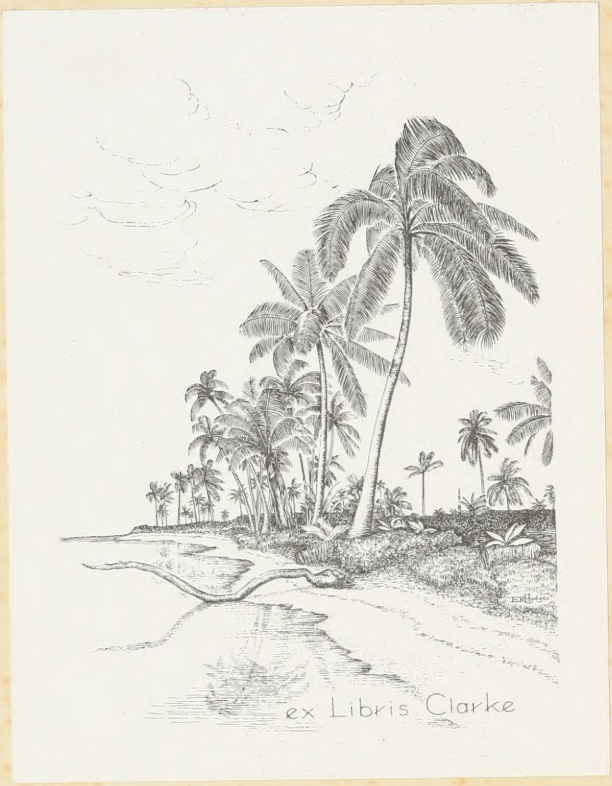
MARVELS OF INSECT LIFE

EDWARD STEP F.L.S.


ex Libris Clarke

In no other division of the Animal Kingdom is found so remarkable a variety of forms as prevails among the Insects. In the picture are brought together, from many parts of the world, a few examples to show at a glance a little of this variety. Insects fitted for life in the air, upon and in trees, in and on the earth, others for existence in the waters. Here are beetles brilliant as gems, butterflies and moths of sombre hue and gorgeous colouring, bugs as bright and as quaint in form; wasps, flies, cicada and stick-insect; may-flies on the water, and termites' hills on the further shore. Each has a story of great interest; and all these stories will be found in the pages beyond.

MARVELS OF INSECT LIFE

A Popular Account of Structure and Habit.

EDITED BY

EDWARD STEP,

F.L.S.,

Author of "Wayside and Woodland Blossoms," "Messmates," "Insect Artisans and Their Work," etc.

A Walking-Leaf Insect.

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Introduction

At long and irregular periods a work on Nature appears that is of immediate practical value, because it may be read by all and understood. Such works loom high above many of the so-called "popular" books on natural history as most of these are mere condensed reviews, not readable from the view-point of sympathetic interest. Moreover, the publications of the systematic workers are intended for the very few initiated into the technicalities of science. The pages within these covers tell a story of a world replete with wonders, beauty, tragedy and, if we are to note the parallelisms to traits in human life, a considerable amount of humor too. Mr. Step should be given due credit for his arrangement: for throughout he has eliminated the atmosphere of classification and attendant weighty details.

Many years ago we were escorted to the threshold of the world of insect marvels by the fertile and sympathetic mind of Fabre. We read and marvelled at delineations of Nature that fascinated like fairy romances. Mr. Step has herewith presented what we might call Fabre brought up to date, enhanced with the assistance of the modern camera and its magnifying lenses.

Few branches of Nature offer such possibilities of fascinating study as the insects, and there are many divergent branches of observation. Many of these relate to the care and observation of the living specimens, there are endless opportunities of studies with the camera, while the collecting and preservation of the more showy forms is replete with never-ending interest. There is a steadily growing interest in Nature's creatures. In this interest, Europe has led for a long while. But in America "natural science" and "biology" classes have become established features in all of the better schools. Twenty years ago the only mention of natural history during the complete course of the average school was at periodical phases of the geography lessons and always associated with a decorative frieze of crudely drawn animals that surrounded the map of the country to be mentally explored. And with this change and the realization among educational institutions that the study of Nature is markedly beneficial upon the minds of the young, the interest in the insects has forged ahead of other branches of Nature's Big Family. There are a number of reasons for this. One is the fact that insects are not necessarily inhabitants of wild places. A modest little flower bed in a back yard will attract an aggregation. Every hedge has its denizens. The great larvæ of the silk-spinning moths may be found within the parks of congested cities and afford the child a view of the magic transformation and the emergence of the moth from the cocoon. The commonest of the insects may be either fearsome or marvellously beautiful creatures when viewed through an ordinary magnifying glass. It is natural that creatures so easily found, so varied in

structure and habits and offering such a fund of wonderful details should elicit particular interest.

A general knowledge of insect life quite changes the character of the great out-of-doors. The student of insects need never look far for diversified types of entertainment and instruction. From the time the buds break until the frost, no matter what type the country, there is always something going on; the eternal struggle for existence, the ways of the sluggard, the efforts of the thrifty, the magic of the conjurer of transformation. And with the close of the day darkness ushers in another phase of life. The songs of the nocturnal insects show other legions have awakened and a powerful light forms a magnet for myriad forms that fly only at night.

The writer well remembers the delight of his little daughters when he first demonstrated to them the possibility of caring for several crickets in a tiny cage, where the insects soon commenced vigorously singing. When the children were a year older they had a veritable chorus of the singing insects in cages. There were three species of crickets, the buzzing meadow locust, the chattering cone-head and the Katy-did adding a basso effect. The interest in this easily acquired but novel collection spread like a prairie fire and my daughters' little friends and their friends in turn were enthused and astonished to *see* their little insect songsters actually sing by raising and rubbing the wings. And is this not an object lesson? — of the wonders going on about us, underfoot. In our busy lives we are too apt to gaze in far perspective upon the paths we trod or look upon the neighboring foliage as merely something green, while actually the grass beneath our feet forms dense jungles with a life more elaborate than the great brakes and dank forests of the tropics.

Give the youthful student a good book for inspiration, a simple collecting outfit — which may be altogether homemade — and what a world is open for study and enjoyment! The collecting of the beetles alone is a fascinating pastime. These are the easiest specimens to prepare and take up the least room. The representatives of different families of them are to be found under widely different conditions. Loose, flat stones shelter many interesting kinds. Many species may be dredged from ponds. There are types that after dark may be attracted to a light. Numerous species are to be found upon blossoms, in decaying wood, or burrowing into fungi. An interesting method of obtaining many species — and of great variety — is to hold an open and inverted umbrella beneath bushes and beat the branches with a stick. For beetle collecting the only paraphernalia necessary for general work is a wide mouthed bottle filled with alcohol — for the specimens — a small dredging net and an umbrella. After the arrival home the specimens are removed from the bottle and an insect pin inserted through the right wing case. The specimens may now be pinned in boxes lined with cork or placed in a deep frame with a glass cover — for the colors of beetles do not fade in the light and the specimens need no preservative except some naphtha cones to prevent minute pests from entering the cases and destroying them. Flies, wasps, grasshoppers, crickets and the true bugs (Hemiptera — insects with a beak) may be prepared like beetles without special mounting. The butterflies and moths must

be "spread" upon a mounting board in order that the wings may be properly set in the desired position. The colors of the moths will fade if exposed to light. The butterflies are but little affected even in a strong light. It is best to collect the larvæ or caterpillars of the moths and butterflies, feed them until they spin cocoons or transform to a chrysalis, then immediately kill and mount the freshly emerged specimen. Unless this is done it is difficult to obtain perfect examples of the larger species. When the caterpillar is collected care should be taken to ascertain the food plant, for it will rarely eat anything else. It should be daily supplied with a fresh branch, the end of the stem imbedded in a can of damp sand. A really fascinating way of collecting the smaller, night-flying moths is to "sugar" the trunks of trees adjacent to a patch of timber. The bait is composed of a mixture of brown sugar, molasses and vinegar and to this savory mixture insects are attracted. The solution is painted over a foot or so of a number of tree trunks and the collector makes the rounds with an electric flash lamp. A warm, muggy night when there is no moon is the best time for this kind of collecting.

With the youthful student these studies may not merely lead to the development of a mere hobby. There are practical results to be derived. The governments of various countries have formed important entomological departments where economic work is carried on to an elaborate extent and is productive of far reaching results. It may surprise the reader to know that the U. S. Department of Agriculture has made a study of the annual losses to the country by destructive insects among such products as cereals, fruits, cotton, farm-forests and the like and has estimated that this reaches the astounding figures of over four hundred millions of dollars. With these conditions existing it will be realized that certain phases of insect life demand very serious study on the part of the agriculturist.

Many valuable observations of insects may be made with the camera both in the field and at home. A really enjoyable pastime is the preparation of greatly enlarged images which will result in the collection of a series of photographs of quite eccentric monsters that rival the restorations of prehistoric creatures. The camera for both out- and in-door work should be of the "long-draw" type and supplied with a quite rigid tripod in order to make long exposures. Many of the caterpillars, when disturbed, will remain quite motionless and permit an exposure of several seconds. This permits the use of a color screen or ray filter that greatly aids in the portrayal of pattern. An event to be awaited with much interest is the emergence of a moth from the cocoon, or the breaking of a butterfly from its chrysalis. It may be shown in various stages as the wings are slowly unfurled.

There are innumerable possibilities in the photographing of insects as well as the general study of them. To start upon these as the writer has previously remarked, the inspiration from a good book is a most able guide. Mr. Step has opened the way for a clear insight among a legion of marvels and many of these are to be found close about us, if we but stop to look.

Raymond L. Ditmars,
The New York Zoölogical Park.

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BLACK AND WHITE ILLUSTRATIONS.

Black and White Illustrations.

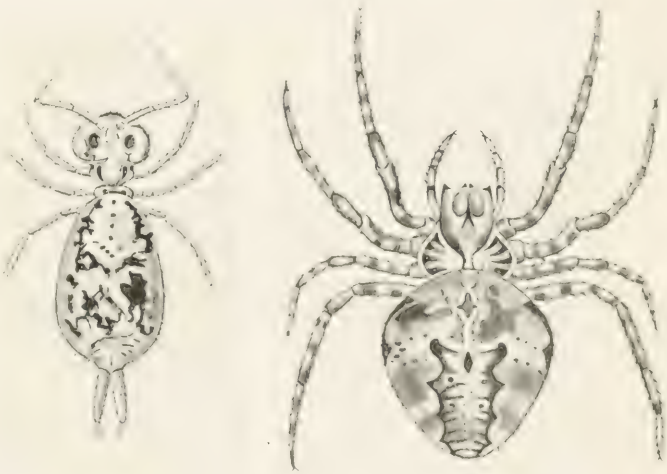
Photo by] [*E. Step, F.L.S.*

THE HERCULES BEETLE.

What is an Insect?

IN a work intended to give a popular account of the Wonders of Insect Life, it is essential that there should be a clear understanding as to the particular animals that are comprised under the term Insect. Formerly any living creature of small size was regarded as an Insect; and we fear that among the present generation there are many persons for whom the word has scarcely any more definite meaning. But in this work we shall deal only with those animals that are accepted as Insects by modern naturalists; for though we shall endeavour to describe their structure and their ways in language "understanded of the people," we hope to speak with the accuracy that is often wanting in popular accounts.

All the multitudinous forms of animal life have been sorted out by naturalists, and placed in a number of grand divisions according to their possession of certain characteristics. There is no present need to name all these, but one division



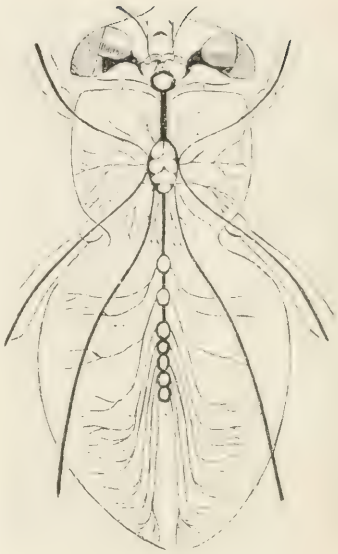
INSECT AND SPIDER CONTRASTED.

A springtail, which is one of the simpler forms of Insect life, is here contrasted with a spider, which is *not* an Insect. Note the eight legs of the spider (right) compared with the six legs of the springtail; the six legs being a distinguishing character in all Insects at maturity, whether they are winged or wingless

RING-LIKE STRUCTURE.

A diagram representing a few segments of an Insect's body. The thick portions of outline indicate the harder parts, which thin away into the supple, inward folds, which allow the hard rings free play. The thin lines connecting the hard and soft parts represent the muscles which move the several parts.

consists of animals to which these authorities have given the name of Arthropods. It includes the crabs and lobsters, spiders, centipedes, Insects, etc. All these creatures agree in having the body built in segments or rings, all or some of which bear jointed appendages. The Insects differ from the others in having these segments grouped, in adult life, into three regions, usually quite distinct. These regions are the head, the fore-body, and the hind-body. The spiders, which are commonly regarded in popular estimation as Insects, have only two body-regions. There are other differences, of course, which are not evident upon a superficial view of the exterior form; but even here two or three additional points may be mentioned, contrasting a spider with an Insect. The head of the Insect bears a pair of antennæ, or "feelers"; the spider has no antennæ. The Insect, with a few exceptions among the simpler forms, has a pair of prominent compound eyes made up of a large number of lenses, and two or three simple eyes, or "ocelli," placed between the compound eyes. The spider's eyes are all simple, and number



THE NERVES OF AN INSECT.

Here is shown the nervous system of a gad-fly. The central trunk line is enlarged into knots or nerve centres at intervals, from which finer nerve threads extend to the extremities of the limbs and to every part of the body.

THE INSECT HEART.

A small portion only of the "dorsal vessel" of a beetle is here shown. The connected chambers of which it consists expand and contract in rotation, and the free blood is drawn in at the valvular openings and discharged from the fore-part of the vessel, whence it finds its way to all parts of the body and limbs.

AN INSECT'S DIGESTIVE SYSTEM.

The body of a bee is here laid open from above to show the digestive system. At the upper part of the diagram its beginning is shown in the extended mouth parts passing back into the gullet with its terminal enlargement, the crop or stomach, and ending with the intestines. The nervous and circulatory systems are here turned aside to the right and left respectively.

FORE-PART OF A LOCUST

[illegible] insect's form shows how the Insect body is built up of ring-like segments; it also shows the openings to the air tubes along the [illegible], the [illegible] of the leaping leg, the large compound eyes, and the antennæ or feelers. The lower wing has been removed in order to reveal the side of the body.

Photos by] [*E. Step, F.L.S.*

BEETLE AND ANT.

A Brazilian beetle is here compared with one of the largest ants from the same region. The limbs, antennæ, and jaws, though agreeing in number and in general structure, yet present considerable modifications of form. The ant is twice the size of life; the beetle is only half the actual size.

six or eight. All the winged Insects pass through a series of changes, called metamorphoses, after they leave the egg, in the last stage having their wings fully developed. Spiders pass through their developmental stages before they leave the egg, and after hatching merely increase in size without change of form. Insects have only three pairs of true legs ; spiders have four pairs.

Owing to the fact that the segments of which an Insect's body is composed are strengthened by the secretion in the outer skin of a substance called chitin—which gives it firmness and serves for the attachment of the muscles—expansion of these segments to meet the growth of the internal parts is impossible. The difficulty is met by the throwing off of the old integument, after a new one has been formed beneath. The new one, before the chitin has hardened, expands sufficiently to permit of a certain period of new growth, and it may be said that when an Insect has thrown off an old skin the new one is much larger than is necessary to accommodate the internal parts. This case of chitin reaches its highest development in the beetles, where it forms a hard, rigid armour ; but it is also present in the soft, pliable skin of the beetle's grub, and in that of all other grubs and caterpillars. Let it be clearly understood that the chitin itself does not constitute the outer covering. As a matter of fact somewhat less than one-half the weight of the skin consists of chitin. This fact may be ascertained by carefully burning, when the animal constituents are destroyed, but the chitin remains and, owing to its uniform distribution, retains its form. The dark colour of chitin is due to the action of light. Beetles, etc., on emergence from the chrysalis are quite white, and remain so if kept in the dark. Those Insects which live in total darkness—as wood-boring grubs, cave Insects, etc. retain their whiteness.

We have spoken of Insects and their allies having the body built up of segments or rings. It must not be supposed, however, that these rings are separate and distinct. Taking a long cylindrical body, like that of a caterpillar or a dragon-fly for example, and making a longitudinal

section of it, we should find that it forms one continuous tube of skin which has been fortified by the deposit of chitin in rings, having connecting rings of thin, supple skin which allows of contraction or distension in length and of lateral curvature of the body, as a whole or in parts. By the attachment of muscles from the hard to the soft rings, such movements are brought under the control of the Insect. This plan of structure allows a considerable amount of elasticity to the body as a whole.

The theoretical Insect consists of twenty of these strengthened rings, but the whole twenty are not evident in most cases. Some of them are combined to form the three distinct regions of the body—the head, the fore-body and the hind-body — and one or more of the hindmost segments are "telescoped" so that they do not appear except on dissection. It is considered that the four first rings have been consolidated to form the head, which bears four pairs of external organs — a pair of jointed feelers or antennæ, a pair of compound eyes, and the appendages of the mouth. In like manner the next three segments have been united to form the fore-body or thorax, bearing on the lower side the three pairs of legs, and on the upper side the second and third rings bear the two pairs of wings. The hind-body, though theoretically it may have thirteen rings, usually consists of ten or eleven, and often of a smaller

Photo by [illegible] *E. Step, F.L.S.*

FIVE-HORNED RHINOCEROS BEETLE

Many Insects that appear much alike to the superficial obser[illegible] magnified to exhibit very striking characteristics which rend[illegible] photograph of the fore-part of a beetle [illegible] realize the fearsome appearance it must p[illegible]

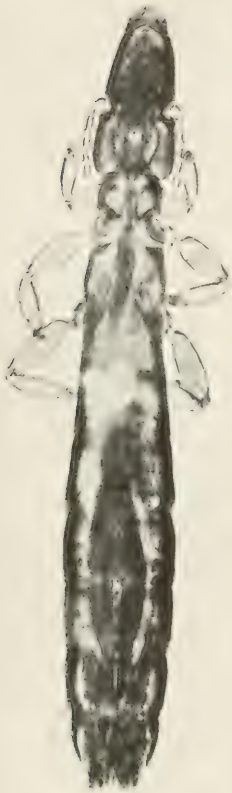


Photo by] [*Lumsden.*

PIGEON PARASITE.

An example of the adaptation of structure to habit. These Insects live among the plumage of birds, and are fitted for secure holding to their host. The actual length of the Insect is about one-eighth of an inch.

number. The hind-body bears no appendages, except those connected with the function of reproduction. Stings, where present, are modifications of these organs.

The limbs of mature Insects are all made up of several joints, and it is remarkable that these joints are constructed on the same principle as in backboned creatures, and are extended or folded by the contraction of similar sets of muscles, though in the one case the muscles are attached to the central bony portion, and in the other to the chitinous exterior. The number of joints in these limbs is not the same in all orders or families of Insects. There is considerable variation in the terminal section of the legs—the foot — which normally consists of five segments, but may be reduced to three or two. In caterpillars the only true legs are the three pairs at the front end of the body: those in the middle and at the hind extremity are unjointed temporary structures. The jaws and sucking apparatus of the mouth are seen by the process of development within the egg to be essentially modified limbs. So also are the feelers or antennæ.

The internal organs of an Insect may be said briefly to consist of the circulatory system, the organs of nutrition, the nervous system, the breathing apparatus, and the reproductive organs. The nervous system occupies the lower side of the body, the circulatory system the upper side, with the alimentary system central. The circulatory system is of a simpler character than is to be found in any of the backboned animals. What may be termed the heart (it is usually known as the "dorsal vessel") is a series of about eight connected sacs extending one behind the other from head to tail, and opening one into the other by valves which permit the blood to flow in one direction only—from behind forwards. There are no arteries or veins, the blood filling vacant

Photo by [illegible] [illegible]

BRAZILIAN RHINOCEROS BEETLE.

Another example of the eccentric forms taken by the fore-parts of some of the beetles. Here only the first horn is from the head, the massive two pointed erection behind it being from the fore-body. Natural size.

THE MOUSE-CATCHING LOCUST AT HOME.

These powerful Insects are here shown (natural size) hunting for their animal food. One has caught a mouse, another one of the bird-spiders, and others are on the watch for any small animals that may come in their way. This spiny-legged grasshopper of the Congo affords, probably, the most remarkable example of a hunting Insect.

spaces between the internal organs. There are valvular openings in the sides of the dorsal vessel as well as at the ends; and as the chambers of the vessel contract and expand in rotation the blood is drawn in from all parts and sent in a stream to the fore-part, whence it finds its way again all over the body.

The nervous system consists of a brain, situated above the gullet, and a double series of nerve-cords extending to the further extremity of the body along the lower surface, connecting up a large number of ganglia, or knots, from which run nerves to all parts.

The digestive system occupies the greater part of the body cavity and consists of various well-defined portions, which differ in the several orders according to the nature of the food. It will be understood that in many Insects whose habits change during their life period, considerable modification takes place in this system.

The breathing system of Insects is a most remarkable one, which must be dealt with in a separate article.

A Mouse-catching Locust.

A remarkable locust from the Congo, which was caught in the act of catching and eating a mouse, and is now with its victim preserved in the Natural History Museum at South Kensington. This photograph is not an arrangement, but is taken from the actual specimens as received from Africa.

A Mouse-catching Locust.

The general impression respecting grasshoppers and locusts is that they are purely vegetarian Insects. It is from that point of view that they are universally considered; but it is highly probable that creatures possessed of such efficient cutting jaws vary their diet, at least on occasion. We have kept examples of

Photo by] THE SPINNING ANT. [*Harold Bastin.*

The ant that makes use of its grub for spinning together the leaves that cover its nest is shown on this page in two of its forms or castes. This winged example is a female, and is depicted about twice the natural size.

and other household scraps to leather slippers!

In the British Museum (Natural History) there is a specimen of one of the largest known locusts,[3] which was received from a missionary in the Congo Free State a few years ago, who had taken it in the act of feasting upon a mouse it had caught. It was from this specimen, with the same mouse held securely in its jaws, that our illustrations were made. A good idea of this locust's size and strength may be obtained from the photograph on page 8 and the drawing on page 7, which show its natural proportions. The locust in question does not confine its attention to mice; large spiders, beetles and other Insects, and probably small nestling birds serve it equally for food.

This is really one of the most extraordinary facts of Insect life upon record. Innumerable species worry the backboned animals, including man himself, with their jaws and stings; the big South American spiders are said to catch small birds; but, so far as we know, this locust is the only Insect that actually catches and kills a four-footed animal.

our native great green grasshopper[1] healthy for months on a diet of flies and moth-chrysalids; and it is within the experience of many entomologists who "sugar" tree-trunks for the capture of moths that the same Insect often robs them of some of their prey. The nearly-related house cricket[2] is a pretty general feeder, its food ranging from breadcrumbs

Photo by] [*Harold Ba*

THE SPINNING ANT

This example is a worker—one of the caste that hold the grubs in their jaws whilst the young spin the leaf edges together. Th photograph gives a representation that is about four times larger than nature. These workers are coloured red-brown, which has caused them to be known as r Ants; but the femal is bright gre

[1] Locusta viridissima. [2] Gryllus domesticus. [3] Cyrtacanthacris rubella.

The Spinning Ant.

In considering the ways of ants one is prepared for almost anything. We know them as creatures of great resource in many ways; but by what process one of them arrived at the idea of what is now to be described, is a great mystery. Its accustomed name is the red tree ant,[1] and in India it is considered one of the chief pests of a country that has a choice assortment of attentive Insects. But, as in the case of some other Insects that annoy us by the exercise of their natural functions, a little study of their methods is calculated to soften our detestation of them through respect for their cleverness or other admirable quality.

Photo by] [*W. West.*

"Brown Bug," Domesticated by the Spinning Ant.

This scale Insect, which may often be found on the rind of oranges, is kept as "domestic cattle" by the spinning ant in special structures, in order that the ant may benefit by the excretions of the scale Insect. It is here shown magnified to thirty-five times larger than its actual size.

The popular name of red ant is a misnomer, and the scientific name indicates emerald-green as the colour. The real hue of the worker is described as sherry-brown colour; it is the female to whom the scientific name refers, and there is a good reason why she should be green, though why the workers should not be of the same colour is not, at present, so clear. They are not stinging ants, so their jaws are the only weapons of defence and offence.

The red ant—which must not be confused with our British red ant[2]—is not confined to India, but is found also in Ceylon, New Guinea, and the tropical parts of Australia and Africa. It lives among the foliage of trees, and constructs its nests of leaves glued or spun together by their edges and tips. In India new nests are begun about July, when a female may be seen sitting in the centre of a leaf brooding as many grubs as she can cover, as shown in the upper part of the picture on page 11. These are the beginning of her family; and at present no attempt is made to construct a nest, because all her efforts are required to feed the grubs. When these have completed their development she has a small company of workers to assist in the feeding of the next batch of grubs. When the latter are almost ready to spin their little cocoons in which to change to chrysalids, their silk-glands are

[1] Œcophylla smaragdina. [2] Formica rufa.

By Theo. Carreras

THE SPINNING ANT CONSTRUCTING SHELTERS.

[illegible]

ready for use, and the workers utilize them in the building operations. Many of the workers draw the edges of several leaves together; another seizes a grub in her jaws and applies its mouth to the leaves and presses out the liquid silk. It is a gum-like fluid and serves to cement the leaves together effectually. Numerous workers hold grubs in the same manner, and draw out threads connecting leaf to leaf. In some cases, by this means they fabricate sheets of webbing with which they surround leafy twigs upon which they are pasturing some of their domestic cattle. One would not be surprised if under the peculiar circumstances of its fabrication, this web was a loosely constructed and flimsy material; but it is closely woven, and in some cases made so solid that it can be written upon like paper. Some of these nests are a foot across; others may be regarded as cattle-sheds, for in them numbers of a scale-insect, known in India as the brown-bug,[1] are enclosed. The ants value these on account of their sweet excretions. Saville Kent found aphides in some of these nests in Australia. Among other Insects taken under their protection (for their own ends) is the caterpillar of a small tail-winged "blue" butterfly.[2] It is now well known that most, or all, of the "blue" caterpillars have a special apparatus on the upper side for the secretion of a presumably sweet liquid which is much in demand by ants all over the world. The particular caterpillar favoured by this red ant varies in colour from light green to dark red. These the ants watch over, and surround each individual, with the leaf upon which it is feeding, with a tent, "protecting them jealously, and attacking most fiercely any living thing intruding upon them." When the caterpillar is about to change to a chrysalis the ants become much excited, and two or three of them guide it down the tree trunk, fixing the place at the foot of the tree where it is to enter the ground for the purpose. Mrs. Wylly says that "If you gently scrape away the earth at the base of the tree, you will see some hundreds of larvæ and pupæ in all stages of development, arranged in a broad, even band all round the trunk, and lightly covered with earth. The ants object to their being uncovered, and will immediately set to work to re-cover them, and if you persist

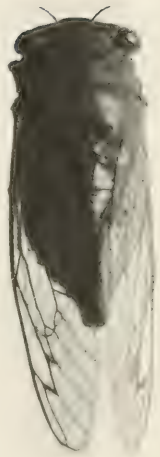


Photo by] [*E. Step, F.L.S.*

CICADA.

The cicada, though of chief repute as a musician, serves as food in parts of Africa, and is mixed with dates for the purpose.

Photo by] [*E. Step, F.L.S*

"VEGETABLE CATERPILLAR."

A New Zealand caterpillar after being killed by a fungus—which grows out from it as shown in the photograph—is esteemed by the Chinese, who sell it in bundles as we sell asparagus. One-third less than the actual size.

[1] Lecanium hesperidium.

[2] Tarucus theophrastus.

they will remove all the chrysalids and bury them lower down. When the butterfly is ready to emerge, which is in about six or seven days, it is tenderly assisted to disengage itself from the shell."

In some parts of India this ant is esteemed as a curry; and elsewhere it is used as smelling salts! The ants being crushed in the hands, the pungent odours from their bodies are inhaled, and said to relieve a headache or cold at once.

Photo by *E. Step, F.L.S.*

HEAD OF PRIONUS.

This beetle, with many jointed antennæ of remarkable form, spends the earlier part of its life as a grub feeding in the wood trees. In some parts of the world these and other fine fat grubs serve as human food.

Insects as Human Food.

A visitor from one of the other planets would probably be surprised to learn that though the civilized races of the earth indulge in the eating of live oysters and some other strange foods, they abstain as a rule from the eating of Insects. Why it should be so is rather difficult to understand, when one considers the things we do eat, and the fact that uncivilized and semi-civilized peoples retain the primitive habit. The abstention from Insects as food has been brought about, no doubt, by fashion, for that it is not merely culture and civilization that produce an abhorrence of such food is proved by the fact that the cultured Greeks and Romans found nothing disgusting in it. They ate their cossus, their cicadas, and their locusts; and even their poets praised such fare.

We are all familiar with the story of John the Baptist subsisting upon locusts and wild honey, and though controversialists have sought to show that

the locusts in question were the seed-pods of a small tree,[1] there can be no doubt that they were the Insects still eaten by the Arabs and other races of countries where the swarms of migratory locusts visit. Hasselquist found at Mecca, when corn was scarce, the Arabs ground locusts in their handmills or pounded them in stone mortars to make a substitute for flour. Moistened with water and worked into a sort of dough, this was made into cakes and baked. He adds that they also eat locusts without waiting for the excuse of a famine, boiling them in water, and then stewing with butter "into a kind of fricassee of no bad flavour." Sparrman, too, tells us of the Hottentots that they rejoice when swarms of locusts visit their country, though it means the destruction of all verdure. They feast upon the locusts, and make a coffee-coloured soup of their eggs, getting "visibly fatter" on such nourishing diet. Forskål, a Swede, says there is no great relish in this diet, and that if indulged in too freely it thickens the blood, and becomes injurious to those of a melancholic temperament. For all that, in Calcutta the natives still regard a swarm of locusts as a providential event, and their dried bodies form an ingredient in the preparation of curries.

Photo by] [*E. Step, F.L.S.*

SHORT-WINGED LOCUST.

This locust is said to be eaten by certain native tribes in South Africa, who value it mainly on account of the relish afforded by the salt flavour of the leaping thighs. This is remarkable, seeing that the Insect is coloured with strongly contrasted red and black, which are considered to be an indication of unpalatability, and therefore known as "warning colours."

In parts of South Africa it is not only the migratory locust that is eaten, but other large grasshoppers, including one that we figure[2] that is coloured black and red. This is a livery that is regarded as being outward evidence of unwholesomeness; but we are told that in spite of it the thick leaping legs are eaten as a relish with "mealies." The entire Insect is fried, and the legs are detached for food as they have a salt flavour. Our informant says the custom of eating Insects is dying out and is now only practised by the poorest of the natives, the

[1] Ceratonia siliqua.

[2] Phymateus ægrotus.

Photo by] THE "WHITE ANT." [*E. Step, F.L.S.*

In parts of Africa the termite, or "white ant," is an important article of food, and is eaten raw or after boiling or roasting. Parched in an iron pot over a gentle fire, much as coffee is roasted, they are delicious, delicate and nourishing.

Photo by] THE SAÚBA ANT. [*E. Step, F.L.S.*

This ant—referred to on another page as a cultivator of mushrooms—is used as food in Brazil. At the time when the winged males and females issue from the nest they are caught by basketfuls and eaten. The portion here shown is four times the natural size

reason being that meat and salt are now so easily obtainable, and most of the natives are in a position to buy them. On the other hand, Mr. W. L. Distant, author of "The Naturalist in the Transvaal," informs the present writer that he never heard of the natives eating this particular black and red species, nor does he think it likely that they do so.

Photo by] [*H. Main, F.E.S.*

PALM WEEVIL.

The large fat grub of this beetle, which feeds internally in palm-trees and is known in the West Indies as the gru-gru, is eaten there and also in Brazil.

Caterpillars of several kinds are eaten by the African Bushmen, the Australian Blackfellow, and the Chinese. The latter also utilize the chrysalis of the silk-worm after the silk has been unwound from the cocoon. Indian rearers of the Tussar silk-moth make a similar use of the chrysalids. More important as a food is the white ant. Sparrman tells us that the Hottentots eat them boiled and raw, and Smeathman says that the Africans among whom he explored parch them in iron pots over a gentle fire, much as coffee is roasted. In that state they are delicious food; and they eat them by handfuls. He thought them delicate, nourishing, and wholesome, being sweeter than the big grub of the palm weevil,[1] and tasting like sugared cream or sweet almond paste. The palm weevil grub, the gru-gru of the West Indies, is also eaten on the Amazons, according to Wallace. In Nyassaland they make a paste of a species of mayfly[2] and gnats, and eat it under the name of "kungu."

Grubs of beetles other than the palm weevil — such as the rhinoceros-beetle and the cockchafer—are also eaten; and in the wilder parts of India the natives are not content with the honey from the comb of the large jungle bee,[3] but they also eat the grubs and chrysalids they find in the cells. Other people eat ants of various species. Kirby and Spence tell us that they

[1] Rhyncophorus palmarum. [2] Cænis kungu. [3] Apis dorsata.

"have no unpleasant flavour." Wallace says that, on the Amazons, the saüba ant[1] is captured in basketfuls for food, at the time the winged males and females swarm out of the nests. He says, "It is rather a singular sight to see for the first time an Indian taking his breakfast in the saüba season. He opens the basket, and as the great winged ants crawl slowly out, he picks them up carefully and transfers them with alternate handfuls of farina (Cassava meal) to his mouth." When, later, he was studying the natural history of the Malay Archipelago, Wallace found there also that the natives made use of the teeming Insect life for their sustenance. He says, "Every day boys were to be seen walking along the roads and by the hedges and ditches, catching dragon-flies with bird-lime. They carry a slender stick with a few twigs at the end well anointed, so that the least touch captures the insect, whose wings are pulled off before it is consigned to a small basket. The dragon-flies are so abundant at the time of the rice-flowering that thousands are caught in this way. The bodies are fried in oil with onions and preserved shrimps, or sometimes alone, and are considered a great delicacy. In Borneo, Celebes, and many other islands, the larvæ of bees and wasps are eaten, either alive or pulled out of the cells, or fried like the dragon-flies. In the Moluccas the grubs of the palm-beetles are regularly brought to market in bamboos, and sold for food; and many of the great horned beetles are slightly roasted on the embers and eaten whenever met with. The superabundance of Insect life is therefore turned to some account by these islanders."

Photo by] [*E. Step, F.L.S.*

MIGRATORY LOCUST.

In all parts of Africa and in Arabia the migratory locust [illegible] utilised as food when [illegible] devastating swarms.

But large Insects with substantial bodies are not the

Photo by] [*H. Main, F.E.S.*

GRUB OF THE COCKCHAFER.

This pest, so destructive to our grasslands, might be turned to account as food, for which purpose it is used in some parts of the world. The cockchafer itself is also eaten, and certainly looks more inviting than the grub.

[1] Atta cephalotes.

Photo by] [*Harold Bastin.*

HEAD OF ROSE-LEAF MANTIS.

A view of the fore-parts of this remarkable Insect. The coloured under-surface is shown with the terrible fore-limbs folded. The slender joint or foot with its fringe of spines is shut down between two rows of longer spines on the edge of the next joint

only ones that serve as food for *some* people. The jumping maggots of the cheese-fly [1] are eaten with the cheese, even by the squeamish Englishman.

The Flower-like Mantids.

There are many clever imitations of leaves among Insects: fresh green leaves, leaves that have passed their prime and have turned to ashy-brown tints, leaves that have been fretted by Insects or attacked by fungi. Such counterfeit presentments are found in several of the unrelated orders of Insect life. But it is very rarely that flowers are mimicked in both form and colour, though in colour alone there are numerous examples of flower-haunting species that become invisible when on the flower, either for feeding upon pollen or nectar, or for securing as food other Insects that frequent the blossoms.

But among the mantis family there is a remarkable species [2] found in India, which is called by the natives by a name signifying the rose-leaf Insect. It is about three and a-half inches long in the body, and, leaving the legs out of consideration, may be described as fiddle-shaped, the neck of the fiddle (the fore-body of the mantis) being very long and slender. The species has long been known in cabinets and from good figures in entomological works, but the descriptions from such specimens were very misleading. In recent years we have had the advantage of descriptions drawn by naturalists from living examples, and from those who have seen it in its natural surroundings. Under such conditions it is quite a different thing from the museum specimens. The fore-body, just behind the head, has a leaf-like expansion on each side; and the second and third pairs of legs have similar expansions

Photo by] [*Harold Bastin.*

HEAD OF ROSE-LEAF MANTIS.

The same aspect as in the preceding photograph, but with the fore-limbs partly extended and exhibiting the terrible spines upon which its Insect victims are impaled when the foot is shut down on the middle joint.

[1] Piophila casei.

[2] Gongylus gongyloides.

By Theo. Carreras.

THE KANCHONG.

This Malayan mantis is the most remarkable of the group of flower imitators. It takes up a position in the centre of a flower cluster and appears to be part of it. Two examples will be seen at the top of the bush, where the flower-like form has attracted a butterfly which is being crushed by the mantis. When on the ground it resembles exactly an orchid blossom that has fallen. The more conspicuous Insect in the foreground is another species—the rose-leaf mantis—with its wings expanded for flight.

Photo by] [*Harold Bastin.*

THE DIABOLICAL SPECTRE.

This mantis, which comes from Africa, is so named from its habit of posing to resemble a violet-coloured flower, and then destroying the Insects that are attracted by the counterfeit resemblance. Its habits are very much like those of the rose-leaf mantis, whose photograph is shown on page 18.

near the extremity of the thighs. There is a similar, but wavy, expansion around the hind-body; and behind the head there is a broad, flat, rhomb-shaped shield. The whole upper surface of the living rose-leaf Insect is green, but the under surface presents an entirely different appearance. From this aspect the expansion behind the head is "a clear, pale lavender-violet, with a faint pink bloom along the edges of the leaf, so that this portion of the Insect has the exact appearance of the corolla of a plant, a floral simulation which is perfected by the presence of a dark, blackish-brown spot in the centre, . . . which mimics the opening to the tube of a corolla." Dr. J. Anderson, from whom we have quoted, goes on to say that "A favourite position of this Insect is to hang head downwards among a mass of green foliage, and, when it does so, it generally remains almost motionless, but, at intervals, evinces a swaying movement, as of a flower touched by a gentle breeze. . . . The object of the bright colouring of the under surface is evident, its purpose being to act as a decoy to Insects, which, mistaking it for a corolla, fly directly into the expectant, serrated, sabre-like, raptorial arms of the simulator." Lefroy, in his "Indian Insect Life," calls it the orchid mantis.

But this rose-leaf Insect, after a long innings as the most remarkable member of the mantis family, is likely to take second place as a flower-imitator after Mr. Annandale's revelations of the habits of the kanchong,[1] a Malayan mantis. In Lower Siam there is a plant known locally as the Straits rhododendron,[2] though it is no relation of *the* rhododendrons. One day Mr. Nelson Annandale was attracted

[1] Hymenopus bicornis.

[2] Melastoma polyanthum.

to a bush of this kind by a curious movement among a cluster of flowers about five feet above the ground. It appeared as though one of the flowers was swaying slowly from side to side, and it was not before several seconds had passed that he realized that the swaying was performed not by a flower, but by a mantis that looked like a flower. When I held the branch on which the Insect had established itself in my hand, I could not tell exactly where the animal tissue commenced and where the flower ended, so perfectly was the one assimilated to the other." Mr. Annandale goes on to state that the Insect had ensconced itself in the very centre of the flower-cluster, and so long as the mantis was on the watch for prey, the hind-body was turned back until its proper upper surface almost touched that of the fore-body. The fore-body and the head were held upright, with the fore-legs in front in the ordinary "praying" attitude of the family. The other two pairs of legs were disposed around the hind-body. When once a position was taken up, it was never changed until the Insect departed from that flower-cluster. The natives believe that it is a flower which has become an Insect. The kanchong mantis is found in Assam, Sikkim, Java, and Sarawak as well as in Siam, but appears to be a rare Insect.

Another species is known to science as the diabolical spectre [1] from its fore-parts on the under side being coloured with a broad band of violet, which, when the Insect has arranged itself among leaves, gives it an alluring resemblance to a flower to which Insects are attracted. The position is pretty much that shown in our photograph on page 20; and if we can mentally endow that figure with the colour mentioned we shall see that it has a very flower-like appearance.

Photo by] GIANT ALDER-FLY. [*H. Bastin.*

In America and India there are enormous alder-flies, which have not only the advantage of size over the European species, but also the addition of greatly developed jaws and a long, thick neck. The jaws give the Insect the appearance of being very formidable, but it is by no means clear what purpose they serve. The spread of wings is over four inches, and the jaws are an inch long.

[1] Idolum diabolicum

The Alder-Fly.

This is one of the angler's Insects, and it is probably to him that it is indebted for having an English name, for there is nothing about it sufficiently attractive or striking enough to warrant it being distinctly labelled with a folk-name. It has a general resemblance to the stone-flies and caddis-flies. It may be seen pretty commonly sitting upon trees and fences near slow or stagnant water, with its wings folded over the back, forming a ridge that completely hides the body. When the wings are spread there are seen to be four of them, of a yellow-brown colour and strongly netted, the hinder pair being a little smaller than the others. Its flight is very heavy, and not sustained.

Photo by] [*W. J. Lucas, F.E.S.*

THE ALDER-FLY.

The two sexes are here shown, the male with expanded wings, the female with them closed. They may be found sitting on tree trunks and fences. The mass of several thousand eggs are often attached to the leaves of trees, though the grubs live in water until they are about to change to the chrysalis condition. The actual size is a little more than an inch across the spread wings.

In its grub state it is a water Insect, but not like some, absolutely dependent upon being in water; a moist atmosphere among vegetation will sustain it for a time at least. Often it has to begin life as a terrestrial creature, for its mother frequently makes the mistake of attaching her mass of eggs to vegetation at some distance from the water. After all, though, this may not be a mistake, but a means of weeding out the least fit; for the egg-mass contains from two to three thousand eggs, and it is certain that more than 99 per cent. of these must perish either as eggs, grubs, or chrysalids if this year's generation of alder-flies is not largely to exceed that of last year. It is probable that the majority perish as grubs from the attacks of other creatures in their search for the nearest water. They are shrimp-like creatures, with a pair of curved, sharp-pointed jaws for attacking the other aquatic animals upon which they prey. The hind-body bears seven pairs of jointed filaments and a long, unjointed tail. These serve as gills for the

GIANT WATER-BUG ATTACKING A FROG. [*By Theo. Carreras.*

Here is seen what frequently happens in the marshes where the giant water-bug lives. Frogs, toads, and fishes are caught in the fold-down joints of the front-legs, and are further secured by the insertion of the beak, through which their blood is sucked. Both frog and bug are shown of the actual life-size.

Photo by] [*E. Step, F.L.S.*

HEAD OF GIANT WATER-BUG.

In this photograph only the head and shoulders of the giant bug are shown, enlarged four times. The large compound eyes will be seen, and between them is the base of the rostrum or sucking beak, but the beak itself lies along the under side when not in use. The strangely-formed antennæ are hidden in special pockets on the under side of the head.

aëration of the blood, for the creature is without the spiracles or breathing holes of land Insects.

When this aquatic larva is fully grown, it leaves the water and searches for a suitable spot in which it can form a cell. Here it changes to a chrysalis, which shows the wings and other characters of the perfect Insect. In this stage it is quite inactive, but after an interval it again casts its skin and emerges fully developed as an alder-fly.[1] It is everywhere common in the neighbourhood of water. There is a second species[2] of darker hue, which appears to be less common, though from their general similarity it is probable that the two are frequently confused. Though these flies measure only an inch across the expanded wings, there are near relations (in another genus[3]) in America and India which are much larger, and, from the enormous development of jaws, of formidable appearance. These jaws are equal in length to the united measurement of the fore-body and hind-body. In their earlier stages their forms and habits are much like those of the alder-fly; and the same may be said for the ultimate stage, except that the extraordinary jaws so well shown in our photograph on page 21 have no counterpart in the alder-fly, and their purpose has not yet been made plain.

Giant Water-Bugs.

Whoever has interested himself in the Insect life of an average pond has certainly become acquainted with a number of interesting aquatic representatives of the bug family.[4] The boatman, the water-scorpion, the water-measurer, and the water-crickets are the species that are most likely to have attracted attention.

[1] Sialis lutaria. [2] S. fuliginosa. [3] Corydalis. [4] Hemiptera

The largest known of these aquatic Insects we may call the giant water-bug,[1] a native of Brazil, Guiana, and Trinidad, where it spends the day in muddy pools and sluggish waters, and in the evening exercises its wings in the air. Its rather flat, yellow-brown back has led some people to suppose it is an extra-large cockroach, and the writer received a large specimen from Trinidad which his correspondent spoke of as the electric cockroach, the prefix having reference to its being attracted by electric lamps. In the water it lurks among the weeds and on the muddy bottom, which is well matched by its colouring, and seizes fishes, frogs, and other aquatic animals, mantis fashion. The two principal joints of the fore-legs fold down on one another, and the stouter of these two (thigh) has a groove along its front to receive the sharp inner edge of the next joint, much as the blade of a pocket-knife folds down in the handle when not in use. All the legs are barred with zebra-like markings. There are no antennæ visible, but they are present, though tucked singly away in special slits for the purpose. It is probable that these may be used only when the creature is in the air.

Photo by] THE SAÜBA ANT. [*H. Bastin.*

A worker of this leaf-cutting ant, enlarged to five times its natural size. The powerful jaws, though here closed, may be seen plainly; and by comparison with the photograph of the male below, the head will be seen to be more highly developed to provide the muscular power for the leaf-cutting, which is accomplished by the workers alone.

Photo by] THE SAÜBA ANT [*H. Bastin.*

The ant that gathers leaves and minces them to make leaf-mould, wherewith to fill its fungus chambers and grow mushrooms for food. This winged form is a male, and is shown on a scale of about one and a-half times the actual size of the Insect.

[1] Belostoma grandis

Two other American species are found further north, the grey water-bug,[1] with a range extending from Lower Canada to the West Indian Islands, and the American water-bug,[2] which is found over a great part of the United States. The two are very similar, but the American has shorter and broader fore-legs with a groove in the thigh, which is absent in the grey species. They both live in pools and the estuaries of tidal waters, hiding among stones and rubbish, from which they dart rapidly to attack any passing fishes or frogs. The victim is clasped by the bug's fore-legs, and the deadly beak plunged into the flesh. This is not a case of taking toll merely of the victim's blood, as in the case of many other sucking Insects; it is speedily followed by the death of the bug's victim. This appears to be due to a copious supply of liquid from around the base of the beak, which finds its way into the puncture. Locy has traced this to a pair of glands in the head of the giant water-bug. Its secretion, he says, "produces death very quickly when introduced on a needle-point into the body of an Insect."

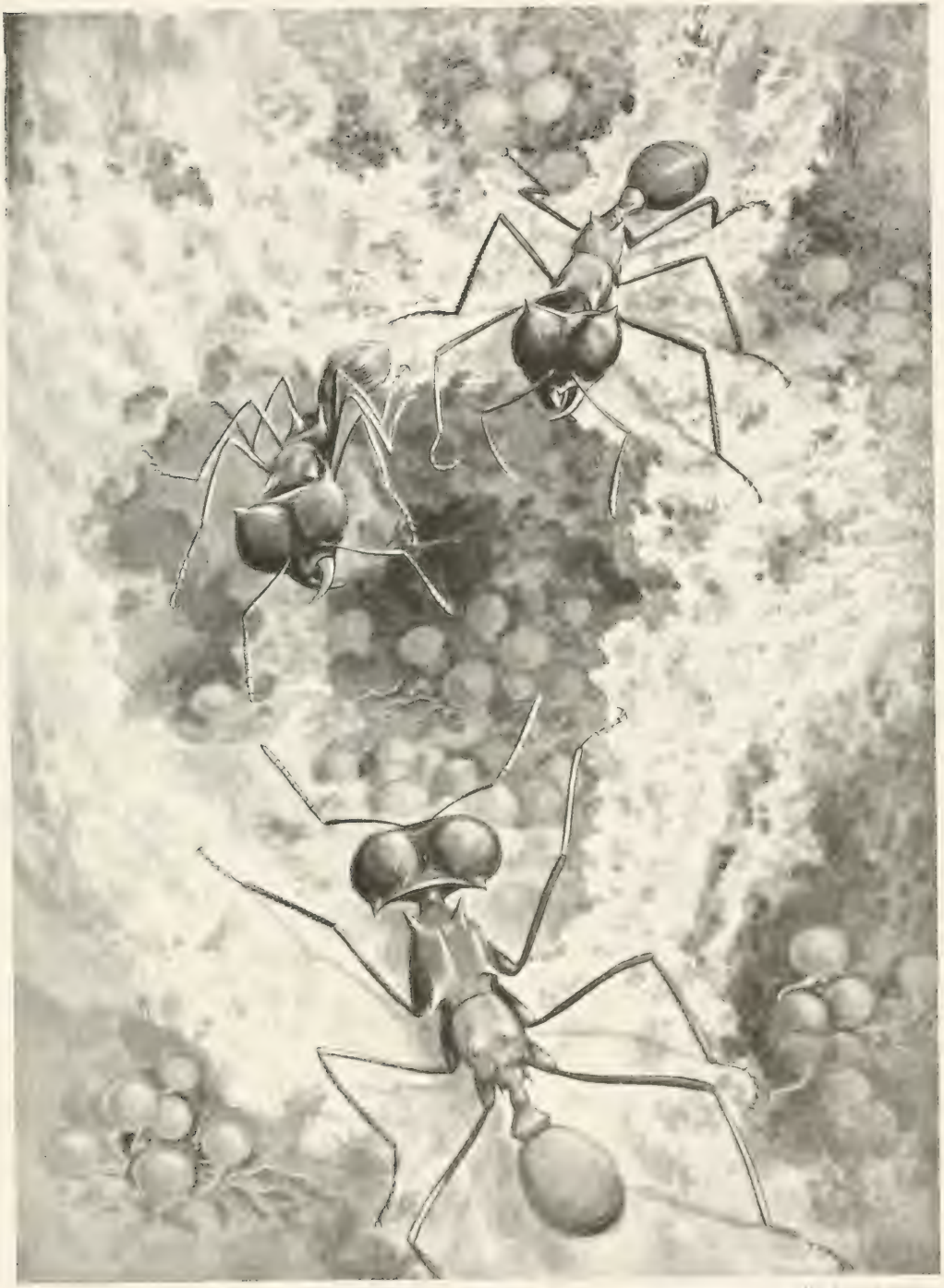
Photo by] [*E. Step, F.L.S.*

"Soldier" Saüba Ant.

In the nest of the leaf-cutters there are several distinct grades of workers, ranging from very small to very large. The present photograph shows the largest of these, with very large head and jaws. It has been called a "soldier," but there does not appear to be any justification for the title. Magnified four times.

A species very like the giant inhabits similar situations in India and China.[3] Though often confused with the former species, it may be distinguished by its pale yellowish colour, and its rather inferior length—three and a-quarter inches. The colossus,[4] a native of Cuba and Central America, is a darker and more heavily-built Insect, with the fore-body coarsely wrinkled and granulated, and the fore-part crossed by a deep bent, depressed line. As is the case with the entire family of bugs, there is no caterpillar or grub stage.

[1] B. grisea. [2] B. americana. [3] B. indica. [4] B. colossicum.

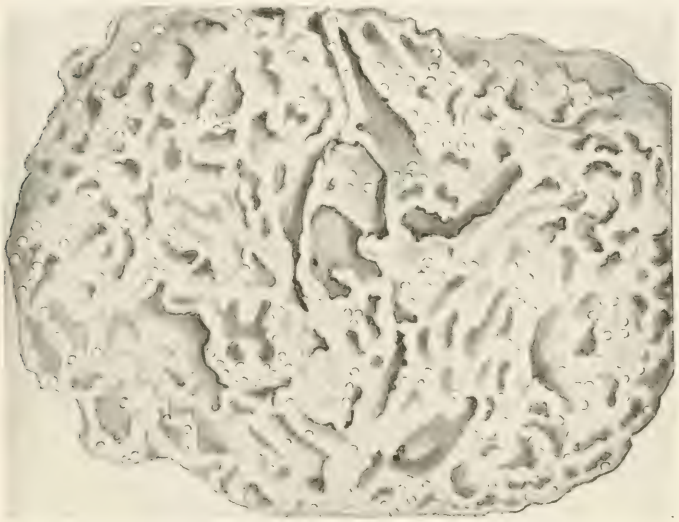


MUSHROOM VAULTS OF SAÜBA ANT.

The hotbed made of cut-up leaves is soon held together by the white "spawn" threads of fungus, upon which later there develop little knobs. These are the tiny beginnings of mushrooms, and if left would grow to a considerable size; but the ants bite them off and use them for the food of the community.

Insect Mushroom-Growers.

After lying under a cloud for years, the reputation of Solomon as a veracious chronicler was vindicated by the discovery in Europe, Asia, and America of different species of ants that have been proved by careful observation to store up grain in underground garners for future use. Following upon these revelations —which were chiefly remarkable because the authorities had concurred in denouncing the Wise King as a romancer—came the stupendous announcement that certain species of ants not merely hoarded food which they found ready to their hands, but that by a somewhat complicated series of actions they took steps to grow their food under artificial conditions in their own homes. When Thomas Belt published his statement to this effect, based upon his investigations into the habits of the parasol, coushie, or saüba ant [1] in Nicaragua, it was received with a smile of incredulity. Belt was not an official naturalist; he was in Nicaragua as a mining engineer, but he was a very cute and painstaking observer, and the professional naturalists, who afterwards went to verify or explode his conclusions, did more than substantiate his wondrous story: they added details which increased the wonder. These ants are also known as leaf-cutters from their reprehensible practice of making the lot of the coffee and orange planter a hard one by stripping his trees of their leaves in preference to taking the wild growths of the forest. In some districts they even make human cultivation impossible. Bates, who gave an account of the operations of these leaf-cutting ants in Brazil, says they mount the tree in multitudes, the individuals engaged in this work being all workers-minor. "Each one places itself on the surface of a leaf, and cuts with its sharp, scissor-like jaws a nearly semi-circular incision on the upper side; it then takes the edge between its jaws, and by a sharp jerk detaches the piece. Sometimes they let the leaf drop to the ground, where a little heap accumulates, until carried



FUNGUS CHAMBERS IN TERMITES' NEST.

The termites ("white ants") are also among the cultivators of mushrooms. The drawing represents a spongy mass of part of the nest, hollowed and excavated into chambers and passages, from which minute white mushrooms grow in abundance.

[1] Atta cephalotes.

off by another relay of workers; but, generally, each marches off with the piece it has operated upon, and as all take the same road to their colony, the path they follow becomes in a short time smooth and bare, looking like the impression of a cartwheel through the herbage."

Bates had not been able to discover for what purpose the leaf-cutters went to all this trouble. He thought he had found the reason, and supposed the leaves were gathered for thatching the entrances to their underground cities. In this surmise, however, he was wrong, as Belt and Fritz Müller have shown. The leaves are taken down and packed in underground

[By Theo. Carreras.

MUSHROOM-GROWING ANTS.

The leaf-cutting saüba ants of South and Central America ascend trees in great numbers and frequently strip them of their leaves. These are cut up into small fragments and packed into special chambers, where they ferment and in time produce a crop of small mushrooms. The ants are here shown returning laden after stripping a tree.

chambers, where they ferment and decay, forming a sort of leaf-mould in which the ants *grow mushrooms!* But why? The saüba or leaf-cutter is a mycophagist! It might be argued that there is no reason why the ants should do this, as there are plenty of naturally-grown fungi in the forests upon which they could feed, without going to the trouble of gathering leaves and preparing their own mushroom beds from them. True, but the naturally-grown mushrooms are seasonal, and their appearance is modified by fluctuations of temperature and humidity. The human mushroom-cultivator has discovered that, by preparing suitable beds in dark places where he can control the temperature, he can have continuous crops; but the saüba was before him in making this discovery.

TERMITE MUSHROOM-GROWER.

The species represented is the best known and most important of the mushroom-growing termites of the Old World. The individual is a winged male. The species may be called the warlike termes, if one adopts its scientific name. It builds tall mounds for nests.

Belt was not content to observe the leaves piled up on top of the nest. He dug out the underground chambers, and found that some of them were rounded and five inches across, three-fourths of the space being filled with a spongy mass of speckled brown material. There were no green leaves to be seen, but he satisfied himself that the spongy mass was the remains of them, acted upon by damp heat after having been finely cut up. Through all the mass ran white threads of fungus mycelium. The ant-larvæ were brought to these same chambers, and were fed upon bits of fungus snipped off by the jaws of the attendant workers-minor. To the larger workers is entrusted the task of making these mushroom-beds. The green leaves are brought to them and they cut them into shreds, cleaning each by licking it, then rolling it into a little pellet and throwing it upon the heap. It is also stated that when they have completed the formation of a new bed, it is inoculated with the fungus by sticking in bits of the old bed with its mycelium threads, just as human mushroom-growers do. Some of the bed on being taken from the nest and placed under conditions more natural for the

Photo by] [*H. Bastin.*

TERMITE CUTTING GRASS.

Although this photograph serves to illustrate the manner in which the fungus-growing termites cut grass for making their mushroom beds, it should be stated that the task of gathering this material is undertaken by the workers, whereas the specimen photographed with the grass blade in its jaws is a soldier.

By Theo. Carreras.

"White Ants" as Mushroom-growers.

The termites—erroneously known as white ants—also have their mushroom beds, and they cut grass and gather leaves to assist in their composition. In the drawing they may be seen on an enlarged scale issuing from their tunnels and gathering the mushrooms in the chambers allotted for their culture.

Photo by] [*A. E. Tonge, F.E.S.*

ORANGE-TIP BUTTERFLY.

The full grown caterpillar is here feeding upon the seed-pods of the hedge-mustard. Its form and coloration are such that it appears to be part of the pod. Slightly enlarged.

Photo by] [*A. E. Tonge, F.E.S.*

ORANGE-TIP BUTTERFLY.

The caterpillar has here changed into the remarkably slender green chrysalis, whose attachment to the stem is such as to suggest to the eye that it is part of the plant. Slightly enlarged.

fungus produced mushrooms six inches across; but the ants do not permit of such development. As soon as the mushroom "buttons" are formed in miniature they are cut off.

Such a method of cultivation adopted by Insects must not be dismissed as a mere curiosity of natural history. The process is so complicated that it implies a much higher order of intelligence than is usually allowed to Insects by our philosophy; for the saübas laboriously collect green leaves which are not their food and carefully prepare them in order that they may support a crop that may be used by them. This is something very different from merely storing grain, and is worthy of being pondered.

Bates says "the underground abodes of this wonderful ant are known to be very extensive. The Rev. Hamlet Clark has related that the saüba of Rio de Janeiro,[1] a species closely related to ours [that is, the Amazon species], has excavated a tunnel under the bed of the river Parahyba, at a place where it is as broad as the Thames at London Bridge."

Alfred Möller, who went out to Blumenau, in South Brazil, specially to study these ants, has described similar fungus-growing habits in two other species[2] of Atta. They make covered ways, nearly thirty yards long and about half an inch broad, leading from their nest to the plants known as cupheas, both in the forest and in the open country. They climb up the stems of the cuphea, and an ant starts at the edge of a leaf, and in five minutes cuts out a piece. When this has been cut almost completely, the ant moves off it to the main portion of the leaf, cuts through the

[1] Atta sexdentata.

[2] A. discigera and A. hystrix.

remaining part, and drags up the now severed disc, grips it with its jaws and lifts it above its head. It then climbs down the stem of the plant, into the covered way, and travels along it at a very uniform pace, and deposits its load in the nest.

The termites, too, who have borrowed so many of the habits of the real ants, appear to have taken a lesson from them in the matter of fungus cultivation. Smeethman stated that some species had special chambers in their nests which were devoted to the growing of a fungus which they used as food; but until quite recently no confirmation of this statement was forthcoming. Now, however, Mr. Haviland has found it to be true in regard to several species. In the case of a South African termite,[1] he found that the nursery cells were built of a material which produced a fungus — a kind of mould — upon which were innumerable white bodies; and a similar condition was found in some nests explored at Singapore. In Natal he discovered a new species,[2] which he found to be a harvester, and there is every probability that the material harvested is devoted to the cultivation of fungi. During the heat of the day the workers issue from holes in the ground, and with their well-developed jaws cut the grass into lengths of about two inches. These pieces they carry to the mouths of the holes and often leave them there until

Photo by] [*E. Step, F.L.S.*

THE ORANGE-TIP BUTTERFLY

When at rest this bright little butterfly often settles in proximity to clusters of small white flowers, whose lights and shadows blend with the green and white mottling of the under side of the hind-wings. In the photograph the flowers are those of the hedge-mustard, the plant upon which the eggs are chiefly laid.

[1] Termes angustata. [2] Hodotermes havilandi.

they have cut sufficient. Where acacia bushes are growing they also gather the leaflets of that plant. After the heat of the day has passed, they take down the heaps that have accumulated around the holes and store the material in chambers about five feet below the surface. A few chambers near the surface may be used temporarily, but these only hold as much as could be collected in the course of an hour or two. Sometimes, after taking in all the cut leaves, they bring up pellets of clay in their jaws and stop the mouths of the holes with it.

Photo by] [*E. Step, F.L.S.*

THE HORNET-FLY.

This, one of the largest of our two-winged flies, belongs to a family known collectively as robber flies, from their habits of pounce upon other Insects of all kinds and destroying them. In the grub stage they live in the earth, attacking other Insects, particularly the grubs of beetles. The example here shown, four times the natural size, is the male; the female is considerably the larger.

The Orange-tip Butterfly.

Although only a small item in the pageant of spring, we should regret the absence of this bright little butterfly from our country lanes in May. The popular name of orange-tip [1] is fairly good as applied to the male, but it is unsuitable so far as the female is concerned, for she is normally without any orange coloration. Even as regards the male the name is not absolutely accurate, for the tip of the wing is black, in which respect it agrees with the female. The orange of the male adjoins and is below this black tip. A little in front of the centre of the fore-wings is a variable black spot, larger in the female than in the male; otherwise the wings are white, more or less tinged with cream. A greenish-grey clouding of the hind-wings is due to the markings on the under side showing through to the upper side. On the under side the hind-wing is seen to be covered with connected blotches of greyish-green, which appear to have considerable value in hiding the butterfly when at rest. It often selects for this purpose one of the smaller umbelliferous plants, such as beaked parsley or wild carrot. The fore-wings are dropped between the two hind ones, which are raised over the back in the usual butterfly resting fashion, and the mottled wing then appears to be merely an extension of the flower mass—the white spaces between the greenish blotches representing the flowers.

[1] Euchloë cardamines

THE HORNET-FLY AND ITS GIANT VICTIM. [*By Thec. Carreras.*

Size does not protect an Insect from the attack of the hornet-fly; neither do powerful jaws and deadly stings. The hornet-fly commonly kills bees, wasps, and tiger-beetles, and has not seldom been seen to destroy even the comparatively huge and by no means unprotected dragon-fly. The principal figure here shows one piercing a dragon-fly in the most vital part. Above another has captured a wasp.

When the female is egg-laying on hedge-mustard or cuckoo-flower, she is protected by this assimilation of her wings to the colour of the flower-clusters.

The eggs are shaped like ninepins, with ribs running from end to end. When freshly laid they are white, but soon become orange, and just before hatching violet. They are laid singly upon the footstalk of a fading flower of hedge-mustard or cuckoo-flower. When the egg hatches, the seed-vessel—which in all this tribe of plants is pod-like—is beginning to lengthen, and the young blue-green caterpillar is exactly like one of these pods. As the seed-pods grow the caterpillars increase in size to correspond, and they are so similar in appearance that the caterpillars are not found without difficulty. A pale line along each side of the caterpillar corresponds with the junction of the valves of the seed-vessel. It is upon these that the caterpillar feeds, but the seeds are preferred to the pods; the caterpillar knows the exact location of the seeds and eats through the pod just where he can get to a seed, eats it, and then excavates for the next. It may eat the remains of the seed-vessel later or it may not. A number of other plants of the cruciferous order serve it for food at times. It may be found in the caterpillar stage during June and July, but about the end of the latter month it becomes a very long and slender green chrysalis. In this condition it remains until the following May, which must be considered as rather a long period for a butterfly chrysalis, but it has been known to remain at this stage for over twenty months.

Photo by] [*H. Bastin.*

GOAT-CATERPILLARS IN OAK-STEM.

A section through the stem of a young oak tree, showing the havoc made by the caterpillars of the goat-moth, of which two are perceptible in their burrows.

The Hornet-Fly.

One of the largest of our two-winged flies is also one of the least known. This is the so-called hornet-fly,[1] that may be seen on heaths and downs vigorously chasing other Insects and impaling them with its stout, black beak. Its general colour is brown, but at the base of the long, tapering hind-body there is a broad band of black. It may be assumed that this style of ornamentation has suggested the name; for in flight, when alone the body is seen, the fly has little other resemblance to the largest of our wasps. When the female is at rest, with her long, brown wings disposed over the body and showing only the pointed tip, there may be some general resemblance to the hornet, to careless observers. We have mentioned the female in this connection, because the male is smaller, and is less likely to be confused with the hornet. From the head to the tip of the hind-body the female measures a little more (25 mm.) and the male a little less (20 mm.) than an inch. The fore-parts of the body and the legs are covered with long, thick, tawny hairs, and just above the prominent beak there is a bushy moustache of the same colour. The three-jointed antennæ are quite short.

No doubt, the tapering form of the hind-body, especially that of the female, would produce the impression of the hornet-fly being a stinging Insect; but its only "sting" is the blood-sucking beak at the other end, though this is equally effective in killing its prey. Its appetite for blood appears to be insatiable, and it does not seem to be afraid of any other Insect, even when provided with defensive weapons in the shape of stings or cutting jaws. One naturalist noted one of these flies that killed eight moths in the space of twenty minutes; but they are as ready to attack wasps, dragon-flies, and tiger-beetles, all of them well-protected and predaceous Insects.

Photo by [*H. Bastin*

CATERPILLARS OF GOAT-MOTH.

The right-hand figure shows the caterpillar nearly full-grown and of the natural size.

Photo by [*H. Bastin.*

CHRYSALIS OF GOAT-MOTH.

The cocoon, constructed of silk and chips, is here cut open to show the chrysalis in place. Before the moth emerges the chrysalis bursts through the cocoon and wriggles half-way out.

[1] Asilus crabroniformis.

Photo by] [*H. Bastin.*

THE GOAT-MOTH'S ENEMY.

The life-story of the goat-moth is often cut short by this parasite, which in the grub state feeds upon the caterpillar and chrysalis, and kills it. The figures are of the male (above) and female, and are slightly less than the actual size.

Photo by] [*A. E. Tonge, F.E.S.*

THE GOAT-MOTH.

Here the moth is seen of the natural size, resting after emergence from the chrysalis. Its brown-grey colouring so nearly resembles the appearance of the bark that it is not at all conspicuous.

The family[1] to which they belong have been well-called robber-flies, and they appear to attack anything that comes in their way.

The grub of the hornet-fly is much like that of the gad-fly. It lives in the ground, and, like its mother, at the expense of other Insects, the grubs of beetles being among its more frequent victims.

The Goat-Moth.

Often during a country ramble the entomologist can surprise a companion by declaring that a tree in the immediate neighbourhood is being destroyed by the caterpillars of the goat-moth.[2] If the other knows that the goat-moth caterpillar is an internal feeder the assertion may appear rather rash, for even caterpillars that are four inches long cannot be seen through the bark of a tree. But the caterpillar in this case gives off a strong odour like that of the male goat, and by some persons its fragrance can be distinguished at a distance. In the neighbourhood of an infested tree in autumn one may meet with great, full-grown caterpillars marching across a road in order to find a suitable situation in which to spin a cocoon and turn to a chrysalis. It is remarkable that so big a caterpillar may do this with impunity, but it is more than probable that its odour is sufficiently offensive to protect it from attack. Its colour is a pinkish yellow along the sides, which merges into polished dark red along the back. It spends about three years boring tunnels into the heart of sound trees, including poplar, willow, oak, elm, and ash. Before each winter it hollows out a space in its tunnel and spins a comfortable temporary cocoon, in which it lies inactive during the cold weather. When full-fed it leaves its burrow, and seeks about for light, loose material in which to spin its final cocoon.

The chrysalis is mahogany-coloured, an inch and a-half long. There is a line of short, hard spines on the back of each segment, and these enable the chrysalis to wriggle half out of its cocoon, so that the moth emerges clear of it. The female is a much

[1] Asilidæ. [2] Trypanus cossus.

THE CARPENTER BEE.

There are many species of carpenter bees, all great burly Insects of bluish-black colour. The one represented is found [illegible] and known as the violet carpenter. It excavates tunnels in wooden posts, dividing them into chambers which it provisions, and lays an egg in each. The bees are seen at work, and in the separate cells are masses of pollen with the egg, the grub feeding [illegible] the chrysalis from back and front. The figures are all about twice the size of the Insects

larger moth than the male, the respective measurements across the outspread wings being—male, two and three-quarter inches; female, three and a-half inches. Apart from the difference in size, the sexes may be distinguished by their antennæ; in the female it is merely toothed, but in the male the teeth are long and comb-like, technically pectinated. The mouth-parts are in a very elementary condition, and there is no proboscis.

Some remarkable stories have been told of the power of the goat-caterpillar to pierce through ordinary receptacles in which it has been imprisoned by collectors anxious to obtain perfect specimens of the moth.

Carpenter Bees.

The carpenter bees, which are the largest of all bees, are not represented in this country, though several species are found in the South of Europe, and the best known of these[1] extends its northern range as far as the neighbourhood of Paris. The details of the industry of this bee were observed and chronicled many years ago by Réaumur, whose account was so accurate and complete that little could be added to it by later investigators. The bee is of portly build, much like a large humble bee, and of a dark violet or black colour—though some species have yellow males.

Broad-footed Carpenter Bee.

The male (above) and female of this large bee are shown of the natural size; and the very hairy character of the legs is evident. It will be seen that in this respect the sexes differ, especially in the fore-legs. There is also a difference in the form of the antennæ.

The female carpenter, having passed the winter in some snug corner, awakens in spring to the important duties of life, and looks out for some post or pole that will serve her purpose; for she does not touch living wood. As a proper carpenter she sees that her material is well "seasoned," and, therefore, more easily worked than timber with the sap in it. In the scheme of nature (which does not take account of man's acquired whims which have developed into necessities) all dead wood has got to be cleared away as speedily as may be; and so a number of creatures devote part of their lives to this laudable object of breaking up effete material and making it available for fresh uses. This they do either by eating it

[1] Xylocopa violacea.

[illegible]

CONFLICT OF SPIRITS

[illegible]

up entirely, as the termites do, or by piercing it with holes and tunnels to admit air and moisture which soften the interior and make it available for workers with less powerful jaws. It is, of course, very annoying to man to find that his fence and gate-posts, his garden stakes, and even the rafters and floors of his house, are regarded as so much of nature's waste which must be broken up and scattered. If he wishes it to be respected as his private property let him put his mark upon it by painting its surfaces, dipping it in creosote, or coating it with some other substance objectionable to Insects.

Having obtained a post suitable for her purpose, the carpenter bee sets about her work by cutting with her jaws an oblique tunnel about half an inch in diameter. Before this has extended far into the wood, she alters the direction of further excavation, and makes her boring run straight downwards. As she gnaws the wood it is reduced to the condition of sawdust, and all this has to be carried out of the hole or her further efforts would be brought to a standstill. But instead of scattering the excavated material as some of the miners in sand and earth do, she keeps it all together in a little heap to be available for use later on. She cuts and gnaws away until her tube is a foot or fifteen inches deep, and of equal width throughout its length. At the bottom she gives it a turn again to the exterior of the post. Having performed this great work she proceeds to what by comparison may be termed cabinet work, the finer and more intricate section of the carpenter's art. Her task is to divide this deep shaft into about a dozen chambers, each about an inch in depth, each designed for the reception of a single egg and a sufficiency of food for the full development of the bee-grub that is to hatch out. This food takes the form, usual among these solitary bees, of mixed pollen and honey. Having made such a deposit at the bottom of her burrow, she has recourse to her heap of sawdust. Taking a little of this material, she mixes it with a salivary secretion and forms it into a ring standing out from the wall of her shaft about three-quarters of an inch from the bottom. When this is set firm she constructs another ring within the circumference of the first, and so on until she has filled all the space across, which gives her a solid floor about an eighth of an inch thick, marking off her lowest cell. Upon this she lays another egg, piles up another heap of provisions, makes a second floor, and repeats these operations until there are about a dozen separate cells one above another from the base to the summit of her shaft, each with its egg and food-supply. If the thickness of the

Photo by [*E. Step, F.L.S.*

THE TEREDO CARPENTER BEE.

The photo is that of a West Indian species, which is shown of the natural si
The [illegible] is much bl[illegible] big humble bee, but [illegible] black and blue.

post is sufficient, several parallel shafts are constructed. Fabre has shown that if she can obtain a hollow reed of the necessary diameter, she has sufficient of the labour-avoiding spirit to be content with utilizing it. She will also repair nests of previous years to make them serve for her brood.

It will be evident that the elaboration of these floors from sawdust, and the gathering of food for each cell must consume some time, so that the larva in the lowest cell must finish its development before the one next above it in this tenement house. If the first fledged bee had to emerge where the mother-bee began her labours, at the top of the shaft, it would have to pierce through all the floors—and incidentally, perhaps, through several of its brothers and sisters—before it could gain its liberty. This is the reason why the carpenter made that lower exit. Each bee-grub at the time it is about to change into a chrysalis fixes itself with its head downwards against the floor of its cell; and so, naturally, each new-born bee cuts through the floor and makes its way through the already vacated cells below.

Photo by] [*E. Step, F.L.S.*

SPOTTED HORIA.

A beetle which in the grub-stage is a parasite in the nest of the carpenter bee, and destroys the grubs of that Insect. It is a native of the West Indies; here shown one and a half times life size.

But all the grubs of the carpenter bee do not arrive at full development. Some of them fall in the way of parasites, who subsist upon and kill them. In the West Indies one species[1] is victimized by the grub of a rather large beetle, the spotted horia,[2] which enters the cells and destroys the inmates.

One regrets that the big carpenter bee has not crossed the English Channel and added its name to the list of British bees. But if we cannot boast of having one of the largest of bees among our fauna, we have one of the smallest,[3] that is also a clever worker in wood, whose metallic blue body only measures a quarter of an inch. It is related, moreover, to the burly continental, and shares its habits, though it works in softer materials as seems fitting to its diminutive size. Ceratina needs no bulky post to accommodate its series of cells. Everybody knows that the long shoots of the bramble that have borne this autumn's crop of blackberries will die off in the winter and become brown and brittle. Next spring ceratina will be taking stock of these, and looking for one that has a broken end. Into this she will tunnel, clearing out the pith to the length of about a foot, dividing the cleared space into tiny cells, laying an egg in each, and leaving a mass of suitable food. The partitions between the cells are made of the fragments of pith cemented together by means of her saliva. The little white and black osmia[4] is another native carpenter bee, which drills out the dead bramble-stems, like ceratina, and constructs its cells of the pith, placing them end to end. In this respect it differs from some of its immediate relations, which are masons and construct cells of sand and clay.

[1] Xylocopa teredo. [2] Horia maculata. [3] Ceratina cyanea. [4] Osmia leucomelana.

Photo by H. W. [illegible]

THE BRONZE-FISH.

This Insect is in general form similar to the silver-fish, but its silver is mottled with brown. The scales producing this mottled pattern are detached by the softest touch. The Insects disdain the sheltered indoor life preferred by the silver-fish and the fire-brat, and are found on rocks on the mountain and sea-shore, and among fallen leaves in woods.

Silver-Fish Insects.

The silver-fish Insect is a familiar representative of the bristle-tail order,[1] the members of which, though exceedingly abundant, are among the least known of Insects. This ignorance is largely due to their minute size, their natural desire for living under cover in damp situations, and the softness of their bodies, which makes them unsuitable as specimens to adorn the cabinets of the collectors. But the silver-fish[2] is known, because it is a household Insect with a weakness for starch and sugar in various forms. It is an Insect of very simple structure, closely allied to the springtails. It is less than half an inch in length, and covered with minute scales, to which the shining silvery appearance is due. There are no wings. The creature has long, many-jointed antennæ, and the hind-body is provided with three long tails, that bear a great number of hairs. It has cutting jaws, which are not hidden in the mouth, as they are in the springtails. The fore-body has its three segments distinct, and each one is of different size ; they are quite distinct from those of the hind-body. On the under side of the eight and ninth segments of the hind-body there are minute false legs, probably similar to those of caterpillars. In this and other respects the silver-fish and its immediate allies are much like caterpillars. They appear, indeed, to be Insects that have stopped short at the caterpillar stage in the process of evolution and never developed wings. They leave the egg in this stage and never get beyond it, as there is here no occasion for any metamorphosis, even of the modified type we find in earwigs, cockroaches, and grasshoppers. The silver-fish has only simple eyes.

The Silver-Fish Insect.

A beautiful little creature, covered with silvery scales, which is often abundant in cupboards where old papers and discarded garments are stored. It is of very simple structure, and never develops wings. The figure is six times the natural size.

In one respect the silver-fish and our only other *very* nearly related Insect differ in taste from the taste prevailing among the bristle-tails, which, as stated, is for a damp, cool retreat. The silver-fish is only found indoors, which implies that it prefers comparatively warm quarters ; and its relative, the fire-brat,[3] likes the additional warmth of a bakehouse. There is little doubt that this Insect was for long confused with the silver-fish, but about twenty years ago it was definitely diagnosed, and its scientific name duly enrolled in the lists of British Insects. In several parts of the country it was discovered to swarm under bakers' ovens, and to congregate around the mouth of the oven when bread was baking. It feeds chiefly upon flour, but also upon its own kith and kin ; and appears to revel in a degree of heat such as would be fatal to most Insects.

A smaller Insect of similar form we might call the bronze-fish Insect,[4] for it is mottled brown in colour with a metallic sheen. It is found only upon rocky coasts.

[1] Thysanura. [2] Lepisma saccharina. [3] Thermobia furnorum. [4] Machilis maritima.

One other member[1] of the genus, figured on page 43, makes its home among dead leaves in woods. The bronze-fish is an advance upon the silver-fish in the matter of eyes. Its two compound eyes are large, and meet in the centre of the head. In front of the head are three other eyes, two of them of a lengthened dumb-bell shape, and these are intermediate in character between simple and compound eyes. There is here a certain amount of development, for Bolivar states that when it leaves the egg the bronze-fish has only simple eyes, which change to compound eyes as it gets older. Dr. Sharp, however, has observed that very young individuals of the woodland species have compound eyes. There may, of course, be a difference between the two species in this respect. The scales with which these Insects are clothed easily separate from the body, and so the appearance of the Insect is quite altered, for when intact these make a mosaic pattern.

Photo by [*H. Main, F.E.S.*

THE FIRE-BRAT.

[illegible] this Insect by bakers to indicate its [illegible] for places of high temperature. It appears to prefer the bake-house to all other retreats, and from this circumstance it is possible that it [illegible] a place on the list of Insects [illegible] (inadvertently) by man.

Not so closely related is campodea,[2] a minute white creature that may be found by turning over clods of damp earth in field or garden, in the plain or on the mountain top above the snow-line, on the open sea-shore or in the darkness of deep caverns. Its total length, including its long antennæ and its longer tails, is about a quarter of an inch, but the body without these appendages is only half that length. These appendages are very hairy, and the tails are so much finer looking, that if the Insect were to tuck its legs under its body the hinder portion might easily be mistaken for the front; and if its size allowed it to be publicly known, it would probably be described as double-headed. It has no eyes, and it is covered with delicate hairs instead of scales. The jaws are not evident, as in the silver-fish, owing to the mouth being sunk into the head, as in the springtails. The legs are comparatively long, and the integuments are very soft and delicate. It is almost impossible to capture them without injury, and they die and shrink almost immediately. This has made it very difficult to get information as to development and life-history, or to compare specimens from other parts of the world. At present, therefore, it stands in the books as a species by itself; but it is probable that with its wide distribution, which includes the whole of Europe, India, and North America, several species are included under the one name.

[illegible] *H. Main, F.E.S.*

THE FIRE-BRAT.

[illegible] processes instead of [illegible] graphs are twice the actual [illegible] Insect.

[1] Machilis polypoda.

[2] Campodea staphylinus

Campodea has false legs on the hind-body like the silver-fish, but here they are more numerous, there being five pairs, situated on the second to the seventh rings of the hind-body. The breathing system is very elementary. There are only six air-openings, or spiracles, three on each side of the fore-body, and each of these, instead of opening into one general system of air-tubes, has a separate unconnected system of its own. Not many years ago this Insect was invested with a great amount of interest for naturalists, because it was contended that it represented the primitive type from which in all probability the entire race of Insects have descended. That view is not held at the present day.

Butterfly Swarms.

Almost from our infancy we have all been made familiar with the fact that devastating swarms of locusts periodically fly from land to land, especially in the East, not only destroying as they go, but leaving behind them the seeds of famine in the shape of countless eggs that produce the far more destructive nymphs. But locusts are not the only Insects that migrate from place to place in millions. Many birds, we all know, perform these associated movements twice a year over enormous distances; but it is not so well known that certain species of butterflies with their fragile wings frequently undertake similar flights, during which they cross seas and battle with adverse winds. From the smallness and fragility of a butterfly's body as compared with the enormous expanse of wings, it appears to be quite unsuited to such an enterprise; and yet the fact remains that it is a successful migrant. Our home-grown stock of the large garden white is frequently reinforced by great immigration from the Continent. A large percentage of the yellow and black caterpillars that have skeletonized our cabbages never produce butterflies because they are killed off by internal parasites; and it is not improbable that the large white[1] might cease to be a British species were these migrations to cease. Clouds of these butterflies have been observed passing across Europe from north-east to south-west, and have been met with half-way across the English Channel. Darwin mentions a flight of another species observed by himself and Captain Fitzroy from

Photo by] [*H. Bastin.*

A Group of Fire-brats.

