OUR INSECT FRIENDS AND FOES

F·MARTIN DUNCAN

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PLATE I

THE INDIAN LEAF-BUTTERFLY

OUR INSECT FRIENDS AND FOES

BY

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WITH 54 ILLUSTRATIONS FROM ORIGINAL PHOTOGRAPHS BY THE AUTHOR

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PREFACE

IN the following pages I have endeavoured to place before my readers, in as simple and non-technical language as the subject will permit, some account of the most striking and interesting features of Insect Life. I have endeavoured to show the important aspect which the study of insects has assumed, more particularly in their intimate connexion with the prosperity or adversity of mankind. How intimate that connexion is, for good or ill, the general public have hardly yet realized, in spite of the oft-repeated warnings of our leaders of scientific research. Surely the fact that out of a population of 300,000 souls once living on the shores and islands of the great and beautiful lake Victoria Nyanza, less than 100,000 remain, the rest having perished within the last six years from sleeping sickness, a disease solely transmitted from one victim to another by the bite of certain flies, should bring home to us all the very great economic importance of the study of insect life.

While so far as possible I have in the space at my command given an account of some of the more remarkable and interesting phenomena of

Insect Life which have come within my own sphere of observation, I have not hesitated to avail myself of the confirmatory and wider investigations of leading authorities on this fascinating subject, so that my readers might have the facts placed before them as broadly and clearly as possible. I believe that in every case where I have so utilized the opinions and observations of other investigators, I have given the name of the author and placed his observations between quotation marks, that I might so far as lay in my power acknowledge my admiration and appreciation of their valuable work.

If what I have written may serve to awaken an interest for this most fascinating and important branch of Natural Science, and will induce some of my readers to observe for themselves somewhat of the habits of those of Our Insect Friends and Foes that they may meet during their country rambles, then the labour has not been in vain.

F. M. D.

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OUR INSECT FRIENDS AND FOES

CHAPTER I

THE STUDY OF INSECT LIFE

THE study of insect life, whether practised as a hobby or a profession, will be found to be one of the most fascinating and absorbingly interesting branches of Natural Science. There is always something fresh to be learned, some new aspect of the subject to be investigated; while from New Year's Day to New Year's Eve, in nearly every quarter of the habitable globe, active insect life abounds, offering an unceasing supply of material for observation and investigation. Up to a comparatively recent date, the economic study of insect life was almost entirely confined to the investigation of those insects which are injurious to agriculture and horticulture; truly valuable work, for, unless held in check, these agricultural insect pests would so quickly multiply that our food crops would be seriously endangered. Of the ravages caused by these all-devouring insect foes, we shall learn something in a subsequent section of this book.

It is only during the last few years that the biological significance of insect life as a factor in the life of man and domestic animals has been fully realized and established; and, as a natural consequence, the study of insect life, now known to be intimately connected with the health and prosperity of the Empire, has assumed a greater and far-reaching importance. Roughly speaking, the teeming hordes of insects inhabiting the earth may be divided into two great groups: one composed of those insects which are harmless to man, or which as collectors of honey, or carriers of pollen from one flower to another, are his true friends; the second, of those insects which as ravagers of crops, or as transmitting agents of disease, are his deadly foes. It is therefore all important that we should be able to distinguish readily those insects which are our friends from those which scientific research has proved to be our foes.

In commencing the study of insect life, the subject should be approached not through the museum specimen and dry-as-dust technical text-book, but by actual personal observation of the living insect in its natural environment. Let your dead museum specimens and technical text-books act as your reference library and dictionaries, through which you may identify each new specimen and correctly name it. But do not rest satisfied with mere jackdaw-like collecting and pedantic classification. Go out into the fields and lanes, through orchard and garden, forest and marshland, hillside and valley, and closely observe every stage in the life-history of the insect. Approached in such a manner, the study of insect life becomes filled with pleasure and interest, an interest that only deepens the further we carry our observations; for we must be dull indeed if we do not quickly realize how important is the part which environment plays in the life of the insect, and yet at the same time that the insect forms only a part of that environment, a factor or link of more or less importance in the wonderful web of life. Working in this way, we shall the better be able to comprehend the true significance of the varied shapes, colours, and modification or elaboration of the structure of insects.

While the museum specimen and technical text-book should only be used as works of reference, it is necessary that, without burdening ourselves with difficult and purely technical nomenclature, we should make ourselves as familiar as possible with the general anatomy of insects, and those most salient features that will enable us to recognize to which Order or Family the insect under our observation may belong. We should also know something, if it is only quite an outline, of the peculiarities of the transformations or metamorphosis through which insects typical of the different species pass. In the following pages I hope to be able to place such information before the reader in as simple and non-technical language as circumstances will permit.

If we compare a Lobster, a Scorpion, a Centipede, a Beetle, and a Butterfly, we shall very easily realize that they are all connected together by a number of common features. That is to say, we find that they all have a more or less tough skin or integument; they have the body more or less clearly divided into segments; and their system of appendages—legs, jaws, feelers, and the like—no matter what part of the body they are attached to, agree in being covered with a hard or tough integument similar to that of the body, and in being divided by a number of joints into segments. Now, these features, common to the five creatures which we have just examined, are characteristic of a very extensive group of animals comprising the *Phylum* or sub-Kingdom *Arthropoda.* Of the five members of this important sub-Kingdom, which we have taken as our examples, four are air-breathers, and one, the Lobster, is an aquatic animal differing from the other four not only in its mode of life, but in having the respiratory organs, in the form of gills or branchiae, modified to suit its particular mode of life. The Lobster is a representative of the class *Crustacea* of the sub-Kingdom Arthropoda; the centipede of the class *Myriapoda;* the Scorpion, and its cousin the Spider, are representatives of the class *Arachnida;* and the Beetle and Butterfly of the class *Insecta.*

The two classes of this great sub-Kingdom of the Arthropoda with which we are now most immediately concerned, are the class Insecta, comprising the Cockroaches, Grasshoppers, Ants, Bees, Wasps, Aphides, Ladybirds, Dragon-flies, Mosquitoes, Houseflies, Beetles, and Butterflies; and the class Arachnida, comprising the Scorpions, Spiders, Mites, and Ticks.

The *Insecta* comprise a larger number of species than any other classes of the Arthropoda, numbering according to Dr. Sharp some 2,000,000 species, of which only about 250,000 have been described. Although the class is such an extensive one, it is characterized by a remarkable degree of anatomical uniformity. If we examine the body of any member of this great class of the true Insects, we shall find that it is segmented, bears a series of pairs of jointed appendages, and that the surface of the body and appendages is covered with a chitinous cuticle, which may be thin and soft as in the body of a caterpillar, or thick and hard as in the body of a beetle. This outward covering or *exoskeleton*, composed of chitine, is intimately connected with the true skin beneath, the latter forming a deep, soft layer. The minute ducts of numerous small glands which are embedded in this layer of soft true skin, pass outwards to the exoskeleton, entering the base of the external hairs. It is the chitinous outer cuticle, which from time to time is cast, or moulted off during the growth and transformations of an insect.

The segmented body of an insect is divisible into three well-defined regions, which are quite constant in their disposition, and comprise—(1) the head, formed by the union of the head-lobe of the embryo with some five segments, which are so closely united as to be indistinguishable in the adult. It bears on its front lower (ventral) surface the mouth; upon its sides two great compound eyes, and upon its upper (dorsal) surface a pair of horns or *antennae*; and in many species of insects, two or more simple eyes or *ocelli*. (2) The *thorax* or middle region, always consisting of three segments, usually firmly united together, bearing on the lower surface three pairs of legs, and upon the upper surface the wings. (3) The *abdomen* or hind region, composed of seven or eleven segments, carries the sexual organs and, when present, the sting. No legs are present upon the abdomen during the adult stage of the insect's life, but during the larval stage, fleshy tubercules, the Pro-legs, varying in number, are present on the under surface. These pro-legs disappear with the final moult, when the larva or grub enters the pupa stage of its existence.

The mouth, while varying considerably both in size and shape in different insects, is practically divisible into three clearly defined types—the sucking mouth, the biting mouth, and the piercing mouth. The typical mouth of an insect will be found to comprise the following parts: the *labrum* or upper lip, which is a small plate usually horny in texture, and although really belonging to the head, functionally forms part of the mouth. Insects that bite have immediately behind the labrum a pair of jaw-like organs, frequently of considerable size, and armed with tooth-like projections; and these biting jaws are called the *mandibles*. What may be termed the second pair of jaws, or *maxillae*, are not quite so simple in structure, each bearing a jointed appendage called a palp. Below or behind the

FIG. 1. TYPICAL JAWS OF AN AQUATIC LARVA

FIG. 2. MOUTH-PARTS OF THE HONEY BEE

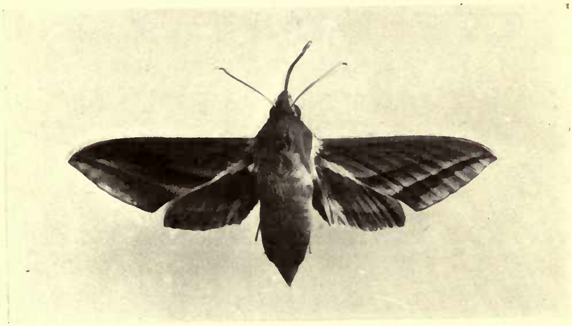

FIG. 3. ELEPHANT HAWK-MOTH, SHOWING THE LONG, SLENDER SUCKING TONGUE OR PROBOSCIS TYPICAL OF THE LEPIDOPTERA

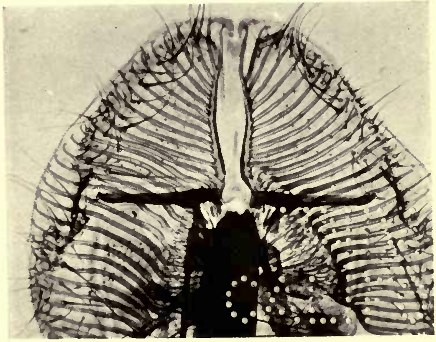

FIG. 4. EXPANDED PROBOSCIS OF THE BLOW-FLY

first maxillae is the lower lip or *labium*, formed by a pair of maxillae united in their basal portions, and also bearing palps. All these mouth parts will be found to be modified in the most remarkable manner, in accordance with the kind of food upon which the insect lives. All the Beetles, Locusts, Cockroaches, and Crickets, which live upon comparatively hard substances, have their mandibles sharp and powerful, well adapted for mastication, while the maxillae are well developed. Amongst the Bees and Wasps (*Hymenoptera*) we shall find the mouth parts adapted for biting, licking, and sucking; thus the mandibles and maxillae are sharp and lancet-like, while the middle part of the labium is produced into a long median tongue, at the sides of which are a pair of accessory organs, so that the maxillae and labium are capable of forming a sort of tube or proboscis, through which the nectar from flowers can be easily sucked up. In the Bugs, Lice, and Aphides (*Hemiptera*) the mouth parts are modified into a sucking proboscis developed from the labium, enclosing the stylet-like mandibles and maxillae. Amongst the true Flies (*Diptera*), House-flies, Gnats, Hover-flies, the mandibles, frequently undeveloped in the males, are biting and piercing organs, the basal parts of the labium forming a proboscis enclosing a sharp spine developed from a process on the roof of the mouth. The extremity of the proboscis, as, for instance, in the House-fly and many of its near relations, is frequently enlarged into a kind of double pad, something like a pair of lips or lobes. Lastly, amongst the Butterflies and Moths (*Lepidoptera*) the mandibles are aborted in the adult insect, while the maxillae become elongated half-tubes, which when brought together, form a long tube, provided at its extremity with minute hooks or spines for rupturing the nectaries of flowers, and when not in use lies coiled in a spiral under the head.

The large, prominent compound eyes, situated on the sides of the head, are the most highly developed organs of special sense possessed by insects. The whole surface is composed of a great number of minute hexagonal facets, closely united together. Each facet is a perfectly transparent bi-convex lens, and under each facet is a crystalline cone, surrounded by pigment cells. The cones are connected to the basal membrane by a series of delicate rods, and round these, united together, are the *retinulae*. The hexagonal facets vary in number in different species of insects, a species of Dragon-fly being said to have some twenty thousand facets in its eye, while a small Bee-parasite has but fifteen. In addition to these wonderful compound eyes, most insects have small, simple, unfaceted eyes upon the vertex or crown of their head, and which are called *ocelli*. A great deal of very interesting experimental work and observation has been carried out concerning the vision of insects. In connection with this work, Lord Avebury's name will be ever intimately associated, for he discovered and demonstrated the curious fact that Ants can perceive those ultra-violet rays of the solar spectrum which are quite invisible to us.

The antennae or horns on the upper surface of the heads of insects are extremely variable in their form, and offer many important points in the identification and classification of insects. They present considerable complexity of structure, and are undoubtedly sensory organs, though whether they are organs of single sense or of a combination of senses has not yet been clearly settled. It has been most conclusively proved, however, that their most important function is to act as organs of touch. Between the minute, microscopic "touch-hairs," which are very numerous on the antennae, are to be found equally minute depressions or cavities, each covered by a thin layer bearing on its outer surface a series of rings. Into the tiny cavity below each hollow passes a nerve-end cell. Other important and complex cavities are situated in small patches at the lower parts of the joints of the antennae. The exact function of these minute cavities is still open to question, being considered by some anatomists to be olfactory organs, while by others they are thought to be auditory organs. Insects have undoubtedly the sense of smell well developed, and considering the large number which have the power of producing sounds, we may also infer that the sense of hearing is developed to a like degree; but the exact seat of these two senses has not been at all clearly and firmly established, although, from their peculiar structure, the pits to be found on the antennae may well be supposed to have something to do with the sense of smell or hearing.

It is particularly interesting to note, for instance, that the minute cavities between the "touch-hairs" have been observed to be more abundant in male insects, and particularly in those species where the females are hidden and have to be sought out by the males.

The wings, normally four in number, are always placed upon the upper surface of the thorax, and are thin, more or less transparent expansions of the integument supported by branching ribs or nervures. The opaque character of the wings of most Butterflies and Moths is due to their being covered with numerous overlapping, microscopic scales of various colours. In the Beetles and Locusts, the posterior wings are membranous, while the anterior pair are hard, tough cases, called *elytra*, and which, when folded up, cover and protect the delicate posterior wings. In the true Flies (Diptera) the anterior wings are alone developed; knobs, or club-shaped structures called the *halteres* or balancers, representing vestiges of the posterior pair. In the Lice (*Pediculidæ*), Spring Tails (*Thysanura*), and Fleas, wings are entirely absent at all stages of the insect's development.

On the ventral surface of each of the three segments of the thorax of an insect will be found a pair of legs, varying in size, strength, and shape according to the habits and mode of life of the insect, and composed of six to nine joints. The terminal part of the leg, which is called the *tarsus*, is composed of a number of short segments, and ends in a pair of claws, varying considerably in shape and size in

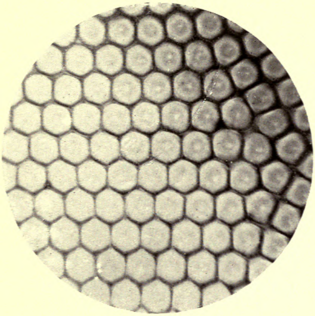

FIG. 1. SURFACE VIEW OF PART OF THE COMPOUND EYE OF AN INSECT, SHOWING THE HEXAGONAL FACETS

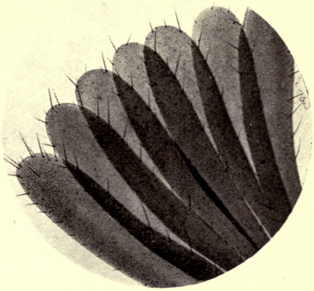

FIG. 2. PART OF AN ANTENNA OF THE COCKCHAFER, SHOWING THE DELICATE HAIRS, AND THE MINUTE PITS WHICH COVER THE SURFACE OF THE LOBES

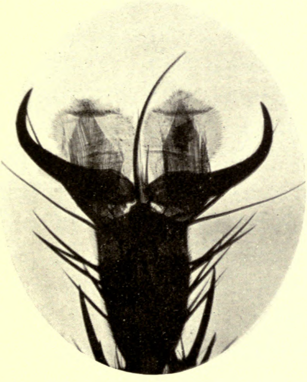

FIG. 3. FOOT OF A FLY, SHOWING THE PADS USED FOR WALKING ON GLASS AND OTHER SLIPPERY SURFACES

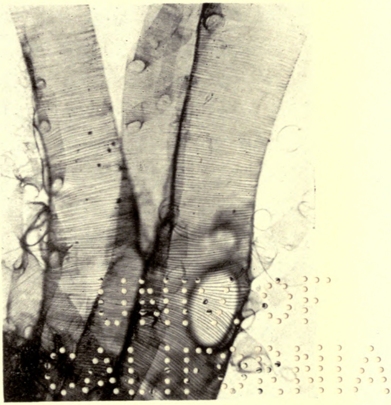

FIG. 4. TRACHEAL TUBES OF DYTISCUS BEETLE

different insects, and frequently having an adhesive pad or sucking disk between them. During the larval stage of the insect's life, the abdomen may bear upon its under surface certain pairs of clasping or sucker feet, by means of which the insect retains its hold on the surface of the foliage on which it feeds; but in the adult (imago) stage there are no paired limbs upon the abdominal segments, the posterior abdominal segment bearing the genital organs, and such appendages as the sting and ovipositor, all being subject to great modification of form.

On examining the internal anatomy of an insect, the alimentary canal will be found to consist of the fore-, mid-, and hind-gut. The length and structure of the alimentary canal varies considerably in different insects, diet playing an important part in the modification of its size and structure. For instance, the gullet, which is included in the fore-gut, may be swollen into a species of crop, or have an appended pouch forming the so-called sucking stomach, or be adapted as a gizzard with hard grinding plates. The mid-gut is glandular, absorptive, and digestive, its length frequently varying inversely with the nutritive and digestible qualities of the food of the insect. The general function of the hind-gut, from which the excretory tubes or Malpighian vessels arise, is absorptive. It is frequently coiled, and in the region of the rectum is associated with certain glands. The nervous system is composed of a double chain of nervous matter extending from head to tail, and having two swellings (*ganglia*), usually closely united together, in each segment of the body. The respiratory system is very remarkable and interesting, consisting of the external breathing apertures, the *stigmata* or *spiracles*, minute oval slits along the sides of the body, from which arise internally tubular structures called *tracheae*, which branch in all directions through the body. These tracheal tubes are very remarkable structures, composed of an inner layer of mucous membrane and an outer layer of serous membrane, the membranes being separated by a spiral band, the coils of which give the walls of the tubes a striated appearance. This spiral band, which is extremely elastic, consists of inward foldings and thickenings of the chitinous wall. The distribution of the tracheae, and position of the spiracles, varies in different insects, for although, as a rule, the spiracles are placed along the sides of the abdomen and thorax, they may, as, for example, in the aquatic larva of the Gnat, be situated on the tail. As might be supposed, the circulatory system of insects is not very highly developed, the need for definite blood-vessels being greatly lessened on account of the very thorough way in which all the organs are supplied with oxygen by means of the ramifications of the tracheae. It consists of a large dorsal vessel or heart, extending from near the apex of the abdomen to the right of the brain, containing a series of cavities, the ventricles, which have openings on each side, and communicate with each other by a valve. The blood is colourless, and the speed of the circulation and the number of pulsations of the dorsal vessel varies with the atmospheric temperature, nearly ceasing at freezing-point.

In connection with the classification of insects, there are still many knotty points which can only be conclusively settled by results to be obtained by future embryological research, consequently considerable difference of opinion and want of unanimity on the subject exists. However, much has been accomplished, and the once long and arbitrary series of Orders into which the insects were divided have been considerably modified. The insects are now generally divided into the following seven Orders :—

1. Order *Coleoptera*, comprising the Beetles, a very numerous group of insects, possessing two pairs of wings, the front pair (elytra) being horny and dense, meeting in a straight line down the back when closed, and forming a protective case to the membranous posterior pair. The mouth parts are strong and masticatory. The insects go through complete metamorphosis.

2. Order *Hymenoptera*, comprising the Ants, Bees, Wasps, and Saw-flies. All the insects included in this Order undergo complete metamorphosis. This group has generally four membranous wings, which in the Bees and Wasps are united during flight by a curious mechanism of minute hooks that engage in a small groove at the posterior edge of the front wings. The Hymenoptera are divided into two divisions, according to the use of the ovipositor. Thus the Sawflies, Ichneumon Flies, Sirex or Wood Wasps, and the Gall Flies, who all have the ovipositor

formed so that it can be used as a borer, belong to the first division, called the *Hymenoptera-terebrantia;* the Ants, Bees, and true wasps, which have the ovipositor modified into a sting, are included in the second division, called the *Hymenoptera-aculeata.*

3. Order *Lepidoptera*, comprising the Butterflies and Moths; insects which all undergo complete metamorphosis. They have in the adult stage four membranous wings, covered with fine and beautifully coloured hairs and scales. The antennae are very variable in form, and are composed of a number of small joints. The antennae of the true Butterflies are always clubbed at the apex, while in the Moths they are never clubbed, but may be feathery or thread-like.

4. Order *Diptera*, includes the Blow-flies, House-fly, Horse-flies, Daddy-long-legs, Mosquitoes, Fleas, etc. In this Order the insects undergo complete metamorphosis. In the adult insect only the front pair of wings are fully developed, the posterior pair being reduced to curious club-like processes called balancers or halteres. The wings may be altogether absent, as in the Fleas and so-called Sheep-Ticks. The mouth parts are both complex and varied, some being formed for piercing, as in the Gad Flies, female Mosquito, Tsetse Flies; others for suction, as in the House- and Blow-flies; whilst in the Ostridae or Warbles, the mouth parts are rudimentary and the adults take no nourishment. The Fleas were formerly considered as a separate Order, under the name *Aphaniptera*, but are now

PLATE IV

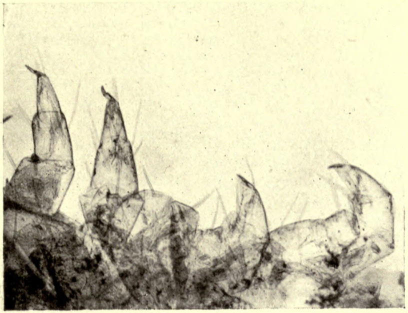

FIG. 1. TRUE-LEGS OF A CATERPILLAR. THESE DEVELOP INTO THE LONG, SLENDER LEGS OF THE BUTTERFLY

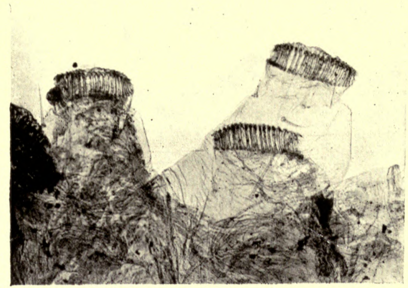

FIG. 2. CLASPER OR SUCKER-LEGS OF A CATERPILLAR. THESE DISAPPEAR WITH THE FINAL LARVAL MOULT, WHEN THE CATERPILLAR ASSUMES THE CHRYSALIS STAGE

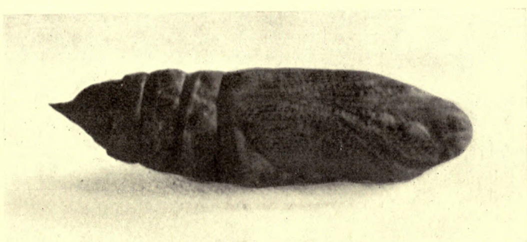

FIG. 3. PUPA OF THE SPURGE HAWK MOTH. NOTE HOW THE FOLDED LIMBS AND WINGS OF THE PERFECT INSECT ARE OUTLINED ON THE SURFACE OF THE PUPA-CASE

FIG. 4. LARVAL STAGE OF THE PRIVET HAWK MOTH

included in the Diptera. While none of the Fleas now have true wings, some possess scale-like plates in the region where the wings of other insects are; and these plates doubtless represent the remnants of wings which have gradually disappeared through disuse.

5. Order *Hemiptera*, comprising the Domestic and Shielded Bugs, the Plant Lice or Aphides, the Scale Insects, the Cicadas, and the true Lice (*Anoplura*). The Hemiptera undergo what is termed incomplete metamorphosis, that is to say, the difference between the larva, pupa, and adult insect (imago) is very slight, the pupae being active creatures, and, like the larvae, more or less resemble the adults in general appearance. The Hemiptera are divided into two distinctive sub-Orders; the *Homoptera*, which includes the Plant Lice or Aphides, the Cicadas, the Lantern Flies, and Scale Insects, all characterized by having four membranous wings, and the rostrum or beak attached to the frontal region of the head. In the second sub-Order, *Heteroptera*, which includes the Bugs, Water Scorpions, and Pond Skaters, the basal parts of the front wings are horny or leathery, while the beak or rostrum springs from beneath the head. Formerly considered as a separate class, the true Lice or Pediculidæ are now generally regarded as degenerate Hemiptera, and under the head Anoplura or Pediculidæ, form a third sub-Order. They have no wings, and are all parasitic.

6. Order *Orthoptera*, comprising the Cockroaches, Crickets, Grasshoppers, and Locusts.

These insects all undergo incomplete metamorphosis, and are characterized by having anterior wings of leathery texture, and much narrower than the posterior membranous ones, which are often large and fan-shaped.

7. Order *Neuroptera*, comprising the Dragonflies, May-flies, Caddis-flies, Termites or so-called White Ants, Thrips, and those curious primitive forms of insect life, the *Thysanura* and *Collembola*. They form a very diverse order of insects, making it extremely difficult to lay down any definite characters as being common to all. This is partly due to the fact that many insects now included in the Neuroptera, were formerly placed in separate Orders. So we find some members of the Order passing through a complete metamorphosis, while in others it is incomplete. Some, like the Termites or White Ants, are social, others, again, are of solitary or gregarious habits. Nearly all are carnivorous, and they have a practically world-wide distribution, from the tropics to the Arctic Circle.

The class *Arachnida*, which forms a connecting link between the Insects and the Crustacea, includes the Scorpions, Spiders, Mites, and Ticks, constituting a much less homogeneous group of creatures than the true Insects, and presenting considerable diversity in structure and mode of life. While many of the Arachnida undergo incomplete metamorphosis in which both larva and nymph are active and bear a close resemblance to the adult, others do not pass through these regular changes, but from time to time shed or moult their skins; and, as each shedding of the skin produces fresh changes and the appearance of new structures, alterations almost equal to those peculiar to the stated periods of metamorphosis, their function is very closely allied, if not identical, to incomplete metamorphosis. In the Arachnida, the body is divided into an anterior region—the *cephalothorax*—representing both head and thorax, which in a large proportion are intimately united, and a posterior region or abdomen. In some cases these two regions are united, and wings are never present. Respiration may be carried on by sac-like depressions in the body—called pulmonary sacs or book-lungs—or by true tracheae analogous to those of the Insects.

The Scorpions are the largest and most formidable members of the Arachnida, and are chiefly confined to the tropics, though a few species are to be found in Southern Europe. The cephalothorax of the Scorpion has its upper surface partially covered by a shield-like horny plate, upon which may be seen from three to six pairs of simple eyes, a pair of extra size being placed close to the middle line of the shield. The slender posterior part of the body bears a terminal appendage, the caudal spine or sting, which is swollen at its base and sharply pointed at the apex. The swollen part contains a pair of glands secreting a poisonous fluid, which is carried by ducts to the acutely pointed and perforated apex of the sting. If we examine the under surface of a Scorpion, we shall find on each side of the very small aperture of the mouth, curious triple-jointed biting appendages, called *falces* or *chelicerae*, and functioning as the true mandibles, which are absent. Behind these are the large pincer-claws, or *pedipalpi*, which give the Scorpion a superficial resemblance to a crayfish, and following upon these great claw-like limbs are four pairs of walking legs.

The Spiders differ from the Scorpions in having the abdomen short, rounded, and segmented, while the falces or *chelicerae* are provided with poison glands, the ducts of which open at the extremities; and the *pedipalpi* are simple. At the extremity of the abdomen is the spinning organ, consisting of four or six elevations, the spinnerets, on the surfaces of which the numerous ducts of the spinning glands open.

No distinction into cephalothoracic and abdominal regions is recognizable in the Mites and Ticks, although there exist the same series of paired appendages as in the Scorpions and Spiders. The study of the life-history and habits of the Ticks is of great economic importance, as many are now known to be the transmitting agents of various diseases to man, and to cattle, sheep, horses, dogs, and fowls. The Ticks pass through an incomplete metamorphosis, and it is interesting to note that while in some species it is the males who go a-courting, in other species it is the females who fight for the possession of the males. The extraordinary part which the Ticks play as carriers of disease will be dealt with in Chapter IX.

Insects are the most ubiquitous of animals, to be met with practically in every part of the habitable world, from within the Arctic Circle to the Equator; on lonely mountain peaks far above the snow-line, in the tropical forests and swamps, in arid "bad-lands" and deserts, in the hot springs of volcanic regions, in underground caves, and even in the sea. Suitable food and climatic conditions play an important part in limiting the distribution of species, which otherwise would have a far greater range, for insects possess almost unique possibilites of dispersal in the adult stage by flight, and by high and prevailing winds which frequently carry them long distances; while the eggs and larvae, through the agency of floods and tides, may be carried on floating tree-trunks, branches, and similar plant debris, not only from one tropical island to another, but across the ocean for many hundreds of miles. Indeed, the winds and tides have ever been Dame Nature's great distributing agents, and will continue, so long as any life exists upon the earth, to be the prime factors in peopling with plant and animal inhabitants new lands that may rise from beneath the surface of the waters. On one occasion when outward bound for Brazil I had the good fortune to witness a demonstration of the long distance to which winged insects may be carried by a strong prevailing wind. We were in lat. 3° 50′ S. and long. 32° 32′ W., and keeping a sharp look out for the interesting volcanic island of Fernando Noronha; the hour was between eleven and noon, and for the past twenty-four hours we had encountered a steady breeze blowing from the West, that is to say, directly off the distant coast of Brazil. One of the ship's officers called my attention to what looked like a small yellowish cloud that had made its appearance and was coming down the wind towards us. As the cloud approached nearer, we were able, with the aid of our glasses, to make out that it was composed of dancing objects, which, as the cloud drew nearer still, turned out to be a great company of pale yellow Butterflies, which soon began to fall upon the deck and settle in the rigging of the ship, the majority appearing to be quite exhausted with their long journey, only feebly fluttering when touched or approached, as if their graceful wings were too tired to carry them further. One of these weary little travellers I gently lifted from the deck and placed on the back of the officer's hand, where it rested quite contentedly while I photographed it. Later in the day, as we were passing close to the island of Fernando Noronha, and an interchange of signals between the ship and the island was taking place, I was able to learn that the cloud of Butterflies had been sighted in the early morning, passing at some distance, by the lookout at the signalling station, so that our Butterfly visitors had been carried to us on the wings of the western wind, direct from the coast of Brazil, probably from the neighbourhood of Cape St. Roque.

When we try to trace out the history and pedigree of insects, we find that it is by the study of Insect embryology and development that most of the chain of evidence will be built up. Fossil insects are so rare, and only to be found well preserved in so few geological formations, that it has been quite impossible so far to trace the gradual development from the simple primitive type to the more complex forms, by the remains that have been found in the various strata. Nevertheless, these geological records do most clearly show us that insects appeared very early in the history of the earth, for the wing of an insect similar to the Cockroach has been found in the Silurian strata, while ancestral Dragon-flies and Lacewing-flies, only slightly less specialized than the present existing forms, have also been found. In the Coal-measures, not only do we find fossil remains of Coleoptera and Hemiptera, but the fossil leaves and tree-trunks show unmistakable signs of the ravages of insects. Fossil remains of species of the Hymenoptera and Diptera are found in the Jurassic Period, and of the Lepidoptera in the Tertiary beds.

If, in attempting to link up the gaps between the simplest and most specialized forms of insect life, we turn our attention to the embryology and development of still existing forms, we are at once impressed by the extraordinary similarity that exists in the general anatomical details in the embryonic and larval stages, between species which in the adult stage are quite dissimilar. Thus, as Lord Avebury has ably stated, "we find in many of the principal groups of insects that, greatly as they differ from one another in their mature condition, when they leave the egg they more nearly resemble the typical insect type; consisting of a head; a three-segmented thorax, with three pairs of legs; and a many-jointed abdomen, often with anal appendages.

Now, is there any mature animal which answers to this description? We need not have been surprised if this type, through which it would appear that insects must have passed so many ages since (for winged Neuroptera have been found in the carboniferous strata) had long ago become extinct. Yet it is not so. The interesting genus Campodea still lives; it inhabits damp earth, and closely resembles the larva of Chloëon (a Cricket), constituting a type which occurs in many orders of insects."

The *Campodeidæ* are included in the Thysanura or Bristle-tails, and are common in loose, damp ground. The species referred to by Lord Avebury, the *Campodea staphylinus* is typical of the family. It is a small elongated insect, about a sixth of an inch long, the head bearing a pair of fairly long, many-jointed antennae; the first, second, and third thoracic segments each having a pair of legs; and the last abdominal segment a pair of caudal bristles. The mouth parts of the Campodea are at once interesting and significant in their structure, for they are intermediate between the prevalent strongly mandibulate form peculiar to larvae of Coleoptera, Orthoptera, Neuroptera, Hymenoptera, Lepidoptera, and the suctorial type of the Homoptera and Heteroptera. To again quote Lord Avebury, who has made such a special study of these primitive wingless insects: "It appears, then, that there are good grounds for considering that the various types of insects are descended from ancestors more or less resembling the genus Campodea, with a body divided into a head, thorax, and abdomen; the head provided with mouth parts, eyes, and one pair of antennae; the thorax with three pairs of legs; and the abdomen, in all probability with caudal appendages. If these views are correct, the genus Campodea must be regarded as a form of remarkable interest since it is the living representative of a primeval type, from which not only the Collembola and Thysanura, but the other great Orders of insects have derived their origin."

While a certain amount of divergence of opinion still exists concerning the still more primitive group from which the Campodea type was derived, the generally accepted opinion held by most biologists is that these wingless "Bristle-tails," which probably represent primitive forms, may be traced back through some of the less specialized Millipedes to the curious caterpillar-like Peripatus, which in the details of its anatomical structure unites the tracheae of an insect and the nephridia or kidneys of a worm. This Peripatus is a most interesting and remarkable creature, belonging to a genus which occupies a unique position between the myriapods (Centipedes and Millipedes) and insects on the one side, and the annelids or worms on the other. The distribution, which is very wide, the interesting structure, and the development of Peripatus all suggest that it is the survivor of an archaic type. It is a handsome little creature, with a plump, round, unsegmented body, about two inches in length; numerous two-clawed feet, and upon the head a pair of wonderfully mobile and sensitive antennae, and a pair of bright simple eyes. The two most striking and interesting features of the internal anatomy are the presence of organs of respiration in the form of tracheae with external openings or spiracles, anatomical structures which at once point to Peripatus and the true Insects having sprung from a common ancestry; and a series of excretory tubes or nephridia similar to those of the annelids or worms, organs which, considered with the predominating vermiform shape of most insects in their larval state, seem to point to the common worm-like ancestor. The Peripatus is nocturnal in its habits, living in moist places under bark and stones, preying upon small insects which it captures by means of a natural slimy secretion. Species of Peripatus are found in South Africa, South America, the West Indies, New Zealand, and Australia.

As I have already stated, first-hand, careful, personal observation in the field is of far greater interest and value than the mere filling of cabinets with dead specimens, for the sake of forming a collection. At the same time it is, for most of us at any rate, very difficult, if not altogether impossible, to devote sufficient time to watch the whole of the various stages of insect metamorphosis take place in the open country, and therefore it becomes essential to provide suitable receptacles at home, which shall, as closely as artificial conditions will admit, resemble the natural conditions of the insect which we wish to keep under constant observation.

The apparatus necessary for the collecting and study of insect life need not be costly or particularly elaborate. Indeed, there are few branches of Natural Science which in the first instance require so small an expenditure on the part of the would-be investigator. The first point for consideration is the provision of suitable cages, in which our living specimens may be safely housed and kept under observation. Light, air, and a constant, fresh supply of food are all important factors if we are to successfully rear the larvae of Butterflies and Moths. For this reason, it is a good plan when possible, to have the natural food-plants growing in the garden. If circumstances will permit of this, matters will be a great deal simplified, for all we shall have to do with the Caterpillars we have collected during our country ramble will be, in entomological parlance, to "sleeve" them out on to their natural food-plant. "Sleeving" consists of placing a butter-muslin bag over the food-plant, in such a way that the Caterpillars may have the benefit of feeding upon the growing plant without being able to make their escape. The muslin "sleeves" should be of fairly ample proportions, and have an opening at each end capable of being tightly closed by a tape or string. In use, the "sleeve" is drawn over the food-plant, and its lower end tied securely to the stem; the larvae are then introduced, and the upper end of the "sleeve" pulled up tight by means of the tape or string which is run around the mouth of the "sleeve."

Where "sleeving" is not possible, or is undesirable, wooden breeding cages should be used. These breeding cages are best constructed with a glass front and top for observation purposes, and with fine perforated zinc let into the sides, so that there is plenty of light and air. It is advisable to have the cages fitted with a removable tray at the bottom, which can hold a layer of mould about an inch deep. This layer of earth is particularly important if the larvae of Moths are being kept under observation, because a very large number will be found to pupate just beneath the surface of the soil. A little moss and a few pieces of bark should also be placed in the cage, to afford suitable accommodation for those larvae which do not pupate in the soil. The food plant should be introduced into these cages in narrow-mouthed jars, filled with water to keep the plants moist and fresh; while to prevent the larvae creeping or falling into the water, the mouth of the jars should be covered by a metal or wooden perforated cap, having apertures just large enough to take the stems of the food-plant.

For keeping aquatic insects under observation, it will be necessary to provide a few aquaria. The most inexpensive forms are the small globes sold for keeping one or two gold-fish, but there is one very great objection to these, and that is the great distortion caused by the rounded sides, which quite prevent one being able to obtain a clear, direct view of the creatures they contain. Small square or oblong tanks are much to be preferred, and are now made in quite a cheap form, expressly for purposes of Nature Study. As nearly all aquatic insects, in both the larval and the adult stages of their existence, are to a greater or less degree carnivorous and extremely pugnacious, it is advisable not to introduce too many specimens, or several different species, into one tank, for battles royal will most certainly take place, and with most dire results. This is more particularly the case with the various species of Water-beetles, and the larvae and active nymphs of the Dragonflies.

Before any insects are introduced into an aquarium, it should be prepared for their reception; that is to say, the bottom of the aquarium should be covered with a layer of well-washed, fine shingle, and one or two water plants established. When the water plants are seen to throw off small bubbles, so that the water is naturally oxygenated, then the insects should be introduced, and will be healthy and vigorous. Beware how you introduce earth into the aquarium, because many aquatic insects have a happy knack of digging down through the layer of shingle which may have been placed on the top of the earth, and thus converting your clean, bright aquarium into a horrible and turbid condition. The best plan is to place the plants in small, shallow pans or bowls, pressing down the well-damped earth firmly, and placing a good deep layer of shingle on the top. If a little care and attention is given to these small but all-important details, all will be well, our insect guests will thrive, and we shall be able to derive much pleasure and knowledge from observing their interesting habits and ways.

For collecting in the field, our knapsack should contain a supply of nested chip-boxes, a few of the metal boxes fitted with glass lids, a small garden trowel, and an old garden knife. We may also with advantage carry some form of sweeping net for collecting larvae and beetles; a good stout ring-net such as is used for capturing Butterflies and Moths will answer both purposes quite well. For collecting aquatic insects, we shall require a small, stout ring-net, with an interchangeable sleeve-bag to which a small, wide-mouthed glass jar can be attached; a small weighted grapple-hook, securely fastened to a length of good snood-line; a few three- and four-ounce wide-mouthed glass jars, fitted with good corks; a wide bore fountain-pen ink-filler, very useful for collecting mosquito larvae; a pair of micro-forceps; and an old tablespoon.

To help us in keeping a true and faithful, illustrated record of our observations, both in the field and at home, we cannot adopt a better means than photography; for with the aid of the camera, it is possible in a few seconds to obtain an accurate record of elaborate details, which would call for great technical skill and some hours of labour to truthfully portray with pen or pencil. Such photographs, in addition to their scientific value, will in the dark winter days bring back to us happy memories of sunny hours spent in woodland and meadow, and will always be a source of interest to our friends. I do not propose to give details here of how to take photographs, for there are hand-books galore dealing with the subject, but will give such hints concerning the selection of apparatus, as, from a long experience of nature photography, seem to me most likely to be helpful to the beginner. Choice of apparatus must necessarily be largely governed by the amount the would-be photographer of insect life is prepared to pay. At the same time the equipment need not be a very expensive matter, provided one is content to start with simple apparatus, exchanging it for the more costly and perfect instruments as one's ability, experience, and requirements advance. The lens, the shutter, and the camera are the three first items to consider, and represent the essential and most costly part of the outfit. Personally, I am a great believer in the reflex camera for all Natural History work, as it permits one to watch and critically focus the object up to the instant of making the exposure, which is very important when photographing such restless creatures as insects. I may say that practically all the illustrations of living insects in this book are from photographs which I took with my Newman and Guardia Reflex Camera.

Although a good reflex camera is costly in the first instance, one quickly makes up for it by the great saving in wasted plates, and the added certainty of one's results.

If an ordinary field stand camera is selected in place of the reflex type, there are one or two points that should be looked for when purchasing. The camera, preferably of quarter-plate size, should be thoroughly rigid when set up, and should have a good extension of bellows, from fourteen to sixteen inches, sufficient to enable one to use the single combination of the lens when photographing objects moderately near the camera. A good rising-front is also important, as well as a rapid means of reversing the back from an upright to an oblong picture. See that the dark-slides are well made, and that they fit quickly and smoothly into place. A focal-plane shutter, although not generally supplied with the ordinary stand camera outfit, is an extra worth careful consideration, because it permits the maximum amount of light to reach the plate during instantaneous exposures. Next to the focal-plane a good roller-blind shutter fitted behind the lens is the best. The tripod should be rigid at its full extension, and have sliding legs permitting of rapid adjustment to various heights. The quality of the lens is all-important, for without a good lens it is impossible to obtain satisfactory results. If a first-class anastigmat with a working aperture of *f*5 or *f*6 is too costly, then a good rapid rectilinear lens working at *f*8 should be selected, and it must cover sharply to the edges of the plate at full aperture. Isochromatic plates should always be used, so that as truthful a monochromatic rendering of the colour values as possible may be obtained. My reasons for giving preference to the comparatively small size of the quarter-plate ($3\frac{1}{4} \times 4\frac{1}{4}$ inches) camera are firstly, its lighter weight and greater portability, advantages which one greatly appreciates towards the end of a long day's tramp across country; and secondly, given a really good lens, and the image on the ground-glass focussing screen critically focussed, the resulting negative should be capable of yielding perfectly crisp and sharp enlargements, up to almost any size. Each negative should be carefully indexed, and a note-book kept in which to enter the subject, plate used, exposure, stop, light, and date.

CHAPTER II

SOME INSECT COMMUNITIES

I KNOW of few more wonderful or interesting sights, that are likely to attract and rivet the attention as one wanders through a pine wood on a summer afternoon, when the air is filled with the resinous fragrance of the pines, than that which a great nest of the common Wood or Horse Ant (*Formica rufa*) presents, with the warm sunlight brilliantly illuminating its countless inhabitants, as they hurry hither and thither about their various tasks. At first all seems to be a hopeless medley, a futile, unorganized running to and fro; but a little close and quiet observation, taking care not to touch or approach too near the nest, so that the little creatures are not disturbed or alarmed by our presence, will soon show that there is really no lack of organization. Some Ants may be seen returning from the wood, carrying additional supplies of pine-needles, bits of stick, and the like, to be used as building materials in repairing and enlarging the nest. Others are busy running over the surface of the nest, shifting the twigs and pine-needles, already closing the apertures they had made earlier in the day, so

FIG. 1. NEST OF THE WOOD ANT

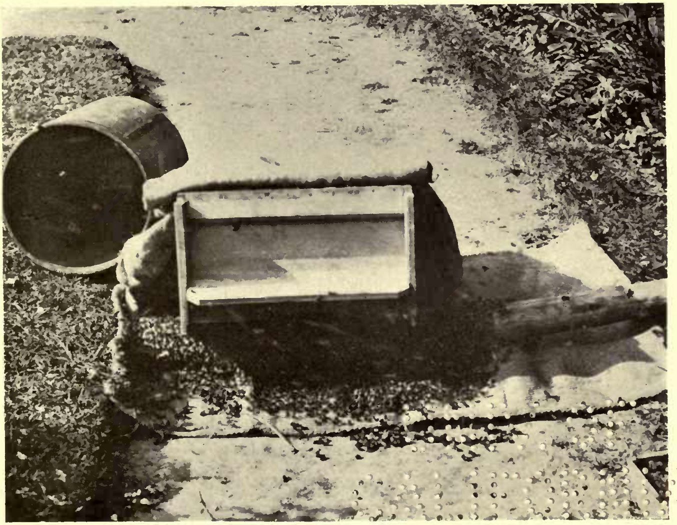

FIG. 2. A SWARM OF BEES ENTERING A NEW HIVE

that, with the approach of evening, all may be snug and safe for the night; while here, again, come some members of the community, who have been out on a hunting expedition, and now return homeward laden with their spoils. The whole scene is one of extraordinary animation and industry, most fascinating and exciting to behold.

