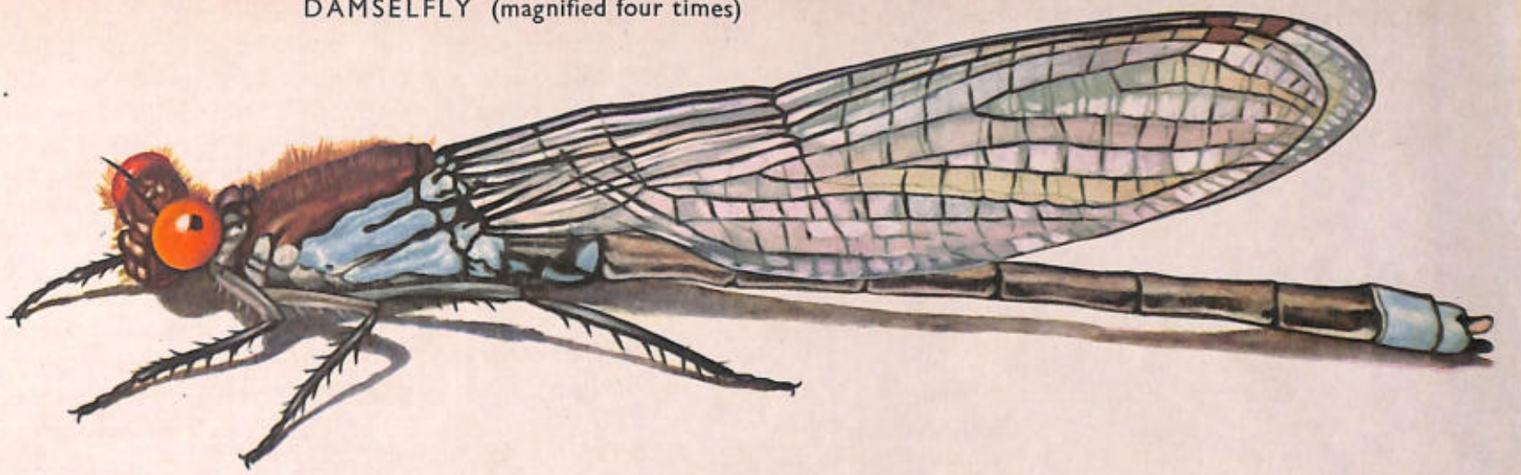
Emperor dragonfly. This dragonfly ignores small insects as the eagle ignores sparrows. As soon as a dragonfly with a large wing-span appears, the Emperor gives furious chase. If its opponent is slower, the Emperor grounds it — overwhelming it with its wings — then decapitates it with one blow of its mandibles.

The body and wings of a dragonfly boast either one or several colours. They have thin, elongated bodies and two pairs of large, membraneous wings. The long, supple wings have a network of sinews which act as a strong but flexible frame. Like helicopters, dragonflies take off vertically and can hover in the air: they can also, while flying, make right-angle turns in any direction and fly backwards if necessary. The fastest of them can travel at about ten yards a second.

Dragonfly larvae are born and live in the water. Their life lasts for weeks, months or years. They have dull skin, a long thin abdomen, and legs and eyes. They are carnivorous and grinding creatures: they capture their prey by means of their lower lip or 'mask'. This ingenious piece of fishing equipment is made up of several articulated parts. When at rest these parts fold back over the mouth of the larva, forming a 'mask'. When prey is in sight, the larva

HATCHING OF A DRAGONFLY (final moulting): 1. The old skin of the thorax splits open on the back; 2. The head and thorax leave the slough; 3. The insect shakes its head downwards in order to free itself more and more; 4. The insect braces itself against its slough in order to free the end of its abdomen; 5. Finally, after all these exertions, the young dragonfly lies resting beside the slough; 6. Unfolding of the wings and drying out of the whole body.

DAMSELFLY (magnified four times)



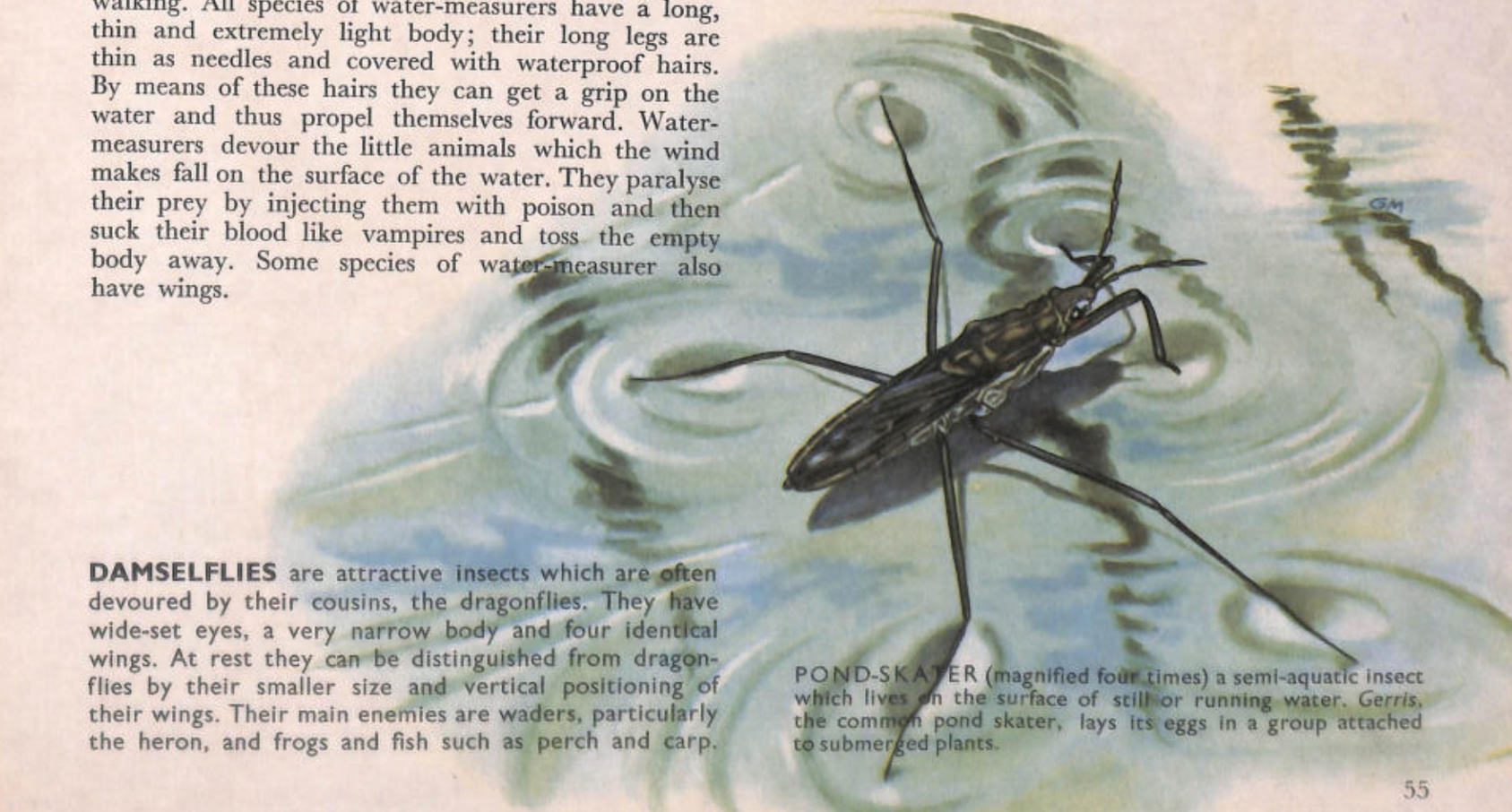
DAMSELFLY LARVA with its mask unfolded in front

approaches slowly and, once in good range, the mask shoots forward and two little claws on the end grip the animal. As it folds itself back the organ carries the prey to the larva's mouth. The whole operation is like the lightning movement of a rake.

Like fish, dragonfly larvae have gills to extract oxygen from the water. They suck water in and out in the same way as our lungs breathe air in and out.

Water-measurers

Water-measurers move untiringly across the surface of the water: their jerky movements give the impression that they are skating, or rowing, so regular and precise seems to be the action of their legs. But they are walking. All species of water-measurers have a long, thin and extremely light body; their long legs are thin as needles and covered with waterproof hairs. By means of these hairs they can get a grip on the water and thus propel themselves forward. Water-measurers devour the little animals which the wind makes fall on the surface of the water. They paralyse their prey by injecting them with poison and then suck their blood like vampires and toss the empty body away. Some species of water-measurer also have wings.



DAMSELFLIES are attractive insects which are often devoured by their cousins, the dragonflies. They have wide-set eyes, a very narrow body and four identical wings. At rest they can be distinguished from dragonflies by their smaller size and vertical positioning of their wings. Their main enemies are waders, particularly the heron, and frogs and fish such as perch and carp.

POND-SKATER (magnified four times) a semi-aquatic insect which lives on the surface of still or running water. *Gerris*, the common pond skater, lays its eggs in a group attached to submerged plants.

Water-scorpions

Other aquatic insects, such as the water-scorpions, *Ranatra*, have a long breathing tube which extends beyond the end of their abdomen. Water-scorpions are unusual underwater hunters. They are bad swimmers, and so are content to walk under the water when they are not lying in wait with their head pointing downwards. In this position they look as if they are suspended from the surface of the water on which the end of their breathing tube lies flush. As soon as a dangerous fish appears, water-scorpions lie dead still so as to remain unnoticed.

Giant water-beetles

The giant water-beetles, or Dytiscidae, are large carnivorous insects, flat in shape and dull in colour, either brown or black. They do not have gills, so when they dive they take with them a bubble of air which allows them to stay underwater a long time. During the day, they swim, dive or walk beneath the water looking for their favourite prey: young fish, tadpoles etc. At night they may fly from one stretch of water to another.

Caddis-flies

Caddis-flies are closely related to the moths, but belong to the order of Trichoptera, a name which comes from the Greek and means 'hair-covered wings'. Unlike the scale-covered wings of the moths, those of the caddis-fly have short hairs. In summer fishermen see the perfect insect flying about over rivers, making sharp turns. The tender flesh of the caddis-fly larvae is a great delicacy to fish and frogs of all sizes, which are therefore all potential traps for the larva throughout its life in the water.

The larva builds for itself a protective shell, for it does not have one at birth. Every larva is endowed with two silk-spinning glands, and also, no doubt, a sense of survival. About forty-eight hours after leaving its egg the larva starts building its case. It weaves a sort of silk pipe or sheath which it then embellishes with various bits of material to be found floating in the water. According to the species of caddis-fly it belongs to, the larva cloaks itself in twigs, leaves, small shells or even minute flat stones. In this way it can turn into a strange living trinket or a tiny bundle of sticks.

WATER BEETLES are excellent swimmers and divers with bodies one to two and a half inches long according to the species. They use their bristle-fringed legs as oars. These insects and their larvae carry very sharp, crescent-shaped mandibles, and in the stagnant waters of marshes and pools they play the role of tiny fresh-water sharks.

Silk producers

The silk-producing insects which are bred by man are either caterpillars or spiders. The largest producer of natural silk in the world is the silk-worm, the caterpillar of the *Bombyx mori*, a moth which originates from China.

The history of the silkworm

The Chinese knew how to make use of the silk from this caterpillar as long ago as the year 2,600 B.C. The Empress Si-lung-chi was the first ruler to become interested in the breeding of the silkworm. And history, or legend, adds that it was her husband, the Emperor Houang-ti, who gave her the idea of using the silk from the cocoons. Already, in those far-off times, it was forbidden to take the eggs or caterpillars of the silkworm out of China, and the pulling up of mulberry trees was a crime punishable by death. The history of the silkworm is that of its long journey towards the west. The precious insect was probably introduced to Central Asia at the beginning of the

A good long time after the arrival of the *Bombyx mori* in Italy, a Florentine began to wonder if this wonderful silk-spinning organism was hiding some other secret. After numerous fruitless experiments he had the idea of dipping a silkworm in vinegar just as it was attaching the end of its thread to a branch. The ingenious breeder then took hold of the silk glands and, steadily twisting them, skilfully drew out the silk so as to obtain a particularly strong sort of thread. This is how the first 'Florentine silk' appeared. For a long time the two main users of this fibre were the surgeon and the angler. The former used it for sewing up the edges of large wounds, while the latter attached his fish-hooks to the end of the thin, strong, flexible thread. It is interesting that the surgeon and the angler both stopped using Florentine silk thread when the early synthetic fibres such as nylon, first appeared.

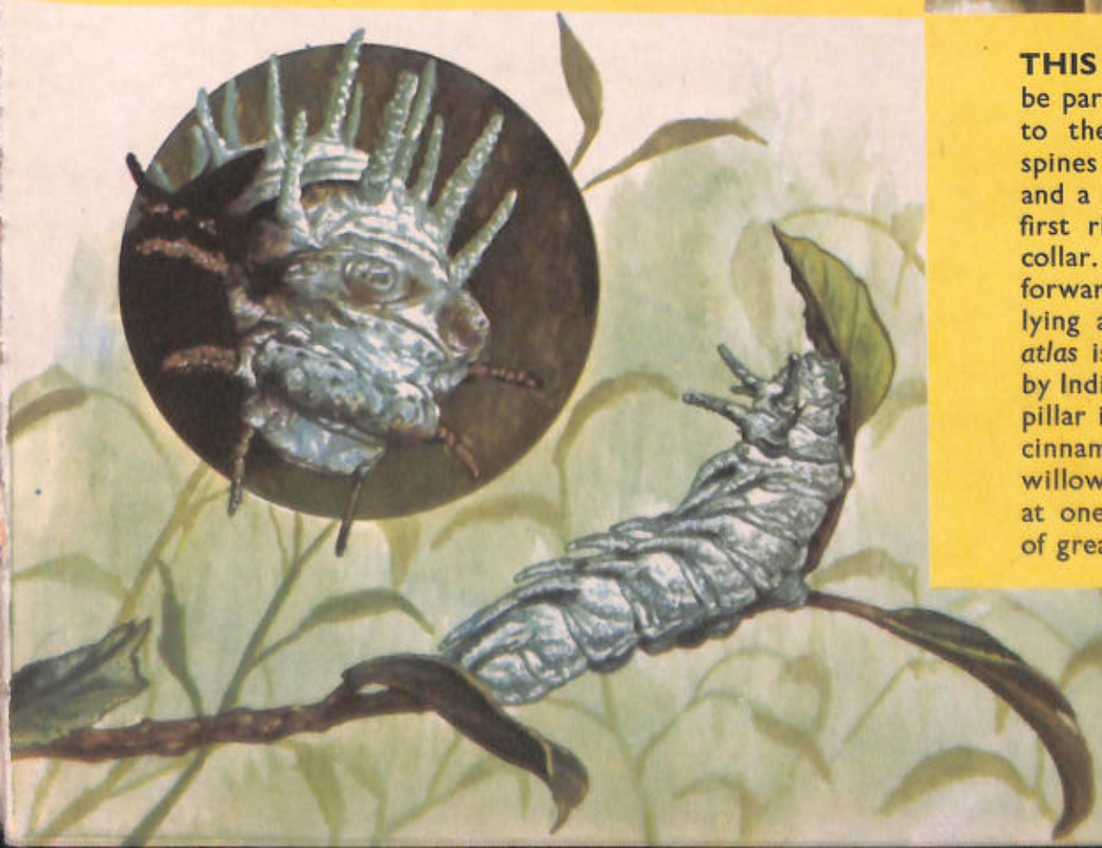
The caterpillar of the *Bombyx mori* has many competitors in the East. Caterpillars of the *Antheraea* moth of Japan, and of the Far-Eastern *Philosamia cynthia*, and of the *Philosamia ricini* of India all spin precious cocoons as well. Other silk-spinning caterpillars originally came from America, such as the Mexican *Rothschildia orizaba*. Man only raises species which are skilful workers, since most silk-spinning insects do not build cocoons. They are usually content to weave spindles or very tightly drawn threads which are no use at all for commercial silk production.

THE RAW SILK is obtained by winding off the cocoons. In the past this was done by reeling the thread on to a sort of wooden drum rotated by the operator's foot while she controlled the actual unwinding of the cocoon with her hand. Nowadays several clusters of threads are reeled off mechanically on a frame. The silk skeins thus obtained are then again wound off and reeled on to more spools.

The caterpillars of many tropical moths have cocoo that may be also unwound as those of the caterpillar the *Bombyx mori*. Moreover, these moths would equa well get acclimatised to southern Europe or to Flor or California.

THE ANTHERAEA YAMA-MAI species is a native Kiou Siou, an island of Japan. The caterpillar (shown he life size) feeds on oak leaves. At the beginning of life it is an attractive golden yellow, while its legs a the first segment of its thorax are mahogany red. La it decks itself out in very pale green. When it has moul four times it spins a yellowish-green cocoon from wh eventually is born a magnificent moth, bright yell with orange glints.

THE PHILOSAMIA CYNTHIA is another Eastern moth. The caterpillar lives on the Tree of Heaven (*Ailanthus glandulosa*), whence its name 'the Tree of Heaven silkworm'. It is regularly patterned with black spots. When fully grown this caterpillar turns emerald green, with its legs and the last segment of its abdomen yellow. The reddish-grey cocoon is closed at one end and open at the other. The Tree of Heaven is a tropical tree, but it was successfully brought to the gardens of southern Europe; *Philosamia cynthia* followed. *Philosamia cynthia* is a large, browny-yellow moth with a white stripe running right across both wings.



THIS TERRIFYING DRAGON'S HEAD might be part of some old Asiatic legend; in reality it bel to the caterpillar of the *Attacus atlas*. Bristling spines and nipples this little monster may reach and a half inches in length and an inch in diameter first ring carries four spines which give it a sor collar. The first three rings have one lateral spine poi forwards, while rings 4 to 10 carry four rows of sp lying almost flat backwards. The habitat of the *Att atlas* is bounded to the north by China, to the by India and to the south by the island of Java. The c pillar is extremely voracious and strips leaves from cinnamon tree, the mulberry tree, the peach tree, willow tree and the oak. It spins a brown cocoon, at one end: with the silk obtained from this mate of great strength may be woven.

SILKWORM
eating a mulberry leaf
(enlarged to twice life size)

SILKWORM
building its cocoon
(life size)

Christian Era by a Chinese princess who was to be married to a King of Boukhara. This stylish princess decided to take with her in her baggage the means to make wonderful clothes. So she hid in her trunks some silkworm eggs and some plants of white mulberry. From the fortress of Boukhara caravans set out in the direction of Constantinople, but it was not until the sixth century that the jealously guarded secret become known to Eastern Europeans. In the eighth century silk eventually reached Spain, following the Arab invasion. As a result the mulberry and the silkworm became established successively in Spain, Sicily, Italy and France.

Making the cocoon

The silkworm is the caterpillar of the *Bombyx mori*, a moth which usually lays eggs in the late summer and autumn. The following spring, minute hairy caterpillars emerge from the eggs. The temperature has to be at about 20° centigrade for hatching to take place. Forty days or so after its birth the caterpillar grows to eight or ten times its original size: from about three millimetres to nine millimetres long. The silkworm is extremely voracious: in a silkworm nursery the noise of its mandibles working on the mulberry leaves is as loud as falling rain. A silkworm moults five times before starting its metamorphosis. Then

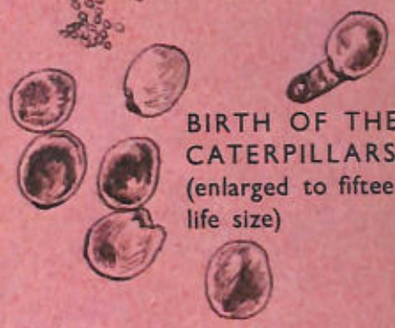
breeders place branches of oak or heather above the beds and the caterpillars climb on to these supports and fix themselves there. The two silk glands which they carry beneath their jaws secrete a sticky substance which turns into silk as it comes into contact with the air and solidifies. The caterpillar moves to and fro from one twig to another and weaves around itself a first loose casing. Then it wraps the thread round itself, pulling it tighter and tighter, so that a sort of opaque shell is formed. In this the larva undergoes its transformation into a pupa. Three weeks later, if man does not intervene, the perfect insect bores a hole in the end of the cocoon and a yellowish-grey moth comes out. Since the silk thread is broken in several places, the cocoon is useless.

Silkworm breeding

In captivity the silkworm never becomes a perfect insect: the *Bombyx mori* never leaves its chrysalis. When the cocoons are made, the breeder collects them and puts them in a stove where they are subjected to a temperature of about 75° centigrade for about fifteen minutes. The pupae die but their silk cocoons remain intact. Afterwards the cocoons are plunged into very hot water to soften them. It is now time to look on the cocoon's surface for the end of the thread which was the starting point. The end is then attached to a winder on to which the silk is reeled. This operation produces a long strand of raw silk which may measure from a half to three-quarters of a mile long.

