

# XIV NATURAL HISTORY

## III. THE INSECT WORLD

**T**HE immense and varied group of Insects constitutes by far the largest class in the Animal Kingdom; it numbers as many as 200,000 named species, the majority of which are predominantly active types. Such a wealth of forms—the species in a single family of insects may outnumber the stars one can count on a clear night—shows that, as a class, Insects are extraordinarily successful. Many reasons are given for this dominance, all pointing to the striking fact that insects, by means of manifold adaptations, are able to fill many niches, and so attain a wide distribution. Few haunts are destitute of insect life. Butterflies and mosquitoes are known to penetrate to extreme Arctic regions; a small kind of butterfly is found in Ecuador at an elevation of 16,500 feet; insects inhabit desert tracts far out of reach of water; and limestone caverns have their cave-dwellers, often pale and blind unless their descent to this unusual haunt has been comparatively recent.

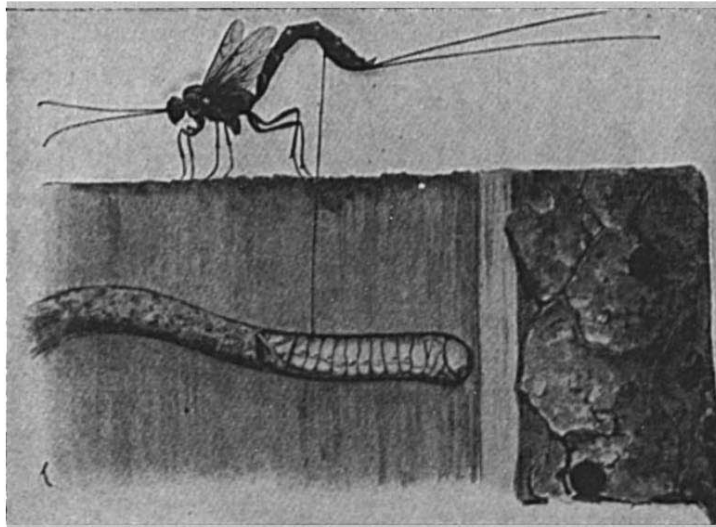
**Insects almost Ubiquitous.** Many forms live in fresh water; even hot-springs have their insects, and some beetles, for instance, are found on the tidal zone of the sea-shore. The actual sea seems very unsuitable for insect life, and yet there is a family of Skimmers (*Halobatidæ*) which run about on the surface of

the open ocean, and even dive when it is stormy.

Insects are typically winged creatures, and their power of flight extends their range, giving the opportunity to colonise new areas and to migrate to fresh localities in times of stress. Their bodies are extremely well adapted from the mechanical point of view; their sense-organs are highly developed—sensitive feelers, compound eyes, and so on—and their mouth-parts are remarkably adapted to suit different modes of feeding. Probably much of their success in the struggle for existence is due to the adaptations of their circulatory and respiratory systems, which enable the nutrition of the organs of the body to go on with great rapidity. The

**The Success of Insects.** tissues are continually bathed in nutritive fluid, while every part of the body is kept aerated by the extensive system of air-tubes. These facts account for the abundant energy and consequent activity which is so characteristic of the class. It may be doubted

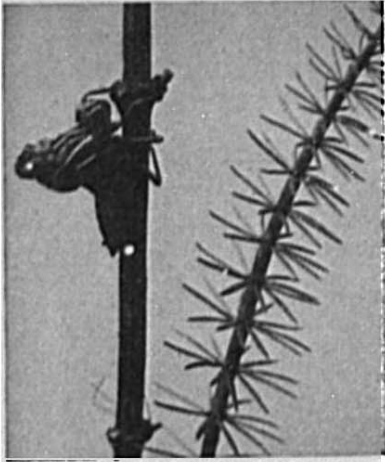
if the insect's blood ever becomes impure. Another factor tending towards success is the change of habit due to the change of form which occurs during the course of many life-histories. This implies changes in diet, and therefore a lessening of the drain on any particular food-stuff. In other



THE FEMALE OF AN ICHNEUMON-FLY (*RHYSSA PERSUASORIA*) BORING WITH ITS OVIPOSITOR IN A POTTED TREE AND LAYING ITS EGGS IN THE GRUB OF THE GIANT SAW-FLY (*SIREX GIGAS*), WHICH IS DEEPLY EMBEDDED IN THE WOOD.

The eggs of the Ichneumon-fly hatch inside the grub of the Saw-fly, which is then devoured by the Ichneumon grubs.

## THE LIFE-STORY OF THE DRAGON-FLY.



Photos: J. J. Ward.

FIG. 1. — Dragon-fly (*Vibellula depressa*) emerging from its nymph skin. "Nymph" is the name given to the immature stage of insects whose life-history shows incomplete metamorphosis. There is no pupa. The adult stage is reached at the final moult of the nymph skin. (See illustrations Nos. 2 to 6.)

temperature and food are unfavourable. Many insects pass the winter in a lethargic state inside well-protected cocoons.

Another factor which helps to give success to insects in maintaining their hold in various habitats is the way in which general form and colour are adapted to the environment. Protective

**Adaptations.**

Protective colouring in animals has formed the subject of a special article, but it may be noted that there are no clearer instances of protective resemblance than among insects. Not only do they very often closely resemble the general

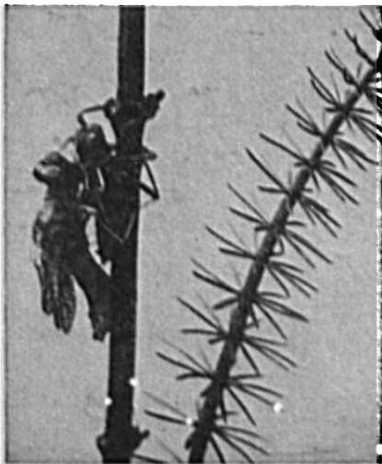


FIG. 3. — A moment later it has extricated its call end and is free. Its wings then commence to extend from their folds. (See next page.)

ways, also, the changes of form and habit may lead to survival in the struggle for life, for there is frequently a tiding over of difficult times; for instance, quiescence during periods when conditions of tempera-

ture and food are unfavourable. Many insects pass the winter in a lethargic state inside well-protected cocoons. Another factor which helps to give success to insects in maintaining their hold in various habitats is the way in which general form and colour are adapted to the environment. Protective colouring in animals has formed the subject of a special article, but it may be noted that there are no clearer instances of protective resemblance than among insects. Not only do they very often closely resemble the general colour of their natural surroundings, but form, as well as colour, may add still more to this similarity, which gives security to the insect by concealing it effectively from

its enemies. We can thoroughly understand the wonder of this protective resemblance only when we study it under natural conditions; many very gaudy butterflies can hardly be distinguished from flowers when they alight on plants. Many moths in their resting position hide the bright colours of the hind pair of wings with the duller fore-wings, which may nearly resemble lichen or the bark of trees.

The coloration may afford an effective protection in other ways, by Warning and by Mimicry. Some insects, such as the Wasp or the Lady-Bird beetle, positively court attention with their vivid colouring and markings; they are coloured, not to be hidden, but to be seen. Such insects always have some other form of protection, a sting or an unpleasant taste, which

their enemies come to associate with their striking hues and therefore avoid. No doubt conspicuous individuals will be snapped at and killed while birds and other enemies

are experimenting, but the enemies learn by experience, and the species with the warning colours gradually attains a position of security.



FIG. 2. — At the end of three minutes the Dragon-fly is free, all but the tip of its abdomen.

### § I

The pedigree of Insects is obscure. They belong to the large group of the jointed-legged Pedigree. Arthropods, which shows numerous affinities with the ringed worms or Annelids, but also many advances such as the greater development of appendages. In Peripatus and its allies, which are widely distributed over the world, worm-like, velvet-skinned little creatures, shy and nocturnal in habit, we find living links between Annelids and Insects. In their excretory tubes, muscular arrangement, and hollow appendages they

strongly suggest the ringed-worm type, but they combine with these and other Annelid features distinct indications of Arthropod characters, such as the system of breathing tubes and the appendages in the service of the mouth, which reach fuller development in the class of Insects.

Insects, Peripatus, Centipedes, and Millipedes have in common a respiratory system consisting of tubular tracheæ, which marks them off from the gill-breathing of Insects. Arthropods (Crustaceans), and sensitive feelers, which distinguish them from the Spider and Scorpion group (Arachnids). In the class of Insects the body in the adult state is divided into three main regions: (1) the head; (2) the thorax or fore-body; (3) the abdomen or hind-body.



FIG. 5.—After the wings have dried and come under muscular control, the insect raises itself and brings them into the natural resting attitude, as shown in Fig. 6.

The outer covering of most insects is hard and firm, composed of a non-living cuticle made of chitin, a somewhat horn-like substance secreted by the underlying living skin. The chitinous plates, which make a protective armour, are firmly fused in the head region, but in the thorax and in the abdominal part the different rings are joined by flexible areas, permitting more freedom of movement. Thus the segmented architecture of the body is more clearly seen in the thorax and abdomen than in the head region, where fusion has obliterated the boundaries of the successive segments of the body. In rapidly flying insects there is often a fusion of thorax rings to form a firm basis for the action of the wings.

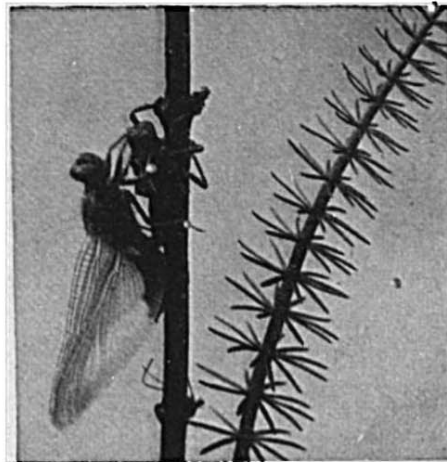


FIG. 4.—Five minutes after its emergence its wings are fully extended.

It must be clearly understood that in the insect's body the muscles are *inside the skeleton*, whereas in ourselves the skeleton is covered by the muscles. The two plans of architecture are utterly different.

The insect's head, which bears one pair of feelers or antennæ and usually three pairs of jaws, is relatively small, firm, and compact, separated from the thorax by a narrow membranous neck allowing freedom of movement. One sees this very well on a common house-fly.