A small company of these remarkable little Insects is here shown on a larger scale, exhibiting the under as well as the upper side.

[1] Pieris brassicæ.

By Theo. Carreras.

A Cloud of Butterflies

The home of the painted lady butterfly is in Africa, but it appears to thrive so exceedingly well that there is too little room, or insufficient food, for its vast progeny. So enormous swarms leave home and visit various countries, where they lay their eggs. But for these visitors from abroad, the painted lady would be very rare as a British butterfly.

Photo by] [*A. E. Tonge, F.E.S.*

BLACK-VEINED WHITE BUTTERFLY.

One of our rarest butterflies as a British-born Insect; but our resident race is sometimes supplemented by visitors from abroad. The photograph shows an individual that has just emerged from the chrysalis condition, and is one third larger than life size.

the deck of the *Beagle* when she was ten miles out from the coast of South America. Darwin says: "Vast numbers of butterflies, in bands or flocks of countless myriads, extended as far as the eye could range. Even by the aid of a telescope it was not possible to see a space free from butterflies. The seamen cried out 'it was snowing butterflies,' and such in fact was the appearance. More species than one were there, but the main part belonged to a kind very similar to, but not identical with, the common English clouded yellow.[1] Some moths and hymenoptera accompanied the butterflies; and a fine beetle flew on board. . . . The day had been fine and calm, and the one previous to it equally so, with light and variable airs. Hence we cannot suppose the Insects were blown off the land, but we must conclude that they voluntarily took flight. . . . Before sunset a strong breeze sprang up from the north, and this must have caused tens of thousands of the butterflies and other Insects to have perished." Captain Fitzroy estimated that this assemblage occupied a space not less than a mile in width, several miles in length, and two hundred yards in height.

The painted lady[2] is a species one of whose homes is in North Africa, but it appears to thrive so exceedingly that there is too little room or insufficient food for its progeny; so vast swarms of the butterflies leave home and visit various countries, where they lay their eggs. In some years the butterfly is exceedingly common here in August and September, but these are not visitors. They are the British-born progeny of the immigrants who arrived here in May or June, and left their eggs upon our thistles. These in turn lay eggs, which hatch soon after, but few of these autumnal caterpillars are able to complete their development; so that, but for the visitors from abroad, the painted lady would be very rare as a British butterfly, and might altogether disappear from our list.

Mr. J. Platt Barrett has recorded the regular annual passing of what he describes as "clouds" of black-veined whites[3] and large garden whites over Sicily, always flying westward.

Other species of butterflies, no doubt, get accessions from time to time in the same way; just as certain rare hawk-moths are occasionally in comparative abundance here. In the latter cases there is not the same room for surprise, because their wings and stout bodies appear to be much better fitted for flights of endurance. Beetles, bugs, dragon-flies, and other Insects also perform these long migrations. Mr. W. H. Hudson has described the periodical swarms of the larger dragon-flies that pass over Patagonia and the pampas, flying in advance of (not

[1] Colias edusa. [2] Pyrameis cardui. [3] Aporia cratægi.

blown by) the *pampero*, the south-west wind that blows from the interior of the pampas.

Basket-Worms and House-Builders.

Among the smaller species of moths there are some that in the caterpillar stage hide themselves from public observation by constructing a moveable tent, somewhat after the fashion of a caddis-worm. A well-known example of this kind of retreat is furnished by the caterpillar of the clothes-moth, which snips out portions of woollen or silken garments in our wardrobes and constructs a portable garment for itself which harmonizes with its surroundings and helps to shield it from the vengeance of the mistress of the robes. But the subjects of the present article are a quite separate group of outdoor moths, whose caterpillars live in the ordinary fashion upon fresh vegetable matter. In some respects their story is much more remarkable than that of the clothes-moth, and it requires separate statement.

Unfortunately the moths [1] have no popular name, but the caterpillars are known in some places as basket-worms in reference to the cases in which they conceal themselves. Our native species are all very small, but there is a Continental species that is larger, and its history has been more fully worked out. We will call it the

Photo by

THE CLOUDED YELLOW BUTTERFLY.

Although specimens of this beautiful butterfly may be taken in Britain in most years, it is only at intervals that we get a season when it is plentiful. This abundance is due to the fact that migrating swarms have reached us in spring from South Europe or North Africa, and have laid their eggs in our fields of clover or lucerne. The photographs are one-fourth larger than life.

[1] Psychidæ.

SNAIL-LIKE CASE OF COCHLOPHORA.

The "basket-worm" that constructs this portable house uses silk only, but finishes it so that it resembles the texture of a snail shell. There are specimens in the British Museum that were received from a collector as the shells of actual snails.

grass psyche.[1] The male moth is a delicate little Insect with slender body, and the wings almost transparent, for they have only a few brown and grey scales and hairs upon them; but it has rather large, feathery antennæ. The female, however, is such an odd little creature that anyone unacquainted with the facts would be indisposed to accept her for a moth: she is much more like a chrysalis with the head and legs free. She has the merest little stumps for antennæ, but no wings and no mouth. In the spring and early summer the caterpillars may be seen dragging their portable houses over the herbage. These dwellings are in this species nearly an inch long, and composed of a silken tube to which are attached pieces of grass, etc., overlapping after the manner of thatch on a roof. The caterpillar clings to the lining by its hinder parts, and only puts out its head and legs for the purpose of moving to fresh food and consuming it. When it desires to be quiet, it spins a few threads, which moor the front of the house to whatever it is on. The one case—enlarged from time to time—serves for their full life as caterpillar and chrysalis, and for the female to the end of life. She is an example of reversion to a simpler condition after she has attained to her final stage of development, for, as already stated, she has neither wings nor mouth. In some species the females have no legs; in others the head is so reduced that the creature looks more like the grub of one of the two-winged flies. It is true that she has attained to sexual ripeness, and mating is effected without her leaving her house. There she lays her eggs in a mass, often in the empty chrysalis skin. It has been said that the newly-hatched caterpillars make their first meal off their mother's body—such as there is of it—but this requires verification. If they are deprived of their cases, they will construct another in the course of a few days.

PSYCHE-MOTH.

The caterpillar constructs a tube of silk, to which are attached bits of grass and leaves, the whole resembling some of the caddis-cases. In these the caterpillar lives protected, for it only protrudes the front end of its body in order to drag the case to a new feeding ground, where it is temporarily moored by a few silk threads. The moth shown is the male; the female is wingless, and does not leave the case.

[1] Pachytelia unicolor.

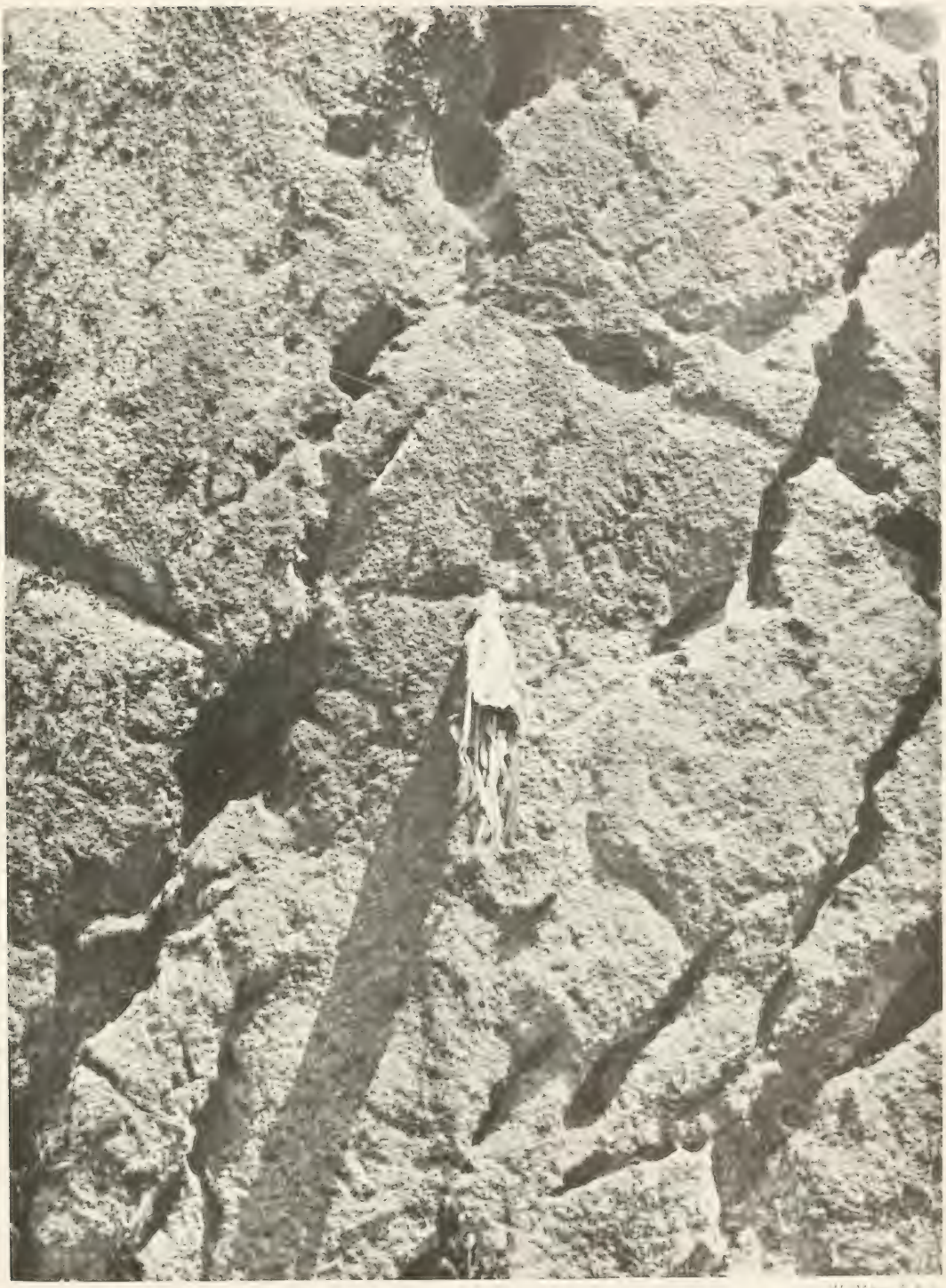


Photo by]

A Basket-Worm.

One of the larger species is shown as photographed on rocks in the Swiss Alps. The caterpillar [illegible] face is covered. The case, added to as the growth of the caterpillar requires [illegible] but for the chrysalis and the female moth. One-fourth larger than life size.

Some of the species live on trees, others on old walls and palings, where they feed upon lichens and construct their cases of the same material. The cases of different species exhibit considerable variety of form, and no doubt some of these are protective, as, for example, when they resemble fallen catkins and the scales of leaf-buds. Some take the form of a snail-shell: such are those of the genus Cochlophora, of which the Natural History Museum possesses examples which were sent to them as actual snail-shells. These snail-like cases are not covered with extraneous matter, but consist wholly of a silky material, which is made to appear of similar texture to the real snail-shell.

Photo by] [*H. Bastin.*

PSYCHE CASES.

Two cases of a British species photographed on a pine-trunk in the New Forest. The [illegible]s are covered with short pieces of heather-shoots.

One of the most remarkable of these Insects, on account of its large size—though it measures less than two inches across the outspread wings—is a native of Central America and the West Indies. It is known as the house-builder,[1] and constructs a case similar to that of the European species described above. It was discovered by Guilding in the West Indies about eighty years ago. Guilding reared the caterpillars for several years, and was puzzled at getting only male moths as the result, never imagining that he had to look in the cases for the wingless female. At length a lucky accident showed him a female opening her case by movements of her head in order to admit the male; and so he was put on the track of the mystery. After mating, the female fills the lower part of the pupa-skin with her very numerous small yellow eggs, and strips the down from her body in order to cover them. He found that as soon as the eggs were hatched the young caterpillars distributed themselves and began to make cases of fragments of leaf and bark. These were cylindrical and open at each end. Whilst very small the cases are carried erectly, but they soon get too heavy, and take a horizontal position. The mouth is furnished

[1] Œceticus kirbii.

with a moveable flap, which the caterpillar can close with its mandibles and fore-legs when danger threatens, and thus closed it hangs suspended by a few threads. When the caterpillar is about to become a chrysalis the case is attached to the tree by a number of strong threads from the front end. The brown chrysalis is furnished with a ring of spines on each segment, which enable it to move about its case. The male moth has black wings with a purplish sheen ; but the wingless female remains much like a chrysalis in appearance : mouth-parts and antennæ are absent, and the short rudimentary legs have no claws. The body is pale brown with a fringe of woolly hairs at each extremity.

THE HOUSE-BUILDER.

A large example of this group of small moths. It is a native of Central America and the West Indies, and is shown here of the natural size. The mass of web at the lower end shows how the case was suspended before the caterpillar changed to a chrysalis. The female is wingless and quite unlike a moth ; she never leaves the case. The moth above is the male.

Nightmare Insects.

There are no Insects that bear this name ; but there is a family,[1] which at present bears no English name, to which the term might be applied with some degree of fitness. Geoffroy gave them the name of little devils in French, but that name has not been adopted by others. They belong to the great order of bugs ; and the latter word originally indicated a spectre or some monstrous and terrifying object. The nightmare Insects, as we have chosen to call them, are certainly among the most eccentric forms of Insect life. Their grotesqueness is due to an astounding and varying development of the front part of the fore-body. They are all small Insects—some of them very minute—and only one species[2] occurs in Britain, whilst the continent of Europe can boast only a few species. The headquarters of the family is in North and South America. Their nearest allies among Insects that are known generally are the frog-hoppers[3] and green-fly.[4] If we were to strip off the remarkable addenda to the fore-body, we should have left a form not differing very widely from that of the green-fly, though with a broader head, set under the projecting fore-body, and with two simple eyes on the face.

As Uhler has remarked of them, " They are of every conceivable form, arched, compressed, depressed, hump-backed, spindle-shaped, pointed at both ends, inflated, hemispherical, conical, and so forth, and are furnished with an equal variety of superficial attachments. The antennæ are short, bristle-shaped, thick at the base, and situated either below or a little in advance of the

[1] Membracidæ. [2] Centrotus cornutus. [3] Aphrophora. [4] Aphis.

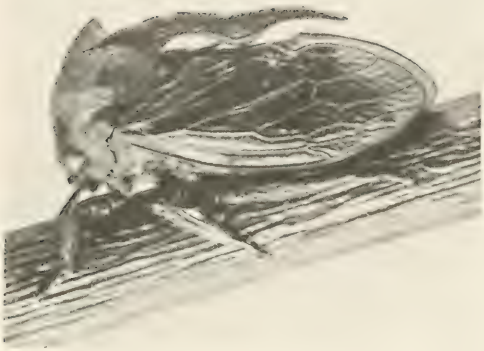


Photo by] [*H. Bastin.*

HORNED MEMBRACID.

A British representative of this remarkable family—here shown six times larger than life. In general build much like a frog-hopper, it has the addition of a pair of horns above the head, and from between these a long,horny process extends over the back and the closed wings almost to the extremity of the body.

eyes. The species are all good leapers, with short, stout legs, armed with a circle of short spines on the tips of the hind-feet." They subsist, like frog-hoppers, by sucking the juices of plants through a delicate beak.

Unfortunately, the forms of most of these curious Insects are better known than their life-histories and habits, but, judging from what is known of a few of them, there can be little doubt that their forms are mimetic and protective. The largest known species,[1] a native of South America, has its supplementary portion developed into a curved, leaf-like expansion standing on edge over the back, and coloured smoky-brown with yellow spots. This species is a giant, as it measures more than half an inch in length. A near relation has this expansion coloured green, and looks exactly like one of the coushie, or leaf-cutting ants, walking off with its piece of leaf carried over the back. The brown colour of the head and legs helps to carry out the deception, for this is the colour of the ant. Mr. Sclater, who shook this Insect from the leaves of a tree in British Guiana, at first thought that it was one of these ants, which were abundant all around him ; but a closer inspection—such as an ant could not make—satisfied him that it was something different. It is probable that this resemblance to the coushie ant protects it from enemies that have considerable respect for that Insect.

Owing to the absence of what the reader would consider reasonable names, we cannot refer to the species individually, but we give a selection of portraits of remarkable forms that their variety may be appreciated. "Many of these Insects affect the axils of twigs and stems of various bushes or small trees, especially near watercourses, and protect themselves by selecting places which well agree with their pattern of marking." In one genus[2] the species are all dark brown in colour, and imitate bits of dried leaves, having a ragged appearance and a wavy outline, as though a piece had been cut out of the back. In some the addition to the fore-body is continued backwards as a pitch-fork or trident. Others have a distinct resemblance to some of the four-winged stinging Insects, and some Brazilian species closely mimic the spinous ants of that region. Many species are cherished by ants,

Photo by] [*H. Bastin.*

GROTESQUE ADORNMENT.

In this species of Cyphonia, one of the Central American membracids, the expansion of the fore-body after developing a couple of pairs of horns, is prolonged backwards and above into three knobs, each ending in a long spine.

[1] Membracis foliacea.

[2] Stegaspis.

By T. Carreras.

NIGHTMARE INSECTS

The grotesque forms shown above suggest that they are creatures of an unhealthy imagination rather than living facts; and as they have no popular name we have designated them nightmare Insects. They are all considerably enlarged. In the bottom right-hand corner are the eggs of one species on a piece of wood, and above them in the upper corner are three stages in the history of another species, the perfect condition being represented by the parti-coloured membracid half-way up, whose true colours are yellow and chocolate. All considerably enlarged.

Photo by] [*E. Step, F.L.S.*

HORNED MEMBRACID.

This photo gives a view from above of the Insect that is shown in profile on page 54. The stout horns are more evident in this aspect, though the long central spine is less so. Eight times the natural size.

Photo by] [*E. Step, F.L.S*

EUROPEAN MUD-DAUBER.

This species—whose cells are shown in the lower part of page 59—in the South of France exhibits a weakness for constructing its cells in the broad open fireplace, in spite of smoke and heat. Twice the natural size.

who protect them and feed upon their excretions.

More than eight hundred species of these remarkable Insects have been described from temperate and tropical America, the West Indies, Africa, and the East Indies. Of these, more than half belong to tropical America. Very few occur in Europe, and these appear to have been derived from the nearer parts of Africa.

The Mud-Daubers.

The term mud-dauber is scarcely a nice descriptive word to apply to the work of an accomplished mason, but it must be taken as marking the resentment shown by people in various parts of the world whose house-property, including ceilings, cornices, door-jambs, and even the furniture, is disfigured by having lumps of clay as big as one's fist strongly attached. The wasps who engage in this kind of misplaced decoration do not do so, as many people imagine, "out of pure cussedness," but as a provision for the comfort of their offspring. The so-called daub of mud is really a cluster of earthen cells, upon which, to disguise its true character, the industrious mother wasp plasters mud and more mud, until she has filled up all the interstices between the cells, and the cluster becomes one mass which looks quite solid. There are many different species of the solitary wasps that construct their cells in this way, and it is remarkable that so many of them should manifest a preference for human habitations as their building sites.

Fabre mentions one[1] that, of all places for its nesting-site, selects a nook in the broad open fireplaces of the peasants of Southern Europe, where, although safe from the flames, it is not free from smoke. In spite of cooking

[1] Sceliphron spirifex.

operations that may be in progress, the wasp flies in and out between its nest and the outdoor source of the clay or mud it needs for its building. In most species of this genus the large cells are formed one against another, in number varying from ten to fifty, and the whole are consolidated into one mass by plastering further mud or clay into the intervening spaces and rounding the composite structure off. The wasp stores the cells with small spiders, and appears to kill these outright by its sting. When the first of the series is dropped into the cell, an egg is laid on it, so that the wasp-grub begins to feed on the least fresh of its food, and has to consume the whole

Photo by] [*E. Step, F.L.S.*

YELLOW-FOOTED MUD-DAUBER.

A life-size representation of the wasp and its mass of cells, which looks as though a liberal handful of mud had been thrown against a wall. As a matter of fact the whole daub was carried in minute portions in the jaws of the industrious wasp.

series of spiders before decomposition begins, though one would suppose this would not take long in a fireplace. On an average this species allows eight spiders to each grub, and these are consumed in about ten days.

Some of these mud-daubers have learned to disguise their carefully-constructed nests. Thus an Indian species[1] that comes into houses and decorates walls and furniture with its nests, appears to be desirous of meriting the name of mud-dauber, for after the nest is completed as a comfortable habitation for the grubs, she sometimes gives a few artistic touches in the shape of radiating streaks of mud, which make it look as though a handful had been thrown against the wall and had splashed. There are only from four to six cells in this nest, and each cell as a rule contains a score of spiders. In a similar fashion, an Australian species[2] adds to the finished nest a few diagonal streaks of mud, which makes the whole affair look like a piece of acacia-bark. Although a piece of bark looks out of place in a house, it may be

[1] S. madraspatanus. [2] S. laetus.

presumed that before the wasp developed a liking for human society it was in the habit of placing its nest on tree-trunks. In parts of the United States the people suffer annoyance from the similar habits of another species.

Mr. W. H. Hudson, when in La Plata, suffered from the pertinacity with which these mud-daubers would enter his dwelling; and his admiration for the beautiful mason and her industry was swallowed up in his disgust with her method of filling her cells. He says: "These Insects, with a refinement of cruelty, prefer not to kill their victims outright, but merely to maim them, then house them in cells where the grubs can vivisect them at leisure. This is one of those revolting facts the fastidious soul cannot escape from in warm climates; for in and out of open windows and doors, all day long, all the summer through, comes the busy, beautiful mason-wasp. A long body, wonderfully slim at the waist, bright yellow legs and thorax, and a dark crimson abdomen—what object can be prettier to look at? But in her life this wasp is not beautiful."

Photo by] [*E. Step, F.L.S.*

MUD-DAUBER'S FINISHED WORK.

This example of the mud-dauber's art was taken from a shed on the Sweet-water Canal at Suez. The shed, both inside and out, was almost entirely covered with similar patches. The portion shown is about seven inches long. The holes show where the newly-matured wasps have emerged from the cells.

In some cases a flesh-fly[1] has noted the stores of spiders and Insects being taken in, and has concluded that they offer a good opportunity for the disposal of a few of her own eggs. The result is that the mud-dauber grub perishes for want of food, and a like fate awaits the flesh-flies owing to their inability to break through the thick walls of their prison.

Beetles: their Structure and Habits.

From the popular point of view beetles have been thought to make a near approach to crabs and lobsters, for their entire outer integument is strengthened by the deposit of much chitin, which renders it hard and horny, just as the similar deposit of chitin mixed with carbonate of lime makes the so-called "shell" of the crab stony. This, of course, is merely an external resemblance: the internal structure and organization of a crab are altogether different from those of a beetle.

[1] Sarcophaga.

By T. Carreras.

MUD-DAUBERS AT WORK.

Several species of these artificers in clay show a special preference for human dwellings, which they decorate with their nests inside as well as out. In the upper right-hand corner of the picture a wasp is seen at work on the unfinished cluster of cells. In the opposite corner a newly-developed wasp is escaping from an older "daub," through which it has had to cut its way to freedom. The upper figures are of a familiar Indian species; the nests in the lower corner are those of the South European species.

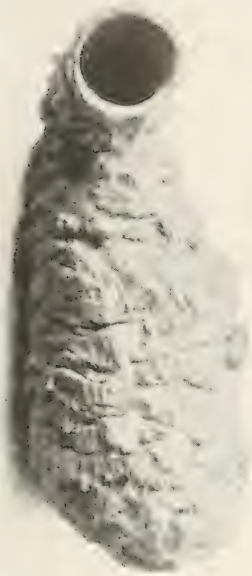


Photo by] [*H. Bastin.*

A Mud-Dauber's Cell.

A first cell of the cluster usually made by the mud daubers. At this stage the lines in the clay show how the structure has been built up piecemeal, and the smooth, regular mouth shows how carefully the interior is finished off.

At all points the beetle is protected by this armour, the limbs and external organs being attached by hinge-like joints that allow great freedom of movement without providing weak places for the attacks of enemies.

Taking a large species, such as the stag-beetle, for the better elucidation of its external form, we find the trunk exhibiting three clear divisions such as we know to be characteristic of Insect structure; but in this case we have to be careful or we may be deceived by what we see. As a matter of fact, the rearmost of the three divisions of the upper side of a beetle does not coincide with the hind-body, but includes also a large part of the fore-body. The latter, as in all Insects, has to support the legs and wings, and as the wings lie over the back they necessarily hide a portion of the fore-body.

Taking the *apparent* divisions from the upper aspect, we see the broad head forms a complete casque, the eyes, antennæ, and mouth-parts effectually closing their respective apertures. What appears in this view to be the fore-body is only the first of the three recognised divisions of that area; the two other portions are to be seen only when the four wings are extended for flight. This first division of the fore-body[1] bears the first pair of legs; the second division[2] supports the second pair of legs and the first pair of wings; and the third division[3] carries the third pair of legs and the second pair of wings. The segments of the hind-body form broad overlapping plates covered above by the wings. These plates of the hind-body are on the upper side soft, being protected by the wings covering them. It is along the margins of the upper side under cover of the first pair of wings that the spiracles, or breathing holes, are situate.

The two pairs of wings differ in character, for whilst the second pair are of thin, semitransparent material, strengthened by longitudinal ribs, or "nervures," and adapted for flying, the first pair are thick and horny, and from their shape unsuited for flight. They have been adapted for use as covers to the second pair, and in flight are merely lifted up to give freedom of movement to the effective pair. When the beetle is not engaged in flight, the

Photo by] [*E. Step, F.L.S.*

Beard-Nose Beetle.

In the large family of weevils most of the species have the head elongated, with the mouth-parts at the extremity. In this example from South Africa the rostrum is decorated with a beautiful curled beard.

[1] Prothorax. [2] Mesothorax. [3] Metathorax.

horny pair,[1] or wing-covers, are closed down tightly over the folded flight-wings, their edges meet with marvellous accuracy along the middle line of the body, and their outer edges as accurately fit the marginal border of the body. The majority of beetles live in the earth, in the water, in decayed wood, and so forth, where, but for this arrangement of the parts, the lower wings would be liable to considerable damage. As it is, neither soil nor moisture can find entrance.

There are numerous departures from this typical perfection of fitting of the wing-covers. In the oil-beetles the shape of these is such that it is impossible for their edges ever to meet, and they are too short to cover the body. In the great family of long-bodied rove-beetles,[2] though their edges meet, they are so exceedingly short that the wings have to be folded up under them something after the manner of the same organs in earwigs. In the case of the ground-beetles[3] the flight-wings are undeveloped, and the wing-covers have their edges united so that they cannot be separated. This is an instance of atrophy due to their life being spent almost entirely underground.

Photo by] [*E. Step, F.L.S.*

CALLIPER BEETLE.

The fore-parts of this beetle are shown twice the actual size. It will be seen that the head, supporting the front horn, is comparatively small. The second and taller horn is an outgrowth from the fore-body. In spite of the bearded inner edge of the horn and [illegible] except that of [illegible].

Beetles exhibit true metamorphosis, with an entire change of appearance and structure between the larval and the perfect stages. The larvæ of beetles are, as a rule, soft, fleshy grubs, but there is a great amount of difference in the character of their external coverings according to the life they lead. Some are legless and inactive, like maggots; others have six well-developed legs, and are very active; some of the grubs of water-beetles have in addition external gills. Of the vast majority of beetles, however, it may be said that at present we know nothing

[1] Elytra. [2] Staphylinidæ. [3] Carabus

Photo by] [*H. Bastin.*

"FIDDLER BEETLE."

So called on account of its fiddle shape. Its form among beetles is unique, and regarded as most remarkable. Found on the under side of fallen trees in Java.

Photo by] [*H. Stafe, F. L. S.*

A TIMBER BEETLE.

The wood-boring beetles have usually a slender, straight-sided body, and long, many-jointed antennæ. This example is a native of Britain, and affects willow and ash trees. Enlarged four times.

certain of their early stages, and this is mainly due to their concealed modes of life making it difficult—in some cases impossible—to study these stages. The chrysalis, as a rule, is soft, the limbs being free from the body. This stage usually lasts but a few weeks, but the perfect Insect after emergence from it mostly remains secluded for a time until its outer integuments have hardened and developed their proper coloration.

Beetles are to be found everywhere, and their adaptation to every kind of environment has produced an enormous number of forms, something like 150,000 species being already known, named, and classified. So little, however, do their habits bring them into prominence that it is usually with surprise that the average person learns that the beetles of the British Islands number more than three thousand distinct species; and it would perhaps be a greater surprise if they could learn how many of these are inhabitants of their own garden—and house! Yet a little observation will reveal them swarming about flowers, running on and in the earth, resting under loose bark, under dead leaves and fallen branches, in decayed stumps, in fungi, in ponds and streams, even under submerged stones on the seashore.

Whilst a few beetles—such as the potato-beetle, the asparagus-beetle, the pea-weevil, the turnip-flea, and the cockchafer—are noxious Insects from the human view-point, the great majority are harmless or positively beneficent, either as scavengers, reducers of effete matter, tillers of the soil, or as direct opponents of Insects that are harmful to cultivation. Most of the ground-beetles, for example, are carnivorous both as grubs and beetles, and are for ever hunting below ground for the

Photo. *Lenscraft*

A Group of Scarabs

A Group of Scarabs. [illegible] beetles. The female [illegible] and the male [illegible] left and [illegible] right. [illegible] of varying degrees of frequency and intensity, and the frontal [illegible] shaped like a shovel and used as such.

Insects that feed upon roots and others that only hide therein by day, ascending at night to feed upon green crops. The brilliant little ladybirds are more obviously useful, as they pursue their destruction of the green-fly on the leaves and stems of our roses and other plants. Beetles of all kinds constitute the order of Insects known to science as the Coleoptera, or sheath-winged Insects.

Photo by] [*E. Step, F.L.S.*

A Three-horned Beetle.

This horned beetle is shown four times the natural dimensions to show the structure of the fore-parts, including the powerful fore-feet, the shovel-shaped head, and the massive horns. Many beetles, especially the males, are so adorned, but their use (apart from ornament) is seldom evident.

The Hump-backed Spider-Fly.

It is quite in accord with what has been named "poetical justice" that, as vast numbers of spiders get their living entirely by sucking the life-juices of flies, there should be at least some flies that exist at the expense of spiders. The small and peculiar flies of the genus Ogcodes come under this designation; indeed, a larger group, the family[1] containing this genus and other genera, appears to have similar habits. The fly[2] whose portrait we present may be taken as a representative of the family. It occurs in this country, but is little known, and its principal locality is the New Forest. It is about the size of the smaller house-fly, but the head is remarkably small and consists almost entirely of the two compound eyes. The great disproportion between the tiny head and the high, rounded body gives one the impression that the latter would be normally much smaller, but that it

[1] Acroceridæ. [2] Ogcodes gibbosus.

has been inflated by some diseased condition. This effect is intensified by the fact that the fore-body is covered by a rather matted coating of whitish-grey hairs, which gives it the appearance of the house-fly that has been killed on our windows in autumn by the activity of the fly-fungus. It is just possible that it may not be so rare as supposed, but that specimens may be passed by with a cursory glance, in the belief that they are merely diseased house-flies.

Photo by] [*E. Step, F.L.S.*

THE HUMP-BACKED SPIDER-FLY.

This fly lays its eggs on the egg-cocoons of spiders, and the grubs feed upon the spider's eggs and the young spiders. It is thought that it may complete its larval life in the body of a spider of large growth. The photograph is six times the actual size.

The grub of this fly lives either in the interior of various spiders as a parasite, or in their egg-cocoons, where it feeds upon the eggs. Now, with such an easy-going mode of life under cover, and with a world full of spiders to feed upon, one might expect these flies to be quite common things; but the fly in turn has an enemy, who takes steps to keep down its numbers. This is one of the little wood-wasps,[1] Insects that make tunnels in decaying wood, bramble-stems, and the like, dividing the tunnels off into cells, in each of which an egg is placed with a number of stung two-winged flies. Each species of wood-wasp appears to have its own special taste in flies, and will provision its cells only with one species of fly. Whether this hump-backed spider-fly is regularly exploited for the purpose is not established, but that it is so used at times is made clear by the Rev. H. S. Gorham, who came upon a hoard of flies in a nest of the wasp. The wasp, with that regard for economy of labour that is shown by many species, instead of making a tunnel for itself, had found one that had been excavated by the caterpillar of the frosted orange-moth[2] in the stem of the marsh-thistle. This she had divided into cells, and packed them all with the hump-backed spider-fly. There were twenty-five to thirty flies in each cell, and the row of cells measured eight inches. In some of the cells the wasp-egg had hatched, and the wasp-grub was already feeding upon the stored-up flies.

Photo by] [*E. Step, F.L.S.*

THE HUMP-BACKED SPIDER-FLY.

The Insect is here seen from the side, a view which shows its hump-backed appearance more clearly. The depressed position of the head is quite natural in this species.

A further peculiar circumstance of this discovery is that Mr. Gorham's attention was attracted to the thistle, not by the entry of the wasp with its prey, but by the fact that several spiders appeared to be watching the hole in the stem. The spider—whose name he did not know—so greatly resembled the fly that he considered it to be a case of mimicry. This would lead one to suppose that it was one of the crab-spiders,[3] which are in the habit of sitting still in or about flowers visited by flies. Mr. Gorham considered these spiders to be

[1] Crabro interruptus. [2] Gortyna ochracea. [3] Thomisus.

of the actual species parasitized by the fly, but we fail to see that he had any evidence to that effect. It might be so; and they may have been watching rejoicingly to see how many enemies of their race were being safely interred in the stem of the thistle!

The Dragon-Moth.

Similar in some respects to the lobster and the puss as a moth, this Insect in the caterpillar stage reminds one most of the lobster, but owing to its method of preparing for the moth's escape from the cocoon, the chrysalis is the most interesting stage. The dragon,[1] though fairly distributed over Europe, does not occur in Britain. It owes its name to the appearance presented by the caterpillar. In this stage it has a rough green skin mottled with yellow, and the head is red. But it is the form and not the colour that is singular: the six middle segments of its body end each above in a pointed red hump. The first of these humps is larger than the others and forked. A long, tapering blotch of flesh tint is conspicuous on each side of the middle segments. It has the lobster-caterpillar's trick of elevating its hinder parts, which here assume the form of a somewhat squarish plate whose centre is marked with a brownish blotch margined with yellow. What are in other caterpillars clasping organs at the extremity of the body here take the form of two downward-pointing spines. Viewed from the rear, this plate looks like the face of some creature whose head is raised in readiness for an attack, and the two downward-pointing spines look like distended jaws. This, no doubt, is an artifice for preventing an attack from the rear. In the juvenile condition this dragon has a pair of side horns in front, but these are discarded in the course of growth. Dr. T. A. Chapman, who is one of the most acute of modern observers, was puzzled to know why any caterpillar should have so remarkable a form and such singular humps and angularities. Pursuing his inquiries he found that, viewed from the side, it exactly resembled an oak-leaf that had been rolled by one of the abundant leaf-rolling tortrix-caterpillars.

Photo by] [*Harold Bastin.*

THE DRAGON-CATERPILLAR.

This caterpillar has a rough, green skin mottled with yellow, and a red head. The six middle rings end above in a pointed hump, of which the first of the series is larger and forked. It has a trick of elevating its hinder parts, which end in a squarish plate with two downward-pointing spines. Viewed from the rear, this looks like a head with distended jaws and raised for attack.

Like the caterpillar of the puss-moth, the dragon spins a close-fitting cocoon in the crevices of the bark, and works into the outer surface fragments of bark and

[1] Hoplitis milhauseri.

THE WOOD-WASP'S LARDER.

A wood-wasp, having found a thistle-stem that has been tunnelled by a caterpillar, has adopted it as a nursery for her grubs, and has packed it with hump-backed flies to serve for their provisions. The thistle-stem, of course, has been split to show the internal arrangements.

Photo by] [*H. Bastin.*

THE DRAGON-MOTH.

This moth, which is common in many parts of the Continent, is remarkable chiefly on account of the strange form of the caterpillar, and by reason of the means adopted by the chrysalis for cutting through the hard cocoon for the release of the moth. These points are made plain in other photographs.

lichen, so that it closely resembles its surroundings, and cannot be found easily until long after the moth has emerged. This cocoon is hard and thick, like that of the puss-moth, but in this case the chrysalis has a special method of preparing a way out before it becomes a moth. If the front part of the brown and black chrysalis be examined, it will be seen that on the centre line in front of the head there is a short but very acute point, and this properly directed becomes a very efficient instrument for the moth's release. Dr. Chapman speaks of this spine as a "sardine-opener," a term which aptly indicates its use. By rotating the fore-part of its body laterally (the hind-body being gripped by the closeness of the cocoon) the spine traverses an oval line in the top of the cocoon over and over again, until the material is so far cut through that it yields to a slight pressure from the head of the moth. It comes out as a clean-cut door, and falls back into its former position as soon as the moth has got free. This is due to the fact that a few wisps of silk are left at one part to act as a hinge; but why does not appear. The door closes so accurately that there is nothing to indicate that the cocoon is empty, and it is not until some time later that the doors

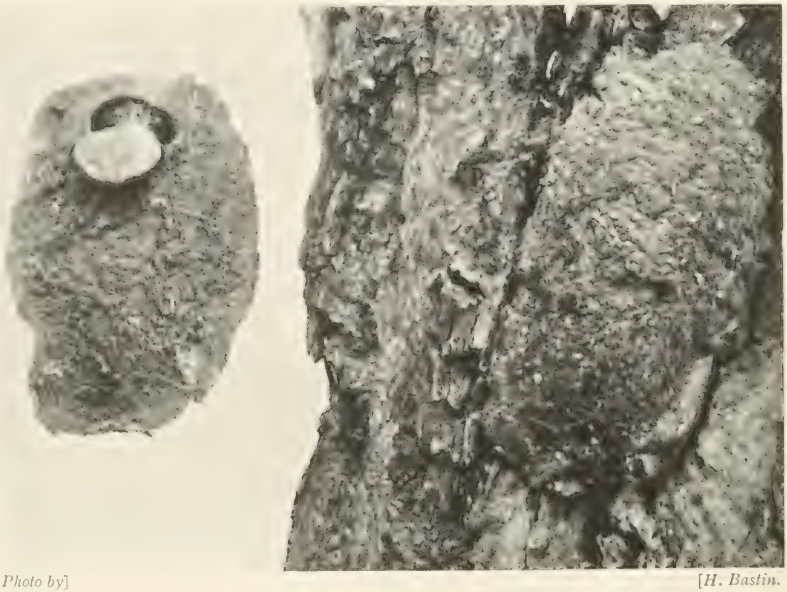


Photo by] [*H. Bastin.*

THE COCOON OF THE DRAGON-MOTH.

To the right is a cocoon still attached to the bark and intact. To the left is another that has been removed, and from which the moth has emerged. The portion cut out by the aid of the "tin-opener" is seen attached by its hinge.

drop from their hinges and reveal the empty cocoon. A portion of the chrysalis skin surrounding the "sardine-opener" remains attached to the head of the moth until it takes its first flight, as shown in one of our photographs, which was made from material kindly supplied by Dr. Chapman.

Frog-Hoppers and "Rain-Trees."

From time to time the sensational periodicals attempt to startle their readers by reprinting stories that have done service for more than a hundred years concerning the so-called rain-tree, which, growing in dry or desert places, waters the ground all around by a constant supply of refreshing showers from the tips of its leaves. It has been seriously suggested in past times to make the desert blossom by planting a sufficient number of these trees. Like many of such stories, this has grown out of the careless observation of a fact. This fact has been put under the journalistic microscope that magnifies a thousand times, and the result is a paragraph which is accepted by the public without question. How it would surprise them to learn that the story has grown out of the doings of certain relations of the insignificant little frog-hopper and its cuckoo-spit that they find in their own gardens. First let us glance at this Insect; we will refer again to the rain-tree later.

Photo by [*E. Step, F.L.S.*

THE DRAGON-MOTH WITH ITS "TIN-OPENER."
A dragon-moth that has just emerged from the cocoon with a portion of the chrysalis skin still attached to the head. This portion includes the hard spine whose repeated traversal of an oval course cuts through the hard cocoon and allows the moth to escape. The photograph is four times the actual size of the moth.

If we go into the garden and, finding one of these accumulations of froth, blow the so-called "spet" aside, we shall find in the middle of it a quaint-looking little yellow Insect, with broad head and big eyes. This is the immature condition of the lively Insect known as the frog-hopper.[1] As in the case of many Insects that annoy us in our gardens by weakening or killing our carefully-tended plants, we are so eager to get rid of the nuisance by destroying it that we seldom pause to consider its wonderful equipment for its work, or even to note what kind of an Insect it is. Owing to this fact, so common an Insect as this frog-hopper and its cuckoo-spit has been much misunderstood. It is true that it is a destructive Insect, chiefly obnoxious to the gardener on account of the harm it does to his carnations and pinks, and having no virtues that can be urged in mitigation of the extreme penalty of garden law.

The frog-hoppers—for the species are numerous—belong to the same tribe[2] of Insects as the cicada, the green-fly, and the plant-bugs, whose mouth-parts are fashioned into a long, sharp beak, which is thrust into tender shoots and employed in sucking up the sap of the plants. The general idea of the frog-hopper is that it

[1] Philænus spumarius.

[2] Rhynchota.

Photo by] [*W. West.*

COMMON FROG-HOPPER.

The frog-hopper is commonly seen at rest, with its wings neatly folded. Here it is shown as a flying Insect, with the wings fully extended. The photograph is nine times the natural size.

is a gourmand, sucking at this sap far beyond the requirements of its nutrition, until it is so full that the surplus oozes through the skin at all points and forms the froth in which it is buried. The possessor of the smallest garden has it in his power to determine in a few minutes that this is not an accurate description. The frog-hopper is one of those Insects that do not undergo any sudden, or apparently sudden, change of form. The only difference, apart from size, between its infant and adult condition is that in the latter it has acquired two pairs of wings, which are not greatly unlike. When it leaves the egg there is no sign of these wings, but after several changes of skin the beginnings of these, tightly packed up in little pads, may be seen upon what popularly may be termed the shoulders. At the final moult these expand to such an extent that they entirely cover the hind-body; the hinder pair folding under the more leathery fore-wings and their edges meeting accurately along the middle line of the back, they form a sort of span-roof to the body.

To return to the frog-hopper in the grub or nymph stage. If we clear off the mass of froth in which it is hidden, by gently prodding the creature from behind we shall get it to move pretty briskly to a clear part of the stem, where we can watch what happens. During its movement the Insect has kept the beak folded close against its breast, but it now unfolds it, and thrusts it into the tender shoot and begins to suck. In a short time we notice that it is discharging a clear fluid from the hinder end of the body, which flows over and under it, so that it appears to be in danger of drowning. There is no sign of froth or bubbles. It is simply retaining the small amount of nutritive matter dissolved in the sap, and passing off the clear liquid, which is slightly viscid, like soapy water. About half an hour after its disturbance it may be seen actively moving its "tail," or hinder segment, up and down and from side to side. With each

Photo by] [*E. Step, F.L.S.*

THE ALDER FROG-HOPPER.

This species is twice the size of the common frog-hopper, and of a greyish-brown colour. It is found chiefly on the alder. From this side view one is struck by the resemblance of the head [illegible] to a hood, and it suggests that the name of frog-hopper has reference not only to the leaping powers of these Insects, but also to the form of the fore-parts. Six times the natural size.

THE RAIN-TREE.

What appear like flowers on the branches of the tree are really Insects related to the frog-hopper, and their constant secretio
fluid sucked from the tree causes a continual stream to drip from the twigs. The drawing shows an East African species. A similar
was noted in Angola by Livingstone, who estimated that one cluster of them would produce three or four pints of fluid in a singl

downward stroke it carries into the fluid a minute portion of air, which becomes imprisoned by the viscosity of the fluid, and so forms a tiny bubble. The process constantly repeated converts the whole of the fluid into froth, and this by the same movements is distributed all over and around the Insect, so that it is again entirely hidden from enemies who would appreciate its tender and juicy body.

The mature frog-hopper is a rather inconspicuous Insect, being coloured grey with somewhat obscure markings, which are subject to considerable variation ; but it has more brightly-coloured relations. In other countries there are Insects of the same family that are not only considerably larger, but also conspicuously and brightly coloured in their ultimate stage. It is these larger species in their earlier stages that produce the phenomenon that has been exaggerated into the rain-tree, weeping-tree, etc. Dr. Sharp refers to a species[1] in Madagascar whose production of surplus moisture is so great that five or six dozen of them would about fill a quart vessel in an hour and a half. Dr. Livingstone met with a species in Angola about

Photo by] [*H. Bastin.*

"Cuckoo-Spit."

The so-called cuckoo-spit is not saliva. If it be blown aside a quaint little yellow Insect will be found with its beak planted in the shoot, from which it sucks the juices. The nutriment extracted, the surplus fluid is passed off, and by continual movements of the tail is whipped into the froth, which hides the Insect and keeps its delicate skin moist.

seventy years ago, which, he said, was found in companies of seven or eight on the smaller branches of trees allied to the fig, and he estimated that one such group would in a single night produce three or four pints of fluid. It will be understood that a tree that had many such companies upon its various branches would be constantly running with water from the tips of the twigs. Every traveller is not a naturalist, and would not dream of tracing these streams to the Insects that were sucking at the younger shoots of the tree ; and so the story has grown that the tree, out of the superabundance of water its roots are abstracting from hidden sources deep in the earth, is watering the desert with fertilizing showers.

A few years ago Mr. S. L. Hinde came across a large, bright yellow species[2] in British East Africa which is worth notice, apart from its production of mimic showers, on account of the mimicry of flowers by the adult Insect. With their

[1] Ptyelus goudoti. [2] P. flavescens.

wings closed these Insects are a little more than an inch in length ; and they cluster round the narrow leaves with the tips of the closed wings touching the leaf and the head slightly away from it. In this position the group presents much the appearance of a branch of broom in flower.

Earwigs.

One of our familiar proverbs has it that if you give a dog a bad name you might just as well hang him off-hand : you have killed him morally though not physically. The truth of the proverb is exemplified by the case of the earwig.[1] Our forefathers called it by this name, which signifies something which runs into the ear, probably because one mistaken individual had been caught in the act of investigating the ear of a human sleeper to see if there was room to shelter it. The consequence is that in the ages that have passed since that incident the comparatively harmless earwig has been avoided with something approaching to loathing, as an enemy that would steal through the ear and eat up the small amount of brain that is possessed by the person entertaining such a fear. As a further consequence there are few persons who know how interesting a creature the earwig is.

Photo by *H. Bastin.*

SPOTTED FROG-HOPPER.

One section of the frog-hoppers, instead of having the wings in variable shades of brown and grey, are rather strikingly coloured. The present species is a native form whose blue-black ground colour is blotched with brilliant scarlet.

As Insects the earwigs are of rather simple organization, and belong to the straight-winged order.[2] They are long, slender-bodied creatures that remind one of a lad in an Eton-jacket, for their wing-covers do not extend over half of the hind-body, and can only act as efficient covers by the expansive and delicate wings being carefully folded in a complex manner that is peculiar to these Insects. One could almost imagine that the difficulty of folding these wings in the right way, to make them pack comfortably under the wing-covers, explains why the wings are so seldom used. As a matter of fact, earwigs have got so much into the habit of relying upon their legs for locomotion, instead of using their wings, that in many species disuse of them has resulted in the wings remaining undeveloped. As compared with most other Insect families the earwigs are few in number ; yet over four hundred species are known, and of these we can claim five as

[1] Forficula auricularia.

[2] Orthoptera

natives of our own island, and two foreigners that have settled down in certain districts and become naturalized.

The head is furnished with a pair of long, slender antennæ, a pair of compound eyes, but no simple eyes ; and the mouth has the cutting-jaws characteristic of all the straight-winged order. At the hind extremity of the body the two antenna-like tails of the cockroaches and crickets are replaced by a pair of horny processes which take the form of callipers. These callipers differ in size and shape in the different species, and in the two sexes of each species. They are certainly used in the packing up of the wings after use, as Mr. F. Enock has clearly demonstrated in a wonderful series of careful drawings showing every stage of the process. It has been suggested that these callipers are used also for wounding leaves and shoots of plants that the earwig may sup the juice, but an Insect that is provided with a good set of cutting-jaws is hardly likely to adopt so roundabout a method, even if the callipers were suitable for such work—which is very doubtful. But there can be little doubt that the mere possession of these organs protects the earwig from some possible enemies. Carried as is usual, with the points somewhat elevated and apart, they look much more formidable than they are, and may produce the impression that they mean business. That the callipers are not intended chiefly for packing up the wings is shown by the fact that they reach their proper development in species that have no wings to pack away ; and there are species in which they are so long that, turned over the back, their tips would reach the earwig's head, but could not possibly touch the wings or wing-covers. Then, too, they appear to be the most variable organs, so far as their size in individuals of the same species goes. In the common earwig the difference in length is almost restricted to the males, where it ranges from $2\frac{1}{4}$ mm. to 9 mm. We have noticed what we think is another way in which these callipers are useful to the earwig—when the Insect is hiding in a dahlia, or other flower, the hinder part of the body with the callipers open protrudes and produces the effect of a head with wide open jaws ready for attack. It is probable that this attitude may have a protective value in respect of certain of its enemies. This becomes more probable when one looks at the photograph of the shore earwig's callipers protruding from under a stone (page 77).

Photo by] [*H. Bastin.*

EARWIG'S PINCERS.

These are the callipers of the male common earwig. They differ greatly in size in different individuals, and are sometimes used to assist in packing away the wings. Magnified about twelve times.

It is a common belief that the earwig exists mainly for the annoyance of gardeners, and there is little doubt that much of the damage to plants that is due to other Insects is debited to the earwig. But there is evidence, not only that it

THE EARWIG AS A MOTHER.

The large earwigs shown are a male above and two females below. At the extreme left in the middle is a heap of eggs which, having been scattered, the mother-earwig is collecting together again. The earwig in the foreground is another female that has hatched her eggs, and is now brooding her young progeny. This is a trait quite exceptional among Insects, which rarely know anything about their immediate descendants.

Photo by] [*H. Bastin.*

AN EARWIG'S WING.

The upper part of the photograph shows a single wing-cover, and below it is the relatively enormous wing, which has to be carefully folded and packed away under the cover. Enlarged about eight times.

nibbles the petals of flowers, but that much of its food—perhaps the major part of it—consists of other Insects.

The common earwig and some others have been noticed to give out a peculiar odour at times. This is, no doubt, a further protection to them. It is believed to proceed from openings on the back. These may be seen just behind the extremity of the wing-covers. Apart from ants, wasps, and bees, Insects are not distinguished for solicitude for their young, beyond making proper provision for their prospective wants when the eggs are deposited. The female earwig, however, watches over her eggs and covers them with her body to protect them, and carefully gathers them together again when they have been scattered experimentally. She also broods her young when they are hatched, until they are strong enough to look after themselves. The eggs are laid late or early in the year, but do not hatch until the spring. The young are miniature replicas of their parents, minus wings and wing-covers. The number of moults on their way to maturity appears to be four. The full-grown females may be distinguished from the males at a glance by noting the character of the callipers: whilst strongly curved in the males, in the females they are almost straight.

Photo by] [*H. Bastin.*

EARWIGS.

The enlarged portrait shows the relative difference in size between the common species and the small earwig (centre); and the contrast between the shape of the callipers of the male (left) and the female (right).

Our finest native earwig is the shore earwig,[1] which only occurs sparingly on a restricted part of the Hampshire coast. It is more than twice the size of the common species, and of a pale colour, which makes it difficult to see on the sand where it lives, sheltering under small stones. It appears to be

[1] Labidura riparia.

much more a feeder upon animal matter than upon plants. Mr. Lucas, who has studied this Insect in captivity, has fed it upon a variety of animal foods; but it also partook of rice-pudding and banana, showing that it had no objection to a vegetarian diet.

Photo by] [*H. Main, F.E.S.*

SHORE EARWIG.

This, our biggest native species, is restricted to certain rocky parts of the coast, where its colour agrees so well with the surroundings that it is hardly seen. One and a half times life size.

The lesser earwig[1] is about half the size of the common species, and is, perhaps, the one that is most likely to have given origin to the legend about entering the ear, for it is much more in the habit of using its wings, and, in places where at all abundant, is more likely to alight upon a person's head or shoulders. Owing to this propensity to flight, it is a much better subject to watch for the process of folding and packing the wings. Another native species[2] comes near to the common earwig in point of size and general appearance, but may be distinguished by the fact that it has no wings.

Two other foreign species have been locally naturalized in this country, and several others turn up casually with plants or merchandise from abroad. Among the most extraordinary forms found in other countries must be included Hügel's earwig,[3] from Java, which has well-developed callipers of peculiar shape, and turns its thighs outward in a singular manner. The callipers, besides being as long as the body, in an earwig from the Himalaya,[4] have an extraordinary bow-legged appearance.

Photo by] [*H. Main, F.E.S.*

SHORE EARWIG.

An illustration of one way in which the callipers may be useful to an earwig. This species is in the habit of hiding its body under stones with the callipers protruding, when they appear to be the jaws of a more powerful Insect.

Insects of Past Ages.

The majority of the ancient animals of which we have knowledge, owing to their preservation in a fossil state in the older rocks, are creatures that dwelt in the sea, or whose dead bodies were swept down to the sea by rivers, and were covered up by the sediment that is

[1] Labia minor. [2] Forficula lesnei. [3] Pygidicrana hugeli. [4] Anechura scabriuscula.

always forming the rocks of the future. Insects, though exceedingly numerous, dwell mostly on dry land, and their bodies are so fragile that they are not calculated to stand the rough and tumble of such a process; so that we may conclude that the fossil Insects that have been found can give us only a very imperfect idea of a few of the multitudinous forms that of old prevailed on the earth. But although this imperfect record will not enable us to trace the evolutionary progress of the race of Insects, it is yet full of interest as showing the antiquity of certain types. The earliest forms of Insects we may presume were as delicate as our modern spring-tails and bristle-tails, which have no hard parts, and so were little likely to leave fossilized remains. It has been claimed that certain remains found in rocks so ancient as the silurian are those of primitive Insects, but this view is contested by some of the best authorities.

The earliest known undoubted Insects are found in the carboniferous rocks, which are of great antiquity and classed by geologists among the primary, or palæozoic, rocks. This was the age of the coal-formation, and from these rocks, both in Europe and in North America, numerous fossil Insects have been obtained. These carboniferous Insects come close to our modern cockroaches in structure. They had four wings of similar size and shape, but all transparent, like the four wings of a termite. In the modern cockroach, it will be remembered, the first pair of wings are thickened and opaque. In the carboniferous cockroach not only are all the wings similarly transparent, but they also agree in having five nervures. Now, in the modern cockroach, though the hind-wings have five nervures, those of the fore-wings have been reduced to four. So here we have evidence of two modifications in cockroach wings. We see something of this modification in the trias and lias of the secondary, or mesozoic, epoch, where the fossils of cockroach-like Insects have wings intermediate in character between those of the carboniferous and those of the present day.

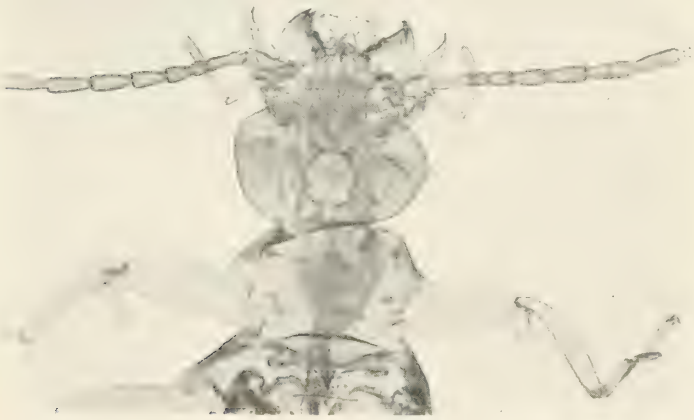


Photo by] [*W. West.*

HEAD OF EARWIG.

The fore-parts of the common earwig are here shown on a scale of twelve times the actual size to illustrate the character of the mouth organs, which are admirably adapted for cutting.

The fossils of the carboniferous period appear to point to the fact that the order[1] to which the cockroaches belong is certainly among the most ancient of Insects with firm structures; for it includes among its families the stick-Insects and the grasshoppers, and both of these families had their representatives at this remote period. Others, still with equal wings, exhibit a tendency towards the structure of the modern may-flies and dragon-flies. It is remarkable that only the

[1] Orthoptera.

INSECTS OF THE COAL PERIOD.

Dragon-flies were numerous in the period of the coal formation, and some of them were of enormous size. The one represented in the upper part of the picture was found at Commentry, in France, and measured more than two feet across its expanded wings. Below (centre) is an enormous may fly, and to left and right of it a large species of earwig and a cockroach of that period.

Photo by] [*W. West.*

FLY IN AMBER.

A two-winged fly with wings delicately fringed and covered with hairs. It appears to have affinity with our modern wheat-midge or hessian-fly. It is shown on a scale of twenty-five times the actual size.

winged adult forms of these Insects have been found as fossils, which supports our suggestion that more ancient forms with less firm structures decomposed before they could become fossilized.

The remains of Insects become more frequent in the secondary epoch, and abundant in the tertiary, or cainozoic, epoch. According to Scudder, these remains indicate conditions of existence very similar to those we find around us in the present day. Some of the ants had already evolved to such an extent that certain of the females showed modification into the worker caste, and a similar state of affairs existed among the termites in the separation of the soldier caste. The grasshopper family had developed its musical apparatus, the green-fly produced living young, the young of the oil-beetle was already parasitic on bees, and the present races of gall-wasps already made galls.

Fossils of the long-horned grasshoppers first make their appearance in the mesozoic rocks, but are more abundant in the tertiaries, where several existing genera are represented. A cricket has been discovered in the lias, but a number of species have been found in tertiary rocks. Dragon-flies, as already indicated, have been found in numbers in the carboniferous rocks, and many of these are remarkable for their large size—far exceeding that of any Insects of the present time. One dragon-fly[1] was of such a size that, did it exist to-day, people might have cause for the alarm they pretend in the presence of a modern "horse-stinger," so-called. This creature, which was found in the carboniferous beds of Commentry, France, measured more than two feet across the extended wings. It is shown on a much reduced scale in the illustration on page 79. It had long, narrow wings, and the hind-body was terminated by a pair of very long and slender "tails," such as we see to-day in the may-fly. Only the adult winged

Photos by] [*W. West.*

FLIES IN AMBER.

These examples, which are magnified twenty-five times, show the natural order to which they belong by the character of the two wings and (in the upper photograph) by the little balancers behind them.

[1] Meganeura monyi.

THE WASP AS FOOD PROVIDER

The grubs in the combs of the Social Wasps require to be as constantly fed as do unfledged birds. To meet enormous demands made upon them for fresh food, the worker wasps wage an unceasing war upon other insects, and during one season many thousands are destroyed to afford food for a single nest. In this picture the wasps have found a community of caterpillars of the small tortoise-shell butterfly crawling upon their tents and the nettle leaves. I not too large will be hauled to the nest intact, but those too heavy for carriage will be cut up and taken away piecemea

forms of these Insects have been discovered. Some remarkable forms of book-lice[1] have been found preserved in amber. In one of these[2] the wings are developed and carried so that they resemble the wing-covers of a beetle. Another,[3] which has near relations still living in Ceylon, is covered with scales like those of butterflies.

Reference has been briefly made to the occurrence of Insects like may-flies in the carboniferous period. They began to appear in the Devonian period, which is older than the carboniferous, but in the rocks of the latter period they are represented by so many species that Scudder has been led to remark that our existing species appear to be only the lingering fragments of an expiring group. The marvel is that Insects of so fragile a character should have been preserved as fossils.

The caddis-flies are supposed to date from the secondary epoch on the evidence of some wings found in the lower beds of the Purbeck limestone; and a larval tube has been found in the chalk of Bohemia. In the tertiary rocks their remains are plentiful. They are common in amber, and it is remarkable that a case has been found in this preservative. This implies that in tertiary times some of the species were land Insects in their larval stage. Scudder found them exceedingly abundant in the tertiary lake basin at Colorado; and at Auvergne there are beds known as indusial limestone, two or three yards thick, which consist mainly of caddis-cases. Ants appear to have been the most abundant of all Insects in tertiary times. They are common among the Insects found in amber, which is of the miocene age. Beetles have been found in the secondary rocks; also flies as early as the lias. The bugs are more ancient, and fossils obtained from the Permian series of the palæozoic epoch are supposed to represent both the two sub-orders, and other representatives have been obtained from the carboniferous shales of Commentry. Wasps and thrips have been found in a fossil state in tertiary rocks.

Photos by W. H. [illegible]

INSECTS IN AMBER

The two upper Insects are ants; the other is not very distantly related. All these Insects were caught by the sticky resin flowing from pine trees in [illegible] which afterwards became fossilized into amber. The middle example is magnified forty [illegible] twenty-six [illegible]

[1] Psocidæ. [2] Sphæropsocus kunowii [3] Amphientomum paradoxum.

Photo by [*W. West.*

AN AMBER INSECT.

An example of the same order of Insects as includes the ants and bees; but it is not easy to determine its near relations.

The Emperor Moth.

Although by no means a rare Insect, the emperor moth[1] is not one of those that are generally known except to naturalists. The reason for this is that it does not come into our gardens or greet us in the fields and lanes; otherwise its size and bold markings would make it a familiar form. The moth requires little description, for with the eye-like mark in the centre of each wing we have no other native moth that at all resembles it. In the South of Europe there is one very like it, known as the great peacock moth,[2] but it is more than twice the size of ours. The emperor differs considerably in the size of the sexes, for whilst the male rarely reaches two and a half inches across the expanded wings, the female is nearly three inches. The fore-wings of the male are of various shades of purplish-grey, but the hind-wings are of tawny hue. All the wings of the female are of purple-grey, paler and more purple than the fore-wings of the male. Another difference is seen in the antennæ, which are feathered in both sexes, but in the female so slightly as scarcely to be noticed, whilst in the male the branches are so long and regular as to make these organs very noticeable.

The moths make a public appearance in April and May, and if at that period one rambles across the heath or moorland the male may be seen in rapid flight in the daytime. The female usually rests during the day, but a quick eye may detect her on some of the heath plants. In that position with the upper wings folded over the lower, so that only one pair of eye-spots shows, she looks much like the face of a cat or owl peering through the shrubs; and it is thought that this terrifying resemblance protects her in her exposed situation from the attack of birds. The body of the moth becomes the beak of the owl or the nose of the cat, just as it may strike the beholder.

Photo by [*W. West.*

A MOTH IN AMBER.

The order of Insects consisting of the butterflies and moths did not make its appearance until a comparatively recent (tertiary) period. This example in amber is shown on the scale of twenty times larger than the actual size.

As in the case of some other moths, the female emperor that has recently emerged from the chrysalis gives off some subtle perfume that is far-reaching, and will draw all the males of the countryside to her. There is little doubt that the strongly feathered antennæ of the male are the highly sensitive organs affected by this delicate aroma. Entomologists who wish to acquire a series of male examples of any of the moths that exhibit this extraordinary perception of an odour

[1] Saturnia pavonia.

[2] S. pavonia-major.

Photo by

WING OF THE EMPEROR MOTH

This photograph [illegible] On the left margin, which [illegible]

Photo by [*H. Main, F.E.S*

EMPEROR MOTH.

The photograph shows the male of this beautiful moth, slightly enlarged. Note the abundant feathering of the antennæ, which is a character of this sex.

that makes no impression on the most sensitive human nostril, take advantage of this fact, and when a female appears in their breeding cages they take her out to a suitable locality and soon have a crowd of eager males around her. It does not matter that she is hidden from sight, shut up perhaps in a chip box; the unsmellable odour is so powerful that it pervades the walls of her prison and the pocket of her jailor. It is within the experience of some collectors to have been mobbed, as it were, by male moths when they merely carried a box that had recently contained a fresh female, but was now empty. Infatuated males have been known to come down a chimney in the attempt to reach a female in a collector's breeding cage.

The female lays two or three hundred large eggs, in batches around the stems of the food-plant, as shown in our photograph. At first white, these eggs soon become brownish-grey. The newly hatched caterpillar is black, but after casting its first skin it becomes green. When full-grown it is a beautiful object, being of a bright green, the segments very distinct and plump, and bearing pink or yellow warts from which arise a tuft of black bristles. It feeds on heath, heather, bramble, blackthorn, sallow, purple loosestrife, meadow-sweet, yellow water-lily, and other plants. At the last it spins a pear-shaped cocoon of white or brown silk among the branches of its food-plant, and makes preparation for the easy exit of the moth by constructing the narrow end on the principle of the lobster-pot reversed. This narrow end is composed of straight threads whose ends converge, so that nothing can enter from without, whilst it opens to the slightest pressure from within. There are those who claim that the lobster-pot must have been invented by a man who had examined the construction of the emperor moth's cocoon. This cocoon is made about the beginning of September, and the chrysalis remains in it until the following April or May. In the case of an Insect like the emperor caterpillar, so variable in its food-plants which affect diverse situations in respect of their exposure to light or shade, the power of varying the colour of its silk

Photo by] [*R. Hancock.*

EMPEROR MOTH.

This photograph gives a slightly enlarged view of the female. She is distinguished by a paler coloration, larger size—especially of the body—and by the feathering of the antennæ being greatly reduced.

appears to be a necessity, seeing that it has to protect the chrysalis all through the winter when leafy shelter is deficient. We find, therefore, that its cocoon varies between white and brown according to the situation chosen, the tint being that which will best disguise it under the circumstances.

Photo by [*E. Step, F.*

EMPEROR CATERPILLAR.

This is one of the most beautiful of [illegible] pillars, the colour being a bright gre[illegible] with pink or yellow warts, which bear [illegible] black bristles. Natural size.

Spider-hunting Wasps.

There are many solitary wasps who agree in the habit of mining in the ground, in order to make provision for their offspring. Wasp-grubs require animal matter for their aliment, so the wasp has to hunt for caterpillars, spiders, or flies with which to stock the larder. Certain species restrict their hunting entirely to spiders, others to grasshoppers, others to caterpillars of a particular family of moths, and yet others will take nothing but cockroaches. The catching of caterpillars is a simple matter to a wasp, for its prey has no means of protecting itself. (See coloured plate.) The grasshopper's activity and leaping powers give it a sporting chance; but the spider has to be approached warily, for its poison-fangs might put it upon equal terms with the wasp, were it not for the wings of the latter, which give it considerable advantage in manœuvring. However, the wasp has a due sense of the respect to be paid to those poison-fangs, the additional pair of legs, and the possibility of having strong cords wound around one; she, therefore, resorts to strategy when hunting spiders.

EMPEROR COCOON.

[illegible] he principle of the lobster trap reversed. The narrow [illegible] threads whose ends converge, so that it is easy to get out, but [illegible]

There are a number of spider-hunting wasps belonging to several distinct genera.[1] They have a broad head, a robust fore-body, and a spindle-shaped hind-body which is never stalked, though there is a distinct waist. The hind-legs are long and extend far beyond the body. These legs give them great powers of running, and they may frequently be seen racing over the ground, or on tree-trunks and palings in search of their prey, the wings and antennæ in rapid vibration, as though the wasps are labouring under considerable excitement. There are some differences in the method of working: thus, Calicurgus will seek for a ready-made hole in preference to mining one for herself. Pompilus, though a true and efficient miner, believes in the cookery adage—"first catch your hare"—for she

[1] Calicurgus, Pompilus, Pep[illegible]

catches her spider before digging a hole to put it in. It is probable that this plan may frequently lead to the nest being ready first, owing to the secured prey being carried off by another wasp whilst mining operations are in progress. Fabre gives a detailed account of some experiments he made in order to test her sense of locality, and to ascertain how she would behave under certain conditions. A Pompilus that he had watched catch and sting a spider to render it helpless, left her prey on a tuft of vegetation whilst she proceeded to make a burrow to receive it. She does not wait until the burrow is finished before looking for the victim, but leaves off work at intervals in order to visit the spider, to touch it and so assure herself that it is *her* spider and that it is quite safe. In this case, as soon as the wasp had set to work on her mining operations, Fabre removed the spider to a distance of about eighteen inches. When Pompilus had worked for a spell she left off and flew straight to the spot where she had left her treasure, and exhibited grave concern at its absence. She carefully walked over the surrounding ground, as though to make sure that her memory was not at fault, then satisfying herself that the spider was not there, she extended her survey, and at length found what she sought. Her actions showed that she was greatly astonished at the change of position; and she appeared to be unable to account for it. It was incomprehensible that she could have left the spider in that position; but seizing one of its legs she removed it to another tuft, and resumed her digging. Fabre again removed it, and when the wasp had rested from her digging she flew straight to the place where she had last left it, and, failing to find it, quartered the immediate surroundings as she had done before. Five times the naturalist removed the spider, and every time the wasp went through the same performance, seeking her treasure where she had last laid it, showing that her sense of locality was perfect. Had she been guided by scent she would have gone, probably, to one of the places where the spider had lain previously, but this she never did. Nor could sight have played anything more than a subordinate part in the discovery, for Fabre found that, though the spider was only a couple of inches from the wasp in some of her searches, she passed without seeing it. When, however, her sense of

Photo by] [*H. Main, F.E.S.*

EGGS OF EMPEROR MOTH.

The large eggs, to the number of two or three hundred, are laid around a twig of the food-plant as shown. They are magnified here to the extent of four and a-quarter times.

Photo by] [illegible]

THE GREAT PEACOCK MOTH.

A South European relative of our emperor moth, and very like it in general appearance, but about twice its size. The photograph shows it on a scale of nearly one and a-half times the natural size. Its life-history is much the same as that of the emperor

MEXICAN SPIDER-WASP.

This plucky little Insect adopts the plan of making a frontal attack on the spider as she sits on guard in the centre of her web. The spider is so surprised by the impudence of this attack that she at once drops to the ground; but the wasp is there almost as quickly as the spider, which is stung before it has recovered from its astonishment.

locality had brought her to the exact spot where she had left her prey, it was clear that the sense of vision came into play, for when Fabre placed the spider in a slight depression of the ground and covered it with a leaf, the wasp could not find it.

Although the species of Pompilus are not all miners—for some of them prefer to seek a hole that has been made by some other Insect—yet they are all spider-hunters; and some of them secure their prey, as stated, before they have prepared a nest. They take the precaution to render the spider helpless by stinging it, and then hang the paralyzed body in the forking of some plant until they have excavated a mine, or found some ready-made retreat that is suitable for their purpose. They mine with such energy that the fine earth flies out of the hole like a fountain, so rapid are the movements of their limbs in digging. The Peckhams tried several experiments in the way of substituting healthy spiders for those that had been stung, whilst Pompilus was digging her nest; but the attempt never succeeded—the wasp always knew that some trick had been played upon her, and always refused to be a party to the exchange. Even when a spider that had been stolen by them from one Pompilus was dropped near the mouth of another Pompilus' nest, her interest in it extended only as far as a tactile examination. She refused to accept it, though this would probably have saved her from a tedious hunt for a fresh specimen.

The mining of one of these spider-wasps[1] has been described by these observers:—"She was working away as furiously as though she had studied the poets and knew her *carpe diem* by heart. Faster and faster went the slender little legs; higher and higher rose the jet of dust above her. Then suddenly there was a pause. The burrower had met with some obstacle. A moment more and she came backing out of the hole, her feet slipping on its crumbling edges. In her mandibles she carried a pebble, which was taken to a distance of four or five inches. Then, moving quickly, she swept away the dust that had accumulated near the mouth of the nest, re-entered the hole, and resumed the labour of excavation. We thought that the rate at which she worked was too violent to be kept up very long; and sure enough, before ten minutes had passed the nest was deep enough for her purposes. . . . The wasp came out, circled round the spot three or four times, and then flew off like a hurricane. Never have we seen a creature so fiery, tempestuous, cyclonic. Before we knew her

THE TORNADO-WASP.

One of the smaller wasps that wage war entirely upon spiders as the material for stocking their nursery-larders. So energetic is she in her mining operations that an American naturalist has given her the name of tornado-wasp. See also page 93.

[1] Pompilus quinquenotatus.

proper title we took to calling her the tornado-wasp, and by that name we shall always think of her." She was back in a minute with her spider, dug out a little more earth, then seizing her victim by one leg she dragged it backward into the nest. "She remained hidden for about two minutes, then reappeared, and, seeming to be in as great a hurry as ever, filled the hole with dirt. To disguise the spot and render it indistinguishable from the rest of the field was her next care. Hither and thither she rushed, now bringing little pellets of earth and placing them above the nest, now sweeping away the loose dust which might suggest the presence of the *cache*, and now tugging frantically at a stone which she wanted to place over the hidden treasure, but which was too deeply embedded

[By T. Carreras.

SPIDER-WASP HAULING ITS VICTIM.

Having completed the digging of its shaft, the wasp recovers the spider from the plant whereon she had hung it, and hauls it along the ground to the pit's mouth, into which she carries it backwards.

in the earth to yield to her efforts. She did her work faithfully, although with such eager haste that all was completed at the end of twenty minutes from the time we saw her first."

Some of these spider-wasps are sufficiently bold to beard the lion in his den, that is to say, to seek the spider in her nest, whether that be a hole in the earth or an entangling web. In the case of those spiders that live in holes the wasp goes to the mouth of the burrow and apparently makes sufficient demonstration to bring the spider out in a rage. The wasp seizes a leg of the spider and endeavours to drag it forth; and if successful stings it at once between the fangs to put these

poisonous weapons out of action. If it fails to draw the spider the wasp passes on and seeks another hole. Belt tells us that in Mexico a wasp[1] will make a dash at a spider that is in the centre of its web. This mode of attack so surprises the spider that it drops to the ground. The wasp is there almost as quickly as the spider, which it stings before it has had time to recover from its astonishment. After such an encounter Belt saw the spider—which was too heavy to be lifted from the ground in flight—dragged up a tree by the wasp until it had reached such an elevation as enabled it to fly home with its burden on a descending plane. Even the huge bird-spiders[2] fall victims to spider-wasps of another genus.[3] Buckley tells how the wasp Pepsis circles around the spider, who stands in fighting attitude, but can only do his best to dodge the attack of his winged foe. Seizing her chance the wasp darts upon the spider and inflicts a sting. Some species of Pepsis are two inches long, and therefore more equally opposed to such great spiders than Pompilus would be.

THE RINGED SPIDER-WASP.

Like the other spider-wasps, this species is a miner, digging shafts in the earth and storing them with spiders which have been stung to paralyze them. It is here shown one and a half times the actual size.

Wasps of the allied genus Salius have the same taste for spiders. A common species[4] in India has been observed by T. V. R. Aiyar. It is a yellow wasp, whose wings share the same colour with the body, except their tips, which are purplish-black. It hunts in open meadows where there are innumerable holes in the ground, many of them inhabited by spiders, and the wasp with great patience runs from hole to hole seeking victims. At the Research Institute, Pusa, one was observed to search every hole in half an acre of meadow for two hours and a half, without success; then it flew away to a distant tree, apparently to rest and muse on the hardness of the times. When, however, Salius has found a spider, it observes a definite order of procedure. Finding a hole inhabited by a spider, it quickly withdraws and rests; then it cleans up its antennæ and hind-body by brushing and stroking them with its legs. After this preparation for visiting it enters the hole again and stirs up the occupant. This action is succeeded by the rapid withdrawal of the wasp, followed closely by the spider. The wasp runs a short distance from the hole and turns round with her face to the foe. The spider—usually a big ground-spider—comes to the mouth of the hole and assumes as offensive a defensive attitude as it is capable of—with head erect and jaws extended. The wasp tries tactics, evidently respecting the poisonous fangs of the spider, and tries to attack it from the rear; but the spider, without budging from the mouth of the hole, turns repeatedly to face the wasp. This sort of thing goes on for five minutes or so, until the wasp seizes a favourable opportunity and alights on the spider's back. At once curving her hind-body

[1] Pompilus polistoides. [2] Mygale. [3] Pepsis. [4] Salius flavus.

By Theo. Carreras.

BIRD-SPIDER ATTACKED BY WASP.

A large blue wasp of Texas is known as the tarantula-killer, from its habit of destroying the huge bird-spiders in order to provision its nests. The wasp circles around the spider, who stands in fighting attitude, but can only do his best to dodge the attack of the winged foe. Seizing her chance, the wasp darts upon the spider and inflicts a sting. The victim is then dragged to a convenient hole, or one is bored to receive it, and after an egg has been laid upon it the hole is sealed up.

below the spider she stings the latter in the jaws, and again along the side of the fore-body. The encounter is over, for the spider is paralyzed. After an inspection to satisfy herself that the spider is incapable, Salius goes off to find a hole suitable for conversion into a nest, and sometimes she will use the hole from which she has provoked the spider to issue to its death. Spider-holes, however, do not as a rule commend themselves for the purpose, and the wasp goes off in search of one more suitable, leaving the spider on the ground until she has found it.

Daddy Long-legs.

One of the most familiar of Insects is the large, two-winged fly that is variously known as the crane-fly and daddy long-legs.[1] Its familiarity is due to its habit of coming indoors and straddling about the windows with its ridiculously long legs.

THE TARANTULA-KILLER.

Actual photographs of the species of wasp shown in the drawing attacking the big bird-spider, and known in Texas as the tarantula-killer. The disproportion between the wasp and the spider is so great as to make the contest appear absurd, but it usually ends in victory for the wasp. The sting of the wasp is so effectual a preservative that a stung spider has been known to keep fresh for more than a year

That is to say, its legs appear ridiculous when seen in such a place; but on the grass-land, where it is more at home, its length of leg is not inappropriate. Daddy in its larval stage is a pest; but Mrs. Daddy when engaged in the important task of stocking our lawns and pastures with a new generation is an interesting figure. Her long, slender legs fitting between the grass-blades enable her the better to bend down her hind-body and use it as a boring implement, with which to make a hole in the ground in which she can lay one of her numerous shiny black eggs. Unlike many Insects that have a large number of eggs to dispose of and which drop them in batches, the crane-fly appears to have the desire that each of her offspring shall have a fair amount of feeding ground without undue competition; so she lays them singly and scattered. The termination of her body is more

[1] Tipula oleracea.

Photo by] [*H. S. Cheavin.*
EGG-PLACER OF CRANE-FLY.
The parts are separated to show distinctly the borer (left) and the egg-tube (right). Magnified thirty times.

pointed than that of the male, and has a horny tip more suitable for piercing the ground.

The daddy long-legs is about an inch and a quarter in length, and the narrow wings are a little over an inch long. Behind the latter will be seen the pair of "balancers" which in the two-winged flies[1] represent the hind pair of wings in other Insects. The long legs are very lightly attached and come off with very slight provocation, and apparently with little inconvenience to the Insect. The fore-body is stout, but the head is very small.

The grub is very cylindrical, and its tough skin of dirty grey-brown has gained for it the name of "leather-jacket." When full grown it is an inch and a quarter long, and attains that size by feeding incessantly on the roots of grasses and other plants. Some grass-lands in certain seasons are very full of them, and the grass suffers greatly from their attentions. Fortunately not all the brood reach this stage, for large numbers are destroyed by rooks and starlings, whose strong bills enable them to reach the grubs in their apparently safe retreat underground. Having survived this danger the fortunate ones assume the chrysalis form, and are then much like the chrysalis of a moth—that of a swift-moth, for example. On each ring of the body it is furnished with a row of bristles which point backwards, and enable the creature by a little wriggling to go forward. When it is about to cast off its chrysalis skin, it makes use of this equipment to ascend to the surface, and half-way into the air. In autumn large numbers of them may be seen in this position, quite erect. There are two curved horns standing out behind the head, and these enable the chrysalis to breathe. If one of these protruding chrysalids be watched, it will be seen to split its skin on the back behind the head, and the perfect Insect will emerge, drawing

Photo by] [*E.*
CRANE-FLY
In general appearance this crane-fly is very like the larger but in addition to being little more than half its size, the body will be seen at a glance to be different. The photograp twice the actual size.

[1] Diptera.

out its long wings and longer legs. There are about a thousand species of crane-fly known, but only two others occur in our islands. The Chinese rejoice in a species[1] which measures, when the wings are expanded, four inches across.

The Transformations of Insects.

It is well known that such Insects as butterflies, moths, bees, beetles, and flies pass through four well-marked stages of existence, and among those who are not entomologists it is generally assumed that all Insects exhibit the same abrupt or apparently abrupt changes from stage to stage. As a matter of fact, however, there are great numbers of Insects whose course of development from the egg to the adult winged state shows none of these strong contrasts; their progress is as gradual as that of a man from helpless infancy to full maturity. In reality the same is true of all Insects, but where the food and the habits of the adult differ from those of the infant, it is necessary that the mouth-parts and the digestive system should be reorganized, and there has to be interposed a resting period in which no food is indulged in and no muscular activity undertaken. To take a familiar illustration, the caterpillar lives upon leaves which have to be finely cut and masticated. For this work cutting mandibles are requisite, and a long, complex digestive tract for the proper assimilation of the food. The butterfly, which is the ultimate stage of the caterpillar, takes nothing but a little nectar from the flowers, and to obtain this its mouth-parts have to be reorganized and remade into a tubular sucking organ. The digestive tract is correspondingly reduced in size and complexity, and considerable change takes place in the nervous system. When we consider the great changes thus implied, we see a reason for the resting stage known as the chrysalis.