BOMBYX MORI
(about five times life size)

BOMBYX MORI
depositing its eggs
(life size)



BIRTH OF THE CATERPILLARS
(enlarged to fifteen times life size)

ADULT CATERPILLAR (enlarged by a third)

SPINNING THE COCOON

THE FINISHED CO

LENGTHWISE CUTAWAY OF THE COCOON SHOWING THE CHRYSALIS

BIRTH
THE M

LIFE CYCLE OF THE BOMBYX MOR

ROTHSCHILDIA ORIZABA (slightly enlarged). Its green and yellow caterpillar lives in Mexico and Central America, feeding on leaves of lilac, oak and ash trees. Just before it stops growing, a lateral yellow line appears all along its abdomen. On the underside of its body are short, whitish bristles. Between forty and fifty days after its birth it weaves a large, dented cocoon of brown or light grey silk according to habitat. The cocoon is folded in a leaf and one of its tapering ends is left open like that of the *Attacus atlas*. This caterpillar is fairly hardy and so is easy to rear.

YPONOMEUTA and its caterpillars (twice life size). It is a small European moth, particularly common in the south. The caterpillars live in a colony beneath a large tent (their 'dining-room') which they weave round the branches about three weeks after their birth. These destructive creatures then attack the leaves which they have imprisoned beneath their silky sheets. They feed on apple trees, plum trees, almond trees, hawthorns and, more especially, cherry trees. Each caterpillar shuts itself into a white cocoon beneath the communal tent. A moth is eventually born from the cocoon; the lower wings of this moth are bordered with fine hairs.

OLIVE MOTH and its caterpillar (magnified six times). Each year three generations of caterpillars succeed each other on European olive trees. The first generation gnaws at the leaves of the olive tree in the spring, then each caterpillar withdraws between two leaves held together by silky threads. The pupae give birth to grey moths which, in turn, become the parents of a second generation of caterpillars, caterpillars which this time are leaf-eaters. The third generation caterpillars penetrate the olives themselves and eat the fruit.

THE LEAF TWISTERS are voracious caterpillars, red, green or grey-green in colour, according to species. They owe their name to the rolled leaves in which they go through their transformation. Mostly they attack the tree's buds, although they sometimes also eat the young fruit. They are to be found on practically all fruit trees.

The most common are the red leaf twister and the green leaf twister. The first ravages orchards throughout the United States, Canada and Central Europe. The habitat of the second stretches from Asia Minor to Western Siberia, covering central and southern Europe. Before the start of the cold weather, leaf twisters retreat into a hole in the bark, where they weave around themselves a warm, silky cocoon.

Other species of leaf twister eat the needles of the white spruce, the scales of fir-cones, the bolls of the cotton shrub, the buds and young leaves of the oak. The oak leaf twister winters inside a leaf which it rolls up into a cornet, joining the edges together with a thread of silk. This caterpillar also uses its silk thread to slide from branch to branch.

Immediately after hatching, the small, hairy caterpillars of the black-veined white butterfly gather together on the tops of hawthorn leaves, of which they devour only the outer skin. They moult twice, the second time a few days before the start of the winter, when they construct round the leaves small silk pockets in which they shelter either singly or in little groups of two or three. In the spring each one of these black caterpillars results in a delicately veined white butterfly which has slightly darkened wingtips.

COTTON BOLL
cut-away to show
a leaf twister caterpillar
(twice life size)

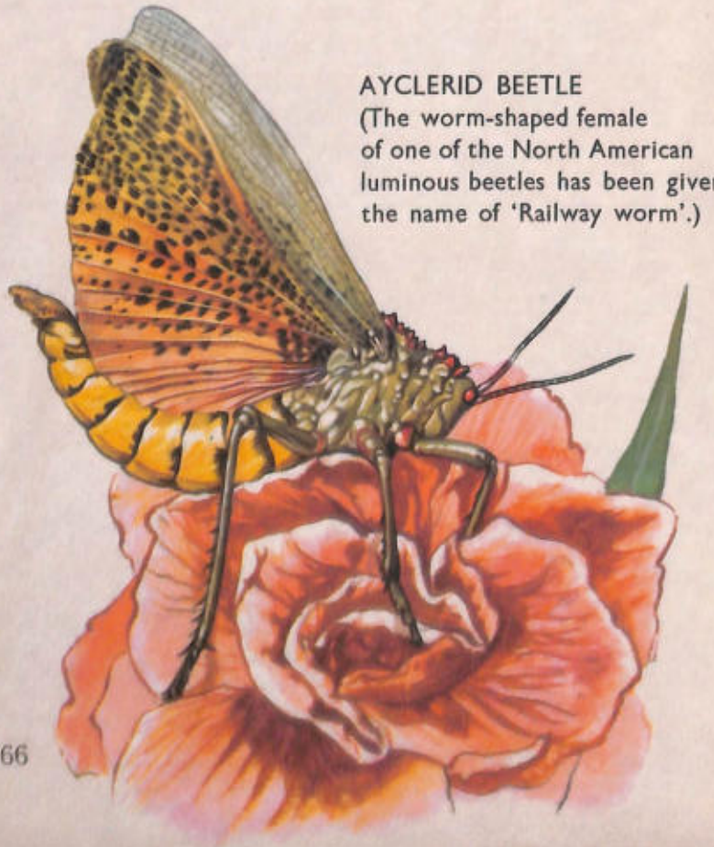
MOTH
and caterpillar
of the oak
leaf twister
(life size)

BLACK-VEINED WHITE BUTTERFLY
and its caterpillar
(life size)

CUCUJO
or South American glow-worm.

THE CUCUJO OR PYROPHORUS BEETLE is a South American burrowing glow-worm. Like the Indians, the Spaniards used *cucujos* to light the way when marching through the night towards the enemy. When an Englishman, Robert Dudley, landed at night on the west coast of South America, he saw a mass of tiny lights coming to meet him and thought that the Spaniards were waiting for him with all the fuses on their cannons ready lit.

PHYMATEUS FLOWER-GRASSHOPPER OF GUINEA
Some species are known to infest the nests of certain bees



AYCLERID BEETLE
(The worm-shaped female of one of the North American luminous beetles has been given the name of 'Railway worm'.)

as a finger. On its head it carries two large yellow luminous spots that look like headlamps; all along its body it has a row of green and red dots like a succession of lighted carriage windows; and on the end of its tail a red disk similar to the rear-light at the end of a train. Among insects of the night, as among deep-sea fish, luminosity is the result of a chemical reaction produced by a complex gland. The gland secretes two substances which give off light when they come into contact with one another. With certain species the intensity of this glow is increased by means of an apparatus of lens-cells and reflector-cells.

The musicians

Insects are not true musicians: their instruments are generally only one-stringed and able to produce only two or three sounds. The cricket and the cicada are the loudest singers. The cricket digs a hole in which it spends winter, spring and rainy days in comfort, and it seems quite probable that this insect's singing on its doorstep merely expresses its joy in being alive. It lifts up its two tegmina or forewings, then smacks

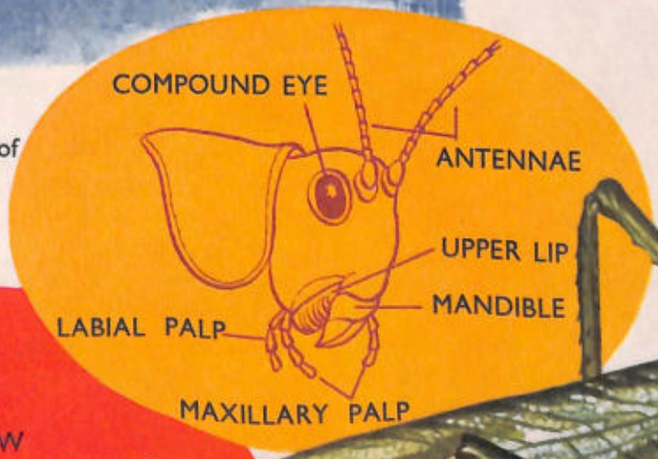
them shut again, making the inside edges rub against each other. The cricket's song is produced by this repeated rubbing. Each stroke of the bow makes a different sound, which means that someone listening to the chirping of one cricket may hear a musical phrase clearly. When a lot of crickets are performing together the individual bow-strokes are lost in the combined noise of the orchestra. The musical organ of the cicada is hollow like the sound-box of a drum. The sound comes from a membrane which is vibrated by a tensioning muscle and then amplified by the sound-box.

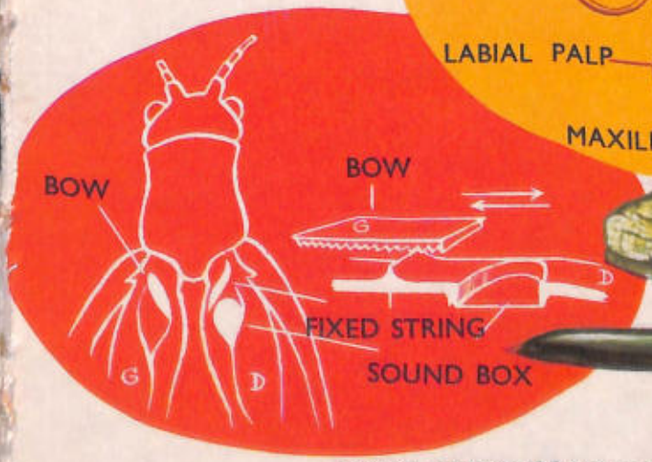
The acrobats

The insects also have their acrobats. There are many species that are talented jumpers. The flea and the grasshopper, for instance, with one spring off their rear-legs, can jump a foot high. Another insect, known as the 'click beetle', does not perform until turned over on its back. Then its thorax curves into an arch and suddenly springs back with a dry click. These movements are repeated till the insect falls back on its feet. At large American fairs one often sees performers capture the crowd's attention by showing 'jumping beans'. The beans dance about because of the extraordinary jumping of tiny caterpillars hidden inside.

The defensive instinct of some beetles has made them into bomb-throwers. On the end of the abdomen they carry a sort of spray which throws out a whitish liquid with particles as small as those of fog. The liquid is usually some toxic substance for driving away enemies.

MALE FIELD CRICKET
singing at the entrance of its burrow
(enlarged to about twice life size)





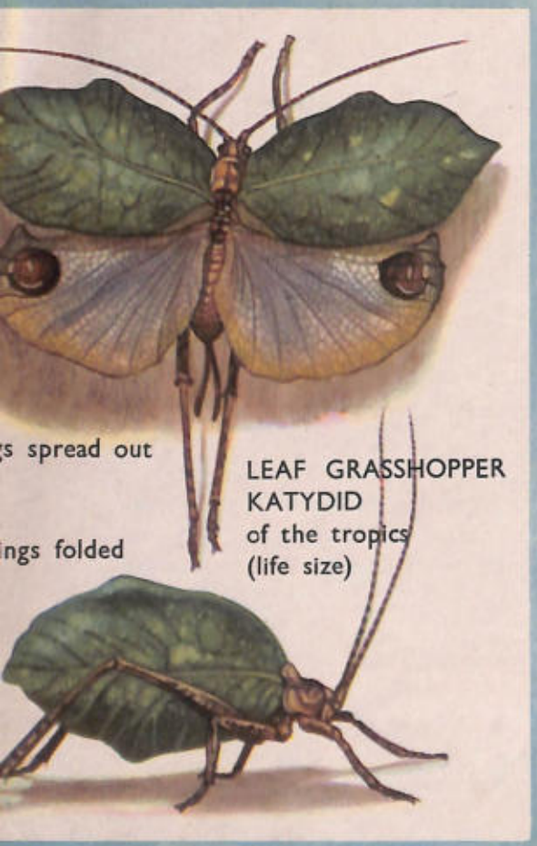
GREAT GREEN GRASSHOPPER
(three times life size)

HOW DOES A GRASSHOPPER SING?

The bow, which is carried by the left hand elytron, moves to and fro against the fixed string, or bridge, on the right elytron. The bridge transmits the vibration of the sound-box which amplifies the initial sound. With the cricket, on the other hand, it is the left elytron which acts as the string and the right elytron which is the bow.

AMONG IMITATING INSECTS a distinction is made between: homochrome insects which copy the colour of the environment in which they live; homomorphs which take on the shape of things around them; and homotypes which imitate both shapes and colours; the mimicking insects which, strictly speaking, must imitate another species of animal.

SOME HOMOTYPE IMITATORS



gs spread out

ings folded

LEAF GRASSHOPPER
KATYDID
of the tropics
(life size)

PHASMID
imitating a twig of dead wood
(twice life size)

LLIUM CRURIFOLIUM
itating a green leaf
(slightly enlarged)

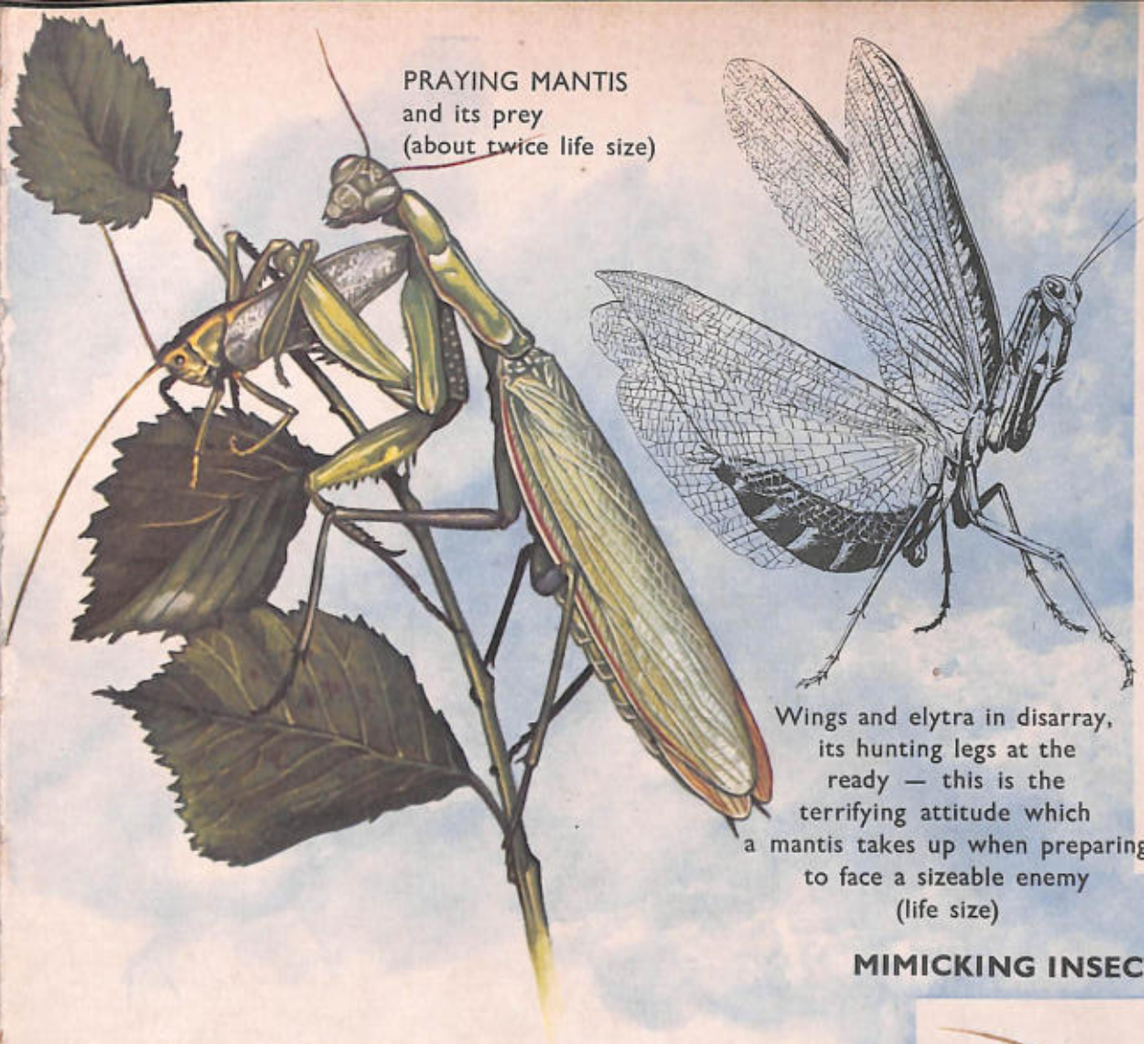
KALLIMA BUTTERFLY
imitating a dead leaf
(enlarged to about twice life size)

The imitators

Among the imitating insects the art of disguise is highly developed. Some entomologists regard the phenomenon as a defence strategy of the weak: they then distinguish between mimetic insects which try to remain unseen and counter-mimetic insects which assume a terrifying appearance. Other experts treat mimicry as the result of over-development of decoration, and say that it serves no purpose since the 'mimicking' species form only a small proportion of insect fauna. However, perhaps mimicry will develop into an effective protection in future millenia.

Throughout the world all sorts of insects are found which are almost exact replicas of parts of plants: the leaf-mantis, the flower mantis, the leaf-grasshopper, the leaf-butterfly etc. The king of camouflage is undoubtedly the rose-tree phasmid. This insect has a green, spindly body and legs like saw blades, tinted with red. In both shape and colour it is a perfect imitation of a twig on a rose tree, so perfect indeed that it is almost impossible to notice it. Of the insect 'terrifiers' the most effective disguises are those of the caterpillars which pretend to be heads of snakes and the butterflies which use their wings to imitate the head of a screech owl.

Although mimicry remains a puzzle, it serves to remind us that experts do not yet know all insects



PRAYING MANTIS
and its prey
(about twice life size)

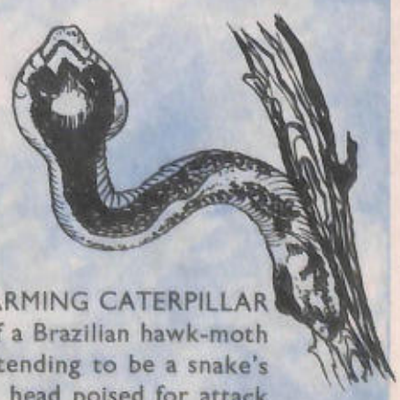
Wings and elytra in disarray, its hunting legs at the ready — this is the terrifying attitude which a mantis takes up when preparing to face a sizeable enemy
(life size)

FLOWER MANTIS OF CEYLON
(slightly enlarged)

MIMICKING INSECTS

SMALL LADYBIRD-MIMICKING COCKROACHES
(enlarged to about eight times life size)

and that all sorts of discoveries are still possible. What would be an entomologist's first reaction if a reliable explorer told him that he had just discovered near the source of the Nile a locust capable of imitating the shrill whistle of the desert boa? Although he might be somewhat incredulous, the scientist would probably take the news quite calmly. For one may well imagine that unknown species of insects do exist on Earth and that, in addition, they possess unheard-of organs. Locusts, like all insects, are without vocal chords: their chirping is produced by the rubbing of their serrated femora against the horny edges of their wing-cases. Yet in one species the femora and elytra might well evolve so as to emit a sort of prolonged whistle like that of the well-known boa, perhaps because the snake preys on a lizard which in turn is itself a great devourer of locusts. Anyway, one could expect anything from an insect like the locust, which has its ears on its abdomen! And in fact insects have not yet finished amazing us. The more complicated organs of sense (smell, hearing and sight) are far from having betrayed all their secrets to researchers. Some scientists now suspect that the antennae of wasps and bees may be organs with a magnetic sense, or a sort of radar system which enables these insects to find their way back to the nest. The science of electronic biology draws many of its ideas from the sensory organs of insects *(see: What is an insect? page 22)*.



ALARMING CATERPILLAR
of a Brazilian hawk-moth pretending to be a snake's head poised for attack
(life size)

ANT (on the left)
and the insect which imitates
example of parasitic mimi
(ten times life size)

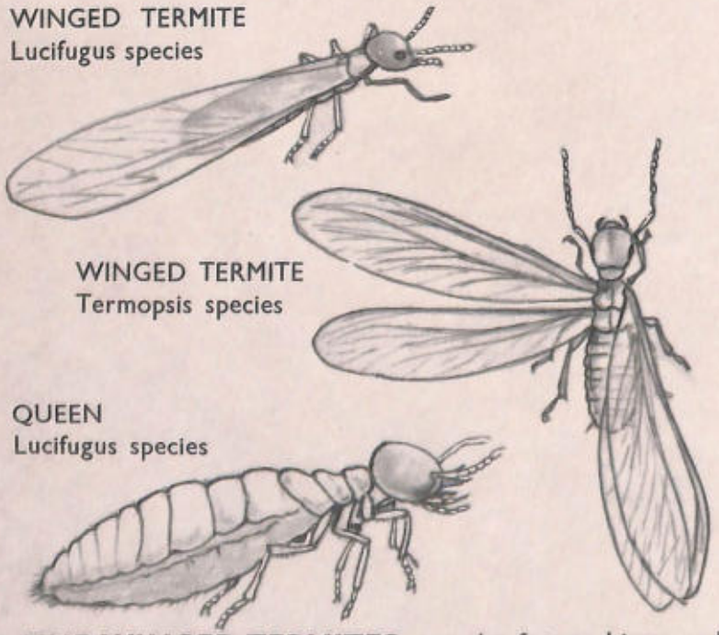
Ants and termites

The black ants attack the red ants. So, without drums or fanfares, the wars of the miniature world of the ants break out.