All adult insects (except some primitive and some degenerate species) have a pair of compound eyes, though simple eyes may be present also. The compound eyes project on each side of the head as convex, immovable structures. There

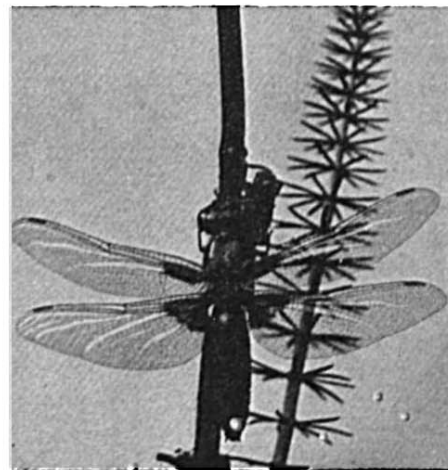


FIG. 6.—Short-bodied Dragon-fly just expanding its wings after emergence from the nymph skin which is seen near its head.

is only one pair, though each eye may be partially divided, as in some of the aquatic Whirligig Beetles in which half of the eye is directed up to keep a look-out for danger from above, while the other half is scanning the water below in search of prey. The compound eye consists of a great many similar parts—each a complete organ of vision but requiring the surrounding elements to form the whole image. Each of the many elements of the eye makes a small image, so that the whole image is a mosaic of separate contributions, which combine in a unified visual impression conveyed to the brain. For the amorous insect does not see 1,000 desired mates,—one through each of its eye-elements. The question is not an easy one, but it should be noticed that, in some cases, e.g., fireflies, the eye-elements no longer act separately, but a single combined image is thrown on the back of the eye. (See figures, pp. 230, 231.)

The antennæ are appendages set in sockets on the crown of the head, and consist of a series of joints, varying from one or two to a large number, and of many different shapes. They are of the greatest importance to the insect as organs of touch, by means of sensory bristles connected with underlying nerve-fibres, and also in connection with the sense of smell. Of hearing, in insects, very little is securely known. Further, the head carries three pairs of mouth-appendages (homologous with legs), which are variously transformed for different modes of feeding, biting, or sucking. It is very interesting to find that the same three parts are changed in scores of different ways.

The legs, which are borne on the three rings or segments of the thorax region, show many different peculiarities to suit different habits. The front pair is considerably lengthened in certain beetles that climb about the bark of trees; in the Mole Cricket they are converted into burrowing implements, the terminal joints being arranged as shears for cutting through plant roots (see figure, p. 236). The "Praying Mantis" and the Water-Scorpion both show the fore-legs modified into pincer-like traps for seizing prey. Usually the middle pair is not greatly modified, but in some water-bugs, like the Water-boatman, the middle legs are the longest and have become effective oars for rowing on the surface of the

**Insects' Legs.**

water. The hind pair of legs of many insects is elongated for jumping, as in grasshoppers and locusts and some beetles. Certain beetles and bees and wasps have a "comb" or bristle-lined cavity on the leg by means of which they clean their feelers, while some butterflies use their feeble front legs to brush off dust from their heads. Ants are particular about their toilet. In the course of the day's work an ant's antennæ may become soiled. On its first pair of legs it is provided with what we may call brushes and combs, as we have described, and the ant may be seen to draw its besmeared antennæ through this brush-and-comb arrangement on the fore-legs. One of the legs will be passed over its head and body, its other legs sweeping off every particle of "dirt." No cat is more fastidious over its toilet. Ants will even wash and brush each other, just as they will exchange greetings, as they meet, by movements of their antennæ. The hind-legs of bees show a modification for pollen-gathering, a broadening of the "shin" to make a "basket," into which the pollen is swept by special bristles.

Breathing takes place by means of a system of air-tubes or tracheæ which penetrate to every hole and corner of the body. **Insect's Breathing.** Tracheæ arise as inpushings of the skin, and the layer of chitin which lines them is continuous with that which covers the whole body. In the larger air-tubes this chitin is thickened spirally in threads, and this keeps the tubes from collapsing. Air enters the body by openings (spiracles or stigmata) occurring on most of the body-rings.

Through these spiracles the air is driven out by movements of contraction; fresh air passes in passively as the body expands. As in birds, so in insects, expiration is the active part of the breathing process. The air-tubes fork and re-fork, sending side-branches to every corner of the body, even to the tips of the feelers, so that the whole body is thoroughly aerated. The extensiveness of the air-tube system compensates for the relatively poor blood-system. In aquatic forms various devices are adopted to secure a supply of oxygen. Some water-insects come to the surface to breathe, others, like young may-flies, have special structures—tracheal gills—of different types. The Water-

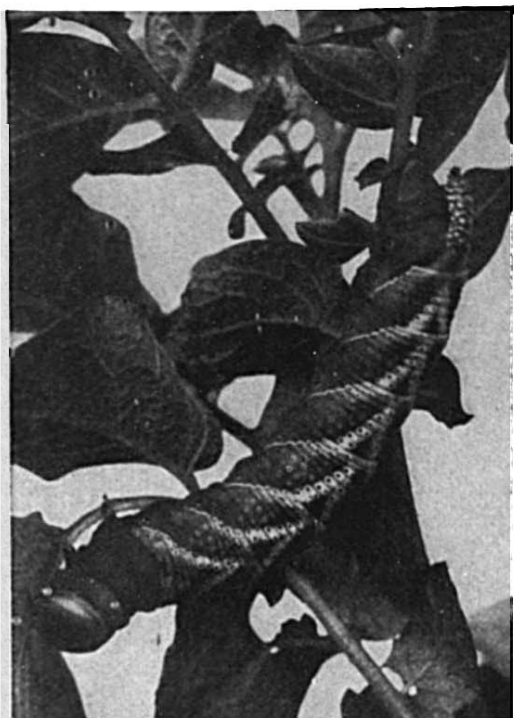


Photo: J. J. Ward.

THE CATERPILLAR LARVA (SECOND STAGE OF LIFE-HISTORY) OF THE DEATH'S-HEAD HAWK-MOTH. THE CATERPILLAR IS FEEDING ON POTATO VINES.

Beetle (*Dytiscus*) has its spiracles on its back, and when it dives under water it carries with it, in an air-tight compartment between its back and its hard wing-covers, enough air to last for several minutes. The bubble-of-air method is another plan, adopted by Whirligig Beetles and some water-bugs, whose covering of fine hairs entraps bubbles of air, ensuring a sufficient supply of air about the body for a short time under water.

In addition to the respiratory system there are inside the body of the insect all the usual organs—food-canal and associated parts, a heart, excretory organs, reproductive organs, and so on. Some insects are so small that they can creep through the eye of a needle, and it is difficult to believe that in such minute dimensions all the ordinary organs are packed away.

Insects are essentially active, and they exhibit various kinds of locomotion. Many

**Locomotion.** grubs and maggots are quite passive, but even limbless larvæ, though naturally not so active as the legged types, have their ways of getting about. They may jerk themselves along with the aid of bristles or jaws,

they may make relatively enormous leaps into the air by taking their tails in their mouths and suddenly letting go, or they may swing themselves from place to place by paying out silken lines from their mouths. Young dragonflies propel themselves through the water by means of the forcible expulsion of water from the end of the food-canal. Insects walk, run, and jump with the quadrupeds, fly with the birds, glide with the serpents, and swim with the fishes. It is often asked how a fly contrives to walk up smooth, perpendicular surfaces, and one answer is that a vacuum is made below a little soft pad which is present on the foot. Another explanation is, that there seems to be a slight exudation of adhesive moisture from the foot. Beetles, which have relatively strong legs, very different from the weak legs of a butterfly, can run with considerable speed, while many insects—one has only to think of a flea or a grasshopper—are pre-eminently leapers. The most primitive insects, the spring-tails and bristle-tails, are entirely wingless, but a spring-tail is an expert jumper. It has at the end of the body an effective leaping apparatus consisting of two elongated prongs, which are bent under the abdomen and pressed down, affording such a leverage when the retaining "catch" is released that the insect springs forward a relatively long distance compared with the size of its body.

From great leaps to the beginnings of flight is an understandable step in progress, and most insects are fliers. There are many patterns of wings, but essentially they are lightly built, mere flattened sacs of skin, often transparent



Photo: J. J. Ward.

PUPA OF DEATH'S-HEAD HAWK-MOTH (MALE).

The larva (a caterpillar in this case) ceases to be active and passes into a state of quiescence, the pupal stage, during which the body is undone and rebuilt. Out of the pupal case the fully-formed insect emerges.

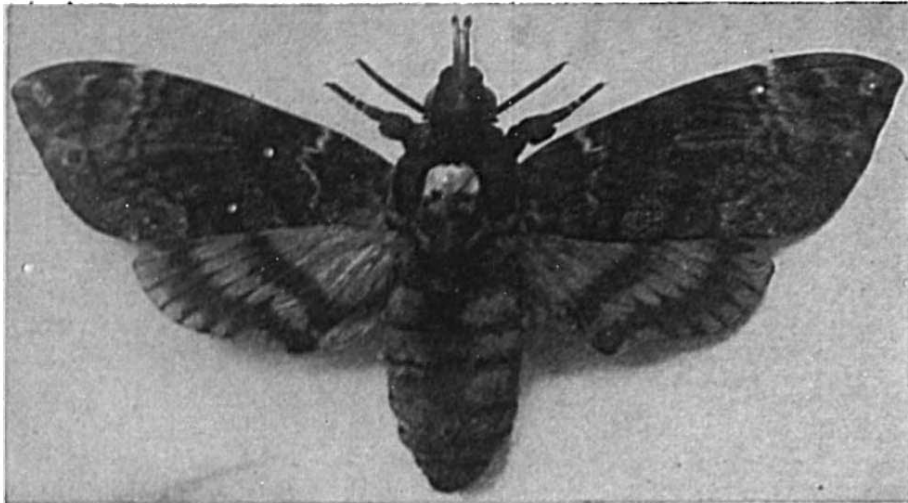


Photo: J. J. Ward.

THE DEATH'S-HEAD HAWK-MOTIL.

The black spotted yellow patch upon the thorax gives the impression of a human skull.

and fragile, but beating the air with an extraordinarily rapid motion. It has been calculated that a fly makes 330 wing-strokes in a second, a humble-bee 240, a wasp 110, a dragon-fly 28, and a butterfly 9. The rapidity of the movement produces a hum or buzz. Bees and wasps have two pairs of membranous wings, but the fore-wing and the hind-wing on each side act as a single organ, for the hind-wing has a row of minute hooklets which fit into the curled-over posterior edge of the fore-wing and lock the two wings together. In dragon-flies the two wings are not attached, but the two pairs are co-ordinated by the action of very strong muscles, and the larger dragon-flies are excellent fliers. They are probably helped in steering by the weight of their bodies, the lightness of most insects being against good steering as they are liable to be blown about by the wind.

Whatever the pattern of wing or the speed of the wing-beats, the total distance insects can fly is not great; they seldom wander far afield. Some insects literally fly but once. A may-fly may rise at noon from the water that cradled it, and by sundown its aerial dance of love may be over and its lifeless body be floating on the surface of the pool.