The Ants belong to the Order Hymenoptera, and in their general structure, habits, and social life strongly resemble the Bees and Wasps, which also belong to this Order. While most Ants are distinctly social insects, living together in great communities, there are a few genera which are solitary in their habits, and in which only two kinds of individuals, winged males and wingless females, are found. One of these solitary genera appears to be at any rate partially, if not entirely, parasitic, inhabiting the nests of the humble-bees; and has the power of giving vent to a curious noise, half buzz, half squeak, when disturbed or alarmed.

If we carefully examine an ordinary Ants' nest, we shall find that the community consists of a vast number of workers, who, for the most part, are sterile or imperfect females; one or more fertile queen-mothers; and a certain number of winged males, who, like the drones in a bee-hive, are short-lived. Although the queens are the real mothers of the community, nearly all nests appear to contain amongst the crowd of imperfect workers a few which are capable of producing eggs; but these eggs, should they develop, almost invariably produce males. The general opinion held by most of the eminent naturalists who have made a special study of these interesting insects, is that the Ants, like the Bees, have the power to determine by the selection and quantity of food given to the larva, whether it shall develop into a worker or a queen; and that the probable explanation of the partial fertility of some of the workers is that they may, as larvae, have received, whether accidentally or intentionally is uncertain, slightly more than the usual worker-larvae's allowance of food.

The males and queens have wings, though the queens lose theirs after the marriage-flight; the workers are wingless. All pass through a complete metamorphosis, the eggs, larvae, and pupae being guarded and tended with the greatest watchfulness by the workers.

On a warm, still summer day, when hardly a breath of air fans the foliage, it is a wonderful sight to watch the winged males and young queens quit the nest, and rise into the bright sunlit air to depart on their marriage-flight. They swarm out and rise in such dense numbers as to appear like a thin column of smoke, iridescent gleams are shot forth ever and anon as the sun strikes upon the countless gauzy wings. Higher and higher the dancing column of insects rises, until meeting a gentle current of air, they disperse and are wafted away. The marriage-flight over, the queens alight upon the ground and strip off their wings, and once established within a nest devote the rest of their lives to their maternal duties; and the males, their mission in life accomplished in their marriage-flight and airy union with the queens, soon perish.

It is curious that in spite of the great amount of careful observation which has been devoted to the Ants, very little is really known as to how their nests are commenced; whether the young queen after her marriage-flight and willing sacrifice of her gauzy wings, founds unaided a new nest; or seeks and obtains the assistance of a small band of workers; or returns to the nest in which she was born; or seeks admission to some other established nest. As Ant communities exist for a number of years, it seems highly probable that new young queens are from time to time adopted, although Lord Avebury's experiments seemed to go against this theory, for in each case where he removed queens of *Lasius flavus* from one nest and introduced them to another of the same species, these queens were at once attacked in a hostile manner by the workers of the nest into which they had been introduced. On the other hand, Mr. McCook gives the following interesting account of the adoption of a fertile queen of *Crematogaster lineolata*, by a colony of the same species: "The queen was taken April 16, and on May 14 following was introduced to workers of a nest taken the same day. The queen was alone within an artificial glass formicary, and several workers were introduced. One of these soon found the queen, exhibited much excitement but no hostility, and immediately ran to her sister workers, all of whom were presently clustered upon the queen. As other workers were gradually introduced they joined their comrades, until the body of the queen (who is much larger than the workers) was nearly covered with them. They appeared to be holding on by their mandibles to the delicate hairs upon the female's body, and continually moved their antennae caressingly. This sort of attention continued until the queen, escorted by workers, disappeared in one of the galleries. She was entirely adopted, and thereafter was often seen moving freely, or attended by guards, about the nest, at times engaged in attending the larvae and pupae which had been introduced with the workers of the strange colony."

That in some instances the queen has the power and instinct to found a colony and successfully rear her larvae unaided, has been shown by another of Lord Avebury's careful and interesting experiments. He isolated two pairs of *Myrmica ruginodis* which he had found flying in his gardens and successfully kept them under observation for a considerable period; watching the queens deposit their eggs and tend their larvae and pupae, until, their metamorphosis completed, the workers were ready to help in the duties of rearing the young and providing a supply of food. It is also interesting to note that the two males captured at the same time as these queens, and kept with them under observation in Lord Avebury's formicary, lived for eight and nine months respectively, after their nuptial flight. Lord Avebury has also most conclusively demonstrated that the duration of the life of the Ant is much longer than was generally supposed, probably longer than that of any other insect. One of his queen Ants lived for nearly fourteen years, from December, 1874, to July, 1887, and another for nearly fifteen years, from December, 1874, to August, 1888; during the whole of which time they were perfectly healthy and active, and every year laid eggs from which workers were produced.

And now let us return to our Wood Ants' nest in the pine wood; this time on an early spring morning, when the inhabitants are beginning to throw off their winter lethargy, and to bestir themselves. On carefully breaking down part of the nest, we shall find that at this early period of the year it contains no winged insects, but only a large number of workers and a few queens, who are readily distinguished by their slightly longer abdomens, and shining, polished appearance. Eggs, larvae, and pupae are present, and these some of the excited workers instantly seize and carry off into the interior of the nest, while others at once set about repairing the breach which we have opened. Although at first sight there appears to be a good deal of confusion, a little closer observation will show that each worker is going about its labours in a very business-like way, carrying the pine-needles, bits of twigs, earth granules, etc., and arranging these materials so as to form chambers, galleries, and passages leading to every part of the nest.

It is quite possible to learn a great deal about the life of these Wood Ants by daily visiting a nest at different seasons of the year, and spending a few hours in quiet and careful observation. Supposing we visit the nest very early on a summer's morning, just after sunrise in fact, when the air is still cool and fresh, and the foliage throws back rainbow scintillations from the sparkling dewdrops, we shall find the exterior of the nest deserted in appearance, and save for a few small cracks through which an Ant might squeeze with difficulty, no openings are visible on its dome-shaped surface. But we have not long to wait for signs of the awaking of the inhabitants, a few early risers soon emerge, stretch their limbs, and greet each other, and run over the nest. Then, as the temperature rises, and the sun begins to shine upon the nest, the little workers appear in ever-increasing numbers, and many large openings on the surface of the nest are formed, communicating within with the principal galleries and chambers. It is not long before a foraging party starts off in the direction of a small bush which is growing near the nest, and whose branches we notice are crowded with Aphides, the so-called Plant-lice or Green-fly. The Ants quickly ascend the branches of the plant, and seek out the Aphides, which they at once proceed to tickle, or gently rub, with the aid of their antennae. This curious action on the part of the Ants seems to please or stimulate the Aphides, causing them to excrete a little drop of sugary fluid at the end of the pair of small cylindrical tubes which are situated at the extremity of their bodies. This sugary fluid the Ants greedily suck up until they are gorged with the sweet food, when they hurry back to the nest and give up a portion of it, which they have retained in their gullet-pouch, to the larvae, and to those workers who are at work in the nest.

This curious habit on the part of the Ants, of caressing the Aphides to obtain the sugary secretion, has attracted a great deal of interest amongst naturalists, with the result that our knowledge concerning the amicable relations which exist between various species of Ants and Aphides has been considerably enriched. The Ants not only milk the Aphides, which may well be called Ant cows, but to protect them from the attacks of foes even build cowsheds of earth over them, or carry them for greater safety into the nest, where they are tended with the greatest solicitude. The little Yellow Ant (*Lasius flavus*) is a regular miniature cattle farmer, keeping flocks or herds of root-feeding Aphides in its nest. More remarkable still, is the way in which this Ant collects from the leaves of the common daisy, the eggs of a species of Aphides which live upon this plant throughout the summer months. In late September and early October, as the Aphides lay their eggs upon the daisy plants, the little Yellow Ants collect them with the greatest eagerness, and carry them away into the nest. There the Aphide eggs are tended with great care throughout the winter months until the first weeks in March, when the young Aphides emerge. Directly the climatic conditions are suitable and the young Aphides are strong enough, they are carried out of the nest by the Yellow worker Ants and placed on the tender young daisy leaves, where they are visited and milked daily throughout the spring and summer by their Ant owners. Nor are the Aphides the only insects that are kept, or permitted to live habitually, in the Ants' nests; various species of small Beetles, a species of insect allied to Podura, and a small white crustacean allied to the wood-louse all frequent the nests of certain species of Ants. Some are parasitic on the Ants themselves, others possess secretions which serve as food for the Ants, as is the case with the curious blind beetle called, from its club-shaped antennae, Claviger. This beetle is not only blind, but appears to have totally lost the power of feeding itself, and is quite dependent upon the kind offices of the Ants, who habitully supply it with nourishment in the same way as they do each other. It is a very curious sight to watch the Ants caressing the blind Clavigers with their antennae, taking the tufts of hair that are at the base of the beetle's wing-cases into their mouths, and licking them, and also the whole of the upper surface of the beetle's body, with evident signs of joy and satisfaction.

That the Ants do not confine themselves solely to a diet of honey-dew drawn from their cow-Aphides we shall quickly realize as we watch our friends the Wood Ants (*Formica rufa*). Should a foraging party come upon a nice fat smooth-skinned Caterpillar, they will rush down upon the unfortunate creature, attack it from all sides, fix their powerful jaws deep in its flesh, and hang on to it with grim bulldog-like determination. The poor Caterpillar vainly tries to shake off its foes by squirming and wriggling, and rolling over and over, until at last, overpowered and exhausted, it succumbs, and is dragged off in triumph to the nest. When watching these sanguinary encounters, I have noticed that the Ants are far more ready to attack the perfectly smooth-skinned Caterpillars than those covered with hairs. Indeed, on more than one occasion I have seen the Ants, after making but a half-hearted attack upon one of these very hairy Caterpillars, draw off and permit it to go on its way. They make no demur, however, about attacking any bumble bees, hive bees, or wasps that they find in a semi-torpid condition on the ground, calmly cutting them up limb by limb, and carrying the fragments off to the nest. In the same way they will take to pieces, joint by joint, a lordly stag-beetle, should they come upon him lying helplessly on his back like an overturned turtle. They will also quickly remove the flesh from the body of any small bird or beast that may lie near the nest, leaving nothing but a perfectly cleaned skeleton in a remarkably short space of time. Indeed, in this way the Ants play a very important part as natural scavengers.

Once more returning to our Wood Ants' nest, let us watch the more peaceful, but no less interesting, occupations of those workers who devote themselves to the labours of keeping the nest in order, guarding and tending the precious eggs, larvae, and pupae, and attendance on the queen, or queens. As I have already noted, the adult queens are winged, but after their marriage flight, very shortly after settling on the ground, they tear off their wings and begin their maternal duties. The worker Ants show the greatest respect and affection for their queen, a retinue always attending upon her, feeding her, caressing her with their antennae and displaying in various ways their pleasure at her presence. The very minute, oval-shaped, whitish eggs, directly they are deposited by the queen, are taken under the care of the nurse workers, who place them in special chambers, keep them clean and sufficiently moist by licking, and carry them alternately to the upper and lower stories of the nest, so that they are never exposed to too great heat or cold, but kept at a uniform temperature. When the larvae hatch out, they require even more care and attention, for they are weak legless grubs, unable to forage for themselves, and capable of very little movement beyond a slight curving and elongation of the anterior part of the body when demanding food. Therefore the workers have not only to clean them, but also to feed them and carry them from one part of the nest to another. Early in the morning the workers bring the baby larvae from the night-nurseries, situated fairly deeply in the nest, to the day nurseries, which are situated in the upper part of the nest. Should the morning be warm and sunny, they may bring their precious charges out on the top of the nest. We then have an opportunity of watching how the workers clean the babies by most carefully licking them over and rubbing them down with their palpi. The babies receive from time to time a supply of food from the mouth of the nurse-worker; the amount supplied is believed to be regulated according to whether the baby larva is ultimately to grow into a worker, a queen, or a male. The workers may also be seen to give frequent demonstrations of their affection for the baby larvae by the manner in which they caress them with their antennae. All the time the nurse-workers appear to keep a sharp and anxious watch over the larvae, picking them up and hastily retreating within the nest at the slightest indication of danger, or should the sun beat down too fiercely.

When the larvae are full grown they spin a silky cocoon, within which to complete their metamorphosis. It is these oval cocoons which are known to most people as "Ants' eggs," under which misnomer they are collected and sold for feeding young pheasants and gold-fish. The workers pay the same care and attention to the cocoons as they did to the eggs and larvae; for within the cocoons the nymphs or pupae are confined, and passing through those wonderful changes of structure which are associated with the last stage of complete metamorphosis. Directly the workers perceive that this final stage is completed, they at once set to work with their mandibles to cut open the cocoon and liberate the perfect Ant, which is far too weak to accomplish this task for itself, and would inevitably perish within the silken chamber but for the watchful care of its nurses. The newly emerged perfect Ants are by no means in a condition to fend for themselves, or to at once commence to take part in the work of the community, so they are fed by the nurse-workers that they may grow strong, and are led by them all over the nest so that they may be introduced to the community at large, and in a very short time they are ready to begin to work.

We have seen how the Ants keep Aphides to supply them with honeydew, and how they permit certain other creatures to dwell in the nest as pets or scavengers. Now, there is another interesting phase in their history which is still more remarkable in some respects, and that is the little understood relations existing between our friends the Wood Ants and the two very dwarf species of Ants called the Stenamma and Solenopsis. The tiny Stenammas are found exclusively in the nest of the large Wood Ants, and appear to live on the very best of terms with them. Indeed, when for one reason or another the Wood Ants change their nests, the Stenammas go with them. And as the Wood Ants march along, it is an extraordinary sight to see the tiny Stenammas running about like excited little dogs amongst them, dodging in and out between their legs, climbing on to their backs, and tapping them inquisitively with their antennae, as if seeking to find out where their friends or masters are going; their gambols and friskings receiving but little attention. The relations between the little Solenopsis and the Wood Ants appear to be of a much more sinister character, for these tiny Ants make their chambers and galleries in the walls of the Wood Ants' nest; and from time to time make raids upon the nurseries of the Wood Ant, and carry off the unfortunate baby larvae as food. It is quite impossible for the infuriated Wood Ants to get at these tiny marauders, their bodies being too large to permit them even to squeeze into the diminutive galleries of their foes. Are the tiny Stenammas which live on such good terms with the big Wood Ants really kept as dogs to fight the rapacious Solenopsis and chase them into their tiny galleries? This is a question which can only be answered by further careful observation and experiment.

While most Ants prey upon the nests of other species, carrying off the larvae and pupae and using their captives for food, some carry them off purely for the purpose of making them work as slaves. Thus the Ants called *Formica sanguinea* periodically attack neighbouring nests, and after slaughtering and driving out the adults, select and carry home those larvae and pupae which will ultimately produce workers. But the great slave-making species is *Polyergus rufescens*, a species frequently met with in Switzerland.

For a striking object-lesson of the degrading tendency of slavery, there is no need to go to those dark corners of Africa where it is still practised by man, for these slave-making Ants will demonstrate it to the full. So utterly dependent upon their slaves have these Rufescent Ants become, that they have not only lost most of their natural instincts, but have actually undergone certain structural changes, so that their mandibles have degenerated into mere toothless nippers, and are now only of service in war. They and their larvae have to be fed by their slaves, for they have become quite incapable of feeding themselves, and would perish in the midst of a plentiful food supply if there were no slaves at hand to attend to their wants. It is the slaves that build and keep the nest in repair, and carry their mistresses on their backs when the colony moves into new quarters.

I have on several occasions had an opportunity of watching our English slave-making Ants, *Formica sanguinea*, engaged on a sudden foray, and also the migration of a colony from one nest to another; both most interesting sights to witness. Sanguinea has not been a slave-maker for so many generations as the Rufescent Ants, and consequently has not yet become so dependent upon its slaves. This greater independence on the part of the Sanguineas is seen when a colony of these Ants elect to change their quarters, for they march off to their new home carrying their slaves in their jaws instead of being carried by their slaves, as is the case when the Rufescent Ants migrate. It is the nests of the little Black Ant (*Formica fusca*) which the Sanguinea generally attack and raid, the encounters being of a most desperate character, for the little Black Ants put up a most valiant fight in the defence of their nest, and sometimes succeed in driving off their big and powerful foes. At the approach of the marauders some of the little Black Ants rush forward and attack the advance-guard, while others rush off in great excitement into the nest to give the alarm, and to carry the larvae and pupae away to a place of safety. The Sanguineas ruthlessly kill numbers of their small foes, putting them at last to flight, and having made a successful breach, enter the nest in search of the worker larvae and pupae of the Black Ants, for they do not appear to carry off the larvae or pupae that will ultimately become males or queens. In a very short time the conquerors may be seen to come forth again and begin to retrace their steps in the direction of their own nest, each of the victors carrying in its jaws a larva or pupa captured from the ravaged nest. These larvae and pupae of the little Black Ant are carefully tended by the Sanguinea workers until their metamorphosis is completed, and they are ready to take up their duties as workers within the nest, nursing the babies of their captors and helping in the general work of the nest.

The Sauba, or so-called Umbrella Ants of tropical South America, are most interesting in their habits, and are in many ways very remarkable insects. Every colony of the Sauba Ants will be found to contain no less than five distinct classes of individuals, comprising males, queens, small ordinary workers, sometimes called worker minors, and two types of large or major workers, one with large polished heads, the other with very hairy heads. The true function of these two large major workers has yet to be satisfactorily explained, for up to the present we have no authoritative record of their having been observed to take any part in the work of the nest, or to enter into combat with other species. Bates, who so closely studied these interesting Ants, was never able to satisfy himself absolutely as to the real function of the large-headed workers, and his suggestion that they may serve, in some way, as passive protectors of the real workers, their large, hard, and indestructible heads acting as veritable *pièces de résistance* against the onslaughts made by their foes, while picturesque, does not seem to be quite a logical explanation.

It is the small worker Saubas who ascend the trees in thousands, and with their sharp, scissor-like jaws cut up the leaves into nearly semi-circular pieces, which they bear off in triumph, or throw to the ground to be carried off by one of the small workers. These Ants are a serious pest in tropical America, on account of their habit of attacking and entirely stripping the foliage from the cultivated coffee and orange trees; for although they will confine their attentions to the foliage of the young forest trees, when nothing better to their liking is within reach, directly the unfortunate settler plants his coffee and orange, or other fruit trees, the Sauba Ants quit the surrounding forest and transfer their unwelcome attentions to the recently imported trees and bushes.

It is a most extraordinary sight to see a great army of the Sauba worker minors engaged upon stripping the foliage from a tree. There is a constant procession of the insects ascending and descending the tree; the ascending army hastening eagerly upwards to their work, while the descending multitude pass down the trunk, each individual carrying securely in its mandibles a semi-circular piece of leaf about the size of a sixpenny-piece, which it has cut from the foliage. Indeed the homeward bound army, marching along the path that has been cleared between the tree and the nest, looks like a procession of tiny leaves. On arriving at the nest, these workers drop their burdens, and at once return to the tree; while another swarm of the worker minors seize upon the pieces of leaves, and placing them into position so as to form a kind of thatch to the mounds covering the entrances to the subterranean nest, cover them with a layer of earthy granules, which they have excavated at some depth below the surface and worked up for this purpose.

Not content with stripping the trees of their foliage, the Sauba Ants will enter the houses at night, and plunder the stores of provisions; carrying off grain by grain the farinha or mandioca meal, which is so largely used for bread by the artisan classes in Brazil. Bates noted that on these plundering expeditions, two classes of workers are always seen, namely, the small true workers who carry on all the labour, and the large major workers with huge, smooth heads, who do nothing. The third class of workers, with large heads clothed in front with hairs, have not been observed to take any part in these forays, but appear normally to live deep down below the surface of the ground, in the subterranean chambers of the nest. Altogether these Sauba Ants of tropical South America are most interesting insects, and offer a very fruitful field for further investigation.

The Ecitons or Foraging Ants, the Taucas of the Indians of Brazil, are carnivorous, hunting their prey in large and well-organized armies. The communities consist of males, females, and two types of workers—large-headed majors and small-headed minors. In the small-headed or minor workers the jaws are always of the ordinary shape, but in some species the jaws of the large-headed major workers are so greatly lengthened as to make it quite impossible for them to take part in the labours of their small-headed companions. Ten species of these Foraging Ants were observed and described by Bates during his wanderings in tropical South America, and he found that nearly every species had its own particular method of marching; some, like the giant *Eciton rapax*, which chiefly preys upon a large but defenceless Formica Ant, hunting in single file through the forests; others, like the smaller and more numerous *Eciton legionis*, marching alone in fairly broad columns numbering many thousand individuals; others, again, the blind Ecitons, push forward step by step under covered ways which they construct as they advance. There are two interesting transitional species connecting those Ecitons which are provided with visual organs to those that are absolutely blind. In the first transitional species, *Eciton crassicornis*, the eyes are sunk in rather deep sockets, and the insect habitually shuns the light when on its foraging expeditions, moving along under fallen leaves, and when compelled to cross a cleared space, the workers construct a temporary covered way composed of granules of earth, under which the marauding column of Ants passes. In *Eciton vastata* only the collapsed sockets remain to tell of the gradual atrophy of the disused eyes; while in *Eciton erratica* both sockets and eyes have disappeared, only a faint ring marking the place where they were once situated.

The strange habit the two blind species of Ecitons have of moving about under covered ways has probably been adopted by the Ants as a means of protection. These covered ways, which pass through the undergrowth of the tropical forest from one rotting log or fallen piece of bark to another likely hunting-ground, may be over two hundred yards in length, and differ from the covered ways made by the Termites or so-called White Ants, being composed of uncemented grains of earth, built up from the soil over which the foraging party is passing, whereas the Termites use a glutinous saliva as a cement. In the two classes of workers found in the foraging parties of these blind Ants, the division of labour existing is unmistakable: the small-headed worker minors busily engage in constructing a covered way, while the big-headed worker majors play the part of true soldiers, snapping their jaws with fury when disturbed by the approach of a foe, and offering to do battle for the defence of their small-headed companions. This division of duties, however, appears by no means to be present amongst the species of Ecitons who have their visual organs fully developed, for the large-headed workers are generally rather less pugnacious than the small-headed workers, and their great distorted jaws are not nearly such effective weapons as the normal jaws of the worker minors.

One of the commonest species of the Foraging Ants endowed with fully developed visual organs is the *Eciton drepanophora*, and is probably the insect referred to in some of the rather highly coloured stories about armies of Foraging Ants entering houses and clearing them of rats and mice. As a matter of fact, their ravages are almost exclusively confined to the regions of dense forest. Nevertheless, when they are on the march, there is a great commotion in the forest, every creature, both large and small, endeavouring to get out of the way as quickly as possible, for the Ecitons are most ferocious little insects, burying their pincer-like jaws deeply into the flesh of their victim, and hanging on with bulldog-like tenacity, they turn in their tails, and sting with all their power; allowing themselves to be torn to pieces rather than relinquish their hold. As these Foraging Ants do not ascend the trees to any considerable height, most young nestlings escape their onslaughts. It is the creatures living on or near the ground, such as the burrowing larvae of beetles that tunnel into rotting logs, caterpillars feeding on the undergrowth, ground spiders, cockroaches, and so forth, that suffer most severely. The Foragers will even attack and destroy a Wasps' nest, should they come upon one that has been built low down in a bush near the ground, calmly gnawing away the papery outer covering, and seizing and carrying off the helpless Wasp larvae and pupae, in spite of the infuriated buzzings and angry swoops of the builders of the nest. Should the victim be too large for convenient transportation, it is at once set upon and torn into fragments, and the pieces distributed amongst the worker Ecitons for transit back to the nest.

Of the handsome and ferocious little Fire Ant, the *formiga de fogo* of the Portuguese settler, which is a perfect plague when it attacks mankind, Bates gives the following graphic account in the course of a description of his voyage up the Tapajos: "Aveyros was deserted a few years before my visit on account of this little tormentor, and the inhabitants had only recently returned to their houses, thinking its numbers had decreased. It is a small species, of a shining reddish colour, not greatly differing from the common red, stinging Ant of our own country (*Myrmica rubra*), except that the pain and irritation caused by its sting is much greater. The soil of the whole village is undermined by it: the ground is perforated with the entrances to their subterranean galleries, and a little sandy dome occurs here and there, where the insects bring their young to receive warmth near the surface. The houses are overrun with them; they dispute every fragment of food with the inhabitants, and destroy clothing for the sake of the starch. All eatables are obliged to be suspended in baskets from the rafters, and the cords well soaked in copaüba balsam, which is the only means known of preventing them from climbing. They seem to attack persons out of sheer malice; if we stood for a few moments in the street, even at a distance from their nests, we were sure to be overrun and severely punished; for the moment an Ant touched the flesh, he secured himself with his jaws, doubled in his tail, and stung with all his might. When we were seated on chairs in the evening in front of the house to enjoy a chat with our neighbours, we had stools to support our feet, the legs of which, as well as those of the chairs, were well anointed with the balsam. The cords of the hammocks are obliged to be smeared in the same way to prevent the Ants from paying sleepers a visit."

The Honey Ants of Mexico and Australia have gained their popular name partly from the habit of collecting honey, and partly from their extraordinary method of storing it, utilizing certain members of the colony as receptacles. While the workers who are engaged in the ordinary duties of keeping the nest in order, tending the young, and collecting food supplies are quite normal, those which act as living receptacles present a most extraordinary appearance, their abdomens being swollen out into polished membranous spheres; in fact, they have become living honey-pots. The normal workers go forth and, in the case of the Mexican species, collect a sweet secretion which exudes from certain plant-galls, and hurrying home forcibly inject the honey down the throats of the rotund workers until they become fully distended. The honey undergoes in the bodies of these globular workers some slight chemical change, and is then yielded up and drawn forth by the normal workers to feed the young brood. Should one of these living honey-pots meet with an accident so that the honey exudes, the ordinary workers will gather round and quickly lap it up; but should the honey-pot worker die, both corpse and honey will be buried, an act which seems almost to point that the normal workers realize the dangers of decomposition. In Mexico, the globular Ants are collected and sold by measure in the market places of the towns, and from the syrup extracted by pressure from the bodies of the Ants, a rather pleasant, sweetish drink, not unlike old English mead, is made.

The habit of harvesting grain peculiar to certain species of Ants, aptly termed Agricultural Ants, found in the south of Europe, in India, and Texas, is very remarkable. Although this habit was observed and frequently mentioned in ancient literature, it was for a long time regarded with considerable doubt and scepticism by scientific men. Thanks to the careful and critical observations of Lieut.-Col. Sykes in India, of Mr. Moggridge in Southern Europe, and of Dr. McCook in Texas, these doubts have been swept away, and the grain-storing habit proved and established as a fact. The Agricultural Ants of Texas clear disks, ten or twelve feet in diameter, round the entrance of the nest of all weeds and plants, only permitting the so-called ant-rice (*Aristida stricta*) to grow within the clearing so made. Dr. McCook states that "about the 1st of November, at the fall, a green row of the ant-rice, about four inches wide, is seen springing up on the pavement (disk) in a circle of fourteen or fifteen feet in circumference. In the vicinity of this circular row, the Ants do not permit a single spire of any other grass or weed to remain a day, until the rice ripens. After the maturing and harvesting of the seed, the dry stubble is cut away and removed from the pavement, which is thus left unencumbered until the ensuing autumn, when the same species of grass, and in the same circle, appears again, and receives the same agricultural care as did the previous crop. An examination of the grass-covered nests showed that the *Aristida* (ant-rice) has exclusive possession of the surface clearing. This statement rests upon a large number of careful observations, and is made without any qualification whatsoever!"

The Driver Ants (*Anomma arcens*) of West Africa play a very important part as natural scavengers, devouring much dead animal matter, and by attacking all creeping insects and small reptiles, help to hold in check their too rapid increase. They are largely nocturnal in their habits, and, like some of the Foraging Ants of Brazil, already described, are quite blind. Their sting is said to be extremely painful, almost like a sudden stab from a red-hot needle. The dread of them is upon every living thing, for they will attack and quickly destroy even the largest animal, if it cannot promptly make good its escape; so that the great python snake, when gorged with food and rendered stupid by the lethargy of repletion, may be set upon and destroyed by these Ants. Their approach is made manifest by the general stampede of all other living creatures, who make frantic haste to get out of their way; and should they enter a house, they will quickly and most effectually clear it of all rats, mice, cockroaches, and other vermin, and the human inhabitants will be obliged to quit it until the Driver Ants march out again in search of fresh fields to conquer.

The Termites, or so-called White Ants of the tropics, are not Ants at all, for they belong to the Order Neuroptera, and do not undergo complete metamorphosis, whereas the true Ants all pass through a complete metamorphosis, and belong to the Order Hymenoptera. Like the true Ants, however, the Termites are social in their habits, living in large communities and building nests and hills, which frequently assume considerable proportions, and in some parts of Africa form quite a characteristic feature of the landscape. It is on account of their social and nest-building habits, coupled with the somewhat Ant-like appearance of the wingless workers, that the Termites have gained their popular misnomer of White Ants.

A community of Termites is composed of a vast number of small workers, a limited number of big-headed and powerful jawed soldiers, a fertile queen, and a king or fully developed male; in fact, a community very similar to that of the true Ants. This similarity, however, is only of a superficial character, for while the different types of workers in a true Ant community are practically all neuters or imperfectly developed females, in the Termite community they are males and females, who remain sexually immature throughout their lives. Professor

Fritz Muller has also proved, that in many instances a Termite community may contain in addition to the workers and fully developed winged males and females, who are the true future kings and queens, a certain number of wingless males and females. These are apparently kept in reserve by the community, and, in the event of none of the young kings and queens, after their courtship flight, returning and being adopted, then these wingless males and females who never leave the nest, are allowed to mate and become parents.

The winged males and females are produced in great numbers at certain seasons of the year, and on completing their growth, quit the nest and swarm into the air. Here again there is a marked difference between the Ants and Termites, for although the male Termites may commence the courtship of their queens during the brief flight, the actual mating does not appear to take place until the amorous couple have taken up their abode in some hospitable nest, and have been formally accepted as king and queen by the community. Then both the king and queen, who have lost their wings or had them pulled off by the workers, are established in a special royal chamber in the centre of the nest, and in this chamber they pass the rest of their lives, being carefully tended by the workers. The body of the queen becomes enormously distended, until it looks like a sausage-shaped cylinder, of a sickly whitish colour, from two to five or six inches in length. In this condition, the queen is quite helpless and unable to move, and spends the rest of her life consuming the bountiful supply of food furnished by the crowd of ever attentive workers who wait upon her, and in producing a vast number of eggs, of which she is said to be capable, at times, of laying 80,000 a day. As fast as the eggs are laid, they are carried away from the royal chamber by the attendant workers, and placed in special nurseries in the nest.

The duty of the soldier workers is to attack all foes that may attempt to approach the covered ways leading to the nest. They are very formidable in appearance, with their big, oblong heads, and long, wicked-looking mandibles, and they are always ready to do battle, fighting with great courage and determination. The true workers, who look after the eggs and young, gather in the food supplies, build the nest and covered ways, and wait upon the king and queen, have small rounded heads and normal mandibles. In both the Soldier and Worker Termites the eyes are wanting, only the fully developed males and females—the kings and queens—being able to see.

The Termites always work under cover, constructing covered ways to screen themselves from observation and attack, for their soft, plump bodies are much appreciated by many insect-eating birds, lizards, true Ants, etc. Their food consists chiefly of wood, and especially of wood that has begun to decay. In the forests they attack every fallen branch and log, and, in search of decaying timber, ascend to the topmost branches of the trees by forming tunnels and covered ways of earth. Professor Drummond gives the following interesting description of the way in which the Termites build these covered ways: "At the foot of a tree the tiniest hole cautiously opens in the ground close to the bark. A small head appears with a grain of earth clasped in its jaws. Against the tree-trunk this earth-grain is deposited, and the head is withdrawn. Presently it reappears with another grain of earth; this is laid beside the first, rammed tight against it, and again the builder descends underground for more. The third grain is not placed against the tree, but against the former grain; a fourth, a fifth, and a sixth follow, and the plan of the foundation begins to suggest itself as soon as these are in position. The stones, or grains, or pellets of earth are arranged in a semi-circular wall, the Termite, now assisted by three or four others, standing in the middle between the sheltering wall and the tree, and working briskly with head and mandibles to strengthen the position. The wall, in fact, forms a small moon-rampart, and as it grows higher and higher, it soon becomes evident that it is going to grow from a low battlement into a long perpendicular tunnel, running up the side of the tree." The Termites moisten each grain with a sticky secretion from their mouths, before placing it in position, which most effectually cements the whole mass together.

While these covered ways are being constructed by the workers, the Soldier Termites mount guard, ready to do battle with any marauding band of true Ants that may suddenly make a descent upon the builders. Should such an encounter take place, and it constantly does, the warrior Termites, with their scythe-like jaws, make short work of their foes, a few rapid and deliberate strokes of those powerful mandibles sufficing to cover the ground with dead or badly injured opponents.

The Termites may be considered the vegetable scavengers of the tropical forests, excavating all the inner tissues of the fallen trees and branches, so that in an incredibly short space of time nothing is left but a thin, hollow, outer shell of bark. In many parts of India and Africa they are a great pest and source of danger, for they will burrow upwards through the timbers of the houses, making no outward sign of the work of destruction which they are carrying on, so that the first warning of their presence is generally a sudden collapse of some supporting beam, which may bring the rafters tumbling down, mere hollow shells excavated by these tireless workers. On the whole, both the true Ants and the Termites may be ranked amongst those insects which indirectly are of service to man, though occasionally causing him serious inconvenience and loss. They are both natural scavengers, the true Ants devouring animal matter rapidly and in large quantities, thus hastening the complete desiccation of animal bodies, which if left to the slower process of putrefactive decomposition would render the air poisonous by their exhalations. In the same way the Termites prevent the accumulation of vast quantities of rotting vegetation in the tropical forests, and by the enormous amount of earth which they bring up from considerable depths and employ in the construction of the covered ways, they carry on in the tropics that process of earth turning and the formation of vegetable mould, which is carried out by the earthworms in temperate and moister climates.

The Bees, on account of the very important part which they play in connexion with the fertilization of flowers, and also from their honey-storing habits, are insects of the greatest value and assistance to man.

A community of Bees is quite as wonderful and interesting as a community of Ants, and, like the latter, is composed of various types of individuals who perform certain work in connection with the general upkeep and welfare of the hive; the three types of individuals being the very numerous workers, who are all neuters or sterile females, and who are present in the hive all the year round; the limited number of males, or drones, as they are called, who are only present in the late spring and summer; and the one queen-mother, or the fully developed female, who is always present.

If we examine a bee-hive very early in the spring, we shall only find a queen-mother and a fairly numerous company of workers, who are rather lethargic. Directly the sun begins to shine with increasing warmth, however, there is an awakening and general movement in the hive, and the workers come forth on sunny mornings, visit the first flowers of the year, and return carrying fresh supplies of nectar and pollen.

Inside the hive there is a general air of bustle; spring-cleaning is in progress, and the workers may be seen clearing away any debris that has collected within the hive, and dragging out of the hive the bodies of those of their companions who have perished during the winter. Some of the workers, after partaking of a particularly hearty meal, hang together in a small festoon to rest and secrete the wax that is required for repairing and building the combs. The secretion is exuded from eight wax-pockets on the under surface of the worker Bee's abdomen, and projects in small flakes, and is removed by the legs of the Bee, carried to the mouth and masticated, and then laid in heaps ready for the comb-builders. These in their turn work it up into the familiar hexagonal cells of the honey-comb, and the brood cells in which the young are reared, and which vary somewhat in size; those intended for future workers being smaller and lower than the cells in which the drones are reared. The royal cells in which the young princesses will be brought up are not constructed until later in the spring, after the drones have begun to appear; they are of large size, irregular in shape, and are generally made at the edges of the combs with their mouths turned downwards.

The queen-mother, attended by a bevy of workers, passes over the brood comb, depositing one of her long, oval, whitish-coloured eggs in each cell. The workers watch very closely, and should the queen by accident deposit two eggs in a cell, one is immediately lifted out and destroyed. We gain some idea of the arduous duties of the queen when we learn that, in the full tide of her powers, she is capable of depositing 100 eggs per hour, or 3000 per diem. To keep up her strength while depositing her eggs, she is constantly fed by the attendant workers. Three or four days after the eggs have been deposited, the tiny grub-like larvae emerge, and feed upon the masticated food which is placed ready in each cell. As they gain in strength and size, the larvae stretch up to the mouth of their cells, and eagerly devour the food supplied to them by the nurse-workers. After the sixth day, the worker larvae are only supplied with unmasticated food, and the result of this modified diet is a stunting or arresting of the development of their reproductive system. On the other hand, the princess or queen larvae receive an abundant supply of nutritious and stimulating food, which appears to bring about the perfect development of their reproductive system. When the larvae are full fed, their cells are sealed up with a waxen cap by the workers, and then the larvae spin their silken cocoons and turn to pupae. It is curious and interesting to note that while the worker and male larvae spin complete cocoons, the princess larvae only enclose the head, thorax, and first abdominal segment in a silken wrapping. Profound structural changes take place until the pupae in the silken cocoons are gradually modified into young bees. When their metamorphosis is completed, the young worker and male Bees bite through their cocoons and the waxen doors of their nurseries, assisted by the nurse-workers, and, coming out on to the brood-comb, clean themselves, partake of food, and as soon as they have gained sufficient strength, in the case of the workers, begin their labours. When the young princesses have completed their metamorphosis, however, they are not permitted to leave their cells at once, but are kept as royal prisoners, food being passed into their cells through a small hole in the waxen door, until their shrill piping intimates that they have attained their complete sexual maturity.

Now let us watch the community in the hive as the season advances. At first it is necessary to increase the depleted ranks of the workers, and so the queen is seen busy day after day depositing eggs in those cells allocated to the rearing of the worker larvae. In a little while the hive becomes populous with an ever-increasing number of workers, who, we soon observe, are told off to perform certain duties; some must go forth and labour in the fields, flying far from the hive, and returning only when laden with a precious burden of nectar and pollen collected from the flowers they have visited; others must play the part of ever-watchful and faithful nurses, masticating and partly digesting the food before giving it to the hungry larvae; some must be busy attending the queen, to whom they show the greatest respect and devotion; others are at work building new combs, and repairing the old; and, most curious of all perhaps, many turn themselves for the time being into living ventilators, to keep the hive at a suitable temperature. This they accomplish by fanning as hard as they can with their wings, producing currents of air throughout the hive. As soon as the worker population has been re-established and is increasing, the queen begins to lay eggs in the male or drone cells, and when these drones begin to appear, then more eggs are deposited in the worker cells, and also a few in the royal cells. In this way the population increases as the season advances, and by the time that the first of the royal children have completed their metamorphosis, it is necessary that some of the surplus population should emigrate. The queen-mother becomes greatly excited when she hears the piping of the young imprisoned princesses, and becomes filled with a perfect fury of passionate jealousy at the presence in her household of these possible rivals. And now we see the wisdom of the workers in keeping the young princesses imprisoned, for unless they were kept thus under watch and ward, the old queen-mother in her blind passion of jealousy would murder them. The excitement of the old queen is infectious; there is a commotion amongst the drones, whose desires are probably excited by the piping of the princesses, the workers grow tremendously agitated, ceasing from their labours, devouring large supplies of food, rushing in and out of the hive in dense clouds, and sending out scouts to explore the neighbourhood. At last the excitement and temperature within the hive becomes unbearable, and the great swarm of emigrants depart, along with their old queen. She is heavy with eggs and cannot fly far, and directly she alights upon the branch of a tree, or some other convenient spot, all the swarming emigrants gather round her. Safely hived, or established in new quarters, the workers at once set about constructing brood-combs, the queen depositing eggs in the cells directly they are ready.

After the departure of the old queen and her attendant swarm of emigrant workers, one of the young princesses is released from imprisonment, and, if the population of the hive is very dense and vigorous, will in her turn depart as the leader of another emigrating party. In this way a really vigorous and populous stock may send off three or four swarms in succession during the swarming season. When the last swarm has left the hive, the remaining imprisoned princesses are set at liberty and allowed to fight for the sovereignty of the hive. The surviving princess, having established her authority by combat, departs on her nuptial flight, mating, it is generally believed, with a drone, or drones, from other hives. Her brief honeymoon over, she returns to the hive, and takes up the duties of queen-mother.

Swarming-time and marriage-time over, summer is well advanced, and the incoming supplies of honey begin to diminish, warning the inhabitants of the hive that they must begin to economize and prepare for the winter, and get rid of all useless or superfluous consumers of food. The princesses being all impregnated, or destroyed by their successful rivals, the drones are no longer wanted, and as they cannot perform the labours of the workers, their sole duty in life being to mate with the princesses, they are now unproductive, and a useless burden on the community. The workers drive them into a corner of the hive, and keep them without food until their powers of resistance are greatly weakened; then they are ruthlessly dragged forth from the hive, their wings nipped so that they cannot fly back, and they are tilted off the alighting-board of the hive on to the ground, where they perish of cold and starvation, or are eagerly devoured by the first insect-feeding bird that detects them. Nor does this massacre stop with the expulsion of the drones, for the superfluous eggs, infant larvae, and pupae are destroyed at the end of the season, so as to limit the number of workers who, during the winter months, will require food from the surplus honey-store of the hive, which has been accumulated for use during the late autumn and winter.

Few people, I am afraid, have a kind word to say for the wasps, although they are really useful creatures, many of them destroying large numbers of flies, caterpillars, and maggots; for, unfortunately, they are very nervous, hot-tempered creatures, prepared to do battle and to sting at but slight provocation, and this, coupled with their love for ripening fruit, to which in some seasons they cause considerable damage, has given them a bad name. Nevertheless, by preying upon other insects they do good service, which should be placed to their credit, and if treated gently and quietly, they will be quite friendly in their manners, and permit one to watch them closely.

Early in the spring, the queen Wasp, who has passed the winter in some sheltered nook in a state of torpor, awakens and begins to seek a suitable site for the foundation of her nest. If she is a Wood Wasp, she will probably select the bough of a tree; if she is a Common Wasp (*Vespa vulgaris*) she will seek out a cavity in the ground. Let us try to follow the latter species, for it is the Wasp one most frequently meets with. Having found a suitable cavity, the queen Wasp flies off and begins assiduously to collect materials for the construction of the nest, and soon she has laid a foundation of wood-scrapings and reared a kind of foot-stalk to support the first two or three layers of cells. These cells she protects by a waterproof, papery envelope, which she manufactures from well-masticated, woody fibres worked into a paste with a viscid secretion from her salivary glands. In each of the first set of cells she places an egg, and then proceeds to build more cells, which in turn also each receive an egg. Directly the young larvae hatch out they have to be fed, and as they grow the walls of the cells have to be raised so that they shall not be exposed to harm. When the larvae are full fed and grown, they shut themselves in the cells with a silken lid, and change to pupae. All this time the queen-mother Wasp has had to work very hard indeed, bringing in food supplies for her hungry babies, increasing the depth of their cells to keep pace with their growth, adding to the number of cells, and depositing an egg in each new cell as soon as it is completed. The period of pupation is short, and very soon the first worker Wasps emerge, and begin at once to help to lighten the labours of the queen-mother. They work hard at the building of the combs, and as fast as they build up the cells the queen-mother Wasp deposits her eggs therein, so that there is soon established a thriving colony which rapidly increases in its population of workers. So throughout the warm summer days the worker Wasps are busy seeking food for themselves and the larvae, and enlarging the nest as the increasing population demands. As autumn approaches, perfect females (the young princesses who will be the queen-mothers) begin to appear, and very shortly after, the males complete their metamorphosis and emerge. Then the young princesses and the males depart on their nuptial flight which will secure the continuance of the species, for only the young impregnated queens will survive the winter. The workers left behind in the nest proceed to destroy the remaining larvae and pupae, and as the temperature falls lower with the advance of autumn, and the food supply ends, they also perish. The young queens soon after their nuptial flight seek some snug and sheltered nook wherein to pass the long dark winter in the deep slumber of hibernation.

CHAPTER III

SOME AQUATIC INSECTS

AS we stand by the margin of a quiet pool, on a summer afternoon, and watch the exquisite play of colour on the body and wings of the Dragon-flies, as they gracefully poise, or take their swift flight backwards and forwards over the water, we are tempted to think that these handsome creatures have been singularly misnamed, and that surely the old French title of Demoiselle would be more applicable. But, truth to tell, these insects are really magnificent frauds, striking examples of the unwisdom of judging too closely by mere external appearances, for under their graceful and daintily tinted exterior exists the most destructive and bloodthirsty nature imaginable. If we closely watch the Dragon-flies as they hawk backwards and forwards over the pond, we shall see that ever and anon they swoop down upon some unfortunate winged insect, a May-fly, or some other member of the Diptera, or perhaps a small Butterfly, and proceed, while still on the wing, to bite off and let fall the legs and wings of their victim. They certainly capture far more of these insects than they can possibly consume, and seem to hunt down and tear their winged victims limb from limb, out of sheer love of wanton slaughter and destruction.