Photo by] [*H. Bastin.*

DADDY LONG-LEGS.

The length of leg, which appears so ridiculous when the fly is sprawling over our window-panes, bears a different aspect when the Insect is seen making its way easily over the grass. The long, slender limbs pass between the shoots whilst the feet touch the ground. The eggs are laid in grass land, and the grubs—well known as the leather jackets—feeds upon the roots of grasses and other plants.

Now, if we consider such an Insect as a grasshopper, which takes the same food at maturity as it took in infancy, we see that there is no necessity for a radical change in the mouth-parts and the digestive system. Therefore, there is no resting stage—the grasshopper is active throughout its existence, and the wings are developed gradually.

[1] Tipula brobdignagia.

By Theo. Carreras.

THE LIFE-HISTORY OF DADDY LONG-LEGS.

In the foreground a female is boring holes and laying eggs. Near by two full-grown grubs ("leather-jackets") are seen, one in the earth feeding upon grass roots. Several chrysalids have half emerged from the ground, and from one the daddy is escaping. A male—known by the different shape of his hind-body—is flying in the distance. Twice the natural size.

Photo by [*H. S. Cheawin, F.R.M.S*

NYMPH OF A LACE-BUG.

This photograph illustrates the active stage which corresponds with the inactive chrysalis of the butterfly. In Insects thus active throughout life there is no real metamorphosis. Here the wings are seen to be only half-grown.

Of course, the development of the Insect, of whatever kind, begins in the egg. When the larva breaks the egg-shell and creeps out, it has passed through one stage of existence and entered upon a second. All kinds of Insects are not equally developed when they arrive at this point. The newly hatched grasshopper is a more highly developed Insect than the newly hatched caterpillar: a parallel condition to what we find among young birds, where one is born naked, blind, and incapable of picking up its food, whilst another is well clothed with down, has its eyes open, and can find its own food at once.

Most Insects after they leave the egg moult their skin at intervals. Caterpillars as a rule cast their skin five times, and the intervening periods are known as instars. The fifth moult reveals the chrysalis or sixth instar, and the butterfly or moth is the seventh instar. Including the egg, we thus have eight stages instead of the four that are commonly attributed to the butterfly or moth. But in these first five instars of butterfly existence the changes often amount to little more than an increase of size. Sometimes, however, there are changes of colour and ornament to help to hide the increasing bulk of the caterpillar. What are popularly known, then, as the four stages of Insect life must be understood to refer only to those moults where the entire external form of the Insect has suddenly undergone a great change —in a word, transformation.

Now in the case of an Insect like the grasshopper that only moults without showing us any startling changes of form, we cannot speak of caterpillar stage and chrysalis stage. We may speak of it when it leaves the egg up to the time when the hard, packed-up buds of the wings appear, as the larval stage; but an Insect that has no resting period, and is actively crawling and leaping through life without a break is properly called a nymph. Many beetle larvæ are incapable of walking, and to these the term grub is usually applied; some, however, are active, and here again the word larva is the more appropriate.

The third distinct stage in the evolution of the butterfly or moth is properly termed a pupa. In common parlance it is more usual to speak of it as a chrysalis: a strange instance of the public having selected the more difficult of two alternative words. The term, though now pretty generally applied to the resting stage of butterflies and moths (and other Insects), is strictly applicable only to the gilded pupæ of certain butterflies. There are two distinct types of pupa. In one, all

the form of the future limbs, wings, antennæ, eyes, etc., is plainly indicated; in the other these are hidden. The pupa of a butterfly or a beetle is of the first type; that of a house-fly of the second. But this difference is more apparent than real. The butterfly chrysalis has thrown off the skin of the caterpillar; but the maggot of the fly has turned to a pupa without casting its skin, which hardens into a brown case of elliptical form serving as a protective cocoon and known as the puparium.

Now the scientific name larva[1] was given to the caterpillar because its form was believed to be a mask for the butterfly that already existed in a wrapped-up condition within. Swammerdam and other early investigators had detected the rudiments of wings under the last skin of the caterpillar, and as the form of the pupa had been seen through the transparent skin of a species of gnat-larva, it was assumed that the forms of the pupa and the adult Insect already existed in the larva whilst it was still in the egg. Each of these stages was considered to be a distinct Insect, boxed up one within the other, and the shedding of the last caterpillar skin simply revealed the previously existing chrysalis, which in turn perished to set free the winged butterfly. This was not a correct view, though later investigations have shown that there was a small basis of fact in the existence of what are known as imaginal discs. What we know as metamorphoses are really only a continuation of the changes that have brought about the evolution of the caterpillar from the embryo in the egg. To have enabled all these changes to take place in the egg would have necessitated the production of only one or two enormous eggs instead of hundreds, and the Insect would have had to grow after the winged form had been reached. As it is, there is no growth after the final instar has been reached.

The six true legs of the caterpillar may be considered permanent structures. They develop into the feet of the long legs of the butterfly, and any injury to them in the caterpillar stage produces some abnormality in the legs of the butterfly.

Photo by] *F. Noel Clark.*

EGGS OF A MOTH.

A small portion of the cluster of eggs laid by the light brocade moth on broom and other plants. They are magnified thirty times, and serve to illustrate the beautiful manner in which the eggs of Insects are frequently sculptured.

[1] Latin, a mask.

The wings also exist in the caterpillar in the shape of folded buds. The feeding of the caterpillar results in the storing of a large quantity of formative material known as the fat-body. In the chrysalis this is drawn upon to provide for the growth of the wings and other structures of the complete Insect. The chrysalis is formed, of course, before the last caterpillar skin is cast off. A little before what is generally known as pupation, the full-grown caterpillar ceases to eat, and the pupal structures then undergo rapid expansion at the expense of the fat-body. Changes take place in the nervous system and the digestive system, and at the same time the purely larval structures are breaking down and being formed into parts of the new structures.

The caterpillar skin splits in the fore-part of the back and the chrysalis draws itself out of the opening, and by systematic wriggling pushes the old skin back over the narrow hind extremity. This is furnished with hooks which it now catches in the little pad of silk previously spun by the caterpillar for the purpose. At this time the legs, antennæ, and wings are all loosely folded on the exterior of the chrysalis, but a transparent fluid is now poured out which covers the entire creature, and rapidly hardening into a film, glues down all the parts. It is this film which is split at a later stage to release the completely developed butterfly. We say completely developed because, although the wings are small and crumpled on emergence, they are fully formed and need only distension by the inflation of the air-tubes and the circulation of blood between the two membranes of which the wing consists.

Photo by] [*E. Step, F.L.S.*

A Caterpillar.

In this photograph of the privet hawk-moth caterpillar several points described in the letterpress are clearly shown. Just behind the head are the three pairs of permanent legs which develop into the six legs of the moth; below the middle of the body are the four pairs of temporary unjointed legs, and at the hinder extremity the pair of powerful claspers, which are also temporary.

In the foregoing we have taken the butterfly as an example of those Insects in which the metamorphosis is complete. In the others it will be understood that the adult form, minus wings, having been reached when the Insect leaves the egg, the internal changes are not of a revolutionary character, and are mainly concerned with the development of the reproductive system. In the butterfly, the beetle, the bee, and the fly, the perfect Insect being so different from the larva, the latter contains imaginal discs or buds for every part of the future body. In most cases the whole of this important series of changes is passed through very rapidly. To give an example that will show at once the rapidity of change and the vast increase

Photos by

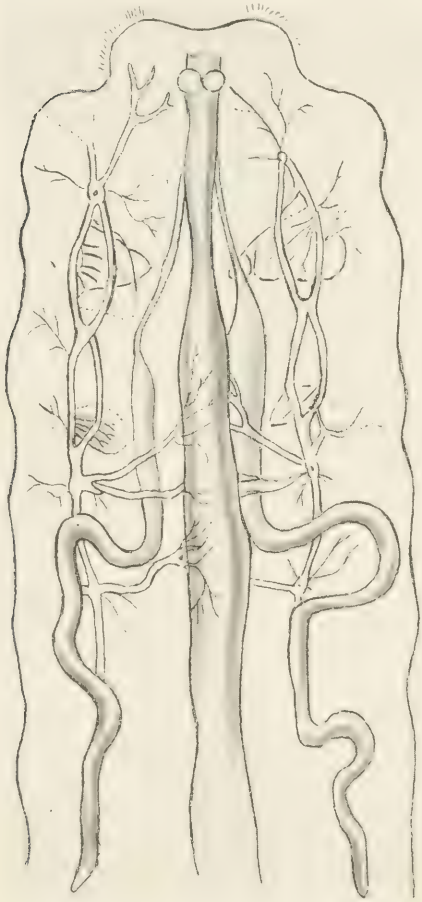
THE TRANSFORMATIONS OF THE CAMBERWELL BEAUTY

The caterpillars are shown fully grown and preparing for a change. A little silk is spun on the chosen surface, to which the [illegible] attached. The skin splits down the head, revealing that part of the chrysalis. By a series of contractions and [illegible] extended, the caterpillar-skin is pushed off at the tail-end, and the chrysalis is fully revealed, as in the next figure. [illegible] show the complete butterfly, under and upper sides.

Photo by] [*W. J. Lucas, F.E.S.*

A Grasshopper Nymph.

A photograph of a skin cast on the assumption of the winged condition. The pads which confined the undeveloped wings will be seen standing out above the middle pair of legs.



How the Butterfly gets its Wings.

This dissection of a caterpillar of the large white butterfly shows that the development of the wings is not so sudden as is popularly believed. These are found in an incipient stage in the caterpillar in the form of minute discs. In its last skin they will be found just below the surface, as indicated by the four crosses above. In the chrysalis, as shown in a previous photograph, they come to the surface.

of bulk, we may borrow Newport's figures relating to the caterpillar of the privet hawk-moth.[1] When the caterpillar leaves the rather large egg it weighs one-eightieth of a grain. In nine days it has cast its second skin, and weighs one-eighth of a grain. On the twelfth day it casts its third skin, and weighs nine-tenths of a grain. When it moults for the fourth time, on the sixteenth day, it weighs three and a half grains, and six days later, when it appears in its last skin, its weight has increased to nearly twenty grains. But this last skin is very accommodating, for this is the caterpillar's period of most rapid increase. By the thirty-second day, when it has reached its full-growth, its weight has increased to 125 grains. That is to say that in the thirty-two days that have elapsed since it left the egg it has increased its weight nearly ten thousand times!

From the foregoing it will be understood that growth proper is restricted to the earlier stages; that when an Insect has reached the winged state there is no further growth or development. One frequently hears people referring to a small fly as a young fly, and some imagine that the small garden-white butterfly represents a juvenile large garden-white; but these ideas are quite wrong. The small garden-white can no more grow into a large garden-white than a bull-frog can develop into a bull. There is one insuperable bar in the case of Insects — with one known exception, Insects are unable to cast their skins after they attain to the winged state. The exception is the may-fly which invariably, after it has left the chrysalis and expanded its wings, casts its skin again, even to the skin of the wings. But apart from the may-flies it may be stated with confidence that all the growth and all the transformations have been got over when the Insect first spreads its wings for flight.

[1] Sphinx ligustri.

Jumping Plant-Lice.

Frequently we may see about apple- and pear-trees in June large numbers of small, prettily coloured Insects [1] that remind us of green-fly by their general shape, and of frog-hoppers by their leaping habits. Those upon the pear are coloured dark red, those upon the apple are clear yellow. Before you have had time to look at one properly it takes a strong leap and, spreading its very delicate wings, has vanished. This is, of course, the fully developed Insect; but if in spring the young shoots, the under sides of the leaf, and especially the cluster of newly expanding leaves at the extremity of the shoot, be examined, we shall in all probability find the earlier stages represented. They may be solitary individuals or in clusters, feeding like green-fly, and passed over as such by the careless observer. A comparison of representatives of the two families of Insects, however, will show distinct differences. They are rather larger than green-fly in their wingless condition, have shorter antennæ, shorter legs, and the body is broader and flatter, sparsely covered with long hairs, and not so delicate in texture. Like the green-fly they have a long rostrum or sucking beak, which is plunged into the tissues of a leaf or tender shoot of their favourite plant, and the sap continuously drawn through it. This method of feeding, though the same as that adopted by the green-fly, has caused these particular Insects to be distinguished by horticultural writers as suckers. Again, as in the green-fly, the surplus fluid from which they have abstracted all the nourishment they require is got rid of in the form of honey-dew, often in great quantity, rendering the foliage sticky. They are sometimes immersed in this fluid, which pours off the leaves, but they do not lash it into froth, as the frog-hoppers do. In the case of the apple-

Photo by] [*H. Ba*

GRUB OF GALL-WASP.

[illegible]

Photo by] [*H.*

CHRYSALIS OF GALL-WASP.

A similar gall cut through at a later date to show [illegible] become a chrysalis. Both photographs show the Insect about three and a half times the natural [illegible]

[1] Psyllidæ.

Photo by] [*H. Bastin.*

THE MAKER OF BULLET-GALLS.

The grub and chrysalis shown on the previous page have completed their development, and the little gall-wasp has bored its way from the centre to the outside. The exit-hole is seen below the Insect. Magnified two and a half times.

sucker[1] it takes the form of milky globules, and the presence of the sucker on the apple-tree may be detected by looking for these spherical pearls on the under side of the leaves. When these are found, a closer examination of the youngest portion of the shoots will probably reveal the presence of the Insect in large numbers. In the case of the box-tree sucker[2] the excrement does not take a liquid form but becomes endless filaments of wax in the shape of a white ribbon, which proceeds from the hind-body and more or less covers the Insect.

They cast their skins about three times as grubs; then appear with longer antennæ and with wing-pads which stand out from their sides and make them as broad as long. The fourth change reveals the perfect Insect with wings longer than the body, the hinder pair of so delicate a structure as to be scarcely perceptible. When not in use these wings are laid along the sides of the body with their upper margins in contact, much after the manner of the green-fly, though in some closely allied suckers, such as that illustrated on page 104, they are wrapped around the back and sides. The jumping is accomplished by means of the comparatively stout thighs; but there is no marked development of leaping legs as in the grasshoppers, and looking at them as they walk rather awkwardly and feebly, there is nothing to indicate that they have jumping powers until they give us a demonstration. In addition to the fairly large and prominent compound eyes, they have three simple eyes arranged in a triangle between the other two, and easily seen with a good pocket lens.

Photo by] [*H. Bastin.*

GALL-WASPS.

Two females are here engaged in depositing their eggs in the buds of the oak, the preliminary to the formation of fresh galls. Magnified about five times.

Their relation to the scale Insects is indicated in some species—such as that of the box-tree already mentioned—by the production of wax in the form of flattened oval scales or cottony wisps. The attack of some species on the under side of the leaf causes the upper side to become swollen and elevated, and looking like a gall; but the under side is hollow and shelters the suckers. A similar result attends the attack of certain species of green-fly and of the vine aphis.

The dark red species previously referred to is the pear-

[1] Psylla mali. [2] P. buxi.

Photo by] [*H. S. Chawin, F.R.M.S.*

NYMPH OF A DRAGON-FLY.

The dragon-flies are continuously active throughout their existence, and have no resting period. The chief difference between their infant and adult conditions lies in their acquisition of wings. This is a gradual process; but a short time before the perfect dragon-fly appears these wings may be plainly seen packed up in pads on the back. In this photograph of an earlier stage (magnified forty times) they may be noted as four dark, wedge-shaped marks between the two hinder pairs of legs, and, of course, within the body.

Photo by] [*E. Step, F.L.S.*

NYMPH OF BOX-SUCKER.

This Insect may be found upon almost any box-tree sucking at the sap, and more or less hidden by a long ribbon of cotton-like material proceeding from its own body. Magnified four times.

sucker.[1] In its early stages it is dark yellow and sucks the leaves and the base of the new shoots. The perfect Insect is at first green with red eyes, but later it becomes more or less marked with red-brown and black. The apple-sucker is greenish-yellow, with dark tips to the incessantly waved antennæ, and the pointed tip of the hind-body is turned up abruptly. Although at times very abundant, it does not occur in such vast numbers as those of the pear-sucker. Fruit-growers are of opinion that the continuous sucking of these myriads at the young shoots and leaf-buds causes a serious impoverishment of the crops. Spraying with a solution of soft soap to which creosote oil has been added appears to be the most effectual remedy.

Many other plants are attacked by different species. The lerp, or leaf-manna, of Australia is the exudation of one that feeds upon the eucalyptus, and takes the form of a covering scale, which is collected and used as food. One[2] of our fifty native species is found on rushes, and may easily be overlooked as one of the seeds of the plant, which it resembles closely. It is brown in colour, and its identification may be helped also by the appearance of two long "ears" produced by the enlarged basal joints of the antennæ. Then there is another family of jumpers,[3] which are something of a compromise between the Psyllas and the frog-hoppers. When the wings are folded they fit close to the back and sides, and they jump by carrying the thighs of the hind pair of legs pressed forward, and suddenly extending them when occasion requires that the Insect should depart. These hind-legs are fringed with stiff spines like the leaping legs of the grasshopper. The adjoining photograph is of a common species found abundantly under the leaves of elm and bramble.

Photo by] [*E. Step, F.L.S.*

ELM-SUCKER.

An exceedingly abundant Insect on elms and low vegetation. The shank of the hind leg bears a row of spines which assist in jumping. The empty skin of the nymph will be seen a little to the left. Magnified five times.

The Humble-Bee's Cuckoo.

There are many strange parallels to be found in different branches of natural history. One of these is the similarity of

[1] Psylla pyri. [2] Livia juncorum. [3] Jassidæ.

the habits of the cuckoo among birds to those of the cuckoo-bees[1] in their relations to the humble-bees.[2] The bird cuckoo is so unlike the small birds it victimizes, both in size and colour, that it is not infrequently mistaken for a hawk; but the cuckoo-bee is so like its victim that only a student of bee-life could tell which was which. But if one examines the hind-legs of the two the difference is at once manifest in the presence and absence of the pollen-basket respectively. It was formerly thought that these cuckoo-bees—of which we have five British species—were merely messmates of the humble-bees, in some way making return for their food and lodging in the humble-bee's nest; but there can be no doubt that they are actual parasites, thriving at the humble-bee's expense, and bringing about the deterioration or absolute ruin of the colony. The cuckoo-bees are all males and females; there is no worker class. Each species in colour mimics that species of humble-bee upon which it sponges, but is usually somewhat larger. Why there should be this mimicry is not clear, for it does not impose upon the humble-bee. The mother of the colony detects the cheat, and in some species attempts to eject the intruder. But this appears always to result in the humble-bee being killed, and the progress of the colony checked, of course. This apparently is the cuckoo's object. She helps herself to the contents of the honey-pot, and with the humble-bee's wax constructs cells for her own eggs. Her grubs have to be fed by the exertions of the humble-bee workers, and the mother of the colony being dead, there are no more humble-bee eggs to develop into more workers. The presence of cocoons belonging to the cuckoo-bees in the combs of the humble-bees can always be detected by their larger size.

Photo by *H. Bastin.*

EGGS OF THE APPLE-SUCKER.

The first stage in the life-history of the bright little jumping plant-louse of the apple-tree. The eggs, which are here shown greatly magnified, are laid on the back of apple-twigs and branches.

We have photographed side by side one of our commonest species of humble-bees[3] and the particular cuckoo-bee[4] that victimizes it. It will be seen that in general appearance they are exactly alike, and their colouring corresponds. But if attention be directed to the hind-legs an important difference will be noted. The humble-bee has the long, thick joint of the leg broad and flat, and the breadth is increased for practical purposes by a fringe of long hairs. This enables the bee to collect a large quantity of pollen on her visits to the flowers, and she packs it in a large solid lump in this open basket. The cuckoo-bee has the corresponding joint

[1] Psithyrus. [2] Bombus. [3] B. terrestris. [4] Psithyrus vestalis.

of its legs narrower, rounded, and the fringe of hairs is so slight as to be ineffective for such a purpose had the cuckoo any desire to labour. But as a matter of fact she does nothing of the kind, unless it be that she may take temporary refreshment in the shape of nectar from the flowers. The actual labour of providing for her own progeny she leaves entirely to the humble-bees.

The Apollo Butterfly.

For many years, owing to a misapprehension, all the books on the British butterflies included this fine species. Long after the error was discovered the Apollo[1] continued to make its appearance in such works; and one can well understand the reluctance with which more recent authors have excluded it as never having had any real claim to the position. But although we may not in this country see it, more than half concealed by its colouring, sitting on the heads of knapweed, everyone who spends a holiday in the Alpine districts of Europe may enjoy such a sight, for it is a common butterfly on the slopes from a thousand to five thousand feet above sea-level. The female, which is the finer of the two sexes, measures from three to three and a quarter inches across the wings, which are semi-transparent and thinly powdered with black scales on the dirty-white ground colour. The outer margin of the fore-wings is practically scaleless and glossy. There are six irregular black spots on each fore-wing, but four of the five on the hind-wing—of which the three smallest run together—are red, ringed with black, whereof the two largest have white centres. These and most of the black spots are red on the under side, which is the surface exposed when the butterfly is at rest, sucking nectar from the flowers. Then with the wings turned up over the back, the fore-wings slipped within the hind ones, and the antennæ tucked away between them, the wing outline is lost and the coloured spots become part of the flowers among which it is resting. The male is smaller than the female, somewhat whiter because rather more liberally clothed with scales, and all its spots are smaller; but its body and the adjacent margins of the hind-wings are covered with longer hairs. When captured the butterfly pretends to be dead, and waits for a favourable opportunity for suddenly expanding the wings and escaping.

Photo by] [*E. Step, F.L.S.*

THE HUMBLE-BEE AND ITS CUCKOO.

The left-hand figure is that of the humble-bee; that to the right is the cuckoo. Note the difference in character of the hind-legs of the two Insects.

The caterpillar when full grown is a handsome Insect coloured a rich velvety black, spotted with bright orange—warning colours. In the first segment behind

[1] Parnassius apollo.

Photo by] [*Hugh Main, F.E.S.*

THE APOLLO CATERPILLAR

The caterpillar is a handsome, velvety, black creature spotted with bright orange, colours which warn birds and lizards that it is not to be eaten with impunity. Secure in such a livery, it feeds exposed upon stonecrops and saxifrages. In addition it flourishes a danger signal in the form of a forked orange whip, which issues when needed from a slit a little behind t[illegible]

Photo by] [*E. Step, F.L.S.*

APOLLO BUTTERFLY.

A common butterfly in Alpine Europe, which was formerly thought to be a rare British Insect. Its wings are semitransparent, and when the butterfly is at rest upon a flower, only the black-ringed, red spots are noticeable, and these appear to be parts of the flowers around it.

the head there is a slit, from which, when the caterpillar is disturbed, there issues suddenly a forked orange process, something like the tongue of a snake. The only other butterflies whose caterpillars possess such an organ are those of the bird-wings and the swallow-tails. It is probable that it has a defensive value, for when extended it gives off a strong and unpleasant odour. It is analogous to the longer red whips that issue from the forked tail of the puss-moth caterpillar under similar conditions. It feeds upon sedums and saxifrages, chiefly upon the large orpine among the former plants. Another noteworthy fact about the Apollo caterpillar is that, like the caterpillar of the grayling butterfly, when about to become a chrysalis, it spins a slight cocoon, only in this case instead of being buried in the ground, it is spun up between a couple of orpine leaves. The chrysalis, as one may be prepared to expect from this behaviour, does not conform to the angulated type so common among butterflies, but is smooth and rounded like that of a moth, and lies loosely in the cocoon instead of being suspended by the tail. It is coated with a purplish "bloom" of wax, which prevents any moisture reaching the skin of the chrysalis. This, and the outer defence of a cocoon, appears to be necessary in the reeking moisture of its customary habitat.

Ant-Lions and Ant-Lion Flies.

It is rather singular that the name ant-lion, which has been in use for over two hundred years, belongs to the larval stage of the Insect,[1] whilst the ultimate winged stage has, properly speaking, no name at all. We propose to call it the ant-lion fly. This four-winged Insect might easily be taken for a dragon-fly by those who do not notice details. The body is long and slender, and the rather narrow wings are longer than the body. These wings are netted much after the manner of those of the dragon-flies, but they cannot be operated with the same muscular power. During the day these ant-lion flies rest on the foliage, and only use their wings at night, when they are said to chase and eat other Insects. They may be distinguished at a glance from dragon-flies by the possession of two stout, club-tipped antennæ, whilst those of the dragon-flies are poor little threads, scarcely noticeable. But the chief interest in this family centres not in the four-winged flies, but in the larvæ—the ant-lion proper. It is to Réaumur we owe the best account of the proceedings of this astonishing little excavator, and his account,

[1] Myrmeleon formicarius.

though often checked by the observations of numerous present-day naturalists, practically stands untouched. The verification is the easier, because the ant-lion if given a good depth of fine sand will perform his excavating task as readily in confinement as if he were at large.

The egg from which he emerged was laid in the neighbourhood of loose sand, and he issued with inherited knowledge of how to secure his meals. Looking out for a spot where the sand is liable to be frequently wetted by rain, and in the shelter of a tree or rock, he sets about sinking a pitfall. His plump, oval hind-body is broad, and his large head somewhat flattened; and the whole of him is covered with short, stiff bristles. The mouth is closed by compression and never opens; but the jaws are developed into a pair of long, curved nippers with toothed inner edges. Down the centre of each on the under side runs a groove, and another of the mouth-parts is adapted to fit into this, and so convert it into a tube communicating with the otherwise closed mouth. Its victims are impaled by the sharp points of these mandibles and their juices are sucked through the tubes.

The ant-lion's first step towards ensuring a succession of meals, after having selected a suitable spot, is to strike out a circle which is to indicate the circumference of its projected pitfall. It does this by walking backwards and using its hind-body as a ploughshare. Then it proceeds to throw outside this circle all the sand contained within it, and does this by shovelling, using its head as the shovel. By a special provision at the junctions of head, fore-body, and hind-body, the ant-lion is able to jerk its head back suddenly, and this power, which is necessary to its particular mode of procedure, is made the most of. With one of its fore-legs it loads its depressed head with as much sand as it will hold, and then with a sudden jerk the little heap is sent flying beyond the boundary of its operations. It moves all around the circuit of the pit thus shovelling, and then takes a circle just inside the last, the newest one always being made deeper than the one outside it. One need not follow every step of the process, but ultimately the sand has only to be hoisted from the centre, for as it is removed thence it falls down the sides until the pit assumes the shape of an inverted cone with steep, sloping sides. It will be seen that with such a construction in dry sand, any creeping thing that reaches the edge and attempts to look over will have the sand fall beneath its feet, and it will be unable to save itself from going to the bottom. All that can be seen there is a pair of callipers sticking up with their points apart. The ant-lion has buried

Photo by [*H. Main, F.E.S.*

APOLLO BUTTERFLY AT REST.

When at rest, and imbibing nectar from the flowers, the fore-wings are slipped between the hind-wings to make the Insect less noticeable. In this study from life in Switzerland the butterfly has not quite settled, as only one antenna has been tucked out of sight. Natural size.

Photo by] [*H. Bastin.*

THE ANT-LION.

The ant-lion is the larval stage of a large, four-winged fly much like a dragon-fly. Its habit of making pitfalls in loose, dry earth has long been known. The excavation is made by going backwards in circles and pushing the sand aside with its hind-body. In the photograph it is beginning the operation.

himself in the sand and only these are exposed. At least, these are all that show ; but at the base of each mandible is a close cluster of six simple eyes by whose aid the creature knows when to act.

Ants were thought to be the chief victims of this pitfall, but other wingless Insects, as well as spiders and wood-lice, are among those that are seized by the points of the mandibles and not released until life has gone and little but a dry skin is left. The head is placed under it, and it is jerked out of the way. Carcases of this kind about the pit might awaken the suspicions of other prospectors, so they have to be hurled as far away as the ant-lion's muscular power will allow.

Sometimes an Insect of resource, on finding itself slipping down the fatal slope, will make a desperate effort to regain the level ground above, but this attempt is rarely successful, for the ant-lion, feeling the sand roll down upon it in the centre, hastily gets a heap of sand upon its head and jerks it back into the air. Though it cannot take aim, some of the grains will almost certainly fall upon its visitor, confusing him and bringing him within reach of the mandible points. In this style of trapping the ant-lion is occupied for two years, passing the winter in sleep, buried at the bottom of its pit. Some lucky days it has a succession of victims and gorges on their blood ; other days nothing chances to topple over the brink. Throughout all this period there is no expulsion of waste from the creature's body—as a matter of fact

Photo by] [*E. Step, F.L.S.*

SINKING THE PIT.

The ant-lion first strikes out a circular trench by working backwards and using its hind-body as a ploughshare. In this way the circumference of the pit is marked out, and by making successive rings inside this and throwing out the sand by jerking the head, a conical pit is sunk.

By Theo. Carreras.

A Long-necked Ant-Lion.

This remarkable Insect, which is found among the tombs and pyramids of Egypt, is believed to be an early stage of the winged Insect in the air. The extraordinary elongation of the fore-body behind the head is probably to enable it to seek Insect victims in deep crevices. It is represented on a large scale, its actual length being about half an inch.

there is no channel for it. Nature has been so careful that the ant-lion's pit should not be polluted by such waste, that arrangements have been made for its retention in the hind-body. It is not until the ant-lion fly emerges from the chrysalis that it is got rid of.

The full-grown ant-lion is provided with a spinning apparatus on the hind-body, with which, when it feels that its feeding days are over, it elaborates a cocoon beneath the sand, in which it changes to a chrysalis. It still has a pair of mandibles, but these are much shortened, and intended to enable it to cut through the cocoon just before the winged fly is ready to emerge.

It is strange that in places where the ant-lion is quite plentiful its fly should be rarely seen. This may be due to retiring habits, or possibly few of the "lions" manage to complete their development to the winged stage. More than three hundred different species of ant-lions are at present known, but they are not all makers of pitfalls. Some of them lead a roving life among grass and undergrowth, lying in wait for their prey. Some of these wanderers, having no necessity for dry sand, are found in quite damp places. The species are found widely distributed in temperate and tropical regions, and one is found as far north as Southern Sweden, though none is found in Britain.

The related families of the ascalaphids and nemopterids are very similar in form to the ant-lions, but the larvæ do not make pitfalls. The winged ascalaphus is still more like a dragon-fly in build, but has clubbed antennæ much longer than those of the ant-lion fly. Nemoptera is a peculiarly graceful fly, for its hinder wings are narrow, strap-shaped, and of extraordinary length. The mouth is formed into a beak, something like that of the scorpion-fly. Several species occur in the Mediterranean region. An extraordinary Insect supposed to be the larva of one of these was found in the Egyptian pyramids where sand had drifted in and accumulated. It has a head and body much like those of an ant-lion, though with longer legs:

Photo by] [*H. Bastin.*

THE PITFALL COMPLETED.

The pit when finished is in shape like a low inverted cone. It is often sunk under the shelter of overhanging rocks, for it is essential that the soil should remain dry and loose. Any creeping thing that comes to the edge is sure to lose its hold on the uncertain material, and the ant-lion's continuous throwing of sand from the centre helps to bring the trespasser within reach of his jaws.

but part of the fore-body is scarcely thicker than its thighs and drawn out to one-half the entire length of the Insect, so that it looks like an extravagant neck.

Photo by *H. S. Cheawin, F.R.M.S.*

THE ANT-LION'S JAWS

The head of the ant-lion is here seen magnified seventy times, to show the jaws and their connections clearly. There is no mouth in the usual sense of the word. All the food of the ant-lion is necessarily of a fluid nature, and is extracted from its prey by means of the sharp-pointed, curved mandibles, whose tips are perforated. The juices of the victim pass along a groove into the closed mouth; and the two ribbon-like processes, shown separated in the photograph, move slightly backwards and forwards in this groove to regulate the flow.

The Blister-Beetle and the Oil-Beetle.

The blister-beetle[1] has long been familiar from its use in medicine as a blistering agent, and under its alternative name of Spanish-fly as a reputed producer of hair on bald heads. But its life-history is more interesting than its uses. It abounds in Southern Europe and South-west Asia, and occurs, though a doubtful native, in the East and South of England. It is a slender beetle, of a shining bronze-green colour, and about three-quarters of an inch in length. It feeds upon the leaves of ash, privet, and lilac. The minute grub that hatches from the egg is unlike the larvæ of most beetles, having six long legs, which fit it for activity, strongly protuberant eyes, and two long, tail-like appendages to the hind-body. Its main object in this stage is to come across a small bee named ceratina, which nests in the stems of bramble and lilac. When it meets with this bee it attaches itself to the hairs of her body, and so gets conveyed to her nest. Taking up its position in the bee's cell it waits till the bee lays an egg, and then indulges in its first meal. This consists of the bee's egg, and it is provided with long, sharp mandibles, apparently for the special purpose of piercing the shell, for it has no other use for them. Having finished this repast, and being now five or six days old, it casts its skin, and becomes a little white grub with six feet. Its mandibles have become short and blunt, for its food in this stage is semiliquid—the honey stored up by the bee for the sustenance of its own grub—and requires no cutting. Five days later it casts its skin again, and now its jaws are still more blunt and its eyes less prominent, for in the darkness of the bee's cell it has no need of them. This phase of its existence lasts five days

[1] Lytta vesicatoria

Photo by] [*E. Step, F.L.S.*

ASCALAPHUS.

The early stages of this Insect are similar to those of the ant-lion; but finally it has a furry body, long, clubbed antennæ like those of a butterfly, and its fine wings are blotched with black and pale yellow.

only, when it casts its skin for the third time and now quite alters its form. It has become much like the grub of one of the dung-beetles, but its eyes have now disappeared altogether. It concerns itself no more with feeding, but makes its way out of the bee's nest, and descends to the ground. Here it excavates a small cavity, and at the end of five days its skin has become hardened much after the manner of a fly's grub when it is about to change into the chrysalis; but the case of the blister-beetle's grub differs from the puparium of the fly in the fact that it has four little protuberances on the part that was the head, and its feet have been transformed into six little warts. It is yellowish-white in colour and exudes a clear fluid.

But there is as yet no change into the chrysalis stage as in the case of the fly. The grub has merely cast its skin again, but this time without breaking it, and it remains in this shelter all through the winter. In spring it breaks open the hard case and walks out, in general appearance much like it was when it went into the ground; but its mouth-parts have become still more rudimentary in character and its feet are now two-jointed, but poorly developed. It remains quietly underground in its cell for about two weeks, and then changes into an ordinary beetle-chrysalis. This is the last stage but one, and it extends to about twenty days; then the bright little beetle emerges and proceeds to feed upon the leaves of its food-plants and to find a mate. Owing to its shining green colour it is not easy to see the beetle upon the leaves, but its presence is revealed by a peculiar odour it gives forth.

NEMOPTERA.

This represents another group of the ant-lions, though they do not construct pitfalls. In the adult state they are remarkable for the slender shape and great length of the hind-wings.

The remarkable thing about this series of changes is what has been called the false-pupa stage. When it assumes the form of a fly's puparium, one would expect that it would change into a chrysalis within. A similar stage—as we shall see occurs only in a few other beetles, and these all have somewhat similar habits. As the metamorphosis departs from the usual course of the Insects which exhibit three distinct changes of form after the egg-stage, it has been described as hyper-metamorphosis.

Among the beetles that are well

Photos by] *H. B.*

THE ANT-LION FLY

Even the contrast between the forms of the caterpillar and the butterfly is not greater than the unlikeness between the fat, squat ant-lion and the airy gracefulness of its winged condition. It is surely one of the marvels of Insect life that these expansive and wonderfully netted wings, packed tightly within the narrow confines of the chrysalis skin, can be spread out without damage or crumpling as shown here. The figures are about twice the natural size.

THE BLISTER-BEETLE.

So called from its medicinal use in producing Blisters. Under the name of Spanish fly it has also had repute as a hair-stimulant. About three-quarters of an inch in length, it is of a strong bronze green colour. Its life history is more remarkable than its uses.

known to all country ramblers is the oil-beetle,[1] though few who are not specially interested in the study of beetle life know anything of its remarkable history. There are numerous species of oil-beetles—we have seven of them in our own country—and a common species may frequently be seen in spring dragging its bloated, blue-black body across country paths. It is probably a female, seeking for a favourable spot in which to deposit her eggs. These she plants in batches in holes in the ground; and it is calculated that her total output of eggs amounts to about ten thousand. Now seeing that these beetles exude an unpleasant, oil-like, yellow secretion from the joints of their legs which renders them objectionable to creatures that feed upon Insects, there does not at first sight appear to be any need for such lavish fruitfulness. What becomes of this progeny? The oil-beetles are not Insects that appear in swarms. It is estimated that not one in a thousand of the tiny grubs that issue from these minute eggs ever gets beyond the first larval stage. Probably, that estimate is far too high, for we do not find the species any more plentiful to-day than they were forty years ago. One may safely say that out of those ten thousand eggs there is produced only one female beetle that survives to lay eggs in her turn. What becomes of the nine thousand nine hundred and ninety odd will appear, and give point to Tennyson's lines:—

> "Nature lends such evil dreams.
> So careful of the type she seems,
> So careless of the single life."

The oil-beetle's eggs hatch, and, like those of the blister-beetle, give origin to larvæ that bear little likeness to the usual types of beetle-grubs. They have six long legs, and are quite active little runners and climbers. They are long-bodied, but this length extends only to about one-tenth of an inch. As soon as they have escaped from the egg-shells and the earth they start climbing the stems of flowering plants and continue until they have reached the flower. Here they wait patiently until some other Insect visits that flower in quest of nectar or pollen. When such a visitor arrives the larva at once clings to its body and is carried away unnoticed. This form of grub is called a triungulin, because each of its six feet ends in three claws, and it appears to be formed solely with a view to this one indispensable act of its life—the clinging to a particular kind of solitary bee. But it is here that instinct fails it; and in this failure we find the explanation of the great fecundity

[1] Meloë.

of the beetle. In order that the triungulin should justify its existence it should cling only to a bee of the genus anthophora or the genus andrena, that being its only avenue to success in life. As a matter of fact it will cling to any Insect that is sufficiently hairy to enable its hooked feet to hold on. But unless it catches the right bee its labour is in vain, and it perishes, the success of the operation depending upon the triungulin being conveyed to the bee's nest.

Let us suppose that the particular individual in which we are interested has boarded the right bus, so to speak, and arrived in the burrow of the anthophora, where there is a cell fully provisioned with honey, upon which the bee now lays a floating egg. The triungulin is waiting for this act, and before the bee has time to seal up the cell, it slips off the bee and balances itself nicely upon the bee's egg. At this stage of its existence it is incapable of feeding upon honey. There is only one thing in the world that will serve for its first meal, and if it does not secure this it perishes. That one thing is the bee's egg, and this obtained it sets to work to devour it. A bee's egg may appear to be a very small matter for a meal, but it serves the triungulin for several days; and then this little gourmet casts its first skin and appears in a different form. It now more closely resembles the grub of the cockchafer, and is capable of floating on the honey and of feeding upon it. But how many of its kindred, hatched from the multitudinous eggs of the same mother-beetle, have perished without getting so far on their journey! In due time it consumes all the honey, changes into a false chrysalis, when it resembles the legless grub of a bee, then into the true chrysalis, and finally into a perfect oil-beetle.

There is another beetle—rare in this country—named sitaris[1] which curiously goes through a similar experience, also in connection with an anthophora-bee. It is more plentiful in the South of France than it is with us, and Fabre has managed to work out its life-history with tolerable completeness, a matter of considerable difficulty, as will be understood from the following brief statement. Sitaris is not nearly so prolific as meloë, but she lays at least 2,000 eggs, and takes

Photo by [*E. Step, F.L.S.*

VIOLET OIL-BEETLES.

A less-common and more slender species, whose life-story is similar to that of the common oil-beetle. The two sexes are here shown the male on the left, the female on the right. A distinguishing difference between the sexes is afforded by the antennæ of the male

[1] Sitaris humeralis.

care to place them in the ground very near to the burrows of anthophora. This probably explains the smaller number of the eggs, as it will be seen that the chances of a grub getting attached to the right bee are much greater. The egg-laying takes place in August, and the eggs hatch about the end of September. There are well-stored honey-cells close at hand, and one would expect that the little black sitaris triungulins would at once go to them and begin feeding. But the sensation of hunger is at present unknown to them; they simply huddle together, and pass the winter where they were born. In spring—about April or May—they wake up and begin to look about them. Should any hairy Insect come within reach, whether it be bee, fly, or beetle, they seize upon it. Here is another failure of "unerring instinct," for the vast majority seize the wrong carrier, and get no further on their proper road. The first of the new anthophoras to issue from their cells are males; and as these hang about in their burrows for several days waiting for their wings and integuments to harden properly, a number of the triungulins have a good opportunity for attaching themselves, and they take advantage of it. But they appear to know that they have not yet got hold of the Insect that can directly help them to work out their destiny. About a month later the female bees emerge, and as these are being courted by the males the triungulins contrive to transfer themselves from one to the other. The females busy themselves, of course, in the making of cells, and the triungulin, knowing that it has reached its destination, gets off as soon as the bee has laid an egg on the store of honey. The cell is sealed up, and the little sitaris proceeds to feed upon the egg. This repast lasts for about eight days, and then the sitaris casts its skin, and emerges as a very different creature, with exceedingly short legs and a shortened, inflated body, which enables it to float on the honey with safety. Its spiracles or breathing-holes are placed along each side of the back, instead of along the sides as usual in larvæ, so that it can breathe without risk of the spiracles becoming clogged by the honey. The only exertion demanded of it is the sucking up of the honey; and there is enough of this to occupy it for about forty days. This brings it to the middle of July, when it changes again, becoming much like the puparium of a fly. In this condition it may remain for a month, or for eight months. Those of the shorter period return to much the same condition as that in which they consumed the honey. A little later it becomes a chrysalis, and in August or September it emerges as a sitaris beetle. The tardy individuals pass the winter in the false-pupal condition and finish their changes in spring. This, it will be seen, is one of the most complicated and remarkable of Insect life-histories.

Photo by] [*E. Step, F.L.S.*

COMMON OIL-BEETLE.

A common Insect by the side of paths in spring. It gets its name from its habit of exuding a yellow, oily fluid with an unpleasant odour from its leg-joints. Its life-history is one of the most remarkable even of Insect stories. Twice the natural size.

THE LIFE-HISTORY OF THE BLISTER-BEETLE.

In its earliest stage the grub of the blister-beetle contrives to get on the back of a certain solitary bee, as shown. On arrival at the bee's nest, excavated in the stem of a bramble, the grub gets into a cell where a bee's egg is floating on honey. Whilst the egg-shell is employed as a raft its contents are eaten; then the grub changes its form to enable it to float on the honey, which it gradually consumes. Other changes of skin bring changes of form, until the grub is full-grown, when it leaves the cell and walks down the stem to the earth, where it constructs a cell of its own and becomes a chrysalis. Two fully developed blister-beetles are seen at the top of the picture. Twice the natural size.

A somewhat similar story is told of an American beetle named Epicauta,[1] whose food in the grub stage consists of the buried eggs of the Rocky Mountain locust;[2] and the life-history of our wasp-nest beetle,[3] as elucidated by Dr. T. A. Chapman, is in general much like it, making allowance for the different character of its food. Our wasps do not fill their cells with honey as do the bees, but feed their grubs upon partly digested Insect food from the mouths of the workers. The wasp-nest beetle was long known to pass its larval stages in the wasp cells and to be parasitic upon the wasp-grubs, but nothing definite was known as to its transformations until 1870, when Dr. Chapman published the results of his patient observations. It is a slender beetle about half an inch long, of a bluish-black colour, and with the wing-covers running off to a point behind, leaving a wide gap between them, much as in the case of the oil-beetle. But the oil-beetle's wing-covers cover no wings, and are themselves soldered together at the base so that they are not moveable. The female wasp-nest beetle is believed to deposit her eggs in spring or summer near the entrance-holes to the underground nests of the common wasp and the equally common German wasp.[4] They hatch into little creatures a fiftieth of an inch long, and much like the triungulin of the oil-beetle, black in colour. The two or three claws of the feet are supported by a large transparent sucker, and there is a similar sucker on the last segment of the hind-body. "The little animal frequently stood up on this, and pawed the air with its feet, as if in search of some fresh object to lay hold of." Each segment of the hind-body bears on each side a short spine, which points backwards.

Photos by] [*E. Step, F.L.S.*

SITARIS-BEETLE.

This beetle has a life-history in its main lines similar to that of the oil-beetle, its victim being a solitary bee. The story is told in a succeeding plate. The two sexes are shown here, four times larger than life-size.

This little creature is supposed to make its way afoot down the passage into the nest chamber of the wasp, and to climb up into the combs and enter a cell in which there is a nearly full-grown wasp-grub. Attaching itself to this grub the intruder bores into its back a little behind the head, and enters the body, remaining a little below the skin. It feeds for a time upon the internal parts of the wasp-grub, and

[1] Epicauta vittata. [2] Caloptenus spretus. [3] Metœcus paradoxus. [4] Vespa vulgaris and V. germanica

By Theo. Carreras

THE GREAT GREEN GRASSHOPPER.

This fine Insect, the largest of our native Grasshoppers, is not found among the grass, but in bushes and trees, where it is largely engaged in the capture of other Insects. The individual shown above, that has captured a marbled-white butterfly, and is tearing off the wings prior to eating the body, is a female, as denoted by the sword-like termination of the body. A male is shown above. Note the great length of the antennæ, which place this species among the long horned grasshoppers

Photo by] [*E. Step, F.L.S.*

WASP-NEST BEETLE.

A rare British beetle that might easily be mistaken for a fly. In its grub stage it lives in the nest of the wasp, feeding upon the wasp-grubs. It is shown four times the actual size.

then breaks out again through the fourth ring, apparently for the sole purpose of moulting. Although it has not yet cast a skin, its appearance is utterly altered by the abundant food it has imbibed. The skin is so distended that the black colour, which formerly covered the whole triungulin, now appears only as isolated patches in the middle of each segment. Though the little fellow is now ten times its former size, these black patches remain the same size as they were when it went into its host. The beetle-grub is now one-sixth of an inch long. At the same time that it emerges through the skin of its victim it casts its first skin, and becomes a more ordinary-looking grub, but with poorly developed legs. It attaches itself by the mouth to the under side of the head of the wasp-grub, and lies there "like a collar" until its next moult, "sucking rather than eating." When about a quarter of an inch long it moults a second time, and becomes much like the grub of a wood-wasp.[1] By the time it is ready for its next change it has entirely eaten the wasp-grub, and has become large enough to fill the top of the cell of its victim, where it changes to a chrysalis. The whole of this life-history from the hatching of the egg to this point is comprised in one week.

Although this article was supposed to be about the blister-beetle and the oil-beetle only, we have thought it well to include these other beetles of similar parasitic habit, as parasitism is a very rare phenomenon among beetles, and the habit produces such similar results in those that practise it, though they are not all closely related.

In the vast majority of beetles the grub is either an active, slender creature with six fairly long legs, or it is somewhat inactive and fat, with very short ineffective feet, or none at all. It may be surmised that the first-named was the type of the primitive beetle-larva, and that at a later stage in the evolution of the race

AN ENEMY TO LOCUSTS.

The epicauta-beetle lays her eggs near the buried egg-masses of the Rocky Mountain locust, and when they hatch the grubs devote themselves to feeding upon the locust eggs, and so help to keep down the numbers of a pest whose ravages have at times caused serious financial difficulties.

[1] Crabro

the type changed to suit a more sluggish mode of life. In the examples we have given of these parasitical beetles we see this evolutionary progression being repeated in each individual, as though it were an object-lesson retained by nature to let us see just how the change from one type to another may have been effected in the branching off of families from the primitive beetle stock. In the majority of beetle-larvæ the triungulin stage appears to have been suppressed, unless the equivalent of it is passed through before the egg hatches.

The Snake-Fly.

The snake-fly[1] gets its name from its remarkable appearance, due to the elongation forwards of the fore-body and of the head behind, which gives a miniature resemblance to the fore-part of a snake. The four wings are much like those of the alder-fly, and the Insects are much about the same size—that is, one inch across the expanded wings. The female snake-fly has a long, slender egg-placer of similar length to the hind-body. What the object of the long neck is, does not appear to have been satisfactorily explained, though it is tolerably certain that there is some reason for it, which will be shown when more attention to its life-history has been paid by observers.

Wasp-nest Beetle.
The female beetle lays her eggs near the entrance to an underground wasp's-nest, and the young grubs make their way to the interior and climb into the nest. Here they attack the nearly full-grown grubs of the wasps and consume them as food. The two sexes are shown enlarged to three times the natural size.

The eggs, which are laid in batches in the crevices of decaying wood, are long cylinders with a small knob at the upper end. We give a photograph of those of the spotted-necked snake-fly,[2] enlarged.

The larva is chiefly noticeable by reason of its big head and the large size of the first segment of the fore-body. There are no appendages to the hind-body, as in the alder-fly larva, for the good reason that the snake larva is not an aquatic, but lives in decaying wood, where it preys upon the numerous Insects there to be found. When it has made the mistake of attacking an Insect larger or more capable of offence than itself, it has a curious habit of wriggling out of the way, backwards, rather than turning tail. By this method it has the advantage of retreating with its face to the foe. It is a very voracious creature, but like many others of that character it can upon occasion fast for long periods. Larvæ that have been kept in confinement for observation purposes, and then possibly forgotten, have survived without food for nine months. Such unfortunate individuals lose bulk, of course, but appear to have the power to make up for lost time when they get the opportunity. It changes into a chrysalis without forming any cell or cocoon. In this

[1] Raphidia notata

[2] R. maculicollis.

THE OIL-BEETLE AND THE SITARIS-BEETLE.

In the upper half of the picture is seen the common oil-beetle, and some of its earlier stages. On the hawkweed flower several grubs are waiting for a mining bee, to whose hairs they can attach themselves, and so get carried to the nest. In one cell of the nest a grub is feeding on the bee's egg, which floats on honey. In another cell it is seen as a chrysalis, after passing through several intervening stages. The lower division illustrates similar stages in the life-history of the sitaris. About twice the natural size.

Photo by] *H. Bastin.*

THE SNAKE-FLY.

The remarkable feature of this Insect is the long, neck-like prolongation of the body and the shape of the head, which give the foreparts a miniature resemblance to a snake. The photograph is two and a half times larger than life-size.

stage it retains the general form of the larva, but has the legs and eyes of the perfect Insect, together with wing-pads, of course; and in the case of the female there is also the long egg-placer already developed, but now laid along the back. The retention of the larval jaws in this stage is remarkable, and appears to indicate that formerly the Insect made a cocoon from which its escape was effected by the use of these cutting-jaws, as is the case with its relative the ant-lion. A short time before it changes into the snake-fly the chrysalis regains the use of its legs, and runs about.

There are three other native species, but the differences between them are not very striking, and are more likely to appeal to the specialist than to others. Many other species are known from different parts of the northern hemisphere, but their life-history is not known; probably it agrees in the main with what has been stated of our native forms. The snake-flies are not related to the true flies—those with two wings only, such as our house-flies. It will be seen at a glance on comparing their photographs that the wing structure and the network of "nerves" is altogether different, to say nothing of the more important evidence afforded by the early history of the two groups. The snake-flies belong to the order of nerve-winged Insects,[1] which includes the ant-lions and lace-wings.

Photos by] [*W. J. Lucas, F.E.S.*

EARLY STAGES OF THE SNAKE-FLY.

The left-hand figure shows the grub of the common snake-fly, and on the right is the chrysalis of a smaller species, the spotted-necked snake-fly; the first enlarged three times, and the second four times.

The Pasha with Two Tails.

One of the most striking of European butterflies is a near relation to our purple emperor, but the people of Southern France call it the pasha with two tails.[2] They might with more fitness call it the pasha with *four* tails, for the hind-wings have each two tails, and two and two make four. However, it is something to have a common name of any sort, and one must not be too critical of such names when they do exist.

The pasha is the only European

[1] Neuroptera. [2] Charaxes jasius.

THE WASP-NEST BEETLE AND ITS LIFE-HISTORY

In the upper part of the picture a wasp engaged in scraping wood is surrounded by newly-hatched grubs of the beetle, which cling to it, and get carried to the wasp's nest. In the first of the enlarged cells below one has got under the skin of the wasp-grub. In the second cell it has changed its form and feeds externally. In the third cell the beetle-grub has grown to a large size, and is sucking the dwindled wasp-grub; finally, it has become a chrysalis. The male (left) and female beetles are shown above the cells. About four times the natural s

representative of a numerous genus of large and handsome butterflies that inhabit the African and Indian regions. It measures about three inches (from two and a half to three and a quarter) across the expanded wings. All the wings are brown in colour, with a kind of marginal band of orange; a row of six orange spots on the fore-wing, parallel to this band; and four small blue spots within the marginal band of the hind-wings, which are edged with a narrow line of black outside the orange. The tails are also black. The under side shows a beautiful but complicated pattern of spots, bands, and streaks of grey, maroon, brown, white, orange, and black. The caterpillar is green and shagreened;

Photo by [*C. B. Williams, F.E.S.*

EGGS OF SNAKE-FLY.

A group of eggs of the spotted-necked snake-fly, from nature, in decayed wood of a tree stump. Enlarged to twenty-three times the natural dimensions.

the head lighter in tint, with four yellow, horn-like points, which are tipped with red. A line of yellow extends along each side from near the head to the hinder extremity. On the back are two orange rings. It feeds at night on the leaves of the so-called strawberry-tree,[1] with which its colour harmonizes; so also does that of the chrysalis, which hangs from a twig and might be overlooked as a curled leaf. Its wing-cases are slightly tinged with blue.

The pasha is very rapid in its flight, and very difficult to capture. It habitually flies high, like the purple emperor, and like that royal butterfly chiefly comes

[1] Arbutus unedo.

Photos by *H. Main, F.E.S.*

LIFE-HISTORY OF THE PASHA WITH TWO TAILS.

The caterpillar is of a rich green that harmonizes with the colour of the arbutus-leaves upon which it feeds. It is active only at night, resting all day in the attitude shown. In the second photograph it is suspended, and about to change to a chrysalis. In the next that change is completed, and the chrysalis hangs only by its tail-hooks. The newly-emerged butterfly, clinging to the chrysalis skin, is shown in the fourth photograph.

Photo by] [*Hugh Main, F.E.S.*

THE PASHA WITH TWO TAILS.

The pasha with his wings extended, showing the markings of the upper side. The wings are brown, margined with orange, and spotted with orange and blue. The tails, of which there are four instead of the two indicated by the name, are black. It is a high and rapid flier, and very difficult to catch.

to earth when attracted by something that we should consider unsavoury. The collectors avail themselves of this weakness by laying snares of rotten cheese in the neighbourhood of its haunts, and so attracting it within reach of their nets. African species of the same genus, however, though fond of such things, and drinking of the juices that exude from trees, are also said by Trimen to be attracted by honey, and the smaller ones to be in the habit of visiting flowers for the sake of their nectar. Some of these African species are much larger than the European pasha, and have their wings glossed with blue or purple, like our purple emperor. In some species the sexes differ considerably in form and colour.

Stick-Insects.

Although related to the mantids and much more closely to the walking-leaf Insects, the stick-Insects[1] differ widely in appearance from both. They are very slender and of relatively great length. In all the species that possess wings the wing-covers are very small and quite inadequate for the office of covering the wings. But in many species neither wings nor wing-covers are developed, and in these cases, of course, the resemblance to a vegetable stem is enhanced by the deficiency. This resemblance is further helped by the fact that all the limbs are very similar in shape, and usually thin. They are mostly held at such angles as would suggest side-shoots from the supposed twig or branch represented by the Insect's body. The hind-legs are not developed for leaping as in their relations, the grasshoppers, nor are the fore-legs adapted for seizing prey as in their nearer kin, the mantids. They are all purely vegetable feeders. Much of the

Photo by] [*H. Main, F.E.S.*

THE PASHA WITH TWO TAILS.

This photograph exhibits the wonderful colouring of the under surface, which is a beautiful but complicated pattern of spots, streaks, and bands of grey, maroon, brown, white, orange, and black.

[1] Phasmidæ.

A Long and Slender Stick.

Space prevents the showing of this Insect with any near approach to the actual size. The body alone is a foot in length; and it would need a page three times the present height to accommodate legs and body. It is a native of Malaya

attenuated, stick-like appearance is due to the elongation of the fore-body, the portion to which the legs and wings are attached. In Insects generally this fore-body consists of three parts, which have definite names in entomological terminology. In the stick-Insects the first section[1] is always very small, the middle portion[2] very long, and the hind portion[3] less than the middle one. The lower portion of the front pair of thighs is often more slender than the remainder of the joint, to enable the fore-legs to be pressed close to the head and extended straight in front, thus hiding the long antennæ and making the Insect still more stick-like.

The majority of the stick-Insects are natives of the tropics, but several small species are found in Southern Europe. Probably the best-known species is one from India[4] which has been largely reared in captivity by entomologists in Britain. In all the species the females appear to be much more numerous than the males, but in that just mentioned we believe not a single male has appeared among the many thousands that have been born in this country. In spite of this fact the females go on producing fertile eggs, and the breeder—after supplying all his friends with eggs or young—is soon at a loss to know what to do with an abundant surplus. Judging from our experience of this Insect, which feeds indifferently on privet, rose, or bramble in this country, feeding is its one occupation, and this is pursued mainly at night; during the day it remains inactive on its food-plant. Its favourite attitude is with the head downwards, and in this position the females drop their eggs singly, taking no trouble, as most Insects do, to ensure their safety by burying them or gluing them to the food-plant. There is no doubt that there is method in this seeming madness. The eggs—which are laid at intervals, and not in batches—are separated by this treatment and there is less likelihood of the young being overcrowded. Each egg is enclosed in a horny capsule of a brown colour, which might easily be mistaken for a seed of one of the pea family. To help out this likeness there is on one side of the capsule a scar-like mark, such as one finds on leguminous seeds, marking the point of attachment to the pod. The reason for such resemblance is hard to seek. It has been suggested by Göldi that it is in order to deceive ichneumon-wasps, but it is well known that ichneumons know these capsules quite well and lay their own eggs in them. The resemblance, though it might protect them from Insect-eating birds, would lay them open specially to the risk of being consumed by seed-eaters. The egg-capsules of all the stick-Insects appear to conform to this likeness to seeds, so there is probably a good reason for it, which has not yet been discovered. In the case of dixippus the capsule is actually made conspicuous by a polished, yellow, bead-like addition to the lid, as though it were intended as a handle by which the lid could be lifted. When the egg hatches the young stick pushes off this lid easily

Photo by] [*E. Step, F.L.S.*

THE BIRTH OF A STICK-INSECT.

Each egg of the stick-Insects is contained in a hard capsule which is much like a seed. When the egg hatches the young stick is a mere thread, but by the time it has pushed off the lid of the capsule and got out it has increased greatly in size. Our photograph was secured before the hind-feet were free, and shows the disparity in size between the egg-capsule and the Insect that has just issued from it.

[1] Prothorax. [2] Mesothorax. [3] Metathorax. [4] Dixippus.

and emerges, but as a rule it has some difficulty in getting rid of the capsule, the hooks of one or both of the hind-legs catching probably in the egg-skin. Now the egg-capsule measures 3 mm. in length, and the newly emerged stick is 10 mm. in the length of its body, not taking the long antennæ and legs into account. Of course, the discrepancy in size between the capsule and the young is explained by the fact that considerable expansion has taken place during actual emergence. Before emergence, for example, the three pairs of legs are fairly close together, but during the struggle to free itself from its prison the two hind-joints of the middle-body lengthen and separate the legs considerably. The young stick grows rapidly, and casts its skin several times before arriving at full size and egg-laying capacity. But in the species described there are no external marks to indicate the larval, nymphal, and mature stages: size is our only guide.

A Winged Stick-Insect.
The palophus, which is a native of West Africa, is one of the largest of the stick-Insects, measuring about a foot in the length of the body. The extension of the fore-limbs in front, as usually carried, adds another half foot to the apparent length. This is a good example also of those "sticks" in which the wings are fully developed. The wing-covers, as will be seen, are very small.

It is worth remarking that these Insects resemble crabs and lobsters in one respect—that is in the restoration of lost limbs. It sometimes happens that in moulting there is a difficulty in getting one of the limbs free from the old skin, and in the effort to do this the limb breaks off. We have sometimes suspected, too, that occasionally one individual displays cannibalistic tendencies and bites off part of the limb of a sister. However, if the loss has occurred during the early part of the cripple's life the defect will be put right before the stick dies of old age. At the next change of skin a new limb will make its appearance on a reduced scale, and at the following moult it will be less out of proportion to its fellows. But if the accident happens later in life there are not sufficient moults to enable the process to be completed. To an inactive creature like a stick the deprivation of a limb or two does not matter greatly: it appears to get along comfortably with four or five.

The feet of the stick-Insect end in two sharp hooks, and between them is a little cushion. These arrangements enable it to take hold rapidly, and to retain that hold securely in spite of jerking of the branch to which it is clinging. The fore-part of the body of dixippus is covered with minute points, which might be the beginnings of spines on a twig, but as they are so small as scarcely to be noticed without a lens, they cannot be considered as having any value in heightening the resemblance to vegetable growth. But they show a tendency which is more manifest in some of the large tropical species, where spines are so well developed as to be an absolute protection against any Insect-eating bird or mammal that was fully aware of the real nature of these fraudulent sticks. An example of these spiny sticks will be found figured on page 133, and another appears at the top of the coloured frontispiece.

Photo by] [*E. Step, F.L.S.*

A Domesticated Stick-Insect.

In recent years this Indian species has been reared extensively in this country, its sluggish habits and the absence of wings making it amenable to close confinement. In almost all cases the individuals are females, the male having been seen on two or three occasions only; nevertheless, the females produce an enormous number of fertile eggs. The hatching of an egg of this species is shown on page 130.

In the winged species the wings are larger and more perfect in the males; and there are species in which only this sex is winged. Brown and green are the prevailing tints of the stick-Insects; and these colours vary a great deal with the growth and habits of the Insect, and, it is suspected, with the seasons also. An infant stick when it leaves the egg on the ground and climbs up the stem of a shrub is brown, but becomes green when feeding among the leaves, and turns brown again in later life when it has to mimic a twig of fair thickness. Some of them have their brown mottled with green markings, which resemble the minute liverworts which cover the stems and leaves of the jungle flora. Many of them have the unpleasant habit of ejecting an acrid and evil-smelling liquid from glands on their fore-body. It is said that this fluid getting into the human eye has caused blindness. Although, as stated, there are European species, not one is found as a native of Britain.

The walking-leaf Insects are regarded by systematists as belonging to the same family as the stick-Insects: but they present so different an appearance that we reserve them for separate treatment.

Gray's Spiny Stick-Insect.

Some of the "sticks" are liberally armed with sharp spines, which increase their resemblance to the thorny bushes on which they feed. They also help, probably, as a protection against enemies. It will be seen that in this Bornean species the joints of the body are not drawn out so much as usual and are much stouter. It is nearly a foot in length, and two inches across the middle of the body.

Photo by] [*Harold Bastin.*

A Foraging Ant.

There is no certainty as to the exact species of ant referred to in the account of the Trinidad spring-cleaning, but in the opinion of "Amazon" Bates it was an eciton or foraging ant, such as is represented in this photograph in the winged condition, twice the actual size.

Ants as Spring-cleaners.

Anglo-Indians tell us how, upon occasion, ants other than those that nest in the walls or under the floors of their bungalows, pay a visit from outside, and make a deadly onslaught upon the cockroaches, crickets, and other domestic pests. But it is in tropical America that this kind of thing is done at times on a grand scale. Madam Merian, who visited Surinam at the very end of the seventeenth century, tells us of a large species of ant that "when they issue from their excavations, which they do twice in the year, their numbers are so great that they fill the houses, and run from one apartment to another, killing all the smaller animals and sucking their juices. . . . Even man himself is obliged to take flight, such multitudes traverse the houses in all directions. When one house has been in this way stripped and cleared, they pass on to the next, till at length they return to their holes."

There is no definite indication of species in this reference, and many authorities have been disposed to cast doubt upon Madam's veracity, owing to the fact that subsequent observers have failed to substantiate her statement that the lantern-fly is a luminous Insect. But Lacordaire, though he denies that these ants of visitation, as Madam Merian called them, behave in this way as a habit, but only when there is scarcity of food out of doors, states that he witnessed such a visitation in Cayenne. Bates is of opinion that the ant referred to was one of the wandering or foraging ants,[1] but he says that during his long stay on the Amazons he heard of no instance of their entering houses. On the other hand, a Mrs. Carmichael has left a vivid and detailed account of the manner in which an army of these ants —which she calls "chasseurs"—effected a most salutary "spring-cleaning" of her house, Laurel Hill, in Trinidad, and by great good fortune Messrs. Kirby and Spence have handed that account on to future generations by quoting it in their classical "Introduction to Entomology." There are certain points in it, such as the reference to the presence of the blackbirds—"never seen but at such times" —which agrees so closely with Bates' account of the ant-thrushes, that they give it the stamp of authenticity. It is a long account, but is really well worth reproduction in full, for Kirby and Spence are only read by the elect in these days.

[1] Eciton hamatum, or E. drepanophora.

Space, however, compels us to abridge it somewhat. The presence of the birds first attracted Mrs. Carmichael's attention.

"I asked the house-negress, who at that moment came up from the garden, what could be the cause of the appearance of those blackbirds? She said 'Misses, dem be a sign of the blessing of God; dey are not de blessing, but only de sign, as we say, of God's blessing. Misses, you'll see afore noontide how the ants will come and clear the houses.' At this moment I was called to breakfast, and thinking it was some superstitious idea of hers, I paid no further attention to it.

"In about two hours after this, I observed an uncommon number of chasseur-ants crawling about the floor of the room; my children were annoyed by them, and seated themselves on a table, where their legs did not communicate with the floor. The ants did not crawl upon my person, but I was now surrounded by them. Shortly after this, the walls of the room became covered by them; and next they began to take possession of the tables and chairs. I now thought it necessary to take refuge in an adjoining room . . . and this was not accomplished without great care and generalship, for had we trodden upon one we should have been summarily punished. There were several ants on the top of the stair, but they were not nearly so numerous as in the room we had left; but the upper room presented a singular spectacle, for not only were the floor and the walls covered like the other room, but the roof was covered also.

"The open rafters of a West India house at all times afford shelter to a numerous tribe of Insects, more particularly the cockroach; but now their destruction was inevitable. The chasseur-ants, as if trained for battle, ascended in regular, thick files, to the rafters, and threw down the cockroaches to their comrades on the floor, who as regularly marched off with the dead bodies of cockroaches, dragging them away by their united efforts with amazing rapidity. Either the cockroaches were stung to death on the rafters, or else the fall killed them. The ants never stopped to devour their prey, but conveyed it all to their storehouses.

"The windward windows of this room were of glass, and a battle now ensued between the ants and the jack-

Photo by] [*E. Step, F.L.S.*

FORAGING ANT.

One of the foraging ants—the sickle-jawed species—that engage in the welcome work of house-cleaning in parts of South America an some of the neighbouring islands. The sickle-sh is well shown in the photograph, which is four tim of the ant.

spaniards on the panes of glass. The jack-spaniard[1] may be called the wasp of the West Indies; it is twice as large as a British wasp, and its sting is in proportion more painful; it builds its nest in trees and old houses, and sometimes in the rafters of a room. These jack-spaniards were not quite such easy prey as the cockroaches had been, for they used their wings, which not one cockroach had attempted to do. Two jack-spaniards, hotly pursued on the window, alighted on the dress of one of my children. I entreated her to sit still, and remain quiet. In an inconceivably short space of time a party of ants crawled upon her frock, surrounded, covered the two jack-spaniards, and crawled down again to the floor, dragging off their prey, and doing the child no harm.

"From this room I went to the adjoining bed-chamber and dressing room, and found them equally in possession of the chasseurs. I opened a large military chest full of linen, which had been much infested; for I was determined to take every advantage of such able hunters. I found the ants already inside; I suppose they must have got in at some opening at the hinges. I pulled out the linens on the floor, and with them hundreds of cockroaches, not one of which escaped.

Photo by] [*E. Step, F.L.S.*

"JACK-SPANIARD."

A common species of wasp in the West Indies is known by this name. Although it naturally builds in trees it is so familiar in its habits as to come freely into the houses and to build there. The photograph shows it one and a half times the actual size.

"We now left the house, and went to the chambers built at a little distance; but these also were in the same state. I next proceeded to open a store-room at the end of the other house for a place of retreat; but, to get the key, I had to return to the under room, where the battle was now more hot than ever. The ants had commenced an attack upon the *rats and mice*, which, strange as it may appear, were no match for their apparently insignificant foes. They surrounded them as they had the Insect tribe, covered them over, and dragged them off with a celerity and union of strength that no one who has not watched such a scene can comprehend. I did not see one rat or mouse escape, and I am sure I saw a score carried off during a very short period. We next tried the kitchen, for the store-room was equally the field of battle between rats, mice, cockroaches, and ants killing them. A huckster negro came up selling cakes; and seeing the uproar, and the family and servants standing out in the sun, he said, 'Ah, misses, you've got the blessing of God to-day, and a great blessing it is to get such a cleaning.'

"I think it was about ten when I first observed the ants; about twelve the battle was formidable; soon after one o'clock the great strife began with the rats and mice; and about three the houses were cleared. In a quarter of an hour more

[1] Polistes annularis.

THE SPRING-CLEANING.

Vast hordes of foraging ants visit a house in Trinidad and drive out or kill all the vermin—cockroaches of [illegible] species, mice, rats, and big wasps—all the fleeing ones having numerous ants attached to them by the jaws, so that they soon succumb to the painful bites.

the ants began to decamp, and soon not one was to be seen within doors. But the grass round the house was full of them; and they seemed now feasting on the remnants of their prey, which had been left on the road to their nests; and so the feasting continued till about four o'clock when the blackbirds, who had never been long absent from the *calibash* and *poisdoux* trees in the neighbourhood, darted down among them, and destroyed by millions those who were too sluggish to make good their retreat. By five o'clock the whole was over; before sun-down the negro-houses were all cleared in the same way; and they told me they had seen the blackbirds hovering about the almond-trees close to the negro-houses, as early as seven in the morning. I never saw those blackbirds before or since, and the negroes assured me that they were never seen but at such times."

Photo by] [*E. Step, F.L.S.*

THE DRUMMER.

The huge cockroach known in the West Indies as the drummer. It is the kind referred to in the account of the ants' spring-cleaning. It is here shown only four-fifths of the actual size.

How Insects Breathe.

One of the details of structure in which Insects differ from most other animals is that they have no lungs and the mouth plays no part in the respiration. As we have already briefly indicated, the air enters the body of the Insect through a series of openings called spiracles, which may be found at intervals along the sides of the body. You may close the mouth of an Insect without affecting its breathing in the slightest degree, for the mouth communicates with the digestive system only. But if an Insect be painted with oil along its sides, so that the spiracles are clogged, death must result though the mouth remains open. In the early stages of dragon-flies, caddis-flies, and some two-winged flies that live in water until they have reached their full development, the prevailing system of respiration is so far modified

that they purify their blood by means of gills, which will be described later.

As already pointed out in earlier pages, the blood flows freely into all available spaces of the body without being confined in arteries and veins; therefore the ordinary apparatus of lungs, where alone the blood can be brought into contact with the air to absorb its oxygen, would not be useful. Under such an arrangement every particle of blood would be brought in turn to the air; in the Insect it is the air that is brought to the blood, no matter in what remote part of the body it may be. This is effected by means of a wonderful system of elastic pipes into which the spiracles open. These pipes, known as trachea, continually branch from the mains and subdivide into most minute ramifications like the veins of the higher animals. In their case the tubes are kept distended by the contained blood being continuously pumped through them with force, owing to the unceasing and rhythmical activity of the heart. The trachea of Insects being open to the exterior would collapse under the pressure of the internal organs but for the fact that they are strengthened by a spiral wire of chitin running right through them, which keeps them distended whilst allowing bends and curves, and the greatest freedom of movement of the body.

Photo by] [*W. West*

How Insects Breathe.

A few of the breathing mouths, or spiracles, of a water-beetle. They are arranged along the margins of the back and covered by the horny wing-covers, which hold a store of air for their supply. They are here shown magnified seven times larger than their actual size.

There is no part of the Insect that is not reached by these air-tubes. They extend through the wings, to the tips of the antennæ, to the delicate extremities of the legs, and into the muscles. Wherever they go they are bathed by the blood, and their texture is so fine that the oxygen of the air passes through and is taken up by the blood. In this way the necessity for an arterial system for circulating the blood is obviated. The circulation and renewal of the air in these tubes is maintained by a rhythmical distension and contraction of the upper and lower walls of the hind-body, which is often perceptible to the eye, and can always be detected by holding any large Insect between finger and thumb. Of course, such a method does not renew all the air at once, as happens in the expansion and

Photo by] [*W. West.*

Breathing Mouth of Water-Beetle.

One of the spiracles seen in the preceding photograph is here magnified to twenty-seven times the natural size, to show the fringe of branching hairs by which the air is filtered before entry.

deflation of the lungs; but it is sufficient, as Insects are not such large consumers of oxygen as the backboned animals. Insects are often enclosed in tight-fitting tin boxes for many hours on collecting expeditions without any injury to their health. Miall and Denny state that though "cockroaches in carbonic acid speedily become insensible," yet "after twelve hours' exposure to the pure gas they survive and appear none the worse." A caterpillar that has fallen into water soon becomes flaccid and apparently dead through the entry of water into the air-tubes, but if rescued and placed where the water can drain out, will revive, and resume its former activity. Insects such as bees and wasps, which exhibit an almost ceaseless activity, are affected by close confinement in restricted air-space much more speedily than the leisurely flying though larger butterfly or moth.

A main air-trunk extends along each side of the body, with short branches connecting with each spiracle, and three ramifying branches to each segment of the body: one to the muscles of the upper side, one to the digestive canal and other

Photo by] [*H. Bastin.*

How an Insect Breathes.

In this photograph a silkworm has been made transparent to show the ramifications of the system of air-tubes, which are here seen as dark, branching threads.

central parts, and the third to the nerves and muscles of the lower side of the body.

The spiracles are slit-like openings along the sides, but they are not as simple as they appear to be from the exterior. In different families there are a variety of means adopted for excluding dust, and valves for closing them when necessary. The simplest forms are seen in some bugs, flies, and beetles. These have round or elliptical openings surrounded by a ring of chitin, whilst within is a funnel-like contraction. In the cockroach the spiracles are permanently open, but there is an internal valve which can close access to the air-tubes. In the grubs and pupæ of some flies each spiracle consists of a series of small openings, each with a separate short tube which unites within before joining the trunk tube. None of the foregoing have lips to the spiracles.

Others are more specialized in character, with lips, furnished with bristles or hairs, sometimes branching so that they form a kind of sieve. In some cases these hairs are external, in others internal, according to the habits of the species, the

Photo by *H. S. Pepper, F. L. M. S.*

AN AIR-TUBE JUNCTION.

A small portion of the respiratory system of the silkworm, magnified about eighty times, to show the spiral thread which in life prevents the air-tubes from collapsing under the pressure of the other organs.

obvious reason being the exclusion of dust and other minute foreign matter from the air-tubes. In the beetles they are covered by the edges of the wing-covers.

As the body contracts in respiration the spiracles open; when it expands the spiracles are closed and the air forced by muscular pressure into the remotest ramifications of the finest air-tubes. In flying Insects the air-tubes expand at intervals into oval, elliptical, or pear-shaped sacs, which, of course, afford a much larger supply of air than the air-tubes alone, and so increase the breathing capacity necessitated by the greater muscular exertion. A former explanation was that the body was lightened by the extra amount of air in it; but this is now known to be incorrect, its specific gravity in air not being affected.

Bacon-Beetles.

Sir Edward Coke, the great sixteenth-century lawyer, has declared that "the house of every one is to him as his castle and fortress, as well for his defence against injury and violence, as for his repose." But although we are all fond at times of boastfully expressing ourselves in the spirit of this legal aphorism, we know that except against the enemies and annoyers that are of our own kind our strong walls and locks are incapable of defending us or ensuring our repose. Numerous enemies

Photo by] [*J. F. Hammond.*

AIR-TUBES OF THE SILKWORM.

A portion of one of the trunk-lines seen in a previous photograph is here shown magnified twelve times. It will be seen that at intervals agreeing with the breathing mouths a number of branch tubes are given off. These convey air to those parts of the silkworm distant from the sides.

find their way in, even where windows are kept closed and doors only opened to allow passage to the inhabitants and their friends. These enemies are so small and individually so insignificant that, like love in the proverb, they can laugh at locksmiths. In warmer lands the owner of the castle has to give shelter to a far greater number of intruders than afflicts the British householder whom Coke had in his mind, but even here there are sufficient of them to form the subjects of a most entertaining book, such as that which Mr. E. A. Butler has written.

Photo by *E. Step, F.L.S.*

THE BACON-BEETLE.

A beetle that is often a serious pest in provision warehouses and other places where dried meats are stored. As shown it is four times larger than life-size. The chief mischief is done by it whilst in the grub stage.

To say nothing for the moment of cockroaches, crickets, flies, and moths, of several kinds, there are beetles that destroy our furniture, others that spoil the cigars of the lord of the castle, and some more daring that attack the food stores of his lady. Among the latter is one that specially attacks hams and bacon, and whose misdeeds are sufficiently well known to have earned it—what very few beetles possess—a popular name, and this name in a latinized form[1] has been accepted by science. The bacon-beetle is only about a third of an inch long, with a breadth not quite half its length, the fore-body and the hinder half of the wing-cases black, but the front half grey. The upper side of the beetle is covered with hairs, and the grey band is due to the colour of the hairs in that region, the wing-cover beneath it being dark red. The remaining principal feature is the form of the antennæ, whose three terminal joints are enlarged, giving a clubbed appearance to the organs.

In these days when we no longer cure our own bacon or keep a stock of hams, this beetle is less seen in the house than formerly; but provision merchants still suffer greatly from its depredations. It is really the grub of the beetle that does the mischief. This is a very hairy beast, and its type of clothing is shared by all the members of its family, one of which is the detested museum-beetle.[2] The hairs form bundles, and they can be contracted or spread out at the will of the grub. They are operated in a way that greatly assists progress in narrow passages, and it is, consequently, a difficult matter to hold one of them between the fingers.

Some years ago we were the recipients of a box containing some hundreds of these grubs which had caused great havoc among bacon in a domestic store-room. The sender was an angler, and wishing if possible to get some countervailing advantage out of his misfortune sent them to know if we thought they would serve as bait. Not being disciples of Izaak Walton we could only express a general opinion and suggest that he should give them a trial. Judging from the numbers which reached us—a mere sample—we hoped that a heavy creel would in part recoup him for the damage the larvæ must have inflicted; but whether the experiment was a success we never heard.

It may be surmised that smoked hams and flitches of bacon not being a direct

[1] Dermestes lardarius. [2] Anthrenus musæorum.

product of nature, such food is not the ordinary pabulum of the species. Its proper place is in the open, and its office in the scheme of nature is to act as a secondary scavenger. When the blow-fly grubs and the carrion-beetles have eaten the soft flesh of a dead bird or mammal, and only the hard sinews and dried skin are left, the bacon-beetle takes the remains in hand and clears them away. Several allied species are only to be met with out of doors, and a good place to find them is in the dry and shrivelled skins of stoats, rats, hawks, and the like that decorate the gamekeeper's gibbets, where he hangs his victims as a warning to their fellows.

One species,[1] whose black fore-body is decorated with a spot of white on each side, has made a dead set upon the skin and leather merchants, and has at times worked such havoc in their warehouses that we have it upon the authority of Westwood that in his time the London merchants in these commodities combined to offer a reward of £20,000 for an effectual remedy against its depredations. The impotence of man against his minute enemies is shown by the fact that this handsome reward was never earned. To annihilate a human army or destroy a fortified city is an easy task compared with the conquest of a tiny Insect. Even the naturalist with his knowledge of the crafty ways of some of these Insects, has to acknowledge himself beaten, when, even with the aid of air-tight drawers and outer doors to his cabinets, he finds his treasured specimens reduced to powder by the industry of the museum-beetle. It is true that with the carefully made modern cabinets there is little chance of the Insect breaking in, even though a newly hatched grub by the aid of its brushes of hair can lever its way through an almost microscopic crevice; but an egg may be attached to an Insect received from a collection housed in a cabinet of older type, and before that drawer is examined again much mischief may be done.

Photo by] [*E. Step, F.L.S.*

An Outdoor Bacon-Beetle.

This beetle attacks the dried carcases of dead animals after the more succulent portions have been consumed by the grubs of blow-flies and carrion-beetles. The grub is shown to the left. It is covered with long, black hairs. The beetle also is black, but a pretty mottled effect is produced by shining scales which reflect the light. The Insects are here shown four times larger than the actual size.

The beetle itself is only a couple of millimetres long; and it has a trick of tucking its head and legs under its body when disturbed, and then it looks like a mere speck of dead refuse. The grubs are quite pretty little creatures. In addition to the general hairy covering there are two brushes at the tail end which are ordinarily laid over the back, but when the creature is disturbed these are erected and the hairs spread out. What can be the purpose of this display it is not easy to determine. Sometimes a box containing surplus specimens that has been put aside and forgotten is found to swarm with these larvæ, the specimens the box

[1] Dermestes vulpinus.

THE BACON-BEETLE AND ITS GRUB AT WORK.

As known to the householder the bacon-beetle is seen mostly in or about the larder. If one can contrive to lay its eggs on a ham or a side of bacon, the hairy grubs will soon be in evidence, but may have inflicted much damage before their presence is discovered. The three stages after the egg are shown in this picture, the lowest figure being the chrysalis.

originally contained being represented by dust and a few glittering scales. The beetle grubs have long consumed everything that was consumable. Under such circumstances they can fast for a long period, casting their skins and slowly becoming smaller. If opportunity offers they will eat each other, but there are always survivors waiting for more food to come to them, or for an opportunity to escape to pastures new. When at length full grown the grub turns to a chrysalis, the larval skin merely splitting down the back to reveal the chrysalis within; and in due course the tiny beetle emerges.