WINGED TERMITE
Lucifugus species

WINGED TERMITE
Termopsis species

QUEEN
Lucifugus species



THE WINGED TERMITES are the future kings and queens. When they leave the nurseries and make their appearance in the mound, there is feverish activity in the whole nest. The workers make openings in the walls of the mound, and then all the winged termites jostle to reach the exits. Sometimes several thousand of them fly off. Only a few will succeed in founding a new mound: the others will be eaten by birds, lizards and so on.

The termites were so called by the Romans, who took them to be 'gnawing worms'. For two hundred million years, fifteen thousand species of termite have been evolving beneath the ground in the tropics, in Africa, Australia and South America. Wherever the sun is hot and the climate humid there are termites. Some of the hardier species have even ventured into Europe.

Although less than a quarter of an inch long, termites are the greatest architects in the animal world. Their dwellings, frequently made from clay, are imposing castles bristling with twin-turreted keeps, cupolas and spires. These fortresses are sometimes so close to one another as to give the impression of a strange reddish village without doors or windows rising up from a forest glade or the savannah.

Termites live on cellulose. For this reason they attack, either in the wild or on man's property, anything made of wood or dry vegetable matter. Their voracity causes fantastic havoc, and in the more termite-ridden countries it is not rare to see a building collapse like a pack of cards, because these gnawing insects have reduced the woodwork to powder. Even artificial materials like the coverings of electric wires, plastic and synthetic rubber do not stand up to the termite.

The population of a termite-mound can total more than a million, of which about five hundred thousand

are workers and three hundred thousand are soldiers. The soldier termites have an enormous rectangular head armoured with chitin and equipped with powerful mandibles. Among some species the military group also includes the nasutes. They form the artillery and tank corps among termites. They have practically no mandibles, but the long perforated snout of their armoured heads enables them to throw out a sticky liquid which traps their enemies. The most powerful of these nasute termites serve in the army of the *Eutermes* of Ceylon, who have such confidence in these troops that they dare to face the ants in daylight and on open ground. During the great egg-moving marches, the nasutes encircle the column of workers, with their heads turned outwards ready to fire. And they are in turn protected by soldier termites armed with cutting mandibles.

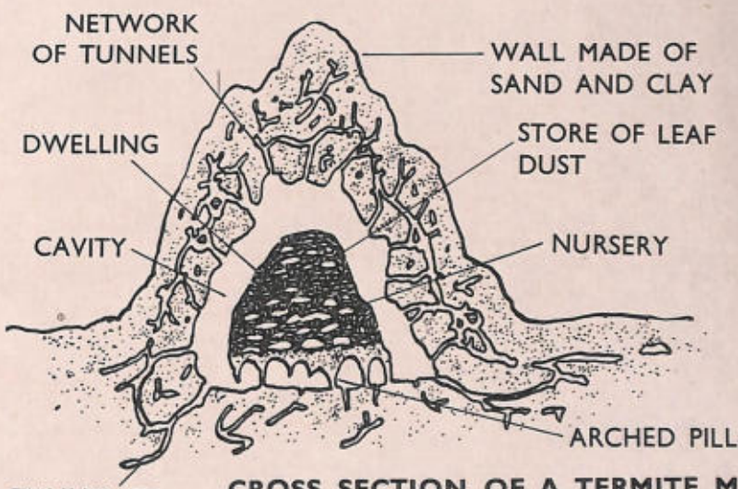
The city has a king and queen round which move a crowd of courtiers and zealous servants. Some of them have the duty of providing food. Others deal with the queen's toilet. A third team, the most highly organised, carry the eggs very carefully between their mandibles from the royal residence to the breeding cells. The breeding cells form a sort of dormitory where larvae are born and reared.

Soldiers of the royal guard surround the palace. They stand firmly planted on the ground or cling to the roof with their heads downwards. Sometimes they all sway their heads together as though marking time to some strange rhythm: this may be their way of telling one another that 'all's well' and that there is no enemy in the camp.

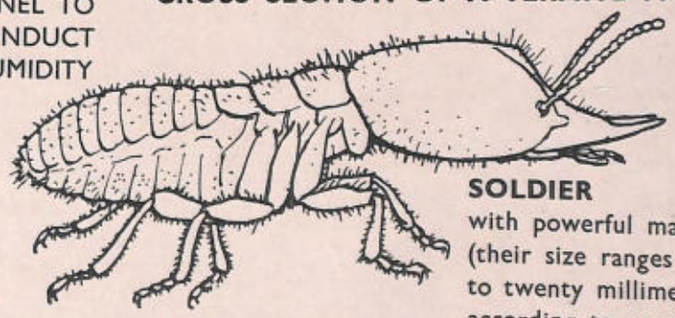
The life of a termite-mound may be compared to the movement of a clock, where instinct is the spring. Or do the inhabitants obey the orders of some headquarters so far undiscovered by entomologists?

Imagine a worker termite in action: he is going along, unemployed, past a site where five other workers are boring a tunnel. The first worker joins this party. He makes a pellet which he is going to take to another

THE TERMITE QUEEN is really the mother of the city rather than its ruler. She lays an egg every twenty seconds, that is, 4,000 eggs a day. She is beak-fed with food that has already been semi-digested by the nurses. This force-feeding adds to her bulk so effectively that she sometimes becomes 30,000 times bigger than the smallest of her subjects. The royal lodge is a rectangular room a foot long and four inches wide, but sometimes the palace workers have to move the walls back to prevent them from suffocating their sovereign.

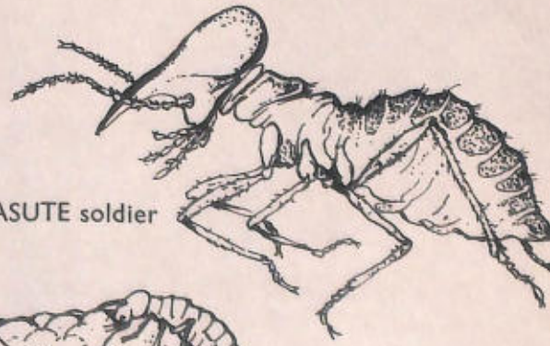


CROSS SECTION OF A TERMITE MOUND



SOLDIER
with powerful mandibles
(their size ranges from
to twenty millimetres
according to species)

QUEEN with her huge abdomen

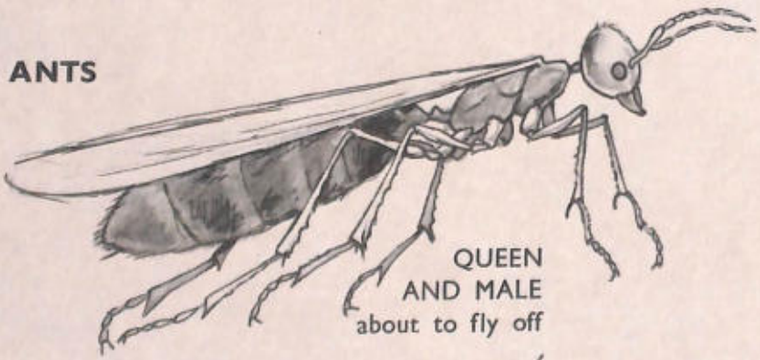


NASUTE soldier

WORKERS
(from three to twelve
millimetres in size)
building an arch

DECOMPOSED BOOK
AND DEAD TREE-TRUNK
eaten away by the
lucifugus (light-fearing)
termite

ANTS



QUEEN
AND MALE
about to fly off

WORKER

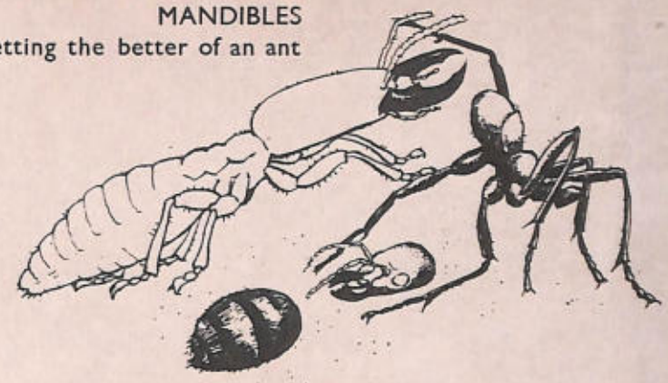
site where they are building a column. He now leaves and on his way meets a third group of termites who are busily licking each other's heads and antennae. Is this some sort of conversation during which one of them gives a message? The termite joins the circle: he gives a lick to one of them, a short hug to another. The meeting lasts several minutes, but then the group splits up, as if some sort of telepathy had cut short their round of caresses. How can we describe this force which brings the worker termites together and guides them to all the different working sites in the city? Can we call it 'intelligence'? For, whereas swallows' nests are always much the same, this can certainly not be said of two termite-mounds made by members of the same species.

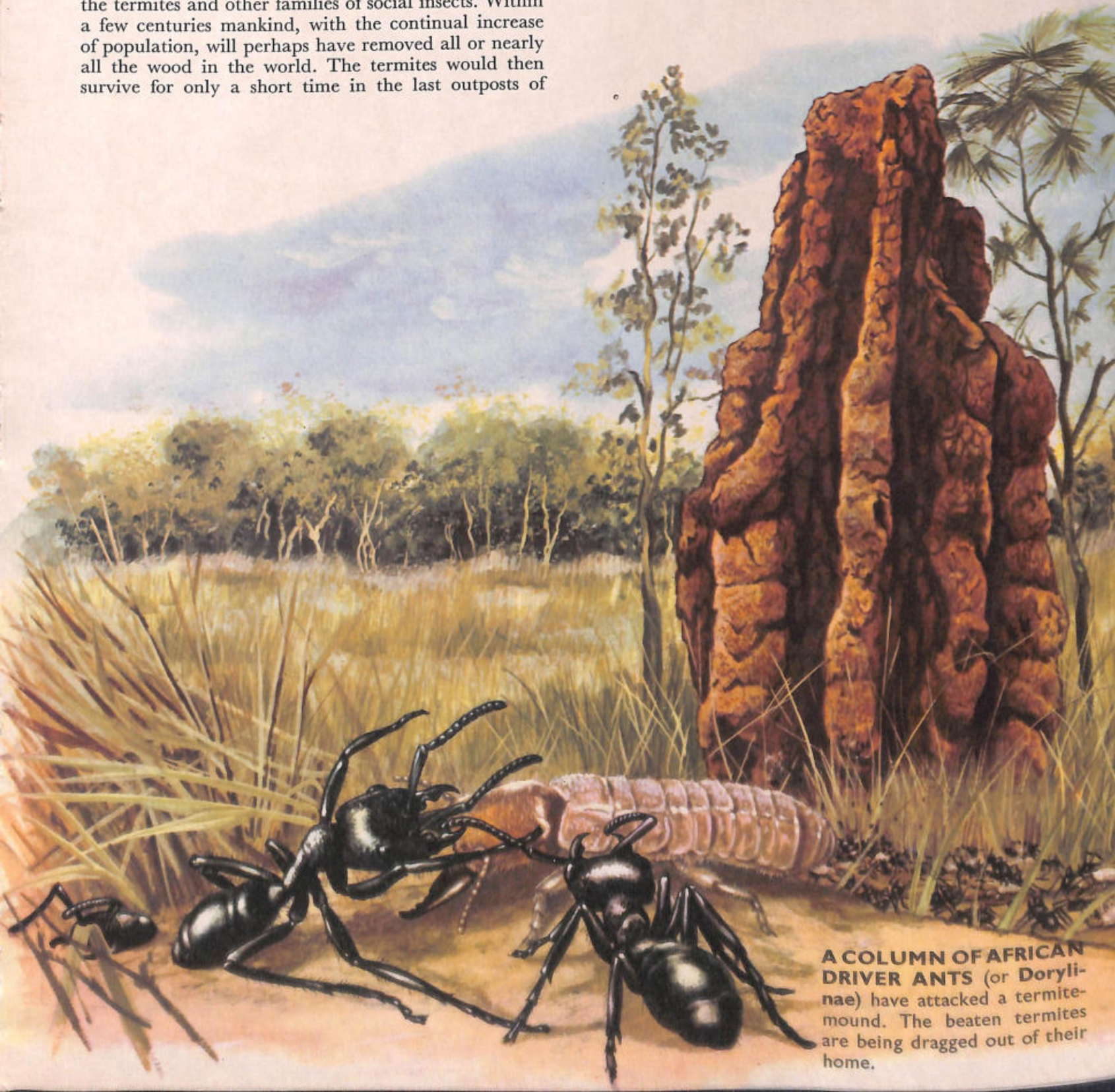
The termites' greatest enemies are the ants, which organise military expeditions against them. Early naturalists believed that termites were 'white ants'. In fact these two vast families of the insect world have nothing in common except their powerful social organisation based on the division of labour. While termites can live only in complete darkness, the ants divide their activities between daylight and gloom. Unlike the termites, most of whose dwellings rise up above the ground, the ants dig down deeply. Termites are continually mining underground and expanding their living quarters from the inside outwards, pushing a protective screen of earth before them. The ants go about it the other way around: that is, by extracting the earth. The entrance to an ant-hill is a shaft

through which the worker ants empty out the earth as they dig their tunnels deeper. In a termite-mound the future of the colony is assured by a royal couple: in an ant-hill this is done by a queen. And lastly, these two rival tribes have neither the same bodily organs nor the same weapons. Termite soldiers are protected only by a chitin helmet, whereas all the ants, both workers and soldiers, have completely armoured bodies, and also have the advantage of carrying a poisonous sting in the end of their abdomen.

The ant family only has about three thousand five hundred species, but in general shows itself to be more active and to have a wider range of operations than the termites and other families of social insects. Within a few centuries mankind, with the continual increase of population, will perhaps have removed all or nearly all the wood in the world. The termites would then survive for only a short time in the last outposts of

SOLDIER TERMITE WITH MANDIBLES
getting the better of an ant





A COLUMN OF AFRICAN DRIVER ANTS (or **Dorylinae**) have attacked a termite-mound. The beaten termites are being dragged out of their home.

forest before disappearing, unless they adapted themselves to some food other than cellulose.

The ants, on the other hand, will have a much greater chance of being able to adapt themselves to the changes man will make to nature. Among the ants there are gardeners, honey collectors, stock-breeders, harvesters, slave-makers and warriors.

The Atta ants are gardening ants which own the largest territories. Their tracks go right through the forests from Texas to Brazil. They cut up leaves into tiny pieces and then pile them up in their huge underground granaries.

The Colorado honeypot ants have not yet discovered how to build honeycombs or racks in which to keep their food allowance. So some of them turn themselves into honey-containers long before the dry season starts. Quickly these living honeypots grow larger and larger in the stomach. Then, during the summer, every time a worker needs food, it strokes the head of one of these 'honeypot' ants with its antennae to make it regurgitate drops of juice.

Stock-breeding ants are to be found in Europe as well as in the United States. Among the more knowledgeable species, the breeding of aphides (greenflies) actually follows a programme. In autumn the ants collect the eggs and store them in their stables. During the winter they give as much attention to the larvae of their future cattle as to their own. Then, when spring comes, they lead their herds to pasture on nearby plants.

The harvesting ants live in desert areas like Texas. During the wet season they can live on other insects,

CROSS-SECTION OF AN ANTS' NEST (harvesting ants) showing the granaries connected up by tunnels

STRUCTURE OF ANTS

MALE DRIVER ANT (about twice life size)

membranous wings

spiracles

QUEEN DRIVER ANT blind (enlarged to about one and a half times life size)

WOOD ANT WORKER

compound eye

claws

cutting mandibles

toilet pick

SERRATED MANDIBLES of a warrior ant from the Solomon Islands

PIERCING MANDIBLES of a legionary eciton

and yet they behave with foresight. Throughout this wet period they never stop harvesting all the plant seeds within a very wide radius of their nests and they store them with great care. When the dry season comes their insect prey become scarce and they change into vegetarians.

The most war-like ants are the hunting and slave-making species. The hunting ants, such as the *Eciton* of South America and the driver ants of Africa, which are known as Dorylinae in America, certainly make raids to kill and devour other ants. The most adventurous slave-making ants in Europe are the Amazons and the blood-red ants. Besides the ants which specialise in capturing others, any of the ordinary species, even the most peace-loving, may occasionally go to war against one another.

When Amazons carry out a raid, they first of all surround the ant-hill which they have chosen as their objective, while their advance guard surprise and overwhelm all the isolated ants who happen to be around outside the ant-hill. If one of them succeeds in escaping and runs to give the alarm, immediately the approach manoeuvres stop, and the whole army rushes forward in order to get the maximum advantage out of a surprise attack. The gates to the ant-hill are a scene of massacre and panic. The defenders' small chitin helmets crack open, pierced by the long, cutting mandibles of the Amazons. The fighting continues right into the galleries and the insects approach one another with mandibles open and sting at the ready. 'Friend or Foe?' In the darkness attackers and defenders recognise each other by smell: one stroke of the antennae brings the answer. All ants, both workers and soldiers, carry their queen's smell as a uniform. Each one of them fights blindly for his own scent against that of the aggressors. At this stage in the battle a strong group of soldier ants gather in the middle of the disordered anthill and prepare to hold their ground. Behind them are piled the small eggs and the white pupae which represent the whole future of the city: they die without surrendering. During this defence the distracted nurses carry off some of the eggs and pupae, all of them crowding into the tunnel which leads to the only gate which has not yet fallen to the enemy. In front of this exit a group of soldiers form a wedge, their chitin-covered bodies hard-pressed against each other. They know that behind them all the refugees from the ant-hill are collecting. Then eventually they try to break out. While the soldiers crack the surrounding wall of Amazons, the workers and nurses flee, their mandibles full of the priceless offspring.

CARDBOARD NEST OF THE CREMASTOGASTER ANT
(Madagascar)

CREMASTOGASTER ANT
arching its abdomen to
project its poison

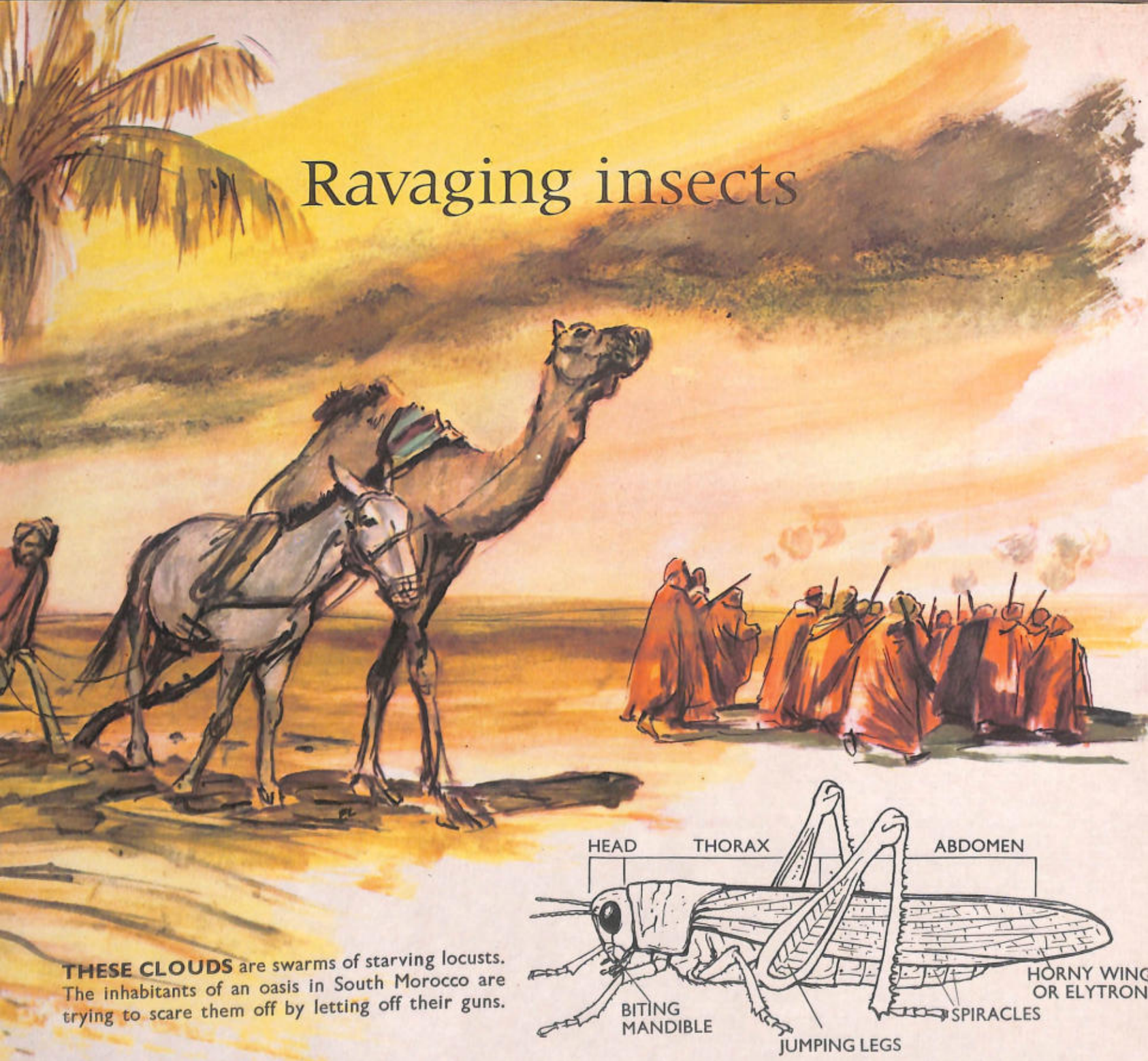
PARASOL ANT
carrying a
piece of leaf

HARVESTING
ANT
loaded with a grai

HONEY POT ANTS
hooked to the roof of the storeroom

THE 'HONEY-POT' ANTS of the Colorado gorge some of their workers with honey-dew. These living containers swell out inordinately, so much so that they are unable to use their legs. During the dry season each member of the city solicits its meals by caressing the antennae of its chosen 'honey-pot'.