Nor is this singularly rapacious character confined to the adult insect, the Dragon-fly throughout the whole of its complete metamorphosis displaying a most sanguinary disposition. The female Dragon-fly deposits her eggs upon or just beneath the surface of the water; or, as is the habit of several species, may make incisions in the succulent, submerged stems of the water plants, depositing a single egg in each incision. The larvae soon make their escape, and spend their life hiding or stealthily creeping about amongst the stems of the plants at the bottom of the pond. They are generally of a brown or greenish hue, and have large heads, somewhat flatter than in the adult stage, and the compound eyes are set wider apart than in the perfect insect. The body is more or less cylindrical in shape, carrying three pairs of slender legs on the under-surface of the thorax, and the abdomen gradually tapers posteriorly, terminating in the rectal tracheal gills, which in some species project from the tip of the body as three semi-transparent leaflets. As the larva grows, it casts its skin from time to time, this stage of its life lasting for a year or more. The respiration of the Dragon-fly larvae is effected in more than one way, that is to say, in the early stages of their growth these larvae obtain the most, if not the whole, of their air supply by absorbing the dissolved air from the water by means of the rectal tracheal leaflets; or by drawing into the

FIG. 1. DYTISCUS LARVA IN THE ACT OF CAPTURING A VICTIM

FIG. 2. DRAGONFLY NYMPH ATTACKING A CADDIS-WORM

FIG. 3. WATER SPIDER DESCENDING FROM THE SURFACE OF THE WATER TO ITS NEST

FIG. 4. NEST OF THE WATER SPIDER FILLED WITH AIR WHICH THE SPIDER HAS BROUGHT DOWN FROM THE SURFACE OF THE WATER, ENTANGLED IN THE HAIRS OF HER BODY. SHE CAN BE SEEN INSIDE THE SEMI-TRANSPARENT NEST

rectum a volume of water from which the air is extracted by the fine tracheal branches lining the rectum; while later on, towards the close of the larval stage, the insect may, and in several species does, rise to the surface of the water and draw in through the thoracic spiracles a supply of air direct from the atmosphere. The vitiated water that has been drawn into the rectum may be either expelled gently and slowly when the insect is at rest, or suddenly and with considerable force should it desire to move quickly forward. Indeed, this sudden expulsion of water is often employed by the Dragon-fly larva to project itself rapidly forward so as to escape some approaching foe. There is no dormant stage in the life-history of the Dragon-fly that is equivalent to the pupa of a Butterfly, the so-called nymph only differing from the larva in the appearance on its back of the wing-cases containing the developing wings of the perfect insect; in all other respects it leads exactly the same life as the larva, sucking the blood of all unwary creatures that come within its reach, and moving slowly and cautiously amongst the submerged stems of the water plants.

The most extraordinary anatomical detail of the Dragon-fly larvae and so-called nymphs is the complex character of their lower "lip," which the insects employ in the capture of their prey. The Dragon-fly larva does not chase its prey, but lies in wait until its victim comes within reach, often remaining almost motionless for hours, clinging by its legs to the stem or branches of some water weed, until some unsuspecting creature comes within the range of the formidable lip. This lip, sometimes called the "mask," is very long, and bears a pair of sharp pincer-like palps; it is attached to a kind of jointed arm or chin, which is also of considerable length, by a sort of hinge, which permits it to lie close against the under part of the body when not in use. When an unsuspecting victim passes within reach, this formidable and telescopic organ is suddenly thrust out, and its sharp pincer fangs seize the unfortunate insect.

When about to undergo the final change, the nymph crawls up the stem of a water plant to the surface, and clinging by it legs to the stem of the plant, allows its body to dry in the sunshine. The first sign of the coming change is the cracking of the skin along the back of the thorax, the slit gradually extending upwards along the neck to the level of the eyes. Gradually the head and the thorax are completely withdrawn, and then the slender legs are disengaged from their sheaths, the insect arching itself backwards so as to more expeditiously accomplish their withdrawal. Once free from their sheaths, the legs are moved about for a few minutes, as if to test their flexibility, and then the insect rests perfectly motionless for a while, gathering strength for the final effort to free its body, an operation which requires considerable exertion. When at last the Dragon-fly has struggled free of its old skin, it has yet to fully develop the full length of its body, and to expand and dry its beautiful wings, before it can take its first flight. So it rests quietly on or beside the old husk from which it has escaped, until the body has grown to its full length and the wings have expanded and hardened. The late Alfred Lord Tennyson has left a very beautiful and accurate description of this final transformation in the following lines:—

> "To-day I saw a dragon-fly
> Come from the wells where he did lie.
> An inner impulse rent the veil
> Of his old husk: from head to tail
> Came out clear plates of sapphire mail.
> He dried his wings: like gauze they grew;
> Thro' crofts and pastures wet with dew
> A living flash of light he flew."

Of far more sombre appearance is the common Dytiscus Water Beetle (*Dytiscus marginalis*), another ferocious insect inhabitant of ponds and sluggish streams. It is in many ways an interesting and remarkable insect, leading a very active life in both the larval and adult stages of its existence, and undergoing a complete metamorphosis. In March and April, the female Dytiscus begins the work of depositing her eggs, making by means of her ovipositor an incision in the stems of the rushes below the surface of the water, and depositing a single egg in each incision. About three weeks later the larvae begin to emerge, and if there is a plentiful supply of food, grow very rapidly, casting their skins from time to time, and attaining their full growth in about five weeks from the time of hatching out of the egg. They then quit the water, and digging a chamber in the earth on the bank of the pool, change to pupae. In the summer the pupal stage only lasts about a fortnight or a little longer, but those larvae which bury themselves in the autumn probably only pupate with the approach of spring.

The larva of the Dytiscus Beetle is a very fierce and courageous creature, attacking minnows, sticklebacks, tadpoles, newts, the larvae of other aquatic insects, and, in fact, nearly every other inhabitant of the pond, including its own relations, so that it is frequently called the "water-devil." It has a large flat head, armed with a most formidable pair of pointed sickle-shaped jaws, which are hollow and have minute openings at the points, through which the juices of the prey are sucked. Its six legs are well developed and arranged in three pairs on the lower surface of the thorax, and the last or anal segment of the body is armed with a pair of curious gill structures, through which the insect takes in a supply of air, when it rises to the surface of the water to breathe. As the larva increases in size, it casts its skin from time to time, until it attains a length of two and half to three inches; it then quits the water, and having excavated a cell in the muddy bank, passes into the quiet pupa-stage of its life.

The fully developed Beetle is every bit as voracious and destructive as the larva, and is, indeed, a perfect terror to all the softer bodied inhabitants of the pond. With its massive body, and hard wing-cases protecting the large membranous wings, the Dytiscus Beetle is a veritable knight in armour, and like the knights of old is always ready to do battle. The wing-

FIG. 1. CADDIS LARVÆ WITH CASES MADE OUT OF PIECES OF LEAVES AND TWIGS

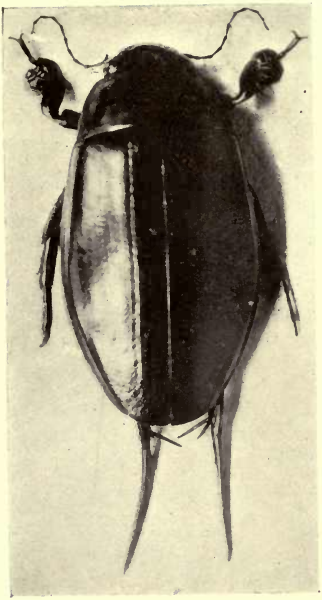

FIG. 3. THE MALE DYTISCUS BEETLE

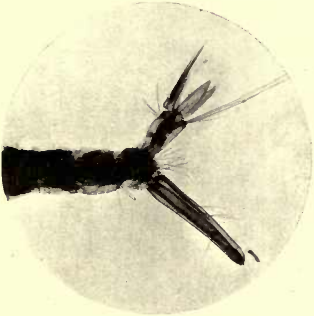

FIG. 2. THE RESPIRATORY TUBE, AND TAIL OF THE LARVA OF THE GNAT

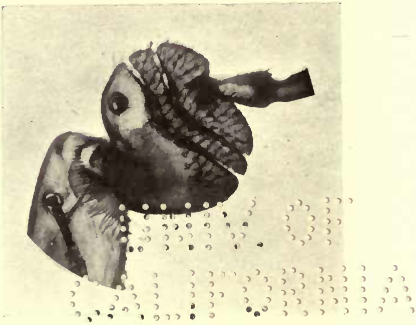

FIG. 4. FRONT LEG OF THE MALE DYTISCUS BEETLE, MAGNIFIED TO SHOW THE CURIOUS SO-CALLED SUCKERS

cases do not rest closely against the body, but are slightly arched, so as to leave a cavity between themselves and the insect's body, the cavity so formed acting as a kind of air reservoir. When the Beetle wishes to breathe, it rises to the surface of the pond, and slightly raising the wing-cases, takes in a quantity of air, which is drawn in by the large oval spiracles situated along the back.

The sexes are easily distinguished in the Dytiscus Beetle by the difference in the structure of the wing-cases, the males having perfectly smooth ones, while those of the female are generally, though not always, grooved. The first pair of legs also differ in the two sexes, those of the male Beetle having the three basal joints of the tarsus flattened and widened, and armed on the under surface with a number of small suckers or *cupules*, and with a pair of large ones. These suckers are used by the male as clasping organs, enabling him to securely grasp a slippery victim, and also to hold his ladylove in a firm embrace. In the female, the first pair of legs are quite simple and destitute of suckers. The second pair of legs terminate in a pair of well-developed claws, and are used chiefly for walking and climbing, while the third pair are flattened out and fringed with hairs, and serve as oars to propel the Beetle through the water. The second and third pairs of legs are similar in both sexes.

The Dytiscus Beetle spends most of its life in the water, where it hunts and captures its prey, but in the summer-time it frequently quits the pond during the afternoon and evening, and flies away to another. It seems highly probable that these migrations from one pond to another have helped to spread the Canadian Pond Weed (*Elodea canadensis*), which has become naturalized in England, as the Beetles have been observed coming out of ponds where the plant has established itself, with fragments of its stem attached to them. This plant, which is a native of North America, was first noticed growing wild in England in 1842, and again in 1847, since when it has spread to nearly every lake and river throughout Britain. So rapid and prolific is it in its growth, that many ponds have been quite choked up by it, and numerous shallow streams seriously affected. The stems of this plant are very brittle, and as the smallest fragment of a stem, if allowed to remain in the water, will develop one or two branches which in turn will throw out new growths, a luxuriant mass is formed in an incredibly short time. All kinds of water-fowl are fond of feeding upon it, and like the Dytiscus Beetle are very apt to bear fragments away with them, so that they also have undoubtedly helped in the spreading of this plant from one pond or stream to another throughout England.

The Great Water Beetle (*Hydrophilus piceus*) attains a length of about two inches, and with the exception of the Stag-beetle, it is the largest of our British Coleoptera. In the adult stage of its life it is a very handsome Beetle, and feeds almost exclusively on vegetable matter, only very occasionally preying upon the smaller inhabitants of the pond, and is quite a placid, inoffensive insect as compared with the Dragon-fly and Dytiscus. Although the Great Water Beetle is nearly twice the size of the Dytiscus, it frequently falls a victim to that bold and ferocious insect. It is easily distinguished from its foe by its greater size, its more convex form, deep glossy olive-black colour, less energetic motions in the water, for it is by no means so powerful a swimmer as Dytiscus, and in the way it works its legs alternately instead of simultaneously, so that it swims with a jerky motion.

The method by which the Great Water Beetle takes in its supply of air from the surface of the pond is quite different to that of the Dytiscus, which protudes its back above the surface of the water when it wishes to obtain a fresh supply of air. The Great Water Beetle rises head first to the surface where it inclines its body slightly to one side, so as to bring the angle between the head and the prothorax on one side of the body to the surface, and at the same time the antenna on that side is curved outwards and downwards in such a manner as to prevent the water entering the cleft between the head and prothorax. Through the opening so formed the air is drawn down by rhythmic movements of the body and wing-cases, and the beautiful silvery air film on the ventral surface of the body may be seen to alternately dilate and contract. Having by this means obtained a fresh supply of air, the Beetle once more dives beneath the surface.

The female Beetle is of considerable interest, for she possesses special silk glands or spinnerets at the base of her abdomen, and with their aid she produces the silky bag or cocoon in which she encloses her eggs. The celebrated Lyonnet's name will always be associated with the study of this interesting Beetle, on account of the beautiful and accurate drawings he made of the insect's anatomy, and his methodical observation of every stage of its life-history. I therefore give the following quotation from Lyonnet's historic narrative, in which he describes most graphically the way in which the female forms her cocoon: "I was particularly anxious to ascertain how the females constructed the floating cocoon which encloses their eggs. For this purpose I placed a few of these insects with some duck-weed in a large wooden trough on the last day of May. On the 1st of June I saw that one of the females, contrary to its usual custom, was incessantly swimming about, and searching on all sides. I expected that this was because she did not find materials suitable for her work, and as I had often seen a filamentous alga attached to the cocoon, it occurred to me to give her some of this. I floated it on the water by means of wooden shavings, and next day, the 3rd of June, I found the beginning of a cocoon, but the insect had abandoned her work, apparently because she had been disturbed by several other kinds of aquatic insects which lurked in the weed. I took them out of the trough, and before long had the pleasure of seeing the female Hydrophilus betaking herself to work under my eyes.

"The construction of the floating cocoon was effected in the following way. At first, lying upside down near the surface of the water, the Beetle buried the hinder part of her body and the two hindermost pairs of legs in the alga, leaving the first pair free, and making use of them to fit and mould the alga to the end of her body. She then began to weave the under side of her cocoon. While the weaving was going on she was careful from time to time to press and flatten the growing cocoon, moulding it with her fore feet against her body, and so giving it the form of a flattened arch. After the first piece, which was intended to form the upper side of the cocoon, was finished, the Beetle turned over and wove another piece, exactly the reverse to the first, to form the under side of the cocoon. The two curved surfaces then were woven together, and the body of the cocoon was finished, the work having occupied about an hour and a quarter. For about two hours after this the Beetle remained still, her back being uppermost. At first her body was buried in the cocoon up to the thorax, but one could now see that she was gradually withdrawing it. During these two hours of her apparent rest she laid her eggs, not at hazard, but in regular order, side by side, the pointed end uppermost. When the work had advanced so far that her body was completely withdrawn from the cocoon, she began to spin about the open mouth of the cocoon, so as to gradually narrow the opening. Then by spinning up and down she closed the end of the cocoon, giving it a truncated appearance. The next thing was to spin a little mast, which gradually rose above the surface of the water, the fore part of the Beetle during this part of the work being constantly immersed. On the 15th of July I observed an opening at the foot of the mast, and saw, floating round, whitish skins, either egg-shells or the envelopes of the larvae. Next day I saw a small larva emerge, and the day after fifty more."

On making their escape from their silken nursery the young mouse-coloured larvae set forth in search of food. Strange to say, instead of being chiefly vegetable feeders like their parents, they are carnivorous in their diet, and are almost as voracious as the larvae of Dytiscus, which they somewhat resemble in appearance. Their bodies, however, are thicker and more fleshy, and their mandibles broader and toothed, while whether at rest, or moving about at the bottom of the pond, both head and tail are slightly turned upward, so that the body always appears more or less curved. From time to time they rise towards the surface of the pond and stick their tails out to draw in through the last pair of spiracles which open at the tail, a fresh supply of air. The full-grown larva is a large insect, of a dark sooty colour, with the hard parts of both the head and the thorax of a lustrous brown. When about to undergo pupation the larva quits the water, and excavates a little chamber in the mud.

The Whirligig Beetles (*Gyrinidæ*) have gained their popular and scientific names from their peculiar habit of moving swiftly in circles upon the surface of the water. Throughout the summer, their rapid gyrations may be witnessed upon the surface of almost every pond or quiet stream. They seem to love to sport together in considerable companies, darting and circling swiftly in all directions, and ever and anon diving towards the bottom, and swimming about beneath the surface; their downward course through the water being easily observed on account of the large bubble of air, glittering like quicksilver, which they carry attached to the extremity of the body. They are small, blue-black coloured beetles, measuring about a quarter of an inch in length.

The Whirligigs pass the winter in a torpid condition, buried in the mud amongst the roots of the water plants. With the first warmth of approaching spring, they awaken, quit their winter quarters, and rising to the surface of the water begin their merry dances, and indulge in amatory embraces. As a result of the mating of these beetles (that spent the winter in a state of partial if not complete hybernation), eggs are deposited, and a new generation of larvae are produced which grow rapidly and, passing through their metamorphosis, emerge as perfect beetles just as the summer begins to wane, appearing in greatest numbers during the latter part of August and the beginning of September.

The female Whirligig Beetle deposits her elongated, oval-shaped eggs upon the submerged leaves and stems of the water plants, and from these eggs the curious centipede-like larvae soon emerge. They are carnivorous in their habits, their mandibles being pointed and perforated by a slit through which they suck the juices of their prey. The slender body of the Whirligig larva is nearly three-quarters of an inch in length, and the three pairs of legs attached to the under thoracic segments are moderately long and slender. Each of the first eight abdominal segments bears a pair of delicate, feathery gills, the ninth segment being provided with two pairs. The small tenth segment carries two pairs of long and sharp, curved hooks, which are used in climbing amongst the water-weeds, etc. Very few naturalists seem to have been able to observe, in its natural environment, the larva forming its cocoon in which to pupate. According to Modeer, the full-grown larva quits the water about the first week in August, by climbing up the stem of a water-plant, and then spins a greyish cocoon, which is pointed at both ends. Pupation then takes place, the perfect beetle emerging about the end of August or the beginning of September.

The large compound eyes of the Whirligig Beetle are divided into two separate portions, so that one-half of the facets are on the under surface, as it were, and the other half directly above. This curious division of the eye has been thought to be a special modification, enabling the beetle to keep a simultaneous watch aloft and below, but this theory needs verification by more careful observation. The three pairs of legs are interesting, on account of their special modification of form to meet the needs of the Beetle. The front pair are the longest, are slender, and in the male bear a number of curious circular, cement-secreting organs, somewhat similar to those on the front legs of the male Dytiscus, and used for the same purpose. The third pair are paddle shaped, broad, and capable of delivering powerful backward strokes as the insect swims through the water. The middle pair of legs are also used as paddles, but are not so broadly expanded as the third pair. The Whirligig Beetles make a curious squeaking noise just before taking flight, the sound being produced by rubbing the under side of the wing-cases against the end of the body. The beetle does not rise directly from the surface of the water in its flight, but first climbs up a plant stem, and then spreads open its long wings. When collecting Whirligig Beetles, it is necessary to handle them with caution, as when alarmed they exude from every joint of their body a milky fluid which smells most unpleasantly like cockroaches. They are most amusing and interesting little insects to keep under observation, but the aquarium in which they are confined should have its top covered with a gauze cap, or otherwise they will, after a good deal of struggling, probably climb up the glass and take flight.

During the summer nearly every weed-grown, shallow pond, covered with a green mantle of duckweed, will be found to contain a rather pretty, small and glossy-black beetle called Hydrobius. Its under surface is overspread by a bubble of air, giving it a silvery appearance; while its method of rising head-first, and poking one side of the head and thorax above the surface of the water, to take in a fresh supply of air, is very similar to that of the Great Water Beetle. It also has a curious habit of rising to the surface and turning over on its back, so as to cause the water-film covering the under side of its body to burst and enable it to respire freely. It will rest in this manner, upon its back, drawing in the air, and then, turning over, will once more plunge beneath the surface of the pool, taking with it a newly formed air-film on the underside of its body.

In April, and again about the end of August, the white silken cocoons filled with the eggs of Hydrobius may be found in great numbers, either floating at or near the surface, or loosely attached to the submerged stem of some aquatic plant. The minute larvae, directly they make their escape from the egg, are extremely active and predatory, and have large heads armed with a pair of very formidable jaws, which they open and shut in a most sinister manner. The larva draws its supply of air direct from the atmosphere by means of its tail, which has a sort of shallow cup upon the dorsal surface formed by a number of valves and flaps. As it always frequents shallow water, it has little difficulty in rising to the surface and sticking its specialized tail out to draw in a fresh supply of air; and while hanging thus head downwards from the surface, it will move its body about in all directions, seeking its prey. When full grown it quits the water and digs a little globular chamber in the moist earth, in which to pupate. If these larvae are collected for the purpose of being kept under observation, they should be placed in a tank with quite a shallow water supply, or they will inevitably drown, for they experience very considerable difficulty in rising from any depth to the surface of the water to take in a fresh supply of air.

Should we when hunting on a summer afternoon for aquatic insects, chance upon a stagnant pool or ditch, the bottom of which is well covered with fallen leaves, but whose surface is free from duckweed, we shall have an opportunity of observing every stage in the life-history of the Common Gnat (*Culex*); a life-history that is of the greatest interest and significance, because it is practically identical with that of the dread Anopheline Mosquito which is the transmitting agent of malaria from man to man.

Over the surface of the pool innumerable Gnats are performing endless airy dances. If we catch a few, and examine them closely, we shall see that they differ slightly from one another, the most marked feature being the difference in the appearance of the antennae, which in some of the captured specimens stand out from the head like beautiful plumes, while in others they appear almost like little wires sparsely clothed with short hairs. Should we carry our examination a little further, and observe with the aid of a magnifying glass the mouth-parts of the two kinds of Gnats which we have collected, we shall find still more remarkable modifications of structure, for we shall see that all those specimens which have simple antennae have their mouth-parts highly developed and adapted for piercing the skin and sucking up blood; while those specimens with the plume-like antennae have comparatively simple mouth-parts. These modifications of the antennae and mouth-parts are the distinguishing features of the two sexes; the specimens with simple antennae but complex mouth-parts are the females, and those with plume-like antennae but less complex mouth-parts are the males. The females, with their piercing lancet and tubular proboscis, are most blood-thirsty insects, and it is from this sanguinary habit that the females of certain species have become transmitting agents of disease.

The female Gnat (*Culex*) lays her eggs upon the surface of stagnant pools in curious boat-shaped masses, each tiny mass numbering some 250 to 300 eggs glued together with a sticky secretion. Each egg is pointed at the upper end, and is provided at the lower end with a lid, through which the larva ultimately makes its escape into the water. The Gnat larva on emerging from the egg, is a curious looking little creature, with a large head, a long slender body, and what at first glance looks like a forked or double tail. The body is destitute of limbs, but the front of the head is provided with vibratile bristles, which are used for sweeping into the mouth the particles of organic matter upon which the larva feeds. From the eighth abdominal segment is developed a curious cylindrical respiratory syphon through which the larva draws in its supply of air, and which is traversed by a pair of large air-tubes continued

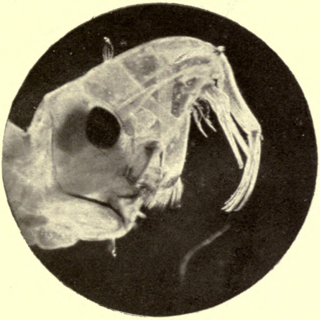

FIG. 1. HEAD OF THE GHOST LARVA (CORETHRA)

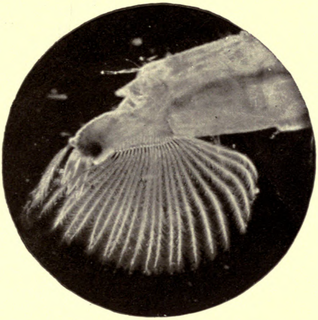

FIG. 2. THE BEAUTIFUL FAN ON THE TAIL OF THE GHOST LARVA (CORETHRA)

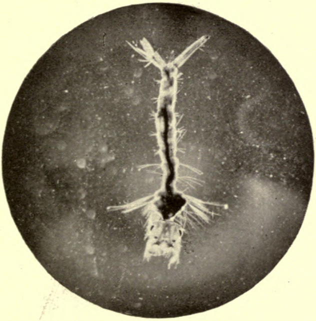

FIG. 3. LARVA OF THE GNAT, RISING TAIL-FIRST TO THE SURFACE OF THE WATER, TO TAKE IN AIR THROUGH ITS TAIL-LIKE RESPIRATORY TUBE

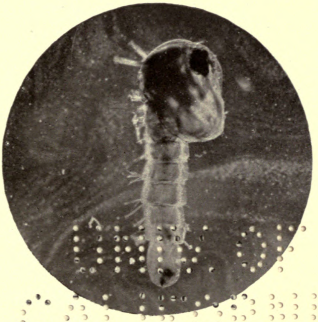

FIG. 4. NYMPH OF THE GNAT, RISING HEAD-FIRST TO THE SURFACE OF THE WATER TO TAKE IN AIR THROUGH THE BREATHING TUBES UPON ITS BACK

throughout the entire length of the body, carrying a supply of air to every part. The terminal segment of the abdomen, which is beyond the origin of the tail-tube, is fringed with bristles and terminated by five slender conical plates.

If a glass jar is carefully dipped in a stagnant pool so as to capture a number of these Gnat larvae, their movement may be conveniently watched. At first there is a great excitement amongst the little creatures at their sudden removal from the pool, and the larvae will be seen swimming about in all directions by curious wriggling movements of their bodies. In a very short time, however, they will calm down and assume their normal positions and movements. They will then be seen to rise and rest in such a position that the tip of the curious respiratory syphon is flush with the surface of the water. While hanging thus head downwards, the body of the Culex larva sways gently backwards and forwards as the insect sweeps the food into its mouth by means of the mouth-bristles. If we examine the tip of the respiratory tube under the microscope, we shall be able to see that it is provided with five flaps, which can be opened or closed at pleasure, and which when opened form a minute kind of cup which prevents the surface film of water entering the air-tube. When the larva wishes to descend towards the bottom of the pool, these flaps are tightly closed, so that the air within the respiratory tube cannot escape, When the larva once more rises to the surface, the pointed tips of these flaps meet the surface-film and adhere to it. The flaps are then expanded, and in an instant the tiny "cup" is filled with air. As the larva grows, it moults or casts its skin, and after three or four moults it is ready for pupation. The head-end now assumes a very strange appearance, having increased enormously in size, so that the whole of the front region of the body looks as if enclosed in a kind of fireman's smoke-helmet; the body has become much shortened, and now terminates in a pair of oval fins which are used in swimming.

The insect has now become an active pupa or nymph, and beneath its great helmet-like mask, the slender legs, the wings, antennae, and mouth-parts of the perfect insect can be traced. On the back of the nymph, just behind the head, are a pair of tubes, the respiratory trumpets through which the insect now draws its air supply, therefore there is no longer any need for it to hang head downwards, as in the larval stage. The encasing helmet makes it impossible for the insect to obtain food. The nymph is active swimming through the water with a jerky motion by means of a pair of oval plates or fins at the end of the body. It now always rises head, or rather back, first to the surface, so that the respiratory trumpets upon its back are brought flush with the surface; the water being prevented from entering the tubes by a coating of peculiar hairs which line and project from their inner surface. When the nymph first regains the surface, after one of its excursions below, the mouths of the tubes are covered with a film of water, which, however, becomes rapidly thinner by evaporation, and soon bursts, permitting a fresh air supply to be drawn in.

When the perfect insect is about to emerge, the nymph brings its body along the surface of the water so that the back of the thorax is well exposed; the skin dries and cracks, and then the perfect insect emerges, gradually extricating its legs, heads, wings, and body from the close-fitting nymphal sheaths. The empty nymph-skin now floats upon the surface of the water, forming a kind of raft, upon which the freshly emerged Gnat rests while its wings expand and dry, and its body and legs harden. This is quickly accomplished on a fine summer day, and the perfect Gnat then rises on its delicate outspread wings and flies away. In windy weather, however, when the surface of the pool is broken into ripples, the final transformation is fraught with considerable danger, and thousands of emerging Gnats are drowned.

The so-called Phantom Larva, the larva of Corethra, frequents still pools that are shaded by overhanging trees. It is two-thirds of an inch long, and has a wonderfully transparent body. This transparent body, coupled with the insect's habit of remaining absolutely motionless in the water for a long time, makes it by no means easy to detect, and it is this that has gained for the Corethra its popular name of Phantom Larva. It attacks and devours the smaller larvae of Gnats and Mayflies, and also the tiny crustaceans Daphnia and Cypris. Save for the beautiful fan composed of a row of feathered bristles on the under surface of the end of its body, used for propelling it through the water, the body of the Corethra larva is destitute of limbs. The head of the nearly full-grown larva presents a most striking and forbidding appearance, the great compound eyes giving the face a very grotesque expression. The antennae are not mere sensory organs as in most insects, but are used very largely in the capture of prey; they project forward and downward like fangs, terminating in four or five long bristles. The mandibles are well developed, and are furnished with four or five long, curved, almost finger-like teeth, which make them look like miniature hands. In the larval stage the Corethra has no spiracles, and but an imperfect tracheal system, which consists mainly of tubes running the whole length of the body; the tubes dilate in the thorax and again near the end of the abdomen into good sized air-sacs, filled with air, and are of dark colour owing to the presence of pigment cells. The nymph, however, draws in its air supply directly from the atmosphere by means of respiratory trumpets, in a very similar manner to the Gnat nymph, which it also somewhat resembles in appearance.

The so-called "Bloodworm" familiar to all anglers, and which abounds almost everywhere in stagnant water, is really the larva of a pretty little gnat-like fly called Chironomous. The pigment which gives the Chironomous larva its characteristic blood-red colour is identical with the hæmogoblin of vertebrate animals, and acts in the same way as an oxygen carrier, readily taking up dissolved oxygen, and gradually parting with it to the body tissues. With the help of the very abundant secretion of its salivary glands, the Chironomous larva weaves together particles of earth and leaves so as to form a kind of burrow in which it rests with its head projecting when feeding; or with the tail-end of its body projecting and waving to and fro in the water, apparently as a help to respiration, which is probably effected through the thin walls of the long flexible tubes attached to the last segment of the body. On account of the great transparency of its body, a young living Chironomous larva is a most interesting creature to examine under the microscope, as its internal organs can be quite clearly seen, and their functions easily observed. It is a wonderful sight to witness the heart of the larva at work. It is a transparent tube, on the dorsal surface and at the hinder end of the body, and the rhythmic contraction of its muscular walls driving the blood along the narrow dorsal vessel, which passes above the alimentary canal to the head, can be clearly followed. The nymph is readily recognized by the almost bushy tufts of respiratory filaments which project from the front of the thorax, and which replace the respiratory trumpets peculiar to the nymphs of most aquatic Diptera. The perfect insect is frequently to be observed in a very characteristic position, with its fore-legs raised, resting upon a window-pane. The antennae of the male are large, bushy, and somewhat cone-shaped; while those of the female are smaller and simple in character.

Probably the quaintest in appearance of all aquatic larvae are the Caddis-worms, who are the veritable "old-clo' men" of the ponds and streams. They are long, more or less cylindrical insects, with only the head, thorax, and legs horny, the rest of the body being quite soft, and it is the necessity of hiding their sleek and tempting bodies from their numerous hungry foes that has made the Caddis-worms adopt the "old-clo'" habit and manufacture out of the most varied materials the curious cases with which they clothe themselves. Tiny pieces of wood, small twigs, bits of leaves, small stones and grains of sand, and minute shells often still containing their living owners, are all pressed into service of the Caddis larva for the purpose of making its body-case; while a little careful observation will reveal the interesting fact that each species of Caddis affects some particular class of material for the construction of its case. Nor are all alike in their habits, some living in fixed cases at one spot, while others wander about freely at the bottom of the pond or stream by protruding the head and first two thoracic segments beyond the mouth of the case, and crawling, or half swimming, by means of the two front pairs of slender legs attached to the thorax. The third pair of legs are frequently tucked away inside the case, so as to help the insect to rapidly withdraw into its shelter. The larva has also on the apex of the abdomen certain hook-like appendages, which enable it to grip the interior of its case.

The cases, formed from such varied materials, give the Caddis larvae a very curious appearance, and make their movements far from graceful, their somewhat shambling gait still further reminding one of a decrepit "old-clo'" man. The cases are made with the aid of silky threads, with which the Caddis larva weaves together the material, bits of stick, leaves, shells, etc., which it collects for the purpose; the supply of silk being produced by special silk-secreting glands which have their opening in the labium of the insect.

When the Caddis larva is full grown, it makes ready for its change into the pupal state by shortening and partially closing each end of its case with silk and plant debris, or small stones. It may also at the same time considerably strengthen its case, and anchor it for greater safety to a stone or submerged plant-stem. Pupation then takes place, and lasts for a varying period in the different species, the pupa or nymph ultimately breaking out of its case and quitting the water, in order that the perfect, winged Caddis-fly may safely emerge. In some of the smaller species the pupae do not leave the water, but rise to the surface and float there, so that the perfect insect makes its escape in a similar manner to the Gnat. The construction of a case by a Caddis larva is a very interesting sight, and one that may be easily witnessed. The larva must be carefully removed from its case without injury. This will be best accomplished by gently slitting or breaking open the case with the help of a pair of micro-forceps. It is quite useless to attempt to pull the larva head-first out of the case, for the insect will generally rather be pulled to pieces than relinquish its hold upon the silken lining of its tube.

When the larva has been successfully removed from its case, it should be placed in a shallow dish or glass tank of water, together with a supply of pieces of stick, dead leaves, sand grains, or other material similar to that employed in the construction of the case from which it has been extracted. The larva will at once begin to select from the materials provided such portions as may meet its requirements, and proceed to form them into a new sheath around its body, the whole operation of building the new case taking from one to three or four hours. Reaumur, who did so much to awaken an interest in, and advance the study of, insect life, has left a singularly clear and interesting account of his observations of the Caddis-fly in all the stages of its life, and gives the following summary on the peculiarities of the perfect insect: "The Caddis-fly exhibits some marked peculiarities of its own. In the classification of Flies, we might assign to them the name of *papilionaceous*, that is, Flies which at first sight resemble Butterflies. These papilionaceous Flies have four wings, of which only the two upper are visible when the insect is at rest. In this position the upper wings are nearly flat above, then they bend at an angle and slope downwards. These two upper wings are moderately transparent, but appear opaque when they overlie the others. It is their opacity which causes them to resemble Butterflies' wings, but on close examination we see that they have none of the scales which are characteristic of the wings of Lepidoptera. The lower wings are very transparent; they consist of a colourless or slightly bluish gauzy membrane. The fly immediately after emergence, and for some days subsequently, has a greenish tint; then it gradually turns dark. The six legs are long, but the fly does not stand high above the surface on which it rests. The antennae are very long, longer than the body, gradually tapering, and of many joints. The legs are compound, like those of other Flies and Butterflies."

The graceful, pretty May-flies have gained their scientific name of *Ephemeræ* from the extreme shortness of the life of the perfect insect, for the majority perish a few hours after reaching their full development. They are delicate, soft-bodied insects, with long, slender abdomens with two or three very long, jointed filaments; while the graceful wings, of which the front pair are the largest, the back pair being smaller or altogether absent, are often very beautifully reticulated. In the perfect winged stage, the mouth of the May-fly is quite rudimentary in structure, so that the insect cannot take in any food, and the short hours of this climax of its existence is devoted to sexual intercourse for the perpetuation of the species, and to light, airy dances over the surface of the pool in which the early stages of its life had been spent. Enormous swarms of these insects suddenly appear for two or three evenings in succession, and then are seen no more until the following year at the same season; a phenomenon due to the fact that these insects are always produced in great numbers, and that the whole of the members of a species within a certain area will reach maturity almost simultaneously.

Although the perfect May-flies are such familiar insects, much still remains to be accurately observed and recorded concerning the length of time occupied by the larval and nymphal stages. These early stages are spent entirely in the water, and appear to last for two or three years, during which time several moults or casting of the skin take place. The larvae are curious looking creatures, and easily recognized, their mouths are well developed, and many of them seem to be exceedingly predaceous in their habits. While some species in the larval stage lead an active life crawling about amongst the debris at the bottom of the stream or pond, others make remarkable chambers with double openings, so that they can enter from either end, in the mud of submerged banks. The larva has a somewhat flattened body, tapering at each end, long bristle-shaped antennae, two or three long plume-like bristles at the extremity of the body, and a series of paired branchial leaflets attached to the sides of the abdominal segments. The nymph resembles the larva in general appearance, except that wing-cases containing the developing wings of the perfect insect are present on the thorax. This nymph in due course quits the water, and very shortly after there emerges from it what at first appears to be the perfect insect, but which, although able to use its wings sufficiently to fly a short distance to some suitable resting-place, is not really quite perfect, for all its parts are covered by an extremely delicate pellicle, hiding the true colours of the perfect insect. This sub-imago, as it is called, attaches itself to any convenient resting-place near the pond or stream, and then, after a short interval that varies slightly in its duration in the different species, the delicate outer skin is ruptured and the perfect insect emerges, with brighter wings and longer caudal bristles, and flies away to spend the brief period of its perfect existence in courtship and merry dancing.

A small, rather compactly built Spider, about half an inch long, and of a deep ashen colour, may frequently be seen running in sudden swift spurts over the floating leaves of the water plants. Its body is densely clothed with fine hairs, the use of which are immediately realized when the Spider dives into the water; for they carry down a supply of air in their interstices, and so enable the Spider to breathe while under water. When the Water-Spider's body is submerged, this coating of hair gives it a very beautiful appearance, as if it were partially coated with burnished silver. The Water-Spider is a most interesting creature in its habits, and may be kept under observation very easily in an aquarium containing growing water plants and a few small aquatic larvae, etc. It will then be seen that the Water-Spider not only spends the greater part of its life beneath the surface of the water, but that it pursues its prey and constructs its nest therein. The Water-Spider builds itself a dome-shaped nest, attached by a series of silken threads to the surrounding stems of the water-weeds, and these threads also act as telegraph lines, warning the Spider when resting within her nest of the approach of prey or foes. When the waterproof silken nest has been constructed, the Spider ascends to the surface and for a moment sticks her body out into the air; she then rapidly descends, taking with her a supply of air imprisoned by the fine hairs covering her abdomen. She at once enters her nest, and proceeds to comb out the imprisoned air bubbles with the aid of her comb-like feet. Again and again she visits the surface and returns with a fresh supply of air, which she at once discharges under her dome-shaped nest until it becomes inflated by the imprisoned air, after the fashion of a diving-bell, and looks as if filled with quicksilver. Within the diving-bell home the Water-Spider spends the greater part of its life, only quitting it in search of food, or to bring down a fresh supply of air to replace that which has been exhausted.

CHAPTER IV

INSECT ACTORS

THE foes of insects are very numerous, and therefore it is not surprising to find how very perfectly and wonderfully Natural Selection has played its part in gradually adapting these more or less defenceless creatures to their environment, and in supplying them with the means of escaping the notice of their enemies. Indeed, nowhere shall we find such striking and remarkable examples of protective mimicry as amongst the denizens of the insect world. Nor is it necessary for us to go far afield in our search, for every English country lane, woodland, and garden will be found to contain these insect actors.

Protective resemblance, with which insect mimicry is intimately associated, is one of the most interesting and remarkable phenomena in nature. Throughout the insect world thousands of creatures are to be found that in colour, form, and attitude, so closely imitate some object in their environment, as to be practically indistinguishable from the leaf, twig, moss or flower that they impersonate.

Protective coloration is of course known to exist throughout the animal kingdom, but it is amongst the denizens of the insect world that it has been brought to the greatest state of perfection; and when we consider the extreme fragility and helplessness of the majority of insects, and how they are preyed upon by bird, beast, and even members of their own tribe, the reason of this at once becomes apparent; for it is obvious that these defenceless creatures must have some means of protection from their innumerable enemies, if they are to hold their own in the universal struggle for existence.

Concealment naturally suggests itself as the simplest and most effective way in which these frail creatures can escape the onslaught of their foes, and so gradually, by a process of natural selection, the wonderful phenomena of protective resemblance and mimicry have been evolved; and it is those insects that have most readily adapted themselves to their environment, that have been most successful in warding off the attacks of their enemies and survived to perpetuate their species.

Colour plays a most important part in protective resemblance. In the old days the beautiful and varied colouring of insects, birds, and flowers was considered to have no special significance, but simply to have been created to please the eye and beautify the world; but thanks to the researches of Charles Darwin, and the investigation and experiments of such well-known naturalists as Bates, Belt, and Wallace, we now know that colour is a most important factor in nature, and has a direct bearing on the welfare of the insect world.

Insects that are protectively coloured are very numerous; in every country lane, field, woodland, and garden they will be found. Butterflies that, when their wings are closed, look for all the world like withered leaves; moths exactly similar in colour and markings to the bark of the trees on which they rest; beetles so like the ground, lichen, or moss on which they crawl that it is only when they move that their presence can be detected.

Most night-flying moths (*Noctuæ*) have protective colouring, so that they may escape observation when resting by day. Although, as the dusk begins to deepen in the pine woods, the beautiful Pine-hawk moth is easily seen, flitting ghost-like on graceful, tapering wings, it takes a keen, practised eye to find it during the noontide hour, when it rests with closely folded wings upon the mottled trunk of a pine tree.

The pretty little buff and silver Buff-tip moth is another remarkable example. Seen in the collector's cabinet its markings look distinctive enough not to be easily overlooked; but when in its natural environment, resting on the bark of a silver birch, or on a lichen-covered limb of some stately forest oak, it very easily escapes detection; while the Lappet moth (*Lasiocampa quercifolia*) looks so like a brown leaf that it is easily passed over when it is resting motionless on the branch of a tree.

The Clifden Nonpareil nearly always settles upon old oak park palings, but it is very difficult indeed to find a specimen; so wonderfully do the soft grey colourings and markings on its broad upper wings harmonize with the fence on which it rests, that it is quite invisible at a distance of three or four feet.

Caterpillars show protective colouring in a very marked degree. A number of species are green, so that they blend perfectly with the plant on which they feed; and it is noticeable that larvae that feed on leaves have oblique markings, while those which are grass feeders are striped longitudinally, the stripes and spots being generally coloured to correspond with the flower of the plant which is the insect's natural habitat.

To thoroughly appreciate the wonderful force of protective resemblance, we must go out into the fields and lanes and discover examples for ourselves; as many insects that are protectively coloured appear so brilliantly tinted when seen away from their natural environment, that it seems impossible that they can ever be anything but conspicuous. Take, for instance, the larva of the Privet Hawk moth (*Sphinx Ligustri*); with its large, brilliant green body and purple markings it would seem almost impossible that such a conspicuous creature could ever be overlooked; and yet again and again it will be passed over, even by an experienced entomologist, when in its natural surroundings. For we have to take into consideration not only the colour of the insect, but the varying effects of light and shadow, that contribute in no small degree in screening it from observation.

The larva of *Papilio machaon* (one of the

European Swallow-tails) is another strikingly marked caterpillar that is perfectly protected when on its food plant; it will be found on various umbelliferous plants in the fen districts. In colour it is a bright green, with black stripes spotted with yellow, a very conspicuous object when seen in a collector's cabinet, and yet in its natural habitat it is exceedingly difficult to find this caterpillar, so wonderfully does its vivid colouring blend with its surroundings.

So far we have considered some of the simplest forms of protective resemblance, in which the insect harmonizes so perfectly with the general colouring of its surroundings that, in its natural environment, it becomes practically lost to view. In other examples the insect mimics some particular object both in shape and colour, and still further adds to the deception by the realistic attitude it assumes.

The Caterpillars of the Geometer Moths, commonly called "loopers," are typical examples of this more intricate form of protection. The loopers mimic the twigs and shoots of their food plant in a wonderfully life-like way. Clasping the stem with the hind pair of pro-legs they incline their bodies outward at a sharp angle, and in this position will remain motionless for hours. So deceptive is the appearance of these Caterpillars that a well-known naturalist, Mr. Jenner Wier, said: "After being thirty years an entomologist I was deceived myself, and took out my pruning scissors to cut from a plum tree a spur which I thought I had overlooked. This turned out to be the larva of a Geometer two inches long. I showed it to several members of my family, and defined a space of four inches in which it was to be seen, but none of them could perceive that it was a Caterpillar."

It is in the tropical countries, however, that the most astonishing instances of protective resemblance and mimicry occur. One of the most well-known examples is the "Indian leaf butterfly" (*Kallima inachus*). On the upper surface the wings of this insect are a deep bluish or purplish tint, with a band of rich orange colour across the fore-wings, so that it is a very conspicuous object when on the wing. Yet when this brilliant Butterfly alights on the branch of a tree, in the dry Indian forests that it frequents, it is quite lost to view, as its wings on the under surface are exact replicas of the withered leaves with which it is surrounded.

When at rest, the insect folds its wings over its back, and raises its head so that it is concealed between them; while the short, blunt tail of the hind pair of wings rests upon the branch to simulate a leaf stalk. A long, curved line runs from the tail to the tapering tip of the fore-wings, corresponding to the mid-rib of a leaf, while on each side of the line are oblique markings to represent the veins.

The colour of the under surface of the wings is remarkably variable, and it is extremely unusual to find two specimens exactly alike. Some are a deep reddish-brown, others a faded yellow, or a dull olive green; yet, whatever tint the wings may be, they always resemble leaves in some stage of decay. So perfectly is the imitation carried out that the paler and more decayed looking wings even bear clusters of dark spots upon their surface, which gives them the appearance of being attacked by fungus.

Perhaps the strangest and most remarkable family of insect actors are the *Phasmidæ* or leaf, grass, and stick insects. These singular creatures belong to the Orthoptera, and are inhabitants of the warmer regions of the world. Those in the tropics grow to very large size, sometimes measuring as much as ten or twelve inches in length. All this group have developed the art of simulation to a most astonishing degree; and carry out the deception so thoroughly that even in the hand it is often difficult to tell whether they really are insects, or the stick, grass, or leaf they so marvellously impersonate.