Clearwings.

In our remarks upon the hawk-moths we have mentioned two near relatives of the humming-bird hawk-moth that shake the majority of the scales from their wings in their first flight, and thereafter present a close resemblance to bees. These bee hawk-moths do not exhaust the examples our fauna can afford of moths assuming a likeness to stinging Insects, and thereby escaping the destructive attentions of at least some of their natural enemies. At the other end of the scale of classification is the family of the clearwings,[1] so called because in nearly all cases the hind-wings are transparent and in many cases the fore-wings also, except for a marginal band covered with scales. Some of these remarkable moths shed their scales whilst they are in the chrysalis stage, others soon after they have emerged, but in some species the scales remain, having been rendered transparent to effect the same result. Fanciful names have been given to these moths by entomologists, indicating a definite likeness to a particular species of the bee or fly orders; but in very few cases is this so, though there is in most of them a startling *general* likeness to an Insect that can defend itself if attacked. The best of these counterfeit presentments among our native species are afforded by the hornet-moth[2] and the lunar hornet-moth,[3] though they do not resemble hornets, but wasps. The hind-body in both species is marked with alternate bands of black and light yellow, whereas the lighter bands on the hornet are more brown than yellow. But the protective value of the likeness is not lessened because their sponsors have given them misleading names. There are, it is true, a few naturalists who decline to receive the modern theory of mimetic resemblance for the protection of certain species; and these tell us that the resemblances are purely accidental. But with the enormous volume of evidence now accumulated it is harder to accept their view than the views of Bates, Müller, and Poulton.

Photos by] [*E. Step, F.L.S.*

THE MUSEUM-BEETLE.

The four stages of this insidious foe of the naturalist. To the left are the eggs and newly hatched grubs feeding upon the dried body of a wasp. In spite of its bad habits, the grub is rather pretty in its adornment of little brushes and in its movements. The chrysalis is contained in the split skin of the full grown grub, which serves it in place of a cocoon. The figures are all four times the natural size.

[1] Sesiidæ. [2] Trochilium apiformis. [3] T. crabroniformis

Photo by] [*R. Hancock.*
THE CURRANT-CLEARWING MOTH.
A familiar, though misunderstood, Insect in gardens where there are currant bushes. The caterpillar is an internal feeder and bores out the centre of the currant stems—a course of procedure that is followed with other plants by the caterpillars of all the clearwings. In the United States it is known as the currant-borer. The moth is here shown nearly twice the natural size.

Anyone not a naturalist who may come upon the hornet-moth, some May morning, as it sits quietly on the trunk of the poplar from which it has recently emerged, will be fully justified in believing it is a queen wasp. Not only is the general appearance that of a wasp, but the hind-body instead of being fluffy with its covering of long scales, as in most thick-bodied moths, has them reduced to so small a size that the appearance presented is that of the smooth, hard corselet of the wasp. Further, the hornet-moths curve the hind-body in such a way that it becomes much more wasp-like than it would be if fully extended as in other moths. The antennæ, too, are exactly the shape of the same organs in the wasp.

Nearly all this group of moths fly by day, and the thick-bodied species are fond of sitting quietly upon tree-trunks. Now other moths that expose themselves in this manner are protected either by their colour and markings assimilating closely to the bark and rendering them inconspicuous, or they are strongly marked with black contrasting with red or yellow in bold spots or lines. The latter colouring indicates that they are dangerous food, and insectivorous creatures turn away from Insects so marked. Wasps and many other stinging Insects have this colour scheme, and it is quite reasonable to suppose that defence less moths that closely resemble them will escape many dangers that would otherwise beset them. The lunar hornet-moth is very similar to the hornet-moth, except that, whereas the latter has a yellow head and black collar, with a patch of yellow on each shoulder, the former has a black head and yellow collar. The hind-body, too, presents some difference, the black bands being heavier in the hornet-moth and the yellow predominating in the lunar hornet.

Photo by] [*H. Main, F.E.S.*
ORANGE-TAILED CLEARWING.
So remarkably like a stinging Insect does this moth appear when on the wing that for many years it escaped the notice of the moth-hunter; and it is only within the last ten years that anything very definite has been known about its habits. Though in general appearance something like the currant-clearwing, it is readily distinguished by its more robust body and the spreading orange "tail."

The other species, of which there are a dozen natives additional to the two mentioned, are all smaller, and present a close general resemblance to various species of solitary-wasps and ichneumon-wasps—all of them beautiful little creatures that fly in the sunshine and walk over leaves with much the air of the wasps they resemble when searching for caterpillars. All of them have long legs, which are displayed in a way that helps the imposture.

Photo by] [*H. Main, F.E.S.*

LUNAR HORNET-CLEARWING.

This fine example of the clearwing family has just emerged from the chrysalis-skin, which is seen below, sticking out from the exit of the burrow in which the caterpillar has passed its life as a wood-feeder.

One of the best known of these moths is the currant-clearwing,[1] with wings of orange and black, and a black body belted with yellow. It may frequently be seen in early summer running over the leaves of currant bushes in gardens. Its early life was spent as a caterpillar in boring out the centre of the currant stems. This is the method of life followed by the caterpillars of all these clearwings—they are all internal feeders, and most of them appear to take two years in arriving at maturity. Both the hornet-moths feed as caterpillars in poplars and willows. The very rare clear-underwing[2] affects the inner bark of the poplar, the Welsh clearwing[3] the same part of the birch, and the white-barred clearwing the stems of alder, where it remains for nearly three years.

Remarkable testimony to the efficacy of the protective resemblance of these moths to stinging Insects is afforded by the case of the orange-tailed clearwing.[4] Until the year 1829 it entirely escaped notice as a British Insect, and up till a few years ago it was supposed to be one of the rarest; but this now appears to have been due to its power of imposing upon moth-hunters, who let it escape in the belief that it was not a moth they saw. It was supposed to feed as a caterpillar in the stems of dogwood, but within the last few years its food-plants have been discovered to be chiefly guelder-rose and wayfaring-tree, and with this knowledge large numbers of the caterpillars and chrysalids have been taken. It is known to be extensively parasitized by ichneumon-wasps, against which the resemblance to their own order is not effective, because the attack is made not upon the moth but upon the caterpillar; and a very large percentage of those reared in captivity are found to be thus destroyed. But that a

Photo by] *E. Step, F.L.S.*

LUNAR HORNET-MOTH AND WASP.

Seen apart, the lunar hornet-moth would be readily accepted as a wasp by most persons; but when, as in this photograph, the two living Insects are seen in proximity some differences as well as resemblances are evident between them.

[1] Sesia tipuliformis. [2] S. tabaniformis. [3] S. scoliæformis. [4] S. andrenæformis.

A. A. Lee, F.L.S.

ORANGE-TAILED CLEARWING MOTH.

[illegible] the clearwing moth [illegible] has been bored by the caterpillar of the moth, which is seen within. The [illegible] photograph shows [illegible] and [illegible] the caterpillar [illegible] protruding from the exit hole proved by the caterpillar.

Photos by *H. Main, F.E.S.*

EARLY STAGES OF THE LUNAR HORNET-MOTH. In these split stems of willow the full-grown caterpillar is revealed above just after it has completed the spinning of its [illegible] awaiting the change into the chrysalis. Below [illegible] stage. The discarded caterpillar-skin is pushed back to the tail-end.

considerable residue does survive to mate and lay eggs is proved by the comparative abundance of the caterpillars in suitable situations. The caterpillar when full grown and about to become a chrysalis prepares an exit for itself as a moth, but closes it with a door that exactly matches the surrounding bark and allows easy egress.

Of the remaining species, the caterpillars of the yellow-legged clearwing [1] feed on the inner bark of the oak, the red-belted clearwing [2] in apple and pear, the large red-belted clearwing [3] in birch, the red-tipped clearwing [4] in osier, the six-belted clearwing [5] in bird's-foot-trefoil, the thrift clearwing [6] in the roots of sea-pink, and the fiery clearwing [7] in the roots of dock and sorrel. All these caterpillars have a nearer resemblance to the grubs of wood-boring beetles than to the larvæ of moths.

Long-horned Grasshoppers.

Grasshoppers are divided into two groups—the long-horns and the short-horns—and the differences between them will be found set out in some detail in a later article on the short-horns.

The best known of the long-horns to English readers in the south is the large green grasshopper, and this is a very fair representative of the long-horn family.[8] Although there are species that exhibit considerable eccentricity of ornamentation, the long-horns may be said to be more graceful, as a rule, than the short-horns. They are less stoutly built, the wings are broader, and the antennæ very long and slender. The females are distinct from the males at a glance, for in most cases they are provided with a sword-shaped addition to the end of the body—the egg-placer. Often this exceeds in length the rest of the body. It is variously used, sometimes for placing the eggs in the earth, occasionally it is employed for piercing the twigs of

[1] Sesia vespiformis. [2] S. myopæformis. [3] S. culiciformis. [4] S. formicæformis. [5] S. ichneumoniformis. [6] S. muscæformis. [7] S. chrysidiformis. [8] Locustidæ.

plants or the flesh of galls in order that the eggs may be deposited therein.

In this family we find a remarkable feature in the situation of the organs of hearing. To carry them on the back as the short-horns do is strange enough, but to have them in the shank of the fore-legs appears to be a much more extraordinary situation for such organs. But we can at least point to a somewhat parallel case in the lobsters, shrimps, and other long-tailed crustaceans, where the ear is situated in the lowest joint of the antenna. In this leg-ear of the long-horns there are two drums, formed by a thinning of the outer integument of the leg on each side. In the interior there is a large air-chamber close against each drum, and the air-supply for these chambers is derived, not from the general respiratory system, but from special pipes whose inlets are on the back of the fore-body above the front legs. It is not clear why such a special supply should be necessary. When one has got over the first shock of surprise on finding the ears in so

Photo by] [*E. Step, F.L.S.*

THE GREAT GREEN GRASSHOPPER.

This is the finest of the British grasshoppers, but its uniform bright green tint makes it very inconspicuous among the foliage of trees and bushes. The photograph is of a female. The male is a powerful singer.

Photo by] [*H. Bastin.*

VARIABLE GREEN GRASSHOPPER.

This long-horn is frequently found among the foliage of trees, eating not only the leaves, but also the Insects to be found there. In autumn the female deposits her eggs in oak-galls, where they remain during the winter and hatch in the spring.

unusual a situation, one has to admit that they are admirably placed for hearing, for they are carried in front of the body, and the legs can be turned easily so that the ear-slits face the direction from which the sounds are coming.

The great green grasshopper,[1] the largest of our native hoppers, is a very fine creature, and a musician of great power. On this account he is frequently kept as a pet, perhaps not so much because his singing appeals to the musical ear, but rather because of the wonder that so small an animal should produce so strong and penetrating a note. He is probably far more carnivorous than herbivorous, and will catch flies with his fore-legs and devour them. Entomologists who "sugar" trees to attract the night-flying moths often have cause to complain of this Insect, who walks up the tree-trunks and picks off the moths from the sugar-patch for his own supper. They have also, like the moths, a weakness for the sugary fluid itself, and probably are first attracted by its smell, and only by accident find the more substantial fare. Another, the variable green long-horned grasshopper,[2] which is sometimes mistaken for the last-mentioned, has also a taste for an Insect diet, for we have found it devouring the chrysalis of a moth.

A Grasshopper that Mimics an Ant.

The actual size of this species is only one-third of an inch long, and by most observers it would be passed over as an ant. Owing to the disposition of colour on the body it appears to have the form of an ant, and probably it thus escapes molestation in a country where ants are plentiful. It is a native of the Sudan.

The katydids of North America—which we shall deal with separately—are also among the long-horns. Some members of the family are remarkable in ways other than as musicians. Some of them are cave-dwellers, and though these are minus wings and ears, they have legs and antennæ developed to enormous length. The similarity of these one to another is astonishing—though they are only distantly related species and found in parts of the world so far apart as the caves of Austria, Kentucky, and New Zealand. They afford a good illustration of the fact that identity of habit often brings about similarity of structure. Many of the winged species are good examples of protective coloration, their ample wing-covers being not only of a bright green colour, which renders them invisible when at rest among vegetation, but some of them exhibit a close resemblance to the veining of leaves, and a finishing touch is sometimes added in the shape of spots such as in real leaves are due to the attacks of fungi and Insects. One of the leaf-like kind is the great shielded grasshopper,[3] which Wallace found in New Guinea, and which is five inches long. This fine grasshopper has the fore-body covered by a large, triangular, horny shield, two and a half inches long, with toothed edges, a somewhat wavy, hollow surface, and a faint line down the centre, so as to resemble a leaf very closely. "The glossy wing-coverts (when fully expanded more than nine inches across) are of a fine

[1] Locusta viridissima. [2] Meconema varians. [3] Megalodon ensifer.

Photos by] [*W. J. Lucas, F.E.S., and E. Step, F.L.S.*

LONG-HORNED GRASSHOPPERS.

The two upper figures are of the great shielded grasshopper of New Guinea, male and female, much reduced in size. The lower two are wingless forms: that on the left being a female of Peters' hetrodes from Africa, with strong spines along the margin of the fore-body. To the right is the marbled diastremmena, which has recently become established in English greenhouses, having been unintentionally introduced with plants from Japan. Note the great length of the thread-like antennæ.

Photo by] [*H. Bastin.*

THE BUSH CHEEP.

A common, brown-coloured long-horn, whose favourite haunt is about hedgerows. The present photograph is that of the female, indicated by the sword-shaped egg-placer.

green colour, and so beautifully veined as to imitate closely some of the large shining tropical leaves. The body is short, and terminated in the female by a long, curved, sword-like ovipositor, and the legs are all long and strongly spined. These Insects are sluggish in their motion, depending for safety on their resemblance to foliage, their horny shield and wing-coverts, and their spiny legs."

But probably the most remarkable of these protected grasshoppers is a small species,[1] only a third of an inch long, that is found in the Sudan. With the majority of observers it would easily pass for an ant, and the inference is that ants are abundant where it lives, and this disguise has been brought about as a means of preserving a wingless race of grasshoppers from attack by ants. One of the characters of grasshopper structure is the absence of any well-defined waist, the stout hind-body having a straight under side and being attached to the fore-body by its full width and depth. In ants, as the most superficial of observers must have noticed, these two parts are connected by an exceedingly slender stalk that makes one wonder how the vital machinery necessary can be squeezed into so tenuous a strait. This ant-like grasshopper appears at first sight to have such an attenuated junction between fore-body and hind-body; but this is an optical illusion brought about by nature painting the under side and sides of the grasshopper with white in such a fashion that at a slight distance this portion is not seen and only the stalked body of an ant remains.

Photo by] [*H. Bastin.*

THE BUSH CHEEP.

In this photograph the male is shown. The difference between the sexes will be seen at a glance on comparing the hind-parts.

There are other remarkable forms among the long-horns as among the short-horns. A few resemble stick-Insects. Certain of the wingless species attain a large size and an aspect of ferocity, some of them being very liberally

[1] Myrmecophana fallax.

decorated with spines upon the fore-body as well as the smaller ones usual on the legs. There are few representatives of the family in Britain, and of these the majority are found only in the South of England. Quite recently, however, their numbers have been increased by the introduction of a singular alien[1] with foreign plants, which has become naturalized in our greenhouses. This, no doubt, will cause alarm to the owners and gardeners, but it is probable that it will do them far more good than harm by destroying noxious Insects rather than plants.

Digger-Wasp and Cicada.

The digger-wasp[1] is one of the largest species of wasp, and withal one of the fiercest of its kind. Like other of the solitary-wasps whose ways are described in this work, its efforts on behalf of the comfort and well-being of its progeny take the form of excavating deep burrows and provisioning them with sufficient food to last the grub until it is fully grown. It is a fine black and yellow-banded wasp with the black predominating over the yellow; and with a spread of wings amounting to two and three-quarter inches.

Selecting a bank where the soil is dry the female digger drives a shaft into the bank for a distance of about six inches, almost horizontally, but with a slight downward slope. Then it makes a sudden turn, is continued vertically for a similar distance, and ends in a spherical chamber an inch and a half across. Sometimes there are several side branches of the main shafts, each ending in a similar round cell. Each cell has to be provisioned before it is ready to receive one of the digger's eggs, and to this end the digger-wasp sets out on a hunting expedition. Its prey is one of the large cicadas, known in the United States as the lyreman[3] or dog-day cicada, an Insect that is much larger, and in truth quite twice the weight of the digger. The obvious way of dealing with a capture that has this advantage over the captor is for the latter to divide the booty and take it away piecemeal. But the digger wants its victim whole and still alive, though paralyzed and helpless.

The Digger-Wasp.

This solitary-wasp, here shown of the natural size, preys upon the much larger cicada, which it stings and then entombs in a cell in the earth [illegible] support its development.

To hunt for cicadas is not a matter of great difficulty, for the males so persistently and loudly advertise their present situation that they cannot well be overlooked. The digger-wasp has only to fly to the trees from which the doleful chorus of cicada notes is swelling, and pick out the lyreman that appears to be most suitable. But among the branches it is impossible to get a start in flight with so heavy a load. A weight, however, may be dragged or hauled when it cannot be carried; and the digger having stung its victim to ensure quiescence starts hauling it up the tree until it arrives at a clear space at sufficient height to enable

[1] Diastremma marmorata. [2] Sphecius speciosus. [3] Cicada tibicen.

it to make a long sloping flight to its mine shaft. It will spend more than an hour, if necessary, in the task of hauling its load to a favourable position for flying off.

Riley found that in some of the cells there are two cicadas entombed with the digger's egg, and in other cells only one; and he supposes that one cicada suffices to nourish a digger-grub that is to develop into a male, and that two are required for the development of a female. Upon one of these an elongate white egg is laid, and this hatches in two or three days. The grub is broad at the hinder end and tapers to a point forwards. The slender head is thrust between the joints of the cicada's body, whose substance is thus entirely absorbed. In little more than a week only the skin is left, and by that time the wasp-grub is full grown. It now spends a couple of days in constructing a cocoon of mingled silk and earth, in which a number of pores are left, apparently to allow air for the grub until its change into the chrysalis stage. The cocoon is spun in early autumn, but the change of the grub to the chrysalis does not take place until spring, and then it is soon followed by the emergence of the perfect digger-wasp.

The digger-wasp has serviceable jaws, and soon cuts through the cocoon which imprisons it and makes its way through the shaft to the outer world. In summer it is abundant in North America, and is generally avoided on account of a well-deserved reputation for the severity of its sting.

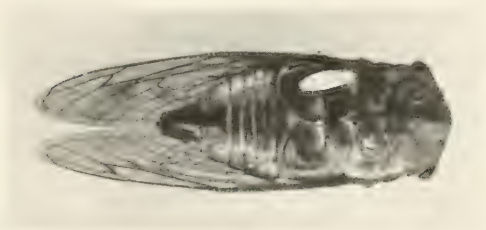


Photo by] [*E. Step, F.L.S.*

THE DIGGER'S VICTIM.

Having stung and carried off the cicada to its underground cell, a single egg is deposited upon it, as shown. Occasionally two cicadas may be found in a cell with only one wasp-egg.

The Bug Family.

The term bug is used here not in the sense in which Americans commonly use it as including Insects in general, but in the sense understood by the British naturalist, to whom it indicates one order of Insect life,[1] an order that includes many remarkable forms, many beautiful forms, and many whose ravages among plants make a knowledge of the order important and even necessary to all who have to do with cultivated vegetation. But, although something like eighteen thousand species have been named, and over a thousand of these occur in the British Isles, it remains one of the least studied orders of Insect life; and, although we have labelled and classified this considerable number of species, of only a few have we learned anything of their natural history. These few, it is perhaps unnecessary to state, are mainly those that come conspicuously into antagonism with man the cultivator; yet even in this restricted view of the family, there is much still to be learned and many debatable points in their economy to be cleared up.

One characteristic of the entire family is that they do not undergo a complete metamorphosis. There is little difference of form between the infant and the adult, though the acquisition of wings, of course, makes considerable difference of appearance in many species. In this matter of changing only by the acquisition of wings they agree with members of the grasshopper and cockroach family;[2] but there is this difference, that whilst the latter have cutting-jaws throughout life,

[1] Order Rhynchota. [2] Orthoptera.

[By L. R. Brightwell.

THE DIGGER-WASP AND THE CICADA.

One of the largest and fiercest of wasps is shown, nearly twice the actual size, in the act of carrying a cicada to its nest. In one of its cells underground its full-grown grub is seen feeding upon a cicada; and in the other cell a grub is spinning its cocoon prior to changing to the chrysalis. In the middle of the cocoon will be seen the pore-like openings always left as though for the respiration of the Insect within.

Photo by] [*H. Bastin.*

LEAF-LEGGED BUG.

A plant-bug of remarkable design from South America. The very long and slender hind-legs spread out at the top of the shank into prettily-coloured leaf-like growths, which must tend to disguise its true nature when seen upon foliage.

the bugs have their mouth-parts designed not for cutting solids, but solely for imbibing fluids—the sap of plants or the blood of animals. This beak consists of a long, jointed sheath, grooved along its inner face, and believed to be composed of the modified upper and lower lips. When not in use it folds out of the way by lying close against the under side of the body. Within this grooved sheath lie four fine bristles which can be lengthened or shortened. Two of these four bristles are barbed at the point. In some species the sheath appears to make an incision in the skin of the animal victim, but in most cases, at least of the plant-suckers, its tip is believed to be merely brought in contact with the spot to be tapped and then the bristles penetrate the surface. The secretion of the salivary glands is then passed down the sheath, which has the effect of thinning the fluid to be imbibed by the Insect, and so reduced it mounts by capillary attraction between the bristles to the closed mouth. This appears to be the method by which the diverse forms of bugs obtain their nourishment.

The bugs are nominally all four-winged Insects, but, as in other families, there are species in which for reasons connected with their habits the wings are not developed. According to the character of the wings the bugs have been divided into two sub-orders. In the first of these, or true bugs,[1] the front pair differ from the hind pair in having the basal half of their area of a thicker, more horny character than the apical half. When the wings are closed at rest these thinner portions overlap. In the second sub-order,[2] which includes the cicadas, the plant-lice, and the scale-Insects, there is more uniformity in the consistence of the front wings, which are not laid flat on the back, but form more or less of a ridge above it from which they slope over the sides of the body. In both sub-orders there is little change of form apart from the acquisition of wings, which are gradually developed outside the body.

One of the characteristics of the race is such as to force itself upon the attention

[1] Hemiptera-heteroptera. [2] Hemiptera-homoptera.

of the least observant. This is the possession of stink-glands, which have, no doubt, considerable importance in protecting the bugs from susceptible enemies. During the immaturity of the Insect the glands are situated on the back, near the middle of the hind-body—the position where they would be most effective as offensive weapons; but when the wings are developed this part is covered by them, so the stink-glands are removed to the lower surface. In the majority of species the odour of the excretion from these is very offensive to the human sense of smell, but there are cases in which it is not unpleasant to us, though it may be presumed that it is objectionable to some possible enemies. A Tasmanian species, which dances in the air like a midge, gives off the odour of musk, and one found on our own heaths is redolent of jargonelle pears!

As a rule the head is small, though in the lantern-flies it is enormously developed. The fore-body is usually broad, and in many species one of its three divisions is curiously enlarged. In the membracids (described in a separate article) it is the first division[1] that takes on the large and grotesque shapes that entirely mask the true form of the body. The second division[2] sometimes becomes a huge shield extending over the third division and the hind-body, and entirely hiding the wings. In some cases this gives the bug the appearance of being a beetle. There are many species in which close inspection is needed to satisfy one that the Insect is really a bug and not a beetle, an ant, or a fly. Some, again, approach very closely to the form of the stick-Insects. Among these may be mentioned our native ranatra, whilst the smaller water-bugs known as water-measurers[3] look like stick-Insects that have newly emerged from the egg. All the members of one genus[4] resemble the seeds of umbelliferous plants. There are two that resemble gnats, not only in the general shape and the wings being longer than the body, but the legs are very long and slender, and held in the positions common to gnats' legs. Another[5] is like a small long-horned grasshopper. Two others are very ant-like, and a third[6] is so in its early stages, but here the resemblance is largely due to a pale mark on each side where the hind- and fore-bodies join. These pale

Photo by] [*H. S. Cheavin, F.R.M.S.*

YOUNG BED-BUG.

A small example of this disgusting parasite is here shown magnified twelve times. It shows the structure of the body. The piercing beak is extended in front of the head.

[1] Prothorax. [2] Mesothorax. [3] Hydrometra. [4] Orthostira. [5] Berytus clavipes. [6] Nabis lativentris.

patches have the effect of painting out as it were part of the body, and so altering its apparent shape that it becomes exceedingly ant-like. This likeness is especially noticeable when the bug is seen from the side. In some of the foreign species this resemblance to other Insects is strongly developed. A Brazilian species[1] is to all appearance a young "stick" with thread-like body, and the exceedingly long legs are, of course, finer still. The first pair have the foot hinged so that it can fold down on the shank, mantis-fashion, and so serve for securing prey. A Chinese bug,[2] three-quarters of an inch in length, is got up exactly like a daddy long-legs; and a related species in Brazil bears an extraordinary resemblance to a large wasp, and imitates the buzz of the wasp.

Very little is known of the life-histories of the various species of bugs; but it has been ascertained that a few species at least display some parental instinct, such as one usually finds restricted to the social Insects—ants, wasps, and bees. The most noteworthy example is a British species[3] found on birch-trees, which emulates the domestic virtues of the earwig, seeing that she not only lays from thirty to forty eggs in a diamond-shaped batch, but mounts guard actually over them for three weeks, when they hatch. The young bugs remain with their mother, who covers them like a hen covers her chicks, until a few days before their first moult, after which they separate. In the South of Europe there is another species,[4] whose sides, legs, and antennæ bristle with long spines, among which the male carries the eggs, which are probably laid in position by his mate; but of this nothing certain is known. The ocean bugs,[5] with which we shall deal separately, also carry their eggs, but the carrier is the female. In some American species of fresh-water bugs[6] it is the male again that is entrusted with this task; they are laid in a broad patch in the middle of his back.

Photo by] [*E. Step, F.L.S.*

BIG-LEGGED BUG.

This bug, a native of Trinidad, etc., is remarkable for the extraordinary development of the hind-legs as compared with the first and second pairs. It is here shown of the natural size.

Among remarkable forms of bugs should be mentioned our common fresh-water species, the water scorpion, which is so flat and thin that there does not appear to be room for internal organs, but they are there, nevertheless. The front legs have the foot bent on the shank to enable it to capture and retain its victims whilst they are being bled to death. A more remarkable adaptation of the fore-legs to this purpose is found in the Burmese crab-bug,[7] whose upper parts are liberally furnished with spines, and the fore-limbs are shaped like the nippers of a crab.

The bugs that suck the juices of plants include several which have the bad taste to select man's crops for the purpose, and they are in consequence included in the list of Insect pests. Among these is the mosquito blight[8] of the East Indies, which has remarkable outgrowths from its fore-body, and one of these looks like

[1] Ghilianella filiventris. [2] Myiodocha tipulina. [3] Acanthosoma interstinctum. [4] Phyllomorpha laciniata. [5] Halobates. [6] Zaitha. [7] Carcinocoris binghami. [8] Helopeltis.

By T. Carreras

THE HUMMING-BIRD HAWK-MOTH

Owing to the extended long tongue, the shape of the wings and the feather-like expansions at the sides of the hind body, together with its habit of remaining poised in air before a flower, this moth closely resembles one of the Humming-birds, and is frequently accepted as such. It is only when it is approaching a flower that its pattern can be seen; when poised, its wings vibrate so rapidly that a halo around the body is all that appears.

a big-headed pin standing erect, and making the bug appear as though it had been in the hands of an entomologist. This bug attacks the growing plants of tea, and an allied species known as moesa blight shares its bad habits. Not only do the bugs suck at the young leaves and shoots, and impair their quality for tea-making, but the female pierces holes in the shoots and plugs them with her eggs, which may account for the unwonted flavour one sometimes gets in a cup of tea. There are at least two others, the chinch-bug[1] and the cotton-stainer,[2] that are destructive, the first to corn and grass, the second to the cotton crop. The latter species has also taken, in Florida, to sucking oranges—not the leaves, but the fruit—and wherever one has dipped his beak through the peel, the orange begins to rot.

Photo by] [*E. Step, F.L.S*

WATER SCORPION.

An example of the aquatic bugs. The broad, flat body is very thin; and the fore-limbs are developed to form admirable clasping organs, the shank and foot closing down in a slit along the front edge of the thigh. Three times the natural size.

But the great pest among bugs, the one which has created a prejudice against the whole race, and almost made the word one to be tabooed, is the atrocious blood-sucker[3] that has attached itself to human habitations, where the structure and the furnishing has made it possible. In this country at the present day it is probably only the poor that suffer from this pest, but in former times all classes knew it too well. Like some other Insect annoyances it is an introduction from abroad, though no one can say which country is its proper home. It has been with us for about four hundred years, probably entering our seaports in home-bound ships, and gradually extending from the circumference to the centre. In the bed-bug wings are not developed, though the vestiges of them may still be found. It is possible that finding man with his ships and couches so good a carrier to extend its distribution, it gave up developing wings as no longer necessary to it. We do not wish to dwell at length upon what many readers will probably consider a disgusting subject, but there are one or two points which, we think, will have interest for them. Many persons tolerate cockroaches in the house in the belief that these Insects protect them from the possibility of an invasion of bed-bugs. This belief appears to be well founded, for it is said that the red-coat is a *bonne bouche* for the brown-coat.

[1] Blissus leucopterus. [2] Dysdercus suturellus [3] Cimex lectularius.

Not only is this so, but there is another bug[1] that flies into bug-infested houses and feeds upon the pests. This bug-killing bug is, however, a rather dangerous ally to call in, for he is so fond of human blood that he takes it from its source, as well as second-hand. In its earlier unwinged condition this fly-bug, as it is sometimes called, covers its back and limbs with dusty rubbish, which makes it scarcely recognizable as what it is. But the bed-bug has another enemy in the shape of a little black ant, allied to the minute yellow ant—an imported species—that often establishes itself under the floors and hearthstones of houses in towns. It is said that these ants if they take up quarters in a bug-infested house will soon effectually clear out the red-coats.

Photo by] [*H. Bastin.*

TYPICAL BUGS.

The two upper corner examples are shield-bugs—so called from their shape. Between them is a very slender form, which might be mistaken easily for a crane-fly. Below it is a species intermediate in slenderness and representative of a large family, of which examples may be seen commonly on garden plants. On either side of this is one of the ditch-skaters, that to the right bearing a close resemblance to a young stick-Insect. All about twice the actual size.

Hawk-Moths.

Though the hawk-moths are the largest and handsomest of our moths, they are little known to the public, except when pinned out in collections. Then they evoke admiration; but if a living specimen should chance to put in an appearance through the open window at twilight, it causes the greatest consternation and alarm. If it is one of the larger species, whether it be the death's-head or not, it is almost certain to be ascribed to that species, and various consequent evils will be feared. No doubt, were they seen more frequently they would inspire less alarm; but they have a way of securely hiding themselves during the day, and do not fly until dusk. The general scheme of colour and marking is such that, when the wings are folded to the sides, there is a general harmony with their surroundings, so that it may happen that one of these large moths is well within range of the eyesight but remains unseen.

The caterpillars, too, from their large size should be frequently seen, but here again colour renders them all but invisible in most cases, and the exceptions are so marked as to make the beholder afraid to touch them, in the belief that they are something other than caterpillars. The largest of these caterpillars is that of the death's-head hawk-moth,[2] which when full grown measures about five inches in length, and has a diameter of more than half an inch. Its colour is yellow-green, upon

[1] Reduvius personatus.

[2] Acherontia atropos.

THE MATERNAL BUG OF THE BIRCH-TREE.

Like the earwig, this bug guards her batch of eggs until they have hatched—a period of about three weeks. Afterwards she covers them as hen covers her chicks, until they are nearly full grown, when they disperse themselves over the tre

Photo by] [*E. Step, F.L.S.*

THE POPLAR HAWK-MOTH.

A characteristic resting attitude of this moth. The hind-wings being brought up in front of the fore-wings, a conspicuous rust-red patch is hidden, and the grey-brown colour of wings and body produces some resemblance to weathered dead leaves.

which are laid on each side seven oblique stripes. These stripes are compound in colour, the upper half of each being violet or purple, the lower part yellow. The tips of these stripes from the two sides meet on the back, so that when viewed from above the caterpillar may be said to be marked with seven V's. Now, in all the hawk-moth caterpillars that bear these stripes, the effect when they are feeding is that of overlapping leaves whose edges or ribs reflect light. In some species there are two colour forms of the caterpillar, one having the usual green, the other brown, for its ground colour. In these cases the illusion produced is that of a dying leaf that has curled up from the sides and shows the strong veins of the under side.

The next largest of our species of hawk-moths is the fine but more soberly coloured convolvulus hawk-moth,[1] and this we can only claim as a sort of half-native, for it is rarely that the caterpillar has been found in this country. In certain years the moth occurs in comparative abundance in our eastern and southern counties, and this fact, combined with the great rarity of the caterpillar, has led to the conclusion that at least most of our specimens have flown over from the Continent. The full-grown caterpillar is four inches long, and feeds chiefly upon the little field-bindweed that mostly trails along the ground. The caterpillar varies in colour from a bright green to dark brown. It is always green in its younger condition, but when full grown it is most frequently brown. The young ones, of course, become associated with the leaves in colour, but when more fully grown, and larger than the leaves, assimilation to the colour of the ground upon which the leaves lie affords them better protection. One of the finest of these caterpillars is that of the privet hawk-moth,[2] which is also one of the most abundant. It is four inches in

Photo by] [*E. Step, F.L.S.*

CATERPILLAR OF THE POPLAR HAWK-MOTH.

One of the most familiar of the hawk-moth caterpillars, frequently to be found on poplars and sallows. Its rough skin is beautifully coloured green with diagonal stripes of white or yellow on the sides. Occasionally the green assumes a brownish tinge.

[1] Sphinx convolvuli. [2] S. ligustri.

length, and of a bright, rather pale green, with the stripes violet above and white or yellow below. These stripes, though in a caterpillar taken away from its food-plant they appear so conspicuous and revealing, so agree with the curves of the smooth margins of the privet-leaf that it is very easy not to see the caterpillar when it is only a few inches from your eyes. An equally plentiful species is the poplar hawk-moth,[1] whose caterpillar feeds on various species of poplar, willow, etc. In this species the colour is yellowish-green, made more yellow by being thickly sprinkled with small raised dots of yellow. The side stripes, too, are yellow. The description is that of the full-grown larva in September, by which date some of the leaves are beginning to show signs of yellowing; but they have come through phases of pale green and blue-green. The caterpillars of the lime hawk-moth[2] and the eyed hawk-moth[3]

THE DEATH'S-HEAD HAWK-MOTH.

The largest of our native moths. The yellow markings behind the head frequently bear a rough resemblance to a human skull, and have suggested its popular name. With most persons its appearance in a house is the occasion for much superstitious alarm. It has the power of squeaking. The huge caterpillar is often found in potato-fields, upon whose vegetation it feeds, and where the diggers know it as a "locust." It is never sufficiently plentiful in this country to cause any real damage.

are—speaking in general terms—similar to the last mentioned. But there is another series of species in which the ornamentation of the caterpillars is quite different—longitudinal stripes or rows of spots taking the place, though not the exact location, of the oblique stripes.

This change in the markings has an evident relation to the different feeding conditions, the plants affected by them not being such as the oblique stripe would harmonize with. To take as an instance the caterpillar of the rare pine hawk-moth,[4] which feeds upon the needle-like foliage of Scots pine and other conifers. At first its colour is brownish-yellow without any definite markings, but as at this time it is only about a sixth of an inch long, no markings are necessary for hiding it: its general colour is sufficiently like the buds and bark of the pine-shoots. After its first moult it is less than half an inch in length, but already its colour has changed

[1] Amorpho populi. [2] Dilina tiliæ. [3] Smerinthus ocellatus. [4] Hyloicus pinastri.

Photo by Hugh Main, F.E.S.

CHRYSALIS OF THE DEATH'S-HEAD HAWK-MOTH.

The chrysalis, here shown of the natural size, is found in a hollow excavated by the caterpillar at a depth of eight or ten inches below the surface. It is dark red-brown in colour, the spiracles or breathing slits along the sides being distinct because coloured black. The chrysalis condition may last only about a month, or may continue for eight months.

to dark green, and down the back run two yellow lines, whilst others appear along the sides. It now closely resembles the pine-leaves upon which it feeds. Later a reddish stripe runs down the back, with a yellowish-white stripe along each side of it, followed by a band of the green ground colour, then another white stripe, followed by green, and so on. Later, as the caterpillar increases in length, the lines get broken into shorter lengths, which better keeps up the similitude to the pine-needles. The moth has its wings dark grey, clouded and streaked with brown. This is quite a sombre type of coloration, but it is wonderfully effective in making the Insect invisible when resting during the day on the bark of the pine-trunk.

Another type of ornamentation is found in the caterpillars of the elephant hawk-moth[1] and the small elephant.[2] In the former the caterpillar is at first yellowish-white and quite uniformly coloured, except that the tail-horn is black. They feed upon the hairy willow-herb and species of bedstraw, and their colouring makes them inconspicuous. A little later they become green, and some of them retain this colour until they have become full grown and three inches long; others become brown. By this time they are dotted with black and have a few pale longitudinal lines. A more important item in their development is the early appearance of eye-spots on certain segments behind the head. After the third moult these are well defined and eye-like. As the size of the caterpillars is now likely to render them rather conspicuous if they feed by day, they retire, after the night's feeding, among dead leaves and debris at the foot of the food-plant, from which they partially expose themselves in the afternoon, apparently for the purpose of getting a sun-bath. When in repose the head and next two segments are drawn into the third, which has the effect of distending this part and enlarging the eye-spots, which become very prominent, and look like the real eyes of some ferocious little beast—an apparition sufficient to scare off any food-seeking bird. The caterpillar of the small elephant hawk-moth, though of smaller size—two inches—is very similar in decoration and habits.

Photo by] [*E. Step, F.L.S.*

THE PRIVET HAWK-MOTH.

One of the commonest species, but, in spite of its large size, it is very rarely seen by those who are not entomologists. The colouring of its brown and grey fore-wings harmonizes with its resting places, and the more conspicuous hind-wings, of rosy hue banded with black, are hidden beneath the fore-wings when not in use. The caterpillar is shown on page 98.

[1] Chærocampa elpenor.

[2] C. porcellus.

Photo by]

THE CATERPILLAR OF THE ELEPHANT HAWK-MOTH

When full grown this caterpillar has a remarkably snake-like aspect when only half its length is visible. The fine black marks upon the green or brown skin produce the effect of scales, and the large black and white marks a little behind the head look like staring eyes. By drawing in its head the eye-spot segments are made to bulge and the creature to appear truly ferocious. There can be little doubt that this aspect assumed at will, serves to warn off enemies. About twice the actual size

One other small group of these interesting Insects must be mentioned, consisting of three species, of which one is that notorious impostor, the humming-bird hawk-moth, and the others the less familiar bee hawk-moths. But for the characteristic horn at the hinder end of the back there is little in the caterpillar to indicate its relationship to the larger hawk-moths. That of the humming-bird hawk-moth is less than two inches long, of a greenish or brownish colour, diversified by lines and dots of paler tints. It feeds upon yellow bedstraw at night, and spends the day among the somewhat matted stems near the ground, where its ornamentation is sufficiently protective. The moth [1] flies during the sunny hours of the day chiefly, and by its habit of remaining suspended on its rapidly vibrated wings whilst its proboscis is extended into a flower, has caused many persons to rub their eyes and wonder if they are dreaming of being far away in sunnier climes, where real humming-birds hover before the flowers. In many cases it is very difficult to persuade such persons that what they are looking at is only a moth. The proboscis thrust straight out in front looks very like a bird's beak, and a tuft of long scales on each side of the other extremity gives a resemblance to the humming-bird's outspread tail-feathers. In the coloured plate (page 160) the artist has represented this moth as it appears when just approaching the flowers it intends to rifle of their nectar. When busy sucking at the sweets the body is suspended almost motionless, but the wings are vibrated so rapidly that little can be seen of them beyond a sort of halo such as would be produced by a wheel revolving at enormous speed. In this picture they are sucking at the wild field-bindweed, as sketched by our artist, but in gardens they are frequently attracted to white jessamine.

Photo by] [*A. E. Tonge, F.E.S.*

THE ELEPHANT HAWK-MOTH.

One of the smaller of the hawk-moths, and of very neat and pleasing appearance. The fore wings are greenish, with two stripes of rose running from the tip, of which one forms the outer margin. The hind-wings — entirely hidden when the Insect is at rest, as in our photograph—have a black base and a broad rose coloured marginal band. Its remarkable caterpillar is shown on page 167.

The bee hawk-moths, distinguished by the breadth [2] or narrowness [3] of the opaque border to their transparent wings, are equally deceptions in another way. Their stout bodies are thickly clothed with long, yellow scales, save for a band across the hind-body, which is covered with scales of black or brown. In conjunction with the transparent wings this produces a striking resemblance to a humble-bee. But when the moth emerges from the chrysalis its wings are clothed with scales all over, and it is only when it takes its first flight that these are all cast off from the centre of the wings. Like the humming-bird hawk-moth, both these bee-hawks fly in the sunshine, and it is obviously to their advantage that they should be mistaken for stinging Insects.

A Fearless Fly that Defies the Driver-Ant.

The driver-ants of Africa are a terror to all other creatures. They march in such enormous numbers that everything which desires not to be eaten has to

[1] Macroglossa stellatarum. [2] Hemaris fuciformis. [3] H. tityus.

Photo by] [*H. Bastin.*

WORKER DRIVER-ANTS.

Two of the wingless worker caste are shown on the same scale of magnification as the male below—twice the size of nature—in order to show the great disparity of size in the same species, which is distinguished as the black driver-ant.

fly before them; from the cockroach and the mouse to the huge python, the elephant, the gorilla, and the warlike native man, the story is the same. The driver-ant has got its name because it is the most fitting term to use: it actually drives all creatures before it, and those that lag or fall by the way are consumed by the ants.

In all the records and observations of naturalists and travellers in Africa there is little said on the other side of any defiance of the all-conquering drivers by other creatures. But quite recently Mr. W. A. Lamborn, in Southern Nigeria, has recorded his observations of the manner in which an insignificant fly, about the size of our common bluebottle, openly deprives the driver of its most jealously guarded treasure—the chrysalids that should develop into mature ants. It was not an accidental or isolated instance of the fly coming across a column of drivers and picking up something, for all the circumstances narrated by Mr. Lamborn show that so many of the same species of fly[1] were similarly engaged in this method of obtaining food that it must be habitual with them. Having noted this strange behaviour of the flies without fully understanding it, he set himself to discover what business connection they could have with such powerful Insects. So recently as November 8th, 1913, he wrote to Professor Poulton, saying: "I succeeded to-day in solving the problem between the flies mentioned in my letter of October 12th and the black driver-ants.[2] A column of drivers was crossing a conduit over a stream, following precisely the same ant-path that I have seen them traverse several times before. . . . I soon saw three or four of the flies flying about the moving column and occasionally settling near it, sometimes on the ground quite close to the ants, sometimes on a blade of grass, stone, or other raised object. Such as settled on the ground were extremely alert, and being able to run rapidly, never allowed any ants to approach any nearer to them than about a quarter of an inch. When, as frequently happened,

Photo by] [*H. Bastin.*

WINGED DRIVER-ANT.

The driver-ant, from its large size and ferocity, and its habit of travelling in great swarms, is feared by all living things, which flee before it. The photograph shows a male, twice the natural size.

[1] Bengalia depressa.

[2] Dorylus nigricans.

any ant made a little circuit away from the main body, a fly would generally pursue it at a distance of about half an inch, but backing away directly the ant turned towards it. . . . Eventually I saw a fly stalking a minor ant which had strayed from the main body carrying a pupa in its jaws. Suddenly the fly rushed forward, and it must have driven its proboscis, which seems to me armed with strong bristles, into the pupa, for the ant was brought to a standstill with a sharp jerk.

"Then ensued a tug-of-war between ant and fly fastened on at opposite ends of the pupa, but neither had the advantage till, as it seemed to me, the ant must have got annoyed and, loosening its hold, rushed towards the fly, which, of course, instantly flew off with the pupa, and this it proceeded to suck on the ground about a foot away from the ants. It allowed me to get quite close before taking to the wing with its prey, and it settled again two or three feet farther off and became so preoccupied with its meal that it fell an easy victim to my net.

"I then carefully watched a fly hovering over the ant-column. It suddenly swooped down and rose instantly with an ant pupa, with the driver that had been carrying it still hanging on, fixed to its proboscis. The fly carried this burden for about a foot, then dropped it and alighted on the ground near by. The ant started to run away with the pupa, but the fly pursued it, again impaled the pupa, and started a tug-of-war with the ant. Neither side had any advantage, and then the fly rose again about three feet into the air with the pupa and ant, and after a flight of about eighteen inches let them fall. The ant being discomposed by this procedure let go of the pupa, and no sooner had it done so than the fly seized it, and, flying off with it triumphantly, settled near by and proceeded as in the previous case to suck the prey. . . .

The Fly that has no Fear of Ants.

This African fly—represented two and a half times the actual size—boldly pursues the marching columns of driver-ants, and with splendid audacity snatches from them their cherished cocoons.

"The flies were not always successful even when they had separated an ant with its burden from the main army, for a large ant carrying a small burden often got away owing to the difficulty the fly experienced in getting hold of the load without falling into the jaws of the ant. I subsequently witnessed these manœuvres many times and secured a little series, each fly with its particular prey and the ant concerned."

Several other species of flies, closely related to this bengalia, have been detected in the last few years preying in the same manner upon ants and termites.

Crickets.

The crickets, belonging to the same order[1] of straight-winged Insects as the grasshoppers and locusts, exhibit their relationship particularly by the hind-limbs being developed for leaping. Their long, slender antennæ, the similar methods of sound-production, and the situation of the ears, connects them with the long-horned family. But there are differences which distinguish them at a glance from

[1] Orthoptera.

THE FLY THAT ROBS DRIVER-ANTS.

The African driver-ants are so formidable and travel in such vast numbers that man as well as the larger beasts get out of their way. [illegible] a fly, bengalia, has the courage to attack it on the march to the extent of seizing its cocoons with the contained chrysalids. The actual size of the fly is slightly larger than that of our common bluebottle.

both long-horns and short-horns. The most conspicuous of these differences is seen in the form of the upper side. In all the grasshoppers this is keeled or ridged, but in the crickets[1] it is flat; and this flatness is not disguised by the wings and wing-covers, for they lie flat upon it. A small point here accentuates their distinction from other families; the right wing-cover overlaps the left, which is the opposite of the fashion prevailing throughout other families of the order. The hind-body ends in two long, slender tails like antennæ, which are called cerci, and believed, in many cases, to act as antennæ. The sensitiveness of these cerci is probably of great importance to Insects habitually taking refuge in holes and crannies, as affording them information as to possible dangers from behind. Another point in which they differ from the long-horns, and agree with the short-horns, is that the foot consists of three joints in most of the crickets—the long-horns have four-jointed feet. The tips of the wings are rolled up, and as they project beyond the wing-covers and are longer than the body, they present the appearance of an additional pair of cerci.

The Cricket of the Hearth.

The merry little chirruper that makes its home in defective brick-work around the kitchen fireplace, is shown in walking attitude and just alighted from its flying leap. The instrument by which it effects its shrill call is shown in other photographs.

We have said that the method of sound-production is similar to that of the long-horns; but even here there is a difference. In both families the chirp is produced by the wing-covers, but in the crickets both of these are provided with a well-formed file which crosses one-half of the breadth of the wing-cover. By the partial opening and closing of the wing-covers the file of one is drawn over the nervures of the other, and the sound thus produced is intensified by a tense, clear area like a drumhead behind the file, and occupying the centre of the wing-cover.

There is a pair of ears in each front leg, of which that on the hinder or outer side of the leg is larger than the one on the front or inner side.

The best-known member of the cricket family, of course, is the house-cricket[2]—Milton's "Cricket on the Hearth." In one sense it is the most remarkable of the crickets, for it is an example of an Insect that has voluntarily given up an outdoor life, and taken up its abode in human dwellings. Where was the original home of the house-cricket no one knows. It is common as a household Insect all over Europe, and indeed over a considerable part of the Old World, from which it appears to have made its way with human colonists to North America; but it is not known anywhere to lead an outdoor life. Occasionally it may be heard, and sometimes seen, out of doors in the warmer days of summer, but then always in the immediate neighbourhood of a house; and it may be surmised that it is then in the act of

[1] Gryllidæ. [2] Gryllus domesticus.

migrating to a house that offers greater accommodation than the one it has left. We have known individual crickets to seek to start a colony in a house that was unoccupied by its kind, but after a day or two to depart again, probably because the builder had not made proper provision for them in the kitchen. It likes a house where, because it is to be hidden by the installation of the "range," the bricklayer has not been too particular to finish off the brickwork of the kitchen fireplace, and has left numerous chinks unfilled by mortar, where the warmth-loving cricket can find cosy lodgment. Or a new house where the new mortar may be easily tunnelled. In such secure quarters it remains quietly all day, and at evening emerges into the room and feeds upon such scraps of food as it can find. As one might expect in a creature that spends much of its life in close proximity to a kitchen fire, the cricket suffers from thirst, and one of its principal searches at night is for the means of allaying it. It is sometimes found drowned in the milk-jug or in vessels of water.

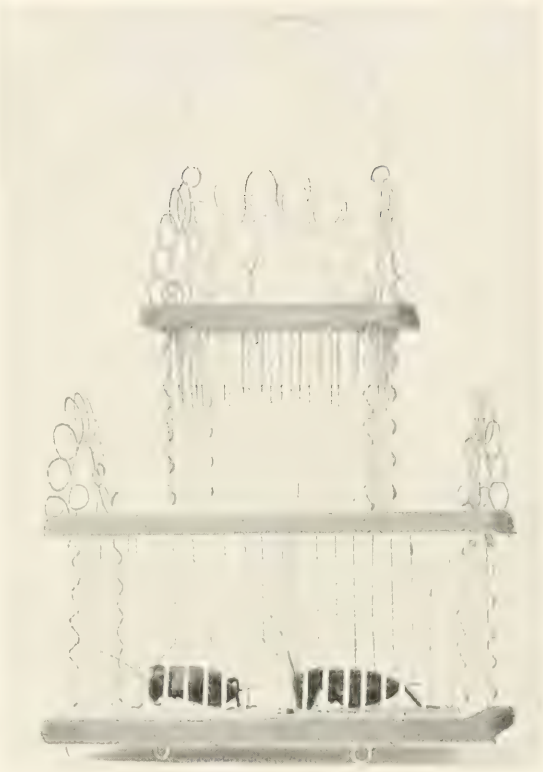


Photo by] [*H. Main, F.E.S.*

THE FIELD-CRICKET AS CAGE-BIRD.

In the Iberian Peninsula, as well as in some Eastern countries, the field-cricket is confined in cages—usually on account of its "singing powers," but sometimes to be handy for a fighting contest. It is the males that are kept for both purposes.

To different persons the song of the crickets—both of the house and the field—is variously considered a pleasure and a nerve-racking infliction. Many of those who would rather be without the music would yet take no steps to dislodge the musician, from a belief that its presence in a house is an omen of good, which might be diverted by the persecution of the crickets.

The developmental history of the cricket follows the same line as that of the grasshoppers. The hind-body of the female ends in a long, slender tube by means of which she

Photo by] [*H. Main, F.E.S.*

THE FIELD-CRICKET.

Though in general it may be said to resemble the domestic cricket, the field-cricket is of much stouter build and black in colour. Fabre has made a comparison between the musical performances of this cricket and the crested lark—to the advantage of the former.

is able to deposit her eggs in safe crevices. From these hatch out minute, six-legged creatures, much like herself, except that they have no wings. They run and leap, and feed and grow, casting their skins five or six times to permit the latter process, and only at the last moult acquire wings.

One of the favourite objects of the microscope is labelled "the cricket's tongue"; but, as usually prepared and mounted, it gives, like the microscopist's "tongue of blow-fly," a totally erroneous notion of the organ as found in the mouth of the Insect. The "tongue" of the cricket is really a grooved eminence on the lower part of the mouth, and serves as a channel for the salivary fluid. Whether it is actually employed in lapping up liquid food, as has been suggested, is open to question.

THE WOOD-CRICKET.

Little as the field-cricket is known, far less so is the wood-cricket. In general appearance it much resembles the domestic cricket, but is considerably smaller. The photograph is three times the natural size.

In addition to the house-cricket, which may be a native or an immigrant from a warmer country—as its adoption of an indoor life suggests—we have the wood-cricket, the field-cricket, and the mole-cricket as our sole British representatives of the cricket family. The mole-cricket differs so remarkably from the others that it calls for separate treatment.

The field-cricket is neither so plentiful nor so well known as the house-cricket. One might go so far as to venture the estimate that to every thousand persons in these islands who have frequently seen the house-cricket, not one has seen the field-cricket—that is to say alive and in a state of freedom. Though the two are built on similar lines, there is little danger of confusing them. The lively pale-brown chirruper that makes our kitchens ring o' nights with his tireless fiddling, is not only smaller, but more slender than his black relation[1] of the fields. He has the same square head and fore-body, the flat back produced by the wing-covers, which turn sharply down to protect his sides. He produces his song in the same way—that is, by scraping his file of one wing-cover over the ridges of the other. He can heighten the sound by loosening the edges of his wing-covers where they lap over his sides, or he can soften it by pressing these closer to him. It is thus that he produces the ventriloquial effect of making his song sound as coming from a distance, when the musician is close at your side. Fabre, who has experimented with captive crickets, says the unmuffled sound can be heard at a distance of four hundred yards. The same observer, whose life spent in Provence has given him ample opportunity for comparing the songs of the cicada and the field-cricket, says

[1] Gryllus campestris.

THE FIELD-CRICKET AT HOME.

At the mating season the field-crickets become very quarrelsome, and encounters between the males are somewhat frequent. Although really serious damage is seldom done, the vanquished combatant sometimes finishes up with fewer limbs than he began with

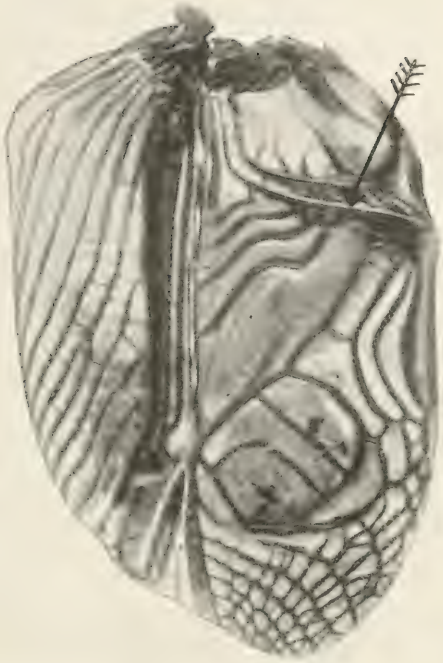


Photo by] [*H. Bastin.*

CRICKET'S MUSICAL INSTRUMENT.

One of the wing-covers of the field-cricket, seen from below and magnified to show the file-like ridge by which the sounds are produced. The arrow points to this ridge. Below is seen the "drum-head" by which the sound is intensified.

Photo by] [*H. Bastin.*

THE CRICKET'S FILE.

A portion of the ridge shown in the previous photograph is here magnified to a far greater extent, showing the cross-furrows which constitute the file.

the one is as powerful as the other, but that the note of the field-cricket has not the displeasing raucous quality of the cicada's. He goes further than this, for he institutes a comparison between the music of the field-cricket and that of the crested lark.

"I am inclined to place the cricket at the head of the choristers of spring. In the waste lands of Provence, when the thyme and the lavender are in flower, the cricket mingles his note with that of the crested lark, which ascends like a lyrical firework, its throat swelling with music, to its invisible station in the clouds, whence it pours its liquid arias upon the plain below. From the ground the chorus of the crickets replies. It is monotonous and artless, yet how well it harmonizes, in its very simplicity, with the rustic gaiety of a world renewed! It is the hosanna of the awakening, the alleluia of the germinating seed and the sprouting blade. To which of the two performers should the palm be given? I should award it to the cricket; he triumphs by force of numbers, and his never-ceasing note. The lark hushes her song, that the blue-grey fields of lavender, swinging their aromatic censers before the sun, may hear the cricket alone at his humble, solemn celebration."

At the beginning of June, the female with the tip of her hind-body bores a number of holes in the earth, and in each hole she deposits a batch of straw-coloured, cylindrical eggs. These various batches amount in the aggregate to about five hundred eggs. The holes containing them are closed by the cricket before she bores another; and the eggs are left. In something less than three weeks the eggs hatch, the upper end pushing off like the lid of a box to permit the flea-like, pale young cricket to escape, and

push its way through the earth above. Like the young grasshopper and locust, the infant field-cricket, roughly speaking, resembles its parent except that there is no faintest hint of wings or wing-covers. Its first business on hatching is to cast its skin, and this is done before it emerges from the earth. Exposure to the light soon darkens his almost white skin until it is quite black. Only a thin, pale line around the middle-body breaks the uniformity of his sable coat. Six or seven times altogether he casts his coats as they become too straight for his increasing corpulence, and before he is full grown the white girdle has disappeared. Wing-buds have appeared, and have in turn developed into expansible and practicable wings with which he can make music or flying excursions.

It is not until the field-cricket is about four months old that he thinks of constructing a retreat for the winter. Hitherto he has been content with the shelter of clods and fallen leaves, but possibly a frosty night has suggested to him the necessity for a burrow. So he sets to work with feet and jaws, and excavates a burrow long enough to contain him, and this is gradually lengthened, and at the far end widened into a chamber where he can turn round. Until this is accomplished he has to back out every time he leaves its shelter, which is a dangerous method, for an enemy in waiting may seize him unaware. Here he passes the winter, only occasionally looking out of the door on mild, sunny days.

Photo by] [*H. S. Chewin, F.R.M.S.*

HEAD OF HOUSE-CRICKET.

The head of the domestic species is enlarged nine times to show the several sets of biting and cutting organs with which the mouth is furnished. The long, jointed appendages are feelers which appear to help the cricket to a knowledge of the class of food it is attacking.

In spring he wakes up fully, and begins to sing like the birds. The mating season comes, and he may have to engage in several fights with other males, who are all pretty quarrelsome about this time, though they do not appear to inflict much damage upon each other. Their battles appear to be much like human duels in which "honour" is satisfied when the opponent receives a scratch, and the scratched one retires from the field, sometimes with the loss of a limb or two.

White says: "It is remarkable that though these Insects are furnished with long legs behind, and brawny thighs for leaping, like grasshoppers, yet when driven from their holes they show no activity, but crawl along in a shiftless manner, so as easily to be taken; and, again, though

provided with a curious apparatus of wings, yet they never exert them when there seems to be the greatest occasion. . . . They are solitary beings, living singly, male and female, each as it may happen. . . . When the males meet they will fight fiercely, as I found by some which I put into the crevices of a dry stone wall, where I should have been glad to have made them settle. For though they seemed distressed by being taken out of their knowledge, yet the first that got possession of the chinks would seize on any other that were intruded upon them with a vast row of serrated fangs. With their strong jaws, toothed like the shears of a lobster's claws, they perforate and round their curious regular cells, having no fore-claws to dig, like the mole-cricket. When taken in hand, I could not but wonder that they never offered to defend themselves, though armed with such formidable weapons. Of such herbs as grow before the mouths of their burrows they eat indiscriminately; and never, in the daytime, seem to stir more than two or three inches from home. Sitting in the entrance of their caverns they chirp all night as well as day, from the middle of the month of May to the middle of July; and in hot weather, when they are most vigorous, they make the hills echo, and in the stiller hours of darkness may be heard to a considerable distance. In the beginning of the season their notes are more faint and inward; but become louder as the summer advances, and so die away again by degrees."

A Mosquito-Bee.

A representative of a family of social bees who fortify their nests with outer walls of clay or resin. The hind-legs are broad and fringed with hairs to enable them to carry this material as well as pollen.

This is the cricket that the Portuguese, Spaniards, and Italians delight to keep in neat little cages, where, fed with lettuce or cabbage, they keep up an almost incessant song. The Japanese, too, are fond of keeping these little cage-birds, and the manufacture of the bamboo cages is an ancient industry of such importance that it has, or at least did have formerly, its own trade guild.

The wood-cricket [1] is of somewhat similar habits to the field-cricket, but is a much smaller Insect—less indeed than the house-cricket.

Mosquito-Bees.

The name we have taken for this group of social bees belongs, properly speaking, to only one [2] or two of the numerous species, because of their smallness, and possibly because they bite instead of stinging. This abstention from stinging is due to a defective development of the stinging apparatus. The sting is there, and all its parts are complete, except that the penetrating point is stunted and blunt. Although it is not sharp enough to pierce human skin, it may still be available

[1] Nemobius sylvestris.

[2] Trigona mosquito.

THE SLIT-FOOTED MONSTER.

This remarkable cricket is a native of India. The extremities of its limbs are fringed with lobes, which doubtless assist it in securing firm hold after a leap, but which have suggested to its scientific sponsors that its feet are slit. The long wings have their tips rolled up and curled in a manner that is not shared by other members of the family. It is usually classified among the long-horned grasshoppers, but its build is clearly that of a cricket.

Entrance Tube to Nest of Mosquito-Bee.

To exclude intruders some of these bees construct entrance tubes, which are easily guarded by sentinels. This example, reduced from actual size—which is about fourteen inches long—was made by a species in the Straits Settlements, and is composed of resin gathered from trees.

for some other purpose, which has not been ascertained at present. Some of the species are also known as dammar-bees from their extensive use of resin for the construction of defensive outworks to their nests. They abound in most tropical countries. Each community consists of an enormous number of individuals, and their combs contain great quantities of honey. In consequence, they are much preyed upon by man, monkeys, and other "sweet-toothed" animals. Instead, therefore, of building uncovered combs on trees like the Indian honey-bees, or in holes of trees or banks like some other honey-storers, the mosquito-bees enclose their combs by building walls of clay or resin. Bates has told us how, on the Amazons, most of the species industriously gathered little pellets of clay much in the same way as they gathered pollen; conveying it to their nests in their pollen-baskets. They nest in tree-trunks or holes in banks, but in either case they build walls of clay to completely shut in their combs, and keep out intruders. That their city is worth sacking may be gathered from Bates' statement that he saw a nest opened which contained two quarts of good honey. The largest species that he met with in that region was half an inch long; the smallest not more than a twelfth of an inch.

One species that is common in Jamaica had its inoffensive character noted by the former Spanish owners, who named it the angelito. Gosse tells us that it makes its nest in trees, and a black species of ant evinces a great desire to obtain admission in order to tap the honey-jars—as big as pigeons' eggs. But the entrance is narrow, and three bees are kept on guard, who are sufficient to block the way. If a worker bee wishes to go out or come in, the middle one of the three sentinels steps aside to make way but immediately resumes her post when the other has passed.

An Australian species, known as karbi,[1] is about three-sixteenths of an inch long. It has the remarkable constructional habit of building its comb in a spiral form, and enclosing it within walls of wax—probably propolis—with an outer labyrinth of passages formed of the same material. Honey and pollen are stored in special

[1] Trigona carbonaria.

pots ; and the entrance is guarded by a line of bees who are jealous in the discharge of their duties. Many of man's inventions have been shown to have been anticipated by nature ; and we may see in the behaviour of these sentinels the first idea of the rack, though the religious inventors of that instrument of torture are not likely to have been inspired by watching the karbi. It is said that when an intruder alights at the entrance, he is at once seized by the guard, who grip his limbs in their jaws, and all stretch them out to their full extent, and keep them so extended for an hour, by which time the prisoner is dead, probably from the exhaustion consequent upon an attempt to use them. The karbi have the reputation of being extremely fierce fighters with their jaws.

Photo by] [*E. Step, F.L.S.*

INSECT EYES.

In this photograph are seen the simple eyes placed between the bug [illegible] cover the greater part of the head in some Insects. With few exceptions [illegible] are only present in the final stage of Insect development. The simple eyes [illegible] transmit images, but to distinguish merely between light and darkness. The [illegible] one of the dragon-flies.

Another species indigenous to Australia is distinguished by the name of kootchar ; and it makes the entrance to its nest in the form of a tube of resinous wax (propolis) an inch long, the mouth of which is kept in a sticky condition in order to trap intruders. At night-time the bees close the entrance by building a perforated curtain consisting of minute globules of nearly liquid gum, which makes burglary difficult. Of a similar character is the much larger entrance to the nest of a species[1] found at Singapore, which is quite an extensive affair of many inches long and very thick. In appearance it is of almost pure resin of a brown tint, and looks as though modelled when in a molten condition rather than being built up bit by bit.

One of the Brazilian species,[2] according to Girard, always makes its nest in that of a species of termite.

The method of rearing the young approaches more to that of the solitary-bees,

[1] Trigona collina. [2] T. crassipes

if we may take Girard's observations of another Brazilian species[1] as applying to the genus. He says the brood-cells are provisioned with pollen and honey before the egg is laid, and that when the queen has supplied this item, the cell is sealed up at once, the resulting grub pursuing its course of development without being attended by nurse-bees, as is the case with the honey-bee. Unfortunately, what goes on in the closed nests of these mosquito-bees is so little known that one cannot be sure that the various species agree in this respect, though it is very probable that they do.

The Senses of Insects.

There are still, we fear, a considerable number of people to whom the mention of senses in Insects must appear to be the purest nonsense. Believing that it is derogatory to man's status as the "lord of creation" to concede the possession of intelligence to the lower animals, Insects are considered by them to be mere automata moved by instincts, and, therefore, not in need of senses. Perhaps, also, there may be a difficulty in believing that it is possible to crowd into such minute bodies the organization that is necessary for the development and exercise of sense. That Insects are not quite so plentifully provided with different senses as man may be admitted, perhaps; on the other hand, there is reason for believing that those they have are finer than the corresponding ones that we possess.

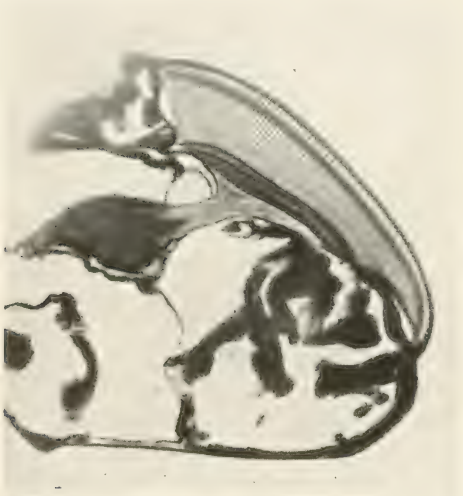


Photo by [H. *Flower Young, F.R.M.S.*

SECTION OF COMPOUND EYE.

The compound eye of the gad-fly is here seen in section, magnified about thirty times. This enables us to see that the lenses do not converge to a single point, and cannot give a combined image. In some Insects one compound eye will consist of as many as 27,000 of these lenses.

We have already mentioned that Insects are endowed with a highly organized and complex nervous system, and with this the special organs of sense are, of course, linked up. Let us glance at these sense-organs in turn.

First let us take the eyes, the organs of vision, as these are usually very prominent features of the Insect. These are of two kinds, the simple eye and the compound eye. The simple eyes are not so well known to the casual observer as are the large compound eyes. They are situated, as a rule, at the top of the head, and are usually three in number, arranged in triangular fashion. All Insects have not got these simple eyes; nor have they all got compound eyes. The simple eye is very similar to what have been called erroneously the eyes of plants. A portion of the outer skin has become convex both above and below, and becoming transparent has formed a lens. The cells of the lower skin immediately below this lens have also become transparent, and thus allow light-rays that have entered through the lens to be transmitted to deeper-seated cells, which have been transformed into a retina. Between the cells of the retina pass the rod-like ends of fibres of the optic nerve,

[1] Trigona scutellaris.

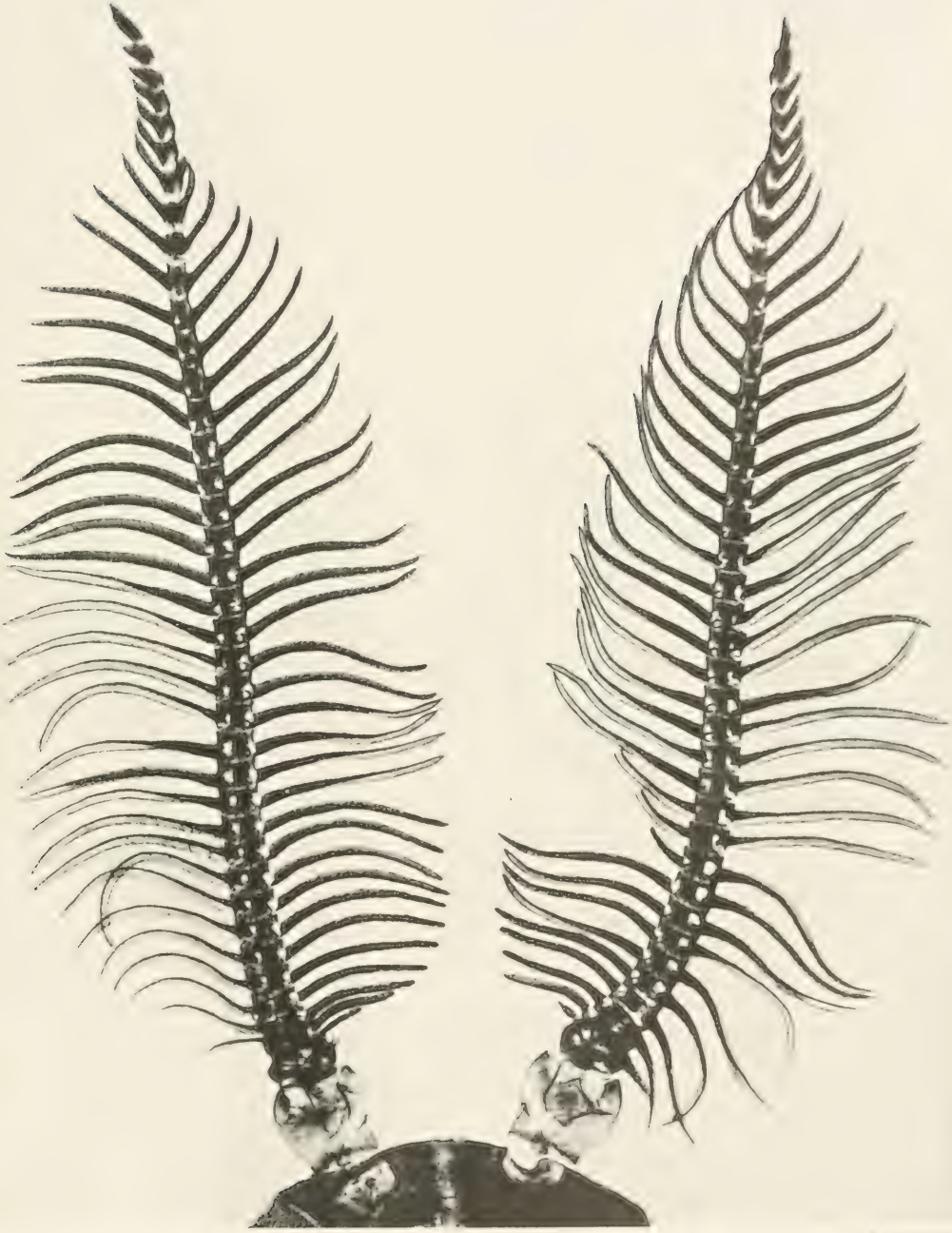


Photo by

THE ANTENNÆ OF THE SILK-MOTH.

The antennæ, or "feelers," are the seat of the sense of smell in most Insects, and probably of other senses a
like projections filled with fluid, each in connection with a nerve. There is great variation in the size and form of these org
species, and they are often more highly developed in the male than in the female. Those shown are from the male mot
silkworm and are enlarged sixteen times.

which connect with the brain. The great convexity of these simple eyes gives them a very short focus, and it is very probable that they are of use more for enabling the Insect to judge of the intensity of the light rather than for purposes of distinct vision. At any rate, Insects that have to rely upon them must be short-sighted. Insects such as bees, wasps, and their allies that have to pass a good deal of time in the darkness of their nests, have them well developed, and the same thing may be said of the night-flying moths, which, however, have only two simple eyes. With the exception of one genus, none of the butterflies have simple eyes. It thus appears that these simple eyes are chiefly useful in the dark. The structure shows that they can only be used for very near objects, probably within an inch.

The compound eye, such as we see standing out prominently on each side of the head of butterflies, moths, flies, dragon-flies, etc., may be considered as an immense assembly of single eyes packed closely together, the separate lenses being called facets. The number of these facets in a compound eye varies greatly. According to Lubbock, a Brazilian species of beetle [1] has only seven facets of unequal size; the silver-fish Insect has twelve, the ant fifty, the house-fly four thousand, the death's-head hawk-moth twelve thousand, the swallow-tail butterfly seventeen thousand, a large dragon-fly [2] twenty thousand, the convolvulus hawk-moth twenty-seven thousand. The size of the facets appear to vary considerably, but is generally proportionate to the size of the Insect—thus the facets of an ant would be much smaller than those of a dragon-fly—but there seems to be a minimum, for the smallest Insects that have been examined from this point of view have facets not less than $\frac{1}{2000}$th of an inch across.

Photo by] [*W. West.*

A Compound Eye.

A portion of a compound eye of the great water-beetle is here shown, magnified sixty-six times. It is believed that each of the numerous lenses of which it is composed gives the Insect an image of only a part of the object it is looking at.

These compound eyes are wonderful in their complex and delicate organization, and compared with them the eyes of backboned animals are very simple organs. The external layer of the compound eye consists of the specialized cuticle, made transparent and broken up into facets. Behind each facet is the crystalline lens or cone, consisting of four or more cells of the lower cuticle. In the earwigs, most bugs, daddy long-legs, and many beetles, the cone is not present. Behind the cone is the rod formed of six filaments of chitin surrounded by nerve fibrils arising from the optic nerve. Both cones and rods are buried in pigment, which prevents the rays of light passing from one facet-eye to its neighbours. Below the rods is the basal membrane which separates the instrumental part of the eye from the optic tract, which perceives the image and transmits it to the brain. The compound eyes are very rarely found in Insects that have not reached their final stage of development; they occur, however, in the nymphs of dragon-flies and may-flies, and in the early stages of one of the gnats.[3] As to what impression is transmitted

[1] Lathridius. [2] Æschna. [3] Corethra.

to the brain by such a multitude of facets, there has been considerable controversy among the experts, but the view most favoured is the "mosaic theory" of J. Müller, who held that—"An image formed by several thousand separate points of which each corresponds to a distinct field of vision in the external world, will resemble a piece of mosaic work; and a better idea cannot be conceived of the image of external objects which will be depicted on the retina of beings endowed with such organs of vision, than by comparing it with perfect work of that kind."

The longest sight is thought to be possessed by butterflies and moths, which can perceive the movements of rather large bodies at a distance of five feet; bees, wasps, and their kindred at a distance of two feet; flies at two and a half feet. Many experiments have clearly proved that Insects can distinguish colours at relatively long distances. In other respects they appear to be guided more by smell than sight.

The sense of smell is—at least in most Insects—seated in the antennæ, popularly known as feelers or horns, the pair of slender, many-jointed organs springing from between or in front of the eyes. From the brain a thick nerve passes into each antenna, and fibres from it connect with sensitive, staff-like cells near the extremity of the antenna, and with accessory apparatus in the form of pits, or of peg-like or tooth-like projections filled with fluid. In some Insects (such as the grasshoppers) there are three or four hundred of such pits on each antenna. In the mantis there are no pits, their place and function being taken by small, hollow, curved teeth with a fine opening at the tip. As might be expected, great variation is found in these pits and processes in the different families and species of Insects, due no doubt to their different habits.

Photo by] [*H. S. Cheavin, F.R.M.S.*

HEAD ORGANS OF MALE GNAT.

The enormous development of the whorled branches of the antennæ is apparently due to the fact that they are organs of hearing. These hairs respond in their movements to a tuning-fork giving 512 vibrations per second; and the hum of the female is of the necessary pitch to set them vibrating.

The organs of taste are in most cases situated on what may be called popularly the palate or roof of the mouth. Where the construction of the mouth does not permit of this they will be found on the organs immediately surrounding the mouth. They are somewhat similar to the organs of smell, taking the form of pits or cups. The exact nature of these organs has not been made out without a great amount of experimenting by numerous investigators, the details of which it is not necessary to enter upon here. One or two examples must suffice. Will, a German entomologist, fed certain wasps with sugar, to which they repeatedly returned. Later he took away the sugar and put alum in its place. The wasps coming eagerly back for more sugar had scarcely touched the alum when they drew back with most comical gestures of disgust, and cleaned their tongues by running them in and out of their mouth, and frequently stroking them with their fore-feet. He

also experimented with quinine, for which the Insects experimented upon evinced a similar disgust. He found that bees and wasps possess a far more delicate taste than flies. Fórel, also, tried similar experiments with ants. Accustomed to being fed with honey, he gave them some with which morphine and strychnine had been mixed, and they began to take it; but as soon as their lips touched it they discovered the fraud, and refused to consume it.

We shall show in another article[1] that many Insects have the power of sound-production, and that the power is usually confined to the male sex. This implies that it is of use in the courtship of the species, and further that the other sex at least must be provided with organs of hearing to render this sound-production effective. Some naturalists have argued that Insects are without ears, and can only appreciate sounds as air vibrations by the sense of touch. Against this, we have the fact that in many of the grasshopper family there is a distinct ear, imperfectly formed in those species that do not produce sounds, but highly developed in those that do. In some species these ears are situated on the upper side of the hind-body, just above the base of the hind-leg (see page 3); in others they will be found on the shank of the front pair of legs, a little below the knee. There is a tense membrane or drum covering an inner chamber in which are auditory rods connecting with the nerves of hearing and collecting impressions from the vibrations of the drum. In other Insects it is believed that the sense of hearing has its organ in the antennæ. Ants and certain species of bees have in their antennæ flask-shaped organs known as "Hicks' bottles" (from their discoverer, Braxton Hicks), and Lubbock believed that they act as microscopic stethoscopes. Some of the hairs on the wonderful antennæ of the male mosquito and gnat have been proved to respond to the vibrations of a tuning fork giving 512 vibrations to the second. "Other hairs were found to vibrate to other notes, extending through the middle and next higher octave of the piano." It was found that the hum of the female mosquito was of just the necessary pitch to set these hairs vibrating. Mayer found that the song of

Photo by] [*E. Step, F.L.S.*

A Grasshopper's Ear.

The long-horned grasshoppers and the crickets carry their ears in their front legs. The photograph is from a South African species, and is four times larger than the natural size. The position of the ear is indicated by the arrow.

[1] "Musical Insects."

Photo by

POWDER-WINGS OF THE HAWTHORN.

This species without any spots on the wings is found on hawthorn, medlar, and a few other garden plants. In [illegible] winged forms, there are also shown many in the larval or grub condition, when they resemble [illegible] Seven and a half times the natural size. See page 180.

the female affected the hairs of one antenna of the male more than those of the other, but by altering the position of its head until both antennæ were evidently affected the male knew in which direction to fly, and was by this means able to guide himself to within 5° of the direction of the female.

In addition to the organs named, others of a special sense have been discovered at or near the base of the wings in flies, beetles, butterflies and moths, dragon-flies, and grasshoppers, with a trace of them in bugs. These have been variously considered organs of smell and hearing. In the two-winged flies there are the rudiments of a second pair of wings, known as halteres or balancers. At the base of the halteres there is a number of small bladders arranged in four groups, to each of which extends a branch of a large nerve—after the optic nerve, the largest in the Insect. Each of these bladders is perforated, and contains a minute hair. It is thought that these sense organs allow the perception of movements which the halteres perform, and which enable the fly to direct its course.

Photo by] [*J. J. Ward, F.E.S.*
TIP OF MOTH'S ANTENNA.
The extremity of an antenna from the male tiger-moth is shown magnified twenty-five times. Each branch is tipped with a long hair, which is apparently sensitive to sounds and odours.

Powder-wings.

There are some common Insects that seem doomed to remain unknown not only to the general public, but to the enthusiastic entomologist also. Among these are the aleurodes, or powder-wings, a name given to them because their wings instead of being covered with microscopic scales, as in the butterflies and moths, are coated with a delicate powder very like flour for fineness. On reference to our photographs of several species that may be found on the under surface of leaves, they will be seen to have a very close likeness to a small moth. Indeed, the great Linnæus actually included these Insects as moths in his natural system of classification. Other great men followed "the illustrious Swede," and it remained for Latrielle in 1795 to show that these Insects had near affinity to the plant-lice, among which he placed them. Later investigators, for good reasons, have removed them from that family, though allowing them to remain in the same order [1] as the plant-lice and the scale-Insects. To the last-named, they are more nearly akin than to any other family.

One of the reasons why so few students of Insect life have paid any attention to this group [2] is to be found, no doubt, in their small size, and in the difficulty—in some cases the impossibility—of distinguishing between the species in their winged condition. The wings are always white or pale yellow, spotless or with indefinite darker marks, reminding one of the finger-and-thumb mark on the sides of the haddock. It is in the earlier stages that we find differences of form, colour, ornamentation, and food-plant, that enable us the better to distinguish between the species.

[1] Homoptera. [2] Aleurodidæ.