Ravaging insects



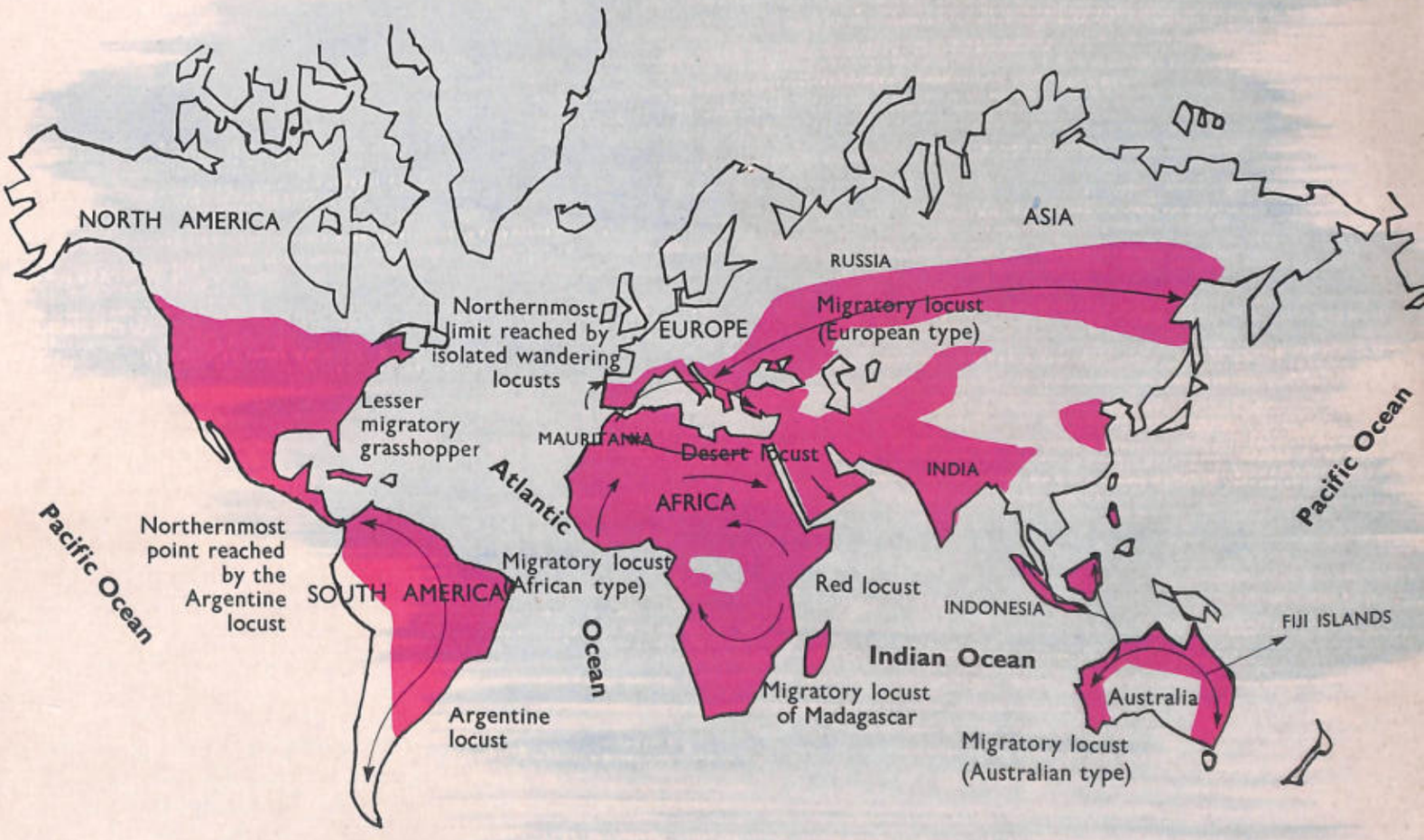
THESE CLOUDS are swarms of starving locusts. The inhabitants of an oasis in South Morocco are trying to scare them off by letting off their guns.

On Earth the balance of life is based on the rivalry of different species. In the struggle for life plants have always been pitted against plant-eaters and plant-eaters against flesh-eaters. Man no longer lives in fear, as his ancestors did, of the last few thousand elephants, or of the buffaloes and large cats which still haunt the wilds. He can round up these large animals in parks or reserves at his leisure. But man will not be the all-powerful master of his planet until he has wiped out the masses of harmful insects. The parasitic and ravaging insects remain some of his greatest natural enemies.

The ravaging insects are all vegetarians and represent about half of the population of the insect world. They consist of both larvae and perfect insects, and they eat leaves, stalks, roots, wood, fruit and seeds, and suck sap.

The leaf- and stalk-eaters have been a threat to man since the early days. The first book of the Bible tells us: 'Then the Lord said to Moses: "Lay thine hand over Egypt to make the locusts come . . ."' And ever since then these voracious insects have been one of the seven plagues, not only of Egypt, but of the whole Middle-East. In the year 125 B.C. an invas-

MIGRATORY LOCUST
Locusta migratoria
(three times life size)

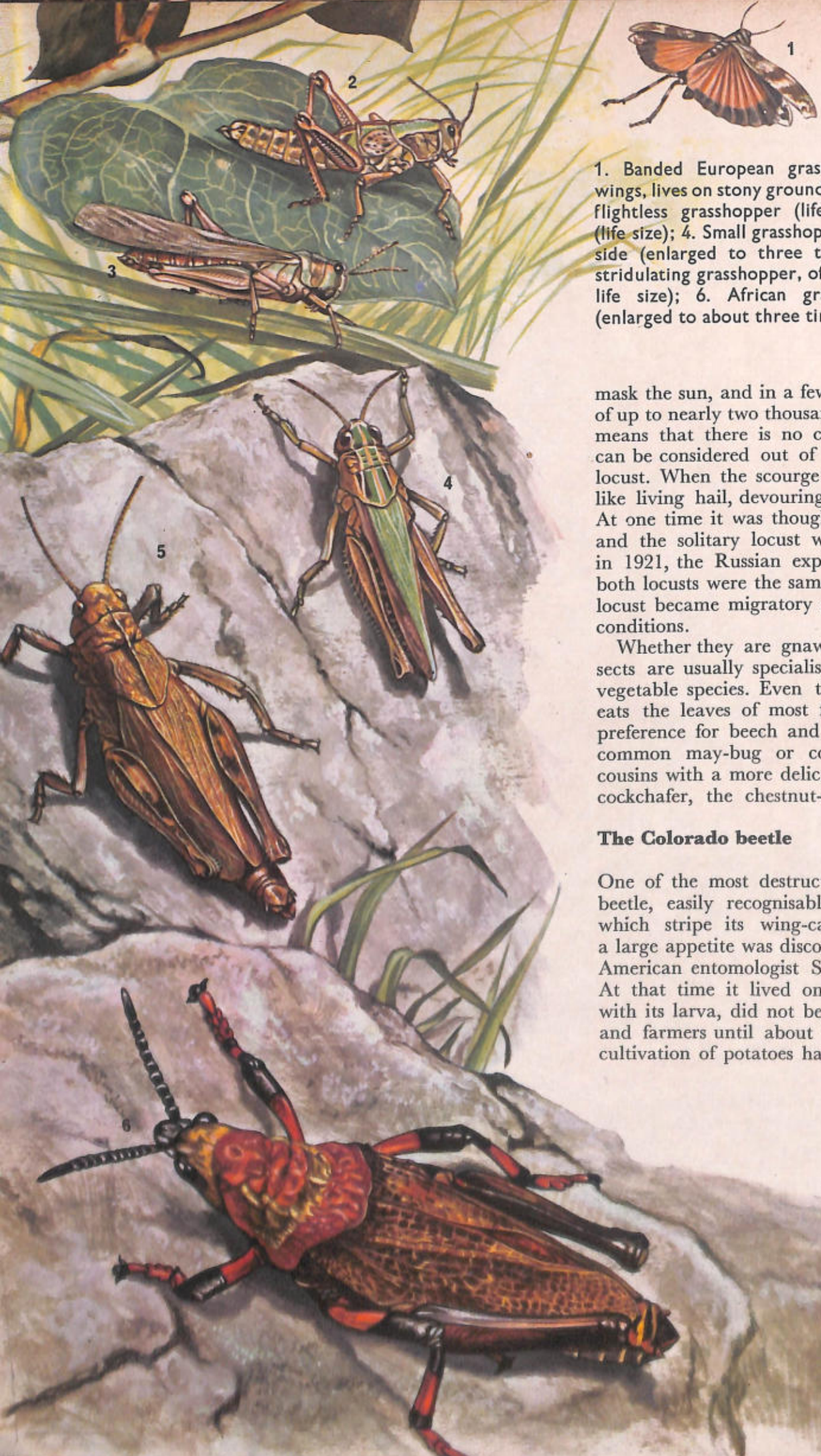


ion of locusts wiped out the civilisations of Numidia and Cyrenaica, by causing eight hundred thousand people to die of starvation.

The mystery of the locust

The migratory locusts are the most formidable troops in the huge army of the grasshoppers. They are reddish-coloured insects, about two inches long, with mandibles that are as powerful, proportionately, as the molars of large herbivorous animals. Swarms of them, several million strong, form clouds which

THIS MAP OF THE WORLD could be a plan of campaign for the commander-in-chief of the locusts. Of all the travelling locusts the migratory locust and the desert locust are most voracious and cover the greatest distances. Both of them are good gliders and let themselves be carried by the winds. The desert locust originated from Egypt and the shores of the Red Sea. The migratory locust has several breeding grounds across the world. The largest is formed by the meandering of the river Niger. The different types of migratory locust ravage different parts of the world in a more or less regular pattern: the long-distance flights of the desert locust, however, take it in practically every direction.



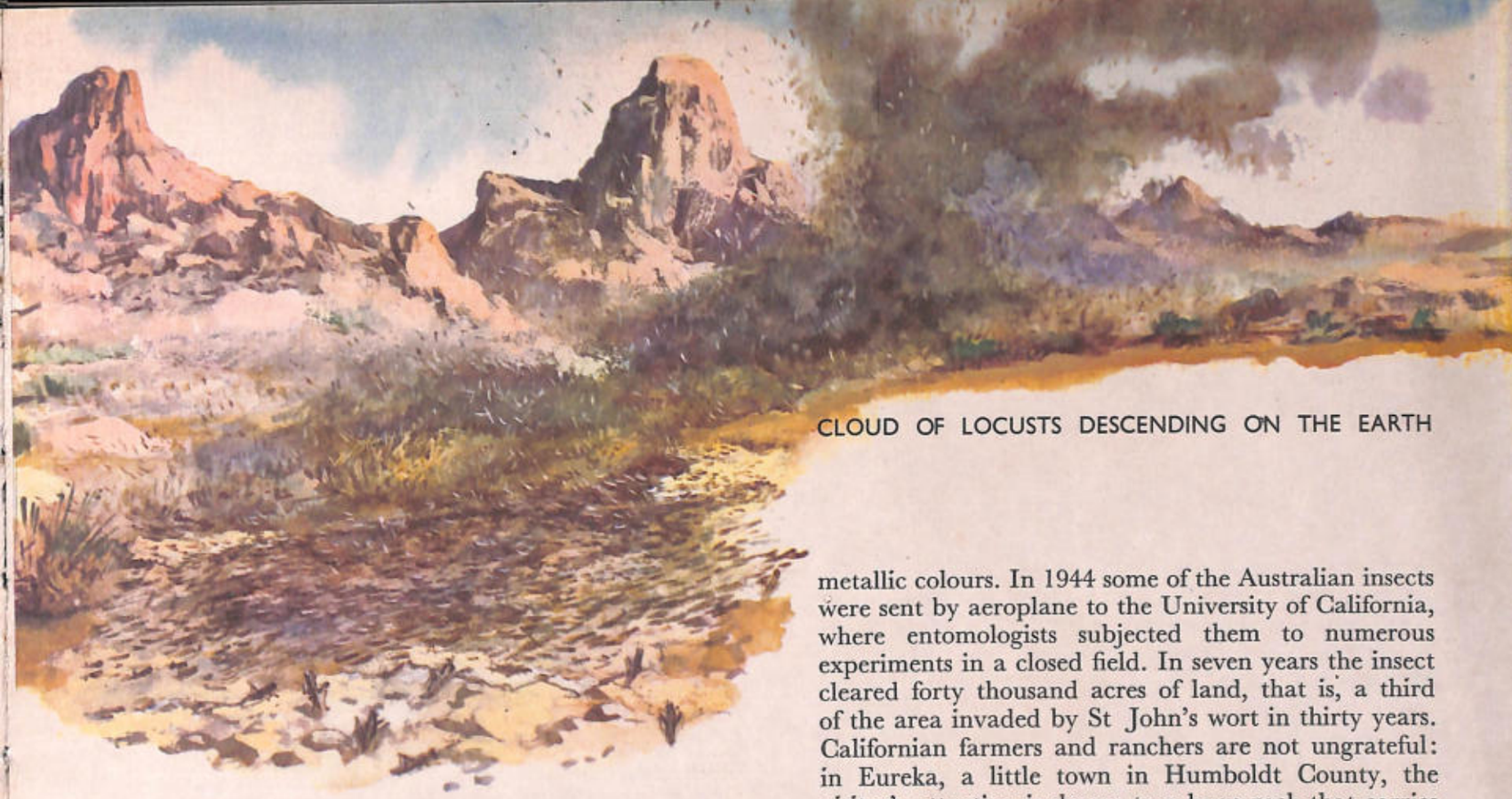
1. Banded European grasshopper, with red or blue wings, lives on stony ground (life size); 2. North American flightless grasshopper (life size); 3. Migratory locust (life size); 4. Small grasshopper of the European countryside (enlarged to three times life size); 5. European stridulating grasshopper, often perches on bushes (twice life size); 6. African grasshopper, *Tapesia spumans* (enlarged to about three times life size).

mask the sun, and in a few weeks may cover distances of up to nearly two thousand miles. Their flying ability means that there is no country in the world which can be considered out of the range of the migratory locust. When the scourge attacks a region it descends like living hail, devouring everything green in sight. At one time it was thought that the migratory locust and the solitary locust were different species. Then, in 1921, the Russian expert Uvarov discovered that both locusts were the same, or rather that the solitary locust became migratory given certain environmental conditions.

Whether they are gnawers or lickers, ravaging insects are usually specialists at the destruction of one vegetable species. Even the common maybug, which eats the leaves of most fruit and forest trees, has a preference for beech and oak. And round about the common may-bug or cockchafer swarm numerous cousins with a more delicate palate, such as the pine-cockchafer, the chestnut-cockchafer, etc.

The Colorado beetle

One of the most destructive insects is the Colorado beetle, easily recognisable by the ten black bands which stripe its wing-cases. This vegetarian with a large appetite was discovered in 1823 by the famous American entomologist Say, in the rocky mountains. At that time it lived on wild plants and, together with its larva, did not become the enemy of potatoes and farmers until about thirty years later when the cultivation of potatoes had become more widespread.



CLOUD OF LOCUSTS DESCENDING ON THE EARTH

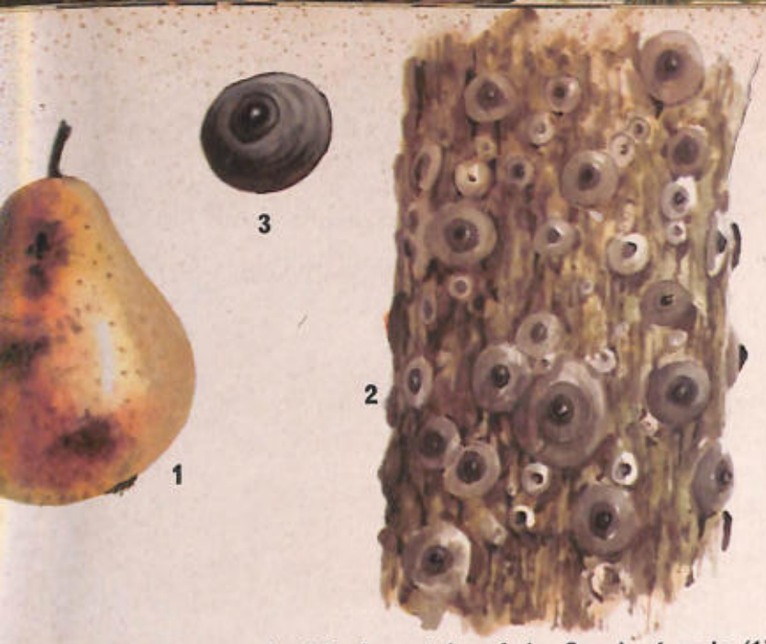
In 1887 it showed itself for the first time in Europe, in the neighbourhood of Cologne.

Botanists also call the Colorado beetle *Chrysomela* as it belongs to the formidable family of Chrysomelidae. In this same family is to be found the vine beetle, which etches out in vine-leaves holes which sometimes look like letters. One of the most voracious of the Chrysomelidae, however, the *Chrysolina*, became one of man's greatest allies.

In 1921 the St John's wort weed invaded the rich valleys of California. American farmers called it *Klamath weed*, because it seemed to have spread from the river Klamath in Humboldt County. By 1932 it had overwhelmed about eighty thousand acres of grassland and was threatening to strangle farms in Oregon. Since the weed resisted all weed-killers, the directors of the Nature Control Office had the idea of trying to fight it with an insect. For, over the last few years, Australian farmers had been congratulating themselves for calling on the services of a European beetle which, it was said, devoured St John's wort quicker than it grew. The *Chrysolina* is a minute beetle with an almost cylindrical body decked in metallic colours. In 1944 some of the Australian insects were sent by aeroplane to the University of California, where entomologists subjected them to numerous experiments in a closed field. In seven years the insect cleared forty thousand acres of land, that is, a third of the area invaded by St John's wort in thirty years. Californian farmers and ranchers are not ungrateful: in Eureka, a little town in Humboldt County, the visitor's attention is drawn to a huge rock that carries a plaque commemorating the value of the *Chrysolina*.

There is an agonising question now facing the directors of the United States Nature Control Office. Which vegetable species will the beetle attack next, when all the St John's wort has disappeared from California?

VINE PHYLLOXERA (1), topside (it is 0.5 of a millimetre long and is seen here enlarged to about sixty times life size). There are two main sorts: one of them attacks the roots of the European vine (2); the other bites more usually the leaves of the American vine (3).



A pear spotted with the pricks of the San José scale (1). Branches that have been attacked (2) appear to be covered with minute shells or shields, more or less visible to the naked eye. The smallest of these belong to larvae: the larger ones are adult females (3) (magnified about fifteen times). Originating from China, this pest ravaged the orchards of California, and from there spread to Europe by boat. Between 1931 and 1932 it appeared in Austria, Hungary, Yugoslavia and Rumania, and in about 1935 it was discovered in south-east France. In 1940 it reached Italy; then, crossing France, it appeared in Germany, Spain and Portugal.