The Phasmidæ are nocturnal in their habits, resting during the daytime in stiff, motionless attitudes upon the plants and shrubs on which they feed. When dusk approaches these weird-looking, dried sticks and twigs suddenly come to life, and creep about with slow and stealthy motions in a most uncanny manner. From their spectre-like ways and appearance these insects have gained their family name of "Phasmidæ," and are sometimes popularly called "Ghost insects."

One species of stick insect found in Africa is exactly like a dried-up wisp of hay, and is so extremely attenuated that squeezing it between the fingers makes no impression on it whatever. When at rest upon the long grass on which it lives, the insect flattens its body closely against the stem, with its fore-legs stretched out straight in front of it so as to form a continuous, thin line practically inseparable from the grass, while the other legs and the antennae stick stiffly out to represent small spikes or blades.

As the colour of the grass varies with the seasons of the year, the insects also change in hue; when, after the rainy season, the grass is fresh and green, green grass insects will appear; then, as under the tropical sun the grass changes to yellow, brown or red, so will the Phasmidæ vary to tone with their surroundings; even when the grass becomes decayed the strange creatures follow suit, and adopt black spots and markings to simulate fungus growth!

Another variation is the "Moss insect." Its twig-like body and legs are covered all over with olive green tufts, so that it looks exactly like a rotten, moss-covered twig. This species is a native of Borneo, and frequents mossy places and lichen-covered trunks of trees.

There are two species of the Phasmidæ to be found in Europe, but these do not attain such a large size as those in tropical regions. "Rossi's Stick Insect," a native of Italy and the south of France, is about two and a half inches in length and mimics a dead twig.

A remarkable member of this family is *Phyllium siccifolium*. This insect departs from the usual custom of its tribe of mimicking twigs and grass, and counterfeits a compound leaf. The large, flat body and the wing-cases are a vivid green, and marked so as to represent the veining and reticulations of a leaf; while the upper parts of the legs (the *femora*) are expanded in the shape of smaller leaves.

Phyllium siccifolium is an inhabitant of East India, and is so extraordinarily leaf-like that many of the natives believe it to be a sort of compound animal and vegetable organism, and sometimes make small artificial trees by binding sticks together to form branches, and fastening upon them numbers of stick insects to represent the leaves.

In direct contrast to the insects that seek to protect themselves by self-effacement are those whose chief aim and object is to render themselves as conspicuous as possible, and by donning the brightest and most startling hues, and flaunting them in the full light of day, seem to court observation and defy the world.

It has been proved by experiment that these brilliantly coloured insects are generally distasteful to insect-eating birds and beasts, or they may be provided with a natural weapon in the form of a sting, which renders them harmful, and dangerous to meddle with. Now, the safety of this type of insect lies in being quickly recognized as disagreeable or harmful, so they have acquired these warning colours as a protection; the vivid hues and conspicuous markings act as danger signals to their natural enemies, who pass them by when on the look out for a meal.

Warning coloration is particularly noticeable in many species of larvae. The conspicuous, gaudy Caterpillars in most cases possess unpleasant juices which make them distasteful to birds, and so are left severely alone by insect feeders.

It has been noticed that birds will not touch the larva of the Magpie Moth (commonly called the gooseberry caterpillar), a striking-looking Caterpillar that has a creamy body marked with orange-coloured stripes and black spots; or the larva of the Fig. of 8 Moth, a bluish-grey Caterpillar with vivid yellow stripes and black spots. Both these Caterpillars do a great deal of damage to bush fruit and fruit trees, and, as the birds do not check their ravages, are very troublesome pests.

Amongst the Butterflies there are several families that are distinguished by warning colours, the best known being the *Heliconidæ* of South America, the *Danaidæ* of Southern Asia, and the *Acræidæ* of Africa. All these Butterflies have unpleasant juices which render them inedible, and possess the power of exhaling a powerful and unpleasant odour when disturbed or alarmed. They are very conspicuous insects and never attempt to conceal themselves, but rely on their distinctive colouring and slow characteristic mode of flight to protect them from attack.

Now, a most remarkable and interesting fact in connection with these insects that are protected by warning colours, is that many of them are so closely mimicked by other insects belonging to entirely different families or Orders, that it is only an expert entomologist that is able to tell them apart. In every case it has been found that the mimicking insect belongs to an edible

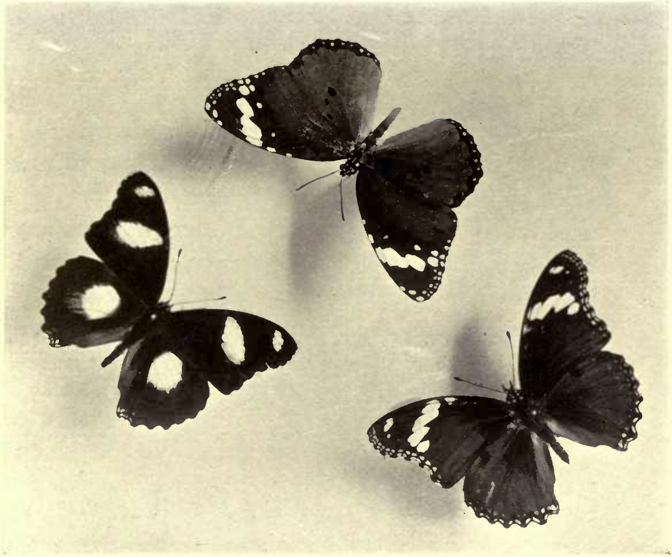

FIG. 1. THE UPPERMOST BUTTERFLY IS LIMNUS CHRYSIPPUS, A BUTTERFLY THAT IS DISTASTEFUL TO BIRDS. BENEATH ARE THE MALE AND FEMALE HYPOLIMNUS MISIPPUS (EATABLE BUTTERFLIES). NOTE HOW CLOSELY THE FEMALE MIMICS THE APPEARANCE OF THE DISTASTEFUL BUTTERFLY

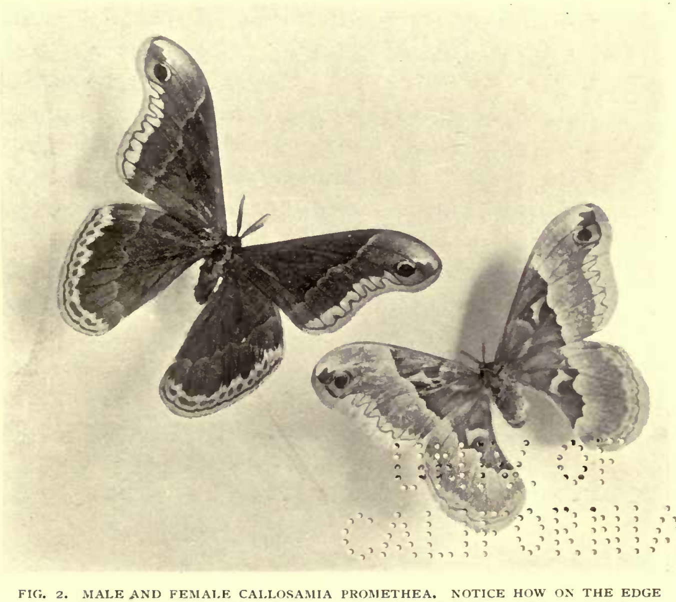

FIG. 2. MALE AND FEMALE CALLOSAMIA PROMETHEA. NOTICE HOW ON THE EDGE OF THE WINGS THE FACE AND UNDER-SURFACE MARKINGS OF A SNAKE ARE MIMICED

variety that, but for its remarkable resemblance to the unpalatable or dangerous species it copies, would readily fall a prey to insect feeders. It is this form of protective resemblance that constitutes *true mimicry*, and Wallace has defined the following general condition as being characteristic of this class of protected insects :

"1. That the imitative species occur in the same area and occupy the very same stations as the imitated.

"2. That the imitators are always the more defenceless.

"3. That the imitators are always less numerous in individuals.

"4. That the imitators differ from the bulk of their allies.

"5. That the imitation, however minute, is *external* and *visible* only, never extending to internal characters or to such as do not effect the external appearance."

Bates, in his travels on the Amazon in 1847, was the first to observe and comment upon the wonderful similarity that exists between certain Butterflies belonging to quite distinct families, and the reason of the resemblance. He noted no less than fifteen species of the *Pieridæ,* a family of Butterflies that have a wide distribution, and to which our cabbage white belongs, that closely imitate different species of the conspicuous and inedible Heliconidæ.

Several species of the genus *Papilio* (Swallow-tailed Butterflies) mimic the Danaidæ of tropical Asia; a brilliant group of Butterflies, some species being a glossy blue-black colour, with white or rich blue markings, some greenish or rich brown with lighter markings, while others are white and semi-transparent with dusky spots and marks. All the members of the Danaidæ family are recognized by insect feeders as unpalatable morsels by their distinctive colouring, so that the Papilios, by their wonderful resemblance to the protected Butterflies, escape destruction and thus reap the benefit of their mimicry.

There are several species of mimicking Lepidoptera found in Africa, and in many parts of Asia. In fact, there are few countries in which some examples of this type of insect mimicry are not present; and although Europe is not so rich as the tropical countries in these brilliant-hued, protected Butterflies, there are a few instances on record in this country of edible species mimicking others that display warning colours.

Occasionally the female alone departs from the original colouring of her allies, while the male remains true to type. In these cases the female Butterfly or Moth is the more brightly coloured of the two—a very unusual thing in the insect world, where, in the ordinary way, the male far outshines the female in splendour of adornment.

Several of our European clear-winged Moths mimic different species of the Hymenoptera, which, being provided with a formidable weapon in the shape of a sting, are less liable to the attacks of birds.

The Bee Hawk Moths (*Bombyliformis* and *Fuciformis*) mimic the humble-bees, and in the early summer months may be seen in company

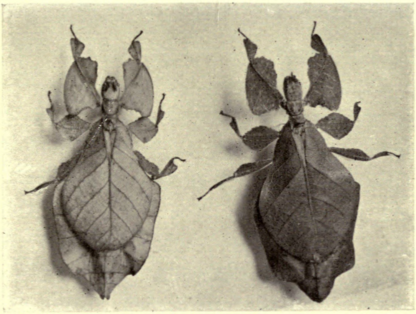

FIG. 1. WALKING LEAF-INSECTS (PHYLLIUM SICCIFOLIUM), WHICH ESCAPE THE NOTICE OF THEIR FOES BY MIMICING THE SHAPE AND COLOUR OF LEAVES

FIG. 2. THE CLIFDEN NONPAREIL MOTH AT REST ON AN OAK FENCE

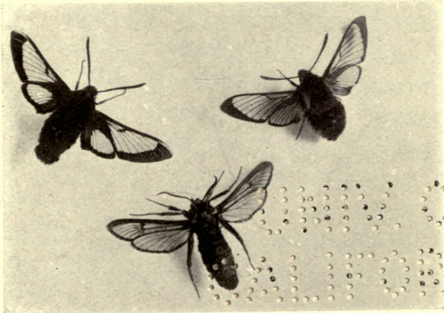

FIG. 3. DAY-FLYING CLEARWING HAWK MOTHS THAT MIMIC BUMBLE BEES AND HORNETS

with the bees hovering over the Azalea and Rhododendron bushes in several parts of the country. In the Rhododendron Walk in the New Forest these moths are fairly common, and it is a charming sight in early June, when the dark-leaved shrubs are a mass of fragrant blossoms, to watch them hovering over the flowers. At first sight it is difficult to distinguish the moths from the bees they imitate, but they may be detected by their different mode of flight and greater length of antennae.

The Hornet Clear-wings (*T. apiforme* and *T. crabriforme*) copy the Hornet in their appearance; they may be found in June in many parts of England, on the trunks of poplar trees and willows, and are so remarkably hornet-like that few people would care to handle them.

The Humming Bird Hawk Moth is fairly common in England, and may be seen in many parts of the country in July and August sucking up honey from the flowers with its long proboscis. A species of Hawk Moth common in South America is so wonderfully like the humming-bird in shape, colour, and mode of flight that they cannot be distinguished when on the wing. The naturalist Bates gives the following interesting description of this moth in his book, "The Naturalist on the River Amazon": "Several times I shot a Humming Bird Hawk Moth instead of a bird. This moth (*Macroglossa Titan*) is somewhat smaller than the humming-birds generally are; but its manner of flight, and the way it poises itself before a flower whilst probing it with its proboscis, are precisely like the same actions of humming-birds. It was only after many days' experience that I learnt to distinguish one from another when on the wing. This resemblance has attracted the notice of the natives, all of whom, even the educated whites, firmly believe that one is transmutable into the other. They have observed the metamorphosis of caterpillars into butterflies, and think it not at all more wonderful that a moth should change into a humming-bird. The resemblance between the hawk moth and the humming-bird is certainly very curious, and strikes one even when both are examined in the hand. Holding them sideways, the shape of the head and the position of the eyes in the moth are seen to be nearly the same as in the bird, the extended proboscis representing the long beak. At the tip of the moth's body there is a brush of long hair-scales resembling feathers which, on being expanded, looks very much like the bird's tail. But, of course, all these points of resemblance are merely superficial. The negroes and Indians tried to convince me that the two were of the same species. 'Look at their feathers,' they said, 'their eyes are the same, and so are their tails.' This belief is so deeply rooted that it was useless to reason with them on the subject."

Even in England people will sometimes mistake the Humming Bird Hawk Moth for the bird. A gentleman, on his return from a visit to Devonshire, once gravely informed a naturalist that humming-birds were to be found there, as he himself had seen them flying about.

Certain of the Diptera mimic the Hymenoptera. The Surphus flies are extremely wasp-like with their gaily striped yellow and black bodies, and a great many people mistake them for the more aggressive insect. The Volucella also mimic wasps and bees in their outward appearance: one member of this family, *Volucella bombylans*, precisely resembles a small, hairy bumble-bee. The particular advantage this fly gains by the similarity is that thus disguised it can enter the nests of the bees and deposit its eggs without being observed, and so provide food for its young, who, when they emerge from the eggs, feed upon the larva of the bumble-bees. Several other species of Diptera mimic bees, most of them being parasitic in the larval stage, and living in the nests of solitary bees.

Several species of Coleoptera have become adepts in passing themselves off as belonging to entirely different Orders of insect. In the tropics many of the Longicorns appear in the guise of wasps, bees or ants, in order to escape the persecution of insectivorous birds, who are particularly fond of this type of beetle. The wing-cases of the Longicorns that mimic hymenopterous insects have become much shortened, so that the membranous wings have freer play, and the yellow banded bodies are exposed. In some species the abdomen is constricted at the base into a narrow wasp-like waist, and others that mimic bees have tufts on the hind legs to represent the pollen-gathering *tibea* of the hymenopterous insect.

Some of the Coleoptera are themselves

imitated by other species of their own Order, or by a different type of insect; and it will always be found that the mimicked beetle either possesses an offensive weapon of some description, or is protected by being distasteful, or by the excessive hardness of the *elytra* (wing-cases) and integument. The Tiger-beetles are mimicked by harmless and inoffensive species of Coleoptera, and several genera of weevils are imitated by softer and more eatable species of beetles; while in the Philippine Islands a cricket is found that is so absolutely like one of the Tiger-beetles that even experienced entomologists have been known to place it in their cabinets amongst the Coleoptera.

Still another form of protective mimicry is shown by certain insects that seek to terrify their enemies by a deceptive resemblance to a venomous snake or bird of prey. Bates describes a large caterpillar inhabiting South America which once startled him, when he was on a collecting expedition, by suddenly thrusting its head out of a bush, and so wonderfully did the insect resemble a small species of poisonous snake that for the moment he was quite alarmed.

The North American Silk Moth (*Callosamia promethus*) adopts this terrifying mode of protection. The rounded margin of the insect's fore-wings mimic the contour of a snake's head, while the markings down the edge of the wings are identical in shape and colour to the broad scales on the under surface of a snake's body. The Moth has a curious habit when at rest, or crawling slowly about the leaves and stems of plants, of keeping up a constant, gentle, fanning motion of the wings, which, when seen from a short distance away, gives them the appearance of a snake's head in the act of striking.

Many of the butterflies and moths have large spots on their wings that closely resemble great eyes, and serve to frighten off small birds and beasts. There is a very pretty Canadian moth, called the "Peacock Moth" from the eye markings on the under-wings, which, like our Lappet Moth, rests during the hours of bright daylight amongst the brown autumn foliage. But this Peacock Moth appears to be even better protected from its foes than the Lappet Moth, for it has, near the margin of each under-wing, a large and beautifully coloured eye-spot, which, in combination with the general markings of the wings, has the appearance, when suddenly viewed from above, of the face of a small owl. As this moth crawls over the leaves preparatory to taking flight the motion of the wings heightens the effect of the eye-spots to a most remarkable degree, so that they appear to move as if actually watching some object.

There are certain insects that use their deceptive talents in an aggressive, instead of a defensive, manner. Chief amongst these are the *Mantidæ*. They are entirely carnivorous in their habits, and use their alluring colours to attract the flies and other insects upon which they feed.

The Mantidæ have a wide distribution and vary considerably in different parts of the world, but all are distinguished by the great length of the fore-legs, which are developed into powerful organs for seizing their prey. The African Mantis simulate different kinds of leaves to perfection, their general colour scheme being green in varying tones; while in the deserts of Arabia and North Africa they are exactly the same colour as the sand upon which they crawl.

The strange way the Mantidæ have of raising their fore-legs as they rest or move slowly about has given rise to many quaint ideas about these creatures. In ancient times the natives of Arabia believed that the insects pointed out the right way to travellers who had lost themselves in the desert, and from this old superstition they have gained their name of "Mantidæ" from Mantes or Soothsayer. In some parts of Europe these quaint insects are called "praying Mantis" (*Mantis religiosa*), and there is an old legend that St. Francis Xavier, once seeing a Mantis moving along with its legs raised as if in prayer, commanded it to sing the praises of God, and the creature immediately raised its voice in a beautiful canticle!

Unfortunately for the truth of these picturesque ideas, the devotional attitude of the Mantis is assumed so that it may be in readiness to seize its prey as soon as it comes within striking distance; and far from being the benevolent and devotional insect these old myths imply, the Mantis is in reality a most voracious and cunning creature.

So that they may the more readily capture their prey many species of Mantidæ assume the form and colouring of flowers. One found in

India looks exactly like a beautiful pink orchid. The Mantis takes up its position on some plant with bright green foliage, and patiently awaits the arrival of any small moth or fly that may be attracted by what appears to be a bright, conspicuous flower; then directly the deluded insect alights upon the Mantis it is seized and devoured.

Other species of the Mantidæ are white, purple, or a beautiful violet-blue in colour, and so wonderfully flower-like are they in every way that even botanists have been occasionally deceived by them.

Many spiders, too, practise the art of alluring their victims by simulating some harmless looking object. Some mimic the droppings of birds, and lie motionless upon a leaf waiting to clutch the unwary insects that alight upon it. *Thomisus citreus*, one of our British spiders, mimics the creamy, white buds of the wayfaring tree, amidst which its lurks waiting for its prey in the shape of flies who visit the blossoms.

The meadow thistle and wild orchid are also used as hunting-grounds by the Thomisidæ family, and so cunningly do they vary in tint and marking, to suit the flower of the particular plant on which they lie in wait for their victims, that although openly exposed to view it is practically impossible to detect their presence.

The way in which insects have acquired these numerous disguises, and become so wonderfully adapted to their particular mode of life, is one of the most interesting subjects in natural history. All these perfect examples of mimicry and protective resemblance have been brought about by a gradual process of evolution that has been going on for millions of years. If we consider the extreme variability of insects, the rapidity with which generation succeeds generation, and the intense and constant struggle for existence that has been going on since the earliest chapters in the history of the world, we shall more readily understand how this has come to pass.

Take, for example, the case of a species of Papilio, an edible butterfly that mimics the distasteful Danaidæ. In the early ages of the world, while the Danaidæ were gradually acquiring the distinctive colouring that was necessary for their preservation, some of the Papilio, by an accidental variation, happened to be mistaken for the obnoxious Danaidae, and were passed over by the birds. This variation of colouring would naturally be transmitted by the Papilio to some of their progeny. Those that were most like the Danaidæ would probably escape destruction, while those not so similar would be detected and devoured. The survivors again handed on the protective marking to their descendants, and so through succeeding generations the resemblance became gradually perfected.

In the same way those insects that by some chance were sufficiently like a leaf, twig, or flower to escape the sharp eyes of their enemies, gradually, through succeeding generations, became more and more like the mimicked object, the less adaptable insects being in process of time gradually exterminated until the protective resemblance became complete. This wonderful process of evolution is still going on around us to-day, and instances of mimicry and adaptation are to be found all over the world; and although through the researches of eminent scientists we are acquainted with a vast number of examples of this interesting phase of insect life, there is still much to be learned and discovered, and this branch of Natural History offers a wide and fascinating field for original investigation.

There is still another class of insects that adopts disguise as a means of escaping the too pressing attention of insect-hunting creatures. These insect actors cannot be classed with the true mimicking insects, as in their natural state they are not protected by an outward resemblance to any other creature, or unobstrusive object in their surrounding; but appear exactly what they are, just ordinary, soft-bodied larvae that would be very much relished by their enemies.

If, therefore, they were exposed to the bright eye of every bird on the look-out for food, or foraging for its young, they would stand a very small chance of arriving at the final, perfect stage of their existence, and would in all probability soon be exterminated; so these defenceless insects deliberately alter their appearance by dressing themselves up in various disguises, or making little dwelling-houses in which they may live unobserved and unmolested.

The larvae of all the *Psychidae* make for themselves little tubes, generally out of vegetable tissues neatly joined with silk; some species use little bits of leaves, which they cut out with their strong jaws, in the construction of their curious houses, others blades of grass, straw, or small twigs. Others, again, adorn their cases with moss or tiny stones, and one Psyche chooses a shell as a model for the construction of its portable home. Although many of these tubes are rough, odd-looking affairs, others are wonderfully compact and symmetrical; all, however are finished off inside with a soft, smooth, silken lining.

The Psyche carries its cases about with it as a snail does its shell; when it moves it grips the inside of the case firmly with its membranous legs and protrudes its head and fore-legs, so that it walks along dragging its house behind it. When alarmed the insect hastily retires within its tube, so as to be completely hidden from view, but the danger being past, head and fore-legs slowly and cautiously reappear and the Psyche continues placidly on its way.

Several species of Psyche are common in England. In the early summer months *Psyche graminella* may be seen crawling over grasses, brooms and heather; its tube is composed of little pieces of leaves all cut to the same size and pattern and arranged round the tube in a series of flounces, each one slightly over-lapping another, while the end is finished off with two or three rows of fine splinters of wood, or twigs, arranged like a spiked collar round the insect's head. From time to time as the insect grows it enlarges its tube by adding another frill of leaves, and when it becomes too tight for comfort Psyche makes a lengthways slit in its covering and widens it by letting in a new piece.

This curious construction not only serves the insect as a protective covering while it is in the larval state, but also takes the place of a cocoon. When ready to pupate, Psyche attaches the tube to a branch of a tree, stem of a plant, or in some cases a wall or a fence, and carefully closes one end; it then turns round so that its head is towards the opening. When the metamorphosis is complete, the male Psyche escapes as a pretty, delicate, little moth with almost transparent wings; but, strangely enough, the female never leaves the shelter of the home that she has made, and has no wings, legs, or antennae; she is, in fact, nothing but an egg-bag. When the eggs are laid the moth dies, and the first thing the larvae do after they are hatched is to make a meal of their mother's dead body. This is one of the very few cases in which larvae of the Lepidoptera are cannibalistic.

In America and Australia some of the Psyches grow to a very large size, and there is one species that constructs a case measuring as much as four or five inches in length. When at rest, the insect suspends its long tube from the branch of a tree with silken threads of such strength that although tossed about by the wind it does not become dislodged.

The larvae of the *Tineidae*, the smallest members of the Lepidoptera, also make tubes or cases from the material on which the female moth has deposited her egg. The depredations of some species of these tiny maggot-like creatures are only too well known, their habit of fashioning for themselves garments, being unfortunately detrimental to our own.

Although such minute creatures, they have very powerful jaws, and no sooner are they hatched than they begin industriously to bite and tear the fabric on which they find themselves, and to weave their wonderfully compact and symmetrical cases. They are remarkably active, and do a great deal of damage in a very short time, as the material not only furnishes them with clothing, but supplies them with food as well. Like the Psyches the Tineina enlarge their cases from time to time, as growth demands it, by splitting them lengthways and weaving in another strip; this is not done all at once, but piece by piece, so that the insect need not expose itself while these alterations to its garment are going on. Some of the Tineina cases are really beautiful little structures, especially when made from bright, variegated fabrics; they are always cylindrical in shape, and open at both ends, so that the little creature can turn itself round within it, appearing sometimes with its head at one end and sometimes at the other.

The Fur or Skin Moth is even more destructive than its relation the Wool Moth, as not only does it fashion a little garment from the skin, which looks as if it were made of felt, but it bites through every hair that comes in its way, mowing them down as it moves along as effectually as if they were shaved off with a razor.

Some of the Tineina that live an outdoor life make tubes from vegetable substances much in the same way as the Psyches. One species with the long name of *Coleophora juncicolella* uses heath leaves, which it joins together two by two to form cups, each cup overlapping the next in symmetrical order.

When the common marjoram is going out of bloom several calyxes may often be found joined together lengthways, one fitting over the other. This is the work of *Gelechia subocella*, an insect of a decidedly economical turn of mind that feeds on the seeds of the plant, and then uses the empty calyxes as a covering. As soon as the contents of one flower is finished the Gelechia bites it off and adds it to its collection until quite a long string has been formed, and the insect's pale, brown head may be seen protruding from its flowery case as it moves cautiously from one blossom to another. Another member of the same family resides on the sandhills near the sea coast, feeding on the roots and leaves of the *cerastium*, and constructs a home of particles of sand fastened together with silk. This insect is partly subterranean in its habits and leaves its case to burrow in the ground, but it always provides itself with a tube in which to retreat when it is above the surface.

One of the most interesting of the insects that adorn themselves is a rare species of Geometer inhabiting Borneo. It decks itself with the tiny buds of the plant on which it feeds, fastening them to the long spines it bears on its back so that it becomes quite covered with them, and looks exactly like a little spray of flowers. Its mode of procedure has been described by the curator of the Sarawak Museum in the following interesting manner: "A bud would be shorn off with the mandibles, then held in the two front pairs of legs, and covered all over with silk issuing from the mouth of the caterpillar. The caterpillar then twisted the front part of its body round, and attached with silk the bud to one of the spinous processes, and another bud would then be attached to this, and so on until a sufficiently long string—generally three or four buds—was made, then operations on another spine would be commenced. The caterpillar fed on these buds, scooping out the interior, and when not hurried, using the empty shells in preference to whole buds for its covering. When irritated it curled up, and remained thus for fifteen or twenty minutes. At other times it would sway about looking like a branchlet blown by the breeze."

An extraordinary insect belonging to the Hemiptera is *Reduvious personatus.* In the larval state it lives in houses, lurking in dark and dusty corners, on the look out for its prey, consisting of flies and other small insects. Naturally, the Reduvius is a slim, flat insect with six slender legs and a smooth body, but it so covers itself with fluff, and particles of dust and dirt, that it appears to be nearly double its real size, and looks more like a bloated, woolly spider than anything else. Under this disguise, this grotesque-looking insect stealthily approaches its prey. Slowly and cautiously it moves, taking a few steps and then remaining motionless for a time, so that it creeps upon its victim unobserved like a Red Indian stalking his prey, and kills it with a stab of its sharp beak.

Amongst the aquatic insects the well-known Caddis-worms construct for themselves quaint, untidy-looking habitations into which they can retreat in safety before the onslaught of the voracious dragons of the pool.

CHAPTER V

INSECTS IN COMMERCE

THE silkworm has been called by an old French writer on entomology "The dog of insects," and although this description can hardly be considered a very appropriate one, the silkworm has certainly been a domesticated insect for a very great number of years. It is impossible to say how long ago it was that the silkworm was first artificially reared, and its fine thread turned to account in the manufacture of silken textures; but it is a certainty that the silk industry existed at a very remote period. The Chinese are generally supposed to have been the first to breed silkworms and practise the art of silk-reeling, though some writers claim that the Tussur silk of India was the first silk fibre produced. The word "sericulture," however, tends to prove that the industry originated in China, as "Series" was an ancient name for the northern part of China, afterwards known as Cathay; and the name "Series" was derived from "sze," "see," or "si," the Chinese word for silkworm. The French "*soie*" is derived from the Latin "*serecum*," which has been traced directly back to the Mongol "sirkeh."

There is a great deal of Chinese literature on the subject of silkworms, chief of which is a remarkable book called the "Silkworm Classic"; in this we are told that sericulture was known in China in the reign of Fouh-hi, who was supposed to have lived a hundred years before the time of the Flood. The invention of the loom for weaving silk is attributed by Chinese historians to a certain Empress Se-ling-she, or Si-ling-chi, the wife of Hoang-ti, and she is supposed to have been the first to rear silkworms and to have instituted the culture of the mulberry tree. The following account of this wonderful personage is given in "L'Histoire général de la Chine," by M. Mailla: "The Emperor Hoang-ti, who lived 2000 years before our era, wished that Si-ling-chi, his wife, should contribute to the happiness of his people; he charged her to study the silkworm, and to try to utilize its threads. Si-ling-chi caused a great quantity of these insects to be collected, which she fed herself in a place destined exclusively for the purpose; she not only discovered the means of rearing them, but still further the manner of winding off their silk and of employing it in the manufacture of fabrics."

Another French writer, M. Duhalde, in the "Description de la Chine," says: "Up to the time of this queen (Si-ling-chi) when the country was only lately cleared and brought into cultivation, the people employed the skins of animals as clothes. But these skins were no longer sufficient for the multitude of the inhabitants; necessity made them industrious; they applied themselves to the manufacture of cloth wherewith to cover themselves. But it was to this princess that they owed the useful invention of silk stuffs. Afterwards the empress, named by Chinese authors, according to the order of their dynasties, found an agreeable occupation in superintending the hatching, rearing, and feeding of silkworms, in making silk and working it up when made. There was an enclosure attached to the palace for the cultivation of mulberry trees." Accompanying this description is a fanciful picture of the Empress Si-ling-chi and her ladies gathering mulberry leaves for the silkworms, all clad in the most elaborately made and embroidered silken garments!

Si-ling-chi was in all probability a mythical person, a Chinese Ceres or goddess of the silkworm; her memory is held in great veneration by the Chinese, and special altars have been erected to her. In the olden times, however, it was the custom of the empresses, queens, and wives of the nobles of the land to personally superintend the culture of the silkworm; and the work was probably undertaken by them in order to set an example of industry to the people, in the same way in which the Chinese emperor at the beginning of each year used with great ceremony to guide the plough with his own imperial hand, and cut the first furrows, and sow the first seeds; so that agriculture might be ennobled and the people encouraged to cultivate the land. Although sericulture is no longer the fashionable pastime for the great ladies of China, in the precincts of the imperial palace there is a large court which is still called "the road which leads to the place destined for the rearing of silkworms."

So much was thought of the culture of silkworms in olden times that there were all sorts of laws and regulations concerning the industry. Tchin-iu, a governor of Kien-Si, commanded that every man in the district should plant fifty feet with mulberry trees; while under one dynasty every man was given twenty acres of land on condition that he planted fifty feet with mulberry trees. In the year 806 another monarch ordered that every acre of land throughout the country should have two feet planted with mulberry trees, and a little over a hundred years later the reigning emperor passed a law forbidding his subjects to cut the trees down.

For a long time China held the monopoly of silk-making and exported it into many other countries, so that it became a source of considerable wealth to the empire. So jealously was the secret of sericulture guarded, that it was forbidden on pain of death to export silkworms' eggs out of the country, or to give to any one of another nationality any information as to the manner in which the silkworms were reared and the textures manufactured. In spite of all this care the secret, as was inevitable, leaked out at last. Two adventurous Persian monks are said to have gone to China as missionaries, and after becoming initiated in the mysteries of silkworm culture they managed to obtain possession of some eggs; and concealing them in hollow canes, smuggled them out of the country and conveyed them to Constantinople. Here they started a silk industry, teaching the people the whole process of silk manufacture; and from these few silkworms' eggs has sprung the enormous industry that has spread practically all over the Eastern world.

At the present day France is the chief silk manufacturing country. Each year 9,918,000 pounds of raw silk is used by the French manufacturers in turning out the silken fabrics, and of this amount of raw silk, France produces about one-eighth, the rest being imported from Italy and Asiatic countries.

Britain unfortunately comes far behind in the manufacture of silk; though formerly an extensive trade was carried on at Spitalfields, Coventry, Macclesfield, Dublin, and Manchester it has been practically killed by the treaty with France, which allows foreign silk to come into the English market duty free.

The common silkworm (*Bombyx mori*) that supplies the raw material from which most of the beautiful fabrics are made, is a very inconspicuous, dull-looking insect, with none of the gorgeous colours and markings which distinguish other members of its family. It has been likened by a French writer to a humble workman toiling in a plain white blouse to produce luxurious array for the favoured people of the world.

The silk Moths belong to the Order Lepidoptera, sub-Order *Heterocera*, or Moths, group *Bombycidæ*. There are upwards of 400 species of known silk producers, but only six species of

FIG. 1. MALE AND FEMALE SILK MOTHS (BOMBYX MORI)

FIG. 2. COCOONS OF THE SILK MOTH (BOMBYX MORI)

Bombyx have been domesticated, the chief being *Bombyx mori*, the common silkworm. Ages of domestication have deprived the silk Moth of a great deal of its natural strength and power. The caterpillar has become passively docile, and will remain where it is placed as long as it is supplied with food, showing no inclination to wander away. The female moth has completely lost the use of her wings, and the male only uses his to flutter round his companion; but it has been proved by experiment that if the moths are reared out of doors in a natural condition, after three generations the males regain their lost power and have a strong, vigorous flight.

The perfect silk Moth is about one inch in length, the female being slightly larger than the male. It is creamy or pale buff in colour, and the wings of the male are tinged with grey or pale brown. The head is large, and the antennae pectinated, or feathery, and are not so well developed in the female. The female silk moth is very sluggish, her sole business being to lay the eggs containing another generation of silkworms. The eggs vary in number from 300 to 700, and are about the size of a pin's head. They are laid singly in little groups side by side, very rarely being placed one on another; when ejected they are covered with a glutinous fluid which causes them to adhere firmly to the place on which they are deposited. The egg-laying lasts for about three days, and soon afterwards, her mission of life being accomplished, the moth dies.

During their short life the males are very restless little creatures, and flutter round the females with rapidly vibrating wings; they remain close to the spot on which they emerged from the cocoon, and do not long survive their mates.

The eggs, when first laid, are a bright yellow colour, and soft and sticky to the touch; they rapidly harden, and gradually change in hue to brown, then to reddish-grey, and finally to a slate colour. They remain thus from the autumn (when they are laid) until the spring of the following year is fairly advanced, when they assume a bluish tint, and then, through successive changes, pass from blue to violet, slate, yellow, and finally to an ashy white.

The egg is now on the point of hatching, and is semi-transparent; if examined with a pocket magnifying lens, a black spot and a brownish crescent may be seen within the envelope. The black spot is the head of the tiny caterpillar, and the dark crescent the minute body, which is already covered with fine hairs.

When quite ready to emerge the larva gnaws its way out of the egg, and directly it is released from its prison attaches a fine silken thread to the nearest object at hand. The little creature is at first almost black, covered with hairs, and about a quarter of an inch in length. It rapidly increases in size until it has attained its full growth, when it measures about three inches long.

During the period of growth the caterpillar moults, or casts its skin, four times; after the first moult, which occurs when the silkworm is five days old, it becomes grey in colour, and is much less hairy, while crescent-shaped markings begin to appear on the second and fifth segments. After the second moult all the hair disappears, and the silkworm is perfectly smooth; with each succeeding moult it grows lighter in colour, until with the final casting of its skin it is almost white.

The caterpillar stage of the silk Moth lasts for about eight weeks; during all this time it feeds voraciously, except just before each moult, when it becomes lethargic and ceases to eat; and its skin becomes somewhat transparent and wrinkled, and changes to a yellowish tint. The silkworm then fastens a few threads to some projecting object within its reach and, slipping underneath them, begins to twist and writhe until the skin bursts, when in a short time it frees itself from its old garment, leaving it caught up in the silk threads.

The period of moulting is a very critical one for the silkworm, which occasionally dies during the process; when it has come safely through the moult it is in a very exhausted condition, and remains motionless for a short time in a state that has been likened to sleep. While in this torpid condition the silkworm assumes a very curious, characteristic position, with its head and fore-legs raised.

When the silkworm is full fed and ready to change into a chrysalis, it ceases to eat, and its skin becomes yellow and transparent. It then begins to wander about looking for a convenient spot in which to pupate, raising its head and fore-legs, and climbing up anything that comes in its way. The spot chosen, the insect proceeds to attach a few loose threads to any twig or leaf that may be within its reach, and produces the rough, tangled fibre that is called "refuse silk." When this is accomplished it begins to unwind a long, continuous thread of silk, moving its head from side to side and bending it backwards over its body so that the silk is disposed all round it, forming an oval-shaped cocoon, which, when completed, is about the size of a pigeon's egg.

The silk, when unwound, is 400 feet or more in length, and the remarkable energy displayed by the insect in unwinding this wonderfully long thread is interestingly described by M. Robinet as follows: "The silkworm makes every second a movement extending over about five millimetres. The length of the thread being known it follows that the worm moves its head three hundred thousand times in making its cocoon. If it employs seventy-two hours at its work, it is a hundred thousand movements every twenty-four hours, four thousand one hundred and sixty-six an hour, and sixty-nine a minute, that is to say, a little more than one a second."

In about four days the cocoon is finished and the silkworm changes to a pupa, remaining in this state from two to three weeks. At the end of this time the skin is ruptured, and the perfect moth is ready to effect its escape from its silken prison. This it does by moistening the cocoon with a liquid contained in a little bladder in its head, this soaks through the silk and disunites the threads, so that the moth is able to push it head through them, and emerge without breaking the silk.

The way in which the silk is formed is exceedingly interesting. Down each side of nearly the entire length of the silkworm's body runs a silk-producing gland; at the tail end of the insect these glands consist of fine tubes about the thirteenth of an inch in diameter, bent and twisted into a number of zigzags, which, when straightened out measure nine inches in length. Within these slender tubes the silky matter is formed; it then passes on into the central portion of.the glands, which are much enlarged, forming a kind of reservoir; here the silk, which is then of a glutinous consistency, is stored. The glands then again become narrowed into two capillary tubes, which finally unite and become joined in a single, short canal opening into the mouth of the insect. As the silky substance passes from the reservoir down these tubes it gathers consistency, and forms two threads which unite at the juncture of the glands and pass out of the mouth of the silkworm as a single thread. As the thread passes down the final conducting tube it becomes imbued with a secretion poured upon it from two neighbouring glands, which acts upon it as a kind of varnish, giving the silk its brilliancy and water-resisting qualities.

During the latter period of the larval state (while the silk is rapidly forming) the silkworm's appetite is simply enormous; and it has been calculated that thirty grammes of eggs will produce silkworms that, on the day before they cease to feed, devour as much in weight as the food of four horses!

Next in order to the silkworm, which is far and away the most important of commercial insects, comes the cochineal insect (*Coccus cacti*) a member of a strange group of insects belonging to the Order Hemiptera. Several species of the *Coccidæ* family are of considerable commercial value, while others do a great deal of harm to plant life.

The life history of the Coccidae is very peculiar, and the male and female are so unlike each other in appearance that they might easily be mistaken for different species of insects.

In the larval state the young Coccus look very much like tiny tortoises, and run actively about the plants on which they feed. When full grown the female, without undergoing any change of form, fixes itself to the plant by the beak, or rostrum; and in this position it remains throughout the whole of its adult life, which lasts for several months, sucking up the juices of the plant, and becoming more and more swollen and shapeless, until it looks just like a little lump, or excrescence, on the tree, and is about the size of a plump currant. The male (which is much smaller than the female) in the perfect state possesses a pair of delicate, gauzy wings (the hind pair being represented by halteres), feathery, beaded antennae, and two fine caudal bristles which are twice the entire length of its body. Curiously enough, while the female spends the whole of her life is absorbing nourishment, the male does not feed at all, its suctorial proboscis being quite rudimentary: its life, in consequence, is probably a short one, and its mission in life of propagating its species being accomplished, it soon dies.

The metamorphosis of the male Coccus is very extraordinary, and unlike that of any other species of insect. The larva when about to change to the adult state becomes passive, and the transformation takes place beneath the scale-like larval skin, so that during the time it is a resting pupa its outward appearance is not altered in any way. When the metamorphosis is complete, the two long tail-hairs protrude from the hind part of the scale-like covering, and the insect emerges backwards with its delicate wings pulled up over its head. In a short time it adjusts its wings and flies away, leaving its old skin intact upon the plant.

The female, without moving from her chosen spot, lays a quanity of eggs between her body and the plant to which she is fixed. As they are deposited her body gradually dries up, and finally becomes a mere shell completely filled with eggs. The insect then dies, and the young are hatched under the covering of her dead horny body, which serves them as a shelter until they are ready to fare forth into the world.

C. cacti, the species that produces the cochineal dye, is so called because it feeds upon the cactus plants. It is a native of Mexico and other warm parts of America, but has been successfully introduced into the Canary Islands, Java, Algeria and Australia, where the cochineal industry is still carried out, although the introduction of aniline dyes has considerably lessened its value.

The insects are reared in specially planted plantations of cactus. In the spring of the year a certain number of females are placed on the trees, where they deposit their eggs, and the resulting larvae spread all over the prickly branches, which in a short time become covered with stationary females. This generation constitutes the harvest, and when they have become swollen with eggs (the time when they are valuable for making the dye) they are scraped from the plants, collected on trays, and killed by being plunged into boiling water, or placed in a hot oven; they are then thoroughly dried in the sun and pounded up into the well-known cochineal powder.

C. lacca, another member of this strange family of insects, is the lac-insect that produces the substance from which shellac is made, and is much used in the manufacture of varnishes, cement, and as a stiffening medium. It also enters into the composition of sealing-wax; while the brilliantly coloured lacquered toys, boxes, and ornaments made in China and India are coated with lac mixed with pigments.

The lac-insect is a native of China, India, Siam, Borneo, and many of the islands of the Eastern Archipelago. It lives on the Indian fig tree, the jujube tree, and one or two others. The female, after the manner of her species, fixes herself on the young sappy branches of the trees and begins to form round her a cell or cocoon of lac, with which she soon becomes entirely covered with the exception of her sucking mouth, an aperture near the tail end, and two other openings for the admission of air. Opinions vary as to whether the lac is a natural secretion, or whether it is the resinous juice of the tree, which becomes altered in character by being sucked up by the insect after it has caused the sap to flow by piercing the bark. The small branches of the trees become quite encrusted with the lac, and are then cut off and the lac removed and converted into the shellac of commerce.

The males also form a lac cocoon, but escape by the anal opening on completing their metamorphosis; and the young, which are hatched within the female cocoon, leave the lac cell in the same way.

A species of the same family, *C. manniparus*, inhabits Mount Sinai and produces a kind of thick, red syrup by piercing the bark of the tamarisk trees on which it lives; it is sweet and rather like honey, and is much eaten by the Arabs and the monks. The syrup overflows the branches and falls to the ground, where it forms into soft sweet cakes, called "Mount Sinai Manna," and it is supposed that this was the manna eaten by the Israelites during their wanderings in the Wilderness.

Yet another member of the Coccidae (*C. ceriferus*) produces a remarkably fine, hard wax. It is found in China, where it lives principally upon the ash tree. The Chinese use this wax for candles, or to coat those made of inferior wax; and for sizing paper and textile fabrics. On account of its high price this wax has never been introduced into England, but it is of considerable commercial value both in China and Japan.

Among the Coleoptera a curious genus of beetles known as "Vesicantia" possess a medical value on account of the strong, irritant fluid they secrete. The Vesicantia are divided into two distinct families, the *Moloïdæ* and the *Cantharidæ;* some species of the Moloïdæ are used as vesicants and are commonly called "oil beetles," but the Cantharidæ are more generally employed as blistering agents.

The life history of most of the species of the Vesicantia family is very curious; in addition to the usual metamorphosis these beetles undergo several supplementary changes, which have been called "hyper-metamorphosis" before arriving at the final stage of their existence and becoming perfect insects. We are indebted to that clever and indefatigable naturalist, M. Fabre, for our knowledge of the ways of these remarkable insects. With untiring energy and patience M. Fabre studied the habits of *Sitaris muralis* (a member of the Moloïdæ family) until he had discovered its complete life history from the egg to the imago.

The eggs of the Sitaris beetle are laid in the summer-time near to the entrance of a gallery constructed by the hard-working little mason bee; and in the course of a few weeks the larvae are hatched and crawl forth as tiny, elongated maggots, possessed of six legs each terminating in a sharp claw, while at the tail end their bodies are provided with two horny hooks.