They are produced from eggs, the mature Insect not sharing the power possessed by the plant-lice for producing living young. These eggs are elliptical in shape, with a short footstalk by means of which they are attached erectly to the under side of a leaf. They are usually coloured pale yellow or orange; and one female lays a large number of them. They hatch in from ten days to a fortnight—on an average, say, twelve days; and it is interesting to note that similar periods bound the larval and pupal stages. The newly hatched larva—one can hardly apply the term grub in this case—immediately selects a suitable spot into which to insert its beak, and there it remains until it has acquired wings. At this period it is elliptical in shape, almost flat, and so thin and colourless as to be nearly transparent. For this reason it is difficult to make out any organs; but as growth proceeds these become more evident. The presence or absence of hairs and spines, differences of colour and of the character of waxy fringes, distinguish the species one from another. One organ is evident in all species from the beginning. This is an opening on the upper side of the hindmost segment of the body, and it is fitted with a sort of lid for closing it or opening to allow the extrusion of a tongue-like process. From this orifice the Insect appears to furnish a sweet, sticky fluid like that supplied by plant-lice and scale-Insects, and it has the similar power of enlisting the kindly offices of ants for their protection. In most respects these larval powder-wings are like scale-Insects.

In most species the pupal stage is entered upon within the skin of the larva; on being withdrawn the rudiments of the future legs and antennæ may be seen. In some cases the larval skin breaks up and reveals the pupa.

The perfect Insects may be distinguished from the two-winged male scale-Insects by the possession of four wings. There is a common species to be found on the under side of bramble leaves near the ground, whose habits the present writer has had the opportunity for watching more closely than in other species. It is found that the female before laying her pale yellow eggs takes care to dust a small area of the leaf with the white meal, presumably from the under surface of her wings. This is a useful clue to anybody searching for the eggs, which are very

Photos by F. Sp[illegible] F.L.S.

POWDER-WINGS.

These beautiful but little-known, minute Insects appear at first sight to be little moths, and they were regarded as such by the great Linnæus. But their four wings are covered with meal instead of scales, and their early development is very different from that of the butterfly and moth. The specimen with one spot near the tip of the wing is found on the under side of bramble leaves; that with two dark marks is found on cabbage leaves. The lowest abound on celandine leaves. Magnified four t[illegible]

Photo by] [*C. B. Williams, F.E.S.*

EGGS OF THE POWDER-WINGS.

The female before laying her eggs dusts an area of the leaf with meal from her wings and body, and in some cases sprinkles her eggs also with the same material. This treatment appears to be for protective purposes, and it is probable that the powder may have a repellant odour. Magnified six times.

minute and not appreciable to some eyes. If these mealy patches are first found, the pocket-lens may be brought into requisition, and the eggs will be found scattered over the patch, and standing on end like ninepins.

There is one species[1] that is found on the under side of cabbage leaves, and, according to the gardening books, in such numbers as to be regarded as a pest. The cabbage powder-wing may be distinguished from that found on bramble by an additional dark patch, extending nearly across the middle of the wing from back to front. A very similar species is that found on the celandine.[2]

One with the wings entirely unspotted[3] may be found in numbers upon the hawthorn and other plants. In the larval stage this is a more striking form owing to the white mealy patches upon its upper side and the fringe of waxy hairs around the margins of the body.

Scorpion-Flies.

A very curious group of Insects, of which at least one species must have attracted the attention of every observant country rambler, has been fitly named scorpion-flies from the fact that the males have the last three segments of the hind-body so curiously formed and so mobile that they usually carry them curled over the back, when they present a striking resemblance to the tail of a scorpion. But the tail end of the male is not the only remarkable feature of the mature Insect: at the other end the head is drawn out into a long beak, at whose tip are the small, toothed mandibles. The head bears a pair of long, slender antennæ and two large eyes. The four transparent, netted wings are long and narrow, and mottled with brown. The legs are long and spiny. They are very active, carnivorous creatures, and the

Photo by] [*W. West.*

CHRYSALIS OF POWDER-WINGS.

The last stage but one of the powder-wings of the bramble. The grub changes to the chrysalis in the grub-skin, which splits down the back to accommodate the larger bulk of the chrysalis. In this case the remains of the larval skin were cleared away before the photograph was taken. Twelve times the actual size.

[1] Aleurodes brassicæ. [2] A. proletella. [3] A. phillyrea.

By Theo. Carreras.

A Four-winged Daddy Long-legs.

The bittacus is a Continental Insect related to the scorpion-fly, but with very long and slender legs that give it the appearance of a daddy long legs. It is reputed to use its feet as hands by curling them around its prey, and so holding them whilst it consumes them. It will be seen that the head is developed into a prominent beak, as in the scorpion-fly.

Photo by] [*H. Bastin.*

SCORPION-FLY.

The scorpion-fly is so called because the last three joints of the male's body are usually carried curled over the back, after the manner of the scorpion's tail. The mouth is developed into a long, straight beak with mandibles at its tip, with which it captures and destroys other Insects.

common species[1] may be seen frequently in bushy places chasing other flies and killing them. The eggs are laid in a mass, in the ground.

The grubs are much like those of saw-flies, and have, besides the three pairs of true legs on the segments of the fore-body, as many as eight pairs of temporary feet on the first segments of the hind-body. Before the first change of skin they are covered with numerous spines, but with the exception of the largest of these on the last segment, which are repeated with each change of skin, they are thrown off at the first moult. They bury themselves in the ground, and appear to feed upon decaying vegetable or animal matter; though Brauer succeeded in rearing newly hatched grubs in a vessel containing damp earth, upon which he laid a piece of meat. The grubs buried themselves in the earth, and he considers that they were nourished with the meat or its juices. He also discovered a batch of larvæ in a moss-covered tree-stump, which was shared by many ants, who appeared to be on quite friendly terms with the scorpion-fly grubs.

We have three native species of scorpion-flies, of which two are quite common and the third scarce. But we have also an allied species[2] of the same family, which, unfortunately, has no popular name, but which should be mentioned in this place. It is a small creature—less than a quarter of an inch long—but it has the long beak of the scorpion-fly and the long legs. It never develops wings, and so its general shape and the long hind-legs, which look as though intended for leaping, give it the appearance of a larval grasshopper. This appearance is specially strong in the case of the female, for her hind-body ends in a long, stout egg-placer. It must be looked for among moss, but does not put in an appearance until late in autumn, continuing through the winter to early spring. It is so hardy that it has been found in winter leaping about on the surface of snow. Another member[3] of the family does not occur in these islands, but is found in various parts of the Continent. It might easily be mistaken, as one of its scientific names indicates, for a "daddy long-legs," for its hind-body is long and slender and its legs very long. It is said to use its feet for capturing and holding Insects whilst it devours them. The early stages of both boreus and bittacus are, according to Brauer, much like those

[1] Panorpa communis. [2] Boreus hiemalis. [3] Bittacus tipularis.

of the scorpion-fly, except that in boreus the larva has only the six true jointed legs.

The Musk-Beetle and Some Others.

Among the few groups of beetles that can claim any sort of popularity is the long-horn family.[1] The sensitive persons who ordinarily shudder at the sight of a beetle make an exception here, for the usual length and slenderness of the body, combined with the great length of the antennæ, give the Insect a graceful air that quite dispels the common prejudice against the race. Then, in addition, many species of these long-horns are endowed with bright colours or striking marks, which render them more attractive. Finally, in the case of our native musk-beetle,[2] to the attractions of elegance of form and brilliance of colouring is super-added a delightful fragrance, which often causes ladies to forget their regulation horror of beetles, and to wrap this species in their handkerchief or glove in order that they may retain its odour.

Though the musk-beetle from its jaws to the tips of its wing-covers measures only an inch and a quarter, the antennæ alone exceed this length, and so appear to add to the length of the beetle. The colour of the beetle on the upper side is a subdued golden-green, changing locally to blue, and in parts with a reddish tinge, which changes the gold to copper. The antennæ consist of eleven joints, most of which are long, and taper to their base. A peculiarity of these antennæ is that they appear to spring out of the eyes. Really the eye partially surrounds the first joint of the antenna. By a slight rotating movement of its "neck," causing it to scrape the next division of the middle-body, the beetle is able to produce a squeaking sound.

Photo by [E. Step, F.

THE MUSK-BEETLE.

Beetle [illegible] additional attractive [illegible] are longer than the combined length of head and body—which is al[illegible] and a quarter only.

In summer we may have the good fortune to come across an ancient willow-tree on whose broad bole several of these beetles may be displaying their

[1] Cerambycidæ.

[2] Aromia moschata.

glories in the sunshine. Our nearness to them may be first intimated through our sense of smell, by the odour of sweet-briar given off by them. Then the eye catches sight of the brilliant colouring as the sunlight falls upon them. The reason for these musk-beetles being upon the willow-tree is that they were bred from its interior, and have to prepare for another generation of their kind continuing the work they have been doing. So they will lay their eggs in its crevices, and when these are hatched the young grubs will bore into the wood and make galleries, right into its heart may be. It is a yellowish-white, fleshy grub, rather flat above and below. When fully grown it is about an inch long, broadest just behind the very small head, from which it tapers slightly behind. Though its head is small, its little jaws are effective instruments for breaking down the wood-tissues, and making them available for food. As their grub-stage extends over two or three years, their burrows are often of considerable length. They appear to follow no definite course, and often extend far in. As a number of larvæ attack the same tree, it becomes fairly riddled, and this often brings about its decay, although the willow can endure much ill-treatment without being killed. When the grub has reached its full size it enlarges part of its burrow and forms a sort of cocoon of wood fragments, and there changes to a chrysalis, from which the perfect beetle emerges in June or July.

Photo by H. Main, F.E.S.

EGG OF MUSK-BEETLE.

The musk-beetle lays her eggs in crevices of old willow-trees, where probably there are many holes and tunnels testifying to the attacks made by several generations of its kind upon the wood. The egg above is magnified four times.

Photo by] *H. Main, F.E.S.*

GRUB OF MUSK-BEETLE.

For two or three years the grub of the musk-beetle feeds upon the wood of the willow, and makes long galleries in doing so. When full grown it enlarges part of its burrow and forms a nest of wood-chippings, and becomes a chrysalis.

The tropics afford us gigantic examples of these long-horned beetles, which are all wood-borers in the grub stage ; but although these exotics make imposing features in our museums, and have had equally imposing scientific names bestowed upon them, scarcely anything is known of their life-histories, the collectors who have been sent out after them being more concerned in making a "good bag," than in getting information. Of several of them, however, something is known which enables us to judge that the habits are pretty much alike throughout the family. Among these large beetles are the titan[1] of the Amazon region, whose grub attacks the largest trees, and the Indian sawhorn,[2] whose jaws are of such a size as to remind one of those of

[1] Titanus giganteus.

[2] Acanthophorus serraticornis.

Photo by] *E. Step, F.L.S.*

SOME LONG-HORNED BEETLES.

This group of long-horned beetles serves to illustrate the general form which makes almost any member of the family known as such at a glance. The body is long and slender, the legs and the antennæ are long also. The fourteen species figured are all European, and with one or two exceptions are all found in Britain. These are all prettily marked or coloured; and in the grub stage they are all wood borers. Many of the tropical species are among the largest of beetles, but large examples are often of sombre tints.

Photo by] [*H. Main, F.E.S.*

CHRYSALIS OF MUSK-BEETLE.

In this photograph, which is twice the actual size of the chrysalis, most of the parts of the future beetle may be seen clearly. The limb-joints are folded, and the wings are laid along the front with the antennæ laid over them and their slender tips curved up.

our much smaller stag-beetle, though the long, graceful antennæ of the Indian beetle give it a quite different appearance. Its grub is of enormous size, and bores into the trunk of the mango-tree. Such succulent morsels as these long-horn grubs are in some parts used by the natives as food. Our own tanner[1] is a large beetle, as long as the musk-beetle, but much wider. The grub is more than two inches in length, and attacks oaks and other trees.

But these giants are mostly of dark-brown colour, and, therefore, in spite of their size, are less conspicuous than some of their small, but brilliantly coloured relations. There is, for example, our violet beauty[2] that bores into pinewood. In length of body it measures only half an inch, but the colour with which it is entirely covered is the deepest, darkest blue. This may not sound like brilliance; but the surface is so roughened that the light catches all the minute projections and makes them gleam. A slightly smaller beetle,[3] found on the Continent, is of a brighter blue, but might easily be mistaken for it, if the larger, rather globular fore-body of the violet beauty did not offer a mark of easy distinction.

Bird-winged Butterflies.

In the tropics of the Old World there are found several species of butterflies which at once attract attention in a museum or private collection on account of their superior size. When the wings are expanded to their full extent, as the collector likes to dispose them, these measure from tip to tip of the fore-wings something between six and nine inches. As these wings are rather slender in proportion to their length, and the outer margin is scalloped, they suggest some sort of resemblance to the wings of a bird. Unfortunately, in spite of their size and striking coloration, very little is known about them, the collectors who have been sent out to the countries where they are found, having been more anxious perhaps to secure large numbers of the butterflies than to discover their earlier stages. The males have the more brilliantly coloured wings, and the colour-note is one of strong contrast. The wings will be heavily framed in black, whilst on the fore-wings the nervures are margined with grey, or a series of bold, green splashes cross the wing. The hind-wings have the margins and the nervures lined in black, whilst the spaces between the nervures are coloured with bright yellow or orange. In others it is violet or purple that is brought into use with the black.

One of the best known of these is Brooke's bird-wing,[4] of the Malay Peninsula, Malacca, Borneo, Sumatra, etc. Great numbers of the male have been imported to this country, often for purposes of mere decoration, but the females are exceedingly scarce, one rapacious collector reporting that in three months, during which he captured eight hundred males, he could not obtain a single female. He adds that

[1] Prionus coriarius. [2] Callidium violaceum. [3] Pachyta virginea. [4] Ornithoptera brookeana.

he "only saw during that period from twenty to thirty females, which were flying high and settled only on flowers on high trees. The bait which attracted the males never attracted the females, which fly mostly by themselves, and seldom near the males, excepting when the latter are in pursuit of them." The bait referred to is animal matter of some sort in a state of decay, and the collectors make use of this weakness of the males by placing such material in suitable spots. A specimen shown to us by Dr. Chas. Hose is interesting from the fact that it was brought down accidentally by a bullet when he was rifle-shooting.

The male has very long, narrow fore-wings of a velvety-black colour, except in the centre where there is a series of seven large, lance-shaped splashes of metallic green. On the hind-wings this green coloration is continued as a broad band across the wing, broken only by the black nervures crossing it. The body and legs are black, but just behind the head there is a broad collar of brilliant carmine. The female is more subdued in coloration. The black is not so rich, but has a tendency to brown, and the green is less vivid and pales away to greyish. Near the tip of the fore-wing it is superseded by a large, greyish-white patch. The body is brown, and the carmine collar is narrower than in the male. The male measures about six and a half inches across the expanded fore-wings, and the female exceeds this measurement by about half an inch. The male will be found in its natural tints in the foreground of the coloured plate, and above it is the female.

Mr. Burbidge, in his *Gardens of the Sun*, refers to the frequency and familiarity

Photo by] *E. Step, F.L.S.*

THE CRŒSUS BIRD-WING.

This is the butterfly—seven inches across the wings—which, on its first discovery by Alfred Russel Wallace in the Island of Batchian, so strongly excited the famous naturalist that he suffered from headache for the rest of the day. The darker parts of the photograph are in the male butterfly a rich velvety black, and the lighter portions are fiery orange. In the larger female the ground colour is brown, with lighter spots of grey and dull yellow.

of this species in Borneo, where, he says, they "are generally most numerous by rivers, or in sunny places by the dry beds of streams, and, singularly enough, are most abundant during the cool, wet monsoon." He says their strong and swift flight resembles that of birds. "One lovely fellow, fully six inches across the wings, settled on my boot as I remained motionless watching it." This butterfly appears to like a high temperature, for H. O. Forbes, records that, in the neighbourhood of hot springs in Sumatra, its "favourite resort was the stones that cropped out above the hot water, and which were of a temperature but little below 130° F."

Photo by] [*Harold Bastin.*

CATERPILLAR OF PEGASUS BIRD-WING.

As might be expected from the size of the butterflies, the caterpillars of the bird-wings are large. On their backs they bear fleshy spines, and from behind the head they can at will protrude bright, scented organs known as osmateria.

Another fine species is the Crœsus bird-wing[1] of the Malay Archipelago, whose colours are chiefly orange and black in the male, and brown with lighter spots of grey and dull yellow in the larger female. This species was first captured and made known by the late Alfred Russel Wallace, during his memorable natural history exploration of the Archipelago, and it was in the Island of Batchian that he came across it. His account of the incident is well worth quoting as showing that the pursuit of such small game as Insects is not without its possibility of exciting situations. He says: "During my first walk into the forest at Batchian I had seen sitting on a leaf, out of reach, an immense butterfly of a dark colour, marked with white and yellow spots. I saw at once that it was a female of a new species of ornithoptera, or 'bird-winged' butterfly, the pride of the Eastern tropics. One day about the beginning of January, I found a beautiful shrub with large, white, leafy bracts and yellow flowers . . . and saw one of these noble Insects hovering over it, but it was too quick for me, and flew away. The next day I went again to the same shrub, and succeeded in catching a female, and the day after a fine male. I found it to be as I had expected—a perfectly new and most magnificent species, and one of the most gorgeously coloured butterflies in the world. Fine

[1] Ornithoptera crœsus.

Photo by] [*E. Step, F.L.S.*

DRURY'S BIRD-WING BUTTERFLY.

The example from which this photograph was taken measures eight inches across the fore-wings, and some specimens are larger. Its wings are all of a tawny ground colour, with the nervures margined with black. It is a native of tropical West Africa, where, however, it is found only sparingly.

Photo by] [*E. Step, F.L.S.*

D'URVILLE'S BIRD-WING.

This magnificent butterfly, which measures six inches across the wings, is quietly coloured, the central area of the wings being a black, and the parts appearing light in the photograph being violet in the butterfly. It is found in New Guinea, the Solomon Islands, Queensland, etc.

specimens of the male are more than seven inches across the wings, which are velvety black and fiery orange, the latter colour replacing the green of the allied species. The beauty and brilliancy of this Insect are indescribable, and none but a naturalist can understand the intense excitement I experienced when I at length captured it. On taking it out of my net and opening the glorious wings, my heart began to beat violently, the blood rushed to my head, and I felt much more like fainting than I have done when in apprehension of immediate death. I had a headache the rest of the day, so great was the excitement produced by what will appear to most people a very inadequate cause."

Photo by] [*Harold Bastin.*

CHRYSALIS OF PEGASUS BIRD-WING.

The chrysalids of the bird-wing butterflies are the largest of butterfly pupæ. Most butterfly chrysalids hang head downwards, but those of the bird-wings, like those of the common garden white butterflies, are fixed by the tail with the head upwards. This photograph is twice the natural size.

A superb species[1] comes from Queensland, Amboina, etc., and measures from seven to ten inches across the fore-wings of the female. In the male these are black, but a little removed from the front margin there is a feather-like streak of vivid green stretching nearly from the base to the tip, and along the hinder margin there is a narrower wavy streak of the same brilliant colour. On the hind-wings this green colour predominates, the black being restricted to a narrow border, the nervures are traced out in black scales across the green, and between the nervures are five large, black spots. Five other spots (two of them minute) on the fore-border are of bright ochre. A fringe of long, brown hairs fills up the space between the inner margin of the hind-wings and the body. The head and fore-body are black, with a sprinkling of green down the centre of the latter. The hind-body is ochre coloured. The richness presented by this contrast of colour is very fine. No one would imagine from an inspection of cabinet specimens that the male and female could belong to the same species, for the female is not only a much larger Insect, but the colours and markings are utterly unlike those of the male. The style of ornamentation can be obtained from the photograph much better than from a detailed description. The prevailing tint is a smoky brown, and the light patches on the fore-wings are white, whilst those on the hind-wings are a dirty grey. A crimson collar separates the head and trunk, whilst the hind-body is whitish with a tinge of yellow on the sides.

[1] Ornithoptera priamus.

BIRDWING BUTTERFLIES

A few examples of these magnificent insects, including a male and female of Ornithoptera [illegible]. These insects are found in a [illegible] region [illegible] the island of Ceram, Indonesia. They are [illegible] and [illegible] a [illegible] between [illegible] the [illegible]. The [illegible] of [illegible] Papilionidae [illegible] and the [illegible] of [illegible] [illegible]

Very similar to the male of the last-mentioned is the poseidon bird-wing from New Guinea and neighbouring islands, but the green near the hind-border of the fore-wings is a more definite band, and a thin, branching streak of the same vivid colour runs through the centre of the wing. The hind-wings are green with a very narrow border of black, a sprinkling of black scales, and two obscure black spots. The hind-body is of a rich, clear yellow. This is another Insect that greatly affected Wallace when he first caught it at Dobbo in the Aru Islands. He thus records the incident : " I had the good fortune to capture one of the most magnificent Insects the world contains, the great bird-winged butterfly.[1] I trembled with excitement as I saw it coming majestically towards me, and could hardly believe I had really succeeded in my stroke till I had taken it out of the net, and was gazing, lost in admiration, at the black velvet and brilliant green of its wings, seven inches

Photo by] [*E. Step, F.L.S.*

PRIAM'S BIRD-WING.

This is one of the largest of all butterflies known, the female measuring as much as ten inches across the outspread wings. The dark parts of the photograph are smoky brown in the Insect, and the light patches are white on the fore-wings and dirty grey on the hind wings. The male is differently marked in black and vivid green.

across, its golden body and crimson breast. It is true I had seen similar Insects in cabinets at home, but it is quite another thing to capture such yourself—to feel it struggling between one's fingers, and to gaze upon its fresh and living beauty, a bright gem shining out amid the silent gloom of a dark and tangled forest. The village of Dobbo held that evening at least one contented man."

Of a quieter type of coloration, but still exceedingly beautiful is a West African bird-wing,[2] in which the ground colour is a clear bluish-grey bordered with velvety-black, in which tint the nervures are also marked out, affording a fine contrast. Another quietly coloured species is D'Urville's bird-wing,[3] from New Guinea, etc., whose prevailing colour is rich black, bordered with violet. Quite different from these is the enormous Drury's bird-wing[4] of West Africa. This butterfly measures

[1] Ornithoptera poseidon. [2] O. xalmoxis. [3] O. d'urvilliana. [4] Drurya antimachus.

eight inches across the fore-wings, and all the wings are of a tawny ground colour on which the nervures are margined in brownish-black. A broad, irregular border and several spots of black ornament the hind-wings, and the tips of the fore-wings are broadly smoke-coloured. First brought home by Smeathman in 1782, no other specimen reached Europe until 1864.

Wallace was of opinion that the bird-winged butterflies had their origin in New Guinea, whence they have spread all over the Malay Archipelago.

The Pellagra-Fly.

Much has been written and said of the influence of two-winged flies in the propagation of disease, and the discovery of their agency has had enormous results in the matter of colonial expansion. The house-fly is instrumental in the spread

Photo by] [*E. Step, F.L.S.*

AFRICAN BIRD-WING BUTTERFLY.

This boldly and beautifully coloured butterfly measures over seven inches across the expanded wings. The light parts of the photograph are coloured a fine pale blue in the butterfly, and the dark lines and bands are black. The rather heavy black border of the hind-wings is relieved by blue spots. The photograph is of the male.

of typhoid and other troubles, the tse-tse fly carries the active agent in sleeping-sickness, mosquitoes of several kinds do the same office for malaria and yellow-fever, and it is highly probable that further research will reveal the connection between biting flies and other diseases whose cause has baffled the medical men hitherto. In this department of entomology vast strides have been made in the last decade or so, owing to the endowment of special research by State aid, and the generous action of philanthropists; so that Dr. Shipley could fairly say in a recent address to the British Association:

"A few years ago no knowledge could seem more useless to the practical man, no research more futile, than that which sought to distinguish one species of gnat or tick from another; yet to-day they knew that that

Photo by

SOME BORNEAN BIRD-WINGS.

Three species of the magnificent bird-wing butterflies of Borneo with their wings raised to show th [illegible] butterflies of so large a size on one page they have had to be reduced considerably. A clue to the actual s [illegible] that in the middle species—Brooke's bird-wing—the fore-wing measures from tip to base nearly four [illegible] inches when the wings are spread for flight.

knowledge had rendered it possible to open up Africa, and to cut the Panama Canal."

Among the obscure maladies which have baffled medical skill for more than a century is the strange skin disease pellagra, which is endemic in Italy and Roumania, and is in some respects similar to elephantiasis. As in the case of cancer, all sorts of theories have been promulgated as to its origin; and of late the accepted doctrine has been that it is due to eating mouldy maize. Recently several cases have made their appearance in Britain; and careful investigations by Dr. Sambon have shown that it has appeared in parts of Scotland during the last half century, and in the Shetland Isles, in addition to the few cases that have

Photo by] [*E. Step, F.L.S.*

CRŒSUS BIRD-WING.

On page 197 will be found a photograph of the male of this magnificent butterfly. Here we give a portrait of the more soberly coloured female. The specimen photographed measured six and a half inches across the fore-wings.

occurred in the South of England. Dr. Sambon has now satisfied himself that the disease follows on the bite of a fly[1] to which no definite English name attaches, but which may well be known in future as the pellagra-fly. In some localities it is called the black-fly, and in other countries certain species are known as sand-flies and buffalo-gnats, the latter owing to their bison-like hump. One species or another is found pretty well all over the world, where there are fast-flowing streams.

They are dark-coloured flies of small size, stout of body, with the appearance of being hump-backed, and having rather short legs and broad wings. They are blood-suckers, like the gnats and midges, and in seasons when they are specially

[1] Simulium reptans.

plentiful thousands of them will alight on a herd of cattle, and many of those bitten die in the course of only a few hours. In certain countries, such as the lands bordering the Danube, great destruction of cattle has followed the attacks of one species;[1] in certain years they appear in such numbers in spring-time that they fill man and beast alike with terror. In these years thousands of cattle die from their attacks. They select those parts of the body that are not thickly clothed with hair, and are particularly attentive to the nostrils and ears. In the nostrils of beasts killed by them they are often found packed in layers. As the result of a bite, burning itching is experienced, followed by a painful, hard swelling, which may last for a week or more. In cases where the bites are numerous and close together they produce an inflammatory fever, and in some bad cases cramps. We cannot go into the details of the disease as it affects the human subject, but we may state that the most obvious symptom is the thickening and reddening of patches of skin, which turn brown and scale off, and are painfully sensitive to exposure to sunlight. These patches appear on the backs of the hands and wrists, the nape of the neck, and around the eyes and nose.

Photo by [*E. K. Pearce.*

EGGS OF PELLAGRA-FLY.

The yellow eggs, in masses of several hundreds, are laid on the leaves or stems of water-plants. A portion of such a group is shown magnified four times.

The fly, as in the case of malaria, yellow-fever, and sleeping-sickness, is merely a carrier which in its blood-sucking operations conveys the germs of a low organism from an already afflicted animal to one that is new to the neighbourhood, and whose blood affords it the necessary aliment for its development and increase. The species of the genus simulium have not been as thoroughly worked out yet as it is desirable they should be, so that it is not at present possible to say whether all the species are blameworthy in this matter; but it is possible that they are, and Dr. Sambon thinks that certain other small flies of blood-sucking habit may be implicated. As in the cases of the gnat (or mosquito), the midge, and the stout, it is only the female flies that indulge in blood-sucking.

Photo by [*E. K. Pearce.*

GRUB OF PELLAGRA-FLY.

The hinder part of this remarkable grub is furnished with a sucker and a circle of hooks, by means of which it takes hold of the bottom of the stream or of parts of the water-plants. On each side of the mouth is a lobe ending in a fan-like arrangement of fine threads, with which it sweeps the water to obtain food. About four times the natural size.

Taking one of our commonest species as a type, let us glance at its life-history. The yellow eggs are laid in masses of several hundreds on

[1] Simulium columbaczense.

aquatic plants, from which the newly hatched grubs can easily reach the water. These grubs, when large enough to be identified, are rather remarkable creatures, being club-shaped and provided at their hinder extremity with a sucker surrounded by a rosette of minute hooks, by means of which they attach themselves to leaves of water-weeds and stand more or less erectly, in a cluster. Their limbs have been converted into suckers, the foremost pair united to form a projection on the middle line of the first body-segment behind the head. With the sucker of this they can find their way along threads spun by the mouth, or can double over and take hold of the leaf or stone to which the hinder end is attached. The body is greenish-brown or black, and soft; but the head is firm, and bears two pairs of pigment-spots which serve as eyes. On each side of the mouth is a lobe bearing about fifty filaments, which form a fan. By sweeping the water with these, microscopical food such as diatoms are borne to the mouth and serve for the creature's food. These grubs must be sought for in swift-flowing streams where there are plenty of water-weeds.

Photo by] [*E. K. Pearce.*

PELLAGRA-FLY ESCAPING FROM CHRYSALIS.

The chrysalis stands in a slipper-shaped case attached to weed or stone, with the head parts exposed. The fly emerges from the chrysalis into a bubble of air, which clings to it and buoys it to the surface.

Before changing to the chrysalis, the grub spins on the stem of a weed, or on a stone, a slipper-shaped case or socket in which the chrysalis can stand with its head exposed. This chrysalis shows the folded-up wings and antennæ of the future fly. On each side of the head is a projection from which spring four long tubes, which branch near their base. These chrysalids are so disposed in their cells that as the weed bends to the current their heads are turned forwards, and the slipper-like case protects them from friction or battering by any solid particles that may be borne by the stream. Just before the fly is about to emerge from the chrysalis its upper part becomes surrounded by air, the skin splits, and the fly emerges into the bubble. The air clings to it and buoys it dry to the surface of the water, over which it walks to land or to the aerial stems of an aquatic plant. This emergence takes place in spring, but there is another emergence in August, the eggs laid in April or May producing a summer brood.

The flies are said to suck the juices of plants and the sweet excretions of the aphis; but this possibly is true of the male fly only. De Geer stated that they attacked and sucked the blood of large, smooth caterpillars. It would be interesting

[By Theo. Carreras.

THE FLY THAT CAUSES PELLAGRA.

According to Dr. Sambon, the disease pellagra is spread by a small black fly, whose life-history is here shown. The eggs are laid in streams, and the grubs that hatch from them have the remarkable form shown at the bottom of the picture. They are attached by their broad, hinder ends to weeds or stones, and their heads are furnished with a couple of fringed lobes with which they sweep microscopic food to the mouth. The figures attached to weed above them are the chrysalids in their open cocoons. The fly is seen above the water. All the figures are considerably enlarged.

to discover whether the pellagra parasite with which it inoculates man passes part of its developmental history in such hosts.

One species that occurs in the southern part of the United States, where it is known as the buffalo-gnat, is in evidence every year, but at irregular and distant intervals it appears in almost incredible swarms. Stock-owners then endeavour to keep it away by means of smoke. The animals when attacked by large numbers of the flies are driven frantic, and seek to elude their tormentors by rolling in the dust or rushing about. They are at such times almost covered by flies, and as the result of their bites an inflammatory fever with rapid pulse is set up, and the animal dies of cramps or convulsions, "when the skin of the entire body will be found to be covered with numerous small ulcers." Mosquitoes and midges become troublesome towards night; but the flies under notice attack beasts, birds and men in full sunlight. There is one case on record of a man being so badly bitten that his death was speedy. A smaller American species known as the turkey-gnat is especially annoying to poultry, particularly turkeys, which they attack in the bare regions about the head, in the ears, eyes, etc., often killing them in great numbers.

Photo by] [*E. K. Pearce.*

PELLAGRA-FLY.

One of the small black flies that are alleged to carry the germs of pellagra to the human subject. The expanse of the two wings in these flies is very great, the depth from front to back being exceptional. The actual width across the expanded wings is nine millimetres.

Sand-Wasps.

Among the many types of solitary-wasps, the sand-wasps[1] stand out distinctly on account of their long, slender bodies, of which the hinder section is connected to the fore-body by a very long, tapering stalk. One species, the red-banded sand-wasp,[2] may be seen busily engaged at work at almost any sandbank. It is an Insect about three-quarters of an inch in length, entirely black, save for a band of red which includes half of the hind-body and a third of the connecting stalk. There is a distinct neck between the fore-body and the head; and the legs are armed with spines and bristles to aid in digging. The invariable food selected by these sand-wasps for provisioning their cells is a caterpillar or caterpillars, according to species, for each kind seems to have its own favourite species of caterpillar for the purpose. There are many species of sand-wasps in different parts of the world, but their habits are so much alike that they can be described in general.

In recent years we have had accounts of the sand-wasps' activities from Fabre and Marchal; but as long ago as the summer of 1667 our countryman, John Ray, and his friend Willughby were observing it, and Ray has told us in his *History of Insects* what they saw. The sand-wasp was dragging along a green caterpillar three times its own size. When it had dragged this huge load along a distance of about fifteen feet, it came to a hole previously dug in the sand, and left the caterpillar beside it whilst it set to work to remove a pellet of earth that blocked the mouth of the shaft. The wasp descended into the cavity, but soon reappeared

[1] Sphegides [2] Ammophila sabulosa.

and took the caterpillar again in tow. They both disappeared below, but the wasp came up alone after an interval and busied itself in rolling pieces of earth into the hole—"at intervals scratching the dust into it like a dog with its fore-feet, and entering as if to press down and consolidate the mass, flying once or twice to an adjoining fir-tree, possibly to obtain resin for agglutinating the whole. Having filled the burrow to the level of the surrounding earth so as to conceal the entrance, it took two fir-leaves lying at hand, and placed them near the orifice, as if to mark the place."

THE POTTER SAND-WASP.

This little wasp when she has filled up her shaft, after provisioning the cell with food and laying an egg, takes a small stone in her jaws and with it pounds down the earth to make it firm and like its surroundings.

There is only a single cell at the bottom of the sand-wasp's shaft, and some species fill this with small or medium-sized caterpillars; others with a single large caterpillar. All of these, of course, are stung in order to paralyze them. Fabre says of the hairy sand-wasp,[1] that she provisions her cell with only one caterpillar, that of a thick-bodied moth,[2] which is an underground feeder and, therefore, cannot be found by sight. This caterpillar she stings about nine times in as many forward divisions of the body. She waits until she has secured this caterpillar before she sets to work at her mining operations.

Dr. G. D. H. Carpenter, watching this same species at Bordighera, dug out the caterpillar and laid it beside the hole to see what the wasp would do when she returned. "When the wasp came back and found the larva lying there it examined it and seemed puzzled, and then deliberately sucked the contents of the egg dry (I watched it shrivel!) and deposited another in its place." She was evidently not sure that it was her own egg, or if her own that it had not been tampered with by an ichneumon-wasp and so rendered useless. To make sure she destroyed it and laid another.

Photo by] [*H. Basti*

RED-BANDED SAND-WASP.

A graceful wasp that may be seen commonly where there are sand-banks, digging deep holes in them. Save for a broad band of red across the long, slender waist, she is entirely black, and measures three-quarters of an inch in length.

Mr. and Mrs. Peckham have given us most interesting accounts of two American species,[3] agreeing in the main with Fabre's observations on the European

[1] Ammophila hirsuta. [2] Noctua. [3] Ammophila urnalis and A. gracilis.

species, but, of course, with variations which mark the different species. One individual, whose behaviour they watched, was so precise in all she did that we cannot refrain from quoting part of their account :—" We remember her as the most fastidious and perfect little worker of the whole season, so nice was she in her adaptation of means to ends, so busy and contented in her labour of love, and so pretty in her pride over the completed work. In filling up her nest she put her head down into it and bit away the loose earth from the sides, letting it fall to the bottom of the burrow, and then, after a quantity had accumulated, jammed it down with her head. Earth was then brought from the outside and pressed in, and then more was bitten from the sides. When, at last, the filling was level with the ground, she brought a quantity of fine grains of dirt to the spot, and picking up a small pebble in her mandibles, used it as a hammer in pounding them down with rapid strokes, thus making this spot as hard and firm as the surrounding surface. Before we could recover from our astonishment at this performance she had dropped her stone and was bringing more earth. We then threw ourselves down on the ground that not a motion might be lost, and in a moment we saw her pick up the pebble and again pound the earth into place with it, hammering now here and now there until all was level. Once more the whole process was repeated, and then the little creature, all unconscious of the commotion that she had aroused in our minds—unconscious, indeed, of our very existence and intent only on doing her work and doing it well—gave one final, comprehensive glance around and flew away."

YELLOW-WINGED SPHEX.

During the month which is the period of this wasp's winged existence, she contrives to dig about ten shafts, each with three or four cells leading from it at the bottom. Each cell is provisioned with three or four field crickets, all carefully stung in the principal nerve-centre, so that though helpless they remain alive.

Dr. S. W. Williston records an experience with another species[1] that is very similar to the hammering noted by the Peckhams.

Sphex—the typical genus of the sand-wasp family—has had its doings chronicled at length by Fabre. We have no representative of the genus in this country, but in the South of France occurs the yellow-winged sphex[2] to which the famous French naturalist has devoted much attention. Like ammophila, sphex is a very strenuous worker, and during the four weeks or so of its existence in the winged state, it sinks no fewer than ten deep, perpendicular shafts, each with three or four separate chambers at the bottom, stored with food, and each furnished with an egg. It selects a slight elevation of the soil, and into this it bores a horizontal gallery two or three inches in length. At the end of this gallery it sinks the perpendicular shaft, also for a depth of about three inches, and at the bottom

[1] Ammophila yarrowii. [2] Sphex flavipennis.

Photo by [*Harold Bastin.*

THE SAND-WASP'S VICTIM.

The same species as that shown on page 209 is here engaged in hauling the caterpillar of a moth—many times her own weight—to the spot she has selected for mining. She always captures her prey before digging the shaft and the cell that is to contain it. The caterpillar is stung, and a single egg laid upon it; then the shaft is carefully filled up.

the oval cells are made side by side. These are so constructed that the longer axes of the ovals are horizontal, and the first formed is provisioned and sealed up before the second one is dug. The provisions for each cell consist of three or four field-crickets, and these are carefully stung in the three principal nerve-centres of the body, which has the effect of completely paralyzing the cricket without killing it. It is carried by the sphex to the mouth of the burrow, where it is dropped, whilst the wasp goes in to ascertain that all is right. Then, grasping the cricket by its antennæ, the wasp going backwards draws its victim into the cell. A cricket so treated will remain alive, though utterly incapable of any movement, for three or four weeks, a much longer period than it takes for the wasp-grub to consume it. The cricket is laid on its back, and on one of the crickets in each cell a sphex egg is deposited between the second and third pairs of legs. As soon as the egg is hatched the young grub attacks the cricket at this point and burrows into its body, eating out all the interior in a week, and leaving nothing but the cricket's skin. The other crickets are similarly disposed of in turn, but owing to the greater size of the wasp-grub, the pace is accelerated, so that in less than a fortnight from the hatching of the egg all the food is consumed. The grub then constructs an elaborate cocoon of two separate cases of white or yellowish silk, and within these a case of firmer texture and dark colour with a glossy surface. This, apparently, is formed of a mixture of fluid silk, with the excrementitious matter that has been stored in the intestines all through the feeding period, and its purpose appears to be to protect the grub from damp during the nine months of its incarceration, prior to its assumption of the winged condition.

Photo by] [*H. Bastin.*

HAIRY SAND-WASP.

This species hunts for, and finds, a large caterpillar which feeds underground, and therefore cannot be found by sight. Having found and stung it, she digs a shaft and cell to contain it and her egg, but never leaves the place.

A curious difference of procedure is shown in sand-wasps of two families: the sphegidæ, as we have seen, ram the earth down with their heads and with stones held in the jaws; the pompilidæ use their hind-bodies as rammers.

Cockchafers.

In some seasons and in certain localities one may see in the warm evenings of May and June the cockchafers,[1] or maybugs, flying in such numbers around the upper parts of trees that, from a little distance, they look like a thin cloud or mist. In such numbers they frequently do considerable damage by eating the foliage; but even so, it is not often realized that on the Continent they prove at times as great a scourge as locusts—not so much in their complete beetle stage, but as

[1] Melolontha vulgaris.

larvæ. In the case of the locust, all its stages after the egg being passed above-ground, it may be watched and warred upon throughout life; but until the warm days of May tempt the cockchafer into the air he carries on a destructive work out of sight, because underground. During this period of congregation around trees the sexes pair, and a few days later the female returns temporarily to the ground.

The cockchafer is about an inch and a quarter in length, and of a light brown colour, with a series of little, white, triangular marks along the sides, just showing below the edge of the wing-cover. These wing-covers are not long enough to cover the whole of the hind-body. As in the stag-beetle, the scarabs, and others, the end joints of the antennæ are greatly developed to one side, so as to form a kind of brush; but here this particular form of antenna reaches its maximum. The joints in question are long, broad, and thin, and very mobile, so that they can be packed closely together or separated. The sexes can be at once distinguished by glancing at these antennæ, for whilst those of the female have each six leaves, those of the male have seven. Even in nature the male is sometimes favoured more than the female! This is more evident in the large mottled-chafer[1] of the Continent, where the antennæ of the male reach an extravagant development, as compared with those of the female.

Photo by] [*H. Main, F.E.S.*

THE COMMON COCKCHAFER.

[illegible] ground.

Photo by] [*H. Main, F.E.S.*

THE COCKCHAFER CHRYSALIS.

A portrait of the white-grub of the cockchafer will be found on the next page. After four years or so of destructive work underground the grub makes itself a cell, in which it becomes a chrysalis, and awaits its final change. Here the earthen cell has been broken open to reveal the form of the chrysalis. Note that the legs and undeveloped wings are free.

When the female seeks the earth she burrows into it to a depth of several inches (four to six), partly by boring with her pointed hind-body, and partly by scraping with her fore-feet. At what she considers a suitable depth, she deposits from fifteen to forty whitish eggs. The depth depends upon the nature of the soil. She likes humus or vegetable soil, as that is light and suitable for the food and the dispersal of her grubs when they emerge from the eggs about five weeks later. These grubs are in form much like those of the rose-chafer and the stag-beetle, with greatly distended hinder parts. When young they are more slender, and can make use of their six weak

[1] Melolontha fullo

legs for crawling through the earth, but in later life, when the soft hind-body has grown fat, they cannot do much in this direction, but lie with the body doubled up, and eat such roots as are within reach. It can content itself with the roots of grass or corn, but if the farmer is growing mangold-wurzel or beet above its birthplace, the white-grub, as it is called, will destroy the crop. They moult several times during the three or four years in which they assiduously work for the farmer's ruin, and when they feel they have accomplished all they can, they retire into deeper earth and hollow out an oval cell, in which they become chrysalids. The period of the grub stage varies in different parts of Europe according to the geographical position. In Britain it is about four years, in Central Europe three years, and in Northern Europe five years.

Photo by] [*H. Bastin.*

COCKCHAFER GRUBS.

That the protected underground life and the interminable meal of roots agrees with this grub is manifest. After three or four years of feeding they attain almost to the size shown here, and are so plump that their legs are of little use except for holding their food whilst they gnaw at it.

In a series of dry summers, when the roots are not so succulent, the period will be lengthened.

We occasionally experience what local devastation this grub can cause in our own country, but it is scarcely worth mentioning when compared with what it has effected in other countries. There are plenty of statistics available giving the amount of damage done in various places at divers times, and the quantities by weight and count of the cockchafers that have been caught and killed where a resolute war has been waged against them. Thus in the years 1857, 1860, and 1862, the crop of beet in the department of l'Aisne (France) was sixty per cent. below the average yield of years when there were few cockchafers in the ground, and the reduction was attributable solely to the ravages of the white-grub. Again, in 1866, the authorities of the department of the Seine-Inferior estimated the loss

Photo by] [*P. H. Fabre.*

THE MOTTLED-CHAFER.

This large chafer is found on the sand-dunes around the Mediterranean, the Baltic, etc. In addition to its superior size, the white mottling on the brown ground colour of its wing-covers makes it a more attractive beetle than the common cockchafer. The disparity in size of the antennæ between the sexes is here very marked.

to the growers from this cause at twenty millions of francs. Two years later they were abundant in Saxony, and the authorities offered rewards for their collection, with the result that fifteen hundred tons of the beetles were brought in. Now it was found that an average pound of beetles contained five hundred specimens; so that the total number thus destroyed was not fewer than fifteen hundred millions of cockchafers. The method of catching them is not to employ entomologists with butterfly nets, but to observe in the evening what trees they are swarming around, and then to go in the early morning with large sheets spread out beneath the branches from which the then sleepy beetles may be shaken, shovelled from the sheets into bags, and fastened up. When dead they can be served up with the food of poultry and pigs; or with the addition of lime they can be used to fertilize the very fields they have wasted.

Photo by] [*J. F. Hammond.*

THE COCKCHAFER'S ANTENNA.

The remarkable fan-like development of the antennæ in these beetles, and the difference between the organs in the two sexes is made clearer by this photograph, being on the scale of eight times the actual size. Beetles being much smaller the female antenna will be seen to have one leaf less than that of the male.

There is good cause for believing that the chief reason for British immunity from serious attacks of this kind is to be found in our respect for the birds that alone aid us in keeping down the numbers of the chafers. Owls and nightjars account for great numbers of them at evening, and the latter bird may be seen flying among them with his bill wide agape to admit them. Bats, too, catch them, and nipping off the wings and wing-covers eat the more succulent parts. Starlings may be observed, at the time of the chafers' emergence from the earth, waiting and watching for them to crawl up into daylight, that they may capture and eat them. No doubt, like the thrush listening on the lawn for the earthworm, they can hear the movements of the cockchafer as it pushes through the soil. Rooks and ravens do not wait for the full development of the Insect, but, knowing by some means where the white-grub is at work below, they plunge their bills into the ground and drag the bloated grub out. Where the plough can be employed on land attacked by them the share turns up great numbers, and it is mainly for these that the ploughman is attended by a crowd of rooks, ravens, jack-daws, and sea-gulls.

Let it not be assumed as the result of reading the last paragraph that we are entirely free from bad attacks of chafers in this country. There is a case recorded in some of the entomological books of a farmer near Norwich whose crops suffered so much from the attacks of this beetle that he and his servant gathered eighty

bushels from his fields; and the local authorities, sympathizing with him in his losses, made him a grant of twenty-five pounds from the poor-rate.

As is the case with the stag-beetle and some other species, the pupa-skin is thrown off months before the perfect beetle makes its public appearance. Some time during the autumn the perfect cockchafer emerges from the chrysalis-skin, but remains in its cell to allow its new integuments to harden and become serviceable. Then at its leisure it gradually burrows upwards until near the surface, where it will be able to form some idea of the weather conditions above-ground. Some time in May the rising of the temperature of the soil around it denotes sunshine above, and with a common impulse thousands of chafers emerge and try their powers of flight.

A very similar, but much smaller chafer is very common in some places, and is known as the summer-chafer, or small-chafer.[1] Its grub is also similar to that of the cockchafer, and its habits are the same in both stages.

Photo by] [*H. Bastin.*

A Mexican Chafer.

This chafer is closely related to the mottled-chafer shown on page 215, but its brown wing-covers are streaked with white instead of being mottled. Moreover, the antennæ of the male, as shown, reach an extraordinary development. The photograph is nearly twice the natural size of the Insect.

Mole-Crickets.

Though most persons who dwell in houses have at some time or other made the acquaintance of the house-cricket, and a few have seen the field-cricket piping at even in his doorway, the number of those who can boast a knowledge of the mole-cricket except from books is very small. In the first place, it is not a common Insect except in a few favoured localities in our land, but if it were much commoner than it is, it would be little known on account of its retiring underground habits. For the mole-crickets, almost alone among their near relations, have the burrowing habit. The field-cricket lives in burrows, but it is not certain that it excavates them. We are rather inclined to think that it adapts and improves burrows already in existence, and which have served the turn of some other creature, such as a mining bee or an earthworm. Such an excavation can be enlarged or modified by the field-cricket's jaws. But the mole-cricket[2] has been dedicated by nature to this class of work, and provided with the outfit of tools proper to it. It has long been remarked that though the two animals are so different in their class and organization, both the mole and the mole-cricket have been built on the same lines and set to the same kind of work.

The most conspicuous part of the body at first sight is an expansion of the front part of the middle-body into an oval hood, which is open in front and allows

[1] Rhizotrogus solstitialis.

[2] Gryllotalpa vulgaris

the head to be partly retracted into it. This hood is smooth and covered with a fine, downy coat of brown, which, of course, suggests further likeness to the velvet coat of the mole. There can be little doubt that this hood is of importance in the work of shaping and consolidating the burrow. Immediately behind this hood, which is all that can be seen of the fore-body from above in the adult Insect, are the wing-covers, which, as usual in the family, are strongly nerved and folded down the side of the body between the second and third pairs of legs. These wing-covers do not cover half the length of the wings, which are longer than the hind-body, and are tightly folded up lengthwise when not in use and extend between the two hairy "tails" at the end of the body, and might be mistaken for an additional pair of these organs.

Photo by [*H. Bastin.*

THE MOLE-CRICKET.

The fore-parts of the mole-cricket bear a striking resemblance to those of *the* mole, particularly in the development of the first pair of legs to serve as digging organs. The deep belt-like arrangement consists of the strongly veined wing-covers, beneath which the long and expansive wings are folded fan-wise, protruding at the rear.

The third pair of legs are formed for leaping; and all the legs, as well as the hind-body, are more or less covered with brown hairs. But the great feature of the mole-cricket is its first pair of legs, and their modification into digging organs. The thigh and shank are flattened from the sides to form a deep and powerful organ, and this is continued in the foot. The broad edge of the shank ends in four hard, finger-like extensions. These are the digging implements. The foot also is formed into a couple of hard, blade-like teeth, which move over the teeth of the shank after the manner of shear-blades. If tough roots extend across the course of the projected tunnel these are brought into action and the roots are severed.

The mole-cricket is not entirely a vegetarian, probably very slightly. Like the mole, he excavates in order to come upon the Insects and other small animals with which the upper layers of soil teem. When his burrows extend into garden ground where there are seedlings and young plants, his practice of severing roots may cause considerable damage. This is sufficient to cause the gardener to put the mole-cricket upon his black list, and even to accuse it of eating his raw potatoes. It is much more probable that the mole-cricket's presence in the potato-bed is due to his having come in search of the wire-worm and other pests that damage the crop.

The female lays her eggs, to the number of two to four hundred, in a special cell excavated just below the surface, and is said to look after the needs of her brood

By T. Carreras.

THE MOLE-CRICKET AT HOME.

The mole-cricket is as expert and rapid a diver into the earth as the [illegible]. The female constructs a special chamber near the surface, in which she deposits her yellow eggs to the number of several hundreds. From the egg to maturity the mole-cr[illegible] over four years.

Photo by] [*H. Bastin.*

FORE-LEG OF MOLE-CRICKET.

A wonderful implement constructed upon the two tools in one principle. The shank ends in four powerful teeth-like points, which make an excellent digging instrument. Across these teeth the foot works as a cutting blade, which quickly severs roots lying in the way of burrow extensions.

until they cast their first skin, when they are able to look after themselves, and each starts burrowing for itself. It is calculated that their development from the egg to sexual maturity is spread over four years. The mother is said to have to keep them away from the male, who otherwise would eat them.

This cannibalistic tendency is not confined to the male and its offspring, as the following incident will show. Quite recently a friend brought us some mole-crickets from Sicily, where they are so plentiful as to be a great nuisance in the gardens. Three of them were imprisoned in a tin full of earth, in which we were told was also included a large millipede and several terrestrial Insects other than the mole-crickets. A small potato was added by way of refreshment *en route*. The tin was carefully opened, but only two mole-crickets were found, and these showed signs of encounters in the shortening of antennæ and "tails." The mould was sifted, but neither millipede nor Insects were there. The potato was untouched, but one mole-cricket had been eaten. Two days later the smaller of the two survivors had likewise disappeared entirely, but the potato still had its skin and tender shoots intact. If the mole-cricket were a vegetarian it surely would have taken a little potato with its animal food.

Like the true cricket, the mole-cricket is musical after a fashion, but its notes are not shrill and piercing. Its call is a dull sound, that suggests in a small way the churring of the goat-sucker among birds. And being musical, it is provided with ears in the front legs. The openings to these may be plainly seen in the form of a slit in a slight fold near the upper edge of the shank, just below the knee.

The mole-cricket is much more plentiful in Central and Southern Europe than with us, and its range extends through Egypt and Western Asia to the Himalaya. A similar but smaller species[1] is found in the Mediterranean region and the warmer parts of Asia to the low hills and plains of India, where it is somewhat of a nuisance in the tea-gardens. It is there known as the mouse-Insect, owing apparently to its colour and the rapidity of its movements. It is probable that the principal harm it does there is the disturbance of the newly planted young tea-shrubs, but it has the reputation of destroying by eating them. Another one that is found in the West Indies has the similar bad character of being destructive to the sugar-canes. Whether this accusation is well founded is a matter that appears to stand in need of further investigation. It is so easy to conclude, upon seeing certain Insects in the immediate neighbourhood of damaged plants, that the Insects are the authors of the mischief; but it is quite possible that the mole-crickets may be present in the capacity of police looking for the real culprits.

[1] Gryllotalpa africana.

The Lobster-Moth.

The lobster-moth, as a moth, is not remarkable. It is one of the larger of our thick-bodied moths, and is among the less plentiful species, and, therefore, always in request by collectors. But anyone strolling through the woods who has the good fortune to see it resting, as in our first photograph, on the stem of a sapling, would wonder how it had obtained its name, for there is nothing suggestive of the crustacean in its appearance. A rather fluffy grey-brown moth, with its upper wings closed along its sides and the lower ones sticking out from under them, whilst its furry fore-feet are extended in front, might be compared more fitly to a cat, but for the fact that we already have a puss-moth. In truth, the name was suggested by the long, sprawling legs of the caterpillar; and it must be understood to indicate the moth of the lobster-caterpillar.

This brown caterpillar is quite the most extraordinary one produced in this country. Apart from its natural surroundings it may be described as grotesque; but considered in relation to the ordinary risks of caterpillar life, its singularity evokes our admiration, for with a twist or two of the body or a slight alteration of position it may appear as an ant, a spider, a curled leaf, or a lizard.

The moths emerge from the chrysalis stage in May or June, and the females lay their hemispherical, cream-coloured eggs on the leaves of beech, oak, birch, hazel, etc. They hatch in about ten days, and the dark brown little caterpillars, with their long, slender legs, present a remarkable likeness to ants. We have no other caterpillar of moth or butterfly that has such an endowment of legs. The fleshy pro-legs, or temporary legs, which are not represented in adult Insects, are quite normal, but the six true or permanent legs just behind the head are unique in this species, being long and thin like

Photo by] [*H. Eastin.*

MOLE-CRICKET IN FLIGHT.

The comparative sizes of the wings and wing-covers are shown clearly in this photograph, where they are expanded as for flight. It will be understood from this view how it is that the front part of the wing when folded up forms a sort of tail extending beyond the body.

those of an ant. The hinder portion of the body is inflated, and ends in two thread-like tails. The little creature moves about in an apparently nervous, fussy manner, but this is probably part of the scheme to get itself accepted as an ant, which it resembles so much in its movements. This hinder part of the body is usually kept elevated or turned over its back, and when the caterpillar is not actually feeding the big head also is raised. The long legs are held forward. When one is quite aware of the identity of the young caterpillars—as when the eggs have hatched in captivity, for example — the ant-likeness may not be obvious. To see it one should come upon the caterpillar unexpectedly, and then the head appears to be the hind-body of an ant whose jaws have seized upon some other Insect (represented by the caterpillar's inflated hind-body) which it is attempting to drag off. Ants are not much interfered with, their jaws and formic acid being respected by most creatures that might be inimical to them. As the caterpillar gets older and larger, this aspect changes, and viewed from the front it looks like a spider ready to spring. From the side, the hind-body with its filament looks like the head of a lizard with forked tongue extended. But whatever the direction from which it may be viewed, it presents an appearance altogether different from that of a caterpillar. To some it has presented a likeness to one of the larger rove-beetles ; and when nearly full grown and viewed from the side it looks like a curled-up and withered leaf. At this stage the peculiar humps upon the back present a close resemblance to the toothed margin of a leaf. In some respects the lobster-caterpillar resembles that of the dragon-moth previously described (see page 66), and the two Insects, indeed, are not very distantly related.

Photo by] [*E. Step, F.L.S.*

THE LOBSTER-MOTH.

Occasionally the rambler through the woods may ... the lobster-moth settled in this fashion on a small tree-trunk, with the upper wings closed over the body and the under wings protruding at the sides, thus breaking up the outline usual in resting moths. Slightly enlarged.

Before changing to the dark brown chrysalis the caterpillar weaves together two or three decaying leaves, and spins a cocoon between them. When the leaves fall the cocoon and its covering go with them, and the winter is spent by the chrysalis among the dead leaves on the ground. Not until the spring is merging into summer will the chrysalis skin be burst, and the fluffy moth crawl out and ascend the nearest tree.

The late Mr. Tugwell has left us an interesting account of the newly hatched caterpillars, which, he says, will not touch vegetable food until they have shed their first skin. Until then the empty egg-shell from which it emerged is its sole food, and it will not eat the egg-shell of one of its brethren. It remains close to its own shell, walking around it, and nibbling at it from time to time ; but if removed from it, it dies.

Photo by]

THE BOATMAN.

A view of the boatman from the upper side, which he seldom shows, as it forms the under side of the [illegible] The photograph is six times the actual size of the Insect. The boatman may be found in almost any pond.

The Boatman.

One of the things that at once strike the most casual observer who may be induced to give attention to the common objects of a stagnant pond is the boatman[1]—whose title usually suffers the unnecessary elongation to water-boatman. It is conspicuous because it lies on the surface, back downwards, with its head slightly under water and its long, hind pair of legs stretched out almost at right angles with the body, like a boatman with his oars ready for action. The boatman is one of the bugs who has become finely modified to fit his mode of life. The majority of bugs have the upper and under sides not very far apart; but if we catch a boatman—at the risk of getting a pin-prick from his sharp proboscis—and turn him right side up, we shall find that his thickness is more than half his width, the back being shaped like a ridge-roof. Turn it the way in which we found it on the water, and you see that we have here Nature's anticipation of the boat—the form that will best maintain a floating body in a position of stability. The ridge of the back has become the keel of the boat. There is, however, an anomaly here, for the bow and the stern have changed places. The boatman, when in pursuit of prey, sets his oars in motion and pushes his broad head forward. If in this pursuit he has had to go deeply into the water, he has no difficulty in regaining the surface, for unless he takes hold of a submerged weed his buoyant body floats up at once, without any use of his limbs. On such an excursion the boatman does not

Photos by] [*J. J. Ward, F.E.S.*

THE LOBSTER-CATERPILLAR.

It is from the strange form of the caterpillar that the name lobster has been applied to the moth; though it must be confessed that there is little resemblance to the crustacean. When quite young it looks much like an ant. In later life it may be passed over as a curled-up, withered leaf; whilst viewed from the rear or side its elevated hind-body has some resemblance to a reptile's head with forked tongue protruded.

[1] Notonecta glauca.

get wet, for his body is covered with a very delicate coating of fine down, which imprisons a thin layer of air, and so keeps the water from actual contact. When under water this film of air shines like silver.

If the long hinder legs of the boatman are examined closely, they will be seen to be flattened and the inner edge fringed with hairs to make them more efficient as paddles. But this adaptation to aquatic uses makes them useless on land. When, however, the boatman wishes to leave his pond—perhaps to find another where food is more plentiful or the competition for it less severe—he has only to spread his tightly packed wings. On such occasions, too, he will display his antennæ, which are ordinarily kept hidden away in little pockets below the large compound eyes. Several other water-bugs appear, as aquatic Insects, to have no antennæ, but it is only apparently so; they are packed away in these pockets because they are useless in the water and might get damaged. Surface bugs, like gerris, that do not submerge their heads, keep their antennæ extended and in constant use.

Photo by] [*E. Step, F.L.S.*

THE BOATMAN ROWING.

A view of the boatman in the position usually assumed, back downwards on the water. The "stroke" begins with the long hind-legs at right angles with the body, and is continued with a steady sweep until they are almost parallel. The bug is here shown three times larger than the real size.

There is one other adaptation to its aquatic life that should be mentioned: its method of obtaining air. Some pond Insects have an air-tube at the hinder extremity whose tip is kept out of water, and so a constant supply of air passes through it to the body. Others have an air-reservoir under their wings, and make frequent excursions to the surface to replenish its contents. The boatman reposes on the surface with the tip of its hind-body exposed to the air, and we might expect to find that it drew the air into its body at this point; but it is not so, at least not directly. Along the centre of the under side there is a low ridge fringed on each side by long hairs, and a similar fringe runs along each margin of the body. The principal inlets to the internal air-tubes are on the fore-body, and the fringes of hair described constitute two covered ways under which air can pass from the tip of the hind-body to the spiracles on the fore-body.

Some observers have noted that the boatman produces a sound like the words *chew, chew, chew*, rubbing its front pair of legs together at the same time.

The female boatman attaches her eggs to the stalks of water-plants, making an incision with her egg-placer, and burying about two-thirds of the egg in the slit. As in the other bugs, there is little difference except in size and the absence of wings between the infant and the adult. The Insect is continuously active throughout life, and the wings make their first appearance as buds, which expand at the final moult.

Green-Fly.

Whoever owns or has owned a garden has suffered from the dreadful oppression of the green-fly, or plant-lice.[1] There is a stage in the development of the amateur gardener in which the green-fly are worse than dragons. So far as one can learn of dragons from old authors, though they may be individually terrible they are not common, not attacking one in hordes, and are large enough to be seen from a distance. Green-fly are so terribly small, so prolific, and so ubiquitous, that you do not notice their advent until they have increased to millions; you destroy a million all but one, and the next time you pass that way the one has become a million again; you spend half your substance on aphis-brushes and insecticides, and drive them from one favourite rose-bush only to find that they have taken possession of another equally desirable. If only we could extirpate the green-fly, what gardens we would have!

Photo by] [*H. S. Chevin, F.R.M.S.*

YOUNG BOATMAN.

A magnified representation of a newly hatched boatman from the under side, showing that it has the same general form throughout life, only modified by the acquisition of wings in the adult state.

And yet, if we look around us when we go abroad into Nature's garden, we do not find that the green-fly, though plentiful, are so painfully evident as in our own little enclosure; neither do any of the wild plants appear to be extirpated by their attacks. The truth is that much of the trouble is due to unnatural conditions, and much of the damage debited to the green-fly is accomplished by much larger and less prolific Insects. Green-fly do not strip off leaves or bite big holes in them, as we have been seriously assured they have done in our neighbours' gardens. The green-fly is not built for the consumption of solids. Its mouth is developed into a delicate hollow needle with which it bores into leaves and sappy shoots, and through which it sucks the fluid from the plant cells it has tapped. The loss of

[1] Aphis.

By Theo. Carreras.

A Butterfly Enemy of Green-Fly.

This Chinese butterfly is related to our "blues." The female lays her eggs among the green-fly that cluster on the shoots of bamboo, et and the caterpillars that hatch from them subsist entirely upon the green-fly. The green-fly are attended by numerous ants for the sake of their excretions; but the ants take no notice of the caterpillars, though these are decimating the ants' domestic cattle.

WINGED GREEN-FLY.

Green-fly that develop wings are usually males, or imperfect females, that have been produced for colonizing purposes. The production of a winged generation takes place as a rule when the juices of the original food-plant are less abundant.

this fluid makes the attacked leaves curl, become spotted with brown, and in bad cases shrivel up; sickly shoots under the attack wither and are shortened. It is one of Nature's methods of pruning. When things are getting desperately bad a summer storm comes on, and the green-fly that defied the gardener's attacks are all but cleared off. Or, failing the storm, a host of lady-birds[1] or hover-flies[2] appear and lay their eggs close at hand. The eggs quickly hatch, and the grubs at once set to, attacking the green-fly like a wolf in a sheep-fold. Several of the smaller insectivorous birds join in the onslaught, small ichneumon-wasps lay their eggs in them, and certain bugs go about spearing them with their sucking needles.

These unprotected minute creatures, that so trouble the gardener, are really among the most remarkable of living things, and though they have been the study of all great naturalists of the eighteenth and nineteenth centuries, we are far from having a complete and satisfactory account of them and the phenomena of their development. In our own day Buckton has devoted four volumes to a description of the British species alone, and something more has been learned since these volumes were published. It will be seen that in a brief account one cannot go into detail.

Throughout the spring and summer the observer will have noticed that the crowds of green-fly that abound on nearly all plants in his garden are wingless; and with the knowledge of the course of development that prevails almost throughout the Insect-world, he would be justified in assuming that these will in the course of a few days develop wings, for he is quite familiar with them in the winged condition. But it is rarely that these summer broods produce winged individuals. In order to do their work of checking somewhat the redundant growth of plants and supplying food for numerous creatures, the ordinary slow process of passing through successive stages before attaining reproductive powers is not sufficient. Eggs that were laid in autumn, and have been remaining dormant during the

Photo. *H. Fastier.*

GREEN-FLY ON ROSE-BUD.

A colony of wingless green-fly has begun to cover a rose-bud in a way that is painfully familiar to the exasperated though patient gardener. Each one has a sucking beak plunged deeply into the tissues of the rose, from which it is sucking the juices that should nourish the flower. Above are some cast skins thrown off in the process of growth.

[1] Coccinella. [2] Syrphus.

winter, hatch in spring, and produce imperfect females. A few of these may become winged, and a few may be males; but these exceptions are not so numerous as to prevent our speaking of this generation being composed of imperfect and wingless females. In from ten to twenty days these imperfect females begin to produce—not eggs, but living young, and continue producing them at the rate of from three to seven per day. These young in turn, after two or three weeks, likewise produce living young, and the same process may be repeated in successive generations until the autumn. Some of these generations may be winged, following upon a falling off in the supply of nutriment. The wings enable the individuals to migrate to some other species of food-plant richer in sap, from which after several months they may return to plants of the original species, and there produce a generation that is sexually perfect, and that lays fertile eggs. These sexually perfect green-fly are smaller than the imperfect individuals; the females are always wingless, and the

[By T. Carreras.

SUBTERRANEAN GREEN-FLY.

Several species live almost entirely underground, where they feed upon roots, and are attended by ants for the sake of their sweet excretions. The ants take charge of the eggs in winter, and in spring plant out the young aphids in suitable places.

males often so, though usually winged. It is remarkable that there are no fewer than three distinct types of males, of which one has wings, and the other two have none. The wingless males are distinct by reason of one possessing a mouth, whilst the other is without one.

One might imagine that with an Insect so generally abundant in temperate climes everything in relation to its structure and habits would have been ascertained, and made widely known many years ago; but at least one fact over which many generations of observers have erred has only been set right within recent years; the error, however, still makes its appearance in print from time to time. This is in reference to the source of the honey-dew, which makes the green-fly so desirable to ants as a kind of milch-cow. Most species of green-fly—not all—possess a pair of siphons which jut out from the upper side of the fifth segment of the hind-body. From these siphons are produced globules of an oil-like matter, which is really

Photo by] [*E. Step, F.L.S.*

APPLE-TREE APHIS.

A batch of wingless green-fly on the leaves of apple. These were not hatched from eggs, but born in their present form. They are all imperfect females, and have the power to produce others like themselves and in the same manner. They are shown about one-half larger than life-size.

fluid wax, and is ejected at their enemies. This was for long confused with the sugary fluid known as honey-dew, and ants have been figured receiving it from these siphons after stroking the green-fly with their antennæ. The honey-dew is received from the extremity of the hind-body, being in fact the excreta from the Insect's intestine. The green-fly would not discharge the product of its siphons at its friend and protector, the ant.

It may be presumed that the species that do not possess these wax-secreting siphons are not so subject to annoyance. This is certainly the case with an underground species of grey colour, that lives on roots, and is known as the ant-aphis,[1] because of the fact that it is found on the roots of grasses, etc., in, or in the immediate neighbourhood of, ants' nests. It is so carefully watched over by the ants that it is quite protected from any enemies it might have otherwise. The ants even collect and take care of its eggs during winter, and in spring plant out the newly hatched green-fly in places convenient for their own control. This habit has become a serious pest to the growers of Indian corn in the United States, for the ants at first plant their "cows" out on the roots of cornfield weeds that are ready for their reception before the maize is sown, and later transfer them to the roots of the latter plant. The amount of fluid produced by such minute Insects may not strike one as being sufficient to make it worth while for the ant to trouble itself in the matter; but careful observation has shown that different species emit from nineteen to forty-eight drops during twenty-four hours, and when one considers the large number of green-fly comprised in an ordinary colony of them it will be seen that the aggregate output must be considerable.

To found a big colony of green-fly it is only necessary to establish a single individual of these prolific, but sexually imperfect, females on a plant in spring. In a few weeks after she has begun to produce living young, the rate of increase is so enormous that, but for the attacks of other Insects and birds, all vegetation would soon be sucked dry. Huxley made a calculation—since declared to be far

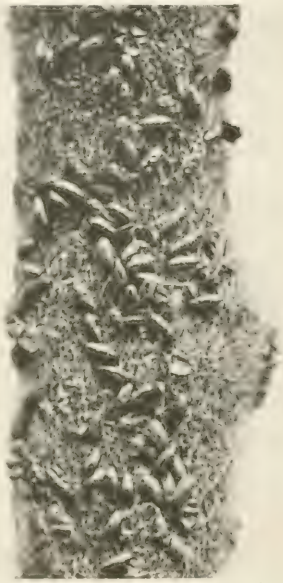


Photo by] [*H. Bastin.*

EGGS OF GREEN-FLY.

A batch of eggs of the apple-tree aphis laid in autumn on a shoot of apple-tree. The eggs are shining black, and hatch in spring. They give rise to imperfect and wingless females, which are able soon to produce living young with similar powers of reproduction.

[1] Forda formicaria.

Photo by]

APHIS OF THE BEECH-TREE.

This little-known species of green-fly is very abundant under the leaves of the beech, but it is very difficult to see the individual Insects as they cover themselves with a profuse excretion of wool-like filaments. They also produce large globules of a sweet liquid. In the small inset photographs above two individuals that have wandered from the crowd are shown. That to the right is a wingless female, with long woolly appendages from the hind-body; on the left is a winged male. About five and a-half times the actual size.

too modest—that if one could eliminate all the natural checks, so that the entire progeny survived, there would be in ten generations (equalling one year) of green-fly "more ponderable substance than in five hundred millions of stout men." Well might Dr. David Sharp say, "Although it is somewhat difficult to make a calculation dealing adequately with the actual facts, yet it is clear that the increase of aphids is such that, drawing as they do their nutriment directly from the plant in its growing state, in the course of two or three years there would be no nutriment available for other animals, except such as might be derived from plants not attacked by aphids. The numbers of aphidæ would be so great that they could not be expressed by ordinary numerical methods, and their increase would be actually limited only by the relations existing between different kinds of plants, and between plants and aphids. This result is avoided by the fact that aphids are themselves the victims of a whole army of Insect enemies."

The green-fly is a member of the great bug family,[1] in which there is no transformation of the individual, but only the acquisition of wings—which in this case may be dispensed with for generations. The sub-division to which the green-fly belongs fold their wings when at rest over the body in a roof-like manner, and the fore-wings are of uniform character from base to tip. In the true bugs the wings lie flat on the back, and the basal half is of a thicker, more horny character than the other part.

[W. West.

An Ichneumon's Tent under its Victim.

Several of the ichneumon-wasps lay their eggs in the green-fly, and the empty skins of the latter, from which the mature parasite has emerged, may be found commonly upon plants. In some cases the ichneumon-grub leaves the body of its victim, from below which it spins a tent to hold its later transformation, as shown in this photograph.

Burnet-Moths.

The popular name of this pretty group, as well as the scientific name of the typical species, appears to be due to a want of precision in the botany of the early entomologists—the salad-burnet and the dropwort being confused, and the name of one used for the English name and that of the other for its scientific appellation. The idea seems to have been that salad-burnet was the food-plant of the caterpillar, and a plant of dropwort was gathered in mistake for it and submitted to a botanist for its scientific name! But the caterpillars do not feed upon either of these plants. However, the moths are well known as burnet-moths, no matter how they came by the name, and there is no reason why they should not continue to be known by that name.

The burnet-moths are among the prettiest of our medium-sized moths, and one species at least may be regarded as tolerably common. This is the six-spot burnet,[2] whose fore-wings and body are dark green with a bluish reflection, with six crimson spots arranged in pairs. The hind-wings are crimson save for a narrow edging of the same colour as the fore-wings. The stout, short, greenish caterpillar is spotted with black and yellow, and feeds upon low-growing plants, such as clover, bird's-foot, and kidney-vetch. It is full fed in June, and then ascends the tall

[1] Rhynchota. [2] Zygæna filipendulæ.

flower stems of grasses and spins the long, yellowish, glazed cocoon, of spindle shape, which is attached to the grass by its full length. This is of a stiff, papery texture, which crackles when pressed. The chrysalis wriggles its head out of the upper end just before the moth is ready to escape, and the perfect Insects may be seen in dozens or scores clinging to the cocoon or the grass flowers whilst their wings expand.

Thereafter they may be seen congregated on flower-heads, showing a preference for composite flowers—thistles, dandelion, daisy, and particularly scabious. Half a dozen of the moths may be congregated on one flower-head, giving it a most remarkable appearance. They sit quietly for hours, as though conscious of the fact that their warning colours protect them from molestation, and the flower may be gathered and carried in the button-hole without disturbing their equanimity. Its favourite haunts are sea-cliffs and sand-hills, and on chalk-downs and heaths inland.

Photo by] [E. Step, F.L.S.

Cocoons of Burnet-Moth.

The stout, greenish caterpillar is spotted with yellow and black, and feeds upon clover and vetches. One is seen having climbed a grass stem to spin its papery cocoon. A number of the cocoons are shown spun up.

The other species, though they differ in the number of crimson spots, the depth of ground colour, and the width of the margin to the hinder wings, are in a general way very much like the common species. Two of them have semitransparent wings owing to the paucity of scales. One of these two is known as the transparent burnet,[1] and it has the spots on the fore-wings replaced by three crimson streaks. It occurs only on the western coasts of Ireland, Scotland, and Wales. The other is the Scotch burnet, which has the five red marks on the fore-wings as definite spots instead of streaks. The only British localities for it are in Aberdeenshire. The five-spot burnet[2] also has only five crimson spots on the fore-wings, and the hind-wings have a broader, dark margin. Another species, the New Forest burnet,[3] is restricted, as its name indicates, to the New Forest in Hampshire; and is found only in certain localities even there.

[1] Zygæna purpuralis. [2] Z. trifolii. [3] Z. meliloti.

Wax-workers.

The workers in wax are not a numerous company, so far as species are concerned; but being social Insects they form communities that more than make up for paucity of species by the abundance of individuals. These communities are also continuous. We must somewhat qualify this statement by admitting that it does not apply to the humble-bees, which like the wasps have to begin again each year; but the humble-bees are not true wax-workers, for they produce very little of the real material, and that of an inferior quality. They have not learned the art of building combs. The true wax-workers are the honey-storing bees,[1] and they may be said to be perennials, whilst other bees are annuals—that is to say, the honey-storing community is perennial, the bees themselves, other than the egg-laying female or queen, being no longer lived than their solitary relations. A wild community of honey-bees in a cave or hollow tree might go on for ever. The huge difference in the two groups—social and solitary—that this implies, has been brought about solely by the discovery of the socials that if they retained honey in their stomachs their vital chemistry would convert it into wax. But for this discovery the honey-bee probably would never have figured largely in literature as she has done, whilst her solitary relatives, equally industrious, no less solicitous for the interests of an unseen progeny and the continuance of the race, have been utterly ignored save by a handful of naturalists. But for this discovery man would never have found the bee worth eulogizing or robbing—and the eulogies have been directed mainly to her habit of storing up honey which man could appropriate to his own use. The discovery of the secret of wax-production and the acquisition of the knowledge of its ductibility and application to the use of the community have made all the difference to the honey-bee, and—*inter alia*—have brought one species[2] completely under the subjection of man.

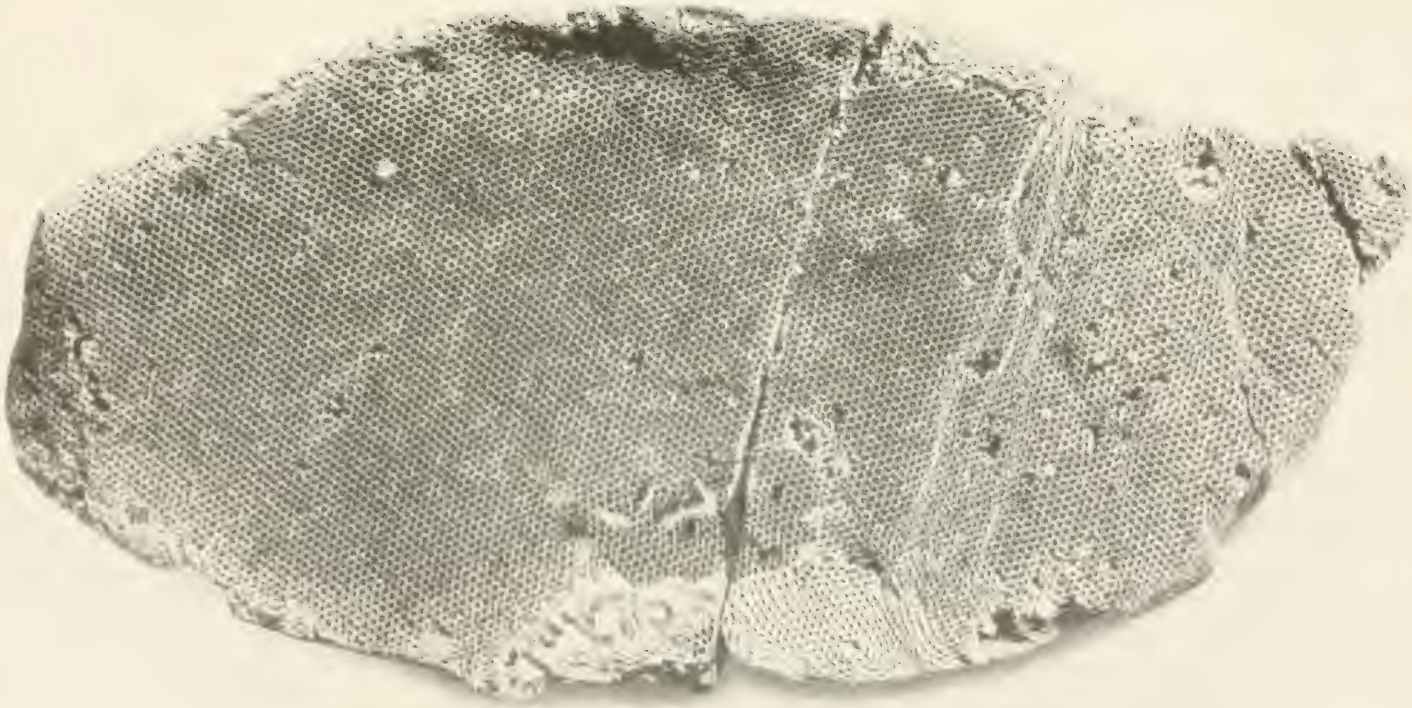
Photo by] [*E. Step, F.L.S.*

Six-spot Burnet Moth.

Just before the moth is ready to escape the chrysalis pushes its head out of the upper end of the cocoon, and the moth walks up the stem and rests until the wings are fully developed.

Wax is a costly substance to produce. It is estimated that the bees need to consume from sixteen to twenty pounds of honey in order to produce a single pound of wax. It is made available for use by its secretion from glands on the surface of the rings of the under side of the hind-body. Here it appears as thin scales, which are removed by the bee's hind-legs and passed to the mouth, where

[1] Apis. [2] A. mellifica.



A Huge Honeycomb.

[illegible] ring of any sort. The specimen from which this photograph was taken measures five feet in length by two and a half feet the other way. The bee that constructs it will be found on the next page.

THE INDIAN HONEY-BEE.

In spite of one of its names—the big bee—and its enormous comb, the Indian honey-bee is no larger than the English honey-bee, which is shown below. It is of so fierce a disposition that all attempts to domesticate it have failed. Twice natural size.

the wax is worked—possibly with the addition of saliva—into a condition suitable for the use of those who have to build up the comb and model the six-sided cells. But before we look further into the economy of the domesticated honey-bee, let us glance at the wild honey-storing bees.

The wild wax-workers as a rule construct no nest in the sense of an external covering like the paper bag of the social-wasps. Instead they utilize an existing hollow—a cave, or decayed tree, or the roof of a human building. But some species of mosquito-bees[1] collect clay instead of pollen, and with it build up a wall around their combs. This is probably due to the fact that their stings are undeveloped and useless for protection. Bates says that most of the South American species of mosquito-bees are workers in clay as well as in wax, and they appear to use it as our honey-bee uses propolis, the gummy varnish scraped from the leaf-buds of certain trees and the stems of some smaller plants. He says that none of these stingless American bees have attained to that high degree of architectural skill in the construction of their comb which is shown by our honey-bee. Their wax-cells are generally oblong, showing only an approximation to the six-sided shape in places where several are built in contact.

The dingar,[2] or big bee, of India differs from these mosquito-bees in the fact that its sting has a very fine and practicable point, and the bee is always ready to use it. It, or a closely allied species (for several appear to have been somewhat mixed up in the accounts), is execrated by archæologists on account of its reprehensible habit of attaching its huge pendant combs to fine buildings like the Taj Mahal at Agra, and the paintings and sculptures in the rock temples at Ajanta. It also attaches its combs to the under side of the horizontal branches of tall trees, such as the cotton-tree. These combs, according to Mr. E. P. Stebbing, are semi-elliptical in shape, five feet long and two and a half feet in breadth. Such a comb may be seen in the Natural History Museum at South Kensington. A single tree may have a dozen of these huge combs on its branches; and woe to the newly arrived and innocent European sportsman who "between beats" indulges in a restful pipe under one of these trees. The ascending reek of burnt tobacco will excite the dingars to fury, and they will descend in thousands and cause the valiant sportsmen—probably military officers—to beat an ignominious retreat at a speed unusual in that climate. One well-known archæologist who was investigating the mural art of Ajanta had to remain in the river for hours, up to his chin in

COMMON HONEY-BEE.