§ 2

Insects are largely creatures of instinct, with inborn capacities for doing apparently clever things, but yet with some degree of intelligence.

In an animal's behaviour there is often, no doubt, a mingling of different kinds of activities unified in a way that baffles analysis.

**Instincts and Intelligence.** In many cases their behaviour under new conditions, their powers of effectively meeting new ends, go beyond mere instinct. What are we to say of the following?

"The tailor-ants, common in warm countries, make a shelter by drawing leaves together, and their co-operative hauling is admirable; their mandibles are their needles, if you like, but they have nothing to fix the leaves with; what does each do but take a larva in its mouth so that the silk secreted from the offspring serves as adhesive gum."

"The tailor ants nest in trees, and they sometimes find it difficult to bring two rather distant leaves close enough together to be sewn. Then, as Bugnion relates, they have recourse to a perfectly extraordinary co-operation. Five or six will form a living chain to bridge the gap. The waist of A is gripped in the mandibles of B, who is in turn gripped by C, and so on—a notable gymnastic feat. Time does not appear to be of much account, but they work definitely towards a result, and many chains may work together for hours on end trying to draw two leaves close to one another. We could not have a better instance of social co-operation."

An eye-witness, Mr. L. G. Gilpin-Brown, writes from Ceylon:

"Sometimes one will see an ant with a larva

on its mandibles stalking aimlessly about on the outside of the nest. It stumbles on a small hole. It proceeds to study that hole, walks all round it, walks over it, and eventually decides that it really is a hole, whereupon it proceeds to business. Feeling round the edge with its antennæ it dumps the head of the larva on one side so as to fasten the thread of silk there, moves over and fastens it down on the other side, comes back again, and so on; each trip leaving a thread of silk behind until the hole is completely sealed up."

"A common harvesting ant of South Europe collects seeds of clover-like plants, lets them begin to sprout so that the tough envelopes are burst, exposes them in the sun so that the germination does not go too far, takes them back underground and chews them into dough, and finally makes this into little biscuits which are dried in the sun and stored for winter use. What a brilliant idea—and yet, it cannot be that!—is suggested by the semi-domestication of green-flies by certain species of ants! and what shall we say of the slaves which others

THE LIFE-HISTORY OF A MOSQUITO.

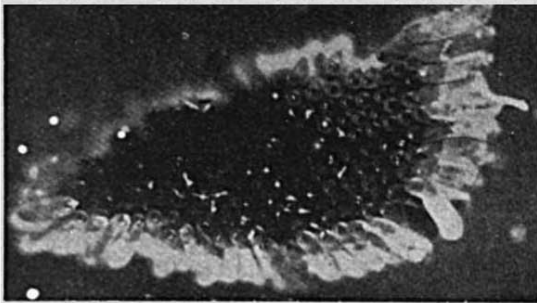


FIG. 1.—The egg-mass of the Mosquito floating on the water. It consists of nearly 300 eggs arranged in the form of a little raft.

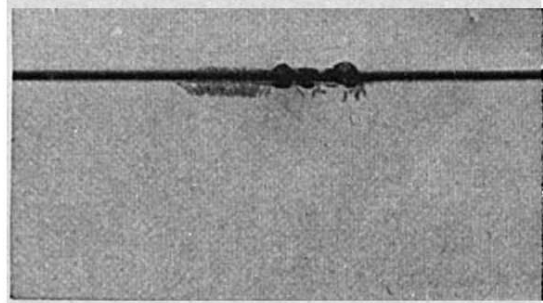


FIG. 2.—Four egg-rafts of the gnat with the young larvae just emerging into the water.

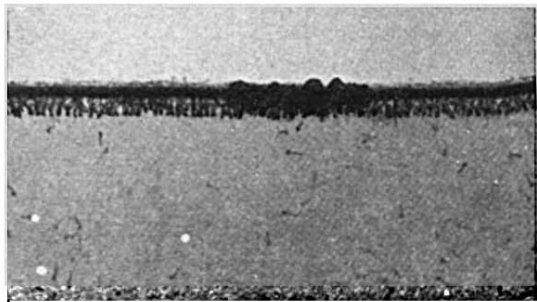


FIG. 3.—Six hours later nearly a thousand larvae have emerged from the four egg-rafts.

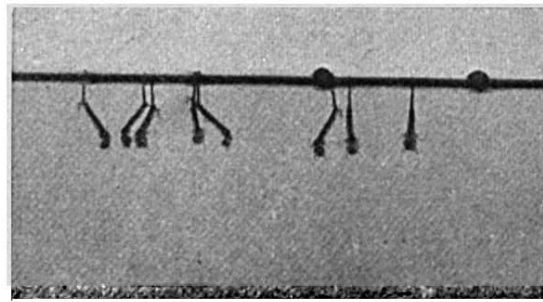


FIG. 4.—The gnat larvae when four days old. They are resting at the surface and taking in air by their tail-tubes.

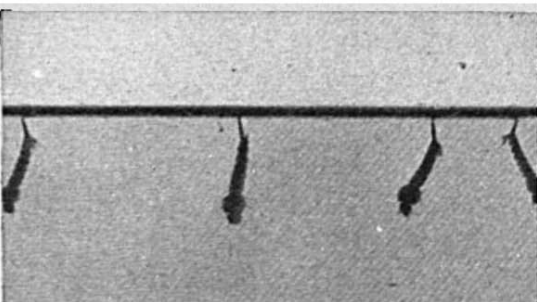


FIG. 5.—When ten days old the larvae are full-grown. They are still hanging from the under-side of the "surface film" and obtaining air from above by means of their tail tubes.

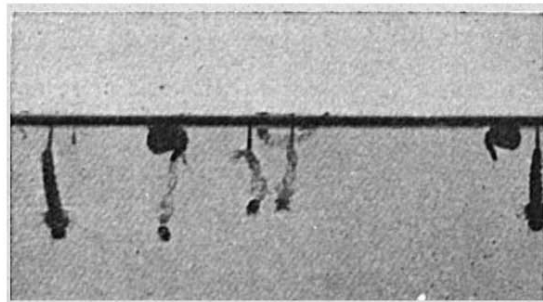


FIG. 6.—On the eleventh day they suddenly moult their skins and change into pupæ, which usually rest passively at the surface, breathing by tubes on the prothorax, but at times show an activity unusual in insect pupæ. One pupa is seen just in the act of casting off the larval skin. (See next page.)

Photos: J. J. Ward.

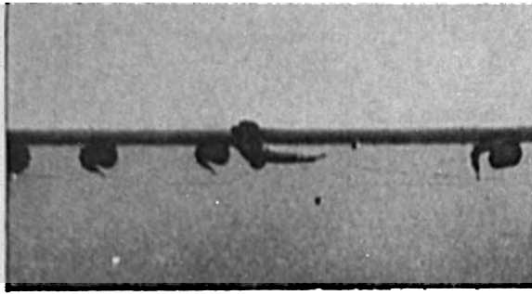


FIG. 7.—On the fourteenth day the pupa bursts its skin at the surface of the water, and the perfect gnat begins to emerge,—

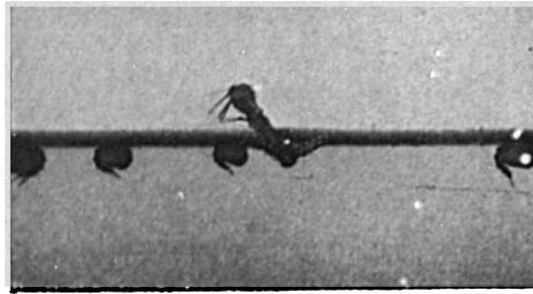


FIG. 8.—and slowly rises into the air, which is henceforth its proper element,—

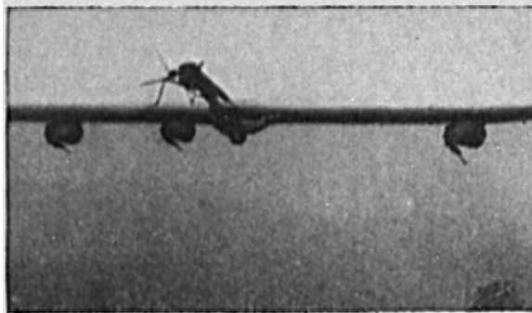


FIG. 9.—finally withdrawing its legs and wings from the last encumbering folds of the pupa skin.

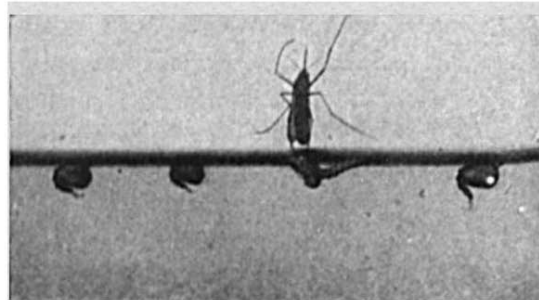


FIG. 10.—Two minutes later it is trimming its wings in readiness for flight.

bluff into service? Many white ants or termites grow highly nutritious moulds in extensive, specially constructed beds of chewed wood, and some of the true ants show a similar habit.

"On wayside plants in early summer we see everywhere the frothy masses called cuckoo-spit, each made by a larval frog-hopper which whips a little sugary sap, a little ferment, and a little wax into a strange persistent foam, protective against enemies and against the heat of the sun, the creature literally saving its life by blowing soap-bubbles. Not far off, on a bare sandy patch, are the deep shafts sunk by the grubs of the beautiful green Tiger Beetle. The grub, with quaint somersault movements inside the shaft, thrusts the loose earth with great force into the walls, and beats them smooth. Eventually it fixes itself near the top of the shaft so that the roof of its head forms a trap-door. When an ant or some other small insect settles down on this living lid, the grub suddenly explodes like a jack-in-the-box, hurling its victim violently against the hard upper edge of the shaft-wall. The sucked body is afterwards jerked out. The world is full of these inventions.

"How are we to understand the behaviour of one of the Digger Wasps which lays its eggs in

a sunk shaft, and provisions this with paralysed caterpillars? While the hunting and storing are in progress, the wasp shuts the mouth of the shaft after each visit, but does so in a rough-and-ready fashion. When the larder is full, however, it seals the entrance with earth and makes a neat job of it; nay, it takes a minute pebble in its jaws and beats the earth smooth. Who said animals could not use tools? It seems that using the pebble is not part of the instinctive routine, but is an individual touch, probably with more vivid awareness than is associated with the rest of the agency. But the difficulty is to think of the origin of either the routine, or the finishing touch without postulating intelligence, or, at least, some appreciation of significance."<sup>1</sup>

It is well known that ants and bees can find their way home from a distance. Ants evidently *Homing*, take impressions, by touch, sight, or sense of smell, of certain sign-posts. There may even be a "muscular memory" of the movements effected and of the amount of work done. Probably ants improve gradually in their way-finding as they learn to make use of a combination of the various hints.