The Phylloxera

Everybody must have heard about the *Phylloxera*, the insect which came over from America with the vines imported into France between 1860 and 1870. This minute creature, about half a millimetre long, in 1862 destroyed French vineyards. It started to multiply and had invaded the whole of Western Europe by the end of the nineteenth century. Phylloxera attacks all parts of the vine, but especially the roots and leaves. It was noticed, however, during the nineteenth century, that the insect showed a preference for the roots of European plants and the leaves of American plants. So European wine-growers grafted their plants to American vine-stock and with the new plant were able to rebuild the European wine industry.

The root-gnawing insects

Most of the important root-destroyers are larvae, and the may-bug larvae are among the worst offenders. The wire-worm, or larva of the acrobatic beetle, known as the skipjack, attacks carrots, lettuce, beetroot and other vegetables as well as the roots of young fruit trees . . . They ravage orchards and vegetable gardens.

The sap-sucking insects

Piercing and sucking insects extract sap from plants by means of their trunk, after thrusting it through the bark. They consist of aphides and coccids.

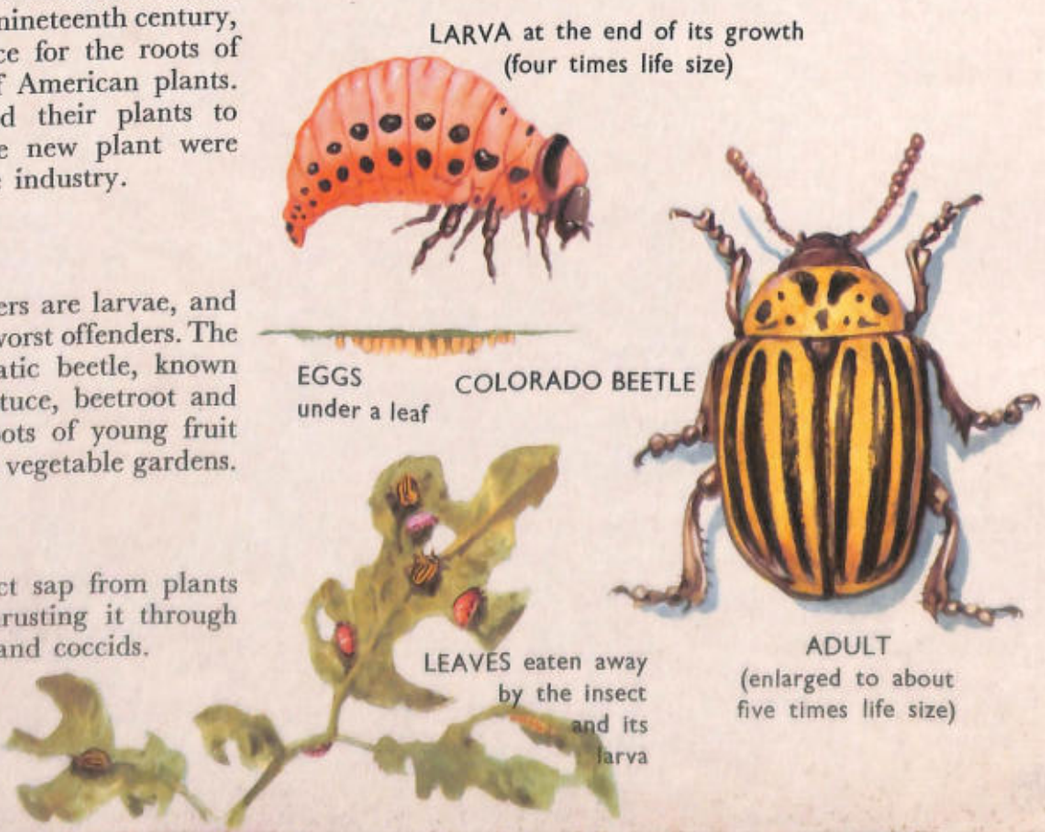
Aphides, or greenflies, suck the juice from a wide variety of plants. Swarms of them are to be seen covering the more tender stalks of bushes and trees: the most widespread are the apple tree aphis and the rose tree aphis, yet one even finds them on water plants. On their backs greenflies have two little hollow horns which, from time to time, glisten with tiny drops of sugary liquid. This liquid is much prized by ants, several species of which breed greenflies to obtain it: for this reason greenflies are sometimes referred to as 'ants' cattle'.

Coccids, or scale insects, drink in juice through bristles which become encrusted in the plant which they attack. The notorious San José scale ravaged American fruit-tree plantations at the end of the nineteenth century. This insect came from China and drew attention to itself in 1873 when it ravaged the orchards of San José in California. It reached Europe in 1931 and has been in France only since 1940. Each year whole new generations are born. It not only attacks fruit in summer but also damages orchard shrubs and many other wild trees during the rest of the year.

Although coccids are a pest in the garden, man has been able to put them to good use in making dyes, sealing wax and lacquer.

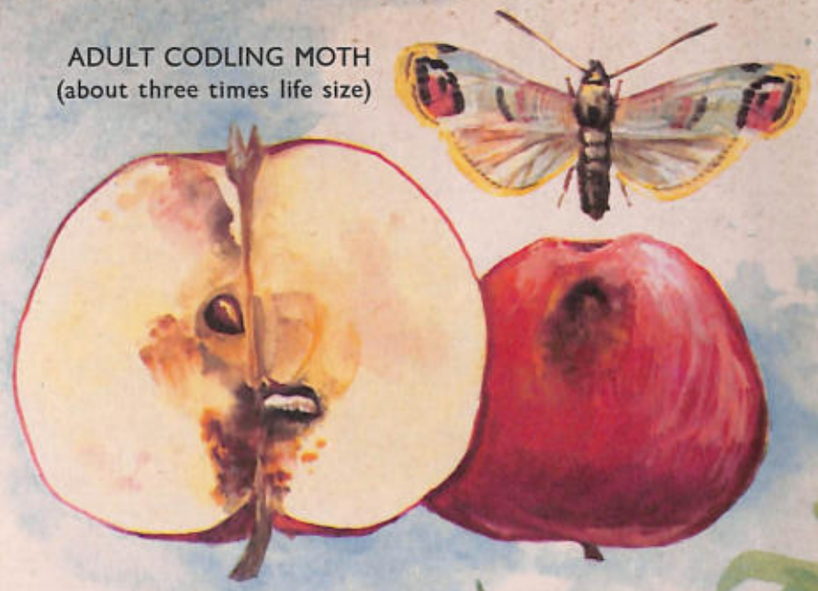
The fruit eaters

The apple-eating grub is the larva of a small moth with grey- and brown-streaked wings. It may be seen flying about at the end of the day, from the beginning of summer. The tiny caterpillar bores a tunnel in the fruit. First of all it eats the pips, then it starts on the fruit.



THE CODLING MOTH attacks several fruit trees, for preference apple trees and pear trees. Its larva finds its way into the pulp of the fruit, and then bores tunnels towards the pips in the case of apples and pears, or towards the stone in other fruit. Shortly after its fifth moult the caterpillar leaves its home and makes a tightly wound, dense, silky cocoon. In winter this is to be found in the place where the fruit is stored, and during the other seasons on the branches or at the foot of the tree.

ADULT CODLING MOTH
(about three times life size)



APPLE
inhabited by the caterpillar
of the codling moth

The cherry-fly invades orchards towards the end of the spring. It is a black, yellow-spotted insect about four millimetres long and it lays its eggs beneath the skin of the cherries when they are still green or just beginning to ripen. The larva, known as the 'cherry worm', lives in the fruit, eating it for about thirty days, before burying itself in the ground to undergo transformation.

CHERRY FLY
(enlarged to about ten times life size)

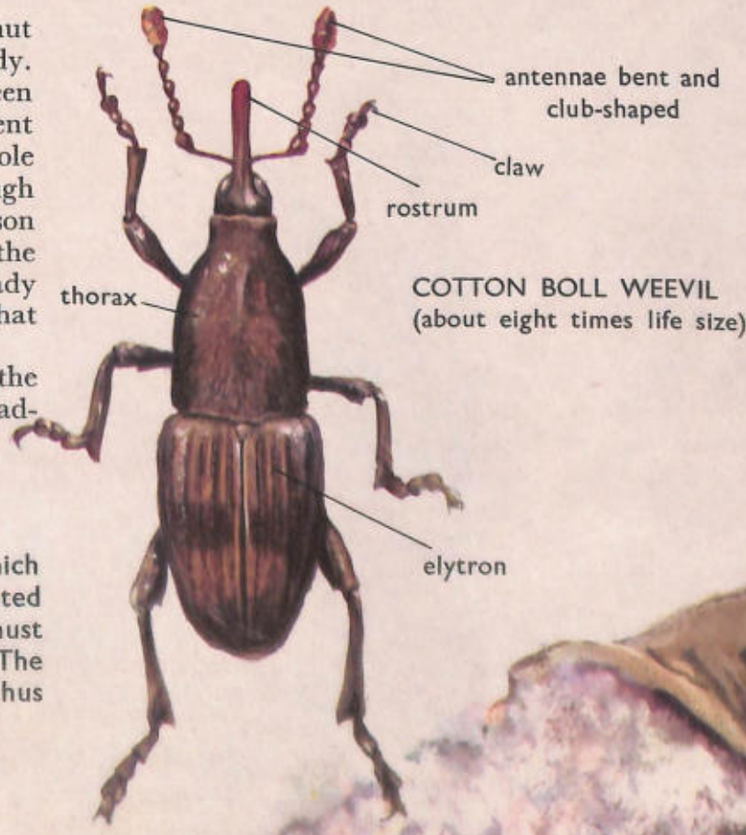
The seed grinders

There are more than thirty thousand species of weevil alive. There is, indeed, no part of a plant which is not attacked by at least one sort of weevil. Among these insects are to be found leaf and stem perforators (the cotton weevil), root eaters (the carrot weevil), bark gnawers (the shrub weevil), fruit piercers and nut and seed borers (the rice weevil, corn weevil, hazelnut weevil etc.). They go for nearly every tree and plant: firtrees, willows, apple trees, pear trees, peach trees, raspberry bushes, vines, cabbages and poppies. And they infest granaries, mills and silos.

Weevils are equipped with an extremely tough precision tool — their rostrum — which they use as a drill. This rostrum is a common feature of weevils all over the world.

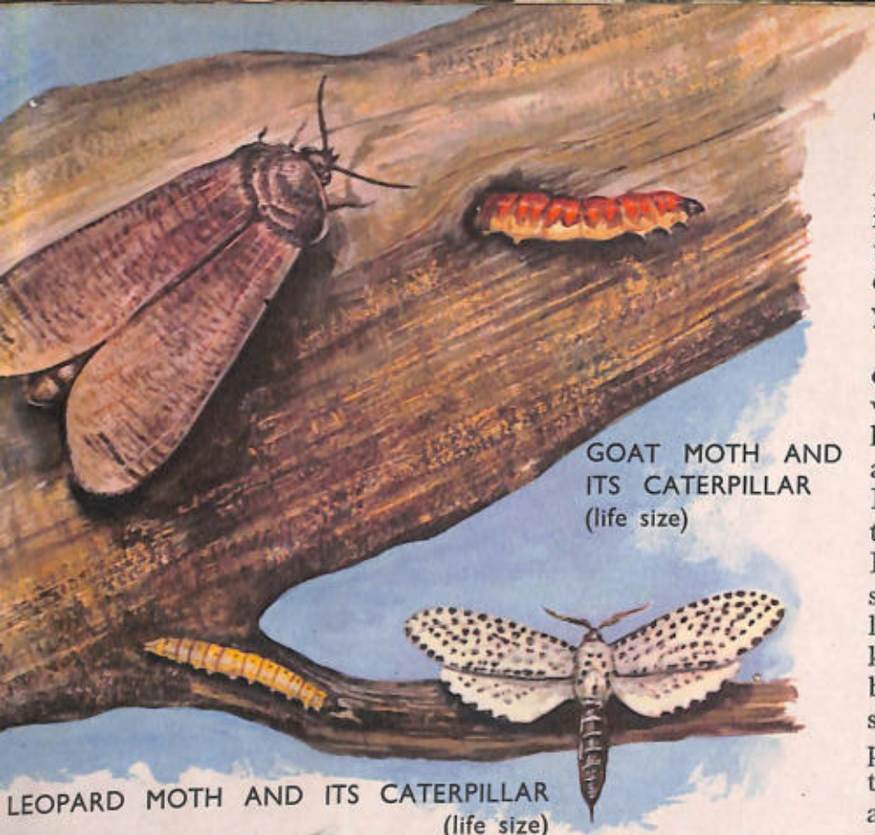
One of the best equipped in this respect is the nut weevil: its tapering rostrum is longer than its body. It lays its eggs and then places each one inside a green hazelnut, where the larva grows up to the detriment of the nut. When fully grown the larva bores a hole in the shell about the same size as its head, through which it extricates its body. Once out of its prison it buries itself in the ground. If the nut is still on the tree, the larva falls to the ground: if the nut has already fallen off, it bores through the side of the shell that touches the earth.

The bruchid beetles are closely related to the weevils and are extremely fond of ferns, beans, broad-beans and peas.



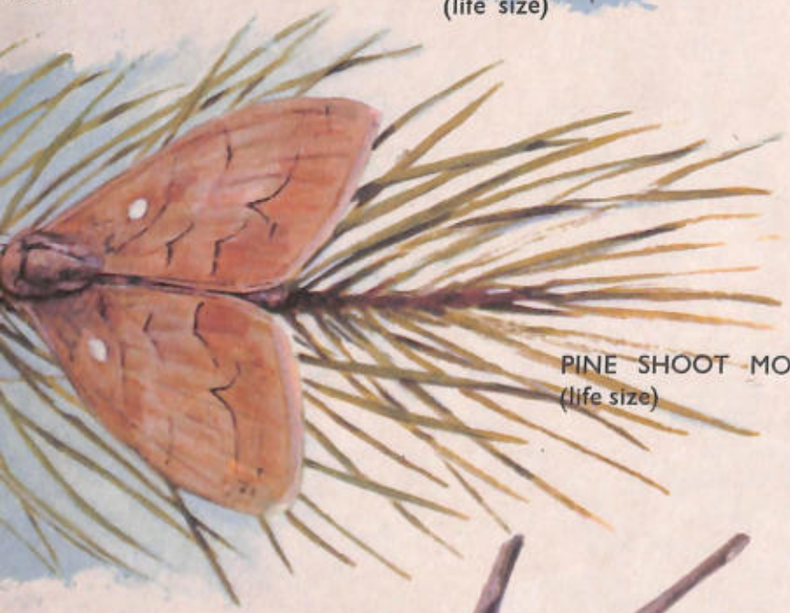
COTTON BOLL WEEVIL
(about eight times life size)

WEEVILS are precision workers. Depending on which species they belong to, their rostra are specially adapted to piercing the case, capsule or shell which they must penetrate in order to reach their chosen food. The rostrum carries the mouthparts on its end, which thus somewhat resembles the trepan on a drill.



GOAT MOTH AND ITS CATERPILLAR
(life size)

LEOPARD MOTH AND ITS CATERPILLAR
(life size)



PINE SHOOT MOTH
(life size)

LAPPET OR DEAD LEAF MOTH AND CATERPILLAR
on an oak branch
(life size)

The wood-eaters

After termites, the sawflies are probably the most important wood-borers. They lay their eggs inside tree roots by means of a serrated probe which they carry at the end of their abdomen. In this way the young larvae can start eating right from birth.

The sawflies are, as their name suggests, well equipped wood-boring insects. One of their most voracious relatives is, however, the giant *Sirex*, or horn-tail, an attractive yellow insect about one and a half inches long and with a wing-span of two inches. It would seem that this insect developed along with the felling of trees and the growth of the wood industry. In the wild the *Sirex* lays its eggs for preference in stumps and dead trees of fir forests, since its enormous larva (over two inches long) likes only dry wood. Also known as 'caterpillars', *Sirex* larvae are without bristles and have a large number of legs and very strong mandibles. When they wish to leave their prison they bore a tunnel towards the light. Nowadays the *Sirex* takes to felled tree-trunks in wood-yards and even to planks in sawmills. It inserts its eggs into the wood through holes invisible to the naked eye.

A large family of wood-eating insects is that of the longicorn beetle; it contains no less than fifteen thousand species. They are superb insects about two inches in length, to which must be added the graceful extension of their long antennae. These may be up to three inches long. In the tropical species the wing-cases are full of glistening colours: gold- or blue-tinged greens, lively yellows, shiny black and violet blues. The larvae are equipped with powerful mandibles which can reduce wood to powder, and their tunnels sometimes penetrate right into the hearts of trees. Longicorns attack old trees, oaks, willows, birches, and sometimes even firewood.

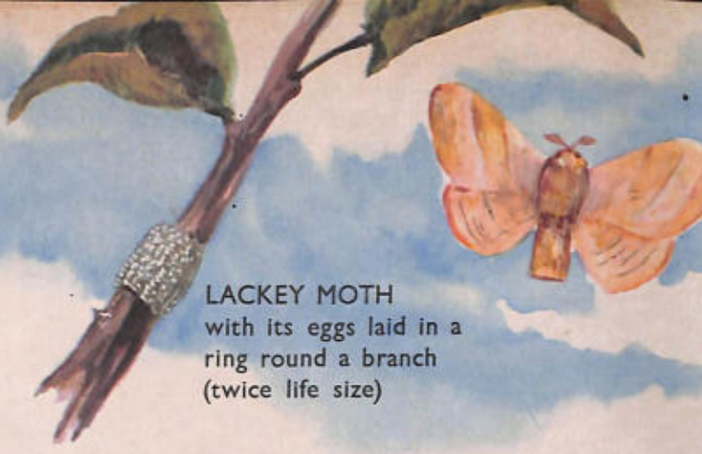
The caterpillars of several species of Lepidoptera also inhabit and feed on tree-trunks. The most voracious are the chestnut and pear tree leopard moths and the goat moths.

The leopard moth, which has a yellow caterpillar, with black spots, becomes a marvellous white moth covered with dark-blue spots, and with yellow-bordered wings. It is common in orchards, but it also burrows into the trunks of many trees, such as chestnuts, walnuts, oaks, willows and elms.

The light-red caterpillar of the goat moth is often more than three inches long and lives for several

THE WOOD-EATING CATERPILLARS, according to which species they belong to, grow up and bore tunnels in the trunks and branches of different fruit and forest trees. The most widely known is the caterpillar of the goat moth. After two years of tunnelling it weaves itself a shell, using bits of bark, and in this turns into a chrysalis, from which is born a large moth with bark-coloured wings. The caterpillar of the leopard moth lives in Europe, and chiefly attacks the branches of the pear tree.

THE LACKEY MOTH owes its name to the red, white and blue stripes on its leaf-eating caterpillar. The mother moth is a meticulous layer and, on some occasions. she places as many as 250 eggs spirally round small branches on apple and pear trees. The caterpillars are skilled spinners and ravenous eaters. If they were allowed to, they would imprison the whole tree beneath their tents of silk.



LACKEY MOTH
with its eggs laid in a ring round a branch
(twice life size)

years. It digs holes in the trunks of oaks, poplars and apple trees. Quite often a large tree that has been mined by many of these insects dies of exhaustion or gets so fragile that it breaks in the wind. These caterpillars have mandibles so sharp that they can give a painful nip to anyone unwise enough to try to pick them up.

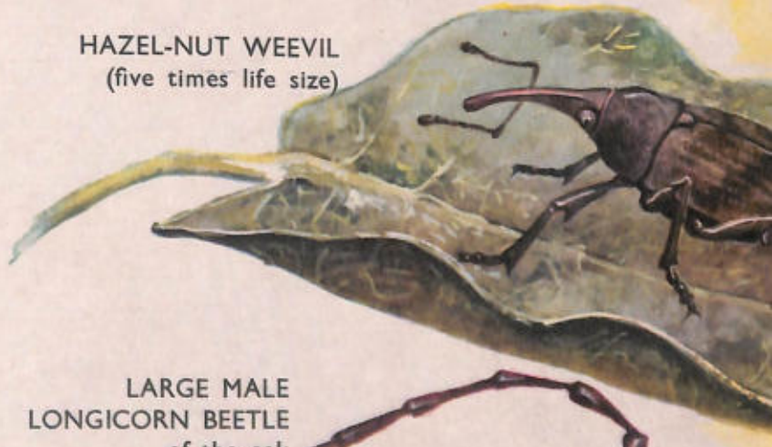
The leaf-grazing caterpillars

Fruit trees and forest trees have no worse enemies than the caterpillars which feed on their leaves, as these are the main organs of their breathing system. Stripped by these little gluttons, large plants are in danger of dying from suffocation.