In spite of its small size, the honey-bee has made a great figure in the literature and symbolism of all the ages. Its importance is attributable to its power of producing wax, which enables it to store honey. Twice natural size.

[1] Melipona.

[2] Apis dorsata.

water, to escape the fury of the resentful bees he had disturbed. In Murray's *Handbook for India*, travellers visiting the caves of Ellora and Ajanta are advised to supply themselves with "a pair of stout leather gauntlets coming up above the wrist halfway to the elbow, and a light wire mask with a backpiece to protect the back of the head and neck, many persons having been so badly stung that in some cases death has ensued." Attempts have been made to domesticate the dingar, but they have failed.

So extensive a literature exists upon the honey-bee that it would be idle to attempt to enter into details of its economy here; we will only consider it as a wax-worker. The production of this wax by the worker-bees does not go on whilst they are out collecting honey or pollen, or whilst they are attending to the brood in the hive. It is a distinct employment, and a number of workers appear to be temporarily charged with this function apart from other duties, and it takes them twenty-four hours to convert the honey eaten into the plates of crude wax. A peculiar rite appears to be essential for the carrying out of this wax production, though why it is necessary is not evident. The bees have to hang in festoons attached to each other by the feet only. When wax is needed these festoons depend from the roof of the hive wherever there is room for them. A festoon is formed in this wise: a couple of bees station themselves apart, each clinging to the roof by its fore-feet only; another bee will with its fore-claws cling to the hind-feet of the first one, and so on in the same manner until two hanging chains of bees are formed. Then the two bottom ones cause the chains to swing until they can hook their hinder feet together to form a festoon. So they hang for about twenty-four hours, when the festoon breaks up and the bees which composed it resort to the cell-makers, and supply them with the material for their work. When the wax-secreting worker has brought the thin plates from her abdominal rings to her jaws and manipulated them into true beeswax as we know it, it issues from the mouth as a thin strip which is brought to the cell-makers and applied by them to the walls of the cells now under construction, a work that is carried on with great rapidity.

Photo by *H. Bastin.*

THE PRODUCTION OF WAX.

A worker-bee engaged in the production of wax is seen here from the under side. The wax issues in thin plates between the overlapping segments of the hind-body. A wax-maker has to consume from sixteen to twenty pounds of honey in order to produce one pound of wax.

As stated, a considerable amount of honey is converted into only a small quantity of wax, and therefore the workers use it with parsimony. There is no

waste, and they have learned to make the maximum structure out of the minimum of material. That is the reason for the six-sided shape of the cell. All the solitary bees make their burrows cylindrical, based upon the form of their bodies, or at least of the body revolved on its own axis, as they have to revolve in finishing off their excavation. Now, though the hexagonal cell admirably fits the cylindrical body of the bee-grub, it cannot be modelled upon the body of the worker-bee. If the individual cells of the comb were fashioned separately as cylinders, and then a number of them were brought together, under equal pressure they would form hexagons; but they are not made separately but are built in a mass, and every part of the walls of one cell forms part of the wall of a neighbouring cell. This is even so with the base of the cell, which forms part of the base of three cells on the other side of the comb. To human artificers the task would necessitate a resort to mathematics, but the worker-bee issues from the chrysalis fully competent to undertake the task without swallowing the books of Euclid, and without parental instruction even. Pure "rule of thumb" practice; but even so, the mathematicians have failed to find any flaw in its results; indeed, there is a well-known record of a mathematician's work being corrected in a sense by the bees. Maraldi, a famous mathematician in the early part of the eighteenth century, took an interest in bees, and invented a glass hive in which he could observe them at work. He found that the bottoms of the cells formed an inverted pyramid, and that they were hexagonal like the walls, but formed of three lozenge-shaped plates. His mathematical mind was curious to know if the bees were mathematicians also, so accurate did their work appear to the eye. So, with great care, he measured the angles of these lozenges, and found that the greater angles were 109° 28′, and the lesser ones 70° 32′. Réaumur, who knew of Maraldi's calculations, and suspected that such prevision on the part of the bee had relation to the desire for economy in the use of the precious wax, thought to test the matter from that point of view by propounding this problem to König, a noted geometrician: "What should be the angles of a hexagonal cell with a pyramidal bottom formed of three similar and equal rhomboid plates, so that the least matter possible might enter into its construction?" König, it should be explained, knew nothing of Maraldi's measurements. König employed the infinitesimal calculus, and found that the great angles of the rhombs should be 109° 26′, and the small angles 70° 34′. Here was a surprising agreement between theory and practice! There for a time the matter rested, and then Maclaurin, a Scots mathematician, took a turn at the problem propounded to König by Réaumur. The results he arrived at agreed precisely with the measurements of Maraldi; and it was then endeavoured to discover how König had made

Photo by [*H. Bastin.*

BEGINNING OF COMB STRUCTURE.

A number of wax-makers deposit their products in a little heap, and a cell-maker then begins to excavate in it the bases of cells from which the cell-walls are built up.

Photo by [illegible]

DRONE-COMB

Though the cells are built up from their base, the comb containing them is built *down* from [illegible] differences in the diameter of the cells according to the purposes for which they a[illegible] drones, the actual size of the cells is a quarter of an inch acro[illegible]

the mistake. It was found that the book of logarithms he had used as the basis for his calculations contained an error which accounted for that 2′ in his results. So the bees led to the correction of the book of logarithms, whose error might have led in other directions to lamentable results.

The comb is not built upwards from the base, but downwards from the roof. A small quantity of wax is deposited by one bee to which others add in succession until sufficient is amassed for the commencement of operations. Then a worker begins to excavate in it the foundation of a cell. She continues for a time and then goes off, another worker taking her place immediately and working for a spell. No one bee, therefore, completes a cell, but each is built up by a number of workers doing a little in succession. When the bottom begins to take form, other bees work at a corresponding cell on the other side of the wax curtain. It will be seen that these three lozenge-shaped plates constituting the bottom of the cell have each two free margins—six in all—and it is by building up the walls from these margins that the hexagonal form of the cell is arrived at. As the work of the builders proceeds, the workers who are making wax come and go, leaving additional contributions of wax for the workers to manipulate. There is a difference in the size of the cells according to the use to which they are to be put. Some of the earlier observers, noticing this discrepancy in size, regarded it as a defect in the calculations of the bees. As a matter of fact, the difference is deliberately designed. The cells intended as cradles for worker-grubs have a diameter of one-fifth of an inch; those for males or drones are one-fourth of an inch; the royal cells for the production of future queens are different altogether from these, much larger and of different form, jutting out from the comb and taking a downward direction. They are somewhat pear-shaped, and about five times longer than the drone cells. There is no evidence of parsimony in the structure of the royal cell; the precious wax is lavished here to form thick walls, rough and irregular without, but smooth and polished within.

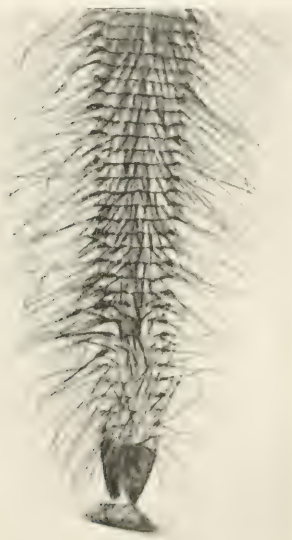


Photo by] [*H. S. Cheavin.*

TONGUE OF HONEY-BEE.

The instrument by which the bee collects the nectar from flowers to be converted into honey. As shown here, it has been dissected out from the surrounding mouth parts and greatly magnified.

The ordinary cells have walls so thin that light passes through them, but the outer edge is thickened into a sort of rim, as this has to be subjected to much friction from the feet of many workers passing over it, whilst the lower parts of the walls are supported by the mutual pressure of the honey in adjacent cells. Roughly speaking, these cells may be said to be horizontal, but there is a slight inclination downward from the mouth to the base. Although the cells are in this position the honey does not run out, chiefly owing to capillary attraction, though it might do so in very hot weather, when the honey becomes more fluid. Until a cell is quite full of honey it cannot be capped, and it will be easily understood that an

By Theo. Carreras

THE ASSEMBLING OF THE OAK-EGGERS

A caterpillar had crept into the hole in the sandbank to undergo its change to a chrysalis. When the final change to a moth came, the entrance was far too small to permit it to emerge. As it was a female, the fact of its presence was communicated by a subtle sense to all the male Eggers of that locality; and they are here shown "'sembling," as the collector calls it, around the hole.

enormous number of journeys is required before the little workers can bring home sufficient honey to fill one cell. To prevent the honey running, the workers have resort to an ingenious device: they obtain a little honey from one of their first filled cells, which is of a firmer consistence owing to evaporation, and this is made to float upon the new honey. This disc of firmer honey floats upon he surface and quite overcomes all tendency of the newer honey to run out. When the cell is full, the workers cap it with a thin sheet of wax attached to the edges. In other cells pollen is stored up for the sustenance of the grubs, the workers as they return from excursions among the flowers simply dropping their collections into the cells and leaving those that are on indoor duty to pack it.

Photo by *H. S.*

HIND-LEGS OF HONEY-BEE.

The hind-leg of the bee is shown from above (right) and below, magnified to make more clear the adaptation of the thigh and shank to the purpose of pollen-carrying.

When the brood cells are ready the mother-bee (usually styled the queen) traverses the comb and lays an egg in each cell. She appears to know what is the character of each egg before she deposits it. The first few may be deposited in the drone cells, then a vast number is laid in the worker cells. The eggs of the two kinds differ in size, just as the cells do. In April and May she will lay eggs at the rate of fifteen hundred to two thousand a week, and continue doing so. In six weeks she has furnished ten or twelve thousand cells with occupants; and during the whole of one season she will lay thirty or forty thousand eggs. During her life she may produce as many as a hundred thousand.

The eggs hatch after three days, and the minute grubs are at once tended by the nurse-bees, who feed them with bee-bread, which is a compound of honey and pollen. On this diet the grub thrives, and when only five days old it is full-fed and fills its cell. The nurse-bees then close the cell with a cap made of wax and pollen, which is porous and admits the air. It is important to notice this distinction

Photo by [*H. S. Chearin, F.R.M.S.*

BEE'S BRUSH AND COMB

In connection with a hinge [illegible] brush and comb arrangement [illegible] kept clean. The leg [illegible] the latter is drawn [illegible] brushed off.

between the capping of the honey-cells and the pollen-cells. Honey would ooze through the porous cap, and the wax cap would cause the asphyxiation of the chrysalis. The grub then spins its cocoon, and changes into the chrysalis condition. About a fortnight later, it appears as a winged worker, and rests for half a day to allow its integuments to harden, after which it is ready to take up duty as a nurse or other indoor worker. The evolution of the drone follows much the same course, but, so far as information goes, when it emerges as a bee, bigger than a worker and with compound eyes that meet on the top of the head, it does no work beyond taking part in the ventilation of the hive by fanning with its wings.

The "royal" cells are mere cups when the eggs are laid in them. In three days also these eggs are hatched, and the nurse-bees drench the young grub with a special food, the "royal jelly." As the grub grows the cell-walls are built up, and in five days full growth is completed, when the cell is finished and sealed up for a fortnight, by which time the female bee issues from her chrysalis-skin, and is soon ready if need be to accompany a swarm to found a new colony. Or she may be killed before emergence by her jealous mother.

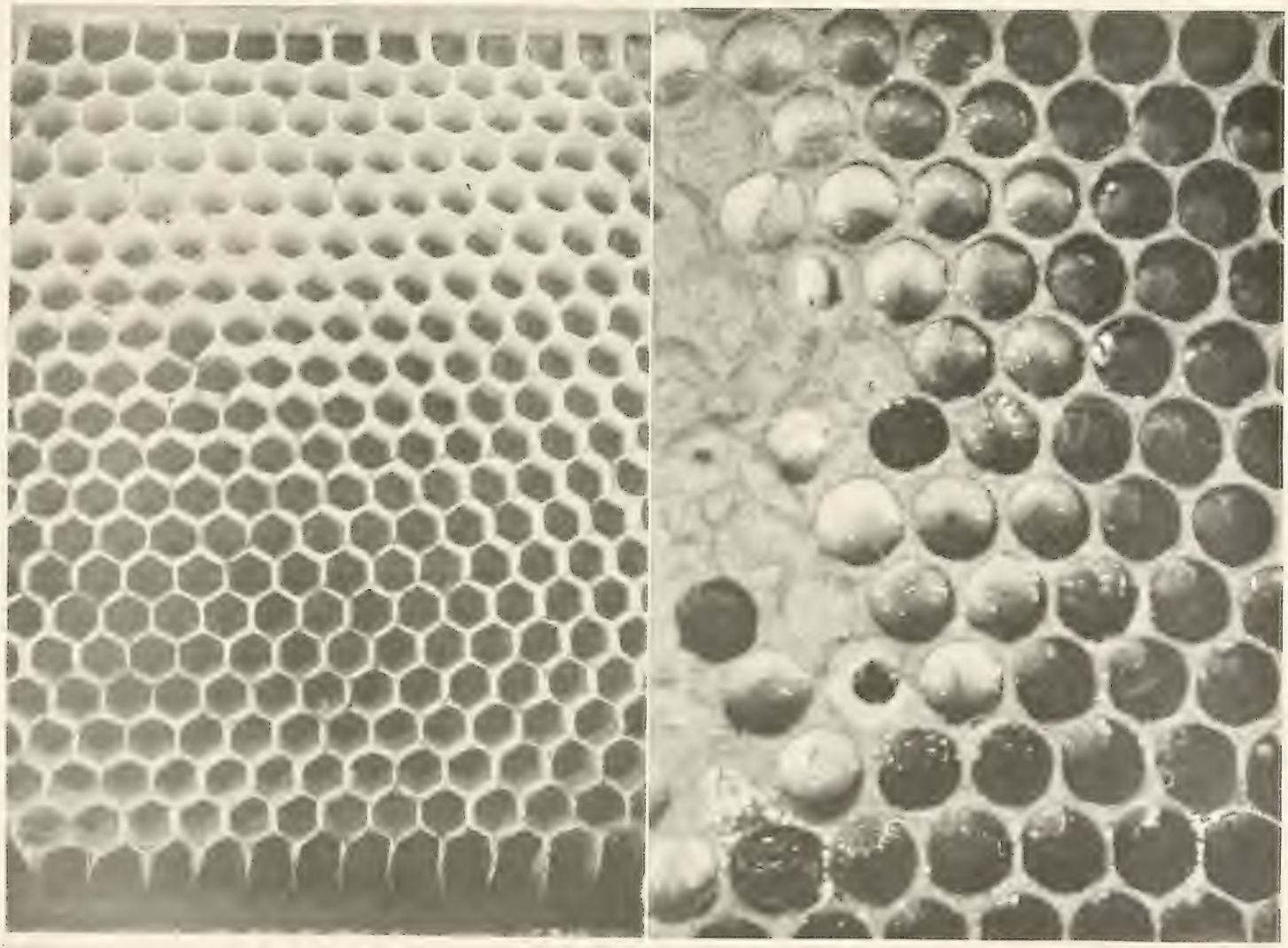
Photo by] [*H. Bastin.*

GRUBS OF HONEY-BEE.

The grubs of the honey-bee lead uneventful lives, each in its separate cell, where food is brought to it as required. They are shown magnified six times. The one on the right is changing to a chrysalis.

Whilst on the subject of wax, we ought to mention that for stopping cracks or sealing up the bodies of invaders whom they have killed but cannot remove, the bees use a substance to which the ancients gave the name of propolis. This is the gummy varnish gathered from the leaf-buds of poplar, horse-chestnut, pines, and the stems of other plants. They take it home, as they do pollen, in the baskets on their hind-legs; but they cannot discharge their loads of propolis as they do their pollen: it is so sticky that it has to be pulled off by other workers.

We have referred to the fact that the combs are built from the top downwards. The favourite explanation of this is that the bees are impelled by instinct so to build, the hanging of a weight of honey in so soft a substance as wax being a much safer plan than resting the weight upon the soft basal cells, which would collapse under it. Mr. Tickner Edwardes, one of the most charming writers on the honey-bee, shows, we think, conclusively that it is inherited experience and not blind instinct that impels the wax-workers. In a passage worth quoting (*Lore of the Honey-Bee*) he says: "It is undoubtedly long racial experience, and not inability to follow the humanly approved method, that guides them here. Rarely—so rarely that the writer, in the course of many years spent among bees, has seen only



Brood Comb

H. [illegible]

[illegible]

a single example of it—bees will build comb *upwards*, if circumstances will allow no other way. And this would seem not only to drive the last coffin-nail for the poor instinct-theory, but to carve its epitaph as well.

"In the instance referred to, a glass-bottomed box had been inverted over the feed-hole of a common hive, and had there remained forgotten. As the season progressed, the hive grew great with bees and honey, and it became imperative to build additional store-comb in the box overhead. But its slippery glass roof would give no foothold to the builders. Time and again they must have tried to get upon it, with their wax-hods filled and ready, and each time failed: the ordinary way of comb-building was clearly impossible. Then the engineers of the hive, inspired by the difficulty, got to work in another way. On the wooden surface below they laid out the plan of a garner-house, not after their usual method of parallel combs, but a regular, oblong house, with cellular store-rooms and communicating passages in between. Upon this they raised storey above storey of horizontal cells, until the glass roof was nearly reached."

Photo by] [*J. F. Hammond.*

STING OF BEE.

The sting of the honey-bee is shown with its guard magnified twelve times. The swollen body to the right is the poison-gland in connection with it, which makes the being stung so unpleasant a matter.

Other wax-workers will be found, as indicated, in the humble-bees,[1] which, however, call for separate treatment.

Egger-Moths.

One of the best-known families of moths in this country is that[2] which includes the oak-egger, the lackey, the fox, the drinker, and the lappet-moth. These are all more or less familiar, either as moths or caterpillars, to all who as boys have had the run of country lanes and woods. The caterpillars attract attention by reason of the soft woolly hair with which they are clothed, and the moths by their stout bodies and their usually dense coating of scales. Another feature of the moths is the comb-like fringe of the antennæ, always more highly developed in the males than in the females, which is, no doubt, a very important sense-organ. The caterpillars spin closely compacted oval cocoons, often with their no-longer-needed hairs mixed up with the silk. The name egger was probably suggested by the size and shape of these cocoons. The egg-like character of the cocoon is in some cases increased by the caterpillar discharging over the silk a solution of calcium oxalate, which gives it a chalky appearance. The moths lay large, smooth eggs, often boldly spotted or blotched.

The typical species is the oak-egger,[3] a fine substantial-looking moth, which, with outspread wings, measures three inches across. This is the measurement of the female; the male is less by three-quarters of an inch, or one-fourth. The general

[1] Bombus. [2] Lasiocampidæ. [3] Lasiocampa quercûs.

Photo by] [*H. Bastin.*

THE LACKEY-MOTH.

The smaller example is a male, the larger a female. The colour varies from yellowish-brown to reddish-brown, with a band of darker tint across the fore-wings. Although feeding on a variety of wild trees the caterpillar often causes havoc in orchards by attacking the fruit trees and rendering them leafless.

colour of the female, wings and body, is tawny, paler towards the margins, and with a light spot in the centre of the fore-wings. The male is much darker, with the exception of a pale band, which crosses all the wings; but the much more slender body and the breadth of the fringed antennæ are sufficient, apart from colour, to distinguish him from his mate. There is considerable variation in the matter of colour in both sexes, and this is especially evident in a variety that has been named the northern egger,[1] from its appearance chiefly in the northern parts of these islands, in which the coloration is deeper and brighter.

The female deposits her dry, brown-mottled eggs whilst she is on the wing, much after the manner of the ghost-moth. This happens in August, and in the same month the young caterpillars may be found upon heather, bramble, dogwood, hawthorn, bilberry, and other shrubs. But they do not feed for long at this period; whilst still quite small they seek safe quarters in which to pass the winter quietly. In spring they wake up and begin to feed again, and by June or July are full-fed. They are now about two and a half inches long, the rings of the body coloured dark brown, which has a violet tinge along the sides, and between the rings the skin is black. Along each side runs a white line, and below this some reddish spots. But this coloration is somewhat hidden by long, brown hairs, which spring from the body in tufts. If touched or otherwise alarmed, the caterpillar drops from its food-plant to the ground, rolling itself into a ring on the way. The long hairs then stand out in tufts all around it, and between the tufts the black skin shows strongly in contrast with the red and white markings on the sides—a warning to all and sundry that it is unwholesome food.

Its feeding concluded, the caterpillar crawls down to the ground, and there among the dead leaves and fallen twigs it spins a firm, closely-compacted, oval cocoon, and changes to a purplish-brown chrysalis. This, however, is a very temporary stage, though

Photo by] [*H. Main, F.E.S.*

THE OAK-EGGER MOTH.

This fine moth is tawny-coloured in the female, much darker in the small [illegible] which also has a finer fringe to the antennæ. The name is a misnomer, [illegible] Insect has no connection with the oak, the caterpillar feeding on heather, [illegible] and other low shrubs. A freshly emerged female imprisoned in a cage, but expo[illegible] to the air, will attract a number of males from far and near. Natural siz[illegible]

[1] Var. callunæ

the character of the cocoon might lead one to suppose that it was intended to protect the chrysalis from the rigours of winter, instead of a few weeks of July. It is probable that at one time the habits of the Insect were rather different in this respect: that the eggs were laid early enough to enable the caterpillar to become full-fed during its first summer and to spend the winter as a chrysalis, making an earlier emergence as a moth the next year. The probability of this being so is suggested not only by the character of the cocoon, but by the fact that occasionally an individual will follow this course, showing a probable reversion to former habits of the species.

Photo by [*E. Step, F.L.S.*

OAK-EGGER CATERPILLAR.

The egger-moths are so called owing to the caterpillars constructing egg-shaped cocoons of large size, firmly woven, and often coated with a chalky substance, which increases the resemblance. The caterpillar shown is about two and a half inches long; in general colour dark brown, and covered with tufts of long hairs. Along the sides runs a white line and a series of red spots.

Having reared one of these Insects through its early stages, and been rewarded by the emergence of a female moth, we can if we will cause nearly all of the male oak-eggers of the district to assemble. All that is necessary is to take her in a gauze-covered cage to the edge of a heath or moor and attach the cage to a low twig. About three o'clock in the afternoon is the best time for this species—with some others dusk is a better time. Before you have waited long a number of males will arrive and swarm around the cage, trying hard to obtain admission.

Our coloured plate illustrates this "sembling" habit, as it is called. It is an incident noticed at Bude by our artist. A small hole in a sandbank was surrounded by several male eggers, and others were flying from all directions, regardless of a strong wind. They made frantic but futile efforts to get into the hole, but it was much too small to admit them. Suspecting what might be the cause of the excitement, Mr. Carreras carefully cut away the sand, and at a depth of a few inches he came upon a female with wings crumpled and most of the scales rubbed off. Apparently a caterpillar had crawled into the hole to spin up, without realizing that as a moth it would be unable to pass out again. Although entirely hidden from sight, all the male eggers of the district appeared to have received intimation of her presence.

A much smaller moth, but one better known from the frequent abundance of its pretty caterpillars, is the lackey.[1] The female measures only an inch and a half across the expanded wings, and the male is a quarter of an inch smaller. They are both coloured entirely in brown, varying from pale yellow-brown to dark reddish-brown, and have a broad band of deeper tint across the fore-wings They fly in July and August, like the oak-egger, but as these are not on the wing until night the moths are seldom seen, except when they fly into the house attracted by the lights. They lay their eggs in close rings around twigs, where they remain until spring. The caterpillar is too frequently a serious pest on fruit trees, on hawthorn hedges, and

[1] Malacosoma neustria.

NESTS OF LACKEY CATERPILLARS

[illegible] caterpillars [illegible] in which they are still [illegible]. When tired of feeding they come out upon the [illegible] then [illegible] have been eaten, they move and spin a larger tent [illegible]

also attacks various trees, such as oak, elm, birch, sallow, etc. When fully grown they are about an inch and a half long, of a slaty-blue ground colour, with a white stripe down the middle of the back, bordered by black through which runs a reddish line, and there are black spots on head and tail. It is thinly clad with pale brown hairs, which are more abundant along the sides. It appears to have been this ornamentation which led to the caterpillar being stigmatized as the lackey. The caterpillar stage extends from April to June, when it constructs a double cocoon of oval shape, whereof the inner part is more closely woven than the outer, and coated with the oxalate of calcium solution referred to previously. The black-brown chrysalis is slightly downy.

A noticeable trait of these caterpillars is their habit of living and feeding in companies until they are nearly full-grown. They spin a common tent, enclosing twigs and leaves, under which they feed, coming out upon the exterior for rest and for shedding their outgrown skins. When the food beneath it is exhausted, they remove in company to another branch and build a new and larger tent. This habit has led in the United States—where they are very injurious—to their being known as tent-worms.

Photos by] [*H. Main, F.E.S.*

COCOON OF EGGER-MOTH.

The first of the two photographs shows the exterior of the cocoon; and in the second half of the cocoon has been cut away to show the chrysalis within. Natural size.

A finer moth in point of size, though of somewhat similar coloration, is the fox-moth,[1] of which the males may be seen in numbers dashing about over the heath on fine afternoons in May and June. They are then engaged in seeking after the less active and heavier females, who restrict their flight to the hours of darkness. The grey-brown eggs are laid in batches on heather and bramble, and hatch about the beginning of July. The caterpillars, which are about two and a half inches long, are black, but except between the rings this colour is hidden by a dense pile of short tawny hairs, above which stand long, brittle, brown hairs. These hairs break off in handling the caterpillar, and if allowed to touch the thinner parts of the skin, such as on the face, they set up a very unpleasant irritation. They have been known to cause blindness by getting into the eyes. The cocoon is somewhat tubular in shape, woven of brown silk mixed with caterpillar hairs, and placed end up among grass or moss.

It is noteworthy that in this family the English names, though now applied to the moths, were in most cases bestowed upon the caterpillars. Thus the egger was the caterpillar that made egg-like cocoons; the lackey because of the caterpillar's variegated colouring; the fox from some resemblance between the caterpillar and a fox's brush. Two others in the same category are the drinker and the lappet. The

[1] Macrothylacia rubi.

drinker has the peculiar habit of sipping at the dewdrops that gather on the grasses; and the lappet-caterpillar has a number of fleshy prominences hanging loosely along its sides almost hidden by the fringe of long, brown hairs. The caterpillars appear to have the power to vary the tint of their silk to make the cocoon harmonize with the surroundings selected for it.

All these moths when at rest present a close resemblance to dead leaves, and even naturalists who are specially looking for them, and know this tendency, are frequently "taken in" by it. Mr. C. G. Barrett, an entomologist of vast experience in the field, tells how he was imposed upon by the small egger.[1] He says: "I was walking down one of the country roads at Norwich some years ago when I noticed a batch of eggs (of this species) on a hawthorn twig, looking particularly velvety and exquisitely arranged; so I picked the spray to carry home, and had carried it several hundred yards before I discovered that an apparently dry hawthorn leaf, drawn closely to the stem below the eggs, was really the living female moth, still clinging to the place on which she had so carefully arranged them. I do not regard this as mere carelessness on my part, for the posture, the colour, the brown band, even the white spot, harmonized in so extraordinary and unexpected a manner with its position and surroundings that even after I had discovered the creature I was amazed at the deception."

Cocoons of the Lackey-Moth.

Cocoons of the lackey in various stages of complet[illegible] of texture are not far advanced; those at the top [illegible] treated with the lime solution ejected by the caterp[illegible] this that produces the shell-like appearance that has probably [illegible]

One of this group is known as the December-moth,[2] because it does not emerge

[1] Eriogaster lanestris. [2] Pœcilocampa populi

from the chrysalis until very late in the year—sometimes as early as October, but usually in November or December. This moth is often a puzzle to the numerous people who imagine that outdoor Insect life is suspended during the winter. On coming late at night through lighted roads on the outskirts of towns, they are surprised to see tolerably large moths fluttering around the electric lamps. At that late period of the year there are several unrelated species engaged in this unremunerative pastime, but among them will almost certainly be the males of the December-moth. They are blackish-brown in colour, looking rather worn owing to the thin coating of scales on the wings, which are crossed by pale lines. The female is a somewhat larger Insect than her mate, and heavy bodied, so that she is more likely to be quietly resting or laying her mottled eggs upon the neighbouring trees than in gadding around lamps. The caterpillar—hairy like its relatives—may be found in spring feeding upon the leaves of various trees. In June it spins a cocoon among or under dead leaves, and remains in it as a chrysalis for four or five months.

Photo by] [*H. Bastin.*

THE LACKEY LAYING HER EGGS.

The female lackey-moth lays eggs to a great number in close bands around the twigs of the food-plants, where they remain through the winter until hatching [illegible] Several of these bands [illegible] at intervals on the same twig.

Tiger-Beetles.

About May or June on a sandy heath one's attention may be attracted by the hum and sparkle of a very active flying Insect that may easily be taken for a brilliant fly. If an example or two be captured and examined it will be found to be a green beetle about three-quarters of an inch long. Its blue-green wing-covers are relieved by a few irregular spots of dull yellow, and its lower surface is shining blue. It is this under side, reflecting the sunshine, that gives the beetle its brilliant appearance when on the wing, and has got for it the name of sparkler in some districts. The fore-body and head are coloured to match the wing-covers, touched here and there with reddish metallic gloss. Examined with a lens, it will be seen that the blue-green mixture, of the wing-covers especially, is due to the fact that the ground colour is largely dull blue, from which stand up minute points of polished green. The long antennæ and the slender legs look as though they had been fashioned out of reddish wire and polished. The pair of feelers attached to the mouth are of the same metallic character; and the mouth is armed with a pair of terrible sickle-like jaws. Each sickle has about the middle of its inner edge a long, sharp-pointed tooth, and seeing these jaws crossed in repose one can understand the deadly work of which they are capable. As these jaws and his name indicate, the tiger-beetle[1] gets his living by the pursuit and destruction of other Insects.

This Insect tiger does not wait until it has attained the winged state to develop its predatory character. In the grub stage it is equally voracious, and subsists

[1] Cicindela campestris.

Photo by

ON GUARD.

The grub of the tiger-beetle has ascended his shaft, and remains at the mouth with eyes and jaws on a level with the surface, waiti some other insect to come within reach. From this point of view his expression is scarcely of an alluring character. Six times the actual

Photo by] [*H. Main, F.E.S.*

THE GRUB OF THE TIGER-BEETLE.

In its larval stage the tiger-beetle is as fully deserving of its name as in the perfect state. The terrible jaws are already a striking feature, and the plump condition of the hind-body shows that they are used to good purpose. In both these conditions the tiger preys upon other Insects. The photograph shows the grub three times the natural size.

entirely upon other Insects. Then, however, it does not pursue its prey and hunt it down, but waits patiently for its victims to come close to it. Like the trap-door spider, the grub constructs a shaft in the ground, from whose smooth, rounded mouth he can watch for the coming of his victims.

But let us begin at the beginning. The female tiger-beetle is provided with a strong egg-laying drill, with which she bores a hole in suitable soil. Through the drill passes a single egg, which is left at the bottom of the hole. She repeats this process about fifty times. About a fortnight later the grub hatches out. It looks a misshapen little creature, its body being thrown into three curves. The head and adjoining fore body are broad and flat, forming a sort of shovel, and in addition to the six legs there are a couple of hooks on the upper side of the fifth segment of the hind-body. At first the little pit dug by his mother is sufficiently large to house him, and he is content with consolidating the walls and rounding the mouth. As he grows he enlarges the pit to suit the increase of his length and girth, and he keeps a circular area around the mouth clear of loose earth. In the operation of enlarging the shaft the shovel head comes in useful for carrying the surplus earth up to the surface, and the curves of the body and the hooks on the back make climbing easy, as well as enabling him with comfort to remain on watch at the top of the pit-shaft. In this position the flat head forms a stopper to the shaft, whilst the position of the eyes enables a good watch to be kept upon the surrounding area. In this matter of waiting for its dinner to come to it the tiger-grub is much like the ant-lion, except that it watches at the top of its pit, whilst the other waits at the bottom. No small animal walking carelessly over the ground could suspect any danger; so it is seized by the terrible jaws, and is then taken to the bottom of the pit to be demolished in private.

Photo by] [*H. Main, F.E.S.*

THE TIGER'S CLIMBING HOOKS.

In this photograph a portion of the hind-body is further enlarged to show the pair of climbing hooks by whose aid the grub makes rapid ascents and descents in its burrow. The view is from the side, and is four times the natural size.

The pit of this and most other species is vertical or at right angles to the surface, whether that surface is horizontal, perpendicular, or sloping. In one of our British species[1] it is curved. The shafts vary in depth according to species and the nature of the soil. That of our common species, when the grub is full-grown, may be a foot deep. When about to change its skin, the grub closes the mouth of its shaft and

[1] Cicindela hybrida.

retires to the bottom until the moult has been effected. It then removes the stopper and makes the necessary widening to allow for its increase in size. It also closes the entrance in early autumn and remains inactive during the winter; waking up again early in the following April, and leading an active life throughout its second summer, it passes the second winter also in hibernation. In its third August it closes its burrow for the last time, and constructs an oblique oval chamber in the side of the shaft, wherein it changes to the pupal form. In the chrysalis the hooks on the back are still retained, and from the four segments in front of them leg-like processes are developed, which serve to keep the chrysalis, as it lies back downward, from contact with the soil. This is well shown in our photograph. This stage does not last long, for in the same autumn it has cast off its pupa-skin and emerged as a perfect tiger-beetle.

But it does not at once venture into the outer world. All the winter it lies quietly in the pupa-cell, waiting for the more genial conditions of spring. Late in April or early in May it makes its appearance, and may then be seen flying vigorously over the heath in the sunshine.

Photo by] [*E. Step, F.L.S.*

THE TIGER-BEETLE.

One of the most brilliant of our native beetles may be seen flying over sandy heaths during May and June. Its wing-covers are of a beautiful blue-green colour with spots of dull yellow, and the under parts are shining blue. Its mouth-parts include a pair of sharp-pointed, sickle-shaped jaws, and it flies swiftly in pursuit of other Insects. Enlarged four times.

Different species differ somewhat in their habits. An American species[1] makes a shaft that is vertical throughout the greater part of its length, but near the top it makes a sharp curve and becomes horizontal for a short distance, opening into the side of a shallow pit. There is an advantage in this, for the grub lives in loose, shifting sand, which would fill up its burrow if this opened directly to the surface. As it is, it has to cement the grains of sand together to prevent the sides from falling in. The outer pit is also cemented to retain its form, but though this may partly fill up with blown sand the shaft remains clear. The outer pit becomes a snare

[1] Cicindela formosa.

like that of the ant-lion, for crawling Insects and other small animals fall into it within reach of the tiger-grub's jaws. One of our native species[1] has a modification of this plan. Its curved burrow opens on a vertical or sloping bank, and just below the mouth a shallow pit is formed.

Leaf-like Mantids.

The order of straight-winged Insects[2] is richer in what one may term natural frauds than any other. Here are found the numerous stick-Insects and the walking leaves, which form separate families; and of a third family, the mantids, we have already given examples of flower-mimicking species. There are other mantids that mimic leaves instead of flowers; fresh, newly expanded leaves and leaves in process of decay.

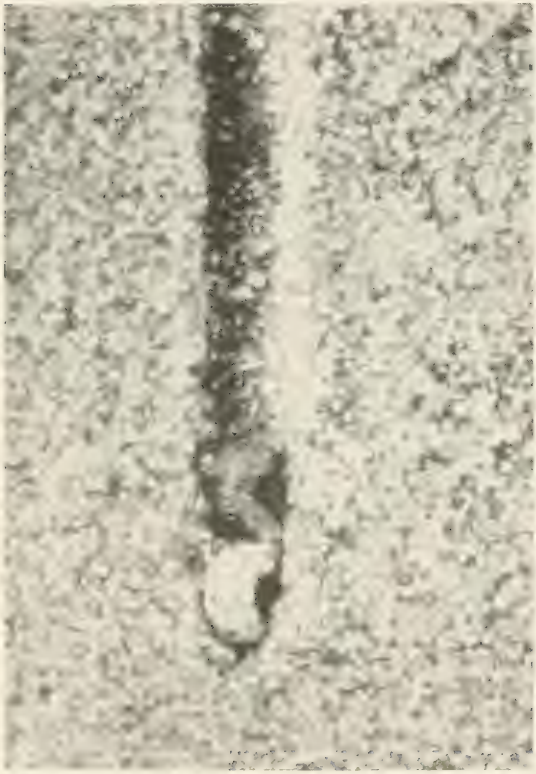


Photo by] [*H. Main, F.E.S.*

THE TIGER IN HIS LAIR.

When the grub of the tiger-beetle has secured a victim at the mouth of his pit, he retreats with it to the bottom of the shaft to consume it. Here he is waiting until appetite prompts him to ascend for fresh prey. Twice the natural size.

A remarkable example of this group is afforded by the dead-leaf mantis[3] of Malaya, whose body is about three inches in length, and the spread wings have an expanse of three inches and a quarter. It is coloured in various shades of brown, variegated with dull red and buff. On the under side of the wing-covers, near their blunt tips, there is a large black spot surrounded by a circle of white. The wing-covers being semi-transparent, this spot shows dimly through to the upper side. But the remarkable feature of this mantis is a very thin expansion of large size on each side of the fore-body, more or less notched, especially at the hinder margin. When the wings are closed these expansions continue the wing-covers forward, and the total effect is that of a small bunch of dead leaves, more or less broken, and fretted by Insects. A closely related species[4] from Borneo is still more ornate in its dead-leaf get-up, and Annandale mentions another[5] he met with in Lower Siam, whose wings, or so much of them as is hidden by the wing-covers, are coloured deep maroon, veined and rimmed with white. He thinks it only uses its wings in the evening, sitting during the day-time waiting for its prey and looking like an innocent bunch of dead leaves. It made no attempt to fly when he captured one that crawled up his leg from the jungle-floor, but when about to be taken it drew blood from his finger.

[1] Cicindela hybrida. [2] Orthoptera. [3] Deroplatys desiccata. [4] D. sarawaca. [5] D. trigonodera.

Photos by [*H. Main, F.E.S.*

THE TIGER BEETLE AND ITS CHRYSALIS

In the first of these two photographs the chrysalis is seen in its underg[illegible] [illegible] hooked at the [illegible], and these, with four pairs of newly-de[illegible] to keep his back from contact [illegible] soil. In autumn or sp[illegible] appears at the [illegible] but it does not [illegible] In the photograph the chrysalis skin has just been shed.

Some of these mantids are coloured differently to enable them to pass the day on the wood of dead trees, where, of course, there is always plenty of Insect life. One of these[1] is coloured a dingy yellowish-grey, speckled with black, and the wing-covers are marked with curious black streaks. "If this mantis is seated among dead wood, its colour makes it inconspicuous; but if it is among dead fern-fronds, or withered selaginellids, its predatory limbs entirely disappear, owing to their colour and form. Among these leaves, the head and wings, though they are inconspicuous, are not invisible; the wings may be detected because they are transparent and glary, the head because it is held well raised above the surface on which the Insect is sitting. Seen in such surroundings, there is nothing that would lead a human being to judge that this mantis is a predatory animal." Somewhat similar must be the unnamed mantis seen by Mr. Graham Kerr on the Pilcomayo river. It was living on tree-branches that were coated with lichens, and its own ornamentation so exactly resembled these that he only detected its real nature when it moved one of its legs.

Siamese Leaf-Mantis.

In spite of the dull, dead-leaf-like appearance of the fore-body and wing-covers, the wings are coloured with deep maroon, veined and bordered with white. But it only shows this colour when flying at night. It will be noted that the thighs of the two hinder pairs of limbs have leaf-like expansions to help in the deception.

It should be noted as an example of totally different habits giving rise to similar adaptations for dissimilar ends, that the walking-leaf, being a defenceless vegetarian, has adopted the leaf-like appearance for protection from Insect-eating enemies. The leaf-like mantis, on the other hand, being able to protect itself, has adopted a similar uniform in order to give confidence to its victims.

Horned Flies.

There is a family of small flies[2] of whose habits and life-history very little is known, but whose forms are so singular that they deserve at least a passing reference. The character which makes them so remarkable is a horn-like, slender extension from each side of the head which bears the large compound eye at its extremity. This protuberance looks very like the eye-stalk seen in many of the crabs, which allows them to elevate their eyes above the body, and get a good look-out all around; but in the case of the fly it is not an eye-bearing limb jointed to the head, but a rigid part of the head itself, and it bears not only the eye, but the antenna also. In an African species,[3] which is only about a quarter of an inch long, the measurement from eye to eye is one-third more than the length of the body from head to tail. The three-jointed antennæ are quite short, and might easily be overlooked, for they are attached close up to the eye, and look more like some outgrowth for the protection of that organ. The thighs of the first pair of legs bear teeth along their front edge, which indicate that the fly is predaceous in its habits, and uses these for the retention or crushing of its prey whilst it is being eaten.

[1] Ceratomantis saussurei. [2] Diopsidæ. [3] Diopsis apicalis.

Another genus of the family may be called giraffe-flies,[1] from the fact that the head is prolonged backwards to form a long neck, which suggests the quadruped Then, in the same family, there are the deer-flies,[2] which Dr. A. Russel Wallace first discovered in the Malay Archipelago, which are remarkable for outgrowths of the head which bear a striking resemblance to the horns of stags. Wallace found four distinct species which were settled upon fallen trees and decaying trunks. He describes them as "about half an inch long, slender-bodied, and with very long legs, which they draw together, so as to elevate their bodies high above the surface they are standing upon. The front pair of legs are much shorter, and these are often stretched directly forwards, so as to resemble antennæ. The horns spring from beneath the eye, and seem to be a prolongation of the lower part of the orbit. In the largest and most singular species, named the stag-horned deer-fly,[3] these horns are nearly as long as the body, having two branches with two small snags near their bifurcation, so as to resemble the horns of a stag. They are black with the tips pale, while the body and legs are yellowish-brown, and the eyes (when alive) violet and green. The next species[4] is of a dark-brown colour, banded and spotted with yellow. The horns are about one-third the length of the Insect broad, flat, and of an elongated triangular form. They are of a beautiful pink colour edged with black, and with a pale central stripe. The front part of the head is also pink, and the eyes violet-pink, with a green stripe across them, giving the Insect a very elegant and singular appearance.

The Dead-leaf Mantis.

One of several species of mantis whose fore-body and wings present a marvellous resemblance to leaves. The leaf-like appearance offers the double advantage of making it difficult for a possible enemy to detect their real nature, and affording an admirable disguise under which they can secure their own Insect prey.

[1] Giraffomyia. [2] Elaphomyia. [3] E. cervicornis. [4] E. wallacei.

The third species (the elk-horned deer-fly[1]) is a little smaller than the two already described, but resembling the second in colour. The horns are very remarkable, being suddenly dilated into a flat plate, strongly toothed round the outer margin, and strikingly resembling the horns of the elk, after which it has been named. They are of a yellowish colour margined with brown and tipped with black on the three upper teeth. The fourth species (the short-horned deer-fly[2]) differs considerably from the rest. It is stouter in form, of a nearly black colour, with a yellow ring at the base of the abdomen; the wings have dusky stripes, and the head is compressed and dilated laterally, with very small, flat horns, which are black with a pale centre, and look exactly like the rudiments of the horns of the two preceding species. None of the females has any trace of the horns, and Mr. Saunders places in the same genus a species[3] which has no horns in either sex. It is of a shining black colour, and resembles the stag-horned deer-fly in form, size, and general appearance."

The Hammock-Moth.

We have in this country a number of very small moths whose caterpillars hide their real nature from birds and other enemies by constructing a coat under whose cover they feed securely. Some of these we have already described under the title of basket-worms (page 49). In America there is a genus[4] of much larger and totally unrelated moths which have a similar habit. One of these[5] is a reddish-grey winged, stout-bodied moth, an inch and a half across the expanded wings. The caterpillar constructs a tough case by spinning leaves together. This case is about an inch long, and open at one end to allow the caterpillar to protrude its fore-parts and carry the case from place to place on its food-plant, temporarily fixing it by silk mooring threads. When it has eaten all the leaves within reach, it cuts the threads and moves to a more leafy part.

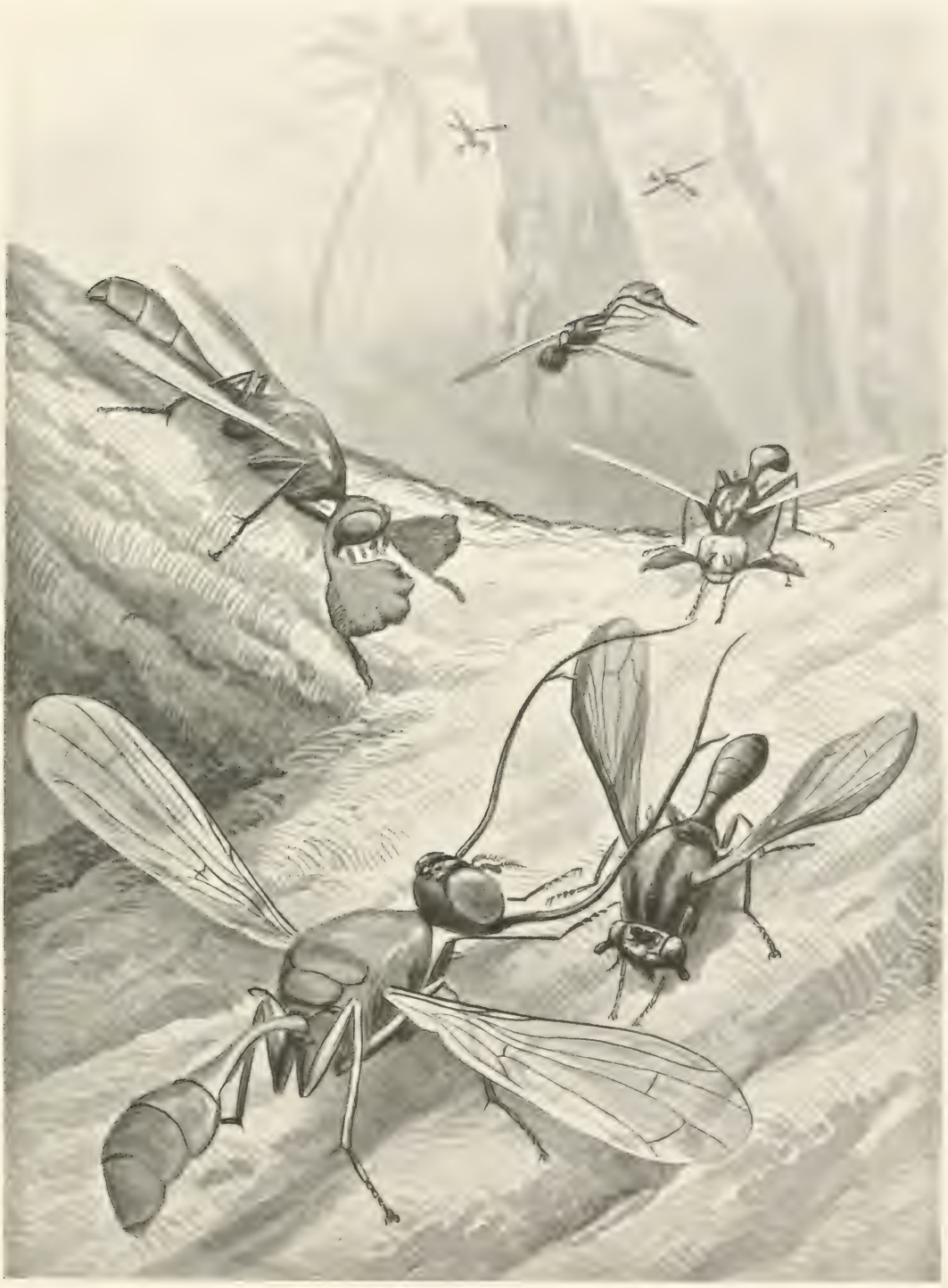
Photo by] [*H. Bastin.*

STALK-EYED FLY.

One of the eccentricities of Nature that recalls the hammer-headed shark among fishes. The eyes are borne upon extensions from the sides of the head; and it will be seen that these outgrowths also bear the small antennæ close up to the eyes. It is a native of South Africa, and is only one-eighth of the photograph in size.

But another species[6] in South America exhibits an extraordinary variation of this habit, for instead of sewing up leaves it utilizes its own excrement, which is of a flattened form specially suited for this use, and builds up a spindle-shaped

[1] Elaphomyia alcicornis. [2] E. brevicornis. [3] E. polita. [4] Perophora. [5] P. melsheimeri. [6] P. sanguinolenta.



[By T. [illegible]

HORNED FLIES.

Quite as remarkable as the stalk-eyed flies are these horned flies, whose head-ornaments take the form of miniature antlers. They are found in the Malay Archipelago. In the foreground is the stag horned fly, with long horns branching into tines. Above it to the left is [illegible] horned fly, with broad expansions that suggest the antlers of the moose.

case which is enlarged as the caterpillar grows. It is slung up hammock-fashion by silk threads at each end; and the caterpillar protrudes sufficiently to reach neighbouring leaves, but withdraws entirely when it suspects danger from exposure. No caterpillars of any other genus construct their cases after this fashion, so that the species may be at once identified by its hammock.

Insect Ichneumons.

Naturalists have borrowed the name of the ichneumon—a kind of mungoose that keeps down the numbers of crocodiles by eating their eggs—to designate in popular language a large number of Insects whose main purpose in life is to keep down the numbers of other Insects. They are sometimes spoken of as ichneumon-*flies*, but this is a somewhat misleading name as the term fly properly signifies a two-winged Insect, whilst these have four wings and belong to that order[1] of Insects which includes the bees and wasps. Ichneumon-wasps would be a less objectionable form. The number of species comprised in this group is enormous—even in Britain more than twelve hundred have been catalogued—and yet the general public knows almost nothing of them. As indicated, their natural office is to keep down the numbers of plant-eating Insects. If it were not for the attacks of these ichneumons some of the caterpillar pests that afflict the fruit and vegetable grower would produce so enormous a percentage of moths that succeeding generations of the species would show such progressive increase as would make the industry impossible. No one knows better than the breeders of butterflies and moths the extent of this parasitism, for their disappointments in rearing the perfect Insects from collected caterpillars are both numerous and frequent. Yet the fruit-farmer and the gardener know little more

Caterpillar of the Hammock-Moth.

The moth gets its name from a habit of the caterpillar, which utilizes its own excrement for the manufacture of a spindle-shaped case into which it can retire when alarmed. This is suspended from a twig, and the caterpillar, taking hold of it with its hind-claspers, stretches out to almost full length and feeds upon the leaves within reach all around.

[1] Hymenoptera.

of the beneficent activities of these friends of theirs than does the average townsman.

The female ichneumon-wasp lays her eggs in or on the bodies of her victims, and the grubs that issue from the eggs become internal or external parasites. In most cases they lack the power of feeding upon the structures of their hosts, and can only suck up the blood or lymph that circulates about the body cavities. This is the reason why the victim does not at once succumb, but survives until it is time to assume the chrysalis condition, by which time its parasite or parasites will be ready to perform a similar change, and either leave the victim to transform outside him or remain in the host-chrysalis. If the victimized Insect could only learn a lesson from human beings as these can from the Insects, it would adopt the very modern defence of the "hunger-strike." If the ichneumoned caterpillar would at once desist from feeding, the parasite would soon die. The caterpillar would die also, but as the attack of the ichneumon always results in death this would only be a slight anticipation of a foregone conclusion, yet it would benefit the race.

Photo by] [*H. Main, F.E.S.*

ICHNEUMONS ESCAPING.

The numbers of the garden-white butterflies are reduced by the action of certain small ichneumon-wasps, which lay their numerous eggs in the body of the caterpillar. By the time the chrysalis should be changing to a butterfly the ichneumon-grubs have finished their work and after passing through their chrysalis stage emerge as winged Insects. Three times the actual size.

It should be stated that there are some real flies—two-winged—that follow a similar mode of life, but at present we are not taking them into consideration.

One of the most plentiful of the ichneumon-wasps is a minute species which might, and ought to be known to every possessor of a garden, for it does great good by its destruction of the white butterfly-caterpillars that ravage the cabbage-patch. Clusters of small yellow cocoons containing the chrysalids of this species[1] may be seen commonly upon fences and palings where the sick butterfly-caterpillars have crawled. Unfortunately, the average person imagines these cocoons to be *the eggs of the caterpillar* (!), and as a rule they are destroyed; whereas, if left alone,

Photo by [*H. Main, F.E.S.*

ICHNEUMON CHRYSALIDS.

An idea of the number of ichneumons engaged in the destruction of one caterpillar or chrysalis may be obtained from this photograph, which shows over sixty chrysalids taken from one chrysalis of the small garden-white butterfly. Magnified three times.

[1] Microgaster glomeratus.

each cocoon would produce an ichneumon-wasp that would at once set to work to check the numerical increase of the white butterflies. If we keep some of the caterpillars of these butterflies under observation we may see them visited by little black four-winged Insects, so minute as scarcely to be felt by the victim when they alight. One of these will pierce the skin of the caterpillar with the keen egg-placer, and through it will pour a great number of eggs into the caterpillar's body. One of our photographs shows over sixty chrysalids of another species of ichneumon, known as a proctrotrupid, taken from a single chrysalis of the smaller white butterfly. This, however, does not give a correct idea of the enormous number of ichneumon-grubs that one caterpillar can support. From a caterpillar of the large white butterfly not fewer than 1,200 of the little black microgasters have been reared. Sometimes the grubs leave the caterpillar before it has had time to change to a chrysalis, and may be seen actively spinning loops of silk, which in a short time are connected to form oval cocoons. Other species wait until the caterpillar has become a chrysalis, when they in turn change, and make their exit later as winged Insects.

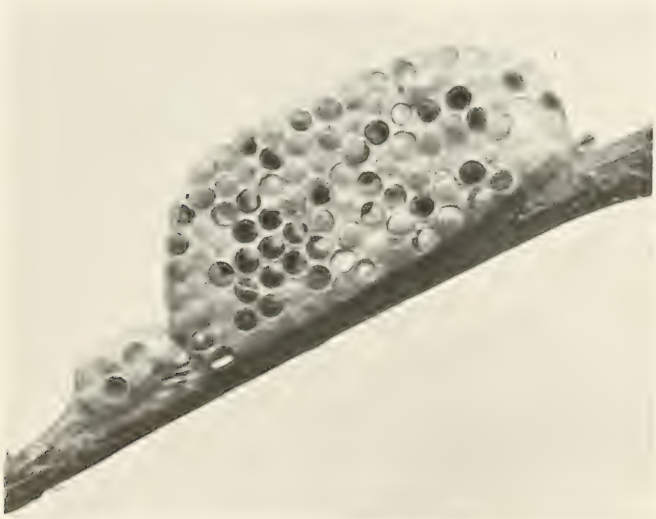


Photo by] [*E. Step, F.L.S.*

A Battery of Cocoons.

Some species of ichneumon leave the all but empty skin of their victim as grubs, and spin their own cocoons. This species construct their cocoons in such admirable order that they form a straight-sided mass as shown. The circular openings are cocoons from which the ichneumons have escaped. Magnified four times.

Other species, such as the straw-coloured ophion[1] shown on page 263, are so large that only a single grub can be accommodated in a caterpillar of large size. Often the caterpillar that has been parasitized by one of these can be detected by a discoloration where the skin has been pierced to admit the single egg. A favourite victim of this species is the large caterpillar of the puss-moth, and the parasite remains in it until the puss-caterpillar has constructed its hard cocoon. When the puss-caterpillars of the next generation are attaining a size sufficient to endure a lodger's drain upon their resources, the ophions break through the cocoons that imprison them and lay their eggs in the caterpillars. Note the compressed, sickle-shape of the body, as shown in the photograph.

But not all the ichneumons are internal parasites. In some cases, as in the girdled paniscus,[2] the egg is laid on the outside of a caterpillar, but attached to the skin. The grub never entirely quits the egg-shell, but retains a hold by its hinder parts, and also attaches itself by its mouth to the skin of the caterpillar, and appears to absorb the juices of the latter through its skin. Newport, experimenting with this ichneumon-grub and its host the caterpillar of the broom-moth, found that

[1] Ophion luteum. [2] Paniscus virgatus.

Photos by[1] *Jessalis.*

THREE ICHNEUMON-WASPS.

The upper photograph is of one of our largest ichneumons, the yellow ophion, which is very destructive to the caterpillars of the puss-moth. Only one egg is laid in a caterpillar. The winged Insect often comes into houses at night, attracted by light. Below, to the left, is a smaller species of the same family, just issued from its cocoon, spun in the empty skin of its victim. On the right are two of a large number of cocoons spun by grubs that had destroyed a large sawfly-caterpillar. One of the ichneumons escaped from a cocoon is also shown. All magnified about three and a half times.

Photos by] [*H. Main, F.E.S.*

THE ICHNEUMON OF THE LARGE WHITE BUTTERFLY.

One of the ichneumons that keep the large white butterfly in check is the pimpla, here shown in three of its stages. First, a chrysalis cut open to show the ichneumon-grub after eating up the contents. The second photograph shows similar chrysalids containing chrysalids of the ichneumon; and the third photograph is of the female ichneumon arrived at full development.

if he detached the mouth of the parasite it could not again seize its victim and continue the sucking process. The caterpillar manages to construct its cocoon, and then the ichneumon-grub emerges and spins its own cocoon within the other.

In some of these ichneumons we find an extraordinary development of the egg-placer—so extreme in certain species that if we did not know the facts from those who have observed the Insects at large, we should imagine that Nature had overshot the mark and made these organs so large as to be ineffective. There is the rhyssa,[1] for example, that lays its eggs in the grub of the horn-tail sawfly, which feeds in the solid wood of pine-trees. The egg-placer is as fine as a hair and of great length; yet it is said to be thrust through the bark and wood exactly above the spot where its victim is feeding out of sight. How so fine an instrument can be manipulated so as to pierce thick wood is a marvel. An American species,[2] shown in one of our photographs, has the hind-body in the female drawn out to an inordinate length to serve, no doubt, for probing deep and narrow burrows, such as those in the earth where lie the eggs of locusts, and the crevices of bark. It has been stated by Doubleday that they pierce wood with this hind-body, and he declares that he found twenty or thirty of them that had perished through inability to withdraw their bodies from wood they had pierced. The male, it should be stated, has a hind-body of quite normal proportions.

The Brimstone-Butterfly.

It is a noteworthy coincidence that the abundant flower that is generally accepted as typical of spring-time, and the earliest butterfly of the year should be of the same uncommon tint. It is a great pity that the fathers of British entomology, who gave most of the popular names to our butterflies, should have missed the opportunity they had of calling the butterfly by the name of the flower

[1] Rhyssa persuasoria. [2] Pelecinus polyturator.

that is contemporary with it in the spring. The primrose-butterfly would certainly have been a more poetic name than brimstone-butterfly,[1] whilst giving an equally explicit idea of colour.

It is, perhaps, not correct to speak of the brimstone-butterfly as a spring Insect, because it emerges from the chrysalis about the beginning of August; but though it is then abundant it does not attract public attention so strongly as it does in spring, for the reason that, thus early, it has the field practically to itself. Early in autumn it goes into hibernation and, though on a mild sunny winter day it may wake up and indulge in a flight, it waits until April before becoming continuously active. Then when the copses and hollow lanes are full of primroses, one may sometimes enjoy the sight of seeing this butterfly sipping nectar from the flower it matches so well in tint. Such a sight, however, is not so frequent as to justify any suggestion that the similarity of colouring is due to such an association.

The brimstone is one of the most distinct of our butterflies, not only in point of colour, but also in the shape of the wings. The fore-wings are sharply angled at the tip, and the hind-wings have a similar angle suggestive of a tail in the middle of the outer margin. Near the middle of all the wings there is a spot of orange. Several minute dots of the same colour occur on the very margin of all the wings. The antennæ are red; and the fore-body is thickly clothed with long, silky, whitish hairs. The sexes may be discriminated at a glance, for whilst the male

Photo by] [*E. Step, F.L.S.*

Two Giant Ichneumons.

Most of the ichneumon-wasps are small, some very minute; but these are shown of the actual size. As may be supposed their victims are caterpillars or grubs of large size. They both attack wood-boring Insects, and they are said to pierce bark and solid timber with their hind-bodies. In the case of rhyssa (left) the piercing implement is composed of the three hair-like appendages, of which the finest is perforated for the passage of the eggs. In pelecinus (right) the boring instrument is the body itself, which is drawn out to great length.

[1] Gonepteryx rhamni.

is a full brimstone yellow, the female is of the paler greenish-yellow that agrees with the tint of the primrose flower.

Many of the butterflies pass through the winter in the chrysalis stage, and come out in the winged condition in early summer; others come out in the late summer or early autumn, and secure a winter retreat in a faggot-stack, a thatched roof, under the branches of a dense holly-tree, or even in a snug corner of a dwelling-house. The brimstone is one of these, and almost any day that is sunny in the early part of the year it may wake up and indulge in a flight to see how things are going on in nature. Then in May, when the young leaves of the buckthorn are expanding, the female brimstone may be seen depositing her eggs singly, on the under side of the leaf. It is a long-shaped, pale green egg, tapering at the upper end, and with ribs running lengthwise. Later it becomes yellow, and finally purplish. The caterpillar, which is rather flat beneath, is coloured a beautiful green which has a distinct tinge of blue in it towards the sides, where there is a line of paler tint. Closely examined, the upper parts are seen to be sprinkled with minute black dots. The general effect of the colour is a close harmony with the under surface of the leaf on which it is feeding.

Photo by] [*E. Step, F.L.S.*

CATERPILLAR AND CHRYSALIS OF BRIMSTONE-BUTTERFLY.

Two stages in the life history of the familiar brimstone-butterfly are included in this photograph. The egg is laid in early summer on buckthorn leaves, where in July the blue-green caterpillar will be found fully grown, possibly the chrysalis also, as in the photograph. Turn the page, and note how the chrysalis looks like a bird in flight.

About the end of July or beginning of August it changes into the rather singular-shaped chrysalis, but still retains its beautiful green colour, which makes it difficult to distinguish from the leaf to which it is attached, and of which it might be a torn and curled-up portion. It remains in the chrysalis stage for a few weeks only; and in suitable places during August and September the newly emerged butterfly may be considered fairly common. Our two species of buckthorn are the only food-plants of the caterpillar, and wherever either of these grows one may expect to meet with the Insect. To-day our cabbage white butterflies would probably, from their extreme commonness in inhabited districts, be considered as the typical butterflies, but in earlier days, when woods and thickets covered the land more thoroughly, and cabbage patches were unknown, the brimstone must have been more plentiful than the whites, which must have been coast Insects, their

Photo by] [*E. Step, F.L.S.*

THE BRIMSTONE-BUTTERFLY AT REST.

The brimstone-butterfly photographed whilst resting on the stems of bilbery, in a state of nature. In this position the strong ven[illegible] the wings is shown, and the tail-like angle of the hinder wing. About one and a half times the actual size.

caterpillars feeding upon the wild cabbage of our sea-cliffs. It was then, probably, that the word butterfly originated, the male brimstone being the fly that is the colour of butter.

Occasionally the orange colour of the central spot spreads more or less generally over the fore-wings, and the individual then becomes very like a form common in the south of Europe, which is usually considered as a distinct species,[1] but which some regard as a variety merely. In America, from Mexico to the extreme South, there is a brimstone of a larger size,[2] and of a different genus. It lacks the sharp angles to the wings which are a conspicuous feature of our species.

Snail-eating Beetles.

The energetic gardener who makes a point of destroying all Insects that come in his way, in the belief that they are inimical to success in horticulture, makes many grievous mistakes. Many of them are his good friends; but as a rule he does not stop to consider how they get their living, and slaughters almost indiscriminately. It is not our intention to attempt to compile a list of these benevolent Insects, but to call attention to a few beetles whose whole mission in life is to destroy snails. In many districts snails are exceedingly destructive in gardens, and it is possible that under more enlightened rule something could be done to mitigate the pest by introducing and taking care of snail-eating beetles.

The glow-worm,[3] so-called, is the best known of these beetles. Its principal habitat is the hedge-bank where snails abound, which glide into adjacent gardens at night and do damage which is too often put down to Insects. For this reason small species of snails may be quite plentiful in gardens where their presence is not even suspected. The glow-worm will come, too, where there are snails to be had, and sufficient cover for the Insects. But there are snail-eaters also among the polished black ground-beetles, that are seen mostly when the gardener is turning up the earth. One of these in particular, the little cychrus,[4] of which we give a portrait, is so addicted to the snail-eating habit, that nature has specially modified his structure

Photo by] [*E. Step, F.L.S.*

RED-BARRED SULPHUR-BUTTERFLY.

A fine American brimstone, which inhabits Central and South America. It is of a beautiful clear sulphur colour, with a patch of orange on the fore-wings and the outer margin of the hind-wings suffused with the same tint. Natural size.

[1] Gonepteryx cleopatra [2] Catopsilia philea. [3] Lampyris noctiluca. [4] Cychrus rostratus.

to enable him the better to pursue it. Most of these ground-beetles, which probably are all carnivorous, have neat and graceful forms; but the cychrus has its head and fore-body made so slender that it can reach some distance into a snail-shell should the snail retreat within when the cychrus makes a call.

But probably the reader will find greater interest in the little-known drilus,[1] which must be sought on chalk downs and similar places where the heath-snail, the banded-snail, and the wrinkled-snail are plentiful. The reason for the greater interest yielded by this beetle is due to the fact that its life-history was carefully worked out a few years ago by Mr. L. R. Crawshay, M.A., and the story communicated to the Entomological Society of London. That drilus was an enemy to snails had been known for many years; but full details of its life had been wanting. As in the case of the glow-worm, the female never attains to the orthodox beetle-form, and remains to the end of life but little changed from the appearance she presented in the grub-stage. The male, however, is a true little beetle with yellowish-brown wing-cases, with wings beneath them, and a pair of much-branched long antennæ. To the beetle collector he appears to be much more plentiful than his mate, but Mr. Crawshay found as a matter of fact that the males are few as compared with the females. The difference in the form of the two sexes will be appreciated by a glance at the foreground figures in the drawing we have had made on a scale of five times the actual life size. In this drawing the upper figures on the snails are all grubs.

Photo by] [*E. Step, F.L.S.*

SNAIL-EATING BEETLE.

A good example of adaptation of structure to habits [illegible] among ground-beetles in cychrus, which is here photographed. The fore-body is greatly reduced in width and the head is lengthened to enable the beetle to push its fore-parts into the shells of snails, upon which it chiefly preys.

Viewed from above, the grubs are seen to be tapered somewhat from back to front, and are covered with fleshy growths from which spring coarse hairs of a red-brown colour. The head also is red-brown, and flattened; the mouth armed with strong sharp mandibles. At the end of the hind-body there are two bristly outgrowths, which are evidently for the protection of the grub when it is in the snail-shell, keeping off any enemy that would otherwise attack it from the rear. The grub begins life about the middle of July, and does not become a beetle until the early summer of the third or fourth year.

Its mode of procedure when about to attack a snail, as observed by Crawshay, is curious. It is deliberate in its actions, and does not begin by poking its nose into the first snail-shell it comes across. First, the grub climbs upon the shell, and examines it to satisfy itself that it contains a snail. But perhaps the snail is not suitably situated to afford drilus a safe and uninterrupted meal—for this is not to be one of the quick-lunch kind, but extended over many days. If the snail is not so placed as to offer a quiet time, the beetle-grub *pushes* it into a more favourable position, probably into cover of some sort. This is often a difficult matter, for the snail may require lifting over

[1] Drilus flavescens.

an obstruction. Crawshay has watched a grub manœuvring a snail for three hours before it succeeded in placing it to its own satisfaction. He found that the larger grubs were not so particular in this matter as the small ones. The larger snails appear to know what is the meaning of this manipulation, and make an effort to glide off in another direction, or twist and shake their shells from side to side. But the grub has a short way with such rebels: it uses its jaws and compels the snail to retreat into its shell.

The meal lasts from eight to sixteen days, and then the grub carefully cleans out the shell, using its brushes, and making many journeys to the exterior with bits of refuse. Then it rests for a time and moults its old skin. The whole process of eating one snail, cleaning out the shell, resting from its labours, and changing its clothes occupies a period of about forty days. It only manages to consume three or four snails each summer, and always moults before leaving the empty shell. In the autumn it goes into hibernation in the shell it has last cleaned out. For its winter rest it changes its form somewhat and becomes inactive. In this state it emits an offensive fluid, no doubt for a protective purpose. In its active condition it contents itself when molested with coiling into a ring, hedgehog fashion, when its brushes of hairs serve to defend it.

Photo by] [*E. Step, F.L.S.*

SNAIL-EATING BEETLE.

The male of this remarkable little beetle is shown magnified eight times. Its colour is yellowish-brown and its antennæ are much branched. The female is quite unlike a beetle.

The female beetle, which is so much like the grub, lays her eggs in July, to the number of two hundred and fifty to three hundred; but distributes them in batches of about thirty. They are pale yellow and measure about one twenty-fifth of an inch across.

Drone-Flies.

There is a group[1] of two-winged flies which presents us with several cases of mimetic resemblance which, however, have not been quite satisfactorily explained. To an earlier generation, before there was any theory of protective or mimetic resemblance, the explanation was simple enough—though it might not bear examination. Thus Kirby and Spence, in their *Introduction to Entomology*, tell us that "Another tribe of these little animals . . . is secured from harm by a different kind of imitation, and affords a beautiful instance of the wisdom of Providence in adapting means to their end. Some singular larvæ . . . live in the nests of humble-bees, and are the offspring of a particular genus of flies (*Volucella*), many of the species of which strikingly resemble those bees in shape, clothing, and colour. Thus has the Author of nature provided that they may enter these nests and deposit their eggs undiscovered. Did these intruders venture themselves amongst the humble-bees in a less kindred form, their lives would probably pay the forfeit of their presumption." It is all very well to be called upon to admire the wisdom of Providence in fitting out an impostor so that it escapes the observation

[1] Volucella.

[By T. Carreras.

THE SNAIL-DESTROYING DRILUS AND ITS GRUBS.

In the foreground are the female and male beetles, the former much more like a grub than a mature Insect. The three upper figures are the hairy grubs engaged on their life-work. The middle one is making its preliminary examination of a snail. That to the left is biting a snail that evinces a disposition to escape, and that to the right is pushing its snail into a place more convenient for its consumption. They are all on a scale of five times the actual size.

of the innocent humble-bee, but we naturally inquire what the inoffensive humble-bee has done that its insidious foe should have Divine backing? As a matter of fact, the early Victorians were on the wrong track entirely in this matter, for the bee-like fly is no enemy, but a friend, and its counterfeit resemblance is not intended to impose upon the bee, but upon creatures who know the bee has a sting and who may be disposed to let the unarmed fly go scatheless under the impression that it is not a fly but a bee. From which it appears that Darwinism has vindicated Providence from the well-intentioned assaults of the teleologists.

That the grub of one of the drone-flies[1] lived upon the grubs of the humble-bee was assumed to be a fact until yesterday, probably owing to confusion of this species with another we shall have occasion to describe separately. Observers of the bees had seen the volucella-grub among the cells of the humble-bee, nay actually in the cocoons; and if the cocoons were empty, was not that presumptive evidence that the volucella-grub had emptied it by eating the bee-grub? The facts of the case show that the grub of the fly, though there solely to serve its own ends, that is, to get a living, is at the same time rendering valuable service to the bee by its consumption of filth and effete matter. The bee apparently recognizes the value to the community of these offices, and it offers no hindrance to the scavengers. When a cocoon has been vacated by its inmate coming to the winged stage, and quitting it, the workers adapt it to a new use by storing pollen in it; but they could not do so unless it were first cleaned out in a way that is impossible to the bulky humble-bees. The humble-bee grub when casting its last skin to become a chrysalis throws out the accumulated waste of its larva-hood, and later there is the empty chrysalis skin also. All this useless material the volucella-grub turns to account as food. Its body is broad behind and tapers away to the front, and as the body is capable of considerable elongation forward, it is able to reach and thoroughly clean the deepest part of the cocoon as well as the top and middle depths. It is just possible that if the modern hive were not so carefully constructed to keep out as far as possible all but the honey-bees, foul-brood might not be so common and increasing a scourge. The volucella-grubs might do for the honey-bee what they do for the humble-bee.

Photo by] [*E. Step, F.L.S.*

THE HUMBLE-BEE'S DRONE-FLY.

The breadth and hairiness of the body of this two-winged fly gives it a superficial likeness to some of the smaller humble-bees; and it was formerly assumed that the resemblance was for the purpose of enabling the fly to enter the bee's nest unobserved, there to lay its eggs and so bring about the destruction of the bee colony. This fly is not an enemy, but a friend to all bees and wasps. It is here magnified three times.

To make it quite clear that the old idea of these grubs feeding upon the grubs

[1] Volucella bombylans.

and chrysalids of the humble-bees is an erroneous one, it may be stated that attempts have been made to bring up the fly-grubs on such a diet, but they preferred to starve rather than attack living Insects; though on being presented with dead bee-chrysalids they eagerly availed themselves of such food, showing that their mission is to prevent putrefaction and all the horrors that ensue from it.

Other members of the same genus attach themselves to the service of the social wasps, but the remarkable thing here, in the light of the teleologists' view, is that the species concerned do not resemble wasps, though if the wasps were not convinced of the benevolent intentions of these flies the latter would need protective resemblance far more than the humble-bee fly, for two-winged flies form a large percentage of the food of wasps. One of these flies [1] we have found particularly abundant in the grub stage in the underground nests of one of the common wasps.[2] We have dug out these nests in autumn when the activity of the community was practically over. A few cells alone remained capped, showing that the new wasp had not emerged. Many had been newly vacated, and in others were dead grubs, which are believed to be killed by the wasps when there are insufficient workers to feed them to maturity. The combs, removed to tin boxes to secure whatever living associates might be in or on them, after being closed up for a few hours yielded an abominable ammoniacal odour from the effete matter contained in the cells. These combs had hundreds of volucella-grubs creeping over them, from the almost full-sized specimens three-quarters of an inch long down to minute individuals that measured only a couple of millimetres, and were apparently newly hatched. Most of them were active. Having cleared out all the refuse from one cell, a grub would look about for the next one that demanded attention. Standing at the edge of it, the fore-part would be extended to make inquiry as to the condition of the cell, and if it was found to have been cleaned out the grub would move on. But if it proved to be in (from this grub's point of view) a nice dirty condition, then he would get inside and pursue his proper avocation. The fully-grown grubs were too large to get quite into the largest cells—those that had produced queens—but all that was visible was the broad hinder segments forming a dark convex cap to the cell with the double breathing organ in the middle.

Photo by [*H. Main, F.E.S.*

CHRYSALIS OF DRONE-FLY.

The grub changes to a chrysalis within the grub-skin, so there is only a slight difference in its outward appearance; but a new feature is seen in two short horns near the broad end. These are the breathing organs. Within the hardened, spiny grub-skin the white chrysalis shows all the parts of the future fly folded close to the body.

The form of this grub will be seen in the photograph. When at rest it is a flattened pear-shape. The ground colour is a dirty white mottled with dark brown. The body is rough with transverse ridges and low spines. Along the centre of the upper side is a row of stouter bushy spines, and along the margin of the back is

[1] Volucella pellucens. [2] Vespa germanica.

a fringe of much longer fleshy spines which stand out straight and horizontally. The slender half, which terminates in the mouth, can be extended to twice its resting length. On the under side there is a double row of short, fleshy feet covered with hooked bristles, which cannot be seen until the grub is turned upon its back. At the rear-end on the upper side will be seen a double coronet, or rather two coronets side by side. These are the openings to the breathing organs of the grub. As we have already shown, in most Insects the spiracles or breathing holes are situated along the sides, but clearly this arrangement would be useless to a grub whose sides are pressed tightly against the walls of the wasp-cells. The only available place for an intake of fresh air is this last segment of the body, which acts as a stopper to the cell that the grub is cleaning out ; and here it is placed. The creature has no head, no eyes, only a mouth.

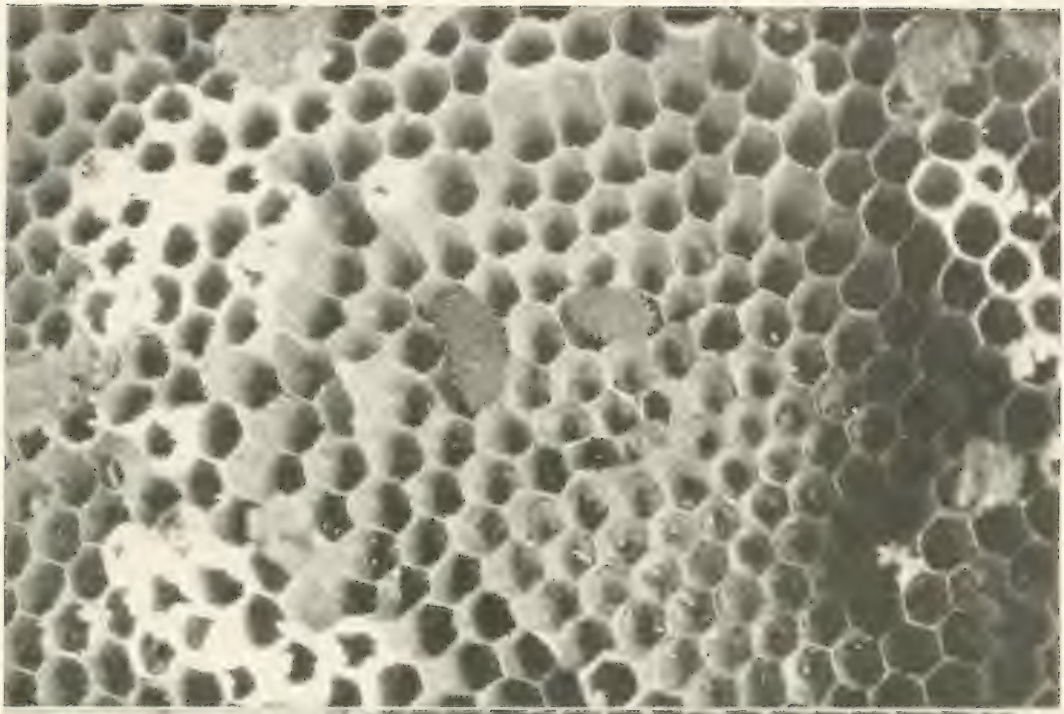
The chrysalis is much like the grub at a glance, but here the broader end is the front, and the position of the breathing organ is changed. Instead of the two coronets on the last segment, we have two short curved horns just behind the head. In truth, the external appearance is deceptive and due to the real chrysalis being covered by the skin of the grub. Within, the chrysalis shows all the parts of the future fly folded close to the body.

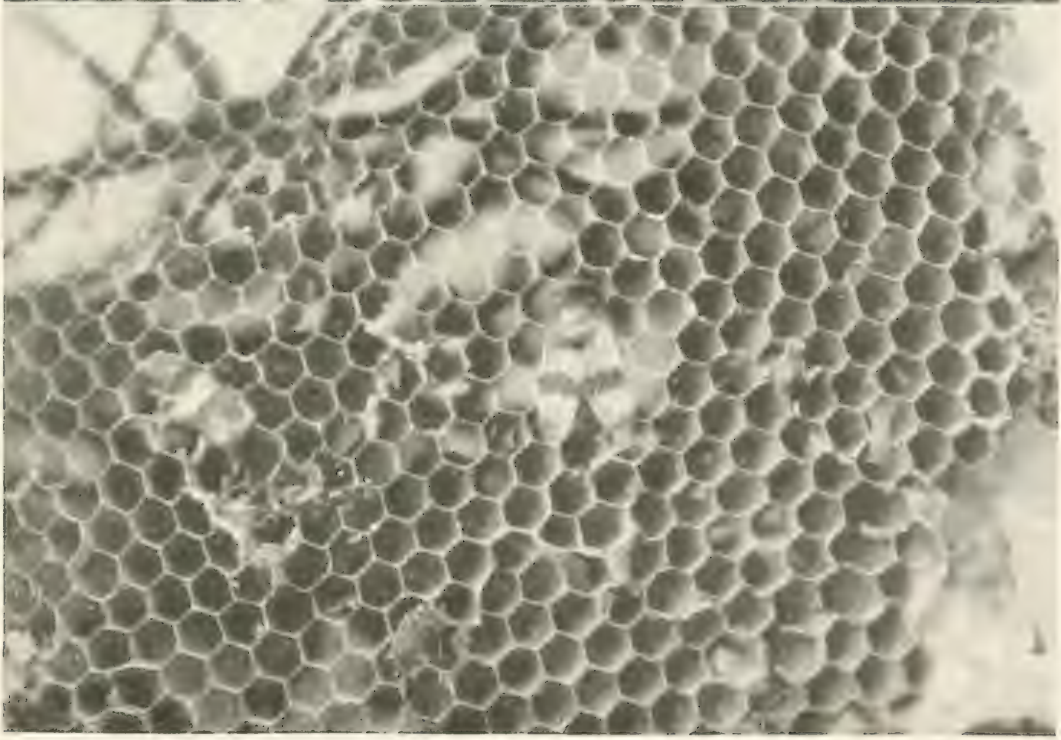
Photo by] [*E. Step, F.L.S.*

GIRDLED DRONE-FLY.