<sup>1</sup> J. Arthur Thomson, *Secrets of Animal Life*.



An interesting experiment suggested that bees build up a knowledge of the country round about the hive. Professor Yung of Geneva took twenty bees from a hive near the lake and liberated them at a distance of six kilometres in the country. Seventeen returned to the hive, some within an hour. Next day the successful seventeen were taken on a boat to a distance of three kilometres on the lake. When liberated they flew off in all directions, but apparently they missed the necessary signposts, for none of them found their way home. On the other hand, experiments have given results that indicate that bees have a "sense of direction," comparable to that of carrier-pigeons. Even bees with their eyes obscured have been known to make a "bee-line" for the hive from considerable distances. But there is no doubt that bees make cautious and systematic trial "flights of orientation" when a hive is placed in a new position.

An outstanding feature of Ants is that of instinctive socialisation. They do not live unto themselves, but for the general good of the community. They are indefatigable, but whether they toil consciously for the sake of anything, or what we are to read into their capacity for unified action, who shall say? "It is difficult to accept the opinion of some naturalists that instinctive behaviour is unaccompanied by any awareness of meaning or feeling of the end. Whenever this difficulty is obvious, it is customary to say that intelligence has for the time being taken the reins. In any case, the *facts* are wonderful enough."

It is among the Social Insects that the most pronounced evidences of intelligence are found. "Intelligence is an eminently social faculty," as Kropotkin says. "Language, imitation, and accumulated experience are so many elements of growing intelligence of which the unsociable animal is deprived. Therefore we find, at the top of each class of animals, the ants, the parrots, and the monkeys, all combining the greatest sociability with the highest development of intelligence. The fittest are thus the most sociable animals, and sociability appears as the chief factor of evolution, both directly, by securing the well-being of the species while

diminishing the waste of energy, and indirectly, by favouring the growth of intelligence."

Mutual help is practised extensively among insects of various kinds. The Burying Beetles, which usually lead a solitary life, call to their aid a number of their fellows when there is a corpse to be buried. Many caterpillars weave a silken web to make a shelter for a whole brood, while the full-grown Procession Caterpillars march together from their feeding-ground on the trees to a soft place on the ground where they can bury themselves and become moths. Locusts display gregarious habits also which are of mutual advantage; for instance, it is a common practice for the wingless young to make a living bridge over a moderately broad stream, plunging into the water and grappling, for sticks and straws, and scrambling for a breathing space on their comrades' bodies, till the whole swarm passes across the stream. Comparatively few are drowned, as the same individuals are seldom in the water the whole time. Such associations for mutual aid suggest the beginnings of societies, but they are not nearly so highly evolved as those seen among the termites, ants, bees, and wasps, where the social habits extend to the welfare of the young, and co-operation reaches a high level. Kropotkin says, "If we knew no other facts from animal life than what we know about the ants and the termites, we already might safely conclude that mutual aid (which leads to mutual confidence, the first condition of courage) and individual initiative (the first condition for intellectual progress) are two factors infinitely more important than mutual struggle in the evolution of the animal kingdom." The fact is that in the struggle for existence, which includes all the answers back that living creatures make to envioning difficulties and limitations, sociality pays just as well as intensified competition, or, it may be, *pays better*.

### § 3

#### THE STORY OF ANTS

Of all insects, Ants must be placed on the highest level, for none have better mastered the art of living together in a mutually beneficial manner, and many ant communities show considerable elaboration. Let us, then,

take the case of ants as a particular illustration of the distinctive features of insect societies.

**The Marvels** Here we have "a community of of the Ant- separate individuals with more or less hill.

of a corporate life, and with the power of acting as a unity." Many Ants live for a number of years, so that one generation may teach another the profitable arts which lead to the success of the community. The welfare of the species is the important matter, and the individual is often sacrificed, as well as specialised, for the common good. There are three types of individuals—winged males, winged females, and

Mutual aid and harmony seem to reign within the community, but there are terrible wars with other species, which are carried out in a well-organised fashion. Ants have the instinct of acting together and seldom make individual attacks, but they never seem to hesitate to sacrifice themselves for the protection of the community. Sometimes these warlike expeditions are initiated with a definite end in view, that of capturing slaves. For instance, the Amazon Ants, which have jaws well suited for warfare but inconvenient for the peaceful occupations of life, habitually keep slaves to wait upon them. Professor Wheeler thus describes them: "While in the home nest they sit about in stolid idleness or pass the long hours begging the slaves for food, or cleaning themselves and burnishing their ruddy armour, but when outside the nest they display a dazzling courage and capacity for concerted action." Scouts report their discovery of a Brown Ant colony, and a raid promptly follows, the Amazons returning victorious with a large number of prisoners, which become faithful slaves. Darwin's suggestion "of the origin of slave-making was that many ants capture the pupæ of other ants for food, that some of the stored pupæ might be unintentionally reared, that if their presence in the community was not resented

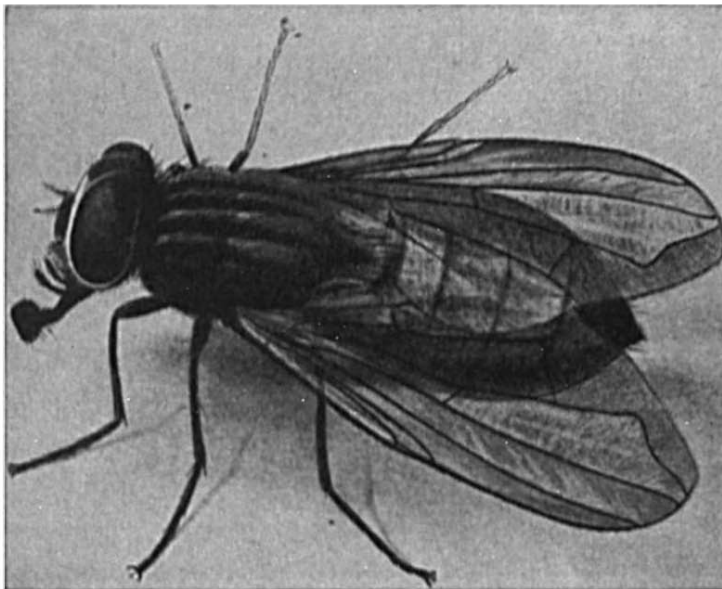


Photo: James's Press Agency.

#### HOUSE-FLY (*MUSCA DOMESTICA*).

It is bred in rubbish heaps during the summer months. The House-Fly is an agent in carrying typhoid germs, which readily adhere to the numerous hairs seen on the fly's body and appendages. (The Blow-fly, or Blue-bottle, lays its eggs on dead animals, and on joints in the larder if it has access to them.)

wingless "workers" or undeveloped females; and the workers may be of different kinds, large and small—or with huge mandibles in the "soldier" type. We see a division of labour. The busy workers tread the neighbourhood of the nest into a pattern of "ant roads" by which they come and go on their foraging expeditions. Smell counts for much in way-finding. Within the nest, the workers have their home duties, they look after the young, feeding them and carrying them from room to room to secure a suitable temperature, and they bite open the cocoons when the perfect insects are ready to emerge.

but proved useful, the slave-making habit might make ground."

Like the Termites, the true Ants frequently have guests within their homes. Certain little crickets find shelter and abundant food in this hospitable haunt. They beg food from the ants, and usually they shamelessly steal from the newly-fed young ants. Beetles, too, with a peculiar fragrance that makes them welcome guests, persuade the ants to share the sweet substances they carry in their crops, by stroking them till they deliver up the coveted dainty. One species of ant carries mites about on the body, feeding them and caring for them, but

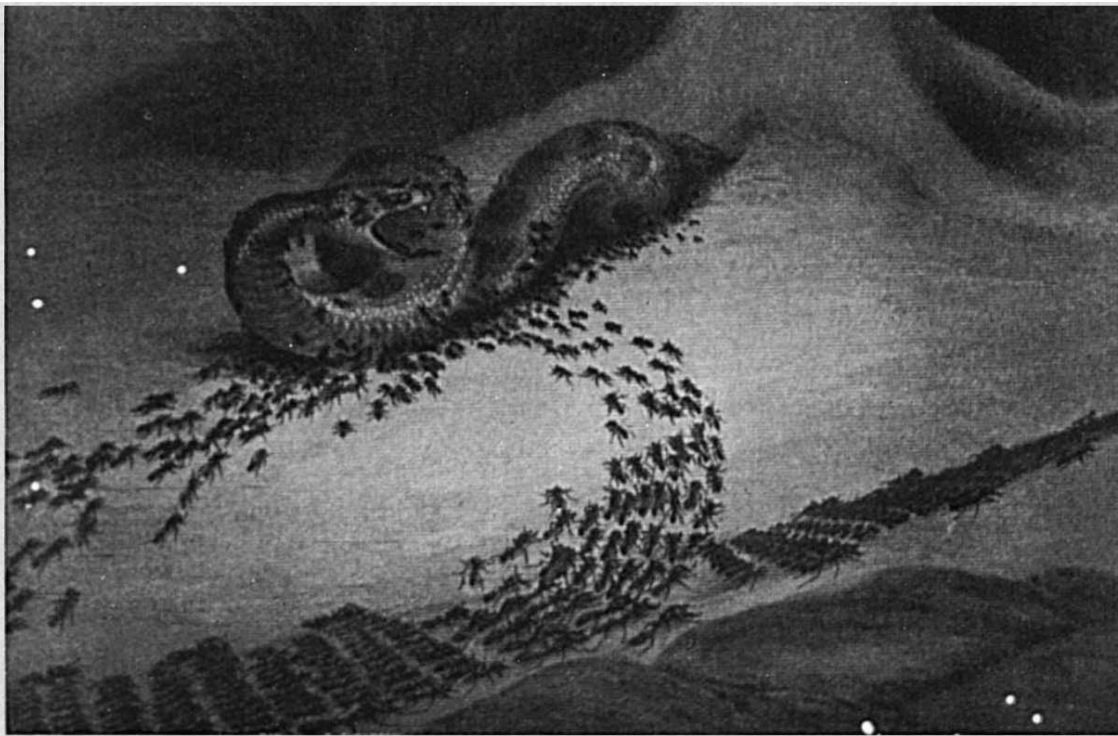
apparently deriving no benefit from them. Evidently ants are fond of keeping pets!