Instead of at once seeking for food after the usual manner of newly hatched insects, the Sitaris larvae remain in a torpid condition until the early spring of the following year. Then, when the male bees, who are always the first to appear, emerge from their galleries and sun themselves at the entrance of their cells, the motionless larvae at once awake from their trance, spring up, and cling to the hairy bodies of the bees with their grappling hooks; there they remain firmly anchored for a short time, and then, when an opportunity occurs, transfer themselves to the females. As soon as the mother bee deposits an egg in a cell well stored with honey, the parasitic larva of the beetle carefully slips from her body on to the egg floating on the sweet, sticky pool, and immediately tears it open and begins to devour the contents. For eight days the carnivorous little larva feasts and increases in size; then, its first repast being quite finished, it at once proceeds to adapt itself to a new mode of life; its skin splits down the back and the larva wriggles out of it quite a different creature. It is now a soft, fat, white grub, and quite blind, while on its back a row of spiracles or breathing-holes have appeared. The grub rolls off the empty egg-shell, for which it has no further use, into the honey, and there it lies submerged with the exception of its back, on which is situated its breathing apparatus.

Here it lies contentedly sucking up the honey until all is gone, then the insect again changes its form and becomes what M. Fabre has called a pseudo-chrysalid; it becomes lethargic, and remains in this state throughout the winter, but with the return of spring it again casts its skin and reverts in appearance to the second stage of its varied existence. It no longer eats, however, and after a short time changes into a true pupa; then, after resting in this condition for about a month, it at last issues forth as a small, winged beetle, the whole process of its complicated transformation occupying two years.

The Cantharidæ also undergo hyper-metamorphosis, but are generally parasitic on the eggs of grasshoppers and locusts. The insect at first is a thin, six-footed larva with a powerful pair of jaws, long legs, and a horny skin. The larvae are extremely active, and run hunting about until they find an egg-pod containing grasshoppers' eggs. Directly a prize is found they rush upon it, and a furious fight takes place, each larva striving to get complete possession of the precious pod; some of the larvae generally get killed in the mêlée and the victors then gnaw their way through the shell of the pod and greedily devour the eggs. After feasting for about eight days the larva is full fed; it then casts its skin and appears as a soft, fat, white grub with short legs. Twice again the larva casts its skin at intervals of first a week and then a few days; after each moult the insect becomes fatter and its legs more rudimentary until, after the third time, it is a very fat, soft, legless grub. During all these changes it has fed continuously upon the eggs, but about a week after the final moult its appetite fails, and it buries itself in the soil and hybernates until the following spring in the pseudo-chrysalis state. After its long rest the insect once more casts its skin and becomes an active larva. It no longer feeds, however, but spends a few days burrowing about in the ground; it then changes into a true pupa, and after another short period of rest reappears transformed into a bright, active little beetle about four-fifths of an inch in length and of a beautiful green colour.

The particular species of Cantharidæ used for making ointment and blisters are natives of Spain, hence their popular name of Spanish fly. They are found principally on the ash, lilac, privet, and elder trees, on which they swarm at times in great numbers, betraying their presence by the strong, pungent odour they emit, which can be detected quite a long way off.

The beetles are collected very early in the morning when they are torpid from the cold night air; cloths are spread at the foot of the trees on which they are congregated, and the branches vigorously shaken to dislodge them. The cloths are then gathered up by the four corners and plunged bodily into a solution of hot vinegar; after this the Cantharides are thoroughly dried and packed in air-tight vessels. Great care has to be taken in collecting and preparing the beetles that they do not come in contact with the skin, as so powerful is the vesicant fluid they emit that it raises very painful blisters.

Cantharides were employed in the art of healing at a very early date. Hippocrates is said to have administered it internally as a cure for dropsy, apoplexy, and jaundice, and Aretæus,

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a Roman physican who lived in the first century, is supposed to have been the first to use it in creating blisters. It is curious and interesting that this old-world remedy should still be in use in the twentieth century.

CHAPTER VI

POISON-FANG AND STILETTO

EVERY one is more or less familiar with the form and sinister appearance of the Scorpion, with its large, claw-like pedipalps and long, jointed tail terminating in its formidable sting. Shunning the strong sunlight, the Scorpion lurks under stones and in nooks and crannies in the rocks, until the short dusk of the tropics gives brief warning of the approach of night. Then the Scorpion quits his hiding-place and sets forth in search of his prey, which consists chiefly of insects, spiders, and even the smaller members of his own family, running actively and pouncing with agility upon his victims. In this way the Scorpion is really a friend to man in helping in some degree to check the swarming insect life of the tropics, but unfortunately it has a bad habit of entering houses and hiding itself away in all sorts of undesirable situations, such as in the beds, under the pillows, and in shoes and boots, with startling and unpleasant results for the human inhabitants. Although the sting of the Scorpion is rarely fatal, it is extremely painful, and always attended with a certain amount of danger, as it is attended with general constitutional derangements, the effects lasting for several days. When about to strike, the Scorpion suddenly straightens its tail and brings the point downwards with great swiftness. If cornered, the Scorpion will generally show fight, jerking his tail and brandishing his claw-like pedipalps in a very threatening manner. Recent carefully conducted experiments have proved conclusively the incorrectness of the old statement that a Scorpion surrounded by a ring of fire would, recognizing the terrible fate about to overtake it, commit suicide by stinging itself on the head. When exposed to great heat, the Scorpion becomes greatly excited and agitated, jerking its tail about rapidly, showing every sign of extreme alarm and discomfort, and it is probably from these rapid movements that the popular idea of the creature committing suicide originated. Although of unlovely appearance, the female Scorpion is eagerly sought by the smaller males, who carry on their courtship with some amount of trepidation, for the lady has an uncertain temper, and may vent her wrath upon a too ardent wooer, even to the killing and subsequent sucking of his blood. Nevertheless, she is a model mother, watching over her offspring with the greatest solicitude.

We shall find this same uncertain temper during courtship, and the subsequent maternal devotion, strongly developed in the Spiders. Indeed, for the onlooker, there are few more curious or laughable sights than the courtship of the common Garden Spider, though it is no laughing matter for the amorous swain. The males of the Garden Spider, as in many other species, are much smaller than the females, and their days of courtship and brief married life are of a most adventurous character. The bachelor Garden Spider, who is readily distinguished from the lady of his admiration by his smaller size and thinner and longer body, approaches her web in the most cautious manner. At first he will only venture to place one, or at most two, of his eight legs upon the outer threads of his lady-love's web, retreating hurriedly should she make the least movement. Gradually gathering courage he will venture a little way on to the web, treading with the greatest caution, taking every step with an uncertainty of demeanour most comical to behold. Should the lady Spider be in coquettish mood, she will play with him coyly, permitting him to advance a little way on to the web, and then move her feet a step or two, just sufficiently to cause the nervous little male to beat a hasty and undignified retreat to the edge of the web. On the other hand, should she disapprove of his appearance, or consider his advances too pressing, she will make a sudden murderous dart at him, and should he not make good his escape, there is a fatal termination to his courting, the lady sinking her poison-fangs into his body and quickly sucking him dry. Even the duly accepted lover has a very nervous time of it, for the lady Spider generally kills and sucks the juices of her husband as soon as she finds that she has no further use for him.

The geometrical web of the Garden Spider is a very wonderful and beautiful object, consisting of a number of stout radiating lines, running from a common centre to a series of slightly stronger lines stretched between the various points of attachment, and crossed by a series of fine short lines which are woven in the form of a spiral starting from the centre and continued to the outer margin of the web. When starting to built its snare, the Spider first of all forms the outermost or foundation lines, which are attached to various accessible points on the surrounding foliage, bridging over the intervening spaces by emitting a thread from its spinnerets and allowing it to be wafted to the nearest point of attachment by the wind. These foundation lines having been made strong and secure, the Spider next proceeds to weave and stretch tightly between them the radiating lines, which are all joined at the centre of the web. Then, finally, she proceeds to spin the delicate cross threads, starting from the centre and working in a spiral to the outer edge of the web. These threads forming the spiral differ entirely in character to the stouter lines forming the framework, for they consist of a slender silk thread covered with minute beads of a viscous substance, and it is these sticky threads that entangle and hold any unfortunate insect that blunders into the web. Few objects are more beautiful than one of these webs, as seen in the early sunlight of an autumn morning, bejewelled with dew-drops which sparkle and flash back all the prismatic hues of the rainbow. One must be out early, however, to see this beautiful display, for long before the dew has evaporated from

FIG. 1. FOOT OF A SPIDER, SHOWING THE COMBS USED IN WEAVING THE SILKEN WEB

FIG. 2. SPIDER'S WEB COVERED WITH DEW-DROPS

FIG. 3. HEAD OF A MYGALE SPIDER SHOWING THE SMALL BRILLIANT EYES

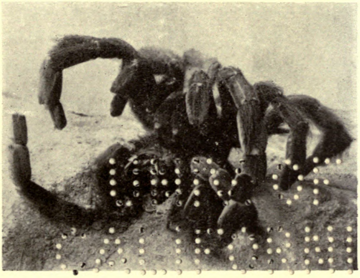

FIG. 4. A COMBAT BETWEEN MYGALE SPIDERS

the foliage, it has totally disappeared from the webs. It is obvious that so long as the web remains a conspicuous sparkling object, flashing bright points of light in the sunshine, no fly will approach or blunder into it, and Madam Spider must needs go hungry. Consequently, when she awakens from her slumber beneath some sheltering leaf on the edge of her snare, her first business is to prepare her web for the capture of her breakfast. Finding her web all sparkling in the bright morning light, she makes a sudden rush to its centre, and by a series of rapid movements sets every strand in rapid vibration, so that in a very few seconds every dew-drop has been shaken off, and the web, except from certain points of view, has become nearly invisible. She then returns to her shelter under the leaf, and keeping a couple of her feet upon the radiating lines of the web, so that she will feel the slightest vibration caused by the impact of an insect, patiently awaits events. It is not long before a large fly blunders into the web, and begins to buzz and struggle wildly; in an instant Madam Spider is on the alert, and rushing upon her unfortunate victim begins to swiftly rotate him by the aid of her first and third pairs of legs, drawing out from her spinnerets, with the comb-like claws and bristles on her hind legs, a number of fine silken threads with which she quickly swathes her now helpless and rapidly revolving prey. In a few seconds she has the fly trussed up from head to foot in a dense silken covering, and then she calmly sinks her poison fangs into the quivering body of her victim and proceeds to suck him dry. The Garden Spider deposits her eggs, which number between seven and eight hundred, in a silken, oval-shaped cocoon. Infant mortality is very great amongst these Spiders, starvation and the attacks of other Spiders and insects being responsible for the death of hundreds, so that from each cocoon, though originally tenanted by some seven or eight hundred Spiderkins, but two or three individuals reach maturity.

A very interesting and fairly common British Spider, frequently to be met with even in London gardens, is the little hunting Spider Salticus. This Spider is about a quarter of an inch long, with black and white markings upon the body and legs, and has a peculiarly alert appearance which renders it readily recognizable. During the summer, Salticus may be found running about, with cautious rapid movements, in the hot sunshine upon tree trunks, walls, and wood or iron palings. It leads a wandering life, building no snare for the capture of its prey, but stalking and springing upon its victims in a singularly cat-like manner. Salticus does not apparently place all her eggs in one basket or cocoon, like the Garden Spider, but constructs two or more cocoons of light texture which are in turn enclosed in a fairly thick-textured, white, silk cell formed in some crack in the bark of a tree, or in a cranny in a wall, or similar suitable hiding-place.

The Wolf Spiders or *Lycosidæ*, like the little Salticus, are wandering, predaceous Spiders, building no snare, but running down their prey.

Many of them are nocturnal in their habits, lurking under stones, fallen leaves, and crevices in the rocks and ground until the approach of dusk, when, like highway robbers, they issue forth to hunt down their victims. There is one British species which has the suggestive name of *Lycosa piratica*, and which certainly lives up to its name. It frequents marshy situations, and is so light that it can run on the surface of the pools without breaking through the surface film, and, taking full advantage of this peculiarity, the Spider adventures forth on the surface of the waters of the marsh like a bold pirate, seizing and sucking the blood of any luckless insect that may come within its reach. One has only to watch the way in which these Spiders run down their prey and the ferocity with which they seize upon their unhappy victims, to realize how well deserved is their name of Wolf Spiders. Although so fierce in their hunting instincts, the female Wolf Spiders are remarkably tender mothers, displaying the most affectionate care for their offspring. The female Dolomedes is a good example of this maternal solicitude. She places her two hundred or more eggs in a rather rough-looking, globular-shaped cocoon which she carries about with her in her wanderings, holding it against the under surface of her body by means of her falces and palpi, and to make it quite secure attaching it to her spinnerets by a few strong threads. When her young are about to emerge from the eggs, she spins a dome-shaped web or nest in the low-growing herbage, and under the shelter thus formed for them, the newly hatched youngsters cluster, carefully guarded by their parent until they are able to fend for themselves. Most famous of all the Wolf Spiders is the Tarantula, one of the largest of the European Spiders, that derives its name from Taranto, in the neighbourhood of which place it is very common. It was the bite of this Spider which was supposed to cause the curious dancing madness or mania called Tarantism, an epidemic, nervous disease of the Middle Ages, resembling in some respects the equally famous St. Vitus's Dance. Although the bite of the Tarantula Spider is painful and may give rise to some feverishness or other disagreeable symptoms, its effects have been grossly exaggerated.

The Crab-Spiders or *Thomisidæ* are an interesting family, which have gained their popular name partly from their short bodies and large arms, partly from their crab-like way of running sideways and of simulating death when alarmed. Many of these Spiders are beautiful in colour, resembling the green of the foliage or the delicate tints of the flowers among which they lie in wait to capture their prey. One of these Thomisidæ is fairly common in the New Forest, and may frequently be seen in the late spring and early summer on the flower spikes of the early orchis (*O. mascula*), the unopened buds of which its body closely resembles in shape and colour. The Spider remains absolutely motionless among the unopened rounded buds at the tops of the flower-spikes, awaiting the insects, chiefly species of bumble-bees, which visit the open flowers lower down the spike in search of honey. When a bee alights upon one of the fully expanded blooms and thrusts its head forward into the opening leading to the honey nectary, the bud-like Spider suddenly becomes animated, and climbing quickly from its hiding-place, leaps down upon the back of the unsuspecting bee, and buries her poison fangs in the body of her victim. The unhappy bee gives vent to a frantic buzz and struggles to escape, but the poison from the jaws of the Spider very rapidly takes effect, and in a few seconds the fight is over, and the Spider carries her victim down under the shelter of the lowest drooping flowers of the spike, and there at her leisure sucks the juices of her prey. When the early orchis has finished flowering, the Spider appears to betake herself to the flower-heads of the meadow thistle, hiding under the flower-head, and playing a deadly game of hide-and-seek with the various insects alighting upon the florets. Most of the insects alighting on the flower-head at once turn their head towards the centre, working from the outer florets inwards. Of this habit the Spider takes full advantage. Dodging round and round the base of the flower-head, she will from time to time very cautiously feel with her long arms the outer florets until she realizes, apparently by certain movements conveyed by them, that she has gained a position at the rear of the insect. Then, with a sudden rush, she springs upon the back of her prey, and sinks her needle-sharp poison-fangs into its body. Having overcome the struggles of her victim, the Spider carries it down the flower stem to the ground, and after sucking it dry, once more ascends to the base of the flower-head. The young Thomisidæ are great aeronauts, delighting on fine autumn evenings to gain some suitable starting-point such as the edge of a leaf or twig, and then allowing long threads of gossamer to float out from their spinnerets until a sort of gossamer air-raft or monoplane is formed, capable of bearing them away on the wings of the wind. In this way the little Spiderkins make quite considerable journeys through the air, and on their descent cover the hedgerows with their gossamer threads.

The Malmignatte Spider, common in the south of Europe and the Mediterranean islands, particularly Corsica, has a very bad reputation, the effect of its bite upon a healthy person being said to cause considerable pain and fever, and even in some cases fatal results, though the latter statement needs authoritative confirmation. Unfortunately, people are only too ready to make the most rash and exaggerated statements about the evils resulting from the bites of Spiders, statements which, though they will not bear calm scientific investigation, yet catch and hold the popular ear, with the result that many of these creatures are still looked upon as being dangerously venomous, although they are probably less harmful than fleas. The Malmignatte measures about half an inch in length, and is black in colour, ornamented with blood-red spots upon its abdomen. It preys upon grasshoppers and young locusts, sinking its fangs into the body of its victim at the junction of the head and thorax, the poison injected from its fangs quickly causing the death of its prey.

In the warmer parts of the globe many Spiders are found that are truly terrifying monsters to encounter. On the great steppes and hot sandy deserts of Central Asia, Southern Russia, and Africa there dwells a great Spider, belonging to the same Order as the well-known "Harvest Spider," with its little button-like body and extraordinarily long legs. This strange creature (*Galeodes araneoides*) possesses a large, hairy body, somewhat pear-shaped in form, and a remarkably powerful pair of pincers, which are furnished with poison glands like those of the true Spiders. The two pairs of palpi are very long and leg-like, so that the Galeodes appears to possess five pairs of legs; only the three pairs of true legs are used in walking, the two pairs of leg-like palpi being carried raised in front of the Spider to act as feelers.

The Galeodes is nocturnal in its habits, concealing itself during the hours of day under stones or in pits that it digs in the ground, and coming forth at night to prowl about in search of prey. So powerful is this alarming creature that it seizes and devours bats, young rats, and small lizards, and attacks Scorpions twice its own size, although in these encounters it is not always the conqueror, as it sometimes happens that the Scorpion kills the Spider with its sting. The Galeodes are exceedingly pugnacious, and when two of them meet a battle royal usually takes place; the Spiders fight until one of them is killed, and the successful combatant then makes a meal of his foe!

The bite of these Spiders is exceedingly venomous and causes great pain and local inflammation, sometimes accompanied by severe headache and fainting fits, and even occasionally by temporary paralysis. To animals they do a great deal of harm, especially to sheep and camels, which are often bitten by the Spider in the feet, or in the body when the animals are lying down. In India many weird tales are told of these Galeodes by the natives, who regard them with considerable dread; and some old writers go so far as to state that certain parts of India, that are now deserted, were once inhabited, but that the people were driven out by the fear of these terrible Spiders!

Many of the *Mygalidæ*, a family of Spiders chiefly found in the warmer parts of the world, grow to an immense size. Several species inhabit the Eastern hemisphere, where some measure as much as six inches in expanse. But it is in the warmer parts of America and the islands of the West Indies that these gigantic Spiders are most commonly seen, where they kill and devour all kinds of insects, and even small animals and birds. The Mygalidæ have stout bodies and thick legs, and are covered with short, stiff hairs, which come off if the creature is handled and cause a very painful irritation of the skin. They differ very much in their habits; some species live on the roofs of houses, where they make a closely woven web, of the thickness of fine muslin, in the thatch or amongst the tiles. In the dusk these creatures come down from their dens and may often be seen crawling stealthily over the wall in the houses. The native West Indians, however, do not seem in the least alarmed by the incursions of these Spiders, and Mr. Bates relates that while he was travelling in the region of the Amazon he once saw a huge, hairy Mygale being led about like a dog by some Indian children who had fastened a cord round its waist.

Mygale avicularia is a frequenter of trees, and Mr. Bates, in his book, "The River Amazons," gives the following interesting account of its habits: "At Cameta I chanced to verify a fact relating to the habits of a large hairy Spider of the genus Mygale, in a manner worth recording. The species was M. avicularia, or one very closely allied to it; the individual was nearly two inches in length of body, but the legs expanded seven inches, and the entire body and legs were covered with coarse grey and reddish hairs. I was attracted by a movement of the monster on a tree-trunk; it was close beneath a deep crevice in the tree, across which was stretched a dense white web. The lower part of the web was broken, and two small birds, finches, were entangled in the pieces; they were about the size of the English siskin, and I judged the two to be male and female. One of them was quite dead, the other lay under the body of the Spider not quite dead, and was smeared with the filthy liquor or saliva exuded by the monster. I drove away the Spider and took the birds, but the second one soon died."

Other species of Mygale live during the daytime under large stones, or in some crack or cranny where they are sheltered from the hot sun, and only come forth at night intent on evil deeds. A few burrow in the ground; *Mygale Blondii* makes a broad tunnel about two feet long, in a slanting direction in the earth, and lines it completely with soft silk, and as sunset approaches, its wicked-looking head may be seen protruding from the mouth of its den on the watch for some hapless victim to pass that way.

The "Trap-door Spiders" are also members of the Mygale family; many species inhabit the old world, but are considerably smaller than their foreign relations. These Spiders are very common in Southern Europe, and are interesting on account of the very remarkable dwelling they construct for themselves. Madam "Trap-door" first burrows a tunnel in the ground; this is generally a vertical shaft, and is beautifully lined with a silken tube. She then hollows out a chamber in the side of the shaft which first inclines upwards and then downwards, and in the doorway hangs a silken curtain, so as to cut it off from the main burrow and form an inner sanctuary, into which she can retreat should an enemy invade her domain. At the top of the main shaft the Spider fixes a lid or trap-door, made of particles of earth held together by several layers of silk, so that it is quite firm and strong. Sometimes this door exactly fits the mouth of the tunnel, like a regular stopper, but in other cases it is merely a flap that lies on the ground, covering the entrance and hiding it from view. This door is attached to one side of the mouth of the burrow by a silken hinge, so that it always remains in position and cannot be pushed away by any clumsy creature that happens to be taking a walk overhead.

In the daytime the Spider rests within her nest, but as evening approaches she ascends the shaft, pushes up the trap-door, and cautiously takes a look all round; if no enemy is in sight, she comes forth and prowls about in search of her evening meal. Should she be alarmed, Madam Trap-door beats a hasty retreat into her den, and firmly holds the door against all intruders by clinging to the underside, and holding on with her legs to the walls of the silken-lined tunnel.

Some species of Trap-door Spiders do not make a second chamber in their burrow, and the doors will be found to vary so that they harmonize with their surroundings; while some are composed merely of earth and silk, others have pieces of leaves, twigs, or moss woven into the upper surface, the better to conceal them from observation.

The "Turret Spider" of America is another very interesting species of burrowing Spider. Above the entrance to her nest she builds a little tower of dried sticks, moss, and earth, fastened together with silk. This remarkable structure is pentagonal in shape, and is raised about three inches above the ground. As there is no door to the turret, the Spider in all probability erects it to prevent unwelcome visitors dropping in upon her unawares.

Although the wasp shares with the Spider the distinction of being generally shunned, and looked upon as exceedingly dangerous, it would be difficult to find two creatures that differ more completely in their habits and mode of life. While the Spider, like some fabulous ogre, lurks within its snare, or hides its bloated-looking body in some crevice or cranny, lying in wait for any unwary insect which it may entrap and devour; the wasp, like a fearless warrior, in uniform of black and gold, fares boldly forth, and openly attacks its enemies and victims with the sharp and deadly stiletto with which Nature has provided it. With dauntless courage many species of the wasp family will attack insects considerably larger than themselves, and which, in many cases, are capable of turning the tables on their intrepid little assailants.

It is not, however, as a weapon of warfare that the wasp principally uses her sting; though swift to defend herself, she is really much more peacefully disposed than is generally imagined, and will rarely use her poisoned dart in an aggressive manner unless she is irritated or alarmed. It is chiefly as a means of procuring the necessary animal food for her young that the mother wasp uses her sting.

The parent wasp feeds her offspring in much the same way as a bird feeds her nestlings. As soon as the larvae are hatched she flies off on a foraging expedition to hunt for suitable food for them. This consists principally of animal matter and a certain proportion of fruit pulp and honey. If fresh butcher's meat is available, *Vespa vulgaris* does not disdain it, but will invade the kitchen, larder, or butcher's shop, and, with her strong scissor-like mandibles, cut tiny scraps from the meat and fly off with the spoil. More often, however, *V. vulgaris* provides her larvae with animal food in the form of dipterous insects which she pursues and kills with wonderful skill and ferocity.

On a warm, sunny day in late summer the little huntress may often be seen at work. Watch some sweet-scented flowering shrub, or clump of flowers over which the flies are hovering with drowsy murmur. Suddenly a wasp in search of game appears upon the scene, and darts with surprising swiftness upon a fly almost as large as herself; with a frightened "buzz" the insect flies off pursued by the wasp in much the same way as a hawk chases a small bird. Should the fly be finally captured, huntress and hunted fall together to the ground, where a furious struggle ensues, until the fly is at length dispatched by the repeated stab of the wasp's sting.

Having killed her quarry, the wasp generally proceeds to tear off the wings and cut up the fly with her strong, sharp mandibles, keeping only the softer and more nutritious parts, which she carries off between her feet. Sometimes, however, the fly is taken intact to the nest, where the wasp makes it into a kind of fly paste before distributing it to the hungry larvae.

Interesting as are the ways of the common wasp, the habits of the solitary wasps, or fossorial Hymenoptera, are even more remarkable and fascinating. The solitary wasps are generally considerably smaller than their social relations, although in general appearance they are very similar. The mandibles, or jaws, are long and slender, and the tarsal claws are deeply toothed, forming perfect little rakes. There are no workers amongst the solitary wasps, and each female acts independently, constructing her nest, or burrow, and supplying her young with food without any assistance from her own kind.

The Wall Wasp (*Odynerus parietum*), or the "False Wasp" as it is sometimes called, is one of the commonest species of the solitary wasps; during the months of June and July these active little creatures may often be seen busily engaged in making their burrows in sunny, hard-baked, clay banks, or old walls. They are pretty, graceful-looking insects with the usual black and yellow livery common to the wasps. The Odynerus excavates a small chamber in the clay or earth with the aid of its sharp jaws and comb-like fore-feet, and to this it attaches a tiny bent tube, made with some of the loose earth it has thrown out from the cell. This little tunnel forms the entrance to the cell, and is so exceedingly fragile that it falls to pieces at a touch, though it is strong enough to bear the light weight of the little Odynerus, who crawls backwards and forwards through this entrance until her work is completed; she then breaks up the little tunnel so that no trace of the entrance to the nest is visible.

As soon as she has constructed a cell, Odynerus starts off on a hunting expedition. She is very particular in her choice of game, and darts rapidly backwards and forwards until her sharp eyes light upon the fat, soft-bodied larva of a beetle or butterfly. In an instant she pounces upon the unfortunate insect, stabs it with her poisoned dart, then firmly grasping her victim's head with her jaws and clasping its body closely underneath her own with her legs, she flies off with it, deposits it in her burrow, and at once is off again in search of further booty. As many as fifteen or sixteen little caterpillars are caught, stung, and stored within the nest, where they lie curled up in the form of a ring, and piled up one on the top of another. On the top of this heap of motionless larvae, the Odynerus deposits an egg, she then closes the cell and sets to work digging another chamber; generally three or four cells are formed side by side, and are all entered by the same little tunnel. When these are provisioned, and an egg laid in each, the insect destroys the tube and closes her burrow.

The larvae stored within the cells by the Odynerus are not dead, as would naturally be supposed, but are paralyzed by the poisonous fluid which is injected into the wound made by the dart. By a wonderful inspiration of instinct, the insect appears to know that the life of her future offspring depends on their being supplied with fresh animal food. If the cells were provisioned with dead insects, the larva of the Wall Wasp would find a heap of dried-up, decaying bodies, and as such food would be utterly unsuitable to the newly hatched, feeble maggot, the little creature would perish for want of nourishment. To store live caterpillars in the cell would be equally fatal to the larva, which, even if it were not trampled to death by the imprisoned insects, would be quite incapable of attacking lively food. The problem the parent wasp has to face, therefore, is how to provide fresh (*i.e.* living) food that will at the same time be incapable of harming her larvae. This difficulty she overcomes by piercing the nerve centres of her prey with her sting, so that the insect becomes paralyzed. While the active life is destroyed, vegetative life still exists, so that the insects remain fresh until the young Odynerus is ready for its first meal, and yet is incapable of doing it any harm.

Another species of Odynerus forms its burrow in the dry twigs of the brier, which it hollows out and divides into a varying number of cells, with a kind of cement composed of earth mixed with tiny stones. As each cell is completed the wasp stores it with provisions, deposits an egg, and seals it with the cement. The most curious fact in connexion with this species is that the egg that is last laid is the first one to hatch out, and the larva makes its escape from the cell, leaving the way clear for the next insect to emerge; and so, in regular order, the eggs hatch, and the perfect insects come forth, in the reverse order to that in which they were laid.

Other solitary wasps make holes for the reception of their eggs in sandy banks or decayed wood, while a few species construct regular little nests of earth. *Vespa coarctata*, a species that is rare in Britain but frequently to be found in Southern Europe, constructs a small globular nest of mud about the size of a hazel-nut, and attaches it to a wall, or stone, or to the stems of plants.

The *Sphegidæ* are a numerous and very interesting genus. Species of Sphegidæ are to be found all over the world, but only one occurs in Great Britain. M. Fabre spent many years in studying the ways of these "sand wasps," as they are often called, which are fairly common in the south of France, and we are indebted in a great measure to him for our knowledge of the habits of these remarkable insects.

In the sunny south of Europe a bright-looking insect (*Sphex flavipennis*), with yellow wings and a red abdomen may be seen towards the end of July flying about in the sunshine, seeking for honey amongst the flowers, and generally leading a careless, vagabond existence; but as autumn approaches the Sphex begins to consider her responsibilities in life, and seeks a suitable situation in which to dig her burrow. A loose, sandy soil is her choice, and a low bank by the roadside is often the scene of her labours. The Sphex prefers a horizontal site for her excavations, and usually selects a flat spot on a sandy bank, though sometimes she carries out her mining operations on the level ground.

On a warm day in September little companies of *Sphex flavipennis* may be seen mining with characteristic zeal and energy, for although solitary in her habits as far as independence of action goes, the Sphex appreciates companionship sufficiently to prefer to work in the vicinity of those members of her own tribe who are engaged in the same task as herself.

Having chosen her site, the Sphex works away with a will, biting at the soil with her sharp mandibles, and raking the loose sand away with her claw-like tarsi, emitting all the time a high-pitched humming note, while her wings vibrate in a perfect frenzy of industry. As the tunnel gets longer the Sphex disappears within it, and little spurts of sand may be seen coming out of the entrance as the insect pushes out the loose soil behind her with her hind feet, in much the same way as a mole does when burrowing in the ground. Every now and then the Sphex emerges to dust her wings, or to take a short rest on an adjacent flower-head in the sun; then, with renewed vigour, she sets to work again on her self-imposed task. So rapidly does the Sphex work that her excavations are generally complete in a few short hours; then, after a critical inspection of her burrow, and a few final touches, she sets off in search of prey. The game that *S. flavipennis* seeks is no helpless, soft-bodied larvae, such as the Odynerus captures, but a large cricket, possessing a pair of pincer-like jaws capable of biting and tearing its assailant, and formidable, club-like hind legs with which to kick and bruise. It is, moreover, considerably bigger than the courageous Sphex, who, nevertheless, attacks the cricket with extraordinary daring and ferocity. The aim of the dauntless Sphex is to turn the cricket over on its back, and this, after a terrific struggle, she generally succeeds in doing; then, having gained the advantage in the fight, she at once proceeds to put an end to the struggles of her victim by stinging it into helplessness. M. Fabre, who several times watched a Sphex attack a cricket, describes her mode of procedure in the following graphic manner: "The murderess soon makes her arrangements. She places herself body to body with her adversary, but in a reverse position, seizes one of the bands at the end of the cricket's abdomen, and masters with her fore-feet the convulsive efforts of its great hind thighs. At the same moment her intermediate feet squeeze the panting sides of the vanquished cricket, and her hind ones press like two levers on its face, causing the articulation of the neck to gape open. The Sphex then curves her abdomen vertically, so as to offer a convex surface impossible for the mandibles of the cricket to seize, and one beholds, not without emotion, the poisoned lancet plunge once into the victim's neck, next into the jointing of the two front segments of the thorax, and then again towards the abdomen. In less time than it takes to tell, the murder is committed, and the Sphex, after setting her disordered toilette to rights, prepares to carry off her victim, its limbs still quivering in the death throes." Grasping the cricket firmly with her jaws, and holding it close against her own body with her legs, the Sphex rises with her heavy burden into the air and conveys it to her burrow by a series of short flights. When within a short distance of her goal she alights, and completes the last part of her journey on foot, dragging the cricket over the ground by one of its long antennae, which she holds between her jaws.

M. Fabre several times witnessed the manner in which the cricket was overcome by the Sphex by providing himself with a supply of live crickets, and substituting them for the paralyzed insects that the Sphex had dragged to her burrow. The substitution of the active for the paralyzed insect was easily accomplished, as the Sphex has a curious habit of leaving her prey on the threshold of her burrow, while she goes down alone on a visit of inspection before finally pulling it down to the chamber she has prepared for its reception.

In every case, M. Fabre asserts, the Sphex stabbed the cricket three times, and always exactly in the same places. Once in the neck, once behind the prothorax, and once near the top of the abdomen. Now, the cricket possesses three nerve centres, each centre animating a pair of the insect's feet, and it is these three separate nerve centres that the Sphex pierces with her sting, and paralyzes by the injection of the poisonous fluid!

That an insect should know exactly in what parts of her victim the three nerve centres are situated, and use this knowledge in such a scientific manner to secure suitable food for her young, appears almost incredible, and seems to endow the Hymenoptlra with an intelligence equal to that of human beings; yet the same insect will in other ways display the most complete stupidity. M. Fabre's patient experiments tend to prove, that the insect is in reality actuated almost wholly by an instinct that compels her to a certain course of action, which she follows blindly without reasoning in any way.

Taking advantage of the Sphex' invariable habit of leaving her prey on the threshold of her burrow while she goes down into it alone, M. Fabre on several occasions moved the motionless cricket further away from the entrance. On returning from her visit of inspection, and finding that her quarry was not where she had placed it, the insect promptly dragged it back again to its former position, and then again left it while she went down into the burrow a second time. No less than forty times was this trick played upon the same Sphex, and forty times did she patiently drag the cricket back again and leave it at the entrance to the burrow while she went below alone. Never once did it occur to the Sphex to take the cricket straight down into the cell without paying this preliminary visit! On another occasion M. Fabre observed a Sphex busily closing the entrance to her burrow; with the aid of his knife he cleared out the stopped-up gallery, carefully removed the motionless prey and the precious egg from the cell, and watched to see what the Sphex would do. I will give his observations in his own words: "Finding the entrance open, she entered and remained some moments, then came forth and took up her work where I had interrupted it, beginning to stop the entrance conscientiously, sweeping the dust backward, and transporting sand grains to build them with with minute care, as if doing a useful work. The orifice being thoroughly blocked, she brushed herself, seemed to give a glance of satisfaction at her work, and finally flew off."

Now, as the Sphex had gone down and inspected the violated cell, she must have seen that it was empty, and yet she acted exactly in the same way as she would have done had the egg and the provisions been safely within. The experiments tend to prove that the insect's actions are purely automatic and instinctive, one act following another with the regularity of clockwork. First, the Sphex makes her burrow; secondly, she provisions it; thirdly, she lays an egg; and lastly, she closes the burrow. The first, second, and third acts having been performed the Sphex is impelled to continue with the fourth and last act of closing her burrow, even when it is an utterly useless and futile proceeding.

On one occasion, however, M. Fabre chanced upon a colony of *S. flavipennis* in which a few solitary individuals acted as though they did possess a certain degree of reasoning power, by taking their prey straight down into the burrow without leaving it on the threshold, after it had been removed several times.

When the Sphex has furnished a cell with sufficient provisions, generally three or four crickets piled one on the top of another, she lays an egg. This is not deposited anywhere in a haphazard fashion, but is invariably placed on one particular spot—the cricket's breast, not exactly in the middle, but slightly to one side between the first and second pairs of feet. This is a precautionary measure on the part of Mother Sphex, as in that position her larva is practically safe from harm; as the paralyzed cricket still retains some power of movement in those parts that have not been punctured by the poisonous dart. Should the larva, on emerging from the egg, bite the cricket in an unaffected part, a convulsive movement might dislodge the little creature, which, too feeble to climb again on to the cricket, would perish for lack of nourishment.

Two or three chambers are hollowed out side by side, and when the last one has been provisioned and an egg laid, the Sphex closes the burrow securely by brushing back into the tunnel the loose sand she had scraped out, and smoothing it over so that all signs of her labours are effaced. The Sphex makes nine or ten burrows, and lays altogether about thirty eggs; then, her task being finished, she flies away to revel once more in the sunshine, and lead a light-hearted, careless existence for the remainder of her short life, which comes to an end with the summer days.

The egg hatches in two or three days' time after it has been laid, and the feeble larva at once begins to feed on the feast provided for it. It grows rapidly in size and strength, and in about a fortnight's time has devoured all the crickets, leaving only the tough, horny skins, feet and heads. It then sets to work to spin a cocoon, in which it rests while its wonderful transformation is taking place. This cocoon is a very remarkable structure. The pupa is contained in an elastic, silken case lined with a purplish, metallic varnish; this is enclosed within another covering of a felt-like substance, reddish in colour and fitting the inner case loosely, so that it is somewhat wrinkled. Outside this is a loose, rough network of coarse threads, mixed up with crickets' feet and skulls, and particles of earth and sand. In this elaborate case the insect rests nine months, passing through wonderful changes from larva to pupa, pupa to nymph, until it finally bursts its bonds and escapes as a perfect insect. It then pushes and bites its way through the sealed gallery and flies off into the sunshine.

It is a curious fact that as far as can be ascertained, all the Sphex hunt some species of Orthoptera; *Sphex occitanica*, an inhabitant of the south of Europe, selects the ephippiger of the vine as her prey, an insect many times larger and heavier than herself.

Sphex occitanica is really solitary in her habits, and invariably makes her nest in some spot where she is quite by herself, in soft, loose ground under the shelter of a projecting rock or stone, or in an old, crumbling wall. She reverses the methods of *Sphex flavipennis*, and first catches her prey, then digs her burrow in the nearest available spot. Only one ephippiger is stored in each cell, and the Sphex drags it to her burrow by one of its long, thread-like antennae. Seizing this in her mandibles, she hauls the heavy, paralyzed insect along on its back, straining and pulling in much the same way as a horse that is harnessed to a heavy load.

An even more remarkable victim is chosen by another member of the Sphegidæ family (*Chlorion compressum*), inhabiting some of the islands in the Indian Ocean. This beautiful little Hymenoptera preys upon the cockroaches that infest the islands, and is often seen hunting up and down the roads and gardens in search of these unwieldly and offensive creatures.

Another genus of sand Wasps, the *Ammophila*, invariably stores its nest with caterpillars, which it paralyzes in the usual way with its poisoned dart. *Ammophila sabulosa*, the British Sand Wasp, fairly common in England as well as on the Continent, is a striking-looking insect nearly an inch long, with a red band round the abdomen. It is very slender, and its abdomen is attached to the thorax by a thread-like petiole. The Ammophila digs a vertical shaft in light, sandy soil, about two inches long, the bottom of which she enlarges to form a single cell. Should her excavation be interrupted by bad weather, the Ammophila closes the entrance to her burrow with a small flat stone, and waits to continue her labours until the sun shines again. When the burrow is finished, the Ammophila always closes it with the little stone while she is away on a hunting excursion, but when sufficient provisions have been stored, and an egg laid, the entrance is finally sealed in the usual way, with the loose earth and sand that the insect has thrown out in making her nest.

Every species of these "solitary wasps" has its own particular prey; while some hunt caterpillars, others attack beetles, flies, aphides, spiders, and even bees. *Philanthus apivorus*, a species found in the south of England, provisions its nest in this cannibalistic manner with a victim belonging to its own order of Hymenoptera. Lying in wait amongst the flowers that the bees frequent in search of honey, Philanthus darts upon her prey, stings it in the abdomen, and triumphantly bears it off to her cell. Perhaps the boldest and most intrepid of all the hunting Hymenoptera, however, is *Pelopæus spirifex*, a native of France, who selects quite large spiders for her prey. Having marked down a large, fat-bodied spider in her web (herself on the lookout for prey), Pelopæus cautiously approaches, so that she may take the spider unawares; then with a sudden dash she darts in and attempts to sting the spider in the body. Should the wasp succeed, the spider is at once placed *hors de combat*, but if the latter is on her guard a terrific battle takes place, the wasp trying to sting the spider, who manœuvres to handicap her enemy by entangling her in her threads. The Pelopæus, by her dash and daring, generally succeeds in surprising and overcoming the spider, although it occasionally happens that the huntress herself becomes the victim, and is devoured by the spider.

The *Scolia*, a genus closely allied to the Sphex, varies the methods employed by most of her near relations, and neither makes a nest or digs a burrow; but prefers to find a cell already made in which to deposit her eggs. Most species of Scolia are very large, and have exceedingly strong mandibles and particularly spiny legs. They inhabit Italy, Spain, North Africa, and some parts of France. The Scolia prefers the larvae of certain large beetles as food for her future offspring; *Scolia flavifrons* chooses that of the Rhinoceros beetle, *Oryctes nasicornis*, a huge, lethargic insect that lives in galleries under the bark of rotten oak trees, or in heaps of tan. The Scolia searches up and down the decayed trunk of a tree, until by some means she discovers that the larva of the beetle is under the bark. She then digs down until she reaches it, stings it into insensibility, and lays an egg, which she glues to the larva's body with a special, natural secretion. In two or three days the Scolia larva hatches out, and at once begins to gnaw a hole in its victim. It steadily continues to devour the beetle larva, growing bigger and bigger in the process, until the whole of the insect is consumed with the exception of the tough skin, which the young Scolia by this time almost fills. Inside the skin the larva now spins its cocoon, so that the Oryctes larva not only furnishes the voracious little creature with food, but afterwards forms a cradle in which its devourer passes the pupal state.

The wonderful industry displayed by these insects, and the instinct that impels them to provide living food for the young they will never see, is truly remarkable, especially as in the adult state they exist wholly on the nectar of flowers, or the sap or gum of trees. *Bembex rostrata*, however, is an exception to the general rule, although she hollows out a burrow and places an egg and suitable provender within it, she does not then altogether abandon it, as do the majority of her kind. The Bembex makes her burrow in fine, shifting sand, of so light a nature that when she comes out of the narrow tunnel the sand falls in behind her and closes the entrance. A winding, narrow passage, from eight to twelve inches long, leads down to firmer soil, and here a chamber is roughly excavated so that the walls are firm enough not to cave in and bury the worker or the future larva. In this chamber the Bembex places a very meagre ration, consisting of a small fly; she then lays an egg, and leaves the burrow, which automatically closes after her by the falling in of the sand. She then scrapes and smooths the sand over the entrance with the greatest care, so that all trace of the tunnel may be concealed, and flies off, in all probability to construct other chambers and furnish them in the same way.

In about three days' time Mother Bembex returns, bringing with her a further supply of food in the shape of another fly. Without the slightest hesitation she flies straight to the spot where her nest lies hidden, lightly scrapes the sand with her fore-feet, pushes it away with her head, and dives below to the underground chamber. There she finds that the young larva (which had hatched out from the egg about twenty-four hours previously) has already finished the first meal she had provided for it, and is quite ready for a second, and this time a larger, fly. For a whole fortnight the little Bembex flies backwards and forwards bringing food to the larva; her visits to the nest becoming more and more frequent as her charge, and its appetite, grows larger. Altogether the Bembex catches and carries to the nest as many as sixty or seventy flies; then, the larva being full fed and refusing any more food, she departs for the last time, leaving her offspring to weave its cocoon, and undergo its metamorphosis.

The Bembex does not paralyze her prey, after the manner of her allies, but kills it outright; probably because, as the victim is to be devoured almost at once, there is no occasion to employ the more scientific method of preserving it alive.

Curiously enough, this huntress of Diptera is herself victimized by a species of the very order of insects that she persecutes. Several small species of flies belonging to the genus *Tachina* are parasitic upon the mining Hymenoptera; and the Miltogramma of Fabre, a minute, dull-coloured species with large red eyes, is especially dreaded by the Bembex. If when bringing food to her larva she sees any of these tiny parasites near her burrow, the Bembex displays every sign of alarm; she is afraid to alight, but hovers uncertainly over the entrance, emitting a low, plaintive hum. Meanwhile the flies, generally three or four in number, wait in a motionless attitude upon the ground; their bright eyes steadily fixed upon the spot that hides the entrance to the subterraneous chamber, in which the larva lies. Presently the Bembex drops to within a few inches of the ground, instantly the flies rise and take up their position in a line behind her, awaiting the moment when she will enter her burrow. Sometimes the Bembex will manœuvre about over the ground trying to shake these troublesome pests off, but with quiet persistence they follow her every movement, always keeping exactly the same distance from her. Sometimes the persecuted insect rises and flies off again with her prey, then the flies drop to the ground, take up their former positions, and patiently await her return. At length, her patience exhausted, the Bembex makes a sudden dart for her burrow. The moment she pushes her head into the sand the flies close in upon her, and with lightning rapidity, those that are nearest, deposit their eggs upon the prey that the Bembex is carrying down to her larva.

In this way the Bembex herself introduces the eggs of the parasites into her burrow, and sometimes as many as ten dipterous larvae have been found in a cell in company with its lawful owner. Strangely enough the Bembex never attempts to destroy or eject the intruders, but philosophically accepting the burden forced upon her, tries to feed all the larvae she finds in her nest regardless of their parentage. In the end, as it is quite impossible for the Bembex to bring enough food to satisfy so many hungry mouths, her own larva perishes for lack of sufficient nourishment, or it sometimes happens, if the supply of food is very short, that the little parasites fall upon their host and devour it!