In its banding of yellow and black this species approaches to a colour resemblance to the wasp, but the form of its body is quite different; and it may be concluded that its livery is not intended to deceive its friend, the wasp, but to act as a warning signal to possible enemies—black and yellow strongly contrasted being a common sign that the Insect is not edible.

The fly that emerges is about three-quarters of an inch in length, reckoning from the base of the antennæ to the tips of the closed wings. In general appearance there is not the remotest likeness to a wasp as one would expect to find on the basis of the teleological view of the humble-bee's drone-fly. As a matter of fact when the fly comes indoors, as it frequently does, it is always taken for a honey-bee. The large compound eyes are dark purple-brown, and cover almost the whole of the upper part of the head. Slightly separating them is a golden-brown interval which broadens in front and becomes downy. The antennæ are short, stout, three-jointed clubs, the first joint bearing a much longer feather-like branch. The fore-body is black, as also the terminal half of the hind-body. The basal half of the hind-body is white and pellucid. There is a smoky patch on the fore-edge of the wings, and when these are closed the dark patches correspond in position with the dark portion of the body beneath them and have the effect of widening it. In this stage of its existence





Photos by *By* [illegible]

PELLUCID DRONE FLY

In the upper photograph the dark-coloured spots are [illegible] waste matter left in them by the wasp grubs. The lower photograph shows this portion [illegible] are shown of the natural size. The wasps, though very destructive to bees in general, take no [illegible] [illegible] [illegible]

it appears to be mainly occupied in visiting flowers to feed upon pollen. Two species have certainly got the black and yellow banding of the wasps. They are probably only forms or varieties of one species which we may term the girdled drone-fly.[1] Although it has the black and yellow livery, it cannot be said to have any strong form-resemblance to a wasp; and we do not think that its coloration is at all for the purpose of imposing upon the wasp, but rather for its own protection from fly-catching birds who would understand the colours to indicate that it is not edible.

Photos by] [*W. West.*

In the first of these two photographs the adult female is shown from the under and upper sides respectively, with the long cloak of wax in two stages of development. The second photograph shows the same Insect in a younger condition before the wax plates have been formed. The first photograph is twelve times larger than the actual size of the Insects, and the second is twenty-eight times.

It should be stated that the term drone-fly is used sometimes for the fly that develops from the rat-tailed maggot,[2] and is more generally known as the hover-fly.

Scale-Insects.

Although the scale-Insects[3] are all plant parasites that spend their existence in sucking the juices of plants, and many exist in millions on a single tree, they are mostly unknown except to practical gardeners and naturalists. Some of them are absolute pests on plants under glass, and most of these have at some time or other been introduced from abroad with the plants they chiefly affect. Those that are real natives of our islands are mostly found upon trees and shrubs in the open air. They are somewhat akin to the green-fly, but those individuals that have wings only possess one pair. The winged Insects are always males, but not all males have wings. The males are much less numerous than the females, and in many species the males have not yet been discovered. One peculiarity of a male is that it never has a mouth. It can take no food, and the sole reason for its existence is the fertilization of the female. Even this does not appear to be necessary to the continuance of the species, for many generations of fertile females may be produced in succession without the intervention of a male. But these generations differ from those of green-fly in that they are not produced rapidly: there is only one brood in a year, but an enormous number of eggs are laid by one female. Exotic species found in our glasshouses know little of our seasons; and these produce more than one

[1] Volucella zonaria and V. inanis. [2] Eristalis tenax. [3] Coccidæ

brood a year. The young are much like mites and are active. They have six legs, a pair of antennæ, and a long hair-like rostrum or sucking-tube. Their activity does not last long. They select a place on the shoot or leaf, thrust in the long rostrum, which looks too feeble for such use, and become fixtures. In most cases at the first moult legs and antennæ are thrown off with the old skin as being of no further use, and a protective shield, formed partly of a waxy exudation and partly of cast skins, begins to form around and behind them. This is the "scale" that is the distinguishing feature of so many of the species, and which has suggested the name by which they are known to gardeners. There are a few genera in which the grubs retain their limbs and their activity. Some of these are known as mealy bugs, from their excretions taking the form of long flocks or strings of a meal-like powder; in both cases these emanations consist of wax.

Photo by] [*W. West.*

FELTED BEECH-SCALE.

In certain parts of the country this is a conspicuous Insect by association. Beech-trees attacked by it have the appearance of having their trunks lightly coated with driven snow (see page 279). In this photograph a few of the Insects have been carefully cleaned from the abundant "wool" that completely hides them in nature. That will be at once evident when it is stated that as shown they are magnified sixty-six times.

The scale of the male grub becomes its puparium in which it rests as a chrysalis. In this stage the wings and legs of the perfect Insects are free from the body, though immature and encased each in its separate sheath. When the chrysalis skin is cast off it is pushed out of the scale from the hinder margin, and the winged Insect follows backwards through the same aperture. It is usually yellow or crimson in colour, though a few species are mauve or brown. The wing is transparent, free from scales, and has not the netted character of the wings in other Insects, there being only a single nervure, which forks, and the two branches run parallel with the fore and hind borders of the wing. A second pair of wings is indicated, as in the diptera, by a pair of balancers, in this case taking the form of "hooked bristles, which fit into minute turned-up flaps or pockets in the wings." When not in use the wings lie flat along the body and usually overlap behind. The body of the male is frequently terminated by two or four very long white filaments.

Although the grubs that are developing into females are at first indistinguishable from those of the male sex, the difference becomes manifest when the latter enter the chrysalis stage, for the females at the corresponding change of skin are unaltered. They grow larger and the scale becomes broader. They have lost all their external

Photo by [*W. West.*

A Common Scale-Insect.

On the twigs of wild rose and dogwood often may be found what look like little drops of fat or wax. Examined under the microscope, it will be seen that the pointed end consists of a female scale-Insect, and the broad, fat-like expansion is a marginal secretion of wax. The photograph shows a portion of a colony of adult females on dogwood, and is magnified twelve times.

organs except the rostrum, which still enables them to feed. The eggs are deposited under the scale, from which the young grubs emerge after a short period of crowding together. Then they disperse and seek unoccupied spots in which to thrust in the rostrum and become fixed.

The scale-Insects are not a large family. Only about eight hundred species are known from all parts of the world, and less than a hundred of these have been found in the British Isles, of which number a very few are real natives, most of them having found their way into greenhouses with foreign plants. It is here that the scale-Insects are chiefly a terror to the gardener; out of doors it is doubtful if much damage is done in our climate, the most serious pests in this department being the mussel scale[1] and oyster-shell scale,[2] which attack fruit trees. In the greenhouse, where they have to deal with more tender plants, and are actively sucking at the sap all the year round, the damage they inflict often amounts to extirpation of the plants. The sucking at the juice is not the only trouble. Scale-Insects, like green-fly, excrete a sweet, clear liquid, which is eagerly sought by ants, bees, wasps, and other Insects, and as some species that have been watched have been found to discharge this liquid twenty times in a day, it will be seen that a considerable quantity accumulates on the leaves of greenhouse plants, where heavy showers cannot wash it away, as they do outside. This sticky coating on the leaves provides a suitable medium for the development of a low form of fungus, which runs riot in it. This fungus does not attack the tissues of

Photo by] [*W. West.*

A Common Scale-Insect.

A single example from the group in the preceding photograph is here shown on a larger scale; that is, twenty-five times the natural size. The dark mark in the broad margin is a juvenile example of the same species.

[1] Mytilaspis pomorum.

[2] Aspidiotus ostreæformis.

Photo by] [*H. Bastin.*

A Giant Killed by Dwarfs.

The felted beech-scale is shown, highly magnified, on page 277. As it appears on beech-trees it is associated in millions, which give a snowy appearance to the trunks. The central tree in this photograph has been killed by its attack, much of the bark having peeled off. Many beech-trees in certain localities are in the same condition through the attack of this scale.

the leaf, but soon covers it with a most unsightly black deposit like soot, which utterly spoils the appearance of peaches and other glass-grown fruit.

On the other side of the account, it must be pointed out that scale-Insects produce some substances that are of importance in human industry. There is, for example, the valuable substance known as "lac," which is the basis of French polish, varnishes, and sealing-wax. This lac is excreted by the female of an Indian scale-Insect,[1] and forms resinous masses upon the twigs where the Insects feed. The female herself yields the beautiful colour which artists distinguish as lake. Then there is cochineal, which at one time was one of our important articles of commerce as a dye-stuff, and is still used as a colouring-matter for medicines, sweetmeats, and as a cure for whooping-cough. It consists of the bodies of several species of coccus that feed upon the prickly-pear and other cacti. The manna of the ancients is believed to be the secretions of a coccus[2] that is found on tamarisk in the countries around the Mediterranean, where it is still used as food. Several Indian and Chinese species produce a beautiful white wax in sufficient quantity to make it worth while gathering. At least, it was worth while before the production of solid kerosene for the manufacture of candles restricted the use of real wax for this purpose. Some of our native species are wax-producers, but not in such quantity as to make them commercially important. The Chinese and Indian species referred to[3] produce it in the form of long, woolly streamers covering the body. Our most conspicuous example of these wax-producers is the felted beech-scale,[4] which makes old beeches to look as though they had been in a recent snow-shower. The Insects

Photo by [*E. Step, F.L.S.*

AN INSECT NECKLACE.

[illegible], worn by native ladies in South Africa, are known as being formed of ground pearls. They are really a species of scale-Insect that attacks the roots of certain trees. At a particular stage in their career the females cover themselves with a secretion which hardens into a brittle shell, varying in hue from clear yellow to brown. In these shells the Insects are believed to remain often for years before completing their development.

[1] Tachardia lacca. [2] Gossyparia mannifera. [3] Ericerus pela and Ceroplastes cerifera.
[4] Cryptococcus fagi.

By T. Carreras

DRIVEN FROM THE HIVE

The Bee-hive Beetle spends its grub-stage in the bees' combs, feeding upon the bee grubs and chrysalids. When arrived at full development it has to come out into the open and run the gauntlet of angry workers, who endeavour to use their stings. It may be presumed that a considerable percentage of these beetles, bred in the hive and driven from it, do not long survive their escape. They are shown here five times larger than life.

take up positions in the long, narrow crevices of the bark, and ultimately kill the tree. One of the species whose wax-secretions take a more solid form is Newstead's scale,[1] in which the covering is a number of curved plates of pure white wax standing out all around. In a related species[2] there are curved plates on each side, and behind them is a row of almost straight plates. This is the adult female as represented in our photograph. Another photograph shows the younger condition of the Insect, before the execution of wax has begun.

One remarkable species of these scale-Insects, though it can scarcely be included among useful Insects, has a certain small commercial value, because it is made up into necklaces. These are known as margarodes or ground pearls, and consist of the female of a South African species,[3] which attacks the roots of certain trees. They are believed locally to be ants' eggs, but consist of the females in the chrysalis stage encysted in a pearly, yellowish-brown cell, which is made up of several layers of a substance resembling lac, but which is said to be thin chitin. A string of these in our possession (see page 280) shows various gradations of colour from a clear yellow to brown.

Photo by] [*W. West.*

NEWSTEAD'S SCALE-INSECT.

[illegible] curved plates of wax with which the upper side is covered and margined. The upper and under sides are shown magnified twelve times.

Leaf-Butterflies.

Among the butterflies of other countries that may be said to be known to the man in the street at home, is one of the leaf-butterflies that is a native of India.[4] The feature that has arrested public attention in this case is the striking resemblance to a leaf that is afforded by the under side of the wings when they are erected in a state of rest. As often mounted by the natural history dealer, and exhibited in museums, on leafy branches, with the "tail" of the hinder wing just touching the branch, it affords some amount of amusement to determine which are leaves and which are butterflies. Now, when flying, these butterflies are among the most conspicuous of Insects, for the upper side is marked by broad bands of purple and orange. Such an Insect flying in bright sunshine offers a mark for an Insect-eating bird to follow. But the butterfly has only to drop upon a leafy bush and close its wings, to become invisible at once; for the under side is coloured like a dead leaf with various tints of yellow, brown, and ash, and dark spots so like fungus discolorations, that it is difficult to believe they have not actually been produced on the butterfly by fungi. The museum preparations are wrong in that the butterfly is represented head upwards. Those who know the butterfly at large say that it always settles head downwards, and so is still more like a dead leaf hanging ready to fall

[1] Newsteadia floccosa. [2] Orthezia insignis. [3] Margarodes trimeni. [4] Kallima inachis.

There are many species of these leaf-butterflies, and they are not entirely confined to the genus kallima. This genus has representatives in Tropical Africa, Continental India and the neighbouring islands, and throughout Malaya. Buxton's leaf-butterfly[1] is a fine example of the group, its closed wings providing a "leaf" three inches long, blotched as though in decay, and with a well-defined "midrib." The upper side is dark purple-brown in ground-colour, suffused with blue, which extends from a large patch of that colour near the body. The tip of the fore-wings is black, and, just below, the wing is crossed by a broad band of dull scarlet.

Photo by] [*H. Bastin.*

INDIAN LEAF-BUTTERFLY.

The leaf-butterfly, usually shown with its wings closed, when alone there is any resemblance to a leaf, is here seen with its wings expanded as in flight. As these are brightly marked with purple and orange, the flying butterfly is very conspicuous and a mark for birds. By alighting in a bush and closing its wings so as to show the dead-leaf-like under side, it at once eludes pursuit and recognition.

Dr. A. R. Wallace has given his experience of another species[2] he met with in Sumatra, which goes to show that this mimicry of leaves is of a character to impose not only upon the undiscerning, and not due to the skilful manipulation of museum curators. Here we have a hardened naturalist used to seizing upon minute points of difference, and so not easily imposed upon by Nature. Yet he admits to having been constantly deceived. He says: "This species was not uncommon in dry woods and thickets, and I often endeavoured to capture it without success; for after flying for a short distance, it would enter a bush among dry or dead leaves, and however carefully I crept up to the spot, I could never see it till it would suddenly start out again, and then disappear in a similar place. At length I was fortunate enough to see the exact spot where the butterfly settled; and though I lost sight of it for some time, I at length discovered that it was right before my eyes, but that in its position of repose it so closely resembled a dead leaf attached to a twig as almost certainly to deceive the eye even when gazing full upon it. I captured several specimens on the wing, and was able fully to understand the way in which this wonderful resemblance is produced.

"The end of the upper wings terminates in a fine point, just as the leaves of many tropical shrubs and trees are pointed, while the lower wings are somewhat

[1] Kallima buxtoni. [2] K. paralekta.

LEAF-BUTTERFLIES AT REST.

When the leaf-butterfly alights on a branch the tails of the wings are brought in contact and complete the resemblance to a leaf by becoming a leaf-stalk connecting the butterfly to the branch. The butterflies are shewn about natural size.

more obtuse, and are lengthened out into a short, thick tail. Between these two points there runs a dark curved line exactly representing the midrib of a leaf, and from this radiate on each side a few oblique marks which well imitate the lateral veins. . . . The tint of the under surface varies much, but it is always some ashy-brown or reddish colour, which matches with those of dead leaves. The habit of the species is always to rest on a twig and among dead or dry leaves, and in this position, with the wings closely pressed together, their outline is exactly that of a moderately-sized leaf slightly curved or shrivelled. The tail of the hind-wings forms a perfect stalk, and touches the stick while the Insect is supported by the middle pair of legs, which are not noticed among the twigs and fibres that surround it. The head and antennæ are drawn back between the wings so as to be quite concealed, and there is a little notch hollowed out at the very base of the wings, which allows the head to be retracted sufficiently. All these varied details combine to produce a disguise that is so complete and marvellous as to astonish every one who observes it; and the habits of the Insects are such as to utilize all these peculiarities, and render them available in such a manner as to remove all doubt of the purpose of this singular case of mimicry, which is undoubtedly a protection to the Insect. Its strong and swift flight is sufficient to save it from its enemies when on the wing, but if it were equally conspicuous when at rest it could not long escape extinction, owing to the attacks of the insectivorous birds and reptiles that abound in the tropical forests."

Photo by] [*H. Bastin.*

A South American Leaf Butterfly.

In addition to the curved tail on the fore-wings which [illegible] the leaf [illegible] the under side [illegible] on the hind-wings [illegible] the right of [illegible] little more. The appearance of the under side in this case is rather of two leaves overlapping, for the midrib mark on the fore-wing is not continuous with the leaf-stalk tail on the hind-wing.

A very near approach to this perfect mimicry of a dead leaf is attained by butterflies of a neighbouring genus,[1] of which one species[2] occurs throughout the East Indies and North Australia. Another,[3] found in Malaya, has the upper side tawny with black tips to the fore-wings; and on the under side it is dull ochreous

[1] Doleschallia. [2] D. bisaltide. [3] D. pratipa.

suffused with olive, with a series of ring-like marks with a central spot, which might be the points of fungus attacks on the dead leaf.

The Cockroach-Wasp.

We have so denominated this Insect[1] not because it has any resemblance to a cockroach, but because the latter Insect is preyed upon by the wasp who makes cockroach-hunting the business of its winged life. This wasp is related to the sand-wasps and the mud-daubers but does not appear to do any burrowing, contenting itself with the utilization of any hole—even a key-hole—that may be handy to the scene of its capture. It is only from three-quarters to an inch in the length of its body, but owing to its long antennæ and long legs it appears to be much larger than this measurement indicates. Its fore-body is continued forward considerably in advance of the wings, and it seems thus to have a stout, tapering neck. The hind-body is connected to the fore-body by a slender stalk as in the mud-daubers, but the stalk is much shorter. Although something was known of this wasp and its choice of food in Réaumur's day, little of its life-history is known even now, and further observations are desirable. It has been found in the East Indies and in the Isle of France, and other species have been found in West Africa, whilst one closely allied occurs, though rarely, in Europe.

Photo by] [*H. Bastin.*

INDIAN ORANGE-TIP BUTTERFLY.

A relation of our familiar little orange-tip, but vastly superior to it in size, measuring four inches across the expanded wings. These are white on the upper side, with an orange tip to the fore-wings. Beneath, the wings are yellowish-grey with dusky mottlings; so that when the Insect is at rest, as shown, it appears to be a withered leaf.

Owing to the fondness that the pestiferous species of cockroach show for a domestic life, it is not surprising to find that the cockroach-wasps come indoors after their prey. The original observation of the species by Cossigni tells how wasp and cockroach eye each other for an instant; then the wasp darts upon the cockroach, "seizes it by the muzzle with its strong jaws, and bending its hind-body

[1] Ampulex compressa.

underneath it, pierces it with its fatal sting. Sure of its victim, it now walks or flies away, leaving the poison to work its effect! but in a short time returns, and finding it deprived of power to make resistance, seizes it again by the head, and drags it away, walking backwards to deposit it in a hole or chink of a wall." If the hole or chink selected is not large enough to admit the cockroach, the wasp is not nonplussed: it reduces the size of its prey by biting off obstructive portions. From certain observations made it appears probable that instead of feeding upon the cockroach from the exterior, as other solitary wasp-grubs do to the caterpillars, spiders, etc., with which their cell is furnished, this wasp's grub enters its prey and feeds within the leathery cuticle. It afterwards spins its cocoon within its victim and changes to a chrysalis; for the empty cocoon is often protruding from the cockroach skin.

Photo by] [*E. Step, F.L.S.*
COCKROACH-WASP.
The species figured is different from that shown in the plate opposite, but the habits of the two are identical. The upper figure shows the wasp with its wings extended as in flight, the lower as at rest with the wings folded. Natural size.

Perkins gives a remarkable account of a species[1] he found in West Africa. This wasp enters houses that are infested by cockroaches, and selects a good specimen for attack—it may be four times the size of the plucky wasp. A bit of a struggle ensues between the two, but when the wasp has contrived to sting its victim the cockroach becomes quiet and allows its conqueror to drag it away to a hole. In one case that he watched, the victim was carried to a keyhole and deposited therein; but the wasp, apparently conscious that its sting only disabled the cockroach and that the movements of the latter might be sufficient to work it out of so shallow a retreat, found some heavy nails and carried these to the keyhole to make its prisoner more secure!

In most places where found the cockroach-wasp does not appear to be at all plentiful; but Lefroy states it is common in the plains of India. "At Pusa this Insect is purely arboreal in its habitat. The chief haunts are the trunks of old peepul[2] and fig-trees, which possess numerous holes and chinks." He says it is not an uncommon sight to see the wasp hurrying along the tree-trunk searching hole after hole for cockroaches, and occasionally flying to a distant branch only to return and continue the search in a few seconds. As far as observed, this species confines itself exclusively to species of cockroach for its prey. The cockroach is invariably bigger than the wasp. The manœuvres employed are much like those of the mud-dauber wasps in capturing spiders, though there is not so much careful tact and dexterity displayed by the wasp in dealing with the cockroach, probably because the latter is not armed with any poisonous weapons: it has to depend on its activity and the irritating spines on its legs for its defence. Often, if the cockroach has wings, it takes to flight, but the wasp quickly overtakes it and alights on its back, when the cockroach submits. The wasp at once thrusts its sting into

[1] Ampulex sibirica. [2] Ficus religiosa.

THE COCKROACH-WASP.

This beautiful, polished green wasp devotes its life to the destruction of cockroaches, which [illegible] and then drags them away to its nesting-holes to provide food for its own grubs.

Photo by] [*H. Bastin.*

FIGWORT-BEETLES.

Two distinct though closely related species, that agree generally in their habits and life-history. That to the left is the species more particularly described. They are shown about six times the actual size.

the side of the cockroach's fore-body, where it reaches the most important of the nerve centres. But the sting does not appear to have the rapid effect noted in other cases, for if the wasp has to leave its victim whilst it searches for a hole to hide it in, the cockroach often manages to slip into some convenient chink and so escape.

The Figwort-Beetle.

A common plant named the figwort, that grows on roadside wastes and about woods, is of interest to the Insect-hunter as well as to the botanist. In June some plants may be found whose leaves present a sorry spectacle, the fleshy portion having been either eaten away entirely or riddled with small holes. Most persons on examining such leaves and finding the creatures that are obviously causing the damage would declare that they were small slugs. As a matter of fact they are the grubs of a beetle[1] belonging to the great family of weevils. Most weevils are very destructive, and many have obtained an unenviable notoriety on account of their attacking fruits and food-plants. In the present case the plant is a mere weed, and so the Insect that attacks it is of no consequence, and is known only to the few. But there are points in its economy that make it worthy of a short description, and may give rise to important thoughts.

If these shining, slimy, slug-like creatures can be divested of their slime, they will be found to be much like the grubs one sometimes finds eating the kernel of a hazel-nut; but on the twelfth segment of the body there is an excretory gland which pours out slime, and this gets diffused all over the body, and effectually disguises the true nature of the grub. In the photograph of the flowering stems of figwort (page 289) a number of these grubs are present feeding upon the flowers and buds, but are only to be distinguished from the latter here and there where the light shines upon their slime. Some of them have ascended for the purpose of undergoing the change to the chrysalis, and these have fashioned cocoons out of the slime. One such is conspicuous in the centre of the photograph owing to the high light upon it, and a glance at its form will lead to the detection of other cocoons not so new and glossy. These cocoons are just about the same size and shape as the seed-vessels of the plant, and as the slime dries into a parchment-like texture there is little to distinguish between seed-vessel and cocoon.

The chrysalis stage lasts little more than a week; and then a neat lid is cut around the cocoon, thrown back, and out walks a rather globular beetle clothed

[1] Cionus scrophulariæ.

in dark grey which is prettily spotted with black and yellow. One of the black spots is much larger than the others and situated on the dividing line between the wing-covers, where it looks precisely like a hole bored through the beetle—which, however, does not look at all like a beetle but more resembles a seed. A very similar but less noticeable spot will be found at the curved extremity of the wing-covers. But the most conspicuous feature of the beetle when viewed from the side is the long and strongly curved rostrum.

The grub does not appear so particular as are many Insects as to the attitude in which it shall spend its chrysalis period. If the vacated cocoons are examined, it will be seen that whilst some have the lids opening upwards, others are quite reversed. In our third photograph two cocoons will be seen adjoining, of which the upper opens above and the lower opens below.

It is remarkable that in these three stages of existence this particular beetle is protected by its resemblances to other things. As a grub its thick slime makes it repulsive, and to appear like a small black slug. As a defenceless chrysalis it avoids observation under cover of its cocoon, which is passed over as one of the figwort's numerous seed-vessels; and the perfect beetle at rest between the base of the leaf and the stem of the plant, with its legs tucked under it, looks like a hard seed. Here is food for thought as to the causes that have brought about these resemblances.

Photo by [*E. Step, F.L.S.*

GRUBS OF FIGWORT-BEETLE.

The grub pours out a thick black slime which covers it and makes it appear like a small slug. From this slime it contrives a parchment-like cocoon in which it changes to a chrysalis, and later to a grey and black portly weevil. These cocoons are much like the seed-vessels of the figwort.

Sanitary Officer and Disease-disseminator.

Among Nature's sanitary officers that are best known to the non-entomological public are the two-winged flies, especially those that make frequent calls upon us in our homes. But the public, as a rule, fail to recognize them in the character of officers for the removal of nuisances, insisting that they are themselves a nuisance. Of late years one very prominent member of this staff of sanitary officials has actually been accused—and with good reason—of being actively engaged in the dissemination of disease germs. This monster—according to recent views of him—is the ubiquitous house-fly.[1] The charge appears to be well founded, but, though we have no desire to whitewash him, it is right that someone should act the part of "devil's advocate," and point out, with a view to mitigation of penalties, that his carrying of noxious germs is not done "of malice aforethought," and that he would not do so if the said germs were not left carelessly in his way to cling to his feet. We play all sorts of tricks with the laws of Nature, and when trouble comes of it we try to set it right in the wrong way.

Photo by] [*H. Baston.*

FIGWORT-BEETLES AND THEIR COCOONS.

The cocoons are attached to the fruiting shoots of figwort, and may be distinguished by the absence of a beak at the upper side. The beetle leaves the cocoon by lifting a distinct lid. One of the beetles is climbing the stem, and two others are present whose exact location the reader may like to discover for himself.

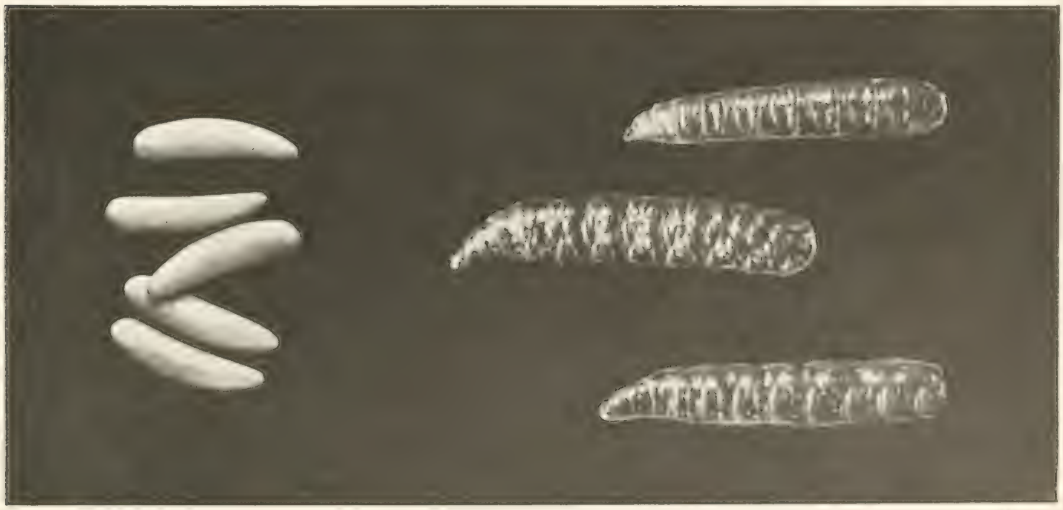
Here we are now, founding "Kill-that-Fly" leagues and preaching crusades against the Insect when we ought to be clearing away the muck-heaps near our homes in which the flies are nurtured. Nearly every man who owns a bit of garden-ground is so impressed with the necessity for feeding up his plants with stable manure that he has a heap handy for the purpose and a smaller heap at the roots of every rose-bush. In some cases he has applied it so continuously that the surface soil of the whole garden is largely composed of it. Then the flies come as Nature's sanitary officers and decide that it must be reduced to an inoffensive condition Every female fly lays about a hundred and twenty eggs upon it, and perhaps repeats the number several times at intervals. These hatch in a day or two, and the maggots

[1] Musca domestica.

Photo by [*A. E. Sw*

THE HOUSE-FLY.

The photograph shows the familiar house-fly enlarged to six times the actual size. On this scale the characters of the legs, the compound eyes, the tongue, etc., are more plainly to be observed.



EGGS AND GRUBS OF THE HOUSE-FLY.

The female house-fly lays about six hundred eggs in several batches on moist refuse. The grubs or maggots a[illegible] to the mouth. They feed upon the liquid portion of the refuse, and in a week are full grown. In another week t[illegible] the chrysalis stage and are winged Insects.

that issue from them set to work with all speed to reduce the most offensive portion of the nuisance. In less than a week they have done what they could, and have become full grown. They turn to chrysalids inside the maggot skin, and in another week they are flies. These lay their eggs, thus ensuring the continuation of the sanitary work by a vastly increased host of workers, and then, attracted by various odours, enter our dwellings for a brief life of enjoyment, partaking of infinitesimal portions of our food, licking up the microbes we foster but do not want, and perhaps coming to an end in the milk-jug or jam-dish, whose contents thereby become impregnated with germs.

It must not be supposed from what has been said that the house-fly confines its attention to stable manure as an egg-laying ground and nursery for its progeny. It feeds in any organic waste that is sufficiently warm and moist to ferment, but mainly in horse manure, human manure, pig manure, spent hops, and malt-waste (brewer's grains). Each female fly lays several batches of eggs, in all about six hundred, which hatch in periods varying with the conditions at the time—often eight hours, sometimes four days. The newly hatched "maggot" at once burrows into the refuse, seeking the moister parts that it may feed upon the liquid portion. The most favourable temperature for development appears to be between 90°–98°.

Photo by] [*H. Bastin.*

PUPARIA OF HOUSE-FLY.

The grub of the house-fly, instead of casting its skin when it turns to a chrysalis, merely detaches itself from the skin, which becomes a hard and dark red barrel protecting the delicate white chrysalis. This case is known as the puparium. To escape, the newly formed fly blows out a bladder on its head, which pushes off one end of the puparium and allows its exit.

Dr. L. O. Howard, who has written a terrible indictment of the house-fly—which he prefers to call the typhoid-fly—has made a calculation of the progeny of a single female fly that, having passed the winter in some snug spot, begins laying eggs on April 15th. By the 10th of September the living issue of that fly will be 5,598,720,000,000! Of course, in fact, all the eggs laid do not produce maggots, all the maggots hatched do not survive to become flies, all the flies are not females, and all the female flies do not become mothers; but to eliminate failure of this sort he reckons that half a generation consists of females and that each female lays only one hundred and twenty eggs, instead of her maximum of six hundred. He shows that, in the United States at least, typhoid, cholera infantum, and "summer complaint" are chiefly spread by these flies carrying the germs from the sick to the well. Most other complaints that flesh is supposed to be heir to are greatly assisted in their spread by the same agency. Several English authorities on sanitation have made similar declarations as the result of their investigations.

Many of these creatures are a sort of Jekyll-and-Hyde combination of two personalities, marking two successive phases of existence. The question is, which is the greater—the harm they do or the good? The answer for the individual may be, the harm, whilst for the race it is probably the good. Anyway, the rational course is to clear away the cause and the effects must cease. It is puerile to be catching single flies in the house whilst we are encouraging millions to breed at the back door. The stable is rapidly becoming an institution of the past. Let the suburban gardener anticipate the early date when it will have ceased to be, by feeding his garden with chemical manures.

But one of our domestic flies, the small house-fly[1]—a paler as well as smaller Insect than the other—feeds in its larval stage on decaying *vegetable* refuse, so the garden rubbish should be burnt, not stacked. This fly has more rounded tips to its wings, and on account of its inferior size is often referred to as a *young* house-fly. Size in the case of Insects that have reached the winged stage, it is perhaps unnecessary to point out, is no criterion of age. This stage reached, growth ceases.

Photo by] [*E. Step, F.L.S.*

BLOW-FLY OR BLUE-BOTTLE.

Here shown four times the actual size. The grub of the blow-fly eats flesh, and when the mother-fly appears indoors she is always seeking for the larder, in order that she may lay her eggs on our joints of meat.

The food of the blow-fly or blue-bottle[2] in its grub-stage is very different. It is a flesh-feeder, and its proper mission in life is to clear away those animals that have met with death from old-age, disease, or in an encounter with an opponent that is not carnivorous. That mission is undoubtedly an important and beneficial one for the human race; but when that race takes to storing meat, poultry, and fish in its larders, and the keen senses of the blow-fly track it to its hiding-place, some fault is found with Nature's arrangements. What seems to be required of Nature to meet the altered conditions brought about by civilization is the evolution of a race of blow-flies that can distinguish between what is common and what is property. The vegetarian's comment upon this suggestion would be, in all probability, that it would be more reasonable to give up converting our larders into charnel-houses!

The truth is that what we dub domestic pests are part of the price we must pay for our domesticity. All the kill-that-fly leagues can do will make no appreciable difference to the fly nuisance; and probably if we were to pull down our houses and return to the pastoral life of our nomad ancestors we should find

[1] Homalomyia canicularis. [2] Calliphora vomitoria.

that we had only got rid of the attentions of one class of pests to fall under the care of another group. Even Mrs. Troglodyte-Smith must have found that there were undesirable creatures who insisted upon sharing her cave. Another fact that militates against the success of the fly leagues is the war that has been waged in late years against the wasp, one of the most inveterate destroyers of flies.

Some of these sanitary or scavenger flies, though their habits in the larval stage are similar to those of the blow-fly, rarely or never enter our houses, and therefore do not become a nuisance to us. Such are the green-bottle[1] and the flesh-fly.[2] The first does occasionally wander into open windows and doors in the summer, but does not stay in the house, preferring to sit on leaves in the hottest sunshine and exhibit its shining golden-green livery to the best advantage. The green-bottle is the special bane of the fishmonger, and if by chance we pass by the back premises where this tradesman temporarily stores his refuse, we shall startle up a cloud of these beautiful but repulsive Insects, who have been engaged not only in depositing eggs in the offal, but in sucking up the more fluid decomposing portions.

The flesh-fly is similar to the blow-fly, but rather longer and of a grey and black coloration instead of the steely-blue which has given the name of blue-bottle. It is a carrion-feeder, but out of doors; and it retains its eggs until they are hatched, so that on the discovery of suitable material for their deposit the sanitary work of clearing away dangerous matter begins at once. In this connection it is worthy of note that these flies have had all the details of their life-history adapted to the necessities of the case. A heap of stable manure is less inimical to animal life than is decomposing flesh, and as innumerable beetles and flies help to clear it away, the fecundity of the house-fly is not nearly so high as that of the blue-bottle and flesh-fly, whose work must be done much more expeditiously. We have mentioned that the house-fly lays about six hundred eggs; the blow-fly lays from five hundred to a thousand, but dissection has shown that the flesh-fly is able to deposit as many as twenty thousand. Of course, these are not all deposited at once, or in the same mass of corruption: they are laid in batches as appears to be necessary. But it frequently happens that a number of egg-laden blow-flies or flesh-flies will lay their eggs in the same food-mass, which may not be sufficient to bring so vast an army of maggots to their full size. In that case some would feed upon their weaker kindred, so that a few could come to maturity and continue the race. The dead matter would be converted rapidly into living matter, and so cease to pollute the atmosphere. The futility of attempting to get rid of the fly-nuisance by killing a few thousand flies here and there is apparent. It is akin to emptying the ocean with a tea-spoon.

Photo by] [*H. S. Cheavin, F.R.M.S.*

BALANCER OR HIND-WING OF HOUSE-FLY.

The balancers or halteres are like minute wings, and probably represent the hinder wings of the four-winged insects. They are believed to be sense organs.

We have spoken of all these flies as laying eggs, but it should be remembered

[1] Lucilia cæsar. [2] Sarcophaga carnaria.

Photo by *W. Plomer Young, F.R.M.S.*

HEAD OF BLOW FLY

[illegible] with the connected [illegible] with the two lobes [illegible] photograph [illegible] upon the surface over which [illegible] it.

Photo by *[illegible]*

FOOT OF BLOW FLY.

The magnified view shows only the last joint of the fly's foot, with its [illegible] and the sticky pads which enable it to walk up smooth surfaces [illegible] The photograph is a hundred times larger than the part shown in the actual foot.

that in the case of the flesh-fly the eggs are hatched before they leave the parent. The maggots are much larger than those of the blue-bottle, and the hinder end is a steep slope deeply hollowed, and in the hollow are the two spiracles or breathing inlets which are made conspicuous by their reddish tint. The edge of the depression in which these lie is fringed with fleshy points which can be turned outwards to expose the cavity to the air or folded in to protect the spiracles from any matter that might clog them and put them out of action. Headless as the maggot is, and therefore eyeless and sightless, it has a keen perception of the difference between light and darkness, always strongly avoiding the light and seeking the dark.

One remarkable power possessed by the maggots of all these flies is that of being able to liquefy rapidly any albuminous substance such as flesh or the white of hard-boiled egg. Though the mouth is provided with a couple of grasping hooks, which are really used as organs of locomotion, they serve no purpose in breaking up their food, which must be liquid to enable them to consume it. To this end they pour out from the mouth a sort of pepsin which rapidly reduces the solid muscle or boiled egg to a fluid.

Photo by] [*P. J. Barraud.*

THE FLESH-FLY.

The flesh-fly is much like a blow-fly, but lacks the blue coloration of the latter, being decorated in grey and black. It is not a house-fly, but an out-of-doors carrion-feeder. The female can deposit about twenty thousand eggs, and her progeny is thus so numerous that it can quickly dispose of offensive matter.

Cockroaches.

There is a well-known story of a certain lexicographer who wrote in his new dictionary, after the word crab, what he considered a particularly concise definition: "A little red fish that walks backwards." The story goes that on submitting this for the approval of a naturalist friend, the latter remarked that it was an admirable definition, but it had three rather weak points: the crab is not a fish, it is not red until it has been boiled, and it does not walk backwards. In a similar spirit of good-natured criticism it has been pointed out that the name black-beetle, which is generally applied to the cockroach, is a good name, but that the Insect indicated is not a beetle and is not black.

Cockroaches are four-winged Insects of the straight-winged order,[1] and the various species constitute a distinct family.[2] Like the other straight-winged Insects, when they leave the egg they are in the form they retain through life with little change beyond increase of size and the acquisition of wings. They are also paler in colour than when they are older. They cast their skins five or six times,

[1] Orthoptera. [2] Blattidæ.

and at the last change their wings are developed. In some species only the male is winged, and some others are wingless in both sexes. In the kind that is only too common in many of our houses the adult male alone has wings, the female having to be content with two minute scales as evidence of the fact that she is theoretically a winged Insect. The young cockroach pursues the even tenor of its way to adult life in full activity, without the resting period that for many Insects precedes the acquisition of wings.

It may appear strange that though we have three native species of cockroaches, neither of them can be said to be known to the public; whilst of several foreign species that have settled among us without being invited two are tolerably well known, and a third perhaps as well known as any British Insect. This third species is the so-called "black-beetle,"[1] whose native land has not yet been satisfactorily made out. It is believed to be Asiatic, and to have set about the conquest of Britain three hundred years or so ago. At first it was content with the occupation of our ports, and, of course, no foreign invader would overlook the rich port of London. Probably hiding itself away in bales of merchandise, as later arrivals have been detected in doing, it got here; and ever since it has been engaged in the subjugation of the inland districts. It is possible that we may owe its introduction to Francis Drake, for Mouffet in his book on Insects, published as early as 1634, tells how our great freebooting hero took the Spanish ship *Philip*, all laden with spices, and found that it contained also a multitude of winged cockroaches. Perhaps it will help the patriotic Englishman, who is suffering from this pest, to bear his lot if he reflects that they may be the direct descendants of the winged portion of that prize cargo. The reason why it is so fond of the kitchen and bakehouse is not merely that there are more chances of picking up food there, but that it comes from the tropical parts of Asia and must have warmth. For this reason also, it is only seen out of doors on hot summer days, when its migrations are effected. Its spread from London to the surrounding country appears to have been slow, and this is probably due to the wingless condition of the female, which enables her to go only from house to house on foot. It might spread rapidly in a town, but to

Photo by] [*H. S. Cheavin, F.R.M.S.*

SPIRACLE OF BLOW-FLY.

One of the minute openings into the air-tubes, showing the system of branched hairs which protect the inlet and detain any particles of dust, etc., that might cause blocking of the finer tubes if allowed to enter.

[1] Stilopyga orientalis.

get to other towns or villages probably had to depend upon man carrying it among his merchandise. Gilbert White, somewhere about the year 1790, complains that cockroaches are swarming in his chimney closets and kitchen, and says he has not observed them till recently. They had, apparently, not long reached Selborne.

This common cockroach is a little over an inch in length when full grown. Only the male is winged, and the wing-covers extend over about two-thirds of his hind-body, whilst the wings themselves are shorter. The wing-covers are leathery and opaque. The female is much broader than the male, and the absence of wings gives her a more repulsive appearance than that of the male. In both sexes there is a pair of long, slender, and sensitive antennæ, and at the other end of the body is a pair of short, stouter, antenna-like organs. The antennæ are a little longer than the body in the male; a little shorter than the body in the female; and they consist of from seventy-five to ninety joints each.

The mouth is furnished with powerful jaws, whose edges are well toothed and capable of cutting up the very various substances upon which the cockroach will feed. Probably no other Insect is so perfectly omnivorous as the cockroach. Anything that man eats, or wears, or otherwise uses, the cockroach will and does eat. This may appear to be too sweeping a statement, but one cannot give a complete list of the things they have been known to consume, because of its excessive length; yet when one selects as examples such unpromising articles as woollen clothes, boot uppers, blacking, ink, emery paper, their own cast-skins, and their dead companions, it may be considered that their possible bill of fare is by no means limited.

Photo by] [*W. J. Lucas, F.E.S.*

COMMON COCKROACH.

[illegible] "black beetle" of domestic parlance. The two sexes are shown, that to the left being the female and to the right the male. The latter, it will be noticed, has wings, but the female is always wingless, although vestiges of the organs are to be seen just behind the head.

Professor Moseley refers to the annoyance he received from the attentions of a larger species on board H.M.S. *Challenger*. He says: "At one period of the voyage, a number of these Insects established themselves in my cabin, and devoured parts of my boots, nibbling off all the margins of leather projecting beyond the seams on the upper leathers. One huge winged cockroach for a long time baffled me in my attempts to get rid of him. I could not discover his retreat. At night he came out and rested on my bookshelf, at the foot of my bed, swaying his antennæ to and fro, and watching me closely. If I reached out my hand from the bed, to get a stick, or raised my book to throw it at him, he dropped at once on deck, and was forthwith out of harm's way. He bothered me much, because when my light was out, he had a familiar habit of coming to sip the moisture from my face and lips, which was decidedly unpleasant, and often awoke me from a doze. I believe it was with this object that he watched me before I went to sleep. I often had a shot at him with a book or other missile, as he sat on the book-shelf, but he always dodged and

Photo by] [*H. Bastin.*

COMMON COCKROACH.

A female of the common cockroach who has just released her egg-case. This is usually carried about [illegible] protected by a shell to allow it to be thoroughly hardened [illegible]

Photo by] *H. Bastin.*

LAPLAND COCKROACH.

The cockroach is the commonest of our three native species, and never comes into our houses as the invading species have done. In Lapland, however, it shares the room of the natives, and becomes a pest by consuming their stores of food. The photograph is a magnified view, the insect being only half an inch long.

escaped. His quickness and agility astonished me. At last I triumphed, by adopting the advice of Captain Maclear, and shooting him with a pellet of paper from my air-gun, a mode of attack for which he was evidently unprepared."

Female cockroaches may often be seen carrying a dark brown, horny purse attached to the hinder body. The upper side is ridged and slightly toothed. This is her egg-capsule, and it contains sixteen eggs arranged in two rows of eight. This will be deposited in some safe crevice. When the eggs hatch, the tiny white cockroaches by the emission of saliva soften the ridged roof of their cradle, and the two sides separate to allow of their escape. They are very active little creatures, running with great ease, and on coming into daylight soon darken to brown.

Photo by] [*H. Main, F.E.S.*
CROTON-BUG OR GERMAN COCKROACH.
Really an Asiatic species which is believed to have been introduced to England with troops returning from the Crimean War. It may be studied easily in some London restaurants. It is photographed from the under side to show how (in cockroaches generally) the head is kept inflexed under the fore-body.

In some houses that are cockroach-ridden the place of the common cockroach is taken by a much smaller species known in the United States as the croton-bug. Linnæus called it the German cockroach,[1] from a belief that Germany was its natural home. It really came from Asia and North-eastern Europe through Russia. It is said to have come to England in the company of soldiers returning from the Crimean War. It is about half the size of the common cockroach, and both sexes are winged. As it reaches maturity in the course of a few months (the common species takes several years), it soon forms enormous swarms. It is of a lighter colour than its larger relation, and the wing-covers extend beyond the end of the body. A much larger species, the kakerlac,[2] came to us from Tropical America, and is established in houses chiefly near the docks, as it is the species most frequent on board ship. It may also be seen in some plenty in certain of the warmer houses in the Zoological Society's Gardens; but otherwise it does not appear to spread much in this country. Occasionally a specimen or two of the still larger drummer,[3] of the West Indies, is caught here, having come on ship-board; but it does not appear ever to have obtained a proper footing. Other species turn up at Kew, with plants from all quarters of the world; and of these we give several portraits.

Our three native cockroaches are small, and being hardy disdain the soft indoor life that appeals to the aliens. They keep to the coast and woods not far inland, where they may be found among dead leaves and debris. One of these, the Lapland cockroach,[4] though only found in thickets in this country and over the greater part of the Continent, shares the homes of the Lapps, and is a pest because it attacks their stores of dried fish. The word cockroach

[1] Phyllodromia germanica. [2] Periplaneta americana. [3] Blabera gigantea. [4] Ectobia lapponica.

is said to be derived from a Spanish word, *cucurácha ;* but as the latter means a contemptible berry, it is not easy to see how it became applied to these Insects.

Dragon-Flies.

These—the largest and most powerful representatives of Insect life in this country—are as well known as to their general form as the butterflies and moths. But, so far as the vast majority of our fellow men and women are concerned, there our knowledge ends. They are too commonly known as "horse-stingers," and the name indicates the wide-spread belief that they are creatures to be feared and avoided. In all probability this libellous designation arose from the fact that the dragon-fly has been seen sweeping around horses in pursuit of the real horse-stingers (gad-flies) and other Insects that annoy horses and cattle. The dragon-fly has no sting, and is not a blood-sucker; but it has a very formidable set of jaws with which it commits great destruction among other Insects. From these attacks the backboned animals are immune. So there is no reason why we should not make close acquaintance with them, and admire their splendid aerostatics without a fear of molestation.

Photo by] [*W. J. Lucas, F.E.S.*

SURINAM COCKROACH.

This is the most recent of our foreign visitors to become naturalized in this country. It is quite black, very shiny, and consequently slippery. There is not at present any indication that it will become a household pest, as it appears to be more at home in plant-houses, and probably feeds upon plants.

The distinctive features of the dragon-fly are the long and mostly slender hind-body, the robust fore-body to which the wings and legs are attached, the enormous compound eyes, and the four transparent, netted wings of great expanse. It is easy to understand, without dissection of the creature, that the robustness of the fore-body is due to the concentration there of powerful muscles needed to work the long wings. The size of the very convex compound eyes, too, is understandable when one inquires how many facets or lenses they include. One species has been found to possess in one of these eyes about ten thousand lenses.

One of the astonishing facts concerning those Insects that excel in flight is that their earlier life does not appear to be a training for that kind of existence. If one watches the continuous wheeling of a dragon-fly over a pond, or its swift sweep up and down a leafy lane, in pursuit of its prey, one is astonished at the contrast with its former sluggish life at the bottom of a stagnant pool. There is one point, however, on which the two periods of life are the same: the dragon-fly throughout its life is a rapacious Insect. As a nymph it lives by stalking other denizens of the pond. It is not provided with fins or a flexible tail with which it can lash

the water and urge itself along; but it can on occasion make a spurt in a double sense by ejecting water forcibly from its breathing chamber in its hind-body, and so propel itself.

In the photograph of the nymph it will be seen that the hind-body terminates in several wedge-shaped "tails" guarding the entrance to a chamber in which is contained organs through which the blood courses, and through whose walls oxygen dissolved in the water can be taken up by the blood. When the nymph expands its hind-body these "tails" separate widely and the chamber is filled with a fresh supply of water. Then the tails close up and constitute a valve, keeping the water in. When the water is exhausted of its oxygen, the valve is opened, the water ejected, and another supply taken in. If the nymph wishes to reach the other side of the pond quickly, it has only to eject the water under great pressure and lift its feet, when the force of the outward stream sends the nymph forward rapidly.

Photos by] [*H. Main, F.E.S.*

EGG-CAPSULES.

The common cockroach lays her eggs in parcels of sixteen, two rows of eight being enclosed in a horny capsule, which is carried about by the female until she can find a suitable crevice in which to hide it. The upper photograph shows the capsule of the common species ("black-beetle"), the lower that of the smaller "croton-bug."

Another remarkable item in the structure of the dragon-fly nymph is the development of its lower lip to almost half the entire length of the body. But it is hinged to the mouth and again near its middle, so that when not in active use it can lie packed close under the head. At its front this structure ends in two curved hooks which fit against the face like a mask. Creeping quietly up towards its prey, it suddenly extends this mask to its full length, secures the victim with its hooks, and holds it close against the real jaws whilst it is consumed.

We have elsewhere spoken of complete and partial metamorphoses, and have explained that where the food of the Insect is of the same nature throughout life, involving no change in the digestive system, there is no need for a resting period known as the chrysalis-stage. The dragon-fly is carnivorous throughout life: therefore, its acquisition of wings is gradual as in the grasshoppers, and until it leaves the water to fully develop these organs it leads an active life.

After a year or two of this kind of life—the period varies in different species—the nymph crawls up a water-plant that has aerial stems and climbs right out of the water. Hooking its feet into the plant it takes firm hold, for it feels that something important is going to happen. Of course, like other Insects, it has had to moult several times in order to allow of an increase of size. Now the change is to be not merely a more roomy jacket of the same pattern as the last, but something more striking. The skin of the fore-body splits above, and the Insect walks out of it, the old shells of its feet retaining their hold of the plant. Its long hind-body

By Theo. Carreras.

EARLY LIFE OF THE DRAGON-FLY.

In its early stages (nymph) the dragon-fly lives in the water. It is remarkable at this period for the extraordinary development of parts of the mouth into what is known as the mask. This is doubly hinged, so that it may be packed close in front of the nymph's face, but can be suddenly thrust forward in order to secure other creatures, as shown in the middle of the picture. To the right another is engaged in devouring a bloodworm. Above the water a nymph has climbed up a stem, and its skin has split behind the head to allow the escape of the mature Insect—the dragon-fly.

Photo by] [*E. Step, F.L.S.*

DRAGON-FLY NYMPHS.

Nymphs of one of the large cylindrical-bodied species. That to the left has its mask retracted; the one to the right has it partially extended, showing the two-jointed portions which fold up under the head. The valves at the end of the body are shown also.

is withdrawn, and it clings to the empty old skin whilst its wings, so long cramped up in the little hard pads on its back, hang limp but visibly expanding.

When man, after many experiments, acquired the means of flying he had to make many trials, a large proportion ending fatally for the intrepid experimenter. But the dragon-fly, after waiting a little to allow his wings and integuments to harden, knows exactly how to use them, and spreading them, starts swiftly on a level course, wheeling sharply to right or left, and backing with facility. In the pond he preyed upon the other inhabitants, and now in the air he pursues the same methods of subsistence, but upon the winged Insects.

In addition to the stout-bodied, cylindrical, and the broad-bodied, flat species of large size, there are others, the demoiselles, with very slender bodies and delicate narrow wings, the bodies striped with blue and black; but the general facts of their life-history are all much alike.

Spinners of Silk.

From very early times man has been acquainted with, and has made use of, the silk-producing powers of Insects. The silkworm[1] that originally came from China or India, has been the principal source of the finest raiment with which the human species has clothed itself, but the faculty of producing silk is shared by many Insects in a minor degree. In most of them it is utilized in the final stage of the grub state to make provision for the security of the chrysalis, but many caterpillars possess it already when newly issued from the egg. As an example of this we may cite the case of the young caterpillar of the puss-moth,[2] which feeds upon the upper surface of the leaves of sallow, willow, and poplar. The latter are not only glossy, affording an insecure foothold, but are kept in a state of constant fluttering by the slightest movements of the air. The tiny caterpillars, looking like smuts that have clung to the leaf and that might be detached by a breath, at once set to work to spin a little pad of silk on the leaf, in which the hooks of their feet may catch, and so enable the animated particle to feed in safety no matter how violent the jerking of the leaf from side to side.

[1] Bombyx mori. [2] Dicranura vinula.

Another simple, but highly useful example of the spinning power is exhibited by the leaf-rolling caterpillars and the elongated caterpillars known as geometers (with which we deal elsewhere) from their peculiar manner of progression, in which they appear to be carefully measuring the distance traversed. Some caterpillars of these two families, when the bough upon which they are feeding is rudely jerked, at once loose their hold, but simultaneously spin a single thread by which they hang suspended in mid-air until the supposed danger appears to have passed, when they ascend the thread and regain their former station.

As a rule the spinning of butterfly-caterpillars is restricted to the fabrication of a silken pad into which the terminal hooks of the chrysalis become attached, and of a girdle around what we may term the waist of the chrysalis. The fluid silk is produced by two large glands, one on each side of the body, whose ducts unite and are continued externally as the spinneret, which is a point on the middle line of the lip, differently developed in the different families and species. The glands are of simple structure and vary in size according to the amount of silk-production required by the species. In some of the moth-caterpillars that elaborate thick cocoons their length and weight are considerable: the silkworm, for instance, possessing a pair of silk-glands each measuring five times the full length of the body. This length is exceeded by some other species, the caterpillar of the polyphemus silk-moth,[1] for example, having silk-glands seven times the length of its body. In those that do not spin cocoons, on the other hand, the silk-glands

Photo by] [*E. Step, F.L.S.*

THE DEMOISELLE DRAGON-FLY.

The demoiselles are distinct among the slender-bodied dragon-flies by reason of their dark purple colour. The cylindrical body is glossy with metallic reflections. The photograph shows the characteristic resting attitude of this species.

[1] Telea polyphemus.

do not equal the length of the body. In the full-grown silkworm the weight of the glands equals two-fifths of the Insect's total weight. This is not surprising when we consider the great length of thread that is produced in the weaving of the cocoon. The average length of silk wound off from a single cocoon is 1,526 feet; but there is a difference between the produce from a cocoon containing a female chrysalis and one containing a male sufficient to enable the silk-farmers to sort out the sexes by the weight of the cocoons. In agreement with this result, it is found that a silkworm which is to develop into a female moth has larger silk-glands than one that is to become a male moth.

Photo by] [*E. Step, F.L.S.*

FOUR SPOTTED DRAGON FLY.

One of our larger native species, of the flat bodied section, whose wings are marked at the base with a blotch of brown, and the hind-body coated with a bluish powder.

The history of the domestication of the silkworm, like that of the honey-bee, extends so far back that its beginnings are hidden in the mists of antiquity. Silk is known to have been in general use among the Chinese at a period compared with which the introduction of the Insect into Europe may be spoken of as recent; and it is probable that the silkworm is a native of China, though some consider it to have originated as a wild species in Bengal. Silk tissues reached Europe from Asia long before anything certain was known as to their origin, "some supposing," Kirby and Spence tell us, "it to be the entrails of a spider-like Insect with eight legs, which was fed for four years upon a kind of paste, and then with the leaves of the green willow, until it burst with fat; others that it was the produce of a worm which built clay nests, and collected wax; Aristotle, with more truth, that it was unwound from the pupa of a large horned caterpillar. Nor was the mode of producing and manufacturing this precious material known to Europe until long after the Christian era, being first learnt about the year 550, by two monks, who procured in India the eggs of the silkworm-moth, with which, concealing them in hollow canes, they hastened to Constantinople, where they speedily multiplied, and were subsequently introduced into Italy, of which

THE TUSSEH SILK-MOTH.

This fine Indian moth is the ultimate stage of the caterpillar whose cocoons are the raw material from which the tusseh silk fabrics are woven. It measures about four and a half inches across the outspread wings, which are fawn-coloured with brown and yellow markings. Near the centre of each wing is a transparent round spot, surrounded by rings of yellow, brown, and black. The silk is obtained from wild caterpillars, which are allowed to remain where found, and their development watched until the cocoons are ready to be gathered.

Photo by] [*H. Main, F.E.S.*

AN OPEN-WORK COCOON.

The caterpillar of the little plutella-moth, when about to become a chrysalis, spins this net-like cocoon, through which the chrysalis may be plainly seen. Six times the actual size.

COCOON OF TUSSEH-SILKWORM.

The cocoon is spun up in a folded leaf or between two leaves, the caterpillar taking care first to spin a long stalk of silk which will attach the cocoon firmly to the branch should the leaf-stalk become detached. The dark-coloured silk is rather coarse and tough, but it makes a very durable fabric.

country silk was long a peculiar and staple commodity. It was not cultivated in France until the time of Henry IV., who, considering that mulberries grew in his kingdom as well as in Italy, resolved, in opposition to the opinion of Sully, to attempt introducing it, and fully succeeded."

But in classical times, long before the introduction of *the* silkworm, very fine silk was produced in the island of Cos, in the Ægean, probably from the cocoons of a large brown moth,[1] a native of South Europe and Western Asia. James I. of England had visions of a British silk industry when he encouraged the planting of mulberry trees in this country; but all attempts to breed silkworms on a large scale in these islands have ended in failure. It has been estimated that in the production of one pound of raw silk the silkworms consume thirty pounds of mulberry leaves.

Most persons have been in their youth amateur silk-farmers, and have reared this Insect right through from lead-coloured eggs and the smooth, white caterpillars with the caudal horn to the insignificant-looking moth, which has been so demoralized by thousands of years of domestication that it no longer has the power or the inclination to fly. There is no moth that has a less interesting life-history than this; and yet, because of this silk-producing power of its caterpillar, it outweighs in importance all other species of moths put together, according to the notions of civilized man. There are finer moths whose caterpillars produce silk of fine quality more abundantly, but they fail in the spinning quality of the thread. Of some of these great hopes have been entertained from time to time, but with the exception of certain wild Indian species which supply the tussa, taser, or tusseh silk and the eri silk, the results have been somewhat disappointing commercially. These big silkworms belong to a family different from that which includes *the* silkworm. They are more closely related to our emperor moth, already described; but a few words upon the chief silk-producing species will not be out of place here. We have seen that the upper part of the emperor's cocoon is so contrived by the untaught caterpillar that

[1] Pachypasa otus.

its exit when it becomes a moth will be easy, whilst entry on the part of any intruder will be difficult. At this upper part the cocoon is not closed in but tapers to a point formed by straight silken hairs converging. These may be pushed against from outside without yielding, but very slight pressure from within will serve to separate them and reveal the opening. At a little distance inside, this structure is repeated, so that the chrysalis reposes in safety behind two puzzle doors which oppose no obstruction to the moth.

In a North American species of silk-moth[1] this type of cocoon is improved upon. There are in fact two cocoons placed one within the other with a packing of loosely spun threads between the two walls, which keep the inner cocoon in place, as shown in the photograph of the cocoon in section. This arrangement must protect the contained chrysalis from great changes of temperature; but

Photo by] [*H. Bastin.*

THE ARRINDI SILK-MOTH.

Another silk-moth of India and the East, which is somewhat larger than the tussch-moth. Its yellowish-olive wings are banded with white and bear crescent-shaped white marks edged with yellow and black. The photograph shows the actual size.

though admirable for the chrysalis and the moth, it is not appreciated by those who would convert its filaments into woven tissues. The upper open end of the cocoon makes it a difficult matter to unwind the silk, and so it does not appear to have a high commercial value, though it is said to have been successfully woven into stockings. As the cocoon is three inches or more in length and nearly an inch and a half broad, one would expect that the extra quantity of silk would make up for the defect. In California, however, a smaller member of the same family is reared for the sake of its silk much as is the silkworm of the old world. The cecropia-moth, as may be supposed from the dimensions of its cocoon, is a large Insect. When the moth spreads its beautifully ornamented wings, the distance between the tips of the fore-wings is about six inches; and the caterpillar that spins the big cocoon is four inches long and nearly an inch in thickness. It is

[1] Platysamia cecropia.

gloriously coloured with a beautiful green shaded with blue, and from each of the rings or segments of its body there stand out five stout, fleshy spines of red, blue, and yellow, some of them knobbed and the knobs supporting sharp, black bristles. The outer envelope of the cocoon is so closely woven, with the interstices filled with liquid silk, that it is as tough and firm as vellum ; the inner lining is of similar consistency but thinner. An Indian species is described as having the cocoon of leather-like texture, and Colonel Sykes said it was cut into strips by the Mahrattas and used as thongs for lashing together the barrel and stock of their guns.

The tusseh silk-moth [1] is a fawn or brown-coloured moth, with a wing expanse of four or five inches, and a strongly marked eye-spot on each wing. The caterpillar is pale yellow-green, with metallic spots along the sides, and is about three inches in length. It feeds upon several kinds of trees in the forest regions of India, where the natives watch the caterpillars at large on the trees rather than properly domesticating them, collecting the cocoons when they are ready. These are large ovals of a dark-brown colour, about two and a quarter inches long, and suspended from a branch by a long silk stalk. As in the case of the mulberry silkworm the chrysalis has to be killed, and then the silk is reeled from the cocoon. It is woven into a fine enduring fabric, and its manufacture is an important Indian industry. The muga silk of Assam is the product of an allied species.[2] Arrindi silk is obtained from a near relation of the atlas-moth,[3] the largest known moth, with an expanse of wings varying from eight to eleven and three-quarter inches. The arrindi-moth [4] is a wild form, and what is believed to be a domesticated race [5] of it produces the eri silk of Assam. In this case the silk cannot be unwound from the cocoon, but has to be woven into threads as cotton is woven.

Photo by] [*H. Bastin.*

THE ARRINDI-SILKWORM.

This handsome caterpillar is coloured green, spotted with black, and bears fleshy spines. It feeds upon the castor-oil plant and the leaves of the ailanthus-tree. The spinning of its cocoon is shown on the page opposite.

Bee's-nest Beetles.

The nests of bees, wasps, and ants give shelter to numerous Insects other than the builders and their progeny. Some of these, as we have already shown, though long considered as enemies, are now known to be very useful friends. But the beetles to which we propose now to call attention have not yet had any advocate declaring that their character has been misunderstood in the past. So far as it goes, our present knowledge of their habits and life-history seems to prove that they are enemies to the industrious bees and wasps ; but we should not be at all surprised if some one discovered that their work was much more that of the

[1] Antheræa paphia. [2] A. assama. [3] Attacus atlas. [4] A. cynthia. [5] A. ricini.

Photo by H. Bolton.

Cocoon Building.

[illegible] the process by which the caterpillar secures the cocoon to the branch to ensure its safety when the leaf falls. Before making the cocoon proper, the caterpillar spins over all the leaf stalks, beginning at the branch, so that there is a slender tube of silk surrounding it. This is continued into the cocoon structure, which is supported by the rolled leaf. In the cocoon photograph [illegible] chrysalis [illegible] and the caterpillar hidden.

scavenger than of the murderer. Although these beetles have been reported as taken occasionally in this country, they are not considered to be natives; but on the Continent they are not uncommon. The one whose photograph we reproduce, and which appears also in the coloured plate, may, following its scientific name,[1] be called the bee-keeper. The perfect Insect is of rather slender form, half an inch in length, and narrower in front than behind. Its legs, head, and the fore-body in front of the wing-covers are of deep blue, which shines slightly beneath the coat of hairs. The wing-covers themselves are crossed by alternate bands of red and blue-black, of which there are three of each. The joints of the antennæ form a wedge-shaped club. The female beetle makes her way into the nests of wasps, solitary bees, and where the bee-master has not exercised proper care, into the bee-hive, where she lays her eggs. When these hatch the young grubs make their way into the honey-comb whence they attack and eat sickly bees, and breaking into the cells devour the bee-grubs and chrysalids. The eggs are laid between May and July, and hatch soon after, the grub performing its destructive work until early in the following year. After attaining full size as a grub, it appears to rest for a time before becoming a chrysalis, and specimens of another species[2] kept under observation have been known to extend this inactive, waiting period for nearly two years; but this may have been due to artificial conditions. We may assume that under normal conditions the chrysalis-skin is thrown off in May, and the perfect beetles seek the flowers where they find their mates.

Photo by] [*H. Bastin.*

THE FINISHED COCOON.

This particular cocoon was spun in captivity, where the caterpillar had no branch to which it could be attached; but, true to inherited habits of its kind, it constructed the silken covering for an imaginary leaf-stalk.

Now, from what has been said in previous articles on the subject of strongly contrasted bands or spots of red or yellow in conjunction with black or other dark colour, it will be evident that the colour-scheme of these beetles denotes inedibility, and this, no doubt, has reference to the risks they would otherwise run from bird attacks when exposed on flowers in the sunshine. But such warning colours are no protection against the stings of bees; and our artist has sought to show what probably happens when the newly mature beetles have left the security of their nests in the substance of the brood-combs, and are making their way out of the hive. They have been detected by some of the watchful workers, who are seeking with their poisoned stings to find a joint in the armour of the beetle.

[1] Trichodes apiarius. [2] T. alveolarius.

The second species we have named has been found chiefly in the nests of the mason-bee and other solitary bees. A third species[1] performs a useful service by destroying the Moroccan locust.

Spring-tails.

The simplest group of the true Insects are the spring-tails,[2] minute creatures with six legs but no wings. Having nothing to develop beyond what they begin life with, they undergo no transformation or metamorphosis. Although some of the species must be perfectly familiar to everybody who has done a little gardening, turned over woodland debris, or hunted on a rocky shore for larger objects of natural history, the actual nature and characters of the spring-tails and their nearest allies appear to be known only to a few specialists. In a greenhouse or garden-frame they often swarm, and if watched for a minute or two they will be seen to indulge in a considerable amount of leaping exercise, though they have no special long legs with thickened thighs as the grasshoppers have for this purpose. The jumping apparatus is of a kind that is special to this order of Insects, and reminds one strongly of the little wooden frogs that are such a delight in childhood. The mechanism of the toy and of the spring-tail Insect is essentially the same.

Bee-hive Beetle.

This prettily marked beetle, whose actual length is little more than half an inch, is shown on a larger scale. The hairy head and fore-body are blue-black, and the wing-covers are banded with the same colour alternating with bands of red.

The division of the body into three portions, usually so pronounced in adult Insects, is, as a rule, obscure in this group. In most cases there appears to the eye only one division into head and body. By analogy, of course, we know that the three pairs of legs are attached to the three segments of the fore-body or trunk, and in a few species this fact is made evident by the trunk being somewhat broader than the hind-body. The Insect is covered with scales or hairs—in most cases with scales—somewhat similar to those of butterflies' wings, exhibiting under the microscope very elaborate and beautiful markings, which have caused them to be used extensively for testing the powers of objective-glasses for that instrument.

The head bears a pair of antennæ or "feelers," and behind these are the eyes, if any. Some of the species are quite blind, and those that have eyes have simple ones similar to those seen between the large compound eyes of bees and other Insects. The mouth is not made prominent as in most Insects by projecting jaws or proboscis. In the spring-tails the mouth is formed more for sucking than for biting, and owing to the masticatory apparatus being entirely within the mouth, the latter is not at all obvious.

Just behind the third pair of legs, or to be more exact on the under side of the first segment of the hind-body, there is a little swelling which opens to permit

[1] Trichodes amnios. [2] Collembola.

the outward passage of a fleshy sucker which is moist and sticky, and enables the Insect to attach itself to any small object it is walking over. Almost at the extremity of the hind-body and extending up to or very near to the legs, there is a long forked process bent on the under surface of the body, and fastened by a sort of catch when not in use. When occasion requires this can be suddenly extended, with the result that the Insect is thrown into the air. The sticky sucker probably has its use in steadying the Insect when alighting from one of these leaps.

The spring-tails, though exceedingly plentiful on moist soil where there is decaying vegetation, are too small to have received more than passing attention from most Nature-students. In consequence, very little is known about them. Forty years ago, Sir John Lubbock (afterwards Lord Avebury) wrote a book upon them, in which he told all that was known about them at that date, and very little has been added to our knowledge of the group since. Beyond the expressive name spring-tail applied indiscriminately to all the species, there are only Latin names to distinguish them, which—helpful as these are to the scientific student—always serve to hinder the layman in acquiring knowledge. An attempt may be made to indicate a few of them by invented names that will agree sufficiently with the Latin ones.

Photo by] [*W. West.*

SCALE OF A SPRING-TAIL.

The spring-tails are clothed with minute scales, which are in some cases long and hair-like. They were long in use by microscopists as tests of the definition of their high power lenses. The photograph shows one enlarged to six hundred times the actual size.

The brown smynthurus is a common species and the largest of its genus, though this is not saying much for size, seeing that it measures less than a tenth of an inch. It is common under loose bark on old stumps, where it appears to feed upon fungus threads. It often has numbers of a minute mite clinging to its under side. The green smynthurus, another common species, is only one-twelfth of an inch, and has green eyes surrounded by black, and long antennæ. The yellow smynthurus also has its eyes surrounded by black, and the tips of its antennæ are coloured violet.

The girdled orchesella is about a quarter of an inch long, the body mottled with yellow and black in variable proportions, and a girdle of black across the hind-body. It has no scales, but is distinctly hairy. It is found among moss and decaying leaves. An allied species, the hairy orchesella, is very similar in its mottling of yellow and black, but is without the black girdle.

The bent-necked lepidocyrtus, viewed from the side, has a very quaint appearance. The fore-part of the trunk is elevated and projecting, whilst the head is depressed. Its scales are metallic-looking and reflect many brilliant colours.

The ringed degeeria is another scaleless species. The ground colour is greenish-yellow, with brown transverse markings which give the ringed appearance.

Photos by] [H. H. S.

SPRING-TAILS.

Several types of structure of this group of primitive Insects. They are remarkable for the fact that they undergo no transformations and develop no wings. Many of them are provided with a forked process on the under side, by whose sudden extension they are thrown into the air. Some have a peculiar tube, also on the under surface, whose function has not yet been explained satisfactorily. They may be said to be Insects that have not advanced beyond the larval stage.

The aquatic podura is the little blue-black creature that may often be found clustering on the surface of stagnant pools and puddles. A somewhat similar Insect, so far as shape is concerned, but white in colour and without a spring, is the dunghill lipura. Its white colour is due to the fact that it lives beneath the soil, where it feeds upon fleshy roots. It is about a tenth of an inch in length ; and a very common species. An allied species, the seaside lipura, is lead-coloured, and found upon seaweed and in rock crevices along the seashore between high- and low-water marks. When the tide is in its hiding places are, of course, under water, but as a rule the Insect appears to keep its body surrounded with air, which enables it to breathe. Another species, white and eyeless, is found in caves.

By some authors the spring-tails are held to be a connecting-link between the Insects and the class represented by the centipedes and millipedes.

Photo by] [*E. Step, F.L.S.*

SPRING-TAIL LEAPING.

The lead-coloured tomocerus is represented as in the act of leaping. The spring, it will be seen, is now fully extended, but before the Insect has reached the ground again it will be folded forward with the fork between the legs. The photograph is thirteen times the Insect's actual size.

Earth-Measurers.

This name in a Greek form[1] has been given to a large family of moths with long and slender bodies and broad but fragile wings. Properly speaking the name belongs to the caterpillars of these moths, for it was their peculiar form and manner of progression that suggested they were engaged in measuring the distance travelled. This peculiarity is due to the situation of their clasping temporary feet. They have the usual six horny permanent legs placed on the first segments of the body behind the head ; but the soft temporary feet, that do not appear in the winged stage, instead of supporting the middle of the body as in other caterpillars, are reduced to a single pair and placed far back, just in front of the tail claspers. In most other caterpillars there are four pairs of these in addition to the tail claspers, and progression is effected by increasing and reducing the distance between these middle feet. In geometer-caterpillars the true feet are at the front end and the clasping feet at the other end, so that in order to go forward the caterpillar has to take hold with its fore-feet and, curving its body into a great loop in the middle, bring its hind-feet close up to the others. Taking hold with the claspers the loop is now straightened out and the body extended to its full length, where the fore-legs again take hold. In this fashion at every step it takes it covers an extent of surface equal to its own length, and does it with an air of deliberation that is quite the opposite of the hurried movements performed by many other caterpillars more liberally furnished with clasping feet.

Relying as they do upon these claspers for their principal support, the geometer-

[1] Geometræ.

caterpillars have learned to balance themselves as it were upon them, to hold the body extended and rigid for hours, so that they look like twigs or branches of their food-plant. In this position, however, they are mostly helped by a thread from the mouth to the stem. Most of them are coloured some shade of green or brown that harmonizes with the stem they are holding to, and in many cases the resemblance is greatly helped by warts upon the skin which bear a wonderful likeness to the leaf-buds upon the real shoots. Although many of these caterpillars feed only in the evening or at night, they do not hide themselves by day as other night-feeders do, but remain extended as twigs, etc., quite openly. Some of the best known, because largest, of these twig-like caterpillars are those of the swallow-tailed moth,[1] the brimstone-moth,[2] the oak beauty,[3] brindled beauty,[4] and peppered-moth,[5] of which we give some photographic examples.

Photo by [*W. West.*

AN AMBER SPRING-TAIL.

A spring-tail, apparently related to the modern species shown below, found in amber, and magnified twenty-eight times.

Some of the smaller species are not large enough to carry out this twig mimicry, and they elude observation by some other resemblances, the brimstone looking like a piece torn out of a leaf but still clinging to it. Another looks like an empty snail-shell[6]—if it looked like a full one it would be as likely to be eaten as though it resembled a caterpillar! The caterpillar of the large emerald[7] feeds on birch and hazel, and so clings to a twig or leaf-stalk that it has the appearance of a catkin. Its colour is brown marked with green, and its segments appear to overlap, and resemble the overlapping scales of the catkin. Its form, which is short and thick, helps the resemblance. The young caterpillar of the early thorn-moth[8] twists itself on a leaf in such a remarkable manner that it looks like the excrement of a snail. The caterpillar of the Brussels-lace moth[9] feeds upon lichens, and its colours and markings are such that it is exceedingly difficult to detect it among the similarly coloured food-plant. The two caterpillars represented slightly in excess of the natural size on page 319, are respectively of the brindled beauty moth and the peppered moth, two of our largest native representatives of the group.

Photo by [*W. West.*

LONG-HORNED TOMOCERUS

With the spring partly extended. Between the second and third pairs of legs will be seen the tube whose function is not understood. The Insect is shown on a scale of nine times the actual size.

[1] Ourapteryx sambucaria. [2] Rumia cratægata. [3] Amphidasys strataria. [4] Lycia hirtaria [5] Pachys betularia. [6] Aspilates gilvaria. [7] Geometra papilionaria. [8] Selenia illunaria. [9] Cleora lichenaria.

A Carpenter-Bee's Lodgers.

Some years ago Dr. R. C. L. Perkins, who has added greatly to our knowledge of tropical Insects, called attention to a remarkable structure in certain large species of carpenter-bees from the Indo-Malay region and South Africa. These carpenter-bees belong to a different genus[1] from that to which the European carpenter[2] belongs. In our article upon the carpenter-bees we gave a portrait of one of these koptorthosomas—the broad-footed carpenter (see page 40). Now, although on a superficial view the hind-body appears to be attached to the fore-body by its entire width, this is not so in reality, the connection being restricted to a short and narrow waist at the lower side. Above this waist the fore- and hind-bodies are separated, though there is only a slight space between them. Down the face of this part of the hind-body in the females of certain species there is an opening which leads to a cavity in the first segment of the hind-body, and the entrance to it is protected by a fringe of stiff hairs. In this chamber dwell a number of mites of a particular species.[3]

Photo by] [*H. Bastin.*

CATERPILLAR OF BRUSSELS-LACE MOTH.

This caterpillar is one of the earth-measurers or geometers, and feeds upon lichens. It will be seen that its type of coloration makes it almost identical in appearance with the lichen-clad branch.

Now it is a well-known fact that our common humble-bees are more or less infested with mites, and it is the prevailing idea that these creatures are parasites. Humble-bees, like other Insects, die; and if one is found in a dying condition with the mites much in evidence as—like the proverbial rats and the sinking ship—they are preparing to seek other quarters, it is assumed that they have killed the poor bee. It is but natural, therefore, that on the discovery of this mite-chamber in the females of the koptorthosomas, it should again be supposed that the mites were parasites. It was contended that being subject to the annoyance of having these parasites, it would be to the advantage of the bee to have them confined to a hidden part of her body where they would be within easy reach of the only soft portion of the bee's exterior—the connection between fore- and hind-body. One can understand a special adaptation of structure to suit the convenience of a

[1] Koptorthosoma. [2] Xylocopa violacea. [3] Greenia perkinsi.

Photos by *E. Step, F.L.S.*

LOOPER OR GEOMETER-CATERPILLARS.

These photographs show clearly the characteristic forms of the earth-measurers. The elongated, cylindrical body is without the temporary legs in the middle of its length, such as are found in the case of most other caterpillars. There is one pair of these pro-legs a little in advance of the hind claspers. The fact that the caterpillar can only take hold at its extremities causes its looping movement.

friendly companion, and there are many examples of such structures, as the present writer has pointed out with some detail in his book on *Messmates*; but it would be much more extraordinary if such provision were made for the comfort of an enemy who is supposed to bring about the untimely death of its benefactor.

The habits of these bees make it a difficult matter to determine precisely what are the relations subsisting between the bee and the mite, but we believe that fuller investigation will show that the mites are scavengers, feeding upon the debris, and possibly germs, that cling to the long hairs with which both carpenter-bees and humble-bees are clothed. It is worthy of note in this connection that the males of both kinds of bees do not perform any of the mining in wood or earth that is calculated to bring about the soiling of this hairy coat. They spend their short existence in the open air and sunshine, and are not troubled by mites; but if the mites were parasites the male bees should be as acceptable food-providers as their mates.

Photo by] [*H. Bastin.*

A Pocket for Mites.

A large species of carpenter-bee which has a special chamber in its hind-body for the accommodation of a swarm of mites, variously estimated as parasites and scavengers. The arrow points to the entrance of the chamber.

Certain butterflies, notably the "blues," frequently have one or more rather large red mites upon them; but it seems probable that in this case they are merely using the butterflies as stage coaches to convey them from plant to plant. On page 138 of this work there is a photograph of the big West Indian cockroach known as the Drummer. In the middle of the back of the specimen photographed there is a light patch, which cannot be resolved into anything definite in the reproduction, but when we examined the Insect with a lens, the patch proved to consist of a large number of mites, which probably kept clean the Drummer's back where the over-lapping wings prevented brushing with the hind-legs. Many beetles have mites constantly upon their under sides in considerable numbers; but the beetles so affected are always such as feed upon filth or burrow in the earth, and it appears most likely that their office is to keep clean those portions of the beetle which the inflexible armour with which it is encased will not permit the Insect to get at with its legs. Among these beetles may be mentioned the dor, or watchman-beetle, that manipulates dung and burrows beneath it, the species of aphodius, that have similar habits, and the burying beetles, that come in contact with filth of another kind. It is the view of the

NEST OF HONEY-WASP ATTACKED BY JAGUAR

The nests of this wasp are often two feet in depth, with twenty-five or more tiers of comb, enclosed in walls of substance like *papier-mâché*, bristling with hard spines. Having regard for the many thousands of wasps such a would contain, few animals would care to interfere with it; but the Jaguar is said to tear it to pieces in order that may feast upon the wasp-grubs in the comb

present writer, that if these Insect-infesting mites were the parasites they are thought to be, they would be found also upon soft-bodied Insects, such as caterpillars and other grubs, where they would certainly be nearer to the juices which they are supposed to suck. It is quite clear that further and closer observation upon both Insects and mites is needed before anything positive can be stated as to their relations.

The remarkable series of photographs illustrating this article makes the position and nature of this mite-chamber very clear. The portrait of the bee shows, by means of the white arrow, the line of separation between the fore-body and hind-body. In the longitudinal section of the hind-body on page 322, the mite chamber is marked B, and the black arrow points to where the fore-body joins on. Two other photographs show the broad end of the hind-body, first with a needle inserted in the entrance to the mite-chamber, and second with a mite issuing from it.

Photos by] [*H. Bastin.*

CARPENTER-BEE'S MITE-CHAMBER.

Views of the bee's hind-body from the front. In the upper photograph a needle is inserted in the opening of the chamber. In the lower photograph one of the mites [illegible] connection with the fore-body, broken off for the purpose of photographing.

Grasshoppers.

The grasshoppers form two large families—the short-horns[1] and the long-horns.[2] Unlike many of the family distinctions of Insects, this is a point of difference that may be memorized easily by those who have no taste for scientific phraseology. This is not a mere arbitrary division, for the difference in the length of the antennæ connotes other differences in structure, but it is sufficient to remember this one item. Such simple distinctions, as a rule, have a way of being puzzling to the novice who would not know where to draw the line between long and short. But here

[1] Acridiidæ. [2] Locustidæ.

there is not such difficulty, for the antennæ of the short-horns *never have more than thirty joints*; whilst those of the long-horns never have nearly so few as thirty joints, being mostly as long as, or longer than, the body. The active little grasshoppers of our fields are short-horns; so are the locusts that migrate in vast armies and inflict agricultural ruin wherever they settle. But with a strange perversity, the high priests of entomology have distinguished the long-horn family by a name that appears to indicate that the all-devouring locusts are included in it—which is quite the opposite of the fact. The *Cambridge Natural History* makes the matter worse by speaking of "the Insects called locusts in popular language," which seems to imply that the users of "popular language" have misappropriated a scientific name, whereas it is science that has misapplied a folk-name that has been in use for ages. Of these locusts we shall have occasion to speak in a separate article: it is sufficient now to make it clear that they are simply large grasshoppers of the short-horned kind that have gregarious habits and the migratory instinct.