One of the peaceful occupations ants pursue is keeping "cattle." Their "cows" are little aphides or green-flies, which they cherish for the sake of the sweet "honey-dew" that exudes from their bodies. Possibly at first it was simply a matter of feeding at the same table, when the ants would discover the sugary fluid and get into the way of licking the green-flies. The eggs of a certain aphis, which are of no direct use to the ants, are brought into the nests and protected carefully from the severities of winter until the warm weather comes, when the young aphides are brought out and put on their food-plant, walled in by little "cattle-pens" of earth. By keeping these eggs safe for six months the ants ensure a supply of the food delicacy during the following summer—a truly remarkable case of prudence!

In North America there are "agricultural ants" which weed a space near the nest and only allow plants with edible seeds to grow there. These seeds they gather in due season,

and store in the form of little biscuits, which are made from a chewed-seed dough dried in the sun. Another industry is the cultivation of fungi for food—another point in which they agree with the Termites—and this habit is seen among the Leaf-cutting Ants. The fungus is grown in the underground nest on a spongy framework of chewed leaves, and the ants not only keep undesirable fungi from growing amongst their peculiar delicacy, but they keep their speciality from fructifying, which would spoil it for their purpose.

Much has been added to our knowledge of the Leaf-cutting Ants by Mr. Beebe, who, in his fascinating book *The Edge of the Jungle* (1921), gives us an account of his own observations of a species of *Atta* in British Guiana. He had the good fortune to see, at one time, a royal procession leaving the nest in preparation for the nuptial flight. The great queen laboured painfully up the tunnel far away from the real entrance to the nest. Behind her came the kings, much smaller than she, but large in



DRIVER-ANTS ATTACKING A SNAKE.

The Horned Viper, shown in the illustration, was attacked whilst casting its skin. The ants covered every portion of its body, hanging on by their pincer-like jaws. The snake writhed and struggled for a quarter of an hour, but in the end was killed and eaten by the ants.

comparison with the workers that ran all about them. When the queen reached the surface she poised herself on the tips of her slender legs and stretched out her great wings, looking like an aeroplane in miniature. Immediately the little workers swarmed over her, inspecting every organ, cleaning her antennæ, legs, and gauzy wings. She endured this for a few minutes, then moved her wings, threw off her load of busy mechanics, slowly rose in the air followed by the males, and was soon lost to view.

But on another occasion the observer was able to follow the story farther, for he saw a queen descend in a long spiral to the ground, rest a few minutes, clean her antennæ, and begin to scrape at the sand with her jaws—the foundation of a new colony at which for many days she labours alone. She plants the little fungus pellet she has carried with her from the old nest in a pouch in the lower part of her mouth, and tends it with the utmost solicitude. The care and feeding in her past life have stored within her the substance for vast numbers of eggs. Nine out of ten she lays, she eats to give her strength to go on with her labours, and when the first larvæ emerge they too are fed with surplus eggs.

There are three castes of workers, large "soldiers," ordinary "workers," and small "workers," or, as Mr. Beebe names them, Maxims, Mediums, and Minims. The first brood, which hatches out in about six weeks, are all minims, and they take charge at once of the fungus, enlarging the nest, attending to the queen and young, and other domestic occupations. When the larger workers emerge, foraging and leaf-cutting begin. In bands they issue forth and search about until they find one of the ant trails trodden down by millions of their kind before them, and stream along it till instinct impels them to climb a tree and drives each ant out upon a leaf. "Standing firmly on the leaf he measures his distance by cutting across the segment of a circle with one of his hind feet as a centre. . . . He does not scissor his way across, but bit by bit sinks the tip of one jaw, hook-like, into the surface and brings the other up to it, slicing through the tissue with surprising ease. . . . Holding his bit of leaf edge wise he bends his head as far down

as possible and secures a strong purchase along the very rim, when as he raises his head the leaf rises with it, suspended high over his back out of the way." From this the ant gets its popular name of Parasol Ant.

Mr. Beebe, with due precautions against attack by the insects, which are formidable collectively, dug out a large nest. At first only workers came forth, but by and by the large, one-eyed, round-headed soldiers lumbered forth to battle, and attacked his well-greased boots. He tells us that their bulldog-like grip, which does not relax with death, is taken advantage of by the Indians, who use them for stitching wounds, applying their jaws to the apposed edges of skin and then snipping off their bodies. As we have mentioned, the leaves the ants bring in are not eaten, but are masticated to a pulp and used as a fertiliser on which to grow the fungus which is their only food—indoors at least. Three feet down the great corridors opened out at intervals to chambers as large as a football, which were filled with the soft whitish mould which is the *raison d'être* of all the ants' labour. In one of these chambers Mr. Beebe found groups of workers in the act of chewing up the leaf-pulp.

Of great interest, too, is Mr. Beebe's account of the habits of the formidable Army Ants.

Discovering a nest of these on the ceiling of an outhouse, the naturalist made for himself an observation post by placing, at the cost of several fiery stings, a chair with its legs in tins of a tarry disinfectant. There, within a foot or two of these myriads of terrible jaws, he spent many hours watching the home life of the colony.

The whole structure—foundations, walls, and ceilings—was made of living ants, their legs stretched out to the utmost, their bodies erect, and their weapons always in a position of readiness for battle. The entrance was guarded by a mat of living ants, and near the door the edges thickened and met overhead to form a tunnel through which every returning worker had to pass with her booty.

Returning soldiers dropped their load of plunder near the entrance to be dealt with by the workers. They were then immediately surrounded by a group of workers, who put them

The Ways of Army Ants.

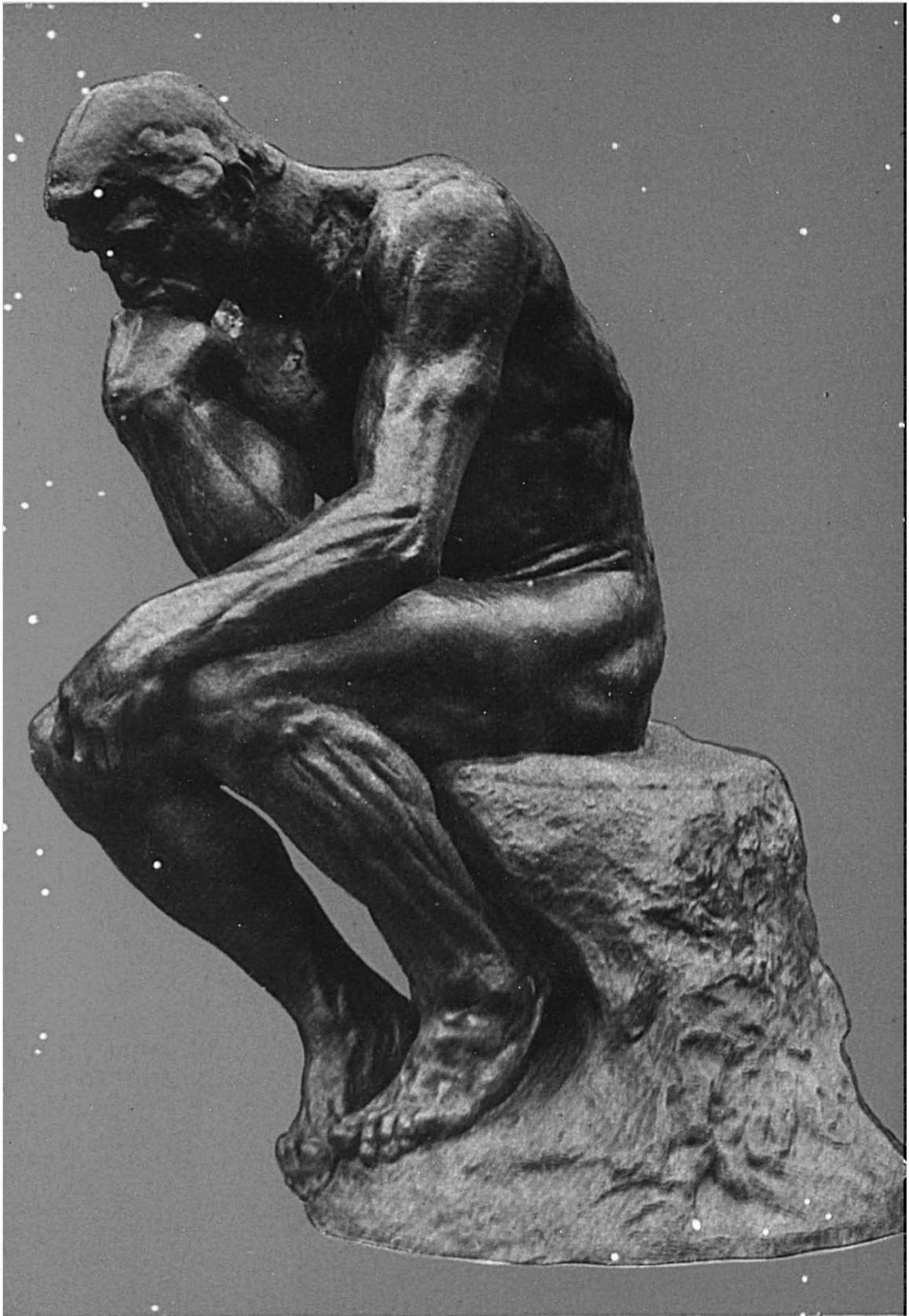


PLATE 100

**THE THINKER**  
From a Statue by Rodin

through a very thorough scraping and cleaning, and they not only submitted with a good grace, but turned over on their backs to facilitate the process.

Spraying with formol disorganised the colony, which broke up in long festoons, and moved away, carrying eggs and larvæ. Next morning it was found that about a third of the ants had remained on the floor in charge of larvæ at the critical stage of passing into the pupal stage. The workers were very busy gnawing wood to dust, and rags to shreds, to provide the light covering which seemed necessary before the larvæ would begin to spin. The following morning the whole hoard had disappeared.

Termites or "White Ants" are not related to the true Ants, but their achievements are equally wonderful. They are abundant in many warm countries, notably tropical Africa. They live together in great communities, sharing a many-chambered earthen nest. The hills or termitaries which they build are often twice a man's height and strong enough to stand upon. In South Africa telegraph posts have to be made of iron to resist their jaws. There is striking division of labour, as with the Black Termite so abundant in Ceylon. When on the march the Black Termites move in great armies, sometimes comprising 300,000 individuals. It has been computed that there are 200 "soldiers" to every 1,000 workers, the number of soldiers guarding a march varying with the danger. The long troop of workers marches between two lines of soldiers. Their tactics are nothing short of extraordinary: there are guides and scouts searching out new lines for foraging. "Very carefully, step by step just like cats, they slink forward, one behind the other, and if the foremost detects anything the least suspicious, he draws nervously back, pulling his 'brave' comrades after him." There are "soldiers" that restore order in the ranks where there is panic; the orders seem to be given through the antennæ or by a quivering of the whole body. Professor Bugnion tells of a war which lasted for three days. The Black Termites often wage a bitter battle with the well-known Tailor-ant, *Ecophylla*; when the latter draw near the termites squirt full in their faces drops of a secretion or fluid which seems to drive the true Ants almost crazy.