The processionary caterpillars of the oak and the pine are great forest ravagers and owe their name to their night-time expeditions in single file. The group is led by a pilot caterpillar which trails a silk thread. The second caterpillar follows this thread and in turn leaves behind a thread for the third. In this way the different members of the expedition are linked together by a sort of band like a mountaineer's rope. After wandering about and gorging themselves with leaves all night, the caterpillars find their way back to their nest by following the thread.

The caterpillars of a large number of moths closely related to the *Bombyx mori*, attack the foliage of forest trees and young fruit trees. In Europe, however, these species are not a great threat, as they are fairly inactive or else thinly distributed. In any case the most harmful are prey to energetic carnivorous insects, such as the *Calosoma sycophanta*, a large multicoloured carabid beetle which untiringly pursues the *Gastropacha pini*, a caterpillar which likes pine needles. The gipsy moth and the brown-tail moth, on the other hand, are notorious in America for having tried to eat their way through the orchards and forests of the New World. Both moths like to feed on buds and young leaves: the first nearly destroyed the forests of Massachusetts, while the second was accidentally imported into Europe in the middle of the nineteenth century.

GIANT SIREX
(life size)
and a cross-section of a tree-trunk showing the holes bored by its larva

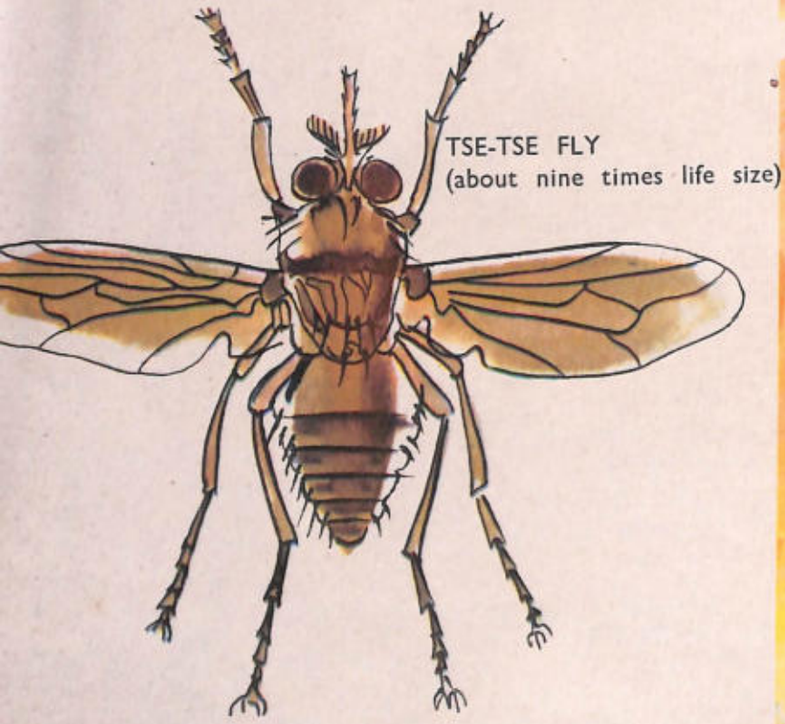


HAZEL-NUT WEEVIL
(five times life size)

LARGE MALE LONGICORN BEETLE
of the oak
(enlarged to twice life size)
its antennae are longer than its body

THE LARVA OF THE LARGE LONGICORN BEETLE lives for three or four years in the half-dead trunks of old oak trees. In relation to other larvae, it is an absolute monster with a small head and a huge body that may reach a length of over three inches.

THE TSE-TSE fly is the fighting name of the *Glossina palpalis*, an insect that lives in Africa. Its bite is not poisonous, but serves to inoculate the sleeping sickness germ. This disease, which originates from the Congo, has now spread to the east beyond Lake Victoria, and right up to Senegal and Lake Chad in the north. Today modern medicines are speedily mastering the sleeping sickness protozoan.



TSE-TSE FLY
(about nine times life size)

The parasites

Parasites spend all or part of their life in plants or animals, feeding at their hosts' expense. Even mankind does not escape these frightful creatures. There are insects which endanger his life.

The epidemics brought about by flies are possibly more to be feared by humanity than natural disasters such as earthquakes and cyclones.

Flies delight in rubbish, carrion and diseased flesh. They are carrying agents for the microbes of the world: cholera microbes, typhoid and paratyphoid microbes, etc.

For years man has been trying to exterminate these blood-sucking insects which spread deadly diseases. The black-list includes the following:

The *tse-tse* fly which spreads the dreaded sleeping sickness in Central Africa;

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The rat flea which leaves plague bacillus on rats.

The louse which carries the typhus germ.

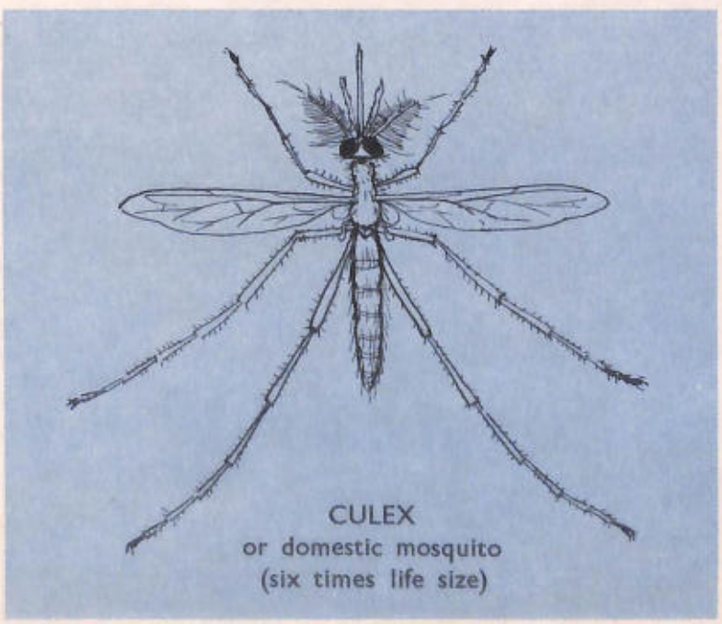
The tse-tse fly and sleeping sickness

The tse-tse fly is a greyish, piercing fly about half an inch long. It can be recognised by its horizontal trunk and wings folded across each other on its back like

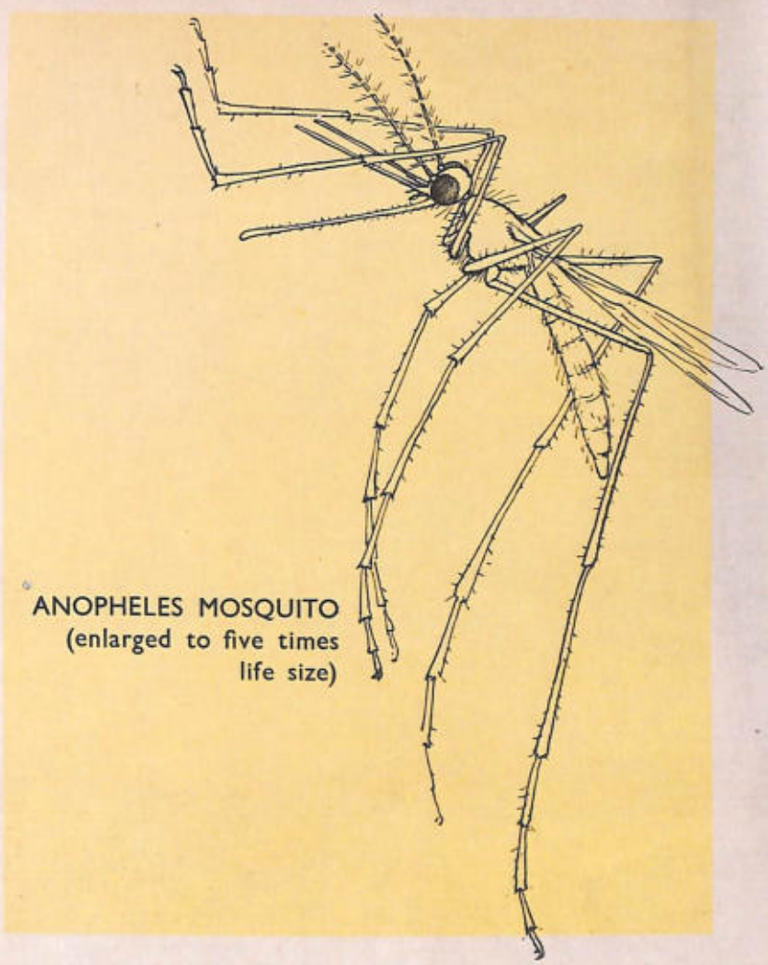
the two blades of a pair of scissors. It is extremely active but pricks only during the day. Its prick causes immediate pain similar to the sensation of being burnt. The tse-tse fly lives on the banks of rivers and in the forests of equatorial Africa, where it harasses large animals and men, in particular canoeists, hunters and wood-cutters. Until doctors arrived in Africa, these flies depopulated huge areas of territory. Some of them carry the agent of sleeping sickness in their blood, a micro-organism less than twenty thousandths of a millimetre long. When the insect sucks in blood from a diseased man or animal, it becomes contaminated and the agent develops in the insect's salivary glands. The fly then spreads the disease by going from man to animal or from man to man. In South America lives an insect which is the carrier of a sort of sleeping sickness called chagas.

The Anopheles mosquito and malaria

The *Anopheles* is a mosquito with long, thin legs and a scaly abdomen. The male *Anopheles* can be recognised by its long, feathery antennae: the female's antennae are very narrow. It is the female which pricks humans and animals; the male is content to suck juice from plants. On each side of its probe the *Anopheles* has two articulated appendages known as palps which are used to discover where the skin is suitably tender. The trunk is a sort of sheath, inside which are a pair of sharp mandibles. After piercing the skin with these mandibles, the mosquito enlarges the opening of the wound with two fine saw-teeth; then it sucks in the blood by expanding and contracting its pharynx to act as a pump. At the time of pricking the insect leaves a small drop of saliva under the skin, which causes a slight pain. A number of these mosquitoes are known to be carriers of the organisms which cause one or more forms of malaria.



CULEX
or domestic mosquito
(six times life size)



ANOPHELES MOSQUITO
(enlarged to five times life size)

The Aëdes aegypti mosquito and yellow fever

At one time, probably one of the most dangerous of the common mosquitoes of the tropics and sub-tropics was the species *Aëdes aegypti*. It occurs mostly in coastal areas and in the neighbourhood of large rivers. In 1881 Finlay thought that there might be a connection between the numbers of the mosquitoes in Cuba and the disease, yellow fever, which was prevalent at that time, and so in 1899 an American commission was sent to Cuba to study the problem. After a while they were able to prove quite definitely that the disease was carried by this particular mosquito. The disease was also rampant in the Panama Canal zone until anti-mosquito measures were started. Now the disease is almost non-existent in the area.

The eggs are laid on any accumulation of stagnant

MOSQUITOES are insect-vampires capable, according to the species, of absorbing between one and three milligrams of blood in one or two minutes. The *Anopheles* and the *Culex* are the two most important families among the mass of mosquitoes. The *Anopheles* is a mosquito of the tropics that can transmit to men and animals all sorts of parasitic diseases, among which is malaria. Mosquito larvae are aquatic and live chiefly in marshy districts. However, they often make do with stagnant puddles left behind after the rain in holes, in trees, or on clay ground.

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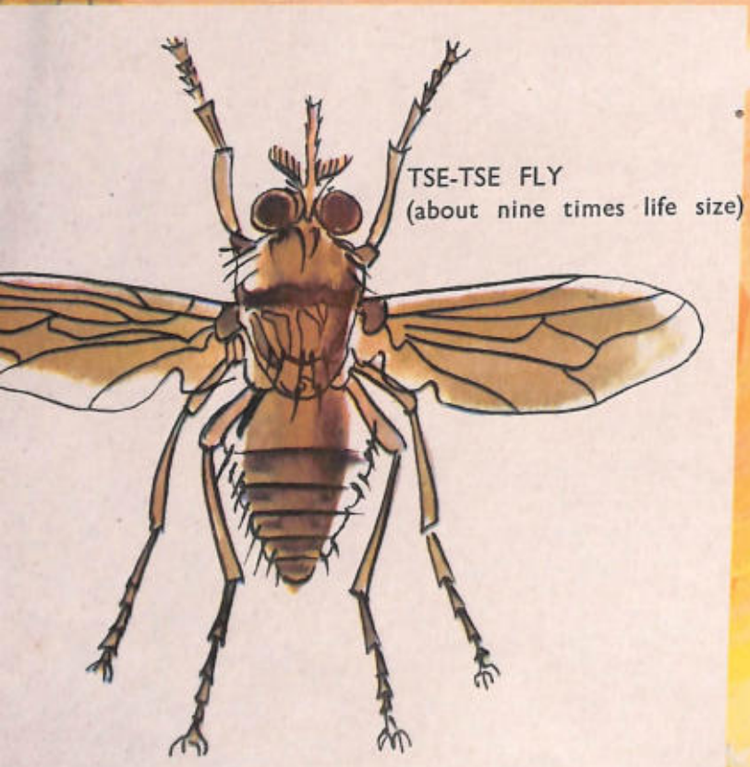

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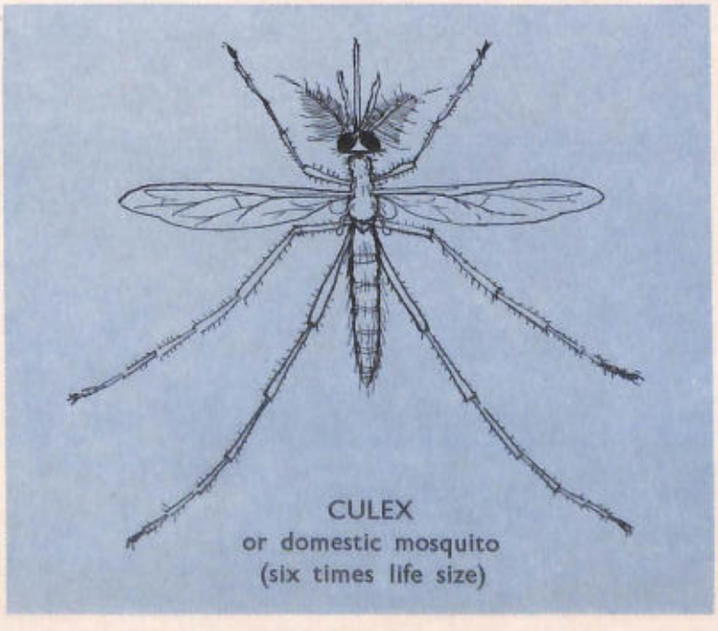

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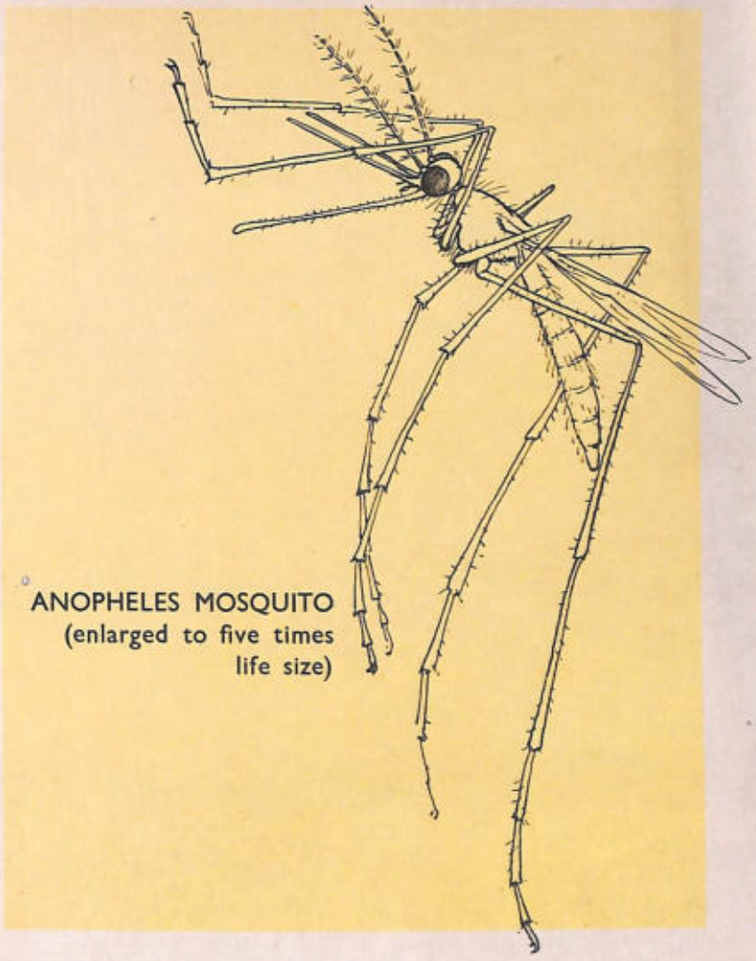

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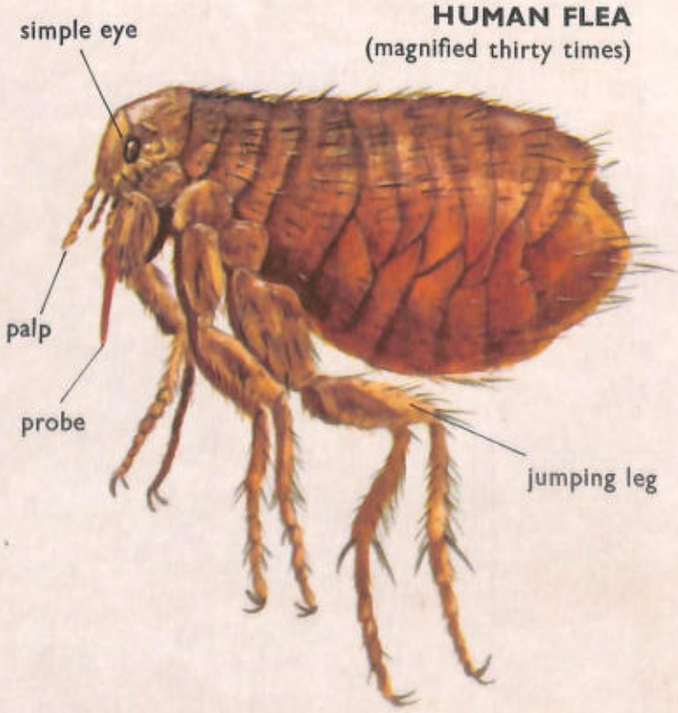
THIS HUNCH-BACKED INSECT which looks as though it is wearing dark glasses to avoid recognition is the *Aëdes aegypti*, the most dreaded mosquito in the world. In Africa and South America it is responsible for spreading yellow fever, a deadly disease against which man's only defence is a vaccine.

water, no matter how small the amount, and the aquatic larvae may be recognised by their colourless appearance and their short, black breathing tube about a quarter of the length of the abdomen. Until modern insecticides were developed, the main method of control was to spread a film of paraffin over the surface of any open area of water or marshland. This blocked up the breathing tubes and killed the larvae.

The rat flea and the plague

No animal is without its flea. Naturalists know one thousand two hundred species, among which are fleas inhabiting rabbits, rats, dogs, elephants and



HUMAN FLEA
(magnified thirty times)

many other animals, not forgetting man. Their length may vary from a millimetre to a quarter of an inch.

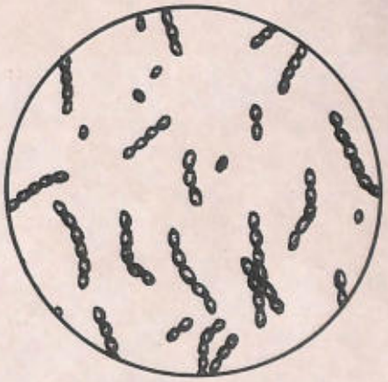
The most dangerous is the rat flea, *Xenopsylla cheopsis*, which also enjoys feeding upon man, to the latter's great misfortune. In the past, people had observed that huge invasions of rats from the East preceded epidemics of the plague. The exact role of the rodents, however, was not discovered until the twentieth century; in fact they act as 'storage tanks' into which the fleas pump plague bacilli. They then put the germs down on the skin of other rats and men. These fleas have a trunk equipped with six probes. They do not inject the virus themselves, but in pricking they make a hole in the skin through which the microbe can get in.