The solitary bees are quite as interesting in their ways as the solitary wasps, which they resemble in their habits of constructing nests, and storing them with provisions for their future offspring. The food that the bees provide, however, is of a totally different nature; as throughout their lives they are vegetarians. The perfect insects feed entirely upon the nectar of flowers, but the larvae, who require a more substantial diet, are supplied by Mother Bee with a cake of pollen mixed with honey. Some solitary bees burrow in the ground after the manner of the Sphegidæ; some mine in wood, old walls, or stems of plants; while others make nests of clay and earth, and affix them to walls, stones, or trees.

The Mason Bee, *Chalicodoma muraria*, makes a nest of gravel and small stones, which she cements together into a hard mass with a kind of mortar made of dry earth mixed with saliva. The Chalicodoma (whose name signifies "stone house") starts her building operations about the beginning of May, soon after she has emerged from her cell as a perfect insect. She first chooses a spot on a sunny wall, or a large stone on the ground suits her admirably, and then flies off to collect building materials. Having found some nice dry earth she takes up a few grains in her mandibles and works them up into a little pellet of mortar with her saliva. This is firmly fixed on the wall or stone by the industrious little mason, to form the foundation of the nest, and she flies backwards and forwards bringing little pellets of mortar, small stones, and particles of gravel which she works into the structure with her mandibles and fore-feet until a cell is completed. The bee then varies her labours by collecting pollen and honey from the flowers. These she mixes into a cake, inside the cell; first she puts her head in and disgorges the honey from her bag, and then she goes in backwards, and brushes the pollen from the under surface of her body with her two hind feet. Every now and then, when she has added some more honey and pollen to the store, she stirs it together into a mass with her mandibles; then when the cell is about half full of this sweet food, she lays an egg on the top of it and closes it up. Several cells, varying in number from six to twelve, are made close together, and then the bee builds a thick roof of mortar over them all, so that the nest when finished looks like a lump of mud stuck on the wall.

The Chalicodoma do not always build new nests, but often economize labour by utilizing the more or less broken-down old ones, that remain attached to the walls. These the bees thoroughly clean and repair, clearing out the remnants of old cocoons that still hang on the walls, and stopping up all cracks with a little fresh mortar. Sometimes it happens that a Mason Bee on the look-out for an old nest, or a suitable site on which to construct a new one, comes upon a nest belonging to another bee, and endeavours to annex it. This the rightful owner naturally resents, and a fierce fight takes place between the rival bees until one of them is driven off.

Chalicodoma muraria belongs to the genus *Osmia*. The male and female are very unlike each other in appearance, and might easily be mistaken for different species. The male insect is much the smaller of the two, and is russet-red in colour, while the female is a beautiful velvety black, with dark violet wings. Like all the Osmiæ, the Mason Bees collect pollen on the underside of the abdomen, which is covered with stiff, backward-directed bristles, taking the place of the pollen-collecting hairs with which the legs of most bees are provided.

The Osmiæ show considerable diversity in their nest-building habits; a small species called *Chelostomes* make their galleries in old straw; they have very long and notched mandibles, with which they cut into the straw, and after cleaning it thoroughly out the bees make little cells with mortar within the slender tube. The thatched roofs of old country cottages, granaries, and barns are sometimes crowded with the galleries of this hard-working little insect.

Osmia aurulenta cleans out the dried twigs of brambles to form galleries for her cells. The Horned Bee (*Osmia bicornis*) is the most common British species, and is easily recognized by the two little horns that project from the front of its head. The female alone is adorned in this way, the male being a much less conspicuous looking insect. The Horned Bee varies her nest-building habits with the locality in which she finds herself; in sandy districts she burrows in banks and cliffs, but where the soil is of a clayey nature she chooses decaying trees, particularly willows, in which to build her nest. Two other British Osmiæ make their nests in the empty shells of the common snail, building their little cells, of well-masticated vegetable fibres, within the whorls.

The *Megachile*, or Leaf-cutting Bee, is a small black insect, with a patch of white down on its head, and a few reddish hairs on the thorax, the first three segments of the abdomen are also ornamented with white down. The Leaf-cutter makes a tunnel in earth that is fairly firm and solid, first working downwards for a few inches, and then continuing in a horizontal direction until a gallery of considerable length is formed. She then flies off to the nearest garden, and selecting a leaf on a rose bush, she cuts out a large piece with her long, four-toothed mandibles, as neatly as if it had been snipped off with a sharp pair of scissors. Ten or twelve pieces of varying shapes are cut from the rose-leaves, and carried by the bee to her burrow; where she twists and folds them, and fits one within the other, to form a compact, little green chamber about the third of an inch long, and rather like a thimble in shape. When the cake of honey and pollen is placed inside the tiny rose-leaf cell, and an egg laid, the Megachile closes it with a circular piece of leaf that exactly fits the opening. Three, and sometimes four of these circular pieces are carefully fitted one over the other, and pressed firmly down before the bee considers it quite safe and secure. Eight or ten little cells are usually constructed, one fitting into the other, so that they look rather like a long sleeve, or a lot of little thimbles fitting closely one against another.

Three hundred species of Megachilidæ are known to exist, and they are to be found in nearly all parts of the world. They all make their burrows in the earth or in wood, and line them with cuttings from leaves or petals of flowers. The Poppy Bee (*Anthocopa papaveris*), called by Réaumior the "Upholsterer Bee," chooses the common scarlet poppy with which to line her nest. She makes her burrows in dry, sandy soils, and pounds and presses the sides to make them hard and lasting. She then lines the cell completely with pieces of delicate, bright red fabric, cut from the petals of the poppy; pressing and smoothing each piece with her head and feet, so that there are no folds or creases, and finally folding in the loose ends of the lining so that no grain of sand can fall into the cell.

One of the largest of the mining Hymenoptera is the Carpenter Bee (*Xylocopa violacea*). It is an exceedingly handsome insect with a velvety black body and beautiful violet-coloured wings. The Xylocopa inhabits the south of Europe, and is found in some parts of Germany. The female constructs her nest in dead trees or old wooden posts; with her powerful mandibles she gnaws straight into the wood for a short distance, and then works downwards until she has bored a tunnel that is often as much as a foot in length and half an inch in diameter. In this the Carpenter Bee forms about a dozen cells, dividing one from another with a paste made from the fine sawdust moistened with her saliva.

CHAPTER VII

INSECTS AND FLOWERS—THE ROMANCE OF PLANT FERTILIZATION

THE intimate relations which exist between flowers and insects form a theme of absorbing and unending interest. It is a subject which offers a wide field for observation and investigation, and is one which richly rewards the investigator, bringing him intimately into touch with the complexity of the web of life, and revealing to him the wonders of adaptation and natural selection. From the opening of the first flowers of spring until the cold winds of approaching winter scatter the last petals to the ground, there is an unbroken sequence of subjects from which we may gather illustrations of how the colours and forms of the wild flowers have chiefly been brought about, by an unconscious natural selection exercised by the insects that visit them, and of how, through the agency of these insect visitors, the flowers gain the great advantage of cross-fertilization.

With the coming of spring and the re-awakening of plant and insect life, every country ramble that we may take will afford us an opportunity of observing the way in which the insects visit the flowers and obtain the honey and pollen from them. Let us on a warm spring morning enter a copse in search of Primroses. The fragrance of the delicate yellow blossoms is carried to us on the gentle breeze, and everywhere we hear the busy hum of insect life. Perhaps as we gather our nosegay, there comes back to us the happy memory of a similar excursion made in our childhood days, and of how we sought for the two kinds of Primrose blossoms which we called respectively pin-eyed and thrum-eyed Primroses. Seeking them once more, we quickly realize that the two types of blossom are never to be found on one plant, but that each bears but one form of flower. In the pin-eyed flower, only the little round stigma is visible at the top of the tube, the stamens being hidden halfway down inside the flower-tube. In the thrum-eyed blossom, on the other hand, only the stamens are visible at the top of the corolla-tube; while the short-styled stigma only reaches to the same position as the stamens in the pin-eyed flower.

Now as we examine these two types of flowers, the fact is born in on us that while the pollen from the stamens of a thrum-eyed Primrose might fall down the tube and lodge upon the short-styled stigma within, it is obvious that the pollen from the stamens of a pin-eyed flower cannot get up to the top of the tube on to the long-styled stigma. How, then, does the pin-eyed flower become fertilized? Let us watch the bees closely as they visit the flowers, and see if we cannot find out for ourselves the answer. A bee visiting a thrum-eyed flower thrusts its long proboscis down the corolla-tube in search of the sip of nectar which it expects to find. In doing this the insect brings the base of its proboscis and the front of its head against the stamens at the top of the tube, and some of the golden pollen dust becomes attached; and so long as it continues to visit the thrum-eyed flowers, it will continue to collect, without getting rid of any of the pollen grains. But when the bee flies away to a pin-eyed Primrose, then the part of its proboscis and head on which the pollen of the thrum-eyed flower has collected, will now come into contact with the long-styled stigma at the top of the corolla-tube, and some of the pollen grains will be rubbed off on to it, and will fertilize it; while at the same time the insect will be collecting on the hairs of his proboscis, lower down the corolla-tube, pollen from the stamens of the pin-eyed flower, which in turn will be rubbed off on to the sensitive surface of the short-styled stigma of a thrum-eyed flower. Here, then, is a most ingenious arrangement for obtaining the benefit of cross-fertilization through the visits of an insect, by which it is assured that every pin-eyed blossom shall always be fertilized by pollen from a thrum-eyed flower, and every thrum-eyed by a pin-eyed one.

A little later in the spring the beautiful dark green leaves of the Cuckoo-pint, or Lords-and-Ladies (*Arum maculatum*), attract our attention, and amongst the leaves we see the paler tints of the flower spathes, peeping up like little green

FIG. 1. PRIMROSES CUT OPEN TO SHOW SHORT AND LONG STYLES

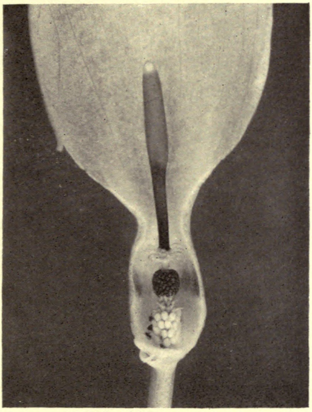

FIG. 2. CUCKOO-PINT CUT OPEN TO SHOW THE IMPRISONED MIDGES ON THE STIGMAS

FIG. 3. BUMBLE BEE IN THE ACT OF POLLINATING AN ORCHID (ORCHIS MASCULA)

FIG. 4. BEE COLLECTING POLLEN FROM BLACKBERRY BLOSSOM

gnome's caps. The Cuckoo-pint is the English Arum, our native representative of the larger tropical plant which we take such pains to cultivate in our conservatories. It is an interesting plant in many ways, and well worth a little attention. The gnome-cap is not really any part of the flower at all, but a protecting outer leaf or spathe surrounding a number of very small flowers. Externally we notice that the spathe narrows downward to a kind of waist or constriction, and then broadens out slightly. Inside, our attention is at once attracted by the curious green or purplish-coloured, club-shaped spike, standing straight up like a barber's pole; and, like the barber's pole, intended to attract attention, though the message it is intended to convey has nothing to do with shaving and hair-cutting, but that certain species of small midges which frequent the neighbourhood of the Cuckoo-pints in considerable numbers, will find within the spathe comfortable quarters and an abundant supply of food. Now let us slit open the spathe so that we can examine the entire length of the barber's pole. We shall find that below the centre it is encircled by a number of curious little knobs and stiffish hairs, arranged in tiers. The knobs on the lowest part of the stem are the female flowers, minus any calyx or corolla, and each consisting of a single ovary. Directly above these come the male flowers, also devoid of calyx or corolla, and each consisting of a single stamen. Above these again, and occupying a place on the main stem, just opposite the waist-like constriction of the spathe which surrounds and encloses them, are the curious stiffish hairs which point downwards and partially outwards, these are really abortive or misshapen flowers, and at this narrow neck form a sort of lobster-pot. It is easy to see that while a small insect will have no difficulty in creeping down past the hairs into the little chamber below the constriction, it will find that retreat is almost if not quite impossible owing to the downward and outward curve of the hairs. On slitting open the spathe, we shall very likely find a number of tiny midges imprisoned within the chamber below the constriction, and all more or less covered with pollen. These insects have arrived after a sojourn in another Cuckoo-pint, and have brought the pollen that covers their wings and bodies along with them. On first entering the chamber, they found no pollen there, for the female flowers at the bottom ripen first, and consequently the insects in creeping over the sensitive surfaces of these, fertilize them with the pollen they have brought from the last plant they visited. On discovering that there is nothing to eat, the midges would fain depart, but are prevented by the lobster-pot arrangement of downward pointing hairs. So they must perforce remain prisoners within the chamber. They crawl about aimlessly seeking for food, and in so doing, all unwittingly fertilize the female flowers. By the time this has been accomplished, the male flowers above begin to ripen and shower down pollen upon the midges in abundance, so that the little insects not only obtain a feast, but incidentally become dusted all over with pollen grains. Directly the pollen is all shed, the downward pointing hairs wither away, leaving a clear passage through which the midges are free to make their escape and fly away to another plant, where they will repeat the process of cross-fertilization. If the stamens of the Cuckoo-pint were the first to ripen, the pollen would fall on to the stigmas of the same plant, but by this device of alluring the midges and holding them prisoners while the stigmas first ripen and are fertilized with the pollen brought from another plant by the midges, the Cuckoo-pint secures with certainty the advantage of cross-fertilization.

The common English spotted Orchis is another plant affording an interesting example of extreme ingenuity in obtaining the benefit of cross-fertilization. The flowers of Orchids are all remarkably complex, many are most extraordinary in appearance, while others may be numbered amongst the handsomest flowers in the world. In more than two-thirds of the Orchids, one of the petals differs considerably from the others in shape, being larger and more conspicuous in coloration, this is called the lip or labellum, and forms a most attractive alighting place for insects. This petal is at first directed upwards in the bud, but in the majority of the Orchids, as the flower develops, the ovary undergoes a spiral twisting which brings the lip-petal below so as to serve as a resting-place for insects alighting in search of honey. Except in the flower of Cypripedium, there is only one anther, which is confluent with the style and forms the so-called "column." This anther is divided into two cells, which are frequently so developed as to have the appearance of two separate anthers. In most Orchids the pollen coheres in masses supported on a stalk or "caudicle," forming together the "pollinia." Theoretically there are three styles, but the stigma of the upper one is modified into a remarkable organ called the "rostellum" (at the base of the caudicle), while the two lower ones are frequently so closely united as to appear like one. If we look at a flower of the common *Orchis mascula*, or *O. Morio* of our meadows, we shall see that the lip-petal or labellum upon which the visiting insects alight, is continued as a spur or tube, the so-called nectary. The stigma is bilobed, and consists of two almost confluent stigmas, lying directly under the pouch-formed rostellum. The anther consists of two fairly widely separated cells, which are longitudinally open in front, each cell including a pollen-mass or pollinium. A pollinium, if closely examined, will be seen to be composed of a number of wedge-shaped packets of pollen grains, united together by extremely elastic, thin threads. At the lower end of each pollen-mass the threads become confluent and compose the straight elastic stalk or caudicle. The end of the caudicle is in turn firmly attached to a viscid disc, consisting of a minute oval piece of membrane which has a ball of viscid matter on its underside. Each pollinium has its separate disc, the two balls of sticky matter lying close together within the rostellum. Altogether, the blossom is extremely complex and interesting. To understand its mechanism, we must shrewdly watch what takes place when an insect visits it. When a Humble-bee alights on the labellum, which from its shape and striking coloration forms a peculiarly attractive alighting place, the insect proceeds to push its head and proboscis into the entrance to the nectary in search of honey. Now the pouch-formed rostellum projects into the gangway of the nectary in such a way that it is practically impossible for any object to be pushed into it without the rostellum being touched. Consequently the insect in reaching forward, brings its head against the delicate outer membrane of the rostellum, which is ruptured, and the pouch bearing the sticky balls of the pollinia is depressed so that one or both touch against the front of the insect's head, to which they instantly firmly adhere, for the viscid matter has a peculiar cement-like property of setting hard and dry in a few seconds. The result is that when the insect withdraws its head from the nectary, one or both of the pollinia will be withdrawn, firmly cemented to the front of the head, erect and projecting like horns. As the bee makes its way to another flower, the pollinia alter their position through the contraction of the minute disc of membrane to which the stalk or caudicle adheres, so that instead of standing erect, they now bend directly forward toward the apex of the bee's proboscis. The result of this movement is to bring the pollenium into such a position that its base will be brought into contact with the stigma. Now although the surface of the stigma is very viscid, it is not so viscid as to pull the whole mass of pollinium off the insect's head, but is just sufficiently adherent to break the elastic threads by which the packets of pollen-grains are tied together, and retain some of them on the stigma. Thus the bee may visit successively several orchid flowers, and fertilize each with some of the pollen-grains from the pollinia attached to its head.

Many and truly remarkable are the contrivances existing among our British Orchids, for obtaining the help of insects in their pollination, but even more wonderful are the methods of a tropical Orchid called Catasetum, which the late Charles Darwin considered "the most remarkable of all Orchids." Lord Avebury gives the following brief and clear description of this wonderful flower: "In Catasetum, the pollinia and the stigmatic surfaces are in different flowers, hence it is certain that the former must be carried to the latter by the agency of insects. The pollinia, moreover, are furnished with a viscid disk, as in Orchis, but the insect has no inducement to approach, and in fact does not touch, the viscid disk. The flower, however, is endowed with a peculiar sensitiveness, and actually throws the pollinium at the insect. Mr. Darwin has been so good as to irritate one of these flowers in my presence: the pollinium was thrown nearly three feet, when it struck and adhered to the pane of a window. This irritability, however, is confined to certain parts of the flower . . . the pollinium is curved and in a state of considerable tension, but retained in that position by a delicate membrane. Now insects alight as usual on the lip of the flower . . . and in front of it are two long processes called antennae. In some species of Catasetum both these antennae are highly irritable; in the present species (*Catasetum saccatum*) the right-hand one is apparently functionless; but the moment the insect touches the left-hand one, the excitement is conveyed along it, the membrane retaining the pollinium is ruptured, and the latter is immediately jerked out of the flower, by its own elasticity, with considerable force, with the viscid disk foremost, and in such a direction as to come in contact with the head of the insect which had touched the antenna. On subsequently visiting a female flower the insect brings the pollen into contact with the stigma." Here, then, to quote the words of the late Charles Darwin in his historic work on the fertilization of Orchids, "we see a flower patiently waiting with its antennae stretched forth in a well-adapted position, ready to give notice whenever an insect puts its head into the cavity of the labellum. The female Monachanthus, not having true pollinia to eject, is destitute of antennae. In the male and hermaphrodite forms, namely, *Catasetum tridentatum* and *Myanthus barbatus*, the pollinia lie doubled up, like a spring, ready to be instantly shot forth when the antennae are touched. The disk end is always projected foremost, and is coated with viscid matter which quickly sets hard and affixes the hinged pedicle firmly to the insect's body. The insect flies from flower to flower, till at last it visits a female plant: it then inserts one of the pollen-masses into the stigmatic cavity. As soon as the insect flies away the elastic caudicle, made weak enough to yield to the viscidity of the stigmatic surface, breaks and leaves behind a pollen-mass; then the pollen-tubes slowly protrude, penetrate the stigmatic canal, and the act of fertilization is completed. Who would have been bold enough to have surmised that the propagation of a species depended on so complex, so apparently artificial, and yet so admirable an arrangement?"

"Lastly I may be permitted to add that Dr. Crüger, after having carefully observed these three forms in Trinidad, fully admits the truth of my conclusion that *Catasetum tridentatum* is the male and *Monachanthus viridis* the female of the same species. He further confirms my prediction that insects are attracted to the flowers for the sake of gnawing the labellum, and that they carry the pollen-masses from the male to the female plant. He says 'the male flower emits a peculiar smell about twenty-four hours after opening, and the antennae assume their greatest irritability at the same time. A large humble-bee, noisy and quarrelsome, is now attracted to the flowers by the smell, and a great number of them may be seen every morning for a few hours disputing with each other for a place in the interior of the labellum, for the purpose of gnawing off the cellular tissue on the side opposite to the column, so that they turn their backs to the latter. As soon as they touch the upper antenna of the male flower, the pollen-mass, with its disk and gland, is fixed on their back, and they are often seen flying about with this peculiar-looking ornament on them. I have never seen it attached except to the very middle of the thorax. When the bee walks about, the pollen-mass lies flat on the back and wings; but when the insect enters a female flower, always with the labellum turned upwards, the pollinium, which is hinged to the gland by elastic tissue, falls back by its own weight and rests on the anterior face of the column. When the insect returns backwards from the flower, the pollinia are caught by the upper margin of the stigmatic cavity, which projects a little beyond the face of the column; and if the gland be then detached from the back of the insect, or the tissues which connect the pollinia with the caudicle, or this with the gland, break, fecundation takes place."

The flower of the common Nasturtium (*Tropaeolum major*) of our gardens, from the time of its first opening until its petals droop, passes through three distinct stages. The brilliant colour of the flower is in itself sufficiently striking to attract the visits of insects, but in addition we find that there is a sip of nectar awaiting these winged visitors in the long tapering spur. When the flower first opens, the anthers are unripe, and the pistil is short and immature; very soon after the opening of the flower, however, one of the anthers matures, opens, and turns up in such a way as to stand directly in front of the opening to the honey tube. The result of this change of position of the anther is that any humble-bee, or other insect of about that size, visiting the flower in search of nectar, must inevitably rub some of the pollen off on to its breast. The remaining stamens in turn ripen and assume the same position, within three, to six or seven, days from the first opening of the flower. After the stamens have all come to maturity, the anthers drop off and the filaments turn down out of the way. The pistil, which in the mean time has elongated, now assumes the position which the stamens had previously occupied, with the result that any humble-bee which had previously visited a younger flower and dusted its breast with pollen, will, on thrusting its proboscis forward and pressing inwards to obtain the nectar, deposit some of the pollen it has brought from the younger flower on to the surface of the stigma.

There are many flowers which open only at eventide, remaining fully expanded throughout the night, and closing with the coming of the dawn. These flowers have generally white, pale pinkish, or bright yellow petals which show out vividly in the dusk, and in addition are frequently very fragrant during the evening and night; the sweet scent being an additional aid to the light-coloured petals in attracting the visits of insects. The Nottingham Catchfly (*Silene nutans*) is an interesting example, for while with its sweet scent and pure white or pinkish flowers it attracts night-flying moths to its blossoms, it repels the visits of creeping insects, like ants, incapable of fertilizing the flowers, by the hairy and viscid nature of its stem. The flower of the Nottingham Catchfly lasts three nights. On the first night it opens at dusk, becomes very fragrant, and fully expands its petals, which spread out like rays and bend somewhat backwards, while five of its ten anthers burst and expose their pollen, and remain in that state the whole night. With the approach of morning the sweet scent decreases in volume, the petals shrivel and roll up, the stamens bend back and the anthers fall off. Throughout the day the flower looks withered, but revives with the approach of evening. The flower again expands, emits its sweet scent, and the second series of five anthers opens. With the approach of dawn, it again loses its scent, and again closes. On the third evening it opens as before, but the long velvety S-shaped stigmas, which until then have been hidden within the flower, are now pushed out and occupy the position which had been filled by the anthers on the two previous nights. The flower is frequented nightly by numerous moths chiefly belonging to the genus *Dianthoecia*, which are attracted to suck the honey, and the female moths also lay their eggs in the flower. We have here one of the many curious and interesting instances of flowers providing temporary shelter and nourishment in return for a reciprocal service. In the case of the Nottingham Catchfly, the Bladder-campion, and the Ragged Robin, the visiting female moths deposit their eggs in the flowers, and in doing so become loaded with the pollen from the flower upon which they have rested; in subsequently visiting other flowers, they dust the stigmas with the pollen from the flower which they had previously visited. At first one would be inclined to suppose that the depositing of eggs in the flowers, the subsequent emergence of the larvae, and their feeding upon the ovules within the shelter of the ovary, would be anything but advantageous to these flowers. This, however, is not the case, for owing to the large number of ovules which the flower produces, they are rarely all devoured, and even should this occur in one seed-capsule, there are always other capsules on the same plant uninjured, and capable of producing a sufficiency of seed.

That charming writer and eminent authority on the reciprocal relations existing between plants and insects, Anton Kerner von Marilaun, gives the following intensely interesting account of the relations existing between the flowers of the Yucca and a small moth, and between the Fig and a minute Hymenopterous insect: "The life-history of one of the moths living on the capsule-bearing species of the genus Yucca, and named *Pronuba yuccasella*, has been made out, and affords one of the most wonderful examples of the dispersal of pollen by means of egg-laying insects. The flowers in all species of Yucca are arranged in large panicles, and each is bell-shaped and suspended at the end of a smooth, green stalk. The perianth-leaves, six in number, are yellowish-white, and are consequently visible from a considerable distance in the dusk and on moonlight and starry nights. After the flower-buds open, which happens regularly in the evening, the perianth forms a widely open bell. The dehiscence of the small anthers, which are supported on thick velvety filaments, takes place simultaneously with the divergence of the petals, and a golden-yellow adhesive pollen is to be seen in the spiral slits of the anthers. Each flower is wide open for one night only; by the next day the free extremities of the six perianth-leaves bend towards one another, causing the flower to assume the form of a balloon or bladder with six narrow lateral apertures. In the twilight and by night, numerous small yellowish-white moths (*Pronuba yuccasella*), which have a metallic glitter in the moonlight, flutter about the flowers of the Yucca plants. The females penetrate into the wide-open bells and there endeavour to possess themselves of the pollen, not with a view to devouring it, but that they may carry it away. For this purpose they are furnished with a special implement. The first joint of the maxillary palp is lengthened to an extraordinary extent, and its inner surface is beset with stiff bristles and can be rolled up like a trunk. It is used to seize the pollen, to conglomerate it into a ball and afterwards to hold it. In a very short time a moth collects by this means a ball of pollen, which is held by the rolled-up palpi close underneath the head, and resembles a great crop. Laden with this lump of pollen, which is sometimes three times as large as its head, the moth abandons the despoiled flower and seeks another forthwith. Having found one, it circles nimbly round it, making a sudden spring off and on, and ends by settling on two of the thick reflexed filaments, sprawling its legs out upon them. It then seeks to reach a favourable spot on the surface of the pistil with its ovipositor, and there deposits its eggs. The ovipositor is composed of four horny bristles, and is adapted to pierce through the tissue of the pistil. After the eggs are laid and the ovipositor is withdrawn, the moth darts to the top of the infundibuli-form stigma, unrolls its trunk-like palpi, and stuffs the pollen into the stigmatic funnel, moving its head too and fro repeatedly during the operation. It is alleged that the same moth repeats the processes of alternately laying eggs and stuffing the stigma with pollen several times in the case of the same flower.

"Most of the eggs introduced into the pistil are deposited in the vicinity of the ovules. They are of oblong shape, narrow and transparent, and increase rapidly in size, soon revealing in each a coiled-up embryo. On the fourth or fifth day the larva is hatched, and at once begins to devour the ovules in the cavity of the ovary. Each grub requires from eighteen to twenty ovules to nourish it during the period of its development. When it is grown up, it bites a hole in the still succulent wall of the ovary, crawls out through the aperture, lets itself down to the ground by a thread, burrows into the earth and spins an oval cocoon underground, in which it remains till the following summer.

Fourteen days before the time of flowering of the Yucca, it begins to show signs of life, and the moment the flowers of that plant open, the silvery moths escape from their pupal envelopes. An important element in the interpretation of the relations subsisting between the Yucca and the Yucca-moth is the fact that without the assistance of insects the sticky pollen of the plant in question could not get to the stigma. In the case of *Yucca aloefolia* alone there seems to be sometimes a transfer of pollen to the stigma through the instrumentality of the petals or of the elongating filaments; but in most species of this genus, that is to say, in those wherein the fruit is capsular, this certainly does not take place. With the exception of the moth referred to, insects but seldom fly to them, and those which alight by chance on the flowers do not cause a deposition of pollen on the stigmas. If it were not for the transport of the pollen by *Pronuba yuccasella* the ovaries and ovules of Yucca would not ripen into fruits and seeds. As a matter of fact, all the fruits of the capsular species are rendered abortive if moths are kept away from the flowers by means of a gauze covering. Also in gardens where there are no Yucca-moths, the production of fruit is suppressed. *Yucca Whipplei*, which in California, its native land, is visited by a particular moth and develops an abundance of dehiscent capsular fruits, has repeatedly flowered in the Botanic Gardens of Vienna, but the moth does not exist in the gardens, and, in consequence of its absence, not a single fruit has ever ripened there. On the other hand, it is ascertained beyond a doubt that the grub of the moth in question lives exclusively on the young seeds of these species of Yucca, so that one is forced to the conclusion that the moth stuffs the pollen into the stigma in order that its grubs may be supplied with the nutriment requisite for the preservation of the species —nutriment which would not be forthcoming unless the ovules were fertilized. It must be observed that the grubs of *Pronuba yuccasella* do not eat up all the developing seeds of the ovary in which the moth lays her eggs. There are about two hundred ovules in each ovary. Even if half or two-thirds of them are consumed, there is still a sufficient number of uninjured seeds left to be scattered abroad when they have reached maturity, whereas, without the intervention of the moth, not a single seed capable of germination would be produced.

"Still more remarkable than the relation between the genus Yucca and its companion moth is that existing between Fig-trees and certain small wasps of the group of the *Chalcididæ.* To understand the relation clearly, it is first of all necessary to examine the construction of the inflorescence in the Fig. Looking at a fig that has been cut open lengthwise, it is observed that it is not a simple flower, but rather a whole collection of flowers inclosed in an urn or pear-shaped receptacle. These pear-shaped shoots are in reality hollow inflorescences bearing numerous flowers on their inner walls. Each fig is termed a 'synconium.' The orifice of the urn is very small, and is further straitened by the presence of small leafy scales. The flowers, which are simple in structure, almost fill the entire cavity; they are of two kinds, male and female. Each male flower is composed of one or two—rarely from three to six—stamens, which are supported by scales, and are borne on a short stalk. In many species, as for instance, in *Ficus pumila*, the stamens are spoon-shaped and have the anthers embedded in the concavity of the spoon. The female flowers possess a unilocular ovary containing a single ovule. The style is inserted rather to one side of the ovary, and terminates in a stigma, which is variously formed. At the base of the ovary are to be seen a few small scales which vary in number, and may be regarded as the perianth. Many species have two kinds of female flower in the same urn or synconium, viz. some with long styles and developed stigmas, and some with shorter styles and abortive stigmas. The latter are called 'gall-flowers,' for a reason that will presently be explained. The relative distribution of male and female flowers is very different in different species. In the inflorescences of the India-rubber Fig (*Ficus elastica*) the male and female flowers are apparently mixed together promiscuously; in that of *Ficus pumila* the female flowers only are found in the lower part of the cavity, and only male flowers near the mouth. This distribution is the most usual, but yet another difference exists in respect of the number of male flowers. In the synconia of many species the male flowers occur in large numbers near the orifice, whilst in others there are very few—indeed, it even happens sometimes that there is an entire absence of male flowers in one inflorescence or another. In many species some individuals only produce inflorescences containing female flowers, and other individuals inflorescences with male flowers near the orifice and with female flowers lower down. But the most remarkable circumstance of all is that in the inflorescences of many species, all or most of the female flowers below the male ones are transformed into gall-flowers. This is the case, for instance, in the common Fig-tree (*Ficus Carica*) cultivated in Southern Europe, a species which includes two kinds of individuals, viz. those whose inflorescences contain female flowers only, and those whose inflorescences contain male flowers near the opening, and gall-flowers lower down. The former individuals are known by the name of Ficus, the latter by the name of Caprificus. We have now to consider what may be the meaning of the gall-flowers. As the name indicates, not fruits, but galls are produced from these modified female flowers, and this happens in the following manner. There is a small wasp belonging to the Chalcididæ, a family of Hymenoptera, already referred to as *Blastophaga grossorum*, which lives upon the fig cultivated in the south of Europe. This insect passes into the cavity of the inflorescence through the orifice, and there sinks its ovipositor right down the style-canal of a flower, and deposits an egg close to the nucellus of the ovule. The white larva developed from the egg increases rapidly in size and soon fills the entire ovary, whilst the ovule perishes. The ovary has now become a gall. When the wasps are mature they forsake the galls. The wingless males are the first to emerge, and they effect their escape through a hole which they bite in the gall. The females remain a little longer in their galls, and are there fertilized by the males. Afterwards they come out also, but only stay a short time within the cavity of the inflorescence, issuing from it as soon as possible into the open air. They accordingly crawl up to the mouth of the inflorescence, and in doing so they come into contact with the pollen of the male flowers and get dusted all over the body — head, thorax, abdomen, legs, and wings. After squeezing through between the scaly leaves at the mouth of the inflorescence, and having at last reached the outside, they let their wings dry and then run off to other inflorescences on the same or on a neighbouring fig-tree. I say 'run' advisedly, for they but rarely make any use of their wings in this act of locomotion. They now seek exclusively inflorescences which are in an earlier stage of development, that they may lay their eggs in the ovaries. Having found such an one they crawl to the opening and slip between the scales into the interior. Sometimes their wings are injured in the act of entering; indeed, the wings are occasionally broken off altogether, and are left sticking between the scales near the aperture.

"Once inside the inflorescence, the wasps immediately devote themselves to laying eggs, and in the process are of necessity brought into contact with the stigmas of female flowers. The wasps are still powdered over with the pollen from their birthplace, and it is now brushed off on to the stigmas, which are thus pollinated from another inflorescence. If the pollen is deposited on normal pistilliferous flowers the latter are able to develop seeds endowed with the power of germination; if it falls on gall-flowers it is, as a rule, ineffectual, because the stigmas are more or less abortive. Moreover, no seeds are formed in these gall-flowers, owing to the eggs of the wasp being laid in their place. In those species of Fig in which gall-flowers are not specially provided, the eggs are laid in a certain proportion of the normally developed female flowers. It has, however, been observed in the case of the common Fig (*Ficus Carica*) that eggs of *Blastophaga grossorum* laid in ordinary female flowers do not come to maturity, or, in other words, that a normal female flower is not converted into a gall, even if the wasp in question sinks its ovipositor into it and deposits an egg in the interior. For the style of the normal female flower of *Ficus Carica* is so long relatively to the ovipositor of *Blastophaga grossorum* that the egg cannot be inserted quite into the ovary, but is left at a spot which is not favourable to its development, and there perishes. The gall-flowers of this species of Fig, with their short styles, are, on the other hand, pre-eminently adapted to the reception of the egg at the spot where the ovule would otherwise develop, whilst at the same time they are not adapted to the production of seeds capable of germination, since no pollen-tubes can develop upon their abortive stigmas. Evidently we have here a case of complimentary functions or division of labour in accordance with the following plan. The wasps which deposit their eggs in the figs carry the pollen both to the short-styled gall-flowers and to the long-styled ordinary female flowers, and attempt to lay their eggs in both kinds of flowers. The gall-flowers are prepared expressly for the reception of the wasps' eggs, and young wasps actually develop in them, but their stigmas not being adapted for the reception of pollen, they do not promote the growth of pollen-tubes, and no fertile seeds are produced. On the other hand, pollen-tubes develop on the stigmas of the long-styled flowers, and the latter produce fertile seeds; but the long-style prevents the proper placing of the wasps' eggs, and consequently galls are never or very seldom produced in connection with these flowers.

"It would take too long to discuss all the numerous diversities which have been observed in other species of Fig, even if they were known with sufficient accuracy to admit of a general survey. We will only mention that there are approximately six hundred species of Ficus, which are distributed over the tropical and sub-tropical regions of both the Old and the New Worlds, and that up to the present time nearly fifty species of small wasps of the genera *Blastophaga*, *Crossogaster*, *Sycophaga*, and *Tetrapus* have been identified as affecting the transference of pollen from one inflorescence to another in the various species of Fig. For the most part each species of Fig has its own particular wasp; only in extremely rare instances have two different species of wasp been found in the inflorescence of one and the same Fig."

Our common English Bulbous Buttercup (*Ranunculus bulbosus*) offers several points of interest in its relations with insects. Its brilliant yellow flower consists of four distinct and successive whorls of organs or floral leaves. In the very centre are the carpels, then the stamens, next the petals, and outside of all, the sepals. At the base of each golden petal is a tiny honey-gland or nectary, which is covered by a small scale to protect it from unwelcome creeping visitors. The sepals, which covered the flower in the bud, are in the expanded blossom turned back on the stem, and will be seen to be covered with small hairs. The blossom of the Bulbous Buttercup may be said to have two stages of development—a male stage which comes first, very shortly after the expanding of the blossom, when the anthers ripen in series from without inward; and a female stage, which begins after the stamens have ripened, shed their pollen, and withered, when the carpels mature, and their stigmas become receptive. It is obvious that here we have an arrangement that renders self-fertilization practically impossible. The brilliant gold of the petals, coupled with the honey-glands, will naturally attract the visits of winged insects.

If we watch a bee at work amongst the Buttercups, we shall see that the insect almost invariably alights upon the carpels in the very centre of the blossom, and that as it seeks the honey stored at the base of the petals, it turns round gradually all over the carpels and stamens, becoming dusted with the pollen from the latter if the flower is in the male or first stage. So long as the bee continues to visit flowers in this stage, it will continue to collect pollen upon its legs and body, without distributing any, for the carpels are still unripe. Directly, however, the bee alights upon a buttercup flower that is in the second or female stage of development, the insect will part with some of the pollen it has brought from some of the younger flowers previously visited; for the carpels being ripe and the sensitive surface of the stigmas sticky, the pollen will readily adhere as the pollen-laden insect moves over them. Now, the Bulbous Buttercup, being short of stem, is very liable to the unwelcome attentions of those indefatigable honey-thieves, the ants. They are very unpopular guests, being indiscriminate seekers after nectar, crawling up one stem after another in their search, and not going from one flower to another of the same sort, as is the habit with most of the flying insects. Therefore, to protect the honey-glands at the base of its petals from these undesirable visitors, the calyx of the Bulbous Buttercup on opening, turns down its sepals in such a way against the stem as to form a most effectual barrier to these creeping insects.

The tube of the flower of the Maiden Pink

(*D. deltoides*) is so nearly closed by the stamens and pistil, that it is only possible for the long and slender proboscis of Lepidopterous insects to reach the honey, and the flower which like the Bulbous Buttercup has a male and female stage, is dependent upon the visits of these insects for the transference of the pollen from the anthers of the younger flowers to the stigmas of the older ones. The stamens are ten in number, and very shortly after the flower opens, five of them emerge from the tube, ripen, and their anthers open. When these have shed their pollen, the remaining five come to maturity. Then the pistil, which during the ripening of the two sets of anthers had remained concealed in the tube, matures, emerges, and its two long stigmas expand themselves, assuming such a position that they cannot fail to be touched by the visiting pollen-laden insects.

The beautiful and fragrant flowers of the Sweet Pea offer an interesting example of the remarkable manner in which the *Papilionaceæ*, by means of a kind of piston apparatus, pump the pollen on to the visiting winged insect. Everybody is familiar with the general appearance of these favourite flowers; the corolla consists of five petals, the upper one called the standard, the two lateral ones forming the wings, and the two lower petals, which are united at their edges into a boat-shaped organ called the keel. Within this keel are the stamens and pistil. When a bee alights on the wings of the flower, her weight presses down the keel, which is locked with the two wings, and some pollen, and also the tip of the pistil, is forced out at the top of the keel against the chest and under-surface of the bee. On the departure of the bee, and the consequent removal of the pressure of her body, the keel springs back into place, and the stamens and pistil resume their former position within the keel. This arrangement may also be seen in the Horse-shoe Vetch, the Lupin, the Rest-harrow (*Ononis*), and the Bird's-foot Trefoil (*Lotous corniculatus*). In the case of the last-named plant, it has been ascertained by careful experiment that the process of pumping pollen from a given flower may be repeated eight times.

The flowers of the White and Yellow Dead-Nettles, and of the Salvia, show a remarkable hammer form of mechanism for depositing pollen upon visiting insects. Like so many of our native wild flowers, those of the common White Dead-Nettle are especially adapted for the visits of humble-bees. The petals form a tubular two-lipped corolla, the flower pointing obliquely outwards and upwards from its attachment to the main stem. The curious, curved and arched upper lip protects the pollen and honey from rain, while the broad lower lip forms an admirable alighting platform for the humble-bees when visiting the flower. The honey-gland or nectary is placed deep down within the tubular corolla, and is further protected from marauding insects incapable of effecting cross-pollination, by a ring of hairs halfway down the interior of the tube, which acts as a kind of rampart against these undesired visitors. The humble-bee in visiting the flower of the White Dead-Nettle, alights on the middle lobe of the lower lip, and pushes its head down the tube in order to reach the honey at the base of the tube. In doing this, the bee brings its back into contact, first with the stigma, and immediately afterwards with the anthers. The consequence is that pollen lodged on the humble-bee's back by a previously visited flower is conveyed to the stigma of a flower before the pollen of this latter is touched by the insect; and so cross-pollination is with certainty obtained.

The flowers of the Foxglove, like those of the White Dead-Nettle, are cross-pollinated through the visits of humble-bees only. The humble-bee creeps bodily into the tubular flower, which its body just fills, and its back comes first into contact with the stigma-lobes and then with the anthers, so that pollen from a previously visited flower is invariably rubbed on to the stigma. All the flowers of the Foxglove family (*Scrophularineæ*) show interesting adaptations and modifications for the visits of insects, thus the flowers of the Speedwell (*Veronica chamaedrys*), having a very short corolla-tube and easily accessible honey, are especially visited and cross-pollinated by various flower-flies; the Figwort (*Scrophularia*), which has short, wide, chocolate-coloured flowers, and readily found honey, is singularly attractive to wasps, and is almost entirely cross-pollinated through the visits of those insects. The Foxglove, the Snapdragon, and the Toadflax all possess flowers with long corolla-tubes and with hidden honey nectaries, and the body of the visiting insect must fit the flower if cross-pollination is to be successfully accomplished; consequently these flowers are dependent upon the visits of the large-bodied humble-bees for the transference of their pollen.

Certain species of beetles, flies, hive and wild bees, including humble-bees, wasps, butterflies and moths, all visit flowers in search of honey or pollen, and by their visits act all unconsciously as the agents for transferring the pollen from one flower to the stigma of another. In watching these various types of insects, one quickly realizes that flowers of different shapes and tints have their own particular insect visitors, thus the great Parsley and Daisy families are chiefly frequented by short-tongued insects like beetles and flies; the Peas, Clovers, and Violets, from the shape of their flowers, requiring insects with slightly longer proboscis to reach their honey glands, are visited in some cases entirely by bees; the White Dead-Nettle and Foxglove are examples of flowers specially adapted to the visits of humble-bees; and lastly, we may take the Pinks and Honeysuckle as flowers specially adapted to receive the visits of butterflies and moths. In general terms flowers dependent upon the visits of insects to fertilize their stigmas are (1) brightly coloured or scented; (2) possess honey glands which attract insects, and are so placed as to be easily accessible only to winged insects—in some instances, *i.e.* Poppy, Potato, etc., honey is replaced by a greater supply of pollen; (3) the pollen-grains are usually sticky, and therefore readily adhere to the hairy bodies of insects; (4) there generally exists a certain correspondence between the positions of the anthers and the stigmas of the flowers.

Here, then, is surely a wide and delightful field for observation and investigation, open to every one interested in the growth of flowers and in insect life. It is a subject full of fascination, surprises, and absorbing interest, and is one that will quickly impress the thoughtful observer with the importance of the study of insect life.

CHAPTER VIII

OUR BEETLE FRIENDS

OF the great group of insects comprised under the order Coleoptera, or Beetles, it is very difficult to give anything like an adequate description; indeed one might easily fill a series of volumes of encyclopedic proportions, and still leave unrecorded a vast amount of interesting material concerning these wonderful insects. At the present time over one hundred thousand beetles are known to science; while even if we confined our attentions to the members of the order inhabiting Great Britain, we should find that they exceed three thousand in number, or nearly one-fourth of the insect fauna of the country. Naturally, in such a vast concourse of insect life, we shall find not only the most diverse shapes and sizes, but also great variation in mode of living. While many beetles are directly the foes of man, ravaging his crops and stores of grain, others must be numbered among his truest friends, and, indeed, in tropical countries, acting as the great scavengers of the forests, render invaluable service. It is chiefly to the examination of one or two of these beetle friends that I propose to devote the present chapter.

If, as so often happens during the course of a country ramble, we should come upon the dead body of some small bird or animal, and pause for a moment to look regretfully upon the once graceful little form, now rendered rigid and unsightly by the grim hands of death and decay, we may be startled to see a slight movement of the stiff body, as if invisible hands were drawing it downwards into the earth. And, indeed, tiny hands are at work; Nature's sextons are busy labouring to bury beneath the soil the little corpse. Turning over the body gently, we find that it is already resting in a freshly excavated hollow in the ground, and that beneath it are several black and orange beetles who are busy scraping, burrowing, and clearing away the earth beneath the dead creature, so as gradually to make a little hole or grave. Had we arrived on the scene shortly after the death of the little animal, we should have seen the Sexton Beetles commence their operations by first loosening the soil at the sides of the body, and then set to work excavating the ground beneath, throwing out the soil with their strong legs until the dead animal sinks below the surface and is covered with the earth which has accumulated around the margin of the pit. They work very hard at their digging, and if undisturbed continue their labours until the body is safely buried. On one occasion I had an opportunity of watching these beetles at work upon the body of a mole, which they successfully interred after a little over twenty-six hours of, so far as I could observe without disturbing them, unceasing labour.