## § 4

## THE STORY OF BEES

In the Hive Bees (*Apis*) we have a further illustration of insect communal life. Whatever the nature of the communal life of bees may be, we cannot liken it to that of human society. The one is run on predominantly instinctive lines, the other is predominantly intelligent.

An element of *permanence* distinguishes their communities, for many workers as well as the queen survive the winter. To the industry and food-storing habit of the Hive Bee is probably due their complex social life; the storing has enabled the community to survive unfavourable seasons and become permanent. When spring reawakens the earth and the willow-trees are bedecked with catkins, and gerse and violets and primroses send out a fragrant invitation, the bee world resumes its busy life again. The workers set to work to "spring-clean" the hive and build new combs of hexagonal cells to accommodate the eggs the queen has again begun to lay. Some of the workers sally forth to bring in fresh stores of pollen and honey, while others are nurse workers in charge of the fast-filling nurseries. In early summer the hive is a prosperous and busy city, inhabited by three distinct types of individuals. The head of the community is the queen, not by reason of her wits, for her daughters far surpass her in brains and activity, but because she is the mother bee, who alone can increase or restore the population.

One of the most remarkable facts about hive bees is the apparently psychical dependence of the community on the presence of the queen. If she is removed, the bad news spreads quickly through the hive and there is a strange disorganisation. When the bee-keeper replaces her, the good news soon circulates, and there is harmony once more. According to some authorities, the queen has a peculiar odour which is reassuring to the workers. There is no doubt that smell counts for much among bees.

The queen bee is concerned only with egg-laying; the life of the hive is sustained by the worker bees, which are active, intelligent, but sterile females, with their reproductive systems in a state of arrested development. Thirdly,

there is the drone section of the community, the males, who take no part in the work, and forage only for themselves, and then not sufficiently to satisfy their greed for honey. It has been said that they comport themselves in the hive as did Penelope's suitors in the house of Ulysses: "indelicat and wasteful, sleek and corpulent, fully content with their idle existence as honorary lovers, they feast and carouse, throng the alleys, obstruct the passages, and hinder the work." But this is not quite accurate. Drones spend much of their time flying about very energetically in the vicinity of the hive. They are on the look-out for an emerging queen, and they are usually disappointed.

nectar into its mouth and thence into the "honey-bag," where it changes into honey, which is deposited in storing cells for the indoor workers to draw on for themselves and also, of course, for the nutrition of the larvæ. The golden pollen is kneaded into a little ball and carried back to the hive in the "pollen-basket," a little cavity in the bee's hind-leg.

There is a popular idea that bees fly about from flower to flower in a haphazard way, sipping nectar from any blossom that takes their fancy. But as a matter of fact, and as Aristotle noticed, many bees keep as a rule to a single species of flower for collecting pollen and nectar. This is an advantage to both flower and insect. If the

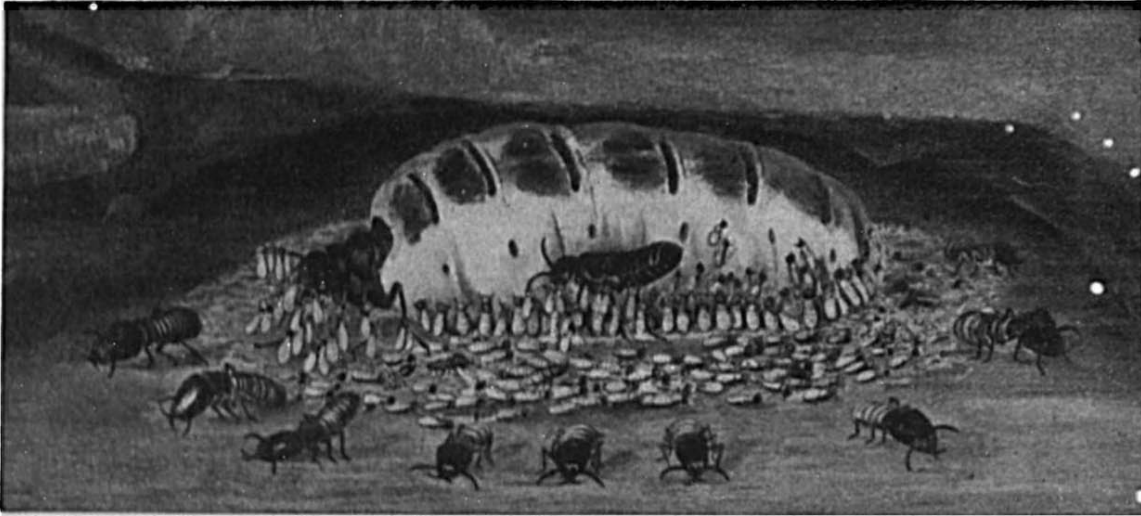


Photo: James's Press Agency.

#### QUEEN OF THE TERMITES AND HER COURT.

The queen Termite is about the length of our middle finger. Most of the length goes to the posterior body, which is bloated with eggs. The relatively small head and thorax are seen in front. The queen is lying in the royal chamber of the termite, the door of which, though originally allowing her entrance, is much too small to allow her exit now. She often lays sixty eggs per minute. She is seen surrounded by a body-guard of workers, and outside these a circle of soldiers.

The stronger workers have to provide food for the whole colony. Their diligence is immense; they toil from morning to night with ceaseless energy, gathering in the precious store of honey and pollen, and it is said that in summer-time the average life of a worker bee is only about two months. Their brains become hopelessly fatigued. In a colony of 50,000 bees it has been estimated that there are 30,000 workers, and if each makes ten trips a day 300,000 flowers would be visited. About 37,000 loads of nectar are required for the production of a pound of honey.

To obtain the nectar, the bee protrudes its tongue into the flower tube and sucks up the

bee were to go from one type of flower to quite a different one, time would be lost in locating the nectar. Moreover, when the bee is constant for a while to the same kind of flower-cups, pollination is effected and waste of pollen is prevented. The mutual aid which is an undoubted fact in the bee society sometimes takes the form of showing each other valuable sources of nectar.

Within the hives the younger workers are busily looking after the nurseries and attending on the queen. The newly hatched grubs are fed on a kind of pap regurgitated by their nurses, but soon they are ready for a more substantial

#### The Bees' Diligence.

#### The Nurseries

diet of pollen and honey. Then the larvæ spin cocoons and the workers shut the cells with little caps of porous wax, and leave their charges to a thirteen-day pupation, after which yet another generation of worker bees bite off the roofs of their cradles and join in the busy life of the hive. In larger cells the queen deposits eggs which are not fertilised, and these develop into drones. Still later in the season "royal" cells are constructed, in which the queen lays fertilised eggs, identical with those laid in the ordinary worker cells, but the grubs which hatch out receive a special "royal jelly" from the mouths of their attendants, instead of the usual fare of masticated pollen, and the effect of this diet is to make the grubs develop into "princesses" instead of workers.

It should be noted that a queen bee receives from a drone in the course of her "nuptial flight" a store of sperm-cells with which she may fertilise the eggs she lays during the next year or more. It depends on the egg-laying movements of the queen whether the laid egg is fertilised or not.

Then comes the remarkable upheaval of the busy hive—the departure of a "swarm," headed by the queen bee. Whether **The Swarm.** swarming is due to the overcrowded state of the hive, or to the queen's excitement when her young rivals are stirring in the royal cradles, or to a sudden desire on the part of the workers, a harking back to the time when there were no hives and motherhood was not given only to one among thousands, a desire to break out of their "prison bounds of order, commendable toil, chill, maidenly propriety," who shall say? But suddenly the routine of the hive is broken through, work is suspended and many of the workers become restless and excited, and gorge themselves with honey till at a given signal the swarm issues from the hive, "in a tense, direct, vibrating, uninterrupted stream that at once dissolves and melts into space, where the myriad transparent furious wings weave a tissue throbbing with sound."

The mad, joyous dance in the sunlight over, the swarm returns to earth, and now there is the morrow to consider and a new home has to be built. Scouts go out, and when they have found a suitable site the workers at once begin to

fashion a new comb, in which the queen lays eggs, and so a new city springs up. The hexagonal cells of the combs are made of thin plates of pliable wax, which comes from little pockets on the bee's abdomen. To start the secretion of the wax great heat is needed, so the bees gather together in a great pendant mass till "a strange sweat, white as snow and airier than the down of a wing, is beginning to break over the swarm." The worker bee removes the wax scales from her body with a pair of pincers she has at one of her knee joints, and then chews

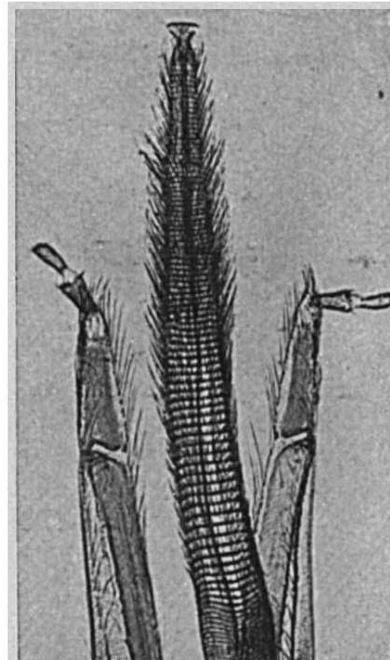


Photo reproduced by courtesy of F. Davidson & Co.  
TONGUE OF HIVE BEE.

By means of this long tongue the worker-bee is able to extract from flowers the nectar which is afterwards stored as honey in the hive.

them into a soft paste which can be moulded into the delicate fabric of the cells.

The bees' comb is one of the wonders of the world. In spite of its extraordinary fragility it is able to suspend a **Honeycomb.** weight thirty times as great as its own. A small block of wax attached to the roof of the hive makes the foundation, from which the layers of cells grow out downwards and sideways, leaving a gangway for the streams of bees to pass to and fro. The usual shape of the cells is hexagonal, individually well suited for the cylindrical body of a grub, together ideally



constructed to prevent waste of space. But bees adapt themselves to unusual circumstances and build triangular, square, or other cells in odd corners if the need arises. The cells are not quite horizontally placed, having a slight upward tilt which prevents the spilling of thin honey. Extreme delicacy of touch is required in the moulding of the plastic wax, for the <sup>top</sup> part of an inch is the thickness of the tissue-paper-like cell-walls.