The louse and typhus

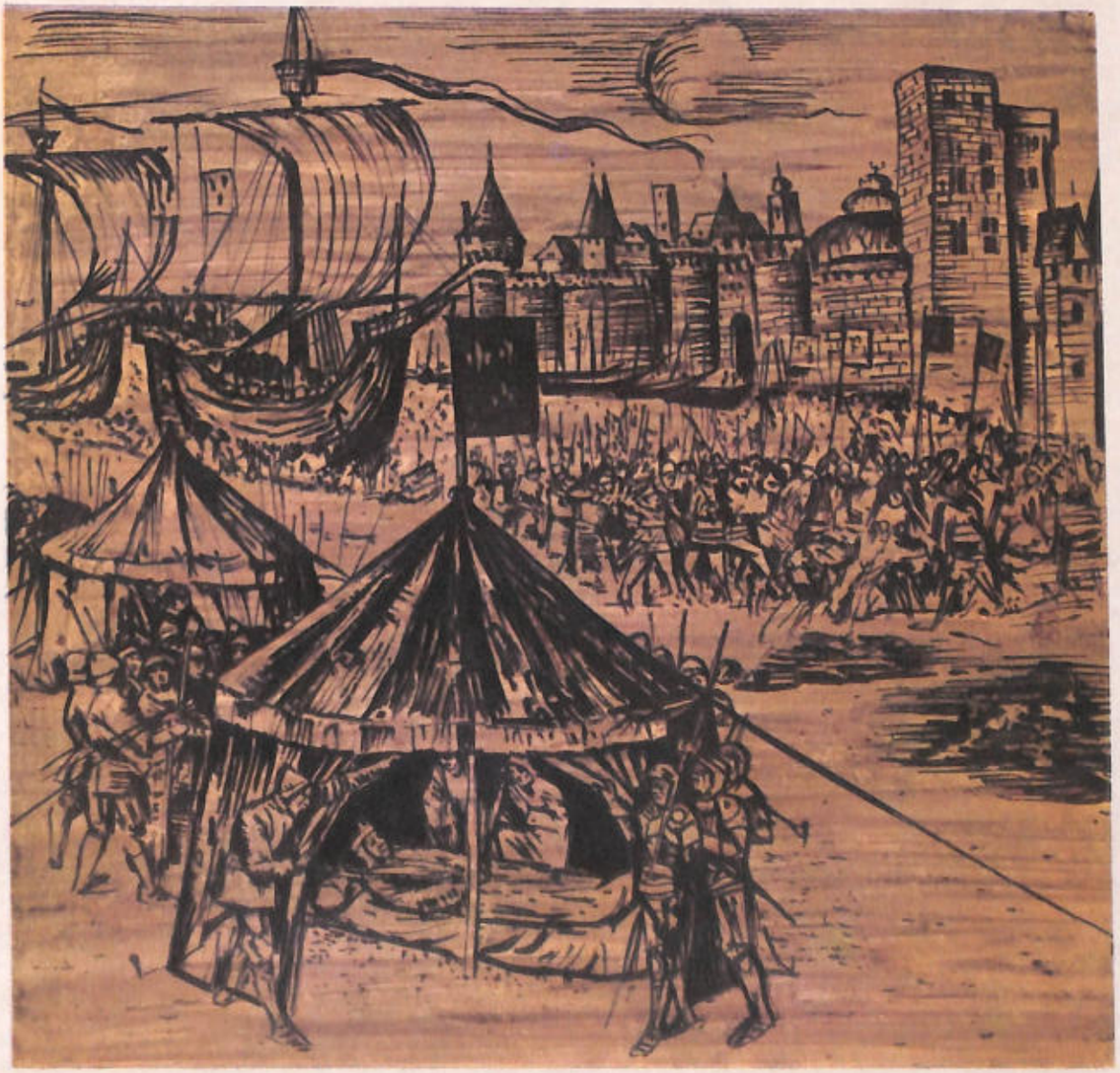
Like fleas, lice live in all climates. Mammals, birds and mankind are persecuted by them. They have a flat body and short, strong legs often ending in a claw which enables them to cling to bristles, feathers and hair. They take in blood through a trunk which can pierce and suck, and, whatever species they belong to, their length is usually somewhere between one and three millimetres.

ADULT JIGGER

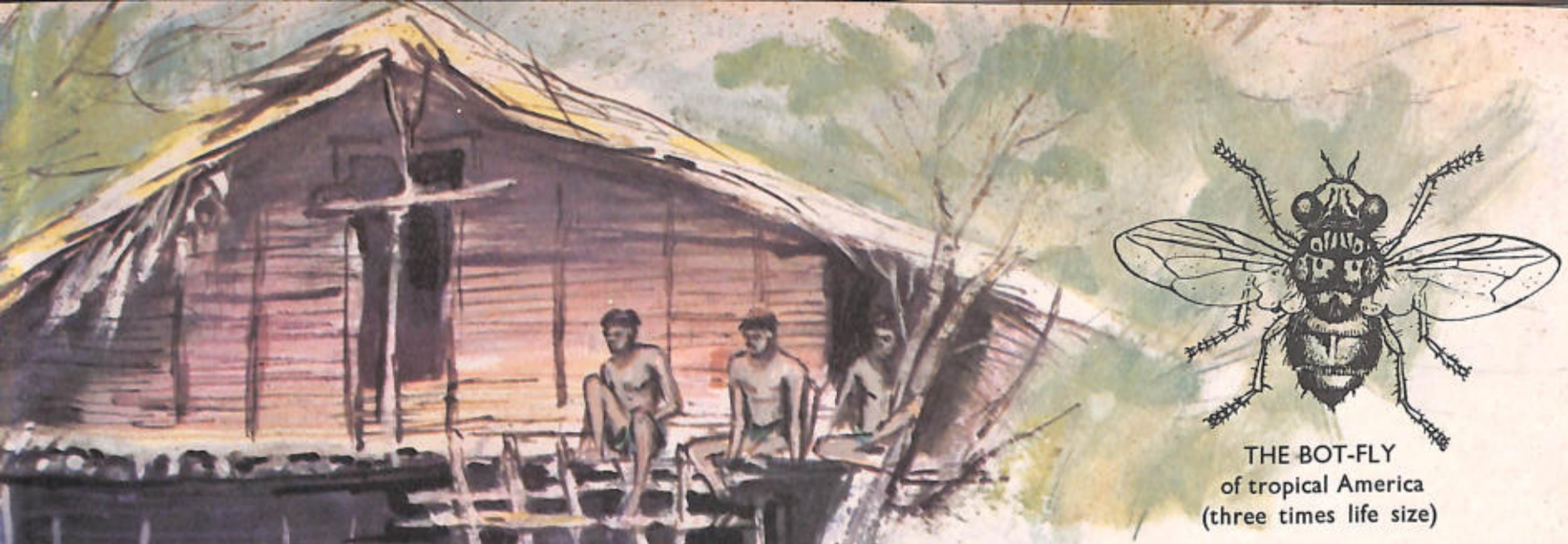
JIGGER about to lay



PLAGUE BACILLI (seen through a microscope)



THE PLAGUE is a contagious disease caused by a bacillus. Man gets it from a plague-ridden rat (by being bitten), or from the rat flea (by being pricked), or even from the dog flea which will bite both man and rat. The plague decimated the populations and cities of Europe and Asia during antiquity and the Middle Ages. And it was the plague which put an end to the seventh crusade by flattening the army of Saint Louis (1250). The French king was also destined to die of it himself twenty years later beneath the walls of Tunis (shown opposite). In our time epidemics have become less and less frequent, but it seems probable that the scourge is still dormant in India and Persia.



THE BOT-FLY
of tropical America
(three times life size)

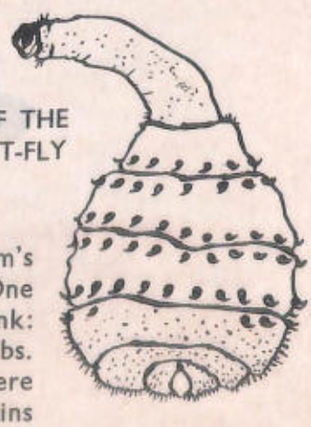
For a long time there was a controversy between scientists as to whether the head-louse and the body-louse were one and the same or two distinct species. In the end they were found to be one.

The louse's main crime is that it is the carrier of the typhus germ.

Town flies . . . and country flies

Flies, even if we do not realize it, are more attracted to decomposing matter and animal remains than they are to living creatures.

The most common is the domestic fly, a dark grey insect which readily enters houses to harass the inhabitants. It has numerous relations, either blue or green, which have the same zig-zag way of flying and are guided by their sense of smell. These other flies, however, prefer decomposing matter and dead flesh to left-overs from meals. By a strange fantasy of Nature these repugnant insects are clothed in luminous, glinting colours. Their larvae always lead a very different life from that of their parents, who may be large or small, pricking or otherwise, carnivorous, or even robbers like the wasps.



LARVA OF THE
HUMAN BOT-FLY

THE BOT-FLY LARVA bores through its victim's skin by turning round and round like a serrated top. One end of it is slender and supple and looks like a trunk: the other is club-shaped and ringed with small barbs. The species *Dermatobia hominis* lives in Guinea, where it attacks man as well as cattle and dogs. The larva remains anchored beneath the skin, in contact with the outside through a minute opening that enables it to breathe.

THE HORSEFLY carries an arsenal of six probes concealed in its short trunk. This greyish-beige fly with enormous eyes may justifiably look down on most of the other piercing flies that have only got two probes in the duct of their sucking trunk.

The human bot-fly is the larva of a South American blue fly. The fly cleverly lays its eggs on the bodies of mosquitos and pricking flies, giving them the job of carrying the eggs to the skin of some large animal: it knows which insects are blood-suckers. Once at its destination the larva insinuates itself between the hairs and works its way beneath the skin of its victim by means of the small hooks round its body.

In the countryside lives another enormous fly, a fly known as the gad-fly. No man, horse, cow or dog can cross a field without being harassed by this blood-thirsty insect. There is no hide or skin which can resist its probe. Its life cycle of birth, transformation and laying takes place by the side of the water.

All these insects, both town flies and country flies, have been given the common name of fly, although they are in fact very different from each other. If an ordinary greenfly were to invite a gad-fly, which usually sucks rich, fresh blood, to share its loathesome meal, the latter would be very disappointed and lose no time in getting back to its green fields.

CHARLES VALENTINE RILEY, the first director of the American Entomological Commission, from 1870 to 1878. During this period he promoted the system of destroying insect by insect.

LADYBIRDS
carnivorous,
they devour greenfly

THE ENEMY'S ENEMY IS A FRIEND. This generally accepted principle of war was applied by Riley to man's struggle against ravaging insects. Our most faithful allies are the ladybirds, great destroyers of the sap-sucking insects, and also the caterpillar-hunting carabid beetles. But how does one distinguish our enemies, the vegetarian ladybirds, from our friends the carnivorous ladybirds? The former are decorated with twenty-four, thirteen or eleven black spots (shown opposite, magnified ten times), whereas the latter only carry two, five or seven. The breeding and releasing of insects is today a frequent practice all over the world.

Nowadays, however, in agriculture there is also a whole range of chemical weapons available: spraying with copper sulphate and nicotine solution, daubing with limewash, sprinkling with sulphur and many other strong insecticides, such as D.D.T. and B.H.C.

Electricity, too, is successfully used against larvae infesting tree-trunks.

Plants that are particularly resistant to the attacks of parasites have been developed, too, by cross-breeding.

Biological control

In this century, entomologists came to the help of the farmer by creating 'biological control'. This method of pest control consists in multiplying the enemies of harmful insects. There are two types of insect which are enemies of other insects: the carnivorous, which hunt and eat living prey (of which the ladybirds are the main example) and the parasitic, which lay

their eggs inside the bodies of certain other species of insect.

The American scientist Riley was the first to make such use of a carnivorous insect, in 1874. He had an English ladybird brought to New Zealand to fight the aphides. The operation was a success, and Riley's idea was repeated on innumerable occasions, so that it has become a standard procedure.

At the beginning of the twentieth century a scale insect, *Aspidiotus destructor*, which had newly arrived in the Fiji Isles, was destroying the coco trees which are the natives' main resource. It was left to an imported ladybird, *Cryptognatha nodiceps*, a natural enemy of the scale insect, to rid Fiji of this scourge.

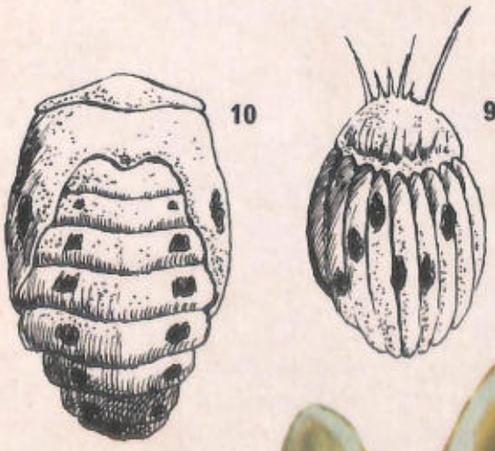
Nowadays the victories of the 'lucky ladybird' are innumerable. The most common European species is the seven-spot ladybird, so called because it has seven small, black spots on its orange-red elytra. This little beast is about a quarter of an inch long and destroys a large number of greenfly.

Another ladybird, the *Rodolia cardinalis*, was introduced to France in 1912 to fight an Australian coccid that was ravaging the Cote d'Azur. This ladybird lays eggs on the body of its enemy, and the larvae with their voracious appetites devour not only the coccid on which they are born but also any others which they meet. This valuable ladybird halted the spread of the Australian invader. It also saved the Californian orange groves, which had been attacked by the same coccid.

Sometimes the carnivorous insect, used to fight a pest, itself becomes the prey of another stronger carnivorous insect or of a parasite.

Experts divide parasites into two groups. The first group attach themselves to the outside of their hosts, while those in the second grow up within the body of their victim. Whereas carnivorous insects actually engage in hunting, the parasites never leave their insect host.

In the eighteenth century the American elm and apple tree aphid overran England and France in turn. In America this insect attacks the elm in the winter and apple trees for the rest of the year. In Europe



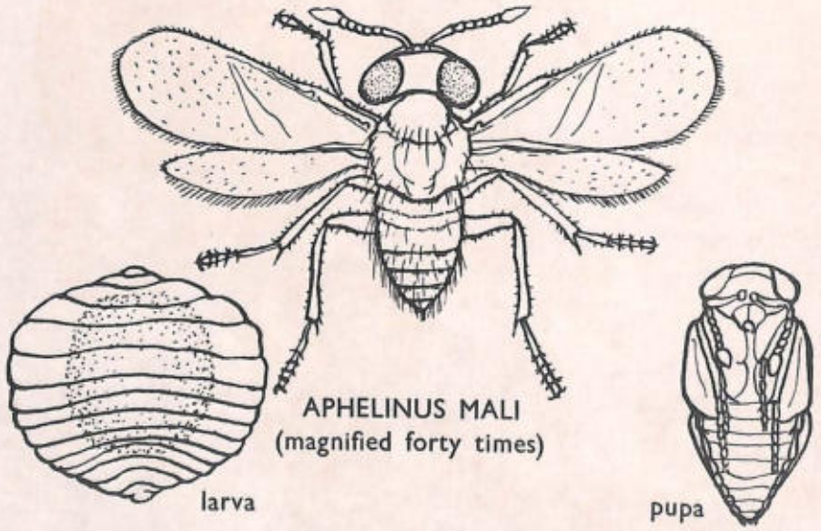
1. Thirteen-spot melon-eating ladybird (enlarged to five times life size); 2,4. Seven-spot bug eating ladybirds (enlarged to eight and six times life size); 3. The novius cardinal ladybird, *Rodolia cardinalis*, exterminator of the Australian coccid (eight times life size); 5,6,7. Sap-sucking greenfly (eight times life size); 8. Ladybird larva (six times life size); 9. Australian coccid (four times its life size); 10. Pupa of a ladybird (magnified thirteen times).

APHELINUS MALI (magnified a hundred times) using its long borer to lay an egg inside the body of a woolly greenfly, which surrounds itself with a waxy, down-like substance.

it abandons the elm and concentrates on the apple tree. An insect's worst enemy in its native country is sometimes much less effective in another: in the case of the American aphid, entomologists had to carry out numerous fruitless experiments. Finally the *Aphelinus mali*, a minute parasite of a millimetre long, showed itself to be the most aggressive in Europe. It has a long, thin borer which it uses to pierce the outer skin of aphides so as to lay its eggs in their abdomen. The *Aphelinus mali's* victory has not been brilliant, but it has managed to keep down the damage caused by the apple tree aphis.

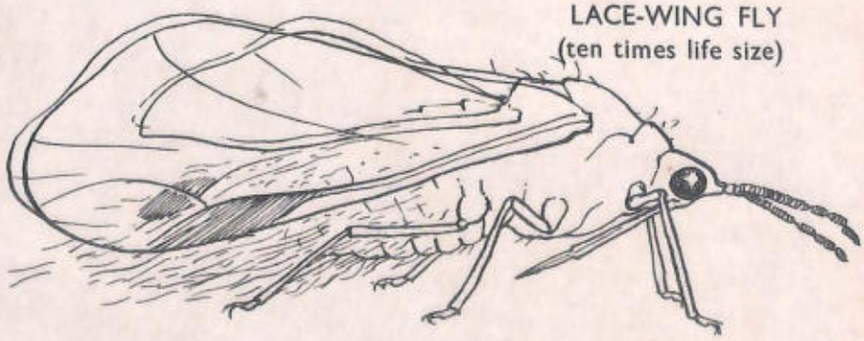
The carabid and the gipsy-moth

The struggle between the *Calosoma sycophanta* carabid beetle and the caterpillar of the gipsy-moth was undoubtedly the most remarkable episode in the history of biological control. From 1895 onwards this caterpillar became the worst enemy of the Massachusetts foresters. It was denuding the forest at an astounding rate. It had had the luck to cross the Atlantic by itself and had not been followed by its parasites: finding no natural enemies in the new land, it was multiplying so fast as to make chemical methods of control ineffective. A staff of experts were installed in the laboratories of Melrose and Boston. Never had insects which are useful to man been the object of so much research on either side of the Atlantic. The insects which were natural enemies of the gipsy-moth in Europe could not become acclimatised to the New World, and their activities were considerably slowed down. Eventually the *Calosoma sycophanta* carabid was shown to be the most diehard enemy of the gipsy-moth. It is a beautiful, blue-green insect with a golden glint, measuring over an inch long. A good climber, in Europe it hunts a large number of caterpillars, and in particular the processionary caterpillar of the oak. Surpassing all hopes, this carabid triumphed over the gipsy-moth and also took to attacking the voracious brown-tail moth of Europe.



A SMALL AMERICAN WASP called the *Aphelinus mali* is a parasite of the woolly greenfly. It lays about sixty eggs, each one in a greenfly. The larva devours the organs of the greenfly which imprisons it, then transforms itself within into a perfect insect, which in order to escape bores a circular hole in the body of its victim.

LACE-WING FLY
(ten times life size)



A RELATION OF THE CADDIS-FLY, the lace-wing fly, is also very fond of greenfly. The French naturalist Réaumur nicknamed its larva 'the greenfly lion': in fact he could even have called it 'the greenfly Hercules', since the lace-wing clothes itself in the sloughs of greenfly, just as Hercules dressed in lion skins.

THE GIPSY MOTH: after transformation its leaf-eating caterpillar (1) gives birth either to the male moth (2) or to the female moth (3) (all enlarged to three times life size)

The flesh-eaters

Besides the ladybirds and carabids mobilised by man against the ravagers, the insects have their other great flesh-eaters. These are the ants, the large and small dragonflies, the praying mantis, ladybirds, wasps . . . In the miniature world of the insects they are all wild beasts equivalent to the wolf, the eagle, the tiger, the weasel and the other killers in the big world of birds and mammals.

The fiercest of the carnivorous ants, the ecitons of America and the driver ants of Africa, hunt in packs like wolves. The millions of mandibles of their expeditionary columns destroy any member of the animal-kingdom which happens to be on their route. They kill and cut up into little pieces any creature that cannot escape or outdistance them: a trapped man, for instance, or a wounded lion, or a maimed insect. These terrifying nomadic insects can strip the carcase of a lion in a few hours or massacre the entire population of an ant-hill in a few minutes.

The large dragonflies hunt in flight in the way tigers hunt, on the run, whereas the praying mantis hunts from ambush, like the lion. Most praying mantises are green in colour like the grass in which they lie in wait. They owe their name to the complete immobility of their watch and the way in which they join their forelegs together like someone in prayer. As soon as a green grasshopper is heedless enough to approach this thick 'blade of grass', the clawed legs of the mantis stretch out to capture the unwary insect.