These Sexton or Burying Beetles (*Necrophorus vespillo*), in thus interring dead animals, render invaluable service in preventing the putrifying of the body in the air. They are true scavengers, and the object of their labours in burying the dead animal is that it may afford safe shelter for their eggs, and food for themselves and their young. As soon as the body is buried, the female Sexton Beetle deposits her eggs in it; these soon become larvae, and feed, like their parents, upon the decomposing matter until they are full grown. They then quit the remains of the body, and dig down into the earth where they form a chamber in which the final transformation takes place.

Another important and interesting group of scavengers are the Scarab Beetles (*Scarabæidæ*), which live upon, collect, and bury manure and stercoraceous matters in general. To prevent the filth they live amongst collecting on their bodies, these beetles keep their skins beautifully glossy by the natural secretion of an oily fluid. The Sacred Beetle (*Scarabæus sacer*), which is to be found in the south of France, the whole of southern Europe, Barbary, and Egypt, and is the Sacred Scarabæus of the Ancient Egyptians, may be considered as typical. It is a beautiful glossy black insect, stoutly built and rather oblong-oval in shape. Its front legs are remarkable, being enlarged and furnished with several strong tooth-like spines, but have no slender, jointed tarsus or foot at their end. These limbs, together with the sharply notched semicircular shape of the front part of the head (the *clypeus*, to give it its anatomical name), appear to have become specially developed to suit the habits of the beetle. The hind legs are long and somewhat distant from the other legs, giving the Scarab a curious appearance and uncertain straddling gait. The Scarab lives upon dung, which it forms into balls and carries away from the main mass of excrementous matter. Owing in the first place to careless observation and the repetition of statements lacking accurate verification, considerable confusion exists in many popular writings concerning this ball-forming habit. The idea that the egg was deposited in the centre of the ball of dung, and then rolled hither and thither until a suitable hole was found for it to fall into, appears to date back to the times of the ancient Egyptians, and to have been handed down through the centuries as an accredited fact. One would have imagined that a moment's careful consideration of the frail character of the egg-contents would have served to stimulate suspicion of this ancient theory. But ancient beliefs die hard, particularly when it is difficult to prove their error, and it was only after the most protracted and untiring research and observation on the part of M. Fabre that this myth was dissipated. As the result of his patient investigations, M. Fabre has shown that the female Scarab excavates a large chamber beneath the soil, which is entered by a narrow passage; that therein she collects a quantity of dung which she most carefully sorts and works up into a round mass, using only the finest and most easily digested portions for the interior, and gradually coarser and coarser material for the exterior. So that when the frail little larva emerges from the egg deposited in the centre of the large ball, it finds itself surrounded by nourishment already partially predigested, and by the time this has been devoured, its digestive organs have become sufficiently strong to tackle a coarser diet. The balls of dung which these beetles may be constantly seen pushing over the surface of the ground with such unceasing assiduity, never contain an egg, and are intended solely for the purpose of providing a feast. It is a most interesting and amusing sight to watch these remarkable insects at their work upon a mass of dung. One of them having got together sufficient material starts away to roll its ball to a place of safety, proceeding backwards and using its long hind legs to propel the precious ball along. Should its departure be observed, however, another Scarab is pretty sure to leave its own partially formed mass, and start off in pursuit. Catching up with the rightful owner of the completed ball, this rascal, whose sole object is to steal the precious mass away, or failing that, at least join in the anticipated feast, proceeds to help in the work of removal; or should the owner show signs of serious objection, will calmly sit on the ball, and, holding tight, allow itself to be rolled along with it. Many and ludicrous are the adventures ere the desired spot where the banquetting chamber is to be dug is reached. Should an incline have to be surmounted, it is only accomplished with the greatest difficulty, and after owner and ball have rolled over and over to the bottom several times. But success at last rewards this strenuous toil, the chosen spot is found, the tunnel and chamber excavated, and the precious ball lowered into it. There in the warm darkness of its subterranean chamber the Scarab sits down at last to its well-earned feast, and does not move from its banquet until the mass collected with so much labour has been devoured. But the rightful owner of a dung-ball is by no means always successful in carrying his property into private seclusion, indeed a ball may change hands two or three times ere it is placed in an excavated chamber, for these Scarabs appear to be sorry thieves, always ready to take advantage of any brother or sister Scarab who they may find in difficulties. Indeed, the humanitarian instincts which have been so lavishly ascribed to them by some authors are simply non-existent, their only reason for offering a helping hand being the hope that an opportunity may arise for filching property from the lawful owner. The greatest danger is during the process of excavating the banquetting chamber, for then the Scarab cannot keep constant watch upon the much coveted ball, and while he is working away underground, any brother Scarab perceiving the untended ball will promptly annex and hastily depart with it.

That the ancient peoples of Egypt held the Scarab Beetle in the greatest esteem and veneration, we have ample evidence from the frequency with which the insect appears carved upon the walls of their temples and monuments; while ancient gems were frequently fashioned in their image. It appears to have been as a religious symbol representing a unique birth—a father—the world. The Egyptians failing to distinguish the sexes, considered that the Scarabæus had no mother, and that therefore its birth was unique. They believed that when the male Scarabæus wished to procreate, the insect took the dung of the ox, and working it up in a ball with the aid of its legs, so as to give it the shape of the world, rolled it with its hind legs from east to west, and placed it in the ground, allowing it to remain there twenty-eight days. On the twenty-ninth day the parent Scarab brought the ball, now open, to the surface and threw it into the water, when the young male Scarab came forth.

An interesting and very useful beetle is the *Carabus auratus*, which in France goes by the name of the Gardener. It has a rather gracefully shaped body of a beautiful golden green colour, the antennae and legs are russet-tinted, and the wing-cases or elytra have three rounded, sculptured ribs running lengthwise. The Carabus may be frequently met with running rapidly about the lanes and fields in search of prey. It has quite a fierce, alert air, and attacks and devours caterpillars, snails, slugs, worms, and even the cockchafers.

In the months of May and June it may frequently be seen preying upon some hapless cockchafer which has blundered against something in its flight, and fallen to the ground, where it lies kicking helplessly on its back, while its foe disembowels it.

A near relation of the *Carabus auratus* is the Calosoma Beetle (*Calosoma sycophanta*), one of the handsomest European beetles. Its large body is a beautiful deep violet colour, and its wing-cases, which are striated and pitted, are a wonderful green and gold tint. It is an extremely active insect, frequenting the trunks of oak trees in search of the caterpillars upon which it preys. It is the hereditary foe of the curious Processionary Moth (*Bombyx processionea*), whose larvae cause such serious damage to the foliage of the oak trees in the forests of France. During August and September the small grey-winged moths appear in the woods, and the females soon begin to deposit their eggs in masses on the trunks and branches of the oak trees, covering the masses of eggs with hairs from their body. In the following spring, the caterpillars hatch out and collect in families which contain hundreds of members. These social larvae form an irregular common web beneath which to rest and shelter quietly during the daytime, only leaving it in the evening when they crawl over the foliage and voraciously devour it. The meal over, they may return to the old web, or form a new one should their search for food have taken them too far from the old home. These nests, having to afford shelter for several hundred members, are often of considerable size, and consist of several layers of web closely woven together. It is from their curious habit of marching forth from the nest in a regular army that these caterpillars have gained their name of Processional larvae. All day long the caterpillars remain perfectly quiet, closely packed together within the shelter of the nest, but directly the dusk draws on, there is a general stir. Then indeed a strange sight may be witnessed; a single caterpillar leaves the nest and begins to ascend the trunk of the tree, in a moment it is followed by another, and this by a third, and then comes a rank of three or four larvae, which in turn is followed by many more, the ranks gradually increasing in their numbers in a wonderfully regular manner, until at last the rear of the column issues in rather confused order from the nest. After they have devoured as much foliage as they can eat, the army forms up once more in precisely the same order and marches off home. There is the same formation should the host migrate from one branch to another in search of food. When full grown, the larvae do not separate, but gradually increase the thickness of the walls of their common web with the aid of their moulted skins, and then each larva makes for itself a cocoon within which to pass through its final transformations. It is during their evening peregrinations that these caterpillars fall hapless victims to the Calosoma Beetle and its larvae, which attack and devour them in large numbers. Indeed, but for the activity of this beetle in both the larval and adult stage of its life, in preying upon the Processionary Caterpillars, they would quickly strip the oak trees of every vestige of foliage.

The Tiger Beetle (*Cicindela campestris*) is another great hunter of caterpillars and other larvae and small insects. The ferocity with which this beetle attacks its prey is remarkable to witness. Pouncing upon some unfortunate fly, it sets to work with its large scissor-shaped jaws and quickly shears off the wings and legs of its victim, and then proceeds to devour the contents of the body. Its powerful jaws, swift movements, and hard armour-clad body, makes the Tiger Beetle a formidable foe, and as if aware of its invulnerability the beetle displays extraordinary courage and alertness, declining to relinquish its prey if disturbed, and always putting up a good fight if cornered. Indeed, if taken up in the hand, it will wriggle and gnash its jaws, and try its best to bite. Nor is it one wit less bloodthirsty in the larval stage of its life, though as its body is then soft and unprotected, it cannot expose itself with the same recklessness when hunting for prey, and therefore has to resort to strategy. The Tiger Beetle larva has six short spiny legs, which enable it to dig a hole in the sandy soil which these insects frequent. At first it burrows down vertically, thrusting out the earth with the aid of its flat head. When this vertical shaft has reached the desired depth, the larva proceeds to tunnel horizontally for a short distance, and finally turns round and rests with its head to the exit. On the somewhat swollen fifth segment of its body, the larva has two curious fleshy tubercles and curved hooks, by means of which it fixes itself against the side of the shaft, near the entrance, so that its flat broad head practically forms a false floor or lid. Beneath this ingenious trap the voracious larva waits, ready to seize and drag down any unsuspecting insect that may incautiously set foot upon the treacherous entrance to the trap.

There is a rare little beetle to be met with in France, living upon dried animal matter and wood, which should be of peculiar interest to every student of insect life, and around which hangs the true halo of romance, for it saved the life of one of the greatest entomologists of France. Its name alone, of Necrobia (from the Greek *νεκρός* and *βίως*), is suggestive, for it means "life in death." Here is the story as given by M. Louis Figuier, in his "Insect World." "Before 1792, Latreille was known only from some memoirs which he had published on insects. He was then priest at Brives-la-Gaillarde, and was arrested with the curés of Limousin, who had not taken the oath. These unfortunates were then taken to Bordeaux in carts to be transported to Guyana. Arrived at Bordeaux in the month of June, they were incarcerated in the prison of the Grand Séminaire till a ship should be ready to take them on board. In the meanwhile, the 9th Thermidor arrived, and caused the execution of the sentence which condemned the priests who had not taken the oath to transportation to be for a while suspended. However, the prisons emptied themselves but slowly, and those who had been condemned had none the less to go into exile, only their transportation had been put off till the spring. Latreille remained detained in the prison of the Grand Séminaire. In the same chamber which he occupied there was at the time an old sick bishop, whose wounds a surgeon came each morning to dress. One day as the surgeon was dressing the bishop's wounds, an insect came out of a crack in the boards. Latreille seized it immediately, examined it, stuck it on a cork with a pin, and seemed enchanted at what he had found. 'Is it a rare insect, then?' said the surgeon. 'Yes,' replied the ecclesiastic. 'In that case you should give it to me.' 'Why?' 'Because I have a friend who has a fine collection of insects, who would be pleased with it.' 'Very well, take him this insect; tell him how you came by it, and beg him to tell me its name.' The surgeon went quickly to his friend's house. This friend was Bory de Saint Vincent, a naturalist who became celebrated afterwards, but who was very young at that time. He already occupied himself much with the natural sciences, and in particular with the classing of insects. The surgeon delivered to him the one found by the priest, but in spite of all his researches he was unable to class it. Next day the surgeon having seen Latreille again in his prison, was obliged to confess to him that in his friend's opinion this Coleopteron had never been described. Latreille knew by this answer that Bory de Saint Vincent was an adept. As they gave the prisoner neither pen nor paper, he said to his messenger, 'I see plainly that M. Bory de Saint Vincent must know my name. You tell him that I am the

Abbé Latreille, and that I am going to die at Guyana, before having published my "Examen des Genres de Fabricius."' Bory, on receiving this piece of news, took active steps, and obtained leave for Latreille to come out of his prison as a convalescent, his uncle Dayclas and his father being bail for him, and pledging themselves formally to deliver up the prisoner the moment they were summoned to do so by the authorities. The vessel which was to have conducted Latreille to exile, or rather death, was getting ready whilst these steps were being taken, and while Bory and Dayclas were obtaining leave for him to come out of prison. This was quite providential, for it foundered in sight of Cordova, and the sailors alone were able to save themselves. A little time afterwards his friends managed to have his name scratched out from the list of exiles. It is thus that the *Necrobia ruficollis* was the saving of Latreille."

A very warlike and pugnacious beetle, frequently to be met with in country lanes and on garden paths, is the "Devil's-Coach-Horse" (*Ocypus olens*). It is a long, fairly slender beetle, black in colour with the antennae tipped with red. The wing-cases are very abbreviated, looking almost like a little waistcoat on the back of the long body, but beneath their shelter are neatly folded a pair of membranous wings of normal length. The beetle is carnivorous in its habits, and very active in its search for prey. When attacked or alarmed, the Devil's-Coach-Horse Beetle has a very characteristic habit of cocking up its head and tail in a most threatening manner, opening and shutting its powerful jaws, and, if greatly excited, thrusting out from the end of its abdomen two little bladders from which it ejects a volatile fluid having a most unpleasant odour. The larva very much resembles the adult insect, but has neither wings nor wing-cases. It hides away under the shelter of stones and logs during the daytime, coming forth at night to seek its prey.

A sight which always awakens feelings of interest during a country ramble on a warm summer evening, is that of the greenish-blue phosphorescent light of the Glow-worm, which shines out so brilliantly from the hedgerow in the gathering dusk. This strange, mysterious light which glows so strongly, yet is practically destitute of heat, shines forth from the last abdominal segments of the body of the beetle—for the Glow-worm belongs to the Coleoptera, its scientific name being *Lampyris noctiluca*. It is the female that glows with the greatest brilliancy, her greater luminosity making up for her lack of wings, and enabling her to attract from afar the attention of her winged mate, who has this same remarkable light-producing power developed in a lesser degree. In the early spring the female Glow-worm deposits her yellowish, slightly phosphorescent eggs, from which the young soon emerge. The larvae have elongated flattened bodies of a dusky hue, and are very voracious. They are really very useful little creatures, for they eagerly attack and devour snails. As the summer advances they change to the pupal state, in which they may remain until the following spring, when they emerge as perfect beetles. Professor Emery carried out many interesting experiments and observations on a continental species called *Luciola italica,* in the meadows round Bologna. By imprisoning females in glass tubes, he was able to prove conclusively that it was by their phosphorescent light alone that they attracted the males, for directly a female caught sight of the flashes of an approaching male through the glass walls of her prison, she at once allowed her full splendour to shine forth. He found that the female is by no means readily satisfied with a mate, for having captivated one suitor, she promptly proceeds to signal to rival swains, until she is surrounded by an excited circle of admirers.

There is always one vivid mental picture which stands out in the mind of the traveller returned from the West Indies and tropical South America, and that is of his first experience of a dark, sultry night in those tropical lands when hundreds of Firefly Beetles gave forth their light on every bush, or moved slowly as if carried by unseen hands from tree to tree; lighting up the sombre forest, as if for some fairy revel. The most brilliant of these living lamps, or *cucujos,* as the Mexicans call them, are species of Pyrophorus, of which *Pyrophorus noctilucus* is most frequently met with in Brazil and the West Indies. This beetle is about an inch and a half long, and of a dark rusty brown colour. The luminous organs are two yellowish oval spots on the upper surface of the first ring of the thorax, and another even more brilliantly luminous organ is situated on the first ring of the abdomen. These light-producing organs are special modifications of the epidermic cells, disposed in two layers, of which the outer one appears to be alone luminous, while the inner one contains masses of waste products, and is pierced by innumerable air-tubes (trachea). The luminosity of these organs depends on a process of oxidation, the oxygen being supplied by the trachea, the brilliancy of the light varying with the respiratory activity of the insect, nervous stimulus having little or no effect upon it. Although the subject has engaged the attention of many eminent chemists and physiologists, what the substance oxidized really is still remains undiscovered. The Indians make considerable use of these beetles, attaching them to their hands and feet when travelling through the forest at night. They attract the beetles by means of glowing coals or other form of light on the end of sticks which are gently waved about, and capture them in nets. The beetles so collected are carefully tended, kept in boxes covered with fine wire gauze, bathed twice daily in tepid water, and fed with pieces of sugar-cane. The beautiful Brazilian and Creole women make use of these Fireflies, or cucujos, fastening them in little transparent bags of light tulle to their dresses and hair; the effect produced by the tasteful grouping of these living jewels being particularly striking and beautiful.

CHAPTER IX

OUR INSECT FOES—RAVAGERS OF CROPS

OUR very numerous insect foes may be roughly classed under two heads, namely, those insects which when allowed to increase in numbers become the ravagers of crops; and those insects which are the transmitting agents of disease to man and his flocks.

Let us first try to realize why certain species of insects have, as the ravagers of crops, become the foes of mankind. But a little careful and discriminate observation is required to bring home the fact that in practically every instance these insects have become the foes of man through his violation of the laws of Nature, either wilfully or in ignorance. While it is very difficult and of rare occurence under absolutely natural conditions for vast swarms of plant-destroying insects to suddenly appear, nothing is easier in the artificial conditions produced by man. The web of natural life is so wonderfully adjusted that all the species, both plant and animal, making up that environment, are associated together in such a way that the excessive multiplication of a single species, either plant or animal, to the detriment of the other species, is held in check, and is practically impossible. Not so, however, in the artificial environment created by man in his cultivated fields and gardens; there we shall find in the various growing crops an abnormally abundant supply of food provided for these injurious insects, while the majority of their natural foes are absent, driven away and destroyed by man. Small wonder, therefore, that thus unchecked and supplied with an abundance of food, the insects should multiply with astonishing rapidity, and become in a short space of time converted into an all-devouring host, whose ravages are only to be combated by unceasing and costly labour. Nor will this annual, and what might be unnecessary, expenditure of capital and labour decrease until the present ruthless and senseless slaughter of insect-eating birds is checked, either by new and more drastic laws, or by the active administration and revision of the existing neglected Wild Birds' Protection Act.

The amount of hereditary ignorance and prejudice existing amongst both farmers, gardeners, and gamekeepers concerning bird life, is as astonishing as it is lamentable, causing as it does the slaughter of hundreds of innocent and useful creatures annually. Every Owl nailed to the barn-door does not represent one foe the less, but one faithful friend, who, if permitted to live, would have destroyed hundreds of mice and rats, and thereby prevented the destruction of much grain and the loss of many an egg and young chick; for nine times out of ten it is the rats that are responsible for the loss of chicks and baby pheasants.

One of the best friends of the farmer is the beautiful Lapwing or Plover, which if encouraged on the land would quickly help to rid it of wire-worms, leather-jackets, and other larvae which attack the roots of grass and growing crops; yet every spring these birds are persecuted for their eggs, which are diligently sought throughout the breeding season, and sent in large quantities to the cities. As a natural result of this annual destruction of the eggs, the handsome and useful Lapwing is steadily decreasing in numbers, is becoming every year more shy, and seeking more remote breeding places far from arable land where its services would be so valuable; and will, unless adequate steps are taken to stop the present wholesale destruction of its eggs, very soon be numbered amongst the ever increasing list of extinct species. The Tits and Finches, so foolishly persecuted by prejudiced and unobservant people, render invaluable service in the destruction of bud-frequenting insects, devouring these serious pests in countless numbers, so that the birds destroy thirty or forty insect-infested buds at least for every sound one that they may spoil in the search for their natural food. The amount of good work accomplished by the Starling, by extracting and devouring grubs from infested lawns and meadows, is truly remarkable, and offers a most instructive object lesson in the extreme importance and value of the insectivorous birds in holding in check our insect foes. It is only by the protection and encouragement of these feathered natural foes of the insects that we can ever hope to hold them successfully in check. That a certain amount of good may be done by supplementing the work of these natural enemies of our insect foes is obvious, but to imagine that their services can be successfully replaced entirely by artificial means, except very occasionally under the most favourable conditions and at very great cost, is absurd, and can only lead to disaster. The very number and variety of the so-called insecticides, of which highly imaginative advertisements crowd the columns of the agricultural and horticultural papers, only serve to testify their own worthlessness and the futility of artificial methods unaided by natural checks.

How, then, can we best help Nature to combat these insect ravagers of our crops? First by encouraging their natural foes, and secondly by striving to become familiar with the lives and habits of the insects, so that we may know when most successfully to apply such artificial means as we have in our power to use for their destruction. It would be impossible within the space at present at my command, to enter fully into the details of the habits of all our agricultural insect pests, therefore I shall only endeavour to trace the habits of some of the most remarkable or important, trusting that these may suffice to illustrate the importance and interest which attaches to the study of this particular branch of insect life.

Although of such diminutive size and fragile structure, the Plant-lice, Green-fly, Blight, or

Aphides, to give them the varied names by which they are known, are the most universal and at the same time the most appallingly destructive of all the insect ravagers of crops. No part of a plant escapes their attack, the stem and branches, leaves, fruit, and roots, all being liable to their unwelcome attentions; while the extraordinary rapidity with which they multiply, render the Aphides one of the most difficult pests to exterminate when once they have been permitted to establish themselves upon the plant. Strictly speaking, the word "Aphis" is a family term for these insects, of which some one hundred and eighty species are to be found in England; and in many cases a species will be found to confine its attention to one particular food-plant, exercising by its almost continuous attacks a very great influence upon the growth of various crops. Some species, however, may be found on different food-plants at certain seasons of the year; thus the Hop Aphis, which is responsible for such appalling destruction in the hop gardens during some seasons, may be found in the earlier part of the year, before the bines make luxuriant growth, feeding upon the sloe.

Individually the Aphides would be comparatively harmless, for they are diminutive in size and of comparatively frail structure; but so great and swift are their powers of multiplication and development, that in an incredibly short space of time thousands may be found crowding the stems and leaves of plants which a week previously harboured but a few specimens.

The life-history of the Aphis is an extraordinarily interesting one, and has attracted the close attention of many of the most distinguished scientific men. Réaumur and Bonnet being the first to accurately investigate its life-history, while their researches have been confirmed and further enlarged by the investigations of Owen, Huxley, and Buckton. The perfect-winged male Aphides make their appearance in large numbers in the autumn, and mate with the oviparous or egg-laying females. These females then deposit their minute eggs upon the plants, frequently covering them with a natural protective secretion; and with the advance of autumnal cold weather, the males and oviparous females soon die. From these autumn-deposited eggs are hatched in the following spring imperfect wingless Aphides which are all females, no males being present amongst them. These wingless females very soon commence to produce, not eggs, but living young, and are therefore called viviparous females. Their offspring in turn give birth to other living young exactly like themselves in appearance, and so on throughout the summer there is a constant succession of these viviparous females, all producing young without the presence of the male; this non-sexual method of reproduction being known as parthenogenetic reproduction. Réaumur, in the course of his experiments with Aphides, succeeded in rearing about fifty parthenogenetic generations, all descended from one mother, by keeping up for several years a constant summer temperature and abundance of food; thus demonstrating that warm weather and a plentiful food supply are conditions which result in the production of parthenogenetic females. The return of autumn, bringing with it a lower temperature and a growing scarcity of food, heralds the birth of winged males and egg-laying (oviparous) females. Sexual intercourse takes place, and the winter eggs, from which the first generation of viviparous and parthenogenetic females will emerge, are deposited.

The offspring of the viviparous females at the time of their birth closely resemble their parents in general appearance; they do not pass through any regular metamorphosis, but at once begin to feed, cast their skins once or twice, and within a few days of their own entry into the world are ready to give birth to young. As under normal conditions viviparous female Aphides live for four or five weeks, it is possible for the parent insect to find itself surrounded, not only by its children, but by its grand-children, great-grandchildren, and great-great-grandchildren. Réaumur estimated that one female Aphis may be the progenitor of no less than 5,904,900,000 individuals during the few weeks comprising the period of her existence. Professor Huxley brings home to us even more clearly the extraordinary fecundity and the astonishing rapidity with which the Aphides increase. Assuming that one thousand Aphides weigh collectively about one grain avoirdupois (and this is rather under- than over-estimating their weight), and that only a very stout man can weigh as much as two million grains, or rather more than twenty stone, Professor Huxley computes that the tenth brood alone of the descendants of a single Aphis, if their multiplication remained altogether unchecked by the usual natural causes which play such an important part in their destruction, would weigh more than five hundred millions of stout men! But for its many natural foes, such as the insect-feeding birds, and certain insects which feed upon it or deposit their eggs in its living body, and those storms and other sudden climatic changes which exercise a very considerable influence upon its numbers, the Aphis would multiply to such a degree as to cause in a few months the total destruction of all existing vegetation.

And now let us just briefly glance at the anatomy and general appearance of this most remarkable and prolific insect foe. The male Aphides are always winged, while the females are frequently wingless. Throughout the summer months the majority of the viviparous females are wingless, but at certain times, particularly when the food-plants are becoming exhausted from the vast numbers of Aphides crowded together, and in the spring and autumn, winged females appear. The Aphides are chiefly brownish or green in colour, often closely resembling the colour of the food-plant, though some species like the Bean Aphis, which is such a pest in the kitchen garden, attacking the tops of the broad-beans, is from its sooty colour often called the "Collier" or "Black Dolphin." Their bodies are soft, fleshy, and swollen in appearance, more or less oval in shape, and generally covered with a mealy substance which serves to repel water. The wings, when present, are very beautiful and delicate in structure, often finely irridescent, the front pair being much larger than the back. The legs are slender and feeble, in keeping with the very sedentary life these insects lead, for the majority rarely move far from the spot where they are born, migration being practically confined to the winged individuals. Most of the species bear upon the upper surface of the abdomen a pair of perforated tubercles, the well-known honey-tubes, or *corniculi*, from which a copious supply of sweetish fluid is poured forth in small drops, and is the sticky substance so often found coating the surface of leaves during the summer months, and called "honey dew." It is for the sake of this honey-dew secretion that the Ants pay such attention and care to certain species of the Aphides. The parts of the mouth are very perfectly adapted for piercing the leaves and stems, and for sucking the juices of plants; they consist of four long stylets within a protecting sheath or proboscis.

The cultivation of hops, once such a characteristic and flourishing English industry, giving constant employment to hundreds of our agricultural labourers, is to-day rapidly approaching total extinction, killed by unfair foreign competition, and the wilful refusal of a purblind Legislature to grant such measures as would afford due protection and enable the unfortunate British agriculturist to compete on fair terms with his foreign rivals. One of the many factors which has helped to bring about this lamentable state of things, and which has always governed the cost of production, the quantity, quality, and price of hops, is one of our insect foes, namely the Hop Aphis, which, frequently appearing in vast numbers in the hop gardens, causes the most terrible havoc among the bines; and the cost of fighting this pest looms large among the causes which render it impossible for the English farmer to compete against the prices of foreign, untaxed, imported hops.

Some idea of the havoc which these insects can cause may be gathered from the following extract from the "Letters of Rusticus," and which also throws an interesting light on the size of the industry in the early years of the last century: "In the year 1802, on the 14 of May, the duty was laid at £100,000; the fly, however, appearing pretty plentifully towards the end of the month, it sank to £80,000; the fly increased, and by the end of June the duty had gone down to £60,000; by the end of July to £30,000; by the end of August to £22,000; and by the end of December to £14,000; the duty actually paid this year was £15,463 10*s.* 5*d.* In 1825 the duty commenced at £130,000, but, owing to the excessive increase of the fly, had in July fallen to £16,000; at the beginning of September it rose to £29,000; but towards the end fell again to £22,000; the amount paid was £24,317 0*s.* 11*d.* In the following year the summer was remarkably dry and hot; we could hardly sleep of nights with the sheets on; the thermometer for several nights continued above 70° Fahr. all the night through; the crop of hops was immense, scarcely a fly was to be found, and the betted (estimated) duty, which began in May at £120,000, rose to £265,000; the gross duty actually paid was £468,401 16*s.* 1*d.*, being the largest amount ever known. From this it will appear that, in duty alone, a little insignificant fly has control over £450,000 annual income to the British Treasury; and, supposing the hop grounds of England capable of paying this duty annually, which they certainly are, it is manifest that in 1825 these creatures were the means of robbing the Treasury of £426,000. This seems a large sum, but it is not one-twentieth part of the sums gained and lost by dealers during the two years in question." Although since those memorable years considerable advancement has been made in the artificial means of combating the ravages of the Hop Aphis, the cost still remains very high, and it is the natural enemies of the Aphides, such as the ladybirds, hawk-flies, lace-wing flies, parasitic ichneumon flies, and insectivorous birds, which are the only really successful agents in preventing their excessive increase.

In like manner, our cereal crops in some seasons suffer very serious damage from the depredations of Aphides; the Corn Aphis (*Siphonophora granaria*), to be found feeding upon wild grasses, at times ravaging the cornfields to such an extent as to seriously impoverish if not altogether destroy the crop. But this Aphis has a deadly natural foe in the shape of a parasitic ichneumon fly which deposits its eggs in the body of the Aphis, the resulting larvae thriving upon the fat, so to speak, of their unhappy host, until the Aphis dies from exhaustion. The tiny ichneumon is ever alert and on the watch for its victims, and the most superficial examination of a few heads of wheat towards the end of the summer will show hundreds of dead Aphides, each with a minute hole in the skin through which the parasite has emerged, after passing through its metamorphosis within.

Every one who has visited an old orchard during the summer months must be familiar with the curious patches of white, cottony looking material attached to the trunks and branches of the fruit trees. These curious patches, on closer observation, will be found to shelter numbers of reddish or slatey grey coloured Aphides, commonly known as the American Blight or Woolly Aphis, and said to have been imported into this country from America in 1787; though there seems to be some uncertainty as to this being a fact, the opinions of experts differing on the subject. Whether indigenous or imported, however, one fact is only too well established, and that is the very serious injury which these Aphides cause every year in our orchards, by their constant puncturing of the tissues and sucking at the sap; indeed, so great has been the havoc wrought by this insect foe, that in some years the entire cider crop has been lost in some counties. The characteristic "wool," is excreted from the back of the insect, and serves a double purpose, namely, as a protection from rain and cold, and as a means of transportation from one tree or orchard to another. In neglected orchards this wool may be seen in masses and festoons hanging down from the branches of the trees, and fragments may be seen ever and anon to become detached and wafted away on the wings of the wind, to spread the infestation in other quarters; for every tuft of wool will be found to contain a number of the Aphides. But for the good work of the Blue Tit (*Parus cocrulens*), who may be seen hunting over the infected boughs and trunks during the winter, clearing off the Aphides wholesale, our orchards would indeed stand but a poor chance of yielding any fruit. These beautiful and interesting little birds deserve to be most thoroughly protected, and encouraged in the orchards, for the enormous amount of good they do far outweighs any slight loss they may cause by destroying a few buds, the greater number of which are probably already infested with some hidden insect foe.

Another of our insect enemies, which though of diminutive size is capable of causing terrible havoc among turnips and similar crops, is the Turnip Flea Beetle (*Haltica nemorum*), or, as it is often called, the Turnip Fly. It measures but a twelfth of an inch in length, belongs to the order Coleoptera (Beetles), and has gained one of its common names from its quick, jumpy movements when alarmed. These little shining blackish beetles may be found in myriads, in fine sunny weather, busily engaged in gnawing holes in the turnip leaves, but skipping off directly they are alarmed, their rapid jumping movements from leaf to leaf producing a curious pattering sound, almost like falling rain.

The female Turnip Flea Beetle lays her eggs on the under-surface of the rough turnip leaf, and in ten days the young whitish-yellow, fleshy, cylindrical-bodied larvae hatch out. Directly they emerge from the eggs, these larvae set to work to gnaw through the lower skin into the soft pulp of the leaf, and thence make their way onwards, eating out winding burrows inside it. Safely housed within these burrows, they feed for about six days, and then they come out and bury themselves at a depth of about an inch and a half in the soil, at the foot of the plant upon which they have been feeding. They then pass into the pupal stage, which lasts for about fourteen days, at the end of which time they emerge as perfect beetles. It is as the adult beetle that this insect does the most serious damage, for it not only gnaws the seed-leaves (cotyledons) and the tender young plant when it first springs into growth, so as to frequently totally destroy it, but also gnaws large holes in the foliage of more advanced crops, thereby causing very serious injury.

In the year 1881 this country suffered from the most severe and general attack of the Turnip Flea Beetle hitherto recorded, the havoc caused by the insects amounting practically to a national calamity. Some idea of the vast extent of the damage caused by these minute beetles, insects measuring but a twelfth of an inch in

PLATE XIV

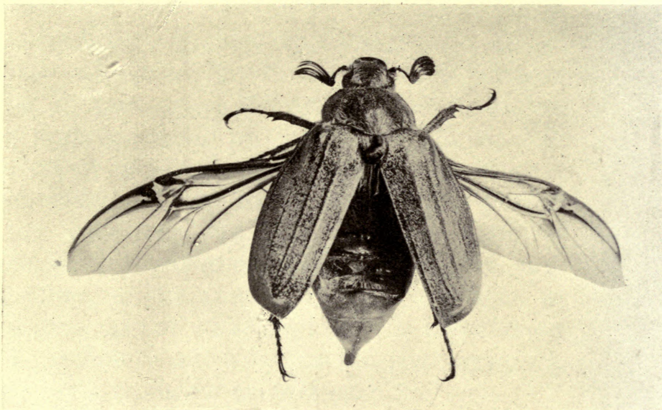

FIG. 1. MALE COCKCHAFER. MAGNIFIED × 2

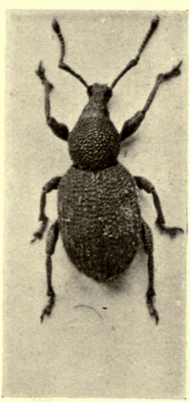

FIG. 2. THE VINE WEEVIL. MAGNIFIED × 3

FIG. 3. THE TURNIP FLEA-BEETLE. MAGNIFIED × 3

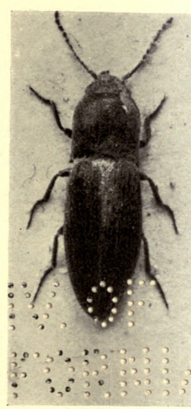

FIG. 4. THE CLICK BEETLE. MAGNIFIED × 3

length, may be gained from the following quotation from Miss E. A. Ormerod's "Observations of Attack of Turnip Fly in 1881." "The acreage under turnips and swedes in the twenty-two English counties reported on, was on the 4th of June, 1881, as stated in the agricultural returns of Great Britain, 1,149,768 acres; and from the reports sent to myself of amount of Turnip Fly infestation, it might fairly be presumed that it was generally present in the counties reported from. If, however, we take half the total of 1,149,768 acres mentioned above, that is to say, 574,884 acres, as the area to be re-sown once in the counties under consideration (a calculation which is probably much below the real amount), we shall get a basis for an estimate.

"1st. Taking loss on *seed alone* for one re-sowing, if we take the price of seed at 9*d.* per pound, and three pounds per acre as the quantity needed, this loss would amount to £64,674 9*s.*

"2nd. Taking loss on one re-sowing of the same amount of acreage, including outlay for scuffling, harrowing, rolling, drilling, seed, and possibly some additional superphosphate, we cannot well put the cost per acre under 15*s.* (if ploughing instead of scuffling should be required, it would be some shillings more, say 5*s.*); but taking the outlay as 15*s.* this would amount to the sum of £431,163 on the 574,884 acres. If, according to the estimate of some of our agriculturists, much better able to estimate outlay per acre than myself, this should be put at £1 rather than 15*s.*, the loss of course agrees in numbers of pounds with the acreage, £574,884 on 574,884 acres.

"In Scotland, Turnip Fly was present in various localities, or was generally prevalent to a serious extent in eleven counties. The acreage under turnips and swedes in these eleven counties, as stated in the Government returns quoted above, was 194,105 acres. Half of this total of 194,105 acres is 97,052, and following the previous method of calculation, the loss on this would be for seed, £10,918 7*s.*; for one re-sowing at 15*s.* per acre, £72,789; for one re-sowing at £1 per acre, £97,052. The loss, therefore, on the amount of acreage named in twenty-two English and eleven Scottish counties would at the above estimate stand thus: For seed alone, £75,592 16*s.*; for one re-sowing, including, seed and cultivation at the rate of 15*s.* per acre, £503,952; the same at the rate of £1 per acre, £671,936. This amounts to just a little more (or considerably more) than half a million, if the larger rate of £1 per acre is taken; but though the direct amount of money loss on unreturned outlay for seed and re-sowings in the districts known to have been attacked amounts to this enormous sum, and can at least be fairly well estimated, beyond this there is still a heavy loss to be considered on lesser value of the white turnip than the swede crop, and also on the deficiency of the late-sown crops, as well as in some cases the total loss. Also the deficiency of crops affects other points of agricultural supply, as want of cattle-food, and consequent lesser supply of manure, depreciation of price of stock, etc.; so that it is impossible to say how far the loss extends."

The Codlin Moth (*Carpocapsa pomonella*) is a striking example of an insect which, through the agency of man, has become a cosmopolitan foe. Its original home, like that of its principal food plant, the apple, was probably south-eastern Europe, and from thence it has spread to almost every part of the world where apples are cultivated, so that to-day this insect foe is to be found causing considerable damage in the fruit orchards of Australia, Canada, New Zealand, Tasmania, South Africa, the United States of America, in Great Britain, Ireland, and the Continent. That it is an ancient foe, there seems to be considerable proof, for Cato in his treatise on Agriculture, written nearly two hundred years before the Christian era, is said to mention "wormy apples"; while Pliny, in the first century A.D., wrote: "The fruits themselves, independently of the tree, are very much worm-eaten in some years, the apple, pear, medlar, and pomegranate, for instance." The first published account of the insect itself, however, does not seem to have appeared until 1635, when the Dutch author Goedaerdt described it under the name of "Pear-eater," in his curious old book entitled "Metamorphosis Naturalis." Its modern name of Codlin Moth appears to have been first given to the insect by Wilkes, in 1747, who, in connection with his description of the Moth, gives an illustration of a Codlin apple tree; other names by which it has been known are "Apple-Worm," "Apple and Pear Worm," "Fruit Worm."

Conservative estimates place the annual loss to fruit growers, caused by the ravages of the Codlin Moth, at from 20 to 75 per cent. of the apple crop; the variation being governed by the amount of work carried out yearly in holding the increase of the moth in check. In the fruit-growing States of America the damage caused by this insect is very serious, amounting, for instance, in the State of New York alone, to something like $3,000,000 per annum.

The Codlin Moth is a pretty little insect, its grey front wings being delicately streaked with copper, and having a dark burnished patch near the hind angle of the wing. The hind wings are of a somewhat lighter greyish-brown colour, with a darker margin. In the spring, just as the apple blossoms begin to fall, the female moth deposits her tiny scale-like eggs upon the skin of the young newly formed fruit, or on the adjacent leaves. In about a week the tiny larva hatches out and usually makes its way into the blossom end of the baby apple, where it remains feeding for several days before eating its way down to the core. Here it lives feeding upon the seeds, and thereby causing the premature fall of the apple. About four weeks after its first entry into the apple, the larva is full-grown, and as a preliminary to quitting the fruit, it gnaws a tunnel from the core to the outside, but closes the opening of this tunnel with a sort of wad composed of silk and apple debris for a few days, while it takes its final feed within. It then emerges by the tunnel, and usually makes its way to the trunk of the tree, where it spins a cocoon under the loose bark. From this cocoon the perfect moth emerges in about a fortnight, or in the following spring, according to whether there are one or two broods in the course of the season. In England the moth appears to be single-brooded, but in France and the greater part of the United States of America it is double-brooded. Apparently it is the second broods that are chiefly the means of spreading this pest from one country to another, for these larvae are frequently still within the apparently good apples when gathered and packed. The larvae on emerging will spin their cocoons in any convenient crack or cranny of the barrel or packing-case, or wherever the apples have been stored, and in due course the perfect moths will emerge to spread the infestation over new ground.

The Cockchafer (*Melolontha vulgaris*), although an all too familiar insect in our country lanes during the months of May and June, is not quite such a serious foe to the British farmer as it is to our friends on the Continent, where vast swarms periodically make their appearance, and strip the entire foliage from the trees. Nevertheless, in England, it is an insidious foe, always present in certain numbers, working throughout its comparatively long larval life beneath the surface of the ground at the roots of trees and various crops, while in the adult stage it devours the foliage. The large, brownish, handsome Cockchafer beetle, with its beautiful, almost fan-shaped antennae, is too familiar an object to need a detailed description, but the larva, leading a subterranean life, is probably not so generally known in appearance. The female Cockchafer deposits her eggs in the ground, and from these emerge the whitish, fleshy looking larvae. The larvae, when full-grown, are curious-looking creatures about two to three inches in length; the head is brown and horny, and the jaws are well developed; the six legs are immediately behind the head, on the thoracic segments of the body; the body terminating in a large sac. When brought up to the surface of the soil by a spade or the plough, the larva assumes a very characteristic and somewhat rigid bent position, only feebly moving when touched.

The larval stage of the Cockchafer lasts from three to four years, during the whole of which period the insect remains beneath the surface, feeding voraciously upon the roots of sapling trees and other plants. When ready to pupate the larva digs deep down into the soil, where it forms a little chamber within which to pass the final stage of its metamorphosis. The perfect chafer soon emerges from the pupa, but does not immediately quit the little chamber in which the final change has taken place, often remaining in a state of hibernation until the end of spring. The Chafer has a heavy, rather blundering flight, and before rising from the ground may be seen to rapidly vibrate its wings for a minute or two, preparatory to taking flight. This curious movement of the Cockchafer, which has something to do with the filling of its tracheal tubes with air, the children of the western provinces of France call "*compte ses écus*," and they sing to the beetle this old-world refrain :—

> "Barbot, vole, vole, vole,
> Ton père est à l'école,
> Qui m'a dit, si tu ne voles,
> Il te coupera la gorge
> Avec un grand couteau de Saint-George."

The two most historic appearances of vast swarms of Cockchafers in the British Isles occurred in 1574, when their corpses clogged and stopped the mill-wheels on the Severn; and again in 1688, when they appeared in county Galway is such swarms as to cause a famine. On the Continent, the visits of these all-devouring hosts have been of much more frequent occurrence. In the summer of 1804, great quantities of these Cockchafers were blown by a gale of wind into the Lake of Zurich, so that a thick bank of their decomposing bodies was heaped up upon the shore, and caused from its putrid exhalation a serious outbreak of illness. On the 18th of May, 1832, it is recorded that a great cloud of Cockchafers in full flight arrested the progress of the diligence on the road between Gournay and Gisors, the horses being so terrified that the driver was obliged to turn back. M. Mulsant, in his "Monographie des Lamellicornes de la France," relates how the streets of Mâcon were, in the month of May, 1841, invaded by so numerous a host of Cockchafers that the insects were shovelled up with spades, while they swarmed in the vineyards of the Mâconnais, doing most serious damage to the foliage.

One of our worst agricultural foes is the so-called "Wireworm," the larval stage of a small oblong beetle, variously known as the Click or

Skip-jack Beetle, all too common in the fields during the summer. The larvae are yellowish in colour, varying in length from a quarter to half an inch; their tough cylindrical bodies looking like little pieces of wire. The destruction which these Wire-worms cause to root, grain, and fodder crops in Great Britain alone, amounts to many thousands of pounds per annum. The larval stage lasts for a considerable period, from three to five years, and the only time that the larvae cease from their voracious attacks upon the roots and underground stems of the various crops, is during very hard winter frosts. Moles, rooks, starlings, plovers or lapwings, and pheasants are the most important natural foes of the Wire-worm, and if encouraged on the land and protected, will far more effectually hold this pest in check than is possible by any artificial means. They are also our best friends in waging successful warfare against the "Leather-jackets," the sooty-brown coloured, cigar-shaped larvae of the Daddy-long-legs fly. Indeed, but for the untiring labours of our bird friends and the moles, large areas of pasturage would annually be laid waste by the depredations of these insects, which also attack the roots of corn, cabbage, kale, and other vegetables.

Of the terrible ravages which our insect foes are capable of causing, we have a striking object lesson in the appalling destruction wrought in the vineyards of France by the Phylloxera, a very small insect closely allied to the Aphides. In the year 1875 the area under cultivation as vineyards in France amounted to 6,382,000 acres, and in 1885, through the ravages of the Phylloxera alone, it had become reduced to 2,868,000 acres. That is to say, in round numbers, within a period of ten years, four million acres of once healthy and prosperous vineyards had been laid waste by these insects. Fortunately preventive means have been found to arrest this swift and appalling work of destruction, and the threatened industry saved from total extinction. Nevertheless, the ravages of the Phylloxera has cost France a financial loss far in excess of that of the Franco-German War. This terrible insect foe appears to have first been discovered in North America in 1854, and to have been carried thence on the exported vine-plants to Europe, where it quickly established itself and appeared as a noticeable infestation about 1863. To-day it is to be found in all vine-growing countries. The greatest difficulties have been experienced in attempting the successful destruction of this scourge without injuring or totally destroying the vine-plants, and but for the fact that the Phylloxera has many natural foes, and that these have wisely been cherished and encouraged in the vineyards, it would have been impossible to check the swift and ever-increasing spread of this terrible pest.