While the new colony is rapidly growing up, life continues in the old hive; it is, in fact, about to renew its youth. One of the prin-

**The Nuptial Flight.**

cesses is awakening, and the remaining workers are watching over her. She appears from the shelter of the royal nursery, and the workers brush her and clean her and caress her. Impelled by some strange instinct, she immediately seeks the other cradles, tears open the cells and relentlessly stings her sisters, her possible rivals, to death! A few days later, on a bright and sunny day, she leaves the hive for her nuptial flight. She soars aloft into the blue sky followed by a crowd of drones from neighbouring hives, and somewhere in the solitude of the blue the strongest male overtakes her and meets love and death in the same instant; and the bride-widow returns to the hive.

For the remainder of the summer the busy life of the hive goes on as before, the queen perpetually egg-laying, the workers foraging and nursing, the drones leading a life of ease. But one day the decree goes forth that those that do not work shall not eat, indeed shall not live; and the massacre of the males begins. Vigorously and pitilessly the long-suffering workers at last turn on the drones and slay them all.

Flowers are becoming scarce, and the days are short and chilly, so the bees cease their labours and prepare for the long sleep of winter, if sleep it can be called, for the life of the hive is slackened, not completely arrested. The bees gather together in a great cluster, with their queen in their midst, and by the beating of their wings they keep up a current of warm air. The bees nearest the store cupboards pass the honey to their neighbors, and so food is circulated through the drowsy mass, enough to keep the fire of life glowing, ready to burst into flame again with the return of spring.

Among different kinds of bees there are different degrees of sociability. Some, such as the Leaf-cutting Bee, are quite solitary; others show a certain amount of co-operation combined with a large amount of independence.

The Humble-Bees (Bombus) live in communities which last for one season only. The queen humble-bee, after her autumn nuptial flight, creeps into a hole under a sun-warmed bank and there lies torpid throughout the cold weather. Spring awakens her and she sets to work to prepare for her expected brood. She secretes wax, makes a few cells, and lays her eggs in these. She has herself to discharge the whole labour of foraging for honey and pollen, keeping the cells clean, kneading the bee-bread, and feeding and tending the hungry larvae. She is a queen in the sense of being the mother of the whole colony, but she is a very hard-working queen for a time. Later, when the first batch of young ones, which are always workers, are fully developed, they take the domestic details on themselves, and the queen can now devote herself to her true business of motherhood. As in the case of wasps, the community dissolves at the end of the summer, workers and drones all dying, but a few young queens surviving through the winter to found the colonies of the following year. In this and in many similar cases it is difficult to know whether one should speak of a large family or of an incipient society.

## § 5

Even Solitary Wasps instinctively provide for their young, though they die before these hatch out. They deposit the eggs in a shelter and leave with them a larder of fresh meat, in the shape of living insects rendered unresisting by the paralyzing effect of the wasp's sting on their nerve-centres. The Social Wasps live in communities which last from spring to autumn. Winter is the time of inactivity, but in some secluded spot, a cranny in a wall or a sheltered nook in a rubbish heap, the queen wasp, who mated at the end of last season, is sleeping her winter sleep, tiding over the hard months in a state of passiveness in much the same attitude that her body assumed during the pupa stage. With the coming of spring she reawakens, and the season's activities

**The Story of Wasps' Nests.**

are soon in full swing. The queen's first care is to choose a suitable site for the nest she is about to build, and a cavity in the shelter of the gnarled roots of an overthrown tree is as good as any. Then she sets to work to collect wood-fibre, which she rasps with her jaws from posts and palings. This wood-pulp she kneads with her saliva into the "paper" with which the nest is built. She spreads the first layer on the root she has chosen as the foundation from which to hang the structure, and gradually, hour by hour, pellet by pellet, she moulds a disc, and then a

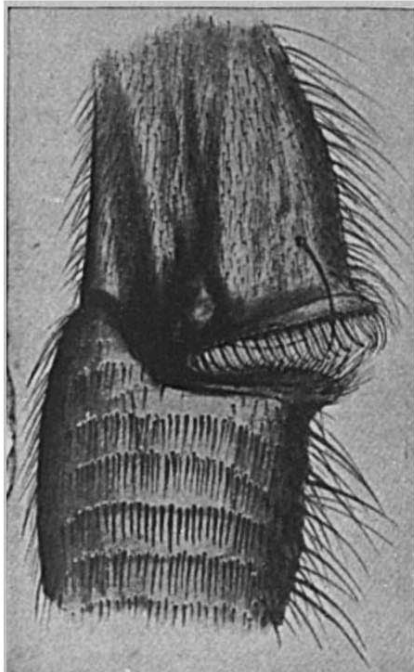


Photo: James's Press Agency.  
POLLEN BASKET ON HIND-LEG OF HONEY-  
BEE (WORKER).

Pollen, kneaded into a little ball, is carried from the flower to the hive in receptacle shown.

stalk, and then a canopy to shelter the first layer of cells. In each cell as it is completed she deposits an egg, which she cements to the cell-wall, for the open end of the cell is directed downwards.

In a few days the legless grubs emerge, and the queen becomes a nurse as well as a home-builder, until the older grubs mature, and a staff of worker wasps is ready to take on the manual labour and allow the queen to devote herself to egg-laying. The workers add to the original comb and suspend a new storey from it by little

stalks. One storey is added after another. The rounded outer covering is also extended, by being hollowed out inside and added to outside. This outer envelope may consist of as many as a dozen layers of the paper, which is a water-proof and non-conducting material, so that the necessary temperature for the development of the young is kept up. The entrance opening of the envelope is always at the foot of the pendant nest, and all the openings of the combs point towards it, so that the young are reared in inverted cradles.

The young wasp grub at first keeps its position by clinging with its tail to the egg envelope while it pokes its head out for food, but later it uses its jaws and a sort of sucker-foot on its tail as grasping organs. If it does happen to fall out, the worker nurses will probably throw it out of the nest, just as they do with rubbish when they are cleaning. The first thing the fully formed young wasp does, if it has safely passed through its head-downwards larval and pupal stages, is to crawl about and visit the grubs, tapping them on the head till they emit a tiny drop of fluid, which the young wasp licks greedily. Then it is ready to help its mother with the housework, and in a few days is strong enough to go out on foraging expeditions. The mother wasp also visits the grubs for this delectable drop.

The young wasp's duties at first consist mainly of paper-making and building, for the nest is continually growing. She works backwards so that she does not tread on the newly applied pulp, and she moulds her material to the proper thickness, testing it with her feelers. But after a week or two her salivary glands are exhausted, so that she has to give up the manufacture of paper and turn to the older wasp's task of caring for the young, feeding them with the soft parts of insects and occasional sips of fruit-juice or nectar, and cleaning them with care. So through the summer the busy life of the community goes on. The queen has laid thousands of eggs, and a great army of her daughters is engaged in enlarging the nest—which may now have seven or eight tiers of combs enclosed in a great ball of grey paper—in keeping it scrupulously clean, and in caring for the rising generations. Some of these workers, though they are never impreg-

nated, may occasionally lay eggs, which, like the unfertilised eggs of the queen, invariably develop into males.

As summer wanes, the workers build larger cells in the lower combs. These are the royal nurseries in which a brood of perfect females, not sterile workers, and males are reared. On this brood the future of the race depends. A few weeks, and a great change takes place—summer is still here and the wasp-colony is at the height of its prosperity, a healthy, active community; then the chill finger of autumn passes over it, and the first shiver marks the beginning of the decline of the colony. Prosperity is succeeded by starvation. There are no stores to fall back on, and deadly numbness and demoralisation break down the orderly routine of the nest. The exhausted workers die in their thousands, and with them the parent queen. None but the young royalties survive, and the males only long enough to mate with the young queens: thereafter they also die. The young queens destined to found new colonies next spring alone escape the common fate, but the demoralisation shows itself in them too, for they devour the remaining eggs and larvæ, and on this rather cannibal fare they are able to survive the winter.

## § 6

### LIFE HISTORIES

The food of Insects is extremely varied, not only in different species, but also within a single life-history, and it naturally follows that there is much variety in the ways of obtaining it, and, in particular, in the structure of the appendages associated with the mouth. Insects depend greatly on their sense of smell when in search of suitable food, and the organs of smell, minute olfactory pits or bristles, are found chiefly on the antennæ. Some insects move their feelers markedly on coming near strong-smelling substances, and some are unable to find their appropriate food without the aid of their antennæ. For instance, Carrion Beetles which had had their antennæ removed were found to be incapable of locating their evil-smelling food. A very striking example of change of diet is seen in the life-history of a butterfly, such as the common Cabbage White Butterfly. The small, sculptured eggs are laid in large numbers on

the plant which is to form the food of the caterpillars. The caterpillar emerges from the egg as a worm-like, short-legged little animal, green against the green of its natural haunt, with simple eyes, short feelers, stumpy abdominal "pro-legs" in addition to the three pairs of jointed thoracic appendages, and strong, hard jaws well suited for gnawing green food. Its business in life is to feed and to grow, and it feeds rapidly and almost continuously. It may eat many times its own weight in a day but probably only digests the fluid part of the food. It outgrows its inexpandible chitinous covering, and has to moult it, an exhausting and dangerous process. Then it feeds and grows and moults again, until at its limit of growth it passes into a resting phase. It becomes a pupa, or chrysalis.

The Cabbage White Butterfly larva suspends itself in a quiet corner by a silken thread, with its tail against a support, and the larval skin forms the pupa case, but many other pupæ (e.g. many moths) have the additional protection of a cocoon, either of pure silk secreted at the jaws, or of silk mixed with leaves, moss, or other extrinsic matter. The larva (i.e. the caterpillar) now undergoes the great change which is called metamorphosis. Within the cocoon the body of the larva is broken down and is built up again on a new architectural plan. When the reconstruction is completed the fully-formed insect emerges. What a contrast! It is now an intensely active butterfly, having left behind it the shrivelled skin of the creeping caterpillar, and for a brief season it lives its aerial life, growing not at all, feeding but little, and then only on liquid nectar by means of the long sucking-tube so different from the strong biting jaws of the caterpillar: hunger is no longer the preoccupation; the butterfly lives for love, and before it dies it deposits its eggs on the green plant which it cannot itself eat, but which forms the right food material for the offspring it does not survive to see.

Beetles are essentially biters, with very strong and hard mouth-parts, one pair of which, the mandibles, are sometimes of relatively enormous size, with sharp saw-like edges. Many of them, such as the Weevils, are vegetarians, feeding on green plants or on the

Story of  
Cabbage  
White  
Butterfly.



Photo: J. J. Ward.