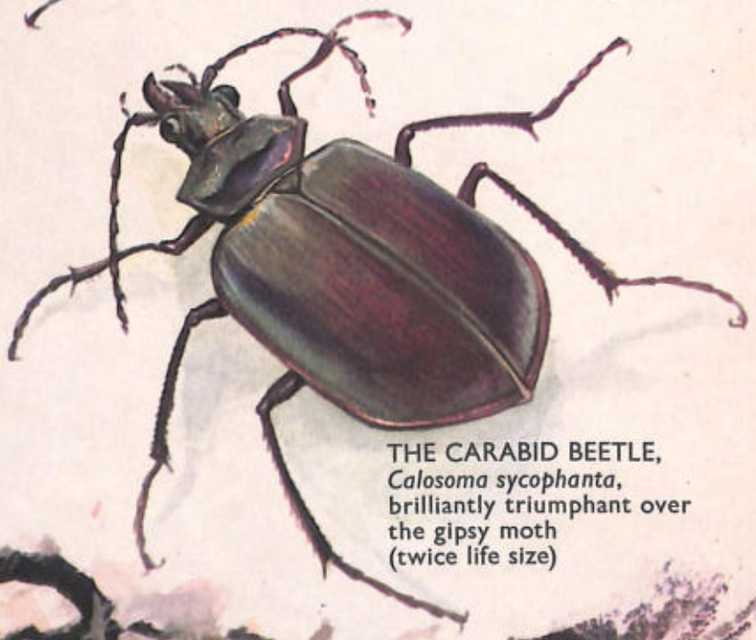
Some of the hunting wasps, like eagles, carry their prey, usually weevils, off into the air to the hole they have made their lair. The boldest of them, the *Calicurgus annulatus*, lives in the South of France. All its life this insect carries on a desperate struggle with the black-bellied tarantula, the most poisonous field spider in Europe.

The tiger-beetle is a thin-bodied beetle with bright colours which have a metallic glint. It is equipped

with very sharp cutting-mandibles and usually hunts running along the ground, although it can also catch its prey in flight, like a miniature sparrow-hawk. The larvae of the tiger-beetle live lying in wait with their head at the entrance of their hole. They pop out to snap up very small insects and are then just as active as weasels.

One of the wiliest of the carnivorous larvae is that of the ant-lion, an insect which, in its perfect form, lives only for a few days. The larva digs its funnel-trap on slopes in sunny, sandy spots. The trap forms a cone, at the bottom of which lurks the larva, hiding its soft, vulnerable abdomen in the sand so well that only the brown ends of its pincer-mandibles are visible. In this position it lies motionless for hours waiting for its prey. Should an ant slide to the bottom of the funnel, the larva bombards it with grains of sand, using its flat head as a spade. The ant makes desperate efforts to get up the slope, but every time, just as it is on the point of getting there, a blast of sand makes it roll back to the bottom of the funnel. The time comes when the ant has no further strength to defend itself. It is seized, dragged beneath the sand and eaten.

THE TIGER BEETLE
hunts both along the ground and in the air small insects like flies and woodlice
(four times its life size)



THE CARABID BEETLE,
Calosoma sycophanta,
brilliantly triumphant over the gipsy moth
(twice life size)

THE CLEVER LARVAE of the ant-lion dig out their funnel-traps by the side of tracks regularly followed by ants. The diameter of the traps varies from half an inch to three inches according to the age and size of the larvae.

ANT-LION
(one and half times life size)

THE CHAMELEON is a crack shot. Its projectile tongue never misses its mark (range: nine inches).

Amphibians and reptiles

Toads and frogs are big eaters of insects. Frogs on ponds spend their time hunting insects and, in particular, insects' larvae.

Toads in tropical regions are also destroyers of insects. After nightfall they can be seen lying in wait near lighted houses. The light attracts swarms of flying insects. As soon as one of them crashes into the windows and falls to the ground, a toad, with surprising speed, mops it up with its tongue.

An African reptile called the chameleon is one of the cleverest and best-equipped hunters in the animal world. This insect-eater has the gift of being able to assume the colour of the branches, leaves or stones over which it moves with measured slowness. The chameleon itself is incapable of even the smallest jump, but shoots out its long, sticky tongue very fast in the direction of its prey. This sticky tongue unwinds and winds back like a trunk and as quickly as a spring.

The chameleon is one of many lizards which like spiders and insects. There are many of them in both the Old World and the New and, whether they are walkers, climbers or swimmers, they nearly always have a spindle-shaped body carried by four short legs. During the hot hours of the day they laze motionless on rocks and tree-stumps. In action, however, they are extremely fast and supple and quickly snap up running or even flying insects.

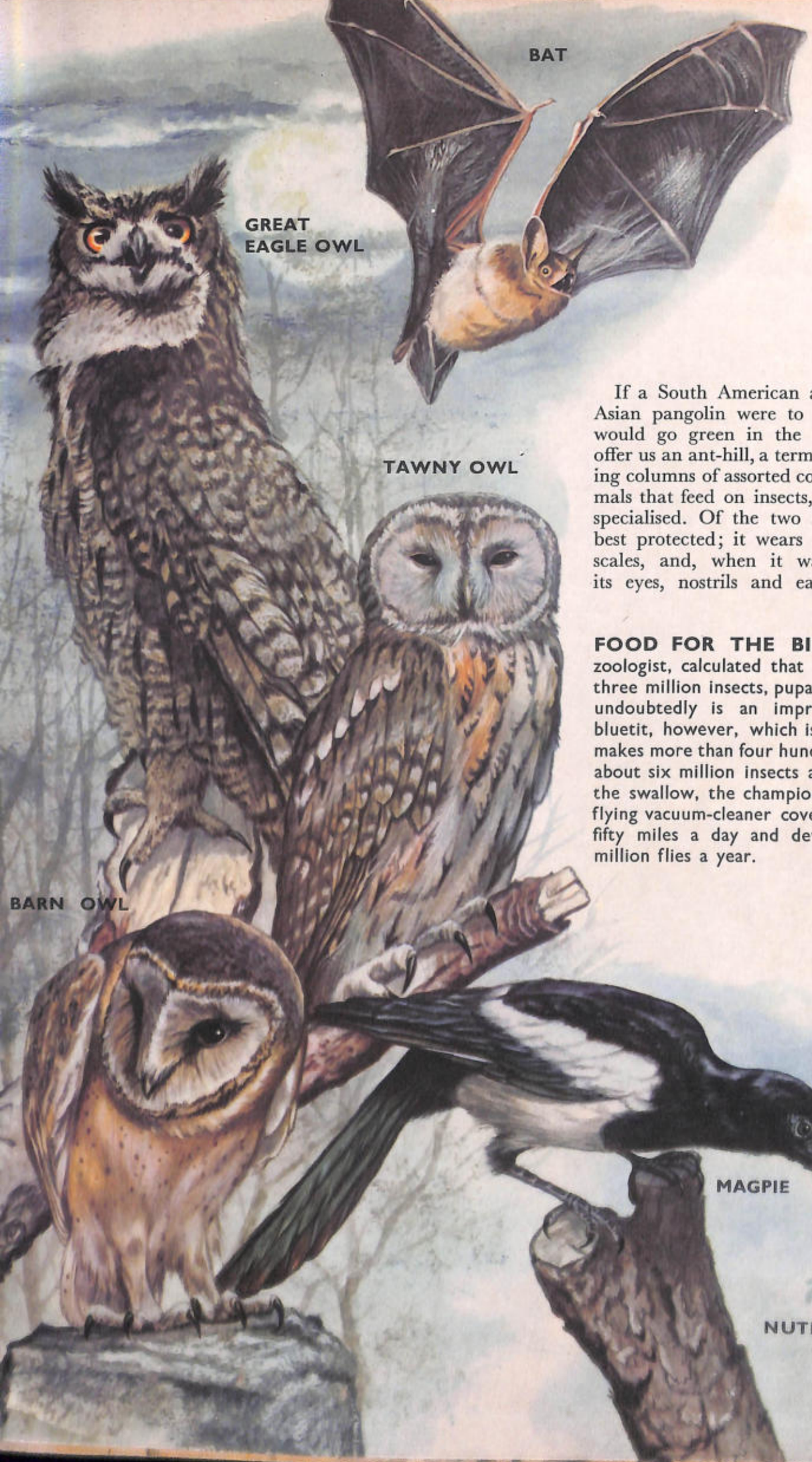
Insect-hunting animals

Insect-hunting animals exist in every sort of environment all over the world. They are the marsupials of Australia and South America (opossums, wombats, marsupial moles) and mammals in other continents (hedgehogs, shrew-mice, moles, bats). Among these mostly small-sized animals the ant-eaters are giants (they are up to five feet in length).

THE INSECTIVORES . . . frogs, toads, newts and salamanders are all amphibians.

SPOTTED TOAD

COMMON TOAD



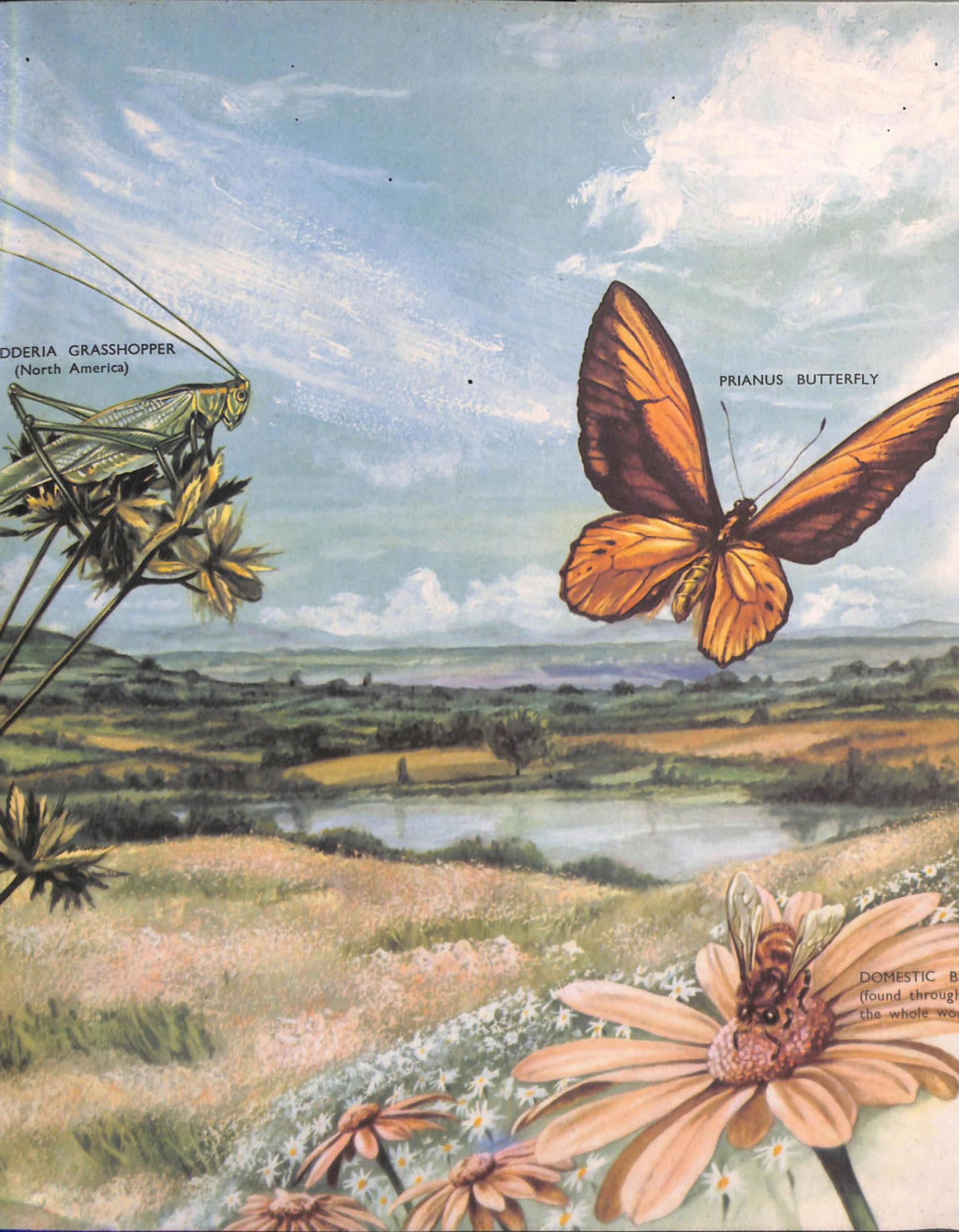
If a South American ant-eater and an African or Asian pangolin were to invite us to a banquet, we would go green in the face. They would probably offer us an ant-hill, a termite-mound and a few wandering columns of assorted coloured ants. Of all the mammals that feed on insects, the ant-eaters are the most specialised. Of the two species, the pangolin is the best protected; it wears an armoured shell of horny scales, and, when it wants, can hermetically seal its eyes, nostrils and ears. The ant-eater is better

FOOD FOR THE BIRDS. Ménégaux, a French zoologist, calculated that each year a wren kills over three million insects, pupae and insects' eggs — which, undoubtedly is an impressive hunting record! The bluetit, however, which is hardly larger than a wren, makes more than four hundred flights a day and devours about six million insects a year. And this is less than the swallow, the champion bird insect-eater. This little flying vacuum-cleaner covers about three hundred and fifty miles a day and devours about seven or eight million flies a year.

equipped for turning out ant-hills and termite-mounds: for opening them it has two giant claws on its hind-legs and for stretching into this hole it has a trunk-shaped snout. Both animals are experts with their long, thin, sticky tongues.

The insects' worst enemies are the birds, which by themselves destroy a greater number of insects than all the insecticides and insectivorous animals put together. No insect, or insect's egg or larva escapes birds' beaks. Climbing birds like the woodpecker carefully search minute cracks in the bark of tree-trunks with their powerful beaks. Other smaller and more agile birds, such as the tomtit and the wren, pilfer eggs and larvae from the smallest branches. The jays in their oaks and the orioles in the poplars eat thousands of caterpillars. Owls hunt at night and are great eaters of moths. It is often untruly said that blackbirds, thrushes and warblers are the plunderers of our orchards. Yet surely an occasional peck at a plum or cherry is a small wage for the systematic 'de-caterpillarisation' which these hopping birds carry on from spring to autumn. There are even some birds that specialise in hunting the parasites of large animals. The wagtail de-louses sheeps' fleeces. The ox-pecker rids buffalo and cattle of their vermin.

Insect-hunting animals, without knowing it, protect the whole of mankind. To fail to protect them would be stupid.


DDERIA GRASSHOPPER
(North America)
PRIANUS BUTTERFLY
DOMESTIC B
(found through
the whole wo

CECROPIA MOTH
(North America)

GLOSSARY

Algae Plants which include sea-weeds, allied freshwater plants and some aerial species.

Amphibians Creatures equally at home on land or in the water.

Antennae Horns or feelers, in pairs, on the heads of insects.

Anthophile Flower-loving; feeding on flowers.

Arborescent Branching like a tree.

Arthropods Species, including crabs, insects, spiders, etc., having jointed feet.

Bacilli Genus of spore-producing microscopic vegetable organisms.

Batrachians Appertaining to frogs and toads.

B.H.C. Benzene hexachloride. An insecticide.

Buccal Papillae A projection in the area of the mouth.

Carnivorous Feeding on flesh; applied to animals which prey on each other.

Chitin A hard covering layer of insects.

Chrysalis The larva of insects in the state through which they pass before becoming mature adults.

Coccids Scale insects.

Cornea The transparent horny membrane that forms the front covering of the eye.

Corollae The group of flower petals within the calyx.

Coxa Basal segment of insect leg.

Crustaceans A class of aquatic animals — such as crabs, lobsters, shrimps — having a hard, close-fitting shell.

D.D.T. Dichlorodiphenyltrichloroethane — an insecticide.

Dorsal Pertaining to, or situated on or near, the back of an animal.

Elytra The outer hard wing-case of beetles.

Entomologist A person who studies insects.

Fauna A collective name for animals and animal life of any particular region.

Femur The third segment from base of leg of insects. The thigh-bone of vertebrata.

Flora The plants or plant of life of a region.

Gall An abnormal growth produced on trees by the action of insects (for example: an oak-apple).

Ganglion Small solid mass of nervous tissue containing numerous cell-bodies.

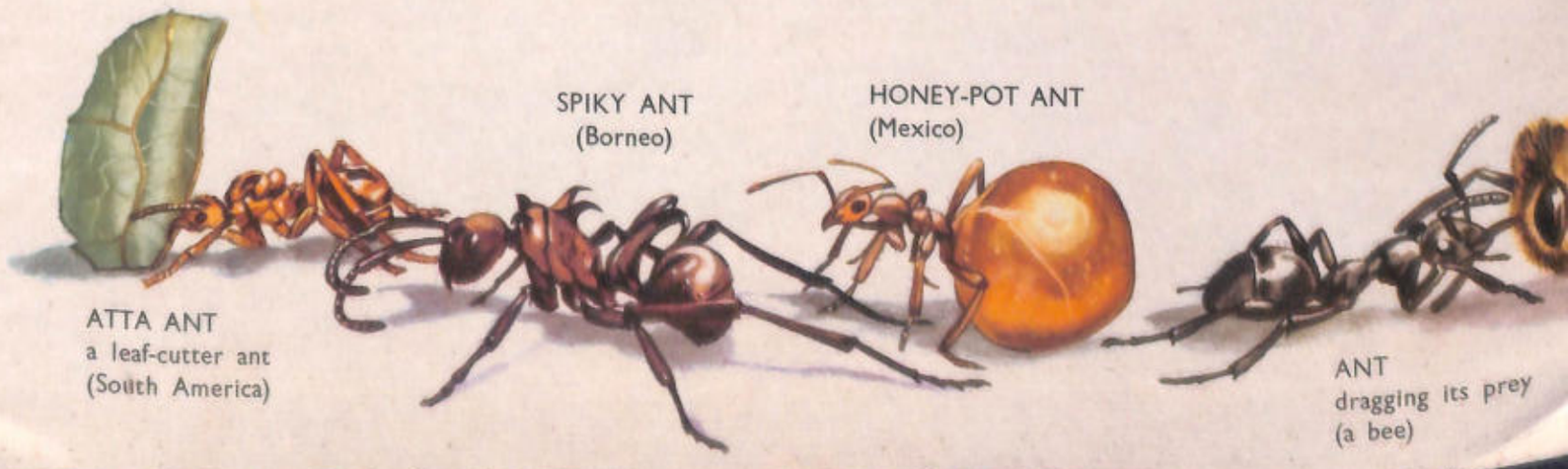
Geniculate Bent like a knee; jointed; knotted.

Herbivorous Animals or insects eating plants.

Insectivorous Feeding on insects.

Invertebrate Not having a backbone or spinal column.

Labial A lip-like part.



ATTA ANT
a leaf-cutter ant
(South America)

SPIKY ANT
(Borneo)

HONEY-POT ANT
(Mexico)

ANT
dragging its prey
(a bee)

Larvae	An insect in the grub state, that is from the time of leaving the egg until its transformation into a pupa.
Lucifugous	Shunning the light.
Mammal	A class of animals which produce milk to feed their young.
Mandibles	In insects, either half of the upper or front pair of jaws.
Marsupials	Animals (like the kangaroo) which have a pouch in which to carry their young.
Maxillae	One of the front limbs of insects modified to serve the purpose of chewing.
Membrane	A thin pliable sheet-like tissue which either serves to connect other structures or to form a lining.
Metamorphosis	A transformation; i.e., as from a caterpillar to butterfly.
Molecule	A small particle.
Mollusca	A group of animals, soft-bodied and usually hard-shelled.
Nectar	The sweet juice produced by plants and collected by insects.
Nymph	The young, immature stage of insects in which adult form develops gradually by successive moults.
Oesophagus	Part of the gut between pharynx and stomach.
Palps	Parts of first and second maxillae, shown to be connected with smelling in some insects.
Papillae	Projections.
Parasites	Animals or plants which live in or on others and draw their nutriment from them.
Pharynx	A cavity situated behind and connecting with the nose, mouth and larynx.
Phosphorescent	Shining in the dark, due to phosphorous.
Pistil	The ovary of a flower, with its style and stigma.
Pollination	Transference of pollen from anther to stigma.
Protozoan	The lowest and simplest of animals, unicellular forms or colonies multiplying by fission.
Pupa	The stage between larva and adult.
Spiracles	External openings conducting air directly to the tissues.
Stamen	The fertilizing organ of a flowering plant.
Tarsus	The fifth segment from base of an insect leg.
Tendon	Connective tissue attaching muscle, usually to a bone.
Thorax	In insects, the group of three segments behind the head which bears the three pairs of legs and the wings (when present).
Tibia	The fourth segment from base of an insect leg.
Trochanter	The second segment from base of an insect leg.
Vertebrate	An animal with a backbone.

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NOTE: Page numbers in italics refer to illustrations.

SHAPES

Coloring With Color