The Migratory Locust (*Pachytylus migratorius*) is of very great historic as well as economic interest, for it is probably one of the oldest insect foes of mankind, and records of its depredations have been handed down from the time of the early civilizations of the East. In the tenth chapter of Exodus, for instance, we have a graphic and dramatic description of a vast plague of Locusts, which arrived, borne on the wings of an east wind, and covered all the land ; and after devouring every green thing, they were swept away by a western wind. Bred in the deserts of Arabia and Tartary, the Locusts are carried into Africa and Europe in innumerable swarms, which look like advancing storm-clouds, darkening the sky, and when they alight, covering the ground and the branches of the trees for many leagues. In a few hours every vestige of vegetation has been gnawed down and devoured, so that the trees stand with bare and broken branches, striped of their luxuriant foliage. Then, as if by some recognized signal, the vast devastating army rises and departs, seeking further what it may devour, leaving behind it pestilence, famine, and despair.

The Abbé Ussaris, who was an eye-witness of the fearful invasion of Poland and Lithuania in the year 1690 by Locusts, when these insects appear to have arrived in three separate swarms by different routes, wrote that "they were to be found in certain places where they had died, lying on one another in heaps of four feet in height. Those which were alive, perched upon the trees, bending their branches to the ground, so great was their number. The people thought that they had Hebrew letters on their wings. A rabbi professed to be able to read on them words which signified God's wrath. The rains killed these insects : they infected the air ; and the cattle, which ate them in the grass, died immediately."

In 1845, and again in 1866, the Locusts

wrought fearful havoc in Algeria, not only devouring every scrap of vegetation, but also penetrating in masses into the barley stores and native wheat-pits, so that great barricades had to be raised in front of the granaries to prevent their entry. In the environs of Algiers alone, during the 1845 invasion, it is computed that 14,760,000 Locusts were destroyed. In the year 1739 they appeared in vast swarms, covering the country from Tangiers to Mogador. All the region near the Sahara appears to have been ravaged, and the wind blowing the Locusts in thousands into the sea, their decomposing bodies gave rise to an epidemic of disease which laid Barbary waste.

During the last century the Locusts appeared on several occasions in great numbers, and caused wide-spread havoc in the south of France. The Locusts have a world-wide distribution; in the south of Europe, India, China, Africa, and the Rocky Mountains of North America, they abound, and from time to time appear in mighty and devastating armies. In size they vary from half an inch to six inches in length. They are all rather handsome, powerfully built insects, with strong hind legs and formidable mouth-organs. They do not undergo a complete metamorphosis, the young Locusts on emerging from the egg resembling their parents in general appearance, save for the absence of wings.

Many are the methods by which man has sought to combat the ravages of this formidable insect foe. During the Middle Ages the priests frequently exorcised the Locusts, who, however, "did not seem one penny the worse," and cheerfully continued in their wickedness. The following quaint description of such a ceremony is to be found chronicled by a pious monk named Alvarez, who during his wanderings in Ethiopia encountered a mighty army of Locusts. Writes the worthy monk: "Thus chanting psalms, we went into a country where the corn was, which having reached, I made them [the Portuguese and natives] catch a good many of these Locusts, to whom I delivered an adjuration, which I carried with me in writing, by me composed the preceding night, summoning, admonishing, and excommunicating them. Then I charged them in three hours' time to depart to the sea, or else to go to the land of the Moors, leaving the land of the Christians; on their refusual of which, I adjured and convoked all the birds of the air, animals, and tempests, to dissipate, destroy, and devour them; and for this admonition I had a certain quantity of these Locusts seized, and pronouncing these words in their presence, that they might not be ignorant of them, I let them go, so that they might tell the rest."

The Arabs, whose crops are so frequently devastated by the Locusts, have many curious legends and ideas concerning them. They have a saying that these insects were formed out of the clay left over from the making of man, and that with the total extinction of the Locust, the human race will quickly disappear, the Locust originally having been destined to serve as food for man. Another legend tells how Mahomet one day found a Locust upon whose wings was written in Hebrew characters, "We are the troops of the Most High God; we each one lay ninety-nine eggs. If we were to lay a hundred, we should devastate the whole world." The Prophet, greatly alarmed by his discovery, made long and earnest prayer to God to destroy these enemies of all True Believers; and the angel Gabriel, in answer to the invocation, told the Prophet that his prayer in part should be granted. From this incident in the life of Mahomet is said to have originated the custom of writing on the wings of four Locusts the four verses of the Koran appropriated to this purpose, and thus liberating the Locusts, each bearing a single sacred verse upon its wings, into the midst of the advancing host; whereupon, the whole swarm are said to at once alter their course and depart.

So far, one of the most practical and successful methods of destroying the Locusts is that which was first adopted in Cyprus at the suggestion of Mr. Richard Mattie, and carried out and perfected by Mr. Samuel Brown. This system is founded on the fact that when the young Locusts, some two days after they are hatched out, start on their march across country in great countless armies, no obstacle will turn them back from their onward progress; the insects climbing and crawling over every object that impedes their progress; and also, that they cannot gain a foothold upon a polished smooth surface. To arrest the forward progress of the Locusts, long canvas screens, furnished at the top with a broad band of slippery American cloth, are mounted on stakes driven into the ground. At intervals of a few yards in front of these screens, and directly in the path of the advancing Locusts, deep pits are dug, and edged and lined to a depth of a few inches with polished zinc. Now the advancing hosts of Locusts are unable to climb to the top of the screens owing to the slippery surface of the band, and fall back into the pits; from these pits they are unable to escape, partly on account of the smooth edging of zinc, and partly on account of the weight of the thousands of fresh arrivals that continue to fall from the screens on top of them. So successful has this method, which owes its origin to Mr. Mattie's careful observations of the habits of these insects, proved, that in five years from its inception the Locusts in Cyprus were practically exterminated, and at the very moderate cost of about two shillings per million insects.

Although most people are thoroughly familiar with the appearance of that somewhat grotesque looking insect the Daddy-longlegs, or Crane-fly (*Tipula oleracea*), the ravages which this insect causes during the larval stage of its life on grass-lands is probably unknown to most town dwellers; save perhaps in seasons like 1884, when Lord's cricket ground was seriously injured by these insects. In the years 1813, 1842, and 1894, hundreds of acres of grass-land were destroyed by the larvae of Daddy-longlegs, so that the shepherds in many important grazing districts knew not where to find sufficient feed for their flocks of sheep. Unfortunately these insects by no means confine their depredations solely to grass-land, for in the year 1880, they were responsible for the destruction of hundreds of acres of autumn-sown wheat on the farms round York.

The general appearance of the Daddy-long-legs is too well known to need description here; the sexes in the adult insect are easily distinguished, the body of the female being slightly longer than that of the male, and terminating in a comparatively sharp-pointed ovipositor. In the autumn the female Daddy-longlegs deposits on the ground, or upon grass and weeds, with the aid of her ovipositor, her minute polished black eggs, from two to three hundred in number, and from these, in about fifteen days, the larvae escape and begin their work of destruction, out of sight, beneath the surface of the soil. Throughout the winter the larvae feed upon the stems of corn and grasses, near the surface if the weather is mild, but going down deeper into the earth and attacking the roots during the periods of frost. In cases of bad infestation I have picked out one hundred and twenty of these larvae from a freshly dug turf-sod about one foot square, which will give some idea of the vast numbers in which these insects appear during some seasons, and the amount of damage they can cause. The larvae when full grown are about an inch to an inch and a half in length, with a cylindrical, somewhat wrinkled, legless body, slightly tapering at the head, and blunt at the tail-end, which bears four tubercles. The colour of the body seems to vary in different localities from a dirty brown to a sooty black. From the toughness of their skin, the larvae often go by the name of "Leather-jackets" in agricultural districts. The larvae change to the pupal stage beneath the surface of the soil, the abdomen of the pupa being furnished with short spines which enable it to push its way upwards until the upper half of its body stands above the surface of the ground. The tough skin of the pupa then splits down the back, and the familiar perfect fly with its long slender legs and two wings makes its escape.

In the Daddy-longlegs, we have a foe who is very difficult to combat by artificial means, owing to the subterranean life of the larvae. But we have many natural allies who, if encouraged and permitted, would render invaluable aid in keeping in check the depredations of the Daddy-longlegs' larvae. Rooks, starlings, lapwings, or peewits as they are called in some districts, gulls, and many other birds, devour the Leather-jacket larvae in a wholesale fashion, and will clear the land of these destructive insects far more thoroughly than is possible by any artificial means at our disposal. Indeed, the serious infestation of land is invariably the result of the wanton or thoughtless destruction of these natural foes of the Daddy-longlegs.

Many members of the great order Coleoptera, the Beetles, cause a vast amount of damage to different crops. Of the harm done by the Turnip Flea Beetle we have already gained some insight. A group of beetles which in some seasons are responsible for most serious loss, not only to the farmer, but also to the fruit grower and market gardener, are the Weevils. They are a large and important family of insects, of which some five hundred and thirty species are to be found in Great Britain; their Latin name of *Rhynchophora* describes one of the chief characteristics of their appearance really better than their popular name of Weevil, for it means "snout-bearing," and refers to the curious beak or snout-like proboscis, which is a characteristic of all the Weevil tribe. In different species this snout is variously modified, so that in some it is long and slender, while in others it may be short and stout, varying according to the natural habits of the particular species. The antennae are generally sharply elbowed, and spring from the sides of the snout, thus giving the beetle a very curious appearance. Our British Weevils are for the most part comparatively minute creatures, only the giants attaining a length of an inch or a little more; many of them are so minute as to require a magnifying-glass to make out clearly their characteristic markings, etc., but individual lack of size and strength is made up for in numbers, the Weevils multiplying with the most astonishing rapidity. The Clay-coloured Weevil (*Otiorhynchus picipes*), the Black Vine Weevil (*O. sulcatus*), and the Red-legged Weevil (*O. tenebricosus*) are all particular foes of the fruit grower, attacking the apple, plum, raspberry, vine, peach, gooseberry, and strawberry, and are responsible for the injury, if not the total destruction, of a very heavy percentage of the annual fruit crop. In some seasons the strawberry fields swarm with the Weevils, which, in the adult stage of their lives, devour the leaves of the strawberry plants, and as larvae attack the roots. In a single season a large strawberry grower in Kent lost £500 by the ravages of these beetles. Unfortunately the Weevils are not the only beetles which attack the strawberry, for the larva of the Green Rose Chafer (*Cetonia aurata*) feeds upon the roots, and as a perfect beetle does most serious damage by devouring the strawberry blossom; while the fruit is particularly liable to the attacks of certain species of ground beetles, so that the insect foes of the strawberry grower are very numerous, and a cause of constant loss and anxiety.

Probably the most injurious of all our orchard insect foes is the Winter Moth (*Cheimatobia brumata*), sometimes also known as the Evesham Moth. Apart from the fact of its being one of our insect foes, the Winter Moth is of considerable interest, owing to the striking difference between the male and female moths, the latter having very imperfectly developed wings, which are quite useless as organs of flight. The insect has gained one of its popular names, that of the Winter Moth, from the fact that the male moths may be seen on the wing from about the middle of October to about the end of November, or even a little later should the weather continue mild, just before, and for some time after sunset; while its second popular name of Evesham Moth originated from its

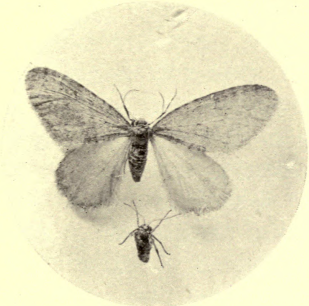

FIG. 1. THE WINTER MOTH. MALE AND WINGLESS FEMALE

FIG. 2. UNDER SURFACE OF A ROSE-LEAF SWARMING WITH APHIDES

FIG. 3. EGGS OF THE HOUSE-FLY

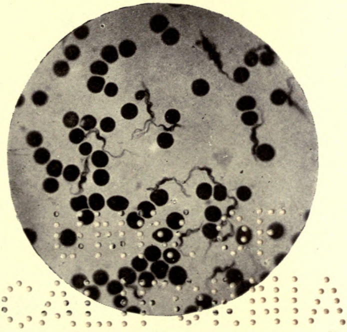

FIG. 4. TRYPANOSOMES OF SLEEPING SICKNESS, TRANSMITTED FROM MAN TO MAN BY THE BITING FLY GLOSSINIA PALPALIS

abundance in the great fruit-growing district of Evesham. The moth, however, has a very wide distribution, and is, unfortunately, all too common during some seasons in most orchards. The male moth is rather a pretty insect, with its greyish or ochry-brown fore wings and pale greyish-white hind wings. The female, on the other hand, presents the most extraordinary appearance, her abdomen being very large in comparison to the fore part of her body. Her legs are long and slender, and her wings are so imperfectly developed as to appear more like scales or abnormal outgrowths from the sides of her distorted body. Flight for her is an impossibility, and courtship takes place upon the ground, or on the tree-trunks. About the second week in October the female Winter Moth comes from her pupa-case beneath the tree, where she has developed from the caterpillar that descended into the soil in the summer, and ascends the trunk to deposit her eggs upon the buds or twigs, or in the chinks and crannies of the bark; and very shortly after the last egg has been deposited she dies. The following spring the caterpillars emerge from the eggs, and at once begin their work of destruction, feeding upon the buds, leaves, and flowers of the fruit trees, until the trees, stripped of their foliage, look as if some scorching, devastating blast had swept over them. When full fed, the larvae either crawl or let themselves down on the end of a silken thread to the ground, where they enter the soil to pupate; though a certain percentage appear to pupate under moss or loose bark upon the trunk and main branches of the trees. The caterpillars vary a good deal in colour during their growth, and also when full grown. Just after emerging from the egg they are yellowish-green, with a faint white stripe along the back; while later they may be green, greyish, or greenish-grey, or blackish. They are very typical in their movements, taking firm hold with the front legs, and then drawing the back part of the body up to the front legs, so that the insect's body is formed into a loop; the front legs then let go their hold upon the twig, the caterpillar stretches its body forward along the branch, and, grasping it, again brings the hind part of its body close forward. The insect thus proceeds by a series of loops, and it is from this peculiar and characteristic mode of progression that the larvae of the Winter Moth, in common with the larvae of other Geometers, are popularly known as "Loopers."

Many are the insect foes of our forest trees, some attacking the foliage, others the roots, trunk, bark, and branches, so that no part of a tree can be said to be safe from the ravages of some winged or creeping insect. Very often during April one may see numbers of tiny beetles about a sixth of an inch long, of various dusky shades of blackish-brown, and with stout, rather oval-oblong bodies crawling about on the ash trees. If we watch one for a little time, we shall be able to see that it is busily engaged in boring a hole in the bark of the tree, and in a very short time it disappears from view. This is the Ash-bark Beetle (*Hylesinus fraxini*), which causes great injury both in the larval and adult stage by boring galleries into and beneath the bark, and sometimes by slightly cutting into the outside wood of the tree. The principal damage, however, is caused by the bark being loosened and the regular circulation of the sap thereby arrested, and by rain soaking in through the innumerable small holes bored in the bark by the young beetles in making their escape, after passing through their metamorphosis under the bark; indeed, after their emergence the bark of an ash tree frequently presents the appearance of having been riddled with shot.

The elm also suffers from the depredations of a bark-burrowing beetle, which bores its galleries between the bark and the wood, but chiefly in the soft inner bark. The tunnels of these beetles present rather a remarkable appearance, showing a large central gallery with numerous smaller galleries opening, and all going off, at right angles from it. The main gallery, which is generally about three to five inches long, is the work of the female beetle, and its excavation takes her about three weeks to complete. In this central burrow she deposits her eggs at regular intervals, and along each side, to the number of one hundred to one hundred and sixty. Directly the larvae emerge from the eggs they start at right angles from the main gallery, and proceed to gnaw their way onwards through the bark, their burrows increasing in size as the larvae increase in bulk. When full grown, they change to pupae within the galleries they have formed, and many remain in that state until the following spring, although a certain proportion complete their metamorphosis by the end of the summer. These Elm-bark Beetles are small black insects, about an eighth to a quarter of an inch long, and have their wing-cases pitted lengthwise with rows of dots.

Of an even more serious character are the depredations of the caterpillars of the Goat Moth (*Cossus ligniperda*), which not only attacks the elm and ash, but also the oak, beech, lime, willow, and poplar trees. These insects remain for three years in the caterpillar stage, attaining a length of three or more inches; they live within the tree for the whole period, gnawing tunnels and chambers of various size and width, some as large as a man's middle finger, right into the solid wood, and causing such serious injury as to kill the tree. These caterpillars have gained their popular name from their very unpleasant smell, which is so strong as to impregnate their burrows. The female moth deposits her eggs on the bark close to the base of the tree, and from thence the larvae, on emerging from the eggs, eat their way into the tree. Some idea of the depredations of burrowing beetles, like the Ash and Elm-bark Beetles, is gained when we learn that in the year 1837 no less than 20,000 feet of oak trees, varying in age from thirty to forty years, had to be cut down in the Bois de Vincennes, as they were completely ruined by the attacks of the bark-burrowing beetles; while in the year 1783 these insects were responsible for the destruction of 1,500,000 trees in the forest of Hartz.

It is impossible here to more than briefly touch upon the subject of our insect foes as the ravagers of crops; indeed, it is in itself a subject upon which one would need to write a very bulky volume, to give anything like a detailed description. The few examples I have been able, in the space at my command, to describe, will, I trust, have given my readers some idea of the vast amount of damage that is caused annually to our crops; of the economic importance of a perfect knowledge of the life-histories and habits of these insect foes; and of the even greater importance which attaches to the encouragement of trained scientific observation, that we may become familiar with, and learn to protect, the natural enemies of our insect foes. Much might be done to help to hold these ravagers of our crops in check, by an active legislation which would render criminal the present senseless slaughter of insect-feeding birds. The existing Wild Birds' Protection Act has never been properly administered, and throughout our rural and agricultural districts is practically unknown, or ignored, and to all intents and purposes is non-existent, the village children being permitted and frequently encouraged, to rob the nests and destroy the eggs and young. If the school authorities would teach children in country districts to take an intelligent interest in their natural surroundings, we should hear less of the exodus from our agricultural districts to the towns, with its consequent appalling effects upon the race.

CHAPTER X

OUR INSECT FOES—TRANSMITTING AGENTS OF DISEASE

DURING the last few years, as I have already stated, the study of insect life has assumed a new and far-reaching importance as a factor in the health and prosperity of the nation. Indeed, the general public have hardly yet awakened to the fact that thousands of human beings, horses, cattle, and sheep perish annually from diseases transmitted by insects. In no branch of natural science has the great importance and value of biological and bionimic investigation been more clearly and triumphantly proved, than in the most modern study of insect life in its connection with the transmission of disease to man, and to the various animals which he keeps in a state of semi- or complete domestication. To Great Britain, with her vast possessions beyond the seas, and particularly in those territories situated in tropical and sub-tropical countries, the study of this new aspect of insect life is of the very greatest importance, for on such investigation depends the possibility of her successfully colonizing or reaping the full commercial possibilities of many of her tropical possessions. Already, thanks to the magnificent work of Sir Patrick Manson, Colonel Bruce, Major Ross, the London and Liverpool Schools of Tropical Medicine, and the Lister Institute, much has been done to safeguard the lives of those Britons whose duties call them to the fever-haunted and malarial lowlands of the tropics. But much still remains to be accomplished, and it is only by the more general increase of modern scientific methods of observation and investigation that effective results will be obtained.

That insects have actually played a very important part in the past history of the peoples of the Old World, and that they undoubtedly acted as subtle factors in the downfall of the great civilizations of Greece and Rome, sounds strange and almost like a fairy tale, and yet the evidence brought together by recent biological and antiquarian research, points to such having been the case. It would be impossible, in the space at present at my command, to deal fully with this most intensely interesting subject, and I must therefore give but a short outline sketch. Those of my readers who desire to obtain a deeper insight into this fascinating subject will find it most clearly and ably set forth in the pages of Mr. W. H. S. Jones' little book entitled "Malaria: A Neglected Factor in the History of Greece and Rome."

To fully grasp the true significance of this historic subject, we must learn something of the nature of malaria, of the life-history of the organism causing the disease, and of how the disease is transmitted from man to man. It is now some twenty years since Laveran, a distinguished French medical man, made his great discovery of the minute animal parasite in the red blood corpuscles of man, which causes malaria; while it was due to the investigations of Golgi that what is termed the developmental cycle of the malarial parasite in the blood was successfully demonstrated. It is this asexual cycle, the febrile cycle, which produces auto-infection of the patient. To Major Ronald Ross belongs the honour and credit of discovering and demonstrating the fact that a further sexual cycle of the parasite is carried out in the stomach of the mosquito, from which new infection in a healthy subject is produced. From the joint investigations of these three distinguished men of science we learn that malaria, that terrible disease of the tropics, is due to the presence in the blood of innumerable minute animal parasites, which produce fever, recurring every one, two, or three days, and termed, according to their period, quotidian, tertian, or quartan fever; and unless the sufferer be treated with cinchona bark—quinine—the parasites remain in the body for some years, and, by auto-infection, cause constant relapses of fever, anæmia, and enlargement of the spleen. Exactly how the disease was transmitted was unknown until Major Ross discovered the sexual cycle in the mosquito.

The mosquitos, or gnats, which transmit the malaria parasite to man, belong to a class called Anophelines, or spot-winged gnats, abounding in marshy localities and the vicinity of stagnant pools. These Anopheline mosquitos become infected by biting a person who has the malarial parasites in his blood, and, after a further life-cycle of the parasite has been passed within their stomachs, pass the parasites into the blood of any healthy person they may subsequently feed upon. It at once becomes obvious, therefore, that a district in which these mosquitos are present, only becomes malarious when a person enters it who has the parasites in his blood; and that a country cannot become malarious unless both these factors are present.

In the history of the Island of Mauritius, which prior to the year 1866 well deserved the title of an earthly paradise, we have a most convincing demonstration of the above facts. Prior to 1866 this beautiful island had been a very popular health resort for Anglo-Indians, many of whom were malarial patients. Then, in an evil hour for the island and its healthy inhabitants, the Anopheline mosquito was by some means introduced, and now malaria has become endemic throughout the island.

What the introduction of malaria into a country means to its unfortunate inhabitants, is brought home to us in the following quotation from Sir Patrick Manson's "Lectures on Tropical Diseases." "Imagine," he writes, "some district in which Anopheline mosquitos abound, but which is luckily free from malaria. A stranger with parasites in his blood comes to the village and is bitten by the local mosquitos, which thus become infected and infective. The disease spreads rapidly and is at first severe. After some years the survivors become immune or partially so. But the children become infected soon after birth, and continue to be diseased for some years, gradually becoming immune. This is the condition of every village in every highly malarious district; the adults are immune, the children are nearly all of them full of malaria parasites."

It is a curious and interesting fact that there is a singular similarity of effect on mankind, between malaria and influenza, an effect in which they differ from most diseases, for neither tend to strengthen a nation by weeding out the physically unfit, but rather to produce a general lowering of the vitality of the people, without a very heavy death-rate. The effects of malaria on its victims is to unfit them for strenuous work or prolonged manual labour, and consequently to diminish generally their producing powers; while if left to itself an area so attacked tends towards moral and physical degradation.

And now let us try to realize the important part which this insidious disease, spread by the Anopheline mosquitos, appears to have played in the downfall of ancient Greece and Rome. We know that prior to 400 B.C. Greece was at the height of her fame and glory—socially, artistically, and philosophically—and prior to that date we find no very definite statement of the presence of malaria, at any rate to a serious extent. But from 400 B.C. onwards, a change gradually came over the Greek character. Patriotism, pride of citizenship, religion, simple living, gave place gradually to an effeminate sentimentalism, pessimism, unbelief, hypocrisy, licentiousness; while those writings of the period which have come down to us clearly show that malaria had become endemic. That the Anopheline mosquito existed in Greece in remote ages is highly probable, but as we have seen, it does not at all follow that malaria necessarily existed at the same time, particularly if ancient Greece was peopled by a race coming from northern non-malarious latitudes. As Mr. Jones points out in his admirable book, there seems much more reason to suppose that the malarial parasite was not introduced until after the Greeks had opened up an intercourse with Egypt; for malaria is essentially an African disease. Probably the infection was brought from Egypt by slaves and merchants, while many of those Athenians who took part in the disastrous expedition to Egypt in 456 B.C., must have contracted the disease and returned with the parasites in their blood. The local Anopheline mosquitos bit them, and drawing up the parasites as they sucked the blood of their victims, became infected and infective. So, gradually, through the agency of those frail insects the insidious disease was spread amongst the inhabitants, their vital energy was sapped, and the glory that once was Greece, departed for ever. To-day, out of her population only amounting to some 2,500,000 people, close upon 1,000,000 are infected with malaria.

Surely here is an object lesson that should bring home to us as we look upon its appalling consequences, the vital importance of our doing all in our power to promote original scientific research and investigation, by which it is alone possible to gain that knowledge which will enable us to cope with those insect foes who are transmitting agents of disease.

Thanks to the splendid work of the little band of scientific men who are devoting their lives to the study of tropical diseases, we now know how to fight the insect transmitting agents of malaria and yellow fever, and good progress has already been made in many districts in the tropics towards stamping out these two diseases.

To gain some insight into the life-history of the spot-winged Anopheline mosquito, there is no need for us to journey to the tropics, for it is very similar to that of the mosquitos or gnats which dance over every stagnant pool and water-tub during the summer months in England. The mosquitos belong to the order Diptera, or true flies, a group of insects to which the common House-fly, the Bot-fly, and the Gad-fly, also belong. They are characterized in the adult stage by the possession of only one pair of wings, the posterior pair being reduced to mere club-shaped processes, called *halteres* or balancers, by a piercing and sucking proboscis; and by undergoing complete metamorphosis—egg, larva, pupa, perfect adult insect.

The mosquitos, or gnats, all belong to the family *Culicidæ*, which is again subdivided into a number of sub-families, based upon certain anatomical peculiarities, therefore it is not surprising to find certain points are common to the life-history of both the Anopheline mosquitos and our common Gnats belonging to the sub-family Culicinæ; both pass the larval and pupal stages of their existence in shallow, stagnant pools, water-tubs, and the like, and also have a superficial resemblance in their general appearance during these early stages of their lives. The female Anopheline mosquito deposits her eggs, which vary in number from fifty to one hundred and fifty, upon the surface of the shallow pools, depositing them singly without any cement-substance, so that they do not appear as raft-like masses, as is the case with the eggs deposited by the Culex mosquito, but float about singly, in star-shaped groups or parallel formation upon the surface of the water. The eggs are boat-shaped, small in size (from about 0·7 to 1·0 mm. in length), and when first deposited white in colour, rapidly darkening to a blackish hue.

From these floating eggs emerge the quaint-looking, wriggling larvae, and start upon their aquatic life, rising to the surface of the pool from time to time to take in a supply of air. There are one or two points by which the Anophelines can readily be distinguished from any other mosquito larvae. For instance, when undisturbed, the Anopheline larva will lie flat along and just beneath the surface of the water, the curious palmate hairs on the body segments, which are peculiar to Anopheline larvae, indenting the surface film of the water. Another distinguishing feature between the Anopheline and the ordinary Culex larva, is that the former has no long syphon-tube on the eighth segment of the body like that of Culex, the stigmatic opening on this segment being in the form of a large quadrilateral space with comb-like processes upon each side. During the larval stage of their existence both Anophelines and Culex rise to the surface of the pool and stick the processes on the eighth body-segment above the surface film of water to take in air; that is to say, they rise tail first, and, so to speak, "breathe through openings in their tails." The pupal stage, which is also spent in the water, is quite as active as that of the larval period, although now the insect ceases to feed, and undergoes a great change in its outward appearance, the whole of the head and chest being swathed in a helmet-like sheath, beneath which the wings, slender legs, and complex mouth-parts of the adult mosquito are formed. The insect no longer rises tail first to the surface of the pool, but head first, for the apparatus for taking in the air supply is no longer situated upon the eighth body-segment, but now consists of two tubular horns on the back of the thorax which are thrust above the surface of the water when the pupa rises to take in air. The pupa does not move through the water with the curious wriggling motion of the larva, but swims in sharp jerks by means of its tail and its two leaf-like terminal organs. At the close of the pupal stage, the insect rises to the surface of the water and flattens itself out, the thorax spilts down the back, and the adult mosquito gradually emerges, and rests upon the raft formed by the empty pupa-case until its legs

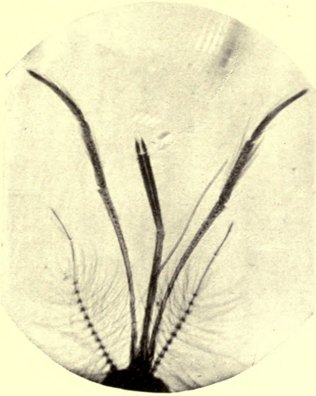

FIG. 1. MOUTH-PARTS, ETC., OF THE MALE GNAT. THE ANTENNÆ ARE HIGHLY DEVELOPED AS LARGE PLUME-LIKE ORGANS

FIG. 2. MOUTH-PARTS, ETC., OF THE FEMALE GNAT. NOTICE THE FORMIDABLE LANCET, AND THE NON-PLUMED ANTENNÆ

FIG. 3. TABANUS BOVINUS WHICH TRANSMITS ANTHRAX TO MAN

FIG. 4. LANCETS AND PROBOSCIS OF TABANUS BOVINUS

and wings are dry and firm, when it flies away. The sexes are easily distinguished in the adult mosquito, as the antennae of the male are handsome plume-like organs, and the palps are long and hairy, giving the whole head a conspicuous appearance. The antennae of the female have very short hairs, and are inconspicuous, while the complex mouth with its formidable lancets and sucking proboscis is more highly developed than in the male. While the male mosquito is absolutely a vegetarian, only using its proboscis to suck up vegetable juices, the female is a most bloodthirsty creature, piercing the skin with her stylets, and sucking up the blood until gorged to repletion. It is the female mosquito that is the transmitting agent of malaria from man to man, for after the sexual generation of the malarial parasite (drawn in with the blood she has sucked from an infected person) has been passed in her body, the resulting needle-shaped spores accumulate in her salivary glands and pass out through her mouth into the wound she inflicts when stabbing a fresh victim.

There is a stage or period in the life-history of most creatures when they are more readily destroyed than at any prior or subsequent period, and it is this most vulnerable period that has to be discovered and taken advantage of, in fighting our insect foes. Now, in the case of the mosquitos, it is during the aquatic larval and pupal stages of their existence that they are most easily destroyed, for they are confined within the limit of the marshy, stagnant pools, or water troughs, *and they have to rise to the* *surface to take in air.* If malaria and yellow fever are to be stamped out, the mosquitos, which are the transmitting agents, must be exterminated, and this, thanks to our knowledge of the insect's life-history, is being successfully accomplished. So far as is possible all swampy lands in the immediate vicinity of towns and villages are being drained, for the mosquito does not appear to be able to fly easily for any great distance from its breeding place, half a mile apparently being well beyond the normal distance of its flight. Again, all stagnant pools, open troughs, etc., which form favourite breeding grounds, have their surface carefully covered with a film of crude oil, which successfully prevents the mosquito larvae and pupae taking in air when they rise to the surface to breathe, the oil choking the stigmatic opening through which the air is drawn, and so the insects are swiftly drowned. The great difficulty, of course, is to keep an absolutely unbroken surface of oil on the water, wind and slight currents causing the film of oil to crack, and so offer clear spaces where the larvae and pupae will quickly congregate to breathe. But in spite of the many difficulties which they have to surmount, those who are engaged in this important work are achieving wonderful success, and it is not too much to hope that in a very few years' time, many large areas now the prey of malaria and yellow fever will, through the extermination of the mosquito, have become prosperous and healthy. Already these two diseases have been greatly reduced in Cuba, and to a very considerable extent in Panama, rendering it possible for the work of cutting the canal to be successfully carried on.

Sleeping sickness, that terrible disease which after existing amongst the natives of the West African coast from the remote past, and occurring, though rarely, as a very serious scourge throughout tropical West Africa, has crept up the newly opened trade routes of the Congo basin, and spread through Uganda into British East Africa, is transmitted direct from man to man by a blood-sucking fly called *Glossina palpalis*, a species of Tsetse-fly. In the case of sleeping sickness, or to give it its proper scientific description, human trypanosomiasis, the transmission of the disease is direct, the fly passing straight from the sick to the healthy person. Indeed, it appears very doubtful that the fly can infect a second person, the adherent blood-parasites sucked up from the infected person being cleared off in the skin of the next person attacked; while at present it is thought that a fly which has bitten a person suffering from the disease ceases to be infective the next day, probably much sooner. This is a point, however, upon which in our present incomplete knowledge of the subject it is unwise to be dogmatic, for these microscopic flagellate, motile parasites, called trypanosomes, are said to undergo certain changes in the mid-gut of the fly, two kinds appearing twenty hours after the fly has fed upon the infected subject; one a large, slow-moving form with a short flagellum, considered a female, and another slender and active, with a long free flagellum, thought to be a male. In forty-eight hours, trypanosomes of a very different type, with short free flagellæ, appear, and in ninety-six hours all traces of the trypanosomes disappears from the tissues of the fly. Although at present unknown, it is quite within the bounds of possibility that the development of the parasite continues in the tissues of the fly in some hitherto unobserved form, causing the insect to again become infective. A curious and interesting fact worth keeping in mind is that a certain percentage of Tsetse-flies, which have never fed upon human or other blood, contain slender and stout forms of trypanosomes in the gut.

The first printed record of sleeping sickness appears to have been written by Winterbottom in 1803. Writing of Sierra Leone, he states that "the Africans are very subject to a species of lethargy which they are much afraid of, as it proves fatal in every instance." It was also described by early nineteenth-century writers as occurring amongst the imported slaves working on the plantations in Brazil and the West Indies, and it is fortunate for those countries that there was apparently no Tsetse-fly to spread the disease, or probably the greater part of the population would have been wiped out. The disease is caused by the presence and multiplication in the blood of a motile, flagellate parasite called a trypanosome, the particular species being called *Trypanosoma gambiense.* These trypanosomes are not confined to man, but certain species are the cause of various diseases in horses, donkeys, mules, camels, monkeys, and other animals, and are known to be present in the blood of many birds, reptiles, and fishes. The unfortunate human being attacked by this practically fatal disease at first becomes dull, feverish, and apathetic. This is followed by difficulty in speech and locomotion, with tremors of the tongue and outstretched hand, accompanied by an ever-increasing drowsiness, until at last complete somnolence sets in and the unhappy victim dies in a state of coma.

Originally peculiar to tropical West Africa, sleeping sickness has spread along the trade routes as they have been opened up, wherever the biting Tsetse-fly, *Glossina palpalis*, which is the principal if not the only transmitting agent, is present, and has swept onwards in its devastating march past the shores of Lake Victoria Nyanza to the confines of the Soudan. Since the disease was first noticed in the west of Uganda in 1901, more than 200,000 people have perished from it. Of 300,000 natives living on the shores and islands of the great and beautiful Lake Victoria Nyanza, less than 100,000 remain, the rest having died from sleeping sickness within the last five or six years. And mark this fact, in every case the disease has been transmitted from one victim to another by the blood-sucking fly *Glossina palpalis*.

Man is not the only sufferer from serious diseases produced by the presence of these flagellate organisms called trypanosomes, in the blood. Thus the fatal disease called Ngana, which is so widely spread throughout Africa, and from which hundreds of horses, cattle, and other animals perish annually, is caused by the *Trypanosoma brucei.* This disease is transmitted from an infected animal to a healthy one, by several blood-sucking flies, closely related to the *Glossina palpalis,* and which are popularly known as Tsetse-flies, which is the native name representing the buzzing noise made by these flies. Slightly larger than the common House-fly, these Tsetse-flies are rather handsome insects, very alert during the heat of the day, and very bloodthirsty. Cattle and horses, mules, and other animals become infected after passing through a "fly belt," that is, a track of country where these blood-sucking flies breed and abound. The trypanosomes causing Ngana have been found in the Kudu, Bushbuck, Wildebeest, etc., and although infected the wild game are apparently quite healthy. Unfortunately, therefore, they act as natural reservoirs from which the Tsetse-flies draw the parasites, for the flies transmit the trypanosomes from the wild game to the domestic cattle. Cattle suffering from a chronic form of the disease also serve to give a constant supply of the parasite, the Tsetse-fly first sucking the blood of an infected animal and then alighting upon and biting a healthy one.

The *Trypanosoma evansi,* which is the cause of Surra and its varieties, a very widely distributed disease prevalent in India, Burma, Indo-China, Java, the Philippines, Mauritius, and North Africa, attacking horses, mules, camels, and, in a slightly less degree, cattle, is transmitted by various species of Tabanus flies, more familiarly known as Gad-flies. The disease is transmitted in the same way as Ngana, by the insect first sucking the blood of an infected animal, and then passing to a healthy one. The Gad-flies are among the handsomest and most powerful of the Diptera, they have large strong wings, broad and stout bodies, and most formidable lancets and sucking proboscis. The females are particularly objectionable, exercising their biting habits to the fullest degree, gorging themselves upon the blood of the horses and cattle upon which they settle. The loud buzzing noise which they produce, and the sharp painful stab of their piercing organ, terrifies the animals to such a degree that they will rush madly about trying to escape these bloodthirsty flies. The Gad-fly is also responsible for the distribution of other cattle diseases, and is frequently the transmitting agent of that dread disease anthrax to man. A disease of all too frequent occurrence in South Africa among cattle, and called gall-sickness (gal-zickte), is transmitted by a curious creeping fly similar to our forest fly, called *Hippobosca rufipes*.

Various species of Ticks (*Ixodidæ*) play an important and sinister part as the transmitting agents of disease to man, and to cattle, horses, sheep, poultry, dogs, and other animals. They are divided into two sub-families, called respectively the *Ixodinæ* and the *Argasinæ*. Though popularly looked upon as insects, their proper place is in the class Arachnida, which comprises the Scorpions and Spiders, the Mites and Ticks, the King Crabs, and several other families of more or less remarkable and interesting creatures. While in the body of a Tick no distinction into regions is recognizable, there exist the same series of paired appendages as are present in the Scorpions and Spiders. The Ticks do not undergo a complete metamorphosis like that of the true insects, the larva on emerging from the egg closely resembling the adult in general appearance, save that it is hexapod—has six legs. After feeding, gorging themselves to repletion on the blood of their host, the larvae remain for a short period dormant, varying in duration in different species. They then undergo their first moult and emerge from their cast-off skins as eight-legged (Octopod) nymphs, active, bloodthirsty, and resembling in appearance the adult females, but with the sexual organs imperfectly developed. This stage of the Tick's life varies in different species from a few days to several weeks, the nymph becoming engorged with blood, and, after a dormant period, undergoing the second moult and emerging as the adult Tick. The adult Ticks gorge themselves upon the blood of their host, mate, and then generally quit their host, and the females shortly after commence to deposit their eggs on the ground or herbage, the number of eggs varying in different species from ten to several thousand. The dormant periods at the close of the larval and nymphal stages may or may not be passed upon the host, and it is in this way that the Tick becomes the transmitting agent of disease, passing, for instance, as a gorged larva from an infected and infective host to the ground, and after the larval dormant period attaching itself to a new and healthy host. In the same way it may pass the nymphal stage on an infected host, and the adult stage upon a healthy one. Although the Ixodinæ ticks only moult at the change from larva to nymph, and again from nymph to adult, the Argasinæ moult at these stages and also several times during both the nymph and adult stages. While the Ixodinæ become enormously distended with blood, the Argasinæ do not become swollen to such a degree.

The body of a Tick is more or less oval or shield-shaped, and is covered with a very tough skin, while in the adult stage four pairs of clawed legs are present. Although many species have eyes, others are destitute of visual organs. The somewhat complex mouth-parts consist generally of a paired anchoring organ called the rostrum, covered with recurved hooks, and forming the equivalent to the pedipalps of other Arachnids; and a pair of sharp mandibles which work in two longitudinal channels situated on the rostrum. The Tick buries its rostrum into the skin of its host and anchors itself securely by means of the recurved hooks, and then proceeds to gorge itself upon the blood of its host. So tenaciously do the Ticks hang on, that it is practically impossible to pull them off without leaving the rostrum behind in the wound. The only way to make the Tick release its hold being to cover its body with a drop of paraffin oil, turpentine, or benzole. A curious microscopic organism called *Spirochaeta duttoni* is the cause of African tick fever, and the disease, as its popular name implies, is transmitted by a Tick. The Spirochaeta causing European relapsing fever, on the other hand, is probably transmitted through the agency of bugs and lice. Amongst the diseases transmitted by Ticks to the lower animals may be mentioned Texas or Red-water fever, Rhodesian fever, or African Coast sickness, Trans-Caucasian fever in cattle, Heart-water in calves, sheep, and goats, "Yellows," the malignant jaundice in dogs, Biliary fever in horses, and the fatal spirillosus of fowls in Brazil and the Argentine.

The heavy loss of human life which occurs annually from diseases transmitted by insects is by no means confined to tropical and sub-tropic countries, for the high rate of infant mortality from zymotic diseases which prevails among the working classes of our cities during the summer months of each year is very largely due to the agency of two of our most familiar native insects, the common House-fly (*Musca domestica*), and the common "Bluebottle" Fly (*Calliphera erythrocephala*). These flies have been most conclusively proved transmitting agents of zymotic disease, from their disgusting habit of alighting and feasting upon every conceivable form of filth and decomposing vegetable and animal matter, and flying direct from such noisesome surroundings, laden with bacteria, to alight upon and crawl over food ready prepared for the next meal of the human inhabitants of the house. Thus, to quote Dr. M. A. Veeder, these insects may in a few minutes, "load themselves with the dejections from a typhoid or dysenteric patient, not as yet sick enough to be in hospital or under observation, and carry the poison so taken up into the very midst of the food and water ready for use at the next meal."

Professor R. Newstead states that the chief breeding places of the common House-fly are: (*a*) stable middens containing fermenting horse manure, or a mixture of this and cow dung; (*b*) middens containing spent hops; (*c*) ashpits containing fermenting matter. It is in the midst of such unsavoury surroundings that the House-fly deposits her pure white eggs, about 120 to 140 in number, and from these eggs the legless maggots or larvae emerge in about eight to twenty-four hours, according to temperature and climatic conditions; temperature playing a very important part in hastening the life-cycle of the House-fly. Though closely resembling the larvae or maggots of the "Bluebottle" and "Blow-fly," the House-fly larvae are much smaller, and, moreover, are essentially vegetable feeders; they thrive and mature most rapidly in fermenting materials, under such conditions completing the larval stage in five to eight days. From the somewhat barrel-shaped pupa, climatic conditions being favourable, the flies emerge in about five to eight days, but the pupal stage may last from fourteen to twenty-eight days, while it is quite possible that some of the autumn insects remain as dormant pupae throughout the winter. Under the most favourable conditions, the life-cycle from egg to perfect insect is completed in about ten to fourteen days.

The common Bluebottle Fly (*Calliphera*

erythrocephala) has, if anything, a worse character than the House-fly, for it feeds to an even greater extent upon putrid, decomposing animal matter, and is also very fond of ripe fruit such as plums, pears, cherries, grapes, figs, and dates displayed for sale outside greengrocers' shops. It is obvious that by crawling over fruit and other food-stuffs this fly has the power to contaminate them with the disease germs carried on its hairy body and legs from some previous noisome repast, and therefore it is most important during the summer and early autumn at least, that all fruit purchased from stalls or barrows should be most carefully washed, and thoroughly cooked before being used for food. The eggs of the Bluebottle Fly are deposited upon raw and cooked meats, the dead bodies of animals, birds, fishes, and, indeed, most animal garbage.

The Blow-fly, or Flesh-fly (*Sarcophaga carnaria*), is a serious foe, not only as a carrier of bacteria, but also on account of its larvae attacking living sheep. In some districts, particularly the Fenland country, the shepherds have to keep a sharp watch upon their flocks during the summer and autumn to protect them from the attacks of this pest. The maggots, if left undisturbed, eat their way into the skin of the sheep, causing the poor animals great suffering, and if neglected, their death. The fecundity of these flies is extraordinary, a single female being capable of producing some fifteen to twenty thousand larvae. The Stable-fly (*Stomoxys calcitrans*) breeds in fermenting horse manure and vegetable refuse, and, loading its proboscis and body with the bacteria swarming in such situations, is a ready carrier of disease. It is a blood-sucking fly, and is therefore particularly dangerous to man in its adult stage. In tropical countries it is one of the recognized transmitting agents of trypanosomiasis.

Such is a brief description of some of the principal insects known at present as transmitting agents of disease. Much still remains to be discovered in this new aspect of insect life, and it is within the power of all careful observers to help in building up such knowledge. Brief as this description of our insect foes as transmitting agents of disease is, I hope that it will suffice to arouse the interest of my readers, and demonstrate of what vital importance to mankind the biological study of insect life has become; as it is certain that the future health, and therefore success, of our Empire is in a great measure intimately associated with it.

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