## TREE WASP.

A queen wasp biting off bits of wood which she chews into a pulp—the raw material which she manufactures into the familiar grey “paper” that forms the walls of her home.

bark and wood of trees, but many others are carnivorous and destroy numbers of wireworms, “leather-jackets” (the larvæ of the “Daddy-long-legs”), Saw-Fly larvæ, and other insects which are detrimental to crops. Others, again, feed on the decaying flesh of dead animals, and the busy “Burying Beetles,” which join forces in their work, act as useful bands of scavengers.

Other groups of Insects, with quite different mouth appendages, belong to the sucking types, which feed on liquid food. Instead of cutting, toothed jaws, they have sucking-tubes, often accompanied by sharp piercing needles as in the Mosquito, which pierce the skin and suck in the blood of the victim. The nectar of flowers is another great source of liquid food, and is sought by Bees, Butterflies, Moths, and others which have sucking mouth-organs. Perhaps the most important linkage in the whole system of animate nature is the linkage between flowers and their welcome insect visitors. For these visitors secure cross fertilisation, and this is often essential to seed-bearing.

## § 7

There are various ways in which the young forms of Insects hatch out from the shells within

which they develop. Some caterpillars eat through the shell; some maggots wriggle until it breaks; and some larvæ have special instruments for the purpose.

Thus the larval flea has a temporary piercing organ on its head. Many larvæ differ markedly from the adult forms, and they are of several different types; they may be active, long-legged, flat-bodied (campodeiform) larvæ (very like the primitive Bristle-tails), e.g. many beetle larvæ, May-Flies, Stone-Flies, etc.; or they may belong to the more worm-like (eruciform) group, such as caterpillars (i.e. young of moths and butterflies), maggots, and various grubs, and these may be more sedentary in habit. In the course of the life-history of many insects a marked change of form takes place—metamorphosis. According to the degree of metamorphosis, insects are divided into three groups: (1) When no metamorphosis occurs, and the young are hatched as miniatures of the adults, e.g. the most lowly insects, the Springtails and Bristle-tails. (2) An intermediate group comprises those insects which show partial



Photo: J. J. Ward.

## NEST OF WASP MADE ENTIRELY BY THE QUEEN.

The nest was built in between the stones of a wall, and one stone has been removed to expose it. This was the nursery for the first generation of worker wasps, which, when mature, would enlarge the home for the rapidly increasing family.

metamorphosis. In this type the insect is able to move and feed practically throughout its development; the change is a *gradual* one. Through a series of moults, made necessary by the inexpandible armour of chitin, the insect reaches the adult condition.

For instance, the young Locust, as it emerges from the egg, has a pale, soft body swathed in transparent skin. It sheds its mantle, and, gaining strength in the sunlight, becomes

skin-casting the locust is a perfect, winged insect, soft and helpless and very vulnerable for a time, but rapidly regaining firmness and vigour.

(3) When complete metamorphosis occurs, a quiescent pupal or chrysalis stage comes between the larval and adult stages. Growth occurs during the larval stage, a period of voracious feeding, rapid growth, and numerous moults. The larva eats far more than is neces-

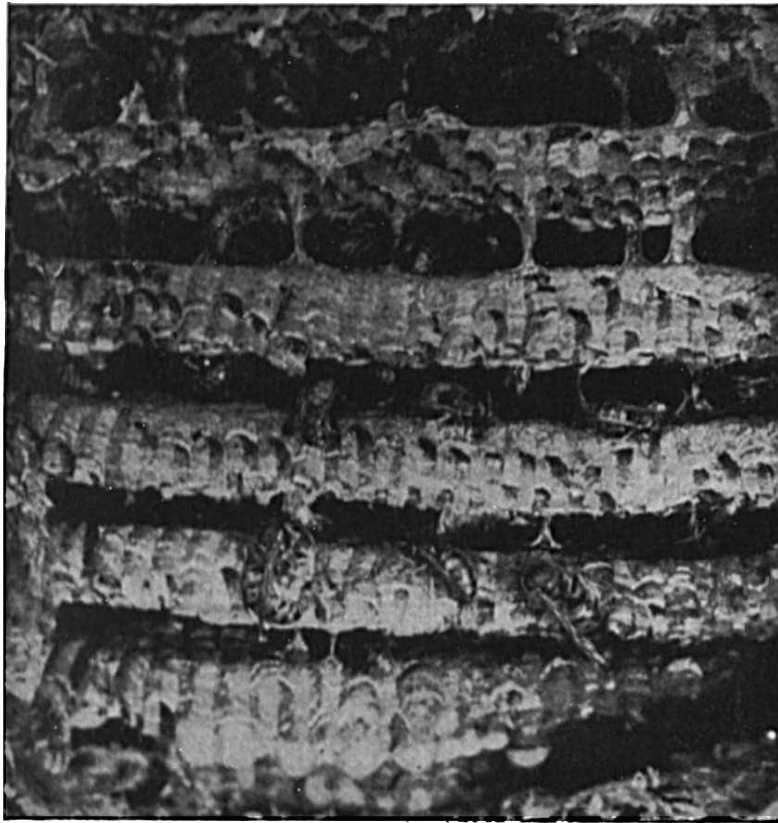


Photo: J. J. Ward.

#### INTERIOR OF A NEST OF ACTIVE WASPS.

On the bottom comb the dome-shaped queen-cells are seen, and on the comb immediately above are two young queens just emerged from the cells, with a male wasp resting on the comb between them. All above are worker wasps, tending the young and making new combs.

firm and black, only differing from its parents in size, colour-markings, and the absence of wings. It feeds hungrily on vegetable substances, and grows and moults, each moult leaving it larger, brighter, and hungrier than before, until after the third moult its wings begin to show. The moulting process lasts only about half-an-hour, and the locust only stops feeding for a few hours. No phase of torpor or quiescence occurs in this "half-metamorphosis" type, and after the fifth

sary to maintain its life, and lays up a reserve store which provides for the resting pupal stage which follows. The pupal stage is a time of little or no external activity but great internal changes. The larval tissues are broken down and their substance is reconstructed into the very different tissues of the adult. From the pupa case the adult insect emerges, different in form and habit, winged and aerial. Metamorphosis implies far more than



*Photo: H. J. Shepstone.*

**AN ILLUSTRATION OF THE GARDEN OF GETHSEMANE BEFORE THE COMING OF THE LOCUSTS (see illustration below).**



*Photo: H. J. Shepstone.*

**THE GARDEN OF GETHSEMANE AFTER LOCUSTS HAD PASSED. EVERY FLOWER AND EVERY SHRUB WAS LEFT QUITE BARE.**

the acquisition of wings, and one of the most marked differences between larva and adult is in most cases the difference in the food and the method of taking it. This is so great that the transition from larval to adult habits could not take place along with continuous external activity—the quiescent period of reconstruction is essential.



Photo: H. J. Shepstone.

#### AN ASIATIC LOCUST.

After several moults the locust is a perfect, winged insect. Immediately after the skin-casting it is soft and helpless, but a short time in the sunlight makes it firm and vigorous. The lower wings are fan-shaped, and fold up longitudinally under the longer, narrow and spotted outer wings.

### § 8

A great many insects live their busy days and perish without affecting man at all, except that they delight him with their exquisite colours and markings and interest him with their ways, but some are his friends, and perhaps more he reckons his foes. Even the Bee he too often shrinks from, remembering the weapon she carries and forgetting her honey and the infinite service she renders by securing the pollination of many flowers. The Termite may be as much a tiller of the soil

Insects  
and Man.

as the Earthworm is, but she attacks his furniture and the wood of his house; the cochineal and "lac" that insects provide are relatively insignificant; and "locusts and honey" may be thought a dainty dish in the East, but a locust swarm will blight every green thing in a district. "He scatters the seed, and when he looks for green heads to appear, the earth opens, and, lo, an army of long-faced, yellow grasshoppers come forth!"

Wherever locusts are resident they do a great deal of damage, but it is their sudden migratory swarms which are so disastrous.

They increase in numbers during favourable seasons; then, one year, when the food-supply is insufficient, they collect in immense swarms and travel long distances, devouring every green thing in their path. A tobacco-grower saw a swarm of locusts descend on a plantation of forty thousand young plants. Twenty seconds later not a leaf remained! The Old Testament speaks of the locust as one of the plagues of Egypt. "They covered the face of the whole earth, so that the land was darkened; and they did eat every herb of the land, and all the fruit of the trees which the hail had left: and there remained not any green thing in the trees, or in the herbs of the field, through all the land of Egypt."

In addition to the formidable list of insects, larvæ and adults, injurious to plants, another list must be added of those which affect the health of man and of his stock. There are a number of ways in which insects may affect the health of man. They may have poisonous bites or stings, as in the case of certain Bugs, Bees, Wasps, etc., which cause inflammation and sometimes feverishness; or they may be parasitic, either true parasites such as fleas and lice, or accidental parasites, such as fly-maggots, which sometimes reach the stomach and cause great pain; again, they may carry disease germs. Most important of all are the cases in which an insect is an essential host in the development of a disease-producing organism, without which the life-history of the organism cannot be completed.

For example, the Mosquito is not only the means of introducing into the blood of man the Protozoön which causes malaria, but the life-history of the malaria organism cannot proceed

without the insect; the different stages can only be reached within the bodies of man and mosquito respectively, so that the extermination of mosquitoes would wipe out malarial fever. In other cases, the insect is not necessary to the life of the disease-producer, but acts as a transmitter, as in the case of plague, where the bacillus is conveyed from rats to man by means of rat-fleas, which inoculate the victims while biting. Further cases of disease-carrying form another list—those of the simple carriers, such as the common House-Fly: it is not a blood-sucking insect, but it has a body and legs thickly covered with hairs particularly well suited for transferring germs, such as those of typhoid fever, from place to place, and it thus brings the microbes of the garbage heap to its next feeding-place, our dinner-tables. There is a long list of diseases in which insects play an important part—typhus fever and Lice, sleeping sickness and Tsetse Flies, relapsing fever and Lice, and many others. Many insects also affect the domestic

animals, for example the "bot-flies," which cause severe boils and other disorders in cattle.

Such examples out of the list serve to show some of the complex inter-relations between man and Insects, and to indicate some of the aspects of the struggle for existence. Man's enemies are innumerable; he tames the wild beasts, and domestication brings its own penalty, for a sucking insect wipes out a whole herd; he exterminates great flesh-eating animals that would rival him, but a common house-fly brings microscopic germs to his table and spreads death through his cities. It is hardly too much to say that the tendency of injurious insects to prolific multiplication is a continual menace to civilisation, and this should lead us to attach increasing importance to the preservation of the numerous insectivorous birds which maintain the balance of Nature. But this subject will be discussed in a special article dealing with Inter-relations.

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