Photo by] [*H. Bastin.*

CARPENTER-BEE'S HIND-BODY.

A longitudinal section of the hind-body to show the situation of the mite-chamber. A is the part containing the internal organs. B is the special compartment for the mites, and the needle is thrust through the entrance. The arrow marks the point of attachment to the fore-body.

Grasshoppers belong to the great order[1] of Insect life that includes the cockroaches, earwigs, stick-Insects, and crickets. These are all characterized by a gradual development from the egg to the fully-winged condition without any resting period: they are active throughout life—the wings growing gradually as the Insects increase in size. These wings are four in number and constitute two distinct pairs. The upper pair (or wing-covers) are of a parchment character; the lower ones are finer and more delicate. The mouth-parts are formed for biting. The grasshoppers share these characters with all the other families of the order. There is one other they have in common with the long-horns and the crickets only: that is, the great development of the hind pair of legs, which are very long, and the broad thigh is broadest near its base. It is to this development, and the power of the muscles attached to these limbs, that the leaping ability for which they are famed is due.

Grasshoppers leave the egg in the same form practically as that of their mature parents, the only difference being the absence of wings. The first indication of

[1] Orthoptera.

Photos by] [*E. Step, F.L.S.*

AN AFRICAN GRASSHOPPER.

In these photographs the same species is shown under different conditions—flying and walking. At rest the voluminous hind-wings are folded fan-fashion, as indicated by the straightness of the radiating "nervures," and covered by the less delicate fore-wings. [illegible] which is portrayed of the natura lsize, is olive-tinted, and a native of the Transvaal and neighbouring parts of Africa.

these comes after the grasshopper has thrown off its second skin. After the third moult these are more evident, but until the final change of skin they are mere buds, the incipient wings being short and folded within a firm envelope. After the last moult they are free from their wrappings, and rapidly expand to their full size, afterwards being folded along the back and sides. Such a course of development is known as partial or incomplete metamorphosis. It is only possible to those Insects in which there is no change, but only a development, of their mouth-parts and their digestive system. This enables them to continue the process of nutrition whilst their wings are developing. The first appearance of the wing-buds marks the beginning of the pupa stage, but as we cannot fitly use the term pupa or chrysalis where the Insect is active, it is known as a nymph until it has got fully developed, free wings. There are some species in which the wings are never developed.

The grasshoppers have both compound and simple eyes, but in the long-horns the latter are often imperfectly developed, and two of the three may be wanting.

Photo by] [*E. Step, F.L.S.*

TWO-COLOURED GRASSHOPPER.

One of the most familiar of the "common grasshoppers," abounding in meadows, on heaths, etc. Although not good runners, owing to the impediment of their long hind-legs, they get along with rapidity by making long leaps and spreading their wings. Their colour—a mixture of green and brown—is such as makes them quite inconspicuous. Nearly twice the actual size.

As the grasshoppers are musical Insects it is not surprising that they should have ears to enable them to appreciate the notes of their fellows. Here, again, there is considerable difference between the short-horns and the long-horns, for whereas the former carry their ears on the back at the base of the hind-body, the latter have theirs in the shank of the front pair of legs, a little below the knee. Other Insects do not possess these organs; and, seeing that only the males produce sounds it has been by some thought strange that ears have not been restricted to the females. There is no doubt, however, that it is important for the maintenance of rivalry between males that these should hear the enchanting strains their rivals are producing. A singular fact is this: that species which to the human ear appear incapable of sound-production are provided with ears. This is thought to indicate that these apparently silent species do produce sounds in reality, but that they are too fine to be appreciated by our ears. The short-horns produce their music by scraping the big thigh over the wing-cover.

The eggs of the grasshoppers are laid in masses in the ground, the female long-horns having a cutlass-shaped egg-placer for this purpose. The short-horns

however, are without such aid, and have to bore a hole by thrusting the hind-body well into the soil. A fluid is poured over the eggs, and this, hardening, unites them and forms a protection. It does not, however, ward off all enemies. The blister-beetle hunts for these egg-masses and deposits her own eggs upon them, and on hatching the beetle-grubs batten upon the grasshoppers' eggs. A similar course is followed by certain two-winged flies; and the nutritive value of the eggs is appreciated by some birds.

All the short-horns are strict vegetarians, but some of the long-horns add other Insects to their vegetable fare. Whilst much attention has been paid to the ravages of locusts, and expensive measures have been adopted to combat them, comparatively little notice has been taken of the effect upon grasslands of the small grasshoppers. If one sits quietly in meadow or pasture for a short time and observes the enormous number of these Insects that are clinging to the grass-stems and eating the leaves, he must come to the conclusion that the quantity of grass consumed throughout the summer must make a considerable difference to the tonnage of hay yielded by the meadow, and to the number of animals that can be fed in the pasture. We are too apt, perhaps, to regard the matter from the æsthetic point of view, and to think of the grasshopper's acrobatic feats and its cheerful chirrup as important items in the amenities of the country. So, indeed, they are; but it is surprising that the economic agriculturists have not given us statistics of the loss the grasshopper causes, and devised some means for reducing its numbers.

Photo by] [*W. J. Lucas, F.E.S.*

SHORT-HORNED GREEN GRASSHOPPER.

A grasshopper of the cultivated and woody places; the largest [illegible] Short-horns. The individual photographed [illegible] the prefix "green" as the female. Three times the actual size.

Having dealt with the long-horns already (see page 150), let us take a few typical examples from the short-horns to show their variety. The common grasshoppers of our meadows[1] are well known, for what reader in his childhood has not engaged in the rather elusive delight of hunting them? They agree pretty generally in form with the large migratory locusts. There are some remarkable departures from this type. One of these is the long-nose,[2]

[1] Stenobothrus and Gomphocerus. [2] Tryxalis nasuta.

a native of Europe, though it does not occur in Britain. It has a long, slender body, two and a half inches in length, and leaping legs more than three inches long; but instead of the stout, squarish head of the typical grasshoppers, in this species the first division of the Insect is prolonged considerably in front of the mouth in a tapering form and an upward direction, as will be seen in the photographs on page 328. The eyes and antennæ are borne near the extremity of this snout-like extension. But in a South American species[1] this tendency to elongation is carried to such an extreme that the grasshopper might easily be mistaken for one of the stick-Insects. It is six inches long and only about a fifth of an inch broad. It sits among withered grass, which it exactly resembles.

Photo by] [*E. Step, F.L.S.*

LUBBER LOCUST.

Some of the large grasshoppers of the southern parts of North America are known as lubber or clumsy locusts from an absence of grace in their movements. They are heavily built, and whilst their antennæ are rather long for short-horns, their wings and wing-covers are not long enough to cover the hind-body. Natural size.

Then in some species of the little grouse locusts—of which we can boast two native representatives, though they are not quite half an inch long—we meet with remarkable disguises. The British species[2] are quite normal grasshoppers at first sight, but what we take for the wing-covers extended over the hind-body is a remarkable outgrowth of the fore-part of the fore-body and known as a pronotum. This species is shown on page 329. In an African species[3] it forms a high-arched ridge extending right over the Insect from head to tail, and gives this grasshopper an exact likeness to a membracid. Another species from Ceylon[4] has the pronotum developed into a hood which covers the head, shoulders, and middle of the back, and extends as a high toothed peak over and in front of the head.

Many of the grasshoppers of other countries are wingless and run into remarkable forms, some of them being very spiny. One such, the toad grasshopper,[5] lives among stones in South Africa, and is so "got up" in colour and surface ornamentation that it may be passed as a stone more easily than recognized as a grasshopper. Another species, from the karoo,[6] resembles a clod of earth, and is so sedentary in its habits that it has lost the power of leaping by disuse of the leaping legs, which it carries pressed along its back, and employs them only in the production of sounds. In this species both sexes produce considerable noise, which appears to serve them as a protection by scaring possible enemies. The apparatus for sound production in this species is not confined to the hind-thigh and the undeveloped wing-cover, but there are also swollen portions of the lower part of the side

[1] Cephalocœma lineata. [2] Tetrix bipunctatus. [3] Xerophyllum. [4] Cladonotus.
[5] Trachypetra bufo. [6] Methone anderssoni.

part of which exhibits several strong folds and another part is finely grooved. The finer ridges of the grooved portion are rubbed by the inner face of the thigh moving over them, and the strong folds are struck by peg-like warts near the base of the same limb. It is very probable that it was a grasshopper of this type, but with wings, which was encountered in Africa by Mr. Gregory. In his book, *The Great Rift Valley*, he says: "Strolling one evening out of the camp at Kurawa, I was startled by a hissing noise like that of a snake coming from a clump of grass. As I was wearing knickerbockers and tennis-shoes, I sprang back and pelted the grass with handfuls of sand. As this did not drive out the supposed snake, I cautiously approached, peering into the clump. I could just detect a small green head among the stalks, and behind this appeared, whenever the noise was repeated, an expansion like the hood of a cobra. I tried to kill the animal by a few sharp blows with my stick behind the head, and one of these knocked it over. I then found that I had been frightened by a big grasshopper, which, by puffing out its wings, assumed a resemblance to the shape of the head of a hooded snake; while its noise was a good imitation of the dull jerky hiss of some species of snakes."

Photo by] [*P. J. Barraud, F.E.S.*

CHORTHIPPUS NYMPH.

A young female of this species enlarged to six times its actual size. The growing wings at present cover only about a third of the hind-body; at full development they will cover it.

Hover-Flies.

Among the Insects that are entitled to the direct encouragement (not mere toleration) of the gardener are the yellow-banded little flies that hang in air, sustained in one place by movements of the wings so rapid that the form of

Photo by] [*H. Bastin.*

SPOTTED GRASSHOPPER.

A female example of this small native heath grasshopper. It is very variable in its colouring, according to the prevailing tints of its surroundings. It will be noticed that the antennæ are clubbed, but this feature is more evident in the males. It is common throughout northern and central Europe.

these organs is entirely lost, and the head and body appear to be surrounded by a delicate haze or a halo. They change from place to place with a darting movement and immediately recommence the wonderful hovering which has gained them their common name. In watching the marvellous manner in which this fly can maintain its position as though it were suspended by an invisible wire, one is struck by its resemblance to the aerial performances of the humming-bird and the humming-bird hawk-moth. But the object in view is very different: the bird and the moth are intent upon the extraction of nectar from flowers, but the hover-fly[1] is prospecting for a suitable place in which to deposit her eggs. The point she is anxious to decide is whether the plant whose leaves and stems she is surveying is affected by green-fly. If so, then it is a suitable plant to receive her eggs. Herein lies the hover-fly's claim to the consideration of the gardener. The green-fly is probably his greatest horror. Its smallness, its power of rapid multiplication without cessation throughout the season, and the mysterious way in which a plant that was apparently quite clean a few days ago is swarming with the pest to-day, make it more difficult to cope with than most of the garden scourges. But a batch of eggs laid by the hover-fly or the lady-bird will result in the thorough cleaning of the plant that has received the attentions of these beneficent Insects. At this date most gardeners have accepted the lady-bird as a friend, but the ministrations of the hover-fly's grub are not so well known to them. The appearance of the fly is to most of them too suggestive of the wasp, and the wasp is undeservedly on their black list. Still, in the case of the hover-fly grub, it is quite easy to afford the

Long-Nose Grasshopper.

This species, which is found in Europe and other parts of the world, differs from the usual grasshopper type in the head tapering to a point considerably in advance of the mouth, and in the eyes and antennæ being borne by the extremity. The antennæ are of peculiar shape and the eyes are modified in shape to suit the situation.

[1] Syrphus.

Photo by] [*H. Bastin.*

GROUSE LOCUST.

Apparently a normally formed grasshopper, it will be found upon close examination that what appears to be the wing-covers is really an outgrowth from the fore-body forming a hard shield that extends back over the wing-covers. The purpose of this shield, so similar to what is found in the Membracids, has not been satisfactorily explained. The actual length of the body is about half an inch.

unbelieving gardener a demonstration of its practical assistance, which may go a good way towards convincing him.

The soft, maggot-like grubs are broad behind and taper away to a fine point forward when the creature is hunting for its prey. It is pale green in colour, with a white line down the middle of the back. It is blind and it has no feet; but like other maggots it contrives to cling by means of slight roughness of the skin, and its lower surface can be so flattened out as to bring it into close contact with the plant. Flattening out its hinder part, it takes hold in this elementary way, and extends the remainder of its body as far as possible. Its mouth is provided with a triple spine which can be hooked into the leaf to secure its hold. Then it releases its hinder part and draws this forwards towards the mouth, takes hold again and extends the fore-part as before, proceeding much after the manner of a geometer-caterpillar. This method of progression, and its extremely soft and ductile body, are of great use to it in the search for its victims. Having cleared the green-fly off one leaf, it marches up the stem to the next leaf, where, taking hold with its hind-quarters, it elevates its body in the air, and sways it about from side to side. It cannot see, but it appears to have the sense of smell. There is a green-fly in the middle of the leaf, and the hover-fly grub correctly locates it. No sooner does he get within reach than his body is stretched to the full extent, and the green-fly is delicately impaled, then held triumphantly in the air as high as the grub can elevate it. It is rather like a drinker tilting back his head in order that the contents of a bottle may run out and down his throat by simple gravitation. Possibly the grub is helped in the same way, for in about a minute the green-fly leather-bottle has been emptied of its fluid contents, and the useless envelope is dropped. The green-fly lives by suction of the fluids of plants, and has no hard parts. The grub of the hover-fly has only to tap the green-fly, and secures in

Photo by] [*E. Step, F.L.S.*

WHITE-LINED HOVER-FLY.

An example of these familiar and useful flies on a scale of four times the natural size. The hind-body is marked by connected bands of black on a yellow ground, as in all the hover-flies; but this species has also two light lines on the fore-body behind the big compound eyes.

a minute what may have taken the green-fly hours to pump up through its hair-fine sucking apparatus. All day, and night, too, for about ten days the hover-fly grub pursues this course, and destroys many hundreds of green-fly. Then it feels it has reached the end of its labours.

It now attaches itself to the stem of the plant, contracts its length, and the skin becomes taut and polished. In shape it becomes much like a grape-stone. Within, the grub has turned to a chrysalis, from which it emerges about ten days later as a black and yellow banded fly. These are bright little creatures, and they may be seen frequently with their wings at rest upon flowers, when they are engaged in feeding upon pollen and nectar. When so engaged, their characteristic markings and the very distinct arrangement of the wing-nervures may be closely examined by those who have no desire to capture them, but to study the living Insects. For this purpose no flowers offer a better opportunity than those of the Michaelmas-daisies in gardens, which swarm with various species of hover-flies. Most of them bear either bands or spots of yellow on a black ground, and those that differ from this style of colouring may be detected by the wing-neuration. What this is may be learned much better from a glance at the photograph of the pear-tree hover-fly[1] on this page than from any detailed description.

Photo by] [*E. Step, F.L.S.*

PEAR-TREE HOVER-FLY.

A common species enlarged four times. It has the yellow and black banding of the hind-body common to all the species. Another feature shared by them all is well exemplified in this photograph—the peculiar pattern formed by the nerves of the wings. The hind-body, too, when viewed from the side will be found to be excessively thin.

A singular fact about these flies is that the mouth is furnished with cutting lancets, as though they were blood-sucking flies requiring instruments for cutting the skin of the higher animals; but we believe they have never been known to draw blood. Such a type of mouth is not the best fitted either for sucking up nectar or for eating pollen. It is probable that some important habit in which the lancets are brought into use awaits the discovery of keener observers than have yet applied themselves to its study.

The eggs are laid singly, always in the neighbourhood of green-fly. If a plant is badly infested with these pests, many eggs may be laid upon it, but they will be distributed over all the affected leaves, the stem, and the flowers, provided the green-fly are on these parts. An estimate of the work accomplished may be formed by a sight of the empty green-fly skins still adhering to the plant, but many of them fall to the ground when the hover-fly grub casts them away.

We have many species of hover-fly, but though they may differ in detail, what we have described applies in general to them all.

[1] Catabomba pyrastri.

By T. Carreras.

LIFE-HISTORY OF THE HOVER-FLY.

The fly in the foreground is laying her eggs where she knows the green-fly to be abundant. Above are several full-grown grubs, actively engaged in destroying these garden pests. The mouth of the grub is furnished with hooks, which hold the green-fly whilst it is being sucked dry. Later, each grub will contract, as shown on the twig to the left, and will change to a chrysalis within the grub-skin. The flies on the wing show the thinness of the broad hind-body. All the figures are about four times the actual size.

Garden White Butterflies.

The two of our native butterflies that are best known to the community are the large [1] and the small [2] garden whites. Yet they are not the commonest of our species, for in point of numbers the meadow brown [3] and the small heath [4] far exceed them. But these are dull coloured and keep to the open country, whilst the two whites named are urban as well as rural, and their white and black coloration renders them exceedingly conspicuous. They might almost be described as domestic Insects, for they are far more abundant in gardens and allotments than in the fields, except where these happen to be cropped with cabbages or plants of the same family. As suggested in the article on the brimstone-butterfly, there is every reason for supposing that these butterflies owe their plentifulness to man the cultivator. He produces their food in abundance, and has taken pains, by selection and cultivation, to make it more tender and luxuriant, and the Insects have taken full advantage of these conditions, and have so thriven on his industry that there are times when the voracity of their teeming caterpillars threatens to extinguish that industry by making it non-productive.

Photo by] [*H. Main, F.E.S.*

THE HOVER-FLY'S GRUB.

The grub of the hover-fly may be distinguished at once by its shape, the body tapering from the broad hinder part to the headless front. It has no legs, and locomotion is effected by the alternate contraction and extension of the body, hold being taken by the two extremities.

With many persons there is a belief that the large and small whites are merely younger and older individuals of the same species, but if they would watch their development they would become easily satisfied that this is not so. As in all other Insects, the full size of the butterfly is reached soon after it has escaped from the chrysalis and before it has taken its first flight. The eggs of the two are very similar, but the caterpillars are quite different, and so are the chrysalids, though, of course, there is a family likeness. Let us glance at these in turn and point out wherein the differences lie.

If one walks down to the cabbage patch and notes that some of the big leaves have been reduced to skeletons, only the thicker and tougher ribs having been left, one may be tolerably certain that the caterpillars of the large white have done this

[1] Pieris brassicæ. [2] P. rapæ. [3] Epinephele ianira. [4] Cœnonympha pamphilus.

mischief. It is probably too late to find any of them on what remains of that leaf, but on a neighbouring one they may be found. Up to a certain point in its development the caterpillar of the large white is gregarious, and this is due to two facts. The female butterfly lays her ninepin-shaped yellow eggs in a batch on the cabbage-leaf, all standing upright. The batch may be as few as six eggs or there may be more than a hundred, and they are laid at the rate of three or four per minute. In from seven to ten days they hatch, and all the young caterpillars, having eaten their empty egg-shells, crowd together and attack the cabbage-leaf in unison. The fact that the eggs are laid in batches is one reason why the young caterpillars keep together, as the cabbage-leaf is large enough to feed them all for a time. But the chief reason is that the caterpillars are uneatable, and their colours indicating that, it is important by associating to impress this fact speedily upon birds that might injure without eating them. The same tactics of rendering themselves as conspicuous as possible in this way is adopted by sawfly-caterpillars. The ground-colour of the caterpillar is green, but the more conspicuous features are five yellow lines running lengthwise, one in the middle of the back and two on each side of it, with dots and blotches of black between them. In addition they have a coat of short, whitish hairs, and they give off an odour that is very unpleasant from a single caterpillar, but when scores of them combine the smell is intolerable. Until they have shed their third skin they continue in company; then they separate and each goes wandering off to find a leaf for himself.

Photo by] [*H. Main, F.E.S.*

LARGE GARDEN WHITE BUTTERFLY.

To most persons the large and the small garden whites present themselves as young and older individuals of the same species. They are [illegible] quite distinct in spite of the superficial resemblance between the two [illegible] insects. The caterpillars are quite unlike. This photograph [illegible]

When full-fed they migrate to the nearest wall, fence, or post upon which to settle for the chrysalis stage of existence. Sometimes they have to go far for the necessary accommodation, and often they may be seen on door and

Photo by] [*R. Han*

THE SMALL GARDEN WHITE BUTTERFLY.

The most familiar and abundant of our native butterflies, distinguished from the foregoing species by its smaller size and by differences in the [illegible] and colours of the caterpillars. The butterfly is shown of the natural size, in the resting position, with wings closed over the back.

window frames, usually with the head upwards, but sometimes horizontally. They spin a little patch of silk in which to hook the tail of the chrysalis, and a loop of the same material to keep the fore-part of the body steady. In this position they throw off the last caterpillar skin and become keeled and angled chrysalids of a greenish-white or whitish-grey colour, liberally dotted with black and streaked with yellow.

Photo by] [*Hugh Main, F.E.S.*

A Butterfly's Eggs.

This cluster of eggs of the large white butterfly, deposited upon a cabbage-leaf, shows the eggs enlarged to twenty times the natural size. This is the first stage in the cycle of butterfly development. From each of these emerges one of the tiny caterpillars that are shown on the page opposite.

At this point we ought to say that there are two broods of the Insect in each year. We will suppose that the Insects we have been describing came from eggs deposited in May. The chrysalis stage is reached at the end of June. In July the butterflies will be laying fresh batches of eggs, and these will produce chrysalids by September. These chrysalids will remain as such until the following spring.

Fortunately for the cottager and the market gardener many of the caterpillars never reach the chrysalis stage, and many chrysalids fail to produce butterflies. The caterpillars are stung by a minute ichneumon-wasp, which lays numerous eggs in its body, for such creatures take no account of the warning colours or objectionable smells that keep off larger enemies. The ichneumon-grubs feed upon the interior parts of the caterpillar, and when it is about to become a chrysalis they make their way out through the skin, and spin minute cocoons for their own pupation. The caterpillar dies exhausted. But if the caterpillar has evaded this deadly enemy and become a chrysalis, it may be immediately set upon by a much smaller member of the same order of four-winged stinging Insects, who may load it with more than a hundred eggs, and these hatching consume the whole of the material that should have gone to the evolution of the butterfly. The

Photos by] [illegible]

THE LIFE-HISTORY OF THE LARGE WHITE BUTTERFLY.

In these photographs and the one opposite the whole of the transformations of a butterfly are shown, the newly hatched caterpillars feeding upon a nasturtium-leaf, and one of these caterpillars when it has finished its growth and has spun a silken pad, to which as a chrysalis it may cling. The chrysalis is also shown, and the newly emerged butterfly waiting for its wings to expand fully and harden. All the figures are enlarged.

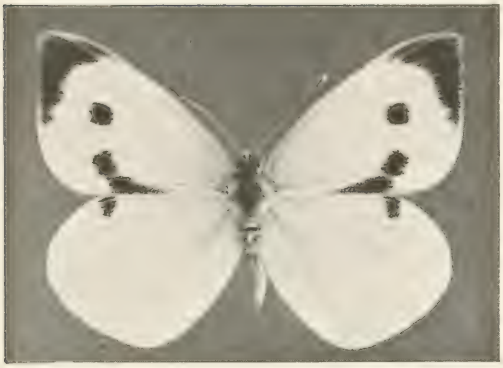


Photo by] [*H. Main, F.E.S.*

LARGE GARDEN WHITE BUTTERFLY.

A view from above to show the markings of the female, and the full spread of the expanded wings. These measure from two and a half to two and three-quarter inches from tip to tip of the fore-wings. The two sexes are differently marked, as will be evident by comparing this photograph with that of the male on page 333.

chrysalis turns brown—a useful indication to the husbandman that this contains friends instead of an enemy—and in spring, instead of a butterfly there issues forth a hundred minute four-winged "flies." It is just as well, for in addition to the large white butterflies that are produced from home-fed caterpillars, we are constantly receiving large hordes of surplus Continental production, who take the Straits of Dover at a flight, and disperse themselves on an egg-laying mission over the country. It is probable that the great abundance of the butterflies here in some seasons is largely due to these immigrations.

Although the butterfly is so well known that a description is unnecessary, there is a difference in the markings of the sexes that should be stated. In both the upper side of the wings is white with a black blotch at the tip of the fore-wing. In addition to that blotch the male has only a black mark on the front margin of the hind-wing; but the female has two black spots on the fore-wing, and a streak of the same hue on the hind-margin of the wing. On the under side the wings of both sexes are alike: the black of the fore-wing tip is replaced by yellow, the spots of the female upper side are repeated below in both sexes, and the hind-wing is yellow powdered with black.

The small garden white is so similar in all respects except that of size, that the uninitiated may surely be forgiven for their assumption that it is only a smaller or younger example of the large white. The only marked difference is in the male, which has a black spot in the centre of the fore-wing, sometimes very small or very indistinct. The tips of the wings, too, in both sexes are not so definitely black as in the larger species. The butterfly makes its first appearance in April or May, a second brood appearing in July.

Its eggs are laid on cabbage and allied plants, not in batches, but singly, so that we do not find the caterpillars swarming on a leaf and reducing it to a skeleton. The downy caterpillar is more distinctly green—a bluish-green—than that of the larger species, in which the yellow markings give the general tone. There is yellow in the smaller species, but it is restricted to a fine line down the centre of the back, and a narrow broken stripe along each side. In addition to plants of the cabbage tribe, it is very partial to garden nasturtiums and mignonette, but these are attacked chiefly by caterpillars of the second brood in July and August, the plants being scarcely ready for the first brood. The chrysalis is much smaller, more slender, usually light greenish-grey, with the angles slightly tipped with yellow, but the black dots are much smaller and less numerous.

The eggs laid in April or May result in butterflies at the end of July or beginning of August, and these lay eggs which hatch in about ten days, and the caterpillars

turn to chrysalids, which produce butterflies in the spring following. As in the case of the large white, our native-grown butterflies are at times largely reinforced by the immigration of swarms from the Continent.

There is another species of similar proportions to those of the small garden white, which, when on the wing, is scarcely distinguishable from it. This is the green-veined white,[1] whose chief distinction is indicated in its name. The veinings of the wings are dusted with black scales, and on the under side of the hind-wings the mixing of these with the yellow ground-colour produces the effect of green. Although the butterflies may be seen flying over gardens, they do not have their origin there. This is a butterfly of the woodside, green lanes, meadows, and marshes. The caterpillar is very like that of the small white, but its green colour is paler, and it lacks the central yellow line. The broken line along the sides is here more distinctly resolved into a single spot upon each segment of the body. Although true to its relative's taste for plants of the cabbage tribe, this prefers the wild species, such as garlic-mustard, wintercress, and watercress. The chrysalis, though in general like that of the small white, is pale green in colour. There are two broods as in the other species.

Of similar proportions and superficial appearance is the bath white or chequered white,[2] which, however, is only doubtfully a native of these islands, though it is common in Europe. From time to time specimens have been taken flying in this country, mostly on or near the South Coast, and the presumption is that like the

Photo by] [*H. Bachin.*

THE WORK OF THE CATERPILLAR OF THE LARGE WHITE.

The photograph represents a portion of a bed of broccoli which has been attacked by the caterpillars of the large garden white butterfly. All the softer portions of the large leaves have been consumed and only the midribs and the stouter branches have been left to show the completeness of the havoc that has been wrought.

[1] Pieris napi. [2] P. daplidice.

large swarms of the common species a few bath whites come across the Channel. It is scarcely to be supposed that they come of their own volition, for their flying powers are weak, and more probably they are blown across the narrow Straits The distinguishing feature of the bath white when viewed at close quarters is that the black on the upper side is stronger and more abundant, but broken up so that the tip of the fore-wing in both sexes and the hind-wing of the female have a chequered pattern. On the under side the yellow scaling of the hind-wing is not continuous as in the other species, but is broken up and alternated with white spaces, so that we have chequers again. The black-spotted yellow and grey caterpillar feeds upon mignonette, wild and cultivated ; but it has never been found at large in this country, though it is known that the immigrant females deposit their eggs, for these have been obtained and the Insect reared through all its stages from them.

Lady-Birds.

Photo by] [*E. Step, F.L.S.*

A Lady-Bird.

The beetle shown is the seven-spotted lady-bird, one of the two most common species : the other being the two-spotted, with a single black spot upon each red wing-cover. Here the same type of colouring is found, but with the spots more numerous. The photograph is four times the size of the beetle.

If we relied upon popular classification for a right view of the nature of things, we should be going astray constantly. The popular notion of a beetle, for example, is an Insect that is at least objectionable, and in most cases repulsive. There are many beetles that are as beautiful and brilliant as gems, but in these cases the public ignores their beetle-nature, and calls them something else. Although the lady-birds[1] do not quite come into the latter category, they are admittedly pretty, and no one objects to their alighting upon hand or clothes. The children have even a doggerel formula for bidding them to spread the delicate brown wings that are packed so cleverly under the glossy red wing-covers, and to fly to a home that does not exist. But they are never acknowledged to be beetles—they are our lady's birds. So they do not cause alarm to the average woman, and even the average gardener has learned to restrain his natural desire to stamp them out. But with the lady-bird in the grub stage, it is a very different matter. Few persons have any notion that it is a phase of lady-bird development, and that it is the stage in which this Insect's important life-work is mainly carried out. We have actually been told by rose-growers who would pass for men of intelligence, that their choicest rose-trees were being eaten up by a " blight " of which they submitted sample specimens for identification ; such samples proved to be the grub of the lady-bird. Sometimes it has happened that a zealous upholder of law and order, whilst engaged in stalking a burglar or other evildoer, has himself been arrested by the police under the impression that he is the actual criminal. So it is with beneficent Insects. Seen in the company of notorious destroyers such as green-fly, the gardener jumps to the conclusion that they are aiding and abetting these pests in their nefarious work.

[1] Coccinella.

In order that the reader may not fall into this serious error and be tempted to destroy a good friend, we give a photographic portrait of this active little helper who, during the four or five weeks of his larval existence, is consumed by a passion for benefiting the gardener. It has six fairly long, jointed legs, which are used with more activity than is the case with most beetle-grubs, and is of a slaty or purplish-brown tint, diversified by raised spots of black, blue, and red. What good, the gardener may ask, can so small a creature effect, even though its intentions are of the best, as you say? The best answer to this question is to bid him watch one lady-bird grub for an hour upon a green-fly-infested leaf or shoot. He will find that in that space of time the grub has destroyed from thirty to forty of the green-fly; and as there are almost certainly a number of them working upon the same plant, a day's work of the squad goes a long way towards clearance. Some of the methods employed by the gardener only result in the green-fly dropping off the foliage, and reascending that or some other plant to continue their work. When the lady-bird grub takes the green-fly in hand it is a thorough clear up. The green-fly that has made acquaintance with the grub's jaws has finished its work, and leaves no descendants in the direct line.

Photo by] [*H. Main, F.E.S.*

EGGS OF THE LADY-BIRD.

A cluster of more than twenty eggs of the common two-spotted lady-bird deposited upon a rose-leaf. As may be judged by the dimensions of the leaf, the photograph is on the scale of twice the natural size.

Photo by] [*W. H.*

LADY-BIRD GRUBS.

A cluster of eggs, such as is shown in the upper photograph, has just hatched, and the young grubs are making their first meal. They will soon disperse over the plant, each seeking for itself a leaf that is attacked by a colony of green-fly.

When its month is up the lady-bird grub fastens its tail to the under side of a leaf, throws off its skin, and reveals itself as a short, stout, conspicuously spotted chrysalis. This hangs for a short time in order to develop its wings, and then breaks out as a black-spotted, scarlet-coated beetle, which continues to feed upon green-fly. In this stage it flies about in the sunshine and inspects plants to find which are most in need of the services of its children. Having found a badly infested plant, the female lady-bird lays about

twenty eggs in a close cluster, and when these hatch the minute grubs at once set to work on their mission in life.

Photo by] [*H. Main, F.E.S.*
GRUB OF LADY-BIRD.
Few persons who see this grub crawling on their rose-bushes have any idea that it is the early—and to them the most important—stage in the history of the lady-bird. During the four or five weeks that this stage lasts its sole food is the aphis, or green-fly, and it consumes from thirty to forty green-fly in an hour.

Photo by] [*H. Main, F.E.S.*
CHRYSALIS OF LADY-BIRD.
When the grub has sucked to the full of green-fly juice, it suspends itself by the tail to a leaf—as shown to the left of the photograph—contracts in length, and turns to the chrysalis shown on the right side of the midrib.

It is a singular thing, but these Insects appear to have no enemies at all. The conspicuous colour spots on the grub and chrysalis, and the strongly contrasted colours of the beetle, warn Insect-eating birds that they are not palatable; but many Insects so protected fall victims to other Insects that deposit their eggs in them. The lady-birds appear to be immune from the attacks even of ichneumon-wasps. It may be that these are kept off by an unpleasant odour emanating from the blood of the Insect. If a lady-bird be touched it will be seen to exude from certain joints of its legs a yellow fluid—really blood—which has a strong, unpleasant smell.

Something like two thousand species of the lady-bird family are known from various parts of the world, and of this number more than forty are British. A few of them are vegetarians. Even among our native species great variety in the matter of spots will be found. In some, yellow takes the place of red in their livery, and instead of definite spots we may have an elaborate labyrinthine pattern. The commonest species in our gardens are the two-spotted[1] and the seven-spotted lady-birds.[2] In seasons when green-fly are abnormally abundant, the grubs appear to get through their feeding more quickly, and soon the perfect beetles are in evidence everywhere. It is more than probable that on such occasions vast swarms migrate from the Continent, for over and over again they have been found washed up by the sea in millions along our southern and eastern shores. These, of course, were only the few weak or unfortunate members of the host that chanced to fly too near the surface, and were caught by the crests of the waves. The vast body has flown on and settled on the green lands of Kent, Sussex, and Surrey, where the extensive hop-gardens have been suffering so badly from green-fly that beer-drinkers have feared a future when all the bitter flavour of their staple beverage would have to be supplied by the chemist. Then, by some means, the lady-birds at a great distance have learned that their services are required here, and they gathered in enormous swarms, and descending upon the sickly hop-bines have cleared them of the pest and so saved the situation for the hop-merchant and the beer-drinker. We can remember

[1] Adalia bipunctata.

[2] Coccinella septempunctata

such a visitation on an enormous scale that occurred in the year 1869, when actually more lady-birds came over than could be absorbed by the hop-fields, and the surplus came on to London, where they streamed over roads, pavements, and walls, so that there were probably far more lady-birds than green-fly. Lots of money had no doubt been wasted that year on poisonous washes; the lady-birds did the work of clearing the hop-gardens without one halfpenny of expense to anyone.

In former times such migrating swarms have filled the people with alarm. The reason for their visit not being understood, they have been regarded as portents of some dire evil that was about to befall the country. Even so recently as the year 1835 the intelligent authorities at Reading appear to have been perturbed by such a visitation, for it is on record that the fire engines, public and private, were called out to repel the "attack," and disperse the invaders with water that had been poisoned with tobacco!—though pure water would have been quite as effective for washing them away.

Photo by [*E. Step, F.L.S.*

FOURTEEN-SPOTTED LADY-BIRD.

The wings of these beetles, it will be seen, are much longer than their wing-covers, under which they are folded. Their extension, as shown in the photograph, is always the preliminary to flight.

Humble-Bees.

Half-way, so to speak, between the honey-storing bees of the hive and the bees that lead a solitary life, come the humble-bees.[1] They are social bees, but their communities are very small when compared with those of the honey-bee. As the results of their communal activity cannot be bought and sold, man has not taken them under his wing and provided them with patent hives and comb-foundation. For all that, their industry is of the greatest importance to all growers of flowers and fruit, for they are most efficient agents in the pollination of plants, and their presence or absence in normal numbers makes all the difference between good and bad fruit harvests. As is the case with the honey-bee, the community consists of males, females, and incomplete females known as workers.

As compared with the honey-bee the humble-bee is a burly giant whose reappearance in spring is always welcomed as she goes about the earliest blossoms and lets the world know by her cheerful humming that she is returning to activity. These early bees are always females that have lain in a torpid state through the winter in some cosy nook, and have temporarily emerged for the refreshment that sallow catkins afford. As you stand under the sallows in March and listen to the organ-like volume of music that emanates from the hundreds of humble-bees that are gathering nectar from the flowers—the so-called "palm"—you may be excused for regarding them as a "swarm" akin to the swarms of honey-bees. As a matter of fact, every individual of that host is an independent female, each the possible founder of a new and separate colony. When they have filled their honey-bags, each goes back to her hibernaculum to sleep again until May. Then she looks

[1] Bombus.

about for a deserted mouse's nest or other suitable retreat, and lays the foundations of her colony that is to be. This may be on the surface, protected by grass or moss, or underground at the end of a tunnel—often a yard long. Different species have their own special tastes in this matter.

The humble-bees are not nearly so eminent as wax-workers as are their cousins of the hive, for they build no proper combs. They produce little wax, and that exudes from under the rings on the back, not from the under surface as in the honey-bee. The wax, too, is brown in colour, and much softer than that of the honey-bee.

It is the custom to speak of the fertile female humble-bee as a queen, just as one speaks of her equivalent in the hive ; but there is a great difference between the

Photo by [*H. Bastin.*

HUMBLE-BEES.

Here are shown the three forms common to all the species of humble-bees. The more burly figure to the left is that of the female or "mother." To the right is a worker, and below is a male or "drone." The community consists mainly of the workers. The figures are one and a half times the natural size.

two. The queen-bee is a mere layer of unlimited eggs : she is too regal to be domestic. We prefer to speak of the founder of the humble-bee colony by the higher title of mother-bee. She is a real mother, with the maternal instincts highly developed. Unaided she lays the foundations of the family, incubates her eggs, nestles and feeds her brood, and when she has raised a bevy of infertile daughters to help her, she still takes part in all this work so long as her physical powers allow her to do so. Having selected a suitable site, she sets to work to prepare the nest. If it is an abandoned nest of the field-mouse, she probably finds it already provided with material suited to her use. This will consist of half-rotted grass, finely divided and cut into short lengths. The mouse is very particular in the selection of material, taking the withered blades from the base of a tussock and dividing them lengthwise

Photos by]

HUMBLE-BEES' NEST AND COCOONS.

On lifting the mossy dome of the humble-bees' nest the view presented is that of the lower photograph, where the tops of a few cocoons show through the surrounding material. The upper photograph is of a mass of cocoons, many of them empty, removed from the nest. It will be seen that they do not exhibit the regularity of arrangement found in the nests of honey-bees and wasps. The cells with small, even mouths in the upper part of the first photograph are honey-pots built up of wax.

Photo by] [*H. Bastin.*

EGGS OF HUMBLE-BEE.

The wax dome turned over to show some of the eggs beneath it. These are here shown magnified considerably.

as well as crosswise, in order to have them perfectly ductile and capable of felting. This also is the quality of material that the humble-bee likes. Sometimes she mixes fragments of fine moss with it, probably to increase its springiness. All this material is taken, bit by bit, in her jaws, passed by her two hinder pairs of legs under her body and accumulated behind her. Then she pierces a tunnel to its centre, where she hollows out an oval chamber Her home is ready for furnishing.

She next sets off on a hunt among the flowers, and comes back a little later with her thighs bulging with masses of pollen and her honey-crop filled with nectar. She brushes off the pollen in a little heap upon the floor of her nest and moistens it with honey ; then with her jaws she kneads it into a paste, which she builds up into a solid mass. Upon this she constructs a ring-like wall of wax—her first cell, of which the pollen mass forms the floor. In this cell she lays about a dozen eggs, and then closes in the top with a dome of wax. She also constructs a pot of thin wax to contain honey, which is placed in the doorway of the nest-chamber and filled with honey. The honey-pot is about half an inch across and about three-quarters of an inch deep. This filled, she is ready for the possible advent of a bad day when she cannot steal a few minutes from her nursing duties to fly to the nearest flowers and obtain food. She now takes up her station over her cell, with her face to the door, and actually incubates her eggs. The grubs hatch out upon the fourth day, and set to work feeding upon the floor of the cell. Each scoops out for itself a hollow in the pollen mass, and so that they shall not eat through it to the exterior the mother-bee collects more pollen and plasters it all around the original heap. She also makes a semi-fluid mess of pollen and honey and, cutting a hole in the wax lid of the cell, drops it in upon her grubs. Between the necessary expeditions for collecting food she sits upon the brood mass, from which she can reach with

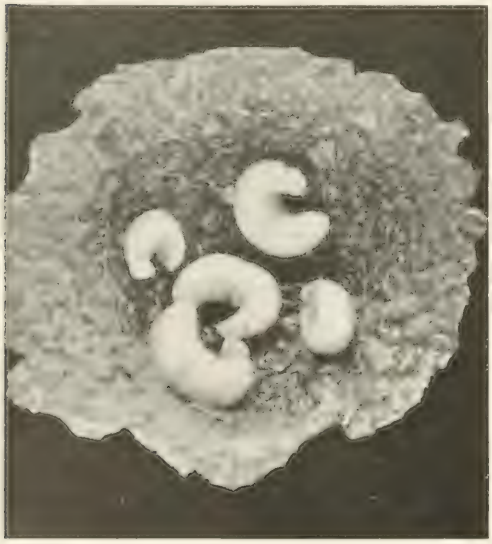


Photo by] [*H. Bastin.*

HUMBLE-BEE GRUBS.

Five grubs are here brought together to show form, etc. In the nest each occupies a separate cell it has eaten into the mass of pollen and honey beneath them. When full grown each spins an oval cocoon, in which it assumes the chrysalis condition, shown in a later photograph. The grub stage lasts only about one week.

her long tongue to the honey-pot at such times as she requires food for herself. Much of this is used up in the production of heat to keep up the temperature of the nest night and day. The honey-pot is always undergoing changes when it is in use. When full it is relatively tall and has a small mouth. As the honey gets lower so do the walls of the pot in agreement, and when it is refilled the walls are built up again. But after about a month, when there are workers about to assist the mother, the waxen pot is neglected and falls into ruin. The honey is of a more fluid character than that stored by the honey-bee.

The legless grubs when they are about five days old increase the size of the hollows in which they repose, each occupying its own cell in the food-mass; and two days later each spins a tough papery cocoon. The mother about this time clears away the brown wax she had been continually adding to for the protection of the grubs, and the clearance reveals the upper ends of all these cocoons standing side by side. A depression runs through the middle of the group, which indicates where the mother's body has lain in her brooding vigils. This groove she continues to occupy, for her offspring still need warmth to help their development, even when they have changed into chrysalids. On the twenty-second or twenty-third day after the eggs were laid she has the reward for all her labour and care, for the chrysalids develop into bees, which begin to bite through the tops of the cocoons and emerge. In this they are assisted by the mother, who enlarges the openings to make their exit easier. The newly emerged bees are all small workers, and as soon as their legs and wings have become firm and their wetted, matted coats are dry, they begin to assist the mother in collecting provisions for their larval sisters. For all this time, the mother-bee has been making other cells and filling them with eggs, so that the broods come on with intervals of only two or three days between them.

H. Bastin.

HUMBLE-BEE CHRYSALIDS.

A couple of chrysalids are here shown, much enlarged. The first is a view of the under side with the legs, tongue, and antennæ folded down to the body. In the second the upper side is shown, with the wings folded down the sides. This stage lasts about a fortnight.

The new workers start collecting out of doors when only three or four days out of the cocoons, and do their work at once as though they had been trained to it. Every few days they are joined by later emergences—all workers for a time. Later, the mother lays eggs which produce males and females. The cells for the second and later batches of eggs are built on the sides of the taller cocoons, so that they can derive warmth from the mother's body as she is imparting it to her first

brood. It is to this arrangement that the higgledy-piggledy appearance of the nest at the end of the season is due.

Later in the season, when the mother-bee is getting enfeebled, the older workers take to laying virgin eggs, but these produce males only. The sexual bees produced by the mother earlier in the season are all much smaller than those produced in early autumn, upon which the continuance of the race depends. For the humble-bee communities all come to an end before winter, and the future of the species depends upon the young fertile females who go into hibernation, and are ready to begin egg-laying in spring.

These humble-bees, of which there are many species—seventeen of them natives of our own islands—differ in their nesting habits, some as indicated going underground, whilst a few, known as carder-bees, form their nests in slight hollows of the surface, covering them with domes of felted grass and moss. These carders are much less numerous in individuals than the subterranean builders. Smith says that the communities of a common underground builder[1] are the most numerous. One such nest he found to contain 107 males, 560 females, and 180 workers; a surface-builder's[2] nest would contain about half these numbers of inmates.

Photo by] [*H. Bastin.*

HONEY-POTS.

The humble-bees' storage for honey shown upon an enlarged scale. The receptacle marked A has been built up specially of wax. B is a vacated cocoon with wax additions to serve the same purpose. The others are all empty cocoons that have been utilized for storage.

The empty cocoons from which came the first batch of workers are utilized by them for the storage of pollen, and by some species as honey-pots for the immediate use of the commonwealth. We have mentioned the readiness of the underground-builders to adapt a mouse's nest and run to their own purposes; and the surface-builders are not above similar economy of labour. We have found them making use of a field-vole's nest. They are not likely to take possession of such places before they have been abandoned by the original owners, for mice are great enemies to the brood, though they know better than to make an attack when the bees are at home. Smith has recorded an instance of a humble-bee[3] taking possession of a wren's nest that was occupied by a clutch of the bird's eggs. Possibly, the bee thought they were cocoons; anyway, she heaped up her collected pollen among them, and so disgusted the wren by her action that the eggs were abandoned, and

[1] Bombus terrestris. [2] B. sylvarum, or B. agrorum. [3] B. agrorum.

Photos by] [*H. Bastin.*

How Pollen is Carried.

As the humble-bee visits flower after flower she collects pollen as well as nectar. The pollen is largely picked up by the hairy coat, then brushed off by the feet and pressed into the "pollen basket" on the thigh of the hind-leg.

it is probable that a new nest was built elsewhere. Mr. Sladen mentions a double case of adaptation. A mouse had utilized a cast-off shoe as a nesting-place, and after the mouse had done with it a humble-bee adapted the nest to her own use. Such a course of procedure saves the colony-founding female the labour of collecting all the material required, and enables her to devote her energies at once to the laying of eggs and gathering of food.

Walking-Leaves.

In speaking of the stick-Insects we have remarked that the walking-leaf Insects [1] are included in the same family. Although superficially these portly-looking leaves appear so different from the sticks, in essentials they are much alike, but only a naturalist, who looks beneath the surface veneer, would dream of bringing them together in this way. Their life-history and course of development are the same. Instead of the hind-body being reduced to almost the narrowest dimensions, it appears in these Insects to be spread out as widely as the material will allow. Each of the limbs bears thin lateral expansions that are leaf-like, and like the majority of leaves have toothed edges.

Photo by] [*H. Bastin.*

THE LABOUR-SAVING HUMBLE-BEE.

In her honey-gathering the humble-bee has learned that much time is to be saved by biting through the flower just above the nectar glands, instead of thrusting her head in at the proper opening. These wounds at the back of the bean-flower have been made by the jaws of the bee in order to obtain the honey illicitly.

In their younger stages, before the wings are developed, the flat hind-body bears a general resemblance to a leaf something like that of the common cherry-laurel of our garden shrubberies; the lines of the segments with a few colour-lines standing for the veining of the leaf. In this condition the young leaf-Insect is said to arrange its position on a shrub with proper regard to the attitudes of the real leaves so that it passes as one of them; though it is only when the wings and their covers are fully developed that the marvellous deceptive likeness to foliage is fully seen. When newly emerged from the egg—which is contained in a seed-like capsule like the eggs of the sticks—the leaf-Insect is reddish-yellow in colour, and therefore fairly conspicuous if it gets upon the upper side of a leaf. But as soon as it has made a meal the colouring matter of its food seems to permeate all its tissues, and makes it harmonize absolutely with the plant it is feeding on. This effect is so remarkable that the colouring matter of the Insect has been submitted to

[1] Phyllium.

examination by spectrum analysis and is found to agree exactly with the colouring matter of leaves.

There is a strange difference in the external appearance of the two sexes. The female has no wings, but her wing-covers are developed to such an extent that they extend over two-thirds of the hind-body, and have a beautiful and complicated system of nervures that very closely mimic the veining of a leaf. This full development is quite contrary to the rule that prevails in the family, as we have shown in the case of the stick-Insects, where the wing-covers (when present) are too small to cover the wings. Now the male walking-leaf has expansive hind-wings which nearly cover the hind-body, but the wing-covers are very small. This is not the end of the peculiar conditions prevailing among these Insects. It must have been noticed that in nearly all Insects the stoutest nervures are situated at or near the fore-edge of the wings to give strength to that part which has to meet the resistance of the air in flight. As there are no flight-wings in the case of the female walking-leaf, Nature did not feel bound to follow the rule. She was getting up these wing-covers to imitate a leaf, and shifted the strong nervures to the hinder margin of the wing-covers, so that when these lay resting on the Insect's back they constitute the apparent midrib of the leaf. If, in our photograph, these are looked at in comparison with the fore-wings of other Insects, it will be seen also that the outline is reversed—the straight edge being behind and the rounded edge in front. As a flying organ such a form must be pronounced utterly wrong; but the female leaf-Insect having given up the ambition to fly, these organs have been devoted to the important office of protection from enemies, and from this point of view the imperfection is turned into perfection.

Photo by [*H. Bastin.*

A Walking-Leaf Insect.

In this photograph of a female the wing-covers are separated to show that there are no wings to be protected by them. This sex having given up the habit of flight has yet retained the wing-covers and developed them in the direction of increasing its likeness to the leaves upon which it feeds.

The walking-leaf Insects are restricted to the Old World, and there to the tropical regions. India, Malaysia, and especially the islands of the Pacific and Indian Oceans from Mauritius and Seychelles to Fiji, provide us with examples. There are several species, but their differences are not great, and are such as appeal more to the classifying entomologist than to the readers for whom this work is intended. In essentials the description of one species will serve for all.

Like those of the stick-Insects, the egg of the walking-leaf is enclosed in a capsule which is so much like a ribbed seed such as is produced by many plants of the parsnip family, that one entomologist who has made a careful investigation into the structure of the capsule of one species,[1] expresses his belief that almost every botanist examining a thin section of this capsule would declare that he was looking at a vegetable production.

All these leaf-Insects are green after their infancy, but it is impossible to go further and say what sort of green, for each individual frequently changes the particular tint of green, according to his food and surroundings, so that he may be alternately yellow-green, red-green, brown-green, blue-green, or any other kind of green. The natives of the places in which they are found shake their heads when told that the walking-leaf comes from an egg like other Insects. It is their fixed belief that a leaf-bud develops into this creature with legs, quits its attachment to the twig, and walks about. The likeness to real leaves is so great that even the Insects themselves are deceived by it, and have been known to begin feeding upon their companions before they discovered — probably by the difference of taste—they had made a mistake. That this was not due to cannibalism is shown by the fact that the attacks never proceeded far enough to injure the bitten one, but only far enough to make the deception appear more convincing.

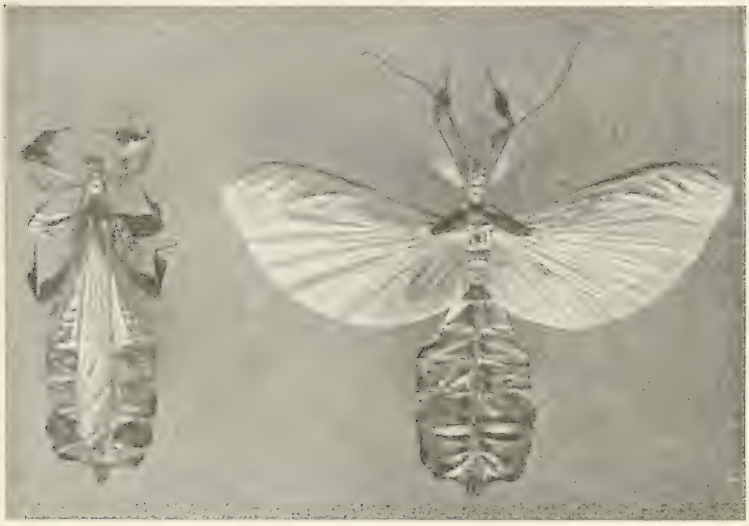


Photo by] [*H. Bastin.*

MALE WALKING-LEAVES.

These are males of the species whose female is shown on the previous page. In the second figure will be seen the wing-covers, so small as to be quite useless for covering the wings. It will also be noticed that the male has long antennæ, whilst in the female they are very short.

The Fly that Causes Sleeping-Sickness.

The tsetse-fly has long been familiar to readers of books on Zululand and other parts of Tropical Africa, where it proved a great scourge by killing off the buffaloes, oxen, and horses. From the sixteenth century onwards, explorers had noted this circumstance, mainly from information derived from the natives, who believed that the disease of their cattle—the *nagana* or fly-disease, as it was called—was due to the attack of the fly. The theory was that the sucking organ of the fly had a poison-gland at its base, some of whose contents were poured into the wounds it made, and that such a "bite" was followed by the illness of the animal that had been

[1] Phyllium crurifolium.

Photo by] [*E. Step, F.L.S.*

A Walking-Leaf Insect.

The best known of the walking-leaf Insects, whose home is in India and adjacent countries. The example photographed is a female, and shows the ample development of the wing-covers, which present a startling resemblance to a leaf. These wing-covers serve no purpose beyond that of making the Insect appear to be what it is not, for there are no wings beneath to be protected, and the covers themselves are useless for flight. The photograph is nearly one and a half times the actual size of the Insect.

attacked. Now, the sting of such an Insect as a wasp is an offensive weapon designed to secure the submission of its prey and for defensive purposes. It is situated at the end of the hind-body and provided with poison glands; but the instrument of the tsetse-fly, as of the mosquito, is a development of the mouth-parts into a hollow tube through which the victim's blood may be sucked. There were not wanting entomological experts who held that any unpleasantness following the operation of the tsetse-fly was solely due to mechanical irritation and the loss of a small amount of blood. It was a mere coincidence, said they, that the flies had been about the cattle before these were stricken with disease and death; and one well-known man spoke of the supposed connection of the fly and the disease as a myth. Cattle that were penned in the native villages were safe: the natives said because the fly avoided the neighbourhood of human filth.

Photo by] [*H. Bastin.*

A Tsetse-Fly.

The tsetse-flies as annoyances to man and cattle have been well known from the sixteenth century, but it is only within recent years that they have been discovered to be the carrying agents by which the healthy are inoculated with the germs of disease.

At this time it was thought that there was only one kind of tsetse,[1] and consequently it was spoken of as *the* fly. About ten years ago more careful investigation showed that there were seven distinct species, and now our knowledge has been increased so rapidly that about fifteen species are known. These vary in size from a quarter to half an inch in length, and roughly speaking may be said to be not unlike our common house-fly in appearance. They are not generally distributed over the country, but are often restricted to comparatively small areas known as "fly-belts." They appear to avoid extensive open tracts of grassland, and to demand the cover of bush, forest, or reed-beds. The different species vary in colour from black through brown of different tints to yellow; and the beak or sucking organ when not in use is carried extended in front of the head. One character of the tsetse-flies—though not confined to them—is that the females do not deposit eggs, as do the majority of flies, but retain them until they have hatched and developed into full-grown yellow grubs. Only one grub is produced at a time, and as a rule it is deposited on light sandy soil into which it immediately burrows and changes to the chrysalis condition, from which it emerges as a fly five or six weeks later. Unlike most blood-sucking flies, the male tsetse as well as the female indulges in this objectionable habit.

[1] Glossina morsitans.

In the year 1895 the Governor of Natal sent Surgeon-Major (now Colonel Sir David) Bruce, of the Army Medical Service, into Zululand, in order that he might investigate the tsetse-fly disease on the spot. Bruce made a number of painstaking researches from which most of our present actual knowledge of the Insect has been derived. He traced out the distribution of the disease, and made experiments with the fly upon the native big game and domestic cattle. He found that before feeding, the hind-body of the fly is so empty that the upper and lower walls appear to be in contact, but after a few minutes the fly has imbibed so much blood that the hind-body swells up to such an extent that its lower wall is transparent and the colour of the imbibed blood shows through. Bruce kept some of the flies in confinement until all signs of their previous meal had disappeared and the hind-body resumed its empty condition, and fed them daily upon dogs for periods varying from ten days to two months. The dogs remained healthy, and showed that the mere bite of the tsetse-fly was not capable of giving rise to the disease.

Then, in turn, the flies were fed upon dogs known to be suffering from nagana, and upon healthy dogs, with the result that the latter became affected by the disease. Many experiments were made, but briefly it may be said that, in all cases where the flies were fed first upon diseased and then upon healthy animals, the blood of the latter yielded after a short interval countless examples of a very low form of life[1] which is always found in the blood of animals. It appears to feed upon the red corpuscles of the blood, producing a condition of anæmia, emaciation, prostration, and finally, death. It is carried from the sick to the healthy by the beak of the fly.

Photo by] [*H. Bastin.*

HEAD OF TSETSE-FLY.

This photograph on a large scale of the head of the fuscous tsetse-fly shows the apparatus by whose use disease is propagated. The hollow proboscis, after insertion in the veins of a diseased beast or afflicted man, carry some of the germs into the system of a healthy victim.

So far we have not mentioned sleeping-sickness; but the foregoing remarks upon nagana are a necessary introduction. At the end of the nineteenth century a disease called sleeping-sickness began to spread with alarming rapidity among human beings in Uganda, and several vessels homeward bound from East Africa were found to have among their crews men suffering from this terrible malady. The disease was proving a formidable barrier to the colonization of Uganda, and the seriousness of the matter was brought to the notice of the Royal Society. The society appointed a commission of three medical men experienced in tropical diseases to inquire into its nature and causes. Colonel Bruce was one of the three. His previous researches into nagana suggested to him that this also might be a fly-

[1] Trypanosoma brucei.

disease. The doctor in charge of the sleeping-sickness patients in the hospital had told him that he had found trypanosomes present in their blood, so Bruce directed his inquiries to test whether these got into the blood through the attacks of a fly. His researches established the fact that sleeping-sickness is caused by a kindred form of low life[1] to that which produces nagana, and that the active agent in its inoculation is a distinct species of tsetse-fly.[2] The intervention of the fly is absolutely essential to the propagation of the disease. When it sucks up the blood of the animal already afflicted it also takes in many of the immature trypanosomes, whose development is further advanced in the fly, and when the latter indulges

Photo by] [*H. Bastin.*

FUSCOUS TSETSE-FLY.

A typical species of tsetse-fly, shown on a much enlarged scale to make more clear its characters. It is here seen about five times the actual size.

in its next meal of blood there are sure to be some germs attached to its beak and so introduced into the blood of the present victim. In the circulation of the blood it finds its way to the brain, and by its action there produces the condition of coma which is the outstanding symptom of the disease. Having determined the exact species of tsetse-fly that is the carrying agent, Bruce found that the ravages of the disease coincided with the distribution of the fly. Sleeping-sickness affects monkeys as well as man. Dogs and rats were found to be partially susceptible to inoculation, but efforts to infect guinea-pigs, donkeys, oxen, goats, and sheep yielded negative results.

Thus it is shown again that though Insects may be regarded by some superior

[1] Trypanosoma gambiense. [2] Glossina palpalis.

Photo by *H. Wood, F.E.S.*

THE DRINKER AND THE LAPPET MOTHS

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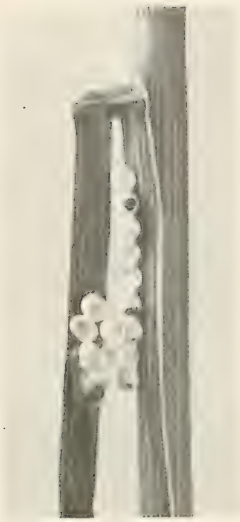


Photo by] [*H. Main, F.E.S.*
EGGS OF THE DRINKER.
The large eggs are laid in clusters on the stems of grasses. In this group some have hatched, and the young caterpillars have made a first meal of the egg-shells. At the bottom of the cluster a caterpillar is emerging from the egg. Twice the actual size.

persons as altogether too insignificant to engage the serious study of intelligent men, a contemptuous ignorance of their forms and habits may result not only in heavy financial loss, but in rendering vast tracts of rich country uninhabitable by man and his herds of domestic animals. Sir Harry Johnston has shown, too, in this connection how the love of finery in one part of the world may result in the infliction of untold misery upon human beings in another part of the world, for he has pointed out that the destruction of Insect-eating African birds for the sake of their plumage has led to the unchecked increase of the very flies that spread this dire disease.

The Drinker and the Lappet.

The drinker[1] is a fine moth much like the egger and the fox moths, but with the fore-wings more pointed at their tips, a diagonal dark line from the tip to the middle of the hind-margin, and a couple of silvery-white spots near the centre of the front margin. It flies in July, and has a preference for moist places, such as green lanes, marshes, and moorlands. The caterpillar is of goodly proportions, about two and a quarter inches long, of a dark slate colour on which are laid innumerable dots of yellow in lines. Its hairy covering is of three or four kinds: along the back are two rows of tufted, short black hairs and between them longer brown hairs; along the sides are shaggy locks of yellowish-white hanging down and almost hiding the legs. Just behind the head stands a pointed hair pencil, and a more bushy brush points backwards from the tail-end of the back. It may be found quite small feeding on various coarse tall grasses from August to October, and again of larger size from April to June. In between these times it is enjoying a winter rest. About June it may be seen spinning its long brown cocoon to a stout grass stem. This is of peculiar form to suit the narrow situation. It is broader in front (or the top end), which is rounded, and tapers considerably to the lower end. The chrysalis is brown. As already mentioned in the article on eggers, the caterpillar is a thirsty creature and imbibes the morning dew-drops, a fact that was observed more than two centuries ago and led to its being named the drinker, whose meaning is repeated in the Latin *potatoria*.

Photo by] [*H. Main, F.E.S.*
THE DRINKER-CATERPILLAR.
This large hairy caterpillar feeds on grasses, and is brown in colour with yellow stripes along the sides. Some of the tufts of hair are white, and on the back near each end is a pointed tuft of black hairs.

But the finest of our representatives of this family is the lappet,[2] both as caterpillar and moth. The caterpillar is

[1] Cosmotriche potatoria. [2] Gastropacha quercifolia.

about four inches in length, of a dark-grey colour, and thickly clothed with fine, short hair. Along the sides is a fringe of much longer and brown hairs. There are two white marks on the back a little behind the head, and at the tail-end there is a short, thick, horn-like elevation. Below the side fringe are the fleshy lappets which have suggested the creature's name. It feeds upon blackthorn, hawthorn, apple, and sallow. When it is feeding upon bushes whose branches are more or less covered with lichens, it is said sometimes to duplicate the white spots on the back, which has the optical effect of breaking up its great bulk and bringing it into closer harmony with its surroundings. Like the drinker, the lappet-caterpillar first sees the light in August, and only feeds for a few weeks before seeking retirement for the winter. It becomes active again in spring, and is full grown in May or June, when it spins a rather long, grey cocoon in which it uses its long hairs to felt in with the silk. This is attached to the lower part of the tree upon which it fed. The dark-brown chrysalis is covered with a sort of "bloom," due to the calcium oxalate referred to in connection with the eggers, and it pretty well fills the cocoon without having room for wriggling.

Photo by [*H. Main, F.E.S.*

LAPPET-CATERPILLAR.

In this photograph the caterpillar is shown of the natural size. Along the sides will be seen the fleshy folds from which the Insect gets its popular name.

The moth is a night-flyer and is, therefore, seldom seen on the wing; but those who know what to look for may find it at rest in the day-time sitting on a leaf. The female measures three inches or more across the wings, which are dark rust-colour suffused with purple and crossed by several dark wavy lines, made up for the greater part of small "half moons." The outer margins of all the wings are scalloped. The reason why it cannot be seen easily when at rest is owing to a characteristic trick of disposing its closed wings. The fore-wings are folded along the sides and over the back to form a sort of span roof, and the front margin of the hind-wings is brought under them and flattened out on the leaf. In consequence we get a resemblance, not to a moth, but to a bunch of withered leaves. This was probably the earliest noticed example of protective resemblance among Insects, and the figure of the moth in its resting attitude was familiar in natural history books long before anybody thought of the important part such resemblances play in the struggle for existence. Much the same trick is played by the rare small lappet.[1] This moth escaped notice as a British species until the year 1852, when Mr. Atkinson, collecting on Cannock Chase, stooped to secure a small moth of another kind, and saw a dead leaf hanging from a bilberry bush. Something about that supposed leaf arrested his attention, and he examined it closely, with the result that the small lappet-moth was added to the list of British Insects.

[1] Epicnaptera ilicifolia.

Cardboard-Wasps.

The social wasps with which we are acquainted in this country protect their many tiers of brood cells by building a bag of several layers of fragile paper, made from wood-pulp prepared by their own jaws. In Tropical America there is a wasp[1] that builds with a view to the society being continued year after year. It has therefore improved upon the flimsy paper bag that needs constant strengthening by means of additional layers of paper on the outside. Our paper-making wasps have a lease on one life only—the queen's—and they build accordingly; but the cardboard workers build as though they had a freehold and the house was to serve for successive generations. They still use wood-pulp for their material, but it is more finely divided and mixed with a greater proportion of their own saliva. Paper is not the word for this material. It is thick, tough, solid, with a smooth finished surface upon which one could write with pen and ink; and the term papier mâché is much more suitable for it.

A tolerably well-known example of this type is the Dutchman's pipe nest of a slim-waisted wasp, which as it hangs from a branch is more suggestive of a bell than a pipe. The pipe-shape is produced by exhibiting it inverted, with a length of the branch to which it is attached by its builders to form the pipe-stem. The style of its architecture is, like that of our native wasps' nests, of an ingenious character, since it allows of increase from small beginnings up to any size that may be required by the growth of the community, without departing from the plan or in any way marring the symmetry, as sometimes happens when man adds wings or other additions to his ancestral abode. The combs in this case are attached by their edges to the firm walls, and all have a curve which makes the upper side concave and the lower side convex. It is to the lower side that the cells are attached so that their mouths open downwards, just as in the comb of the common wasp. The broad end of this bell-shaped nest is of the same solid material as the side walls, and has an entrance hole in its centre. A corresponding hole is in the centre of each comb, and permits passage to and from the successive floors; for there is no means of getting round between the wall and the edge of the comb as in the nests we know most intimately. When the increase of the population makes an increase of cell-accommodation necessary the pasteboard-wasp extends the side walls at the mouth of the bell and builds a new sheet of pasteboard across. The former lower wall is then used as the base of a new comb, a new set of cells being constructed over its lower face. It will be seen that by this method of construction there is no waste of labour, such as is involved in the nests of our common wasps, where the outer layers of the walls have to be constantly renewed as the inner layers are cut away to allow of the addition of new cells to the circumference of existing combs. Another point in this method of building worth notice is that the floors

A Honey-Wasp.

Certain wasps of Tropical America have the remarkable habit of storing honey in their cells as some of the bees do. Their nests are of enormous size. The species whose photograph is given above is the builder of the nest shown on the page opposite. It is only half this size.

[1] Chartergus chartarius.

NEST OF THE HONEY-WASP.

This enormous nest has complete box-like walls with a single orifice for entrance and exit. It is studded all over with thorn-like projections and rough knobs, which may be for the purpose of discouraging the attacks of animals to whom the smell of honey or wasp-grubs may be an attraction. It is suspended from a stout branch around which a strong band of the nest material is constructed. Its interior is shown on page 361.

being a continuation of the walls, there is no need for supporting pillars between the combs, and the whole of the space between any two floors is entirely unobstructed. Owing to the solid character of the pasteboard, and the fact that the only access to the interior is by a single aperture on its lower side, the structure withstands the destroying effects of tropical storms, and lasts for years. Even after the wasps have done with it, it sometimes serves as a nesting-place for birds.

The colonies of these pasteboard-wasps are continuous, like those of the honey-bee; and when the nest has reached its maximum size, the surplus product of the brood combs is got rid of by sending out a swarm, with a queen, to form a new community.

Somewhat similar are the box-like nests of some of the species of polybia. One of the most remarkable of these is that of the honey-wasp,[1] a native of Brazil and Uruguay. It is about a couple of feet in depth with a circumference of three feet. Its envelope is of thick card, but instead of being smooth the exterior is beset with stout spikes, which have been supposed to be a defence against the attacks of mammals that have a "sweet-tooth"—for, strange to say, this wasp stores honey in some of its combs. We say "strange," but it is strange only in contrast to the habits of most of the wasps we know. Even the Insect-feeding wasps are fond of sweets, but they do not store honey because they do not want it for winter consumption. If one considers why bees store honey it appears quite natural that a community of wasps that continues unbroken for years should do the same. This point of view, however, never occurred to the naturalists of a hundred years ago, when the existence of honey-storing wasps was first brought to their notice. They rejected it as a traveller's tale. The first intimation of the existence of honey-wasps was made by the Spaniard, De Azara, who had spent thirteen years in the work of a boundary delimitation commission in Paraguay, at the end of the eighteenth century. His published account of his travels was much criticized because of this statement, and whilst some regarded it as a pure fabrication of the Munchausen class, others thought the Insects he considered wasps were really bees. When about forty years later specimens of the nests reached this country and were examined by Dr. Adam White, of the British Museum, dry honey was found in the combs, and the reputation of De Azara was rehabilitated. Since then other tropical species of the same genus have been found to have the honey-storing habit.

A Cardboard-Wasp.

Another species—albicea—of the cardboard-making wasps. This example is represented on a scale of two and a half times the natural size.

One reason for the suspicion attached to De Azara's statement was the fact that, so far as was then known, wasps are feeders upon animal substances, and feed their grubs upon Insect remains. The sweets that attract wasps in the autumn are not so much taken as food as an indulgence of the appetite. But the normal

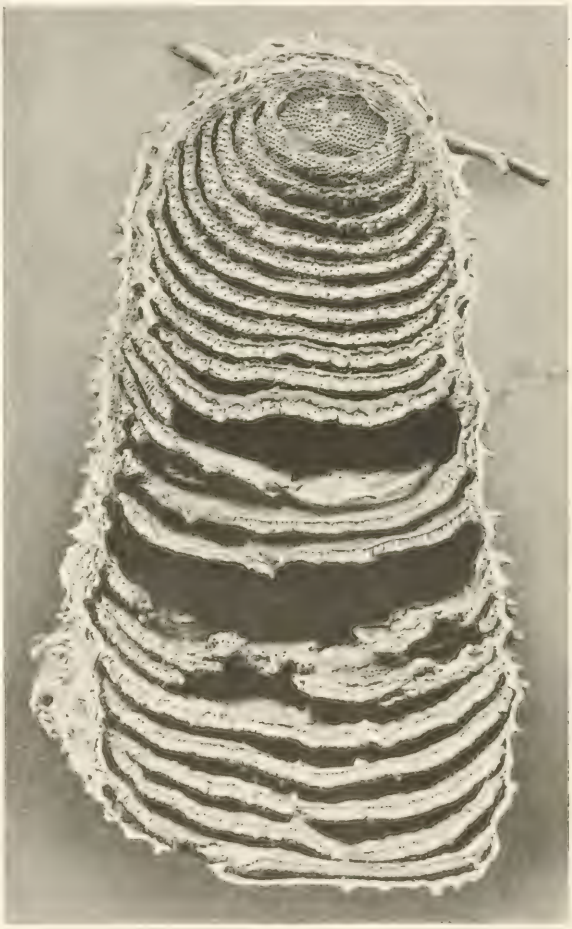
[1] Polybia scutellaris.

THE SLAUGHTER OF THE INNOCENTS

In autumn, when frosty nights and increasing scarcity of insect food teach the wasps that it will be impossible rear their grubs to the final stage, they are dragged from the cells in the combs, stung, and carried into the fields where they serve as food for the birds. The scene shows a nest entrance in a bank from which the wasps emer with their loads

food of the wasps cannot be stored up except in the stupefied living condition; and we may take it that with the evolution of the permanent community came the discovery that honey was a food that could be stored without losing its value.

Most animals would hesitate to attack a wasp's nest, especially one so large as that of the honey-wasp; but the jaguar is said to do so in spite of the stout cardboard spines that bristle all over the exterior of the nest. It may be supposed that the sharp, strong claws of such an animal would have little difficulty in tearing open the cardboard box, and breaking off portions of the comb. Apparently, in this case it is the grubs in the comb rather than honey that is the attraction to the jaguar.



INTERIOR OF HONEY-WASP'S NEST.

A specimen of the nest, whose exterior is shown on page 359, has had t walls partly stripped off to show the internal structure. The walls ar a kind of papier mâché, to which the combs are connected by their edges All the combs are curved, and the cells open on the converse side of th curve. The nest is often upwards of two feet in length, with a circumfer ence of three feet at the lower part.

Katydids.

In reading stories by American authors who have laid their scenes in rural surroundings, one is sure to come upon references to the katydids and their shrill songs, whose sole burden is the reiterated assertion that Katy did something or other. As a rule we get no further. Every American reader knows so well what a katydid is that it is quite unnecessary for the writer to explain that katydids are several species of long-horned grasshoppers which agree in uttering sounds that resemble the words, "Katy did," with variations. The reader who knows the long-horned great green grasshopper[1] of the South of England, that sits in the bushes and pours out a succession of ear-piercing trills, will know in a general way what the katydids are like. The sounds in both cases are not vocal but purely mechanical, and are produced by the bases of the Insect's wing-covers. Riley says of this sound-production by one of the commonest species of katydid:—"The wing-covers are partially opened by a sudden jerk and the notes produced by the gradual closing of the same. The song consists of a series of from twenty-five to thirty raspings as of a stiff quill drawn across a coarse file. There are about five of these raspings or

[1] Locusta viridissima.

trills per second, all alike, and with equal intervals, except the last two or three, which with the closing of the wing-covers run into each other. The whole strongly recalls the slow turning of a child's wooden rattle, ending by a sudden jerk of the same; and this prolonged rattling, which is peculiar to the male, is invariably and instantly answered by a single sharp 'chirp' or 'tschick' from one or more females, who produce the sound by a sudden upward jerk of the wings." The katydid properly so-called[1] is a native of the Southern and Eastern States. The bright-green wing-covers are very leaf-like, and so long that the wings are entirely hidden. The antennæ are considerably longer than the entire length of the body. The female has a long, curved, sword-shaped egg-placer that is almost as long as her hind-body. The end of it is sharp pointed, and the lower edge is slightly toothed at this part. By means of this organ the slate-coloured eggs are placed in crevices of bark and the soft shoots of woody plants.

Photo by] [*H. Bastin.*

NEST OF MARABUNTER WASP.

The nest of a Brazilian species which is attached to a bough so that the single entrance is beneath. The cardboard-like material of the case is so solid that it is said the surface may be written upon with a fine pen.

But the commonest of the North American species is the angular-winged katydid,[2] and this is the species whose life-history has been closely studied and worked out by Mr. C. V. Riley, from whose account we have already quoted his reference to its notes. Its green, net-veined wings are long, and the shorter wing-covers are broad and of the same colour. The egg-placer of the female is very short and strongly curved in accordance with her habit of gluing her eggs to shoots instead of burying them in the ground or hiding them in crevices. This operation is performed mostly at night, and she begins by biting the bark of the selected shoot to make it rough and so afford a better hold for the eggs. There are many batches laid, from the beginning of September onwards, and altogether one female will lay from a hundred and fifty to two hundred eggs.

Towards spring the eggs swell up somewhat and lose their flat appearance. Early in May these hatch, and the young katydids emerge from the free end of the egg. In the act of hatching they cast their first skin, and leave it, a white, crumpled film, attached to the split egg-shell. Its body is now an eighth of an inch long, but with its hind-legs and its antennæ extended fore and aft, it measures half an inch

[1] Pterophylla concavus. [2] Orophus retinervis.

Photo. *J. Steb, F.L.S.*

LAULEE LEAF KATYDID.

[illegible] wing covers are veined in a manner that creates the impression that the katydid is part of the plant [illegible] that shows when at rest is coloured deep green. The photograph shows it on a scale of one-[illegible] the linear [illegible].

After a rest of about twenty minutes to allow full expansion of all its parts and the consolidation of its integuments, the little katydid begins to run around, to take leaps, and to exercise its jaws upon the vegetation. It remains in this larval stage for seven or eight weeks, during which time it again casts its skin three times. The third time (fourth including its moult in the process of hatching) is the end of the larval stage: with the assumption of its fifth skin it has become the equivalent of a chrysalis with incipient wings packed up in wraps upon its back.

At the end of this stage the nymph takes firm hold of a twig with its feet, and rests awhile. It feels that a change is coming, and waits quietly for it. At length the skin splits from the front to the back of the head, and then around the neck or division between the head and the trunk. This enables the Insect to get its newly clad head free from the old helmet, which slides off in front. Then with great care the long, thread-like antennæ are pulled out of their sheaths, the mouth-feelers assisting in the operation by pushing down the old nymph-skin. When these are quite free the Insect indulges in a short rest, as though temporarily exhausted by its exertions. It is soon ready, however, to renew its efforts, and does so by a series of jerks and contractions which impel the body forward, whilst the old skin is held in position by the second and third pairs of legs, their claws being fixed in the twig. "The most difficult part of the whole process seems to be the extrication of the front legs. This once accomplished, the katydid has something to grasp with, and experiences no further trouble in withdrawing the body and the remaining legs from the old integument, often leaving the latter, as an almost transparent shell, in perfect shape upon the twig. It is not allowed to remain long, however, as an object of curiosity, for almost the first efforts of the transformed Insect are directed to the task of eating up this, its outgrown and outworn garment."

Angular-winged Katydid.

The commonest of the North American species. It is coloured a leaf-green, and the wing-covers are veined like leaves. The wings are longer than the wing-covers, and the projecting portions are coloured to agree with the wing-covers. The photograph shows the actual size of the Insect.

There are other species of grasshoppers that are locally known as katydids in different parts of the United States, but their habits are much the same as those of the common one described. A very beautiful form is one from Florida, known as the laurel-leaf katydid,[1] and shown on page 363, whose wing-covers are fashioned and coloured to resemble the leaves among which it lives.

[1] Microcentrum laurifolium.

Ground-Beetles.

The numerous family of beetles so-named are to be reckoned among the best friends of the gardener and farmer, though it is to be feared that they are seldom treated as such. Something like thirteen thousand distinct species of the family have been named and described from all parts of the world, and in this country alone we have over three hundred representatives. It might be expected that in so large a family considerable variety of habits would be found; and it is so. The vast majority of them feed on animal food and hunt for it, attacking the living to obtain it, but not disdaining it if they find it already dead. But there are exceptions to this rule, and a few of them have been detected eating vegetable matter, such as growing corn, and several of them have been accused of a reprehensible weakness for ripe strawberries. Yet when we have made allowance for these few black sheep in an enormous flock, we may still regard the family as most valuable allies of the husbandman in all his variety.

The True Katydid.

This is the Insect whose constantly repeated call has earned for it a name, and given it a place in literature. It is a native of the southern and eastern parts of the United States. The upper example with closed wings is the male, the lower with spread wings is the female. It is only the male that says "Katy did," but the female makes a short answering chirp.

Most of the ground-beetles,[1] as their name indicates, live a subterranean life, and have become so habituated to it that they have ceased to develop wings. There are strong, hard, and to all appearance, well-finished wing-cases, but in the majority of species these only serve to protect the back in their burrowing operations, for the edges are united and they cannot be lifted to disclose the absence of flight-wings. When they are not actually underground they are no further away than the surface, where they run with great agility. In the tropics, however, there are a number of species that live among the foliage of trees, and these have well-developed wings, which they use freely. Some that keep much underground have shorter and stouter legs, more fitted for digging than running.

[1] Carabidæ.

The characteristic form of these beetles is neat and even graceful. As a rule they are black, or of some dark, inconspicuous tint that harmonizes with the surface when they are above-ground; but often their wing-covers are grooved, pitted, or shot with metallic lustre. In the genus[1] which gives its name to the family the fore-body and the wing-covers have a flattened margin, which is coloured golden-green or violet. The head, which is kept extended in front of the fore-body, is furnished with a pair of large, sharp-pointed mandibles, which will be found equally well developed in the active grub, which has predaceous habits similar to those of the mature beetle.

Some of the greatest pests to the market-gardener are those caterpillars of moths that feed only at night. Their work is plainly to be seen in the morning in the shape of leaves riddled or skeletonized, but a daylight search affords no clue to the identity of the destroyer. At the dawn of day he has retired into the earth or under the clods, with which his dirty-brown colour harmonizes. Here the ground-beetle or its grub may come across him; then the sharp mandibles will be brought into use, and the gardener will have one enemy the less. Of course, when he is digging and comes across ground-beetles or their grubs, he does not discriminate in their favour. He knows nothing of their habits, and regards their presence in the soil as evidence of evil intentions towards his crops. So wire-worm and ground-beetle—enemy and friend—share the same fate. Some of them abroad have been found to do good service by killing and eating locusts in their early stages. Others make a speciality of destroying slugs and snails, and in order that they may pursue the latter when they withdraw themselves well into their shells, the beetles have had their structure modified, the fore-body being narrowed and the head made long and slender to enable the jaws to reach the snail. One such[2] is fairly common in this country, among moss and dead leaves and under stones, in the places where snails are numerous (see page 268).

Photo by] [*H. Bastin.*

VIOLET GROUND-BEETLE.

A common garden beetle that renders good service by the destruction of root-feeding grubs. It is photographed as usually seen when it comes above-ground. Its black colouring gives violet reflections, and it is margined with a line of golden-violet. Its actual length is about an inch.

The beetles of this family that are best known to the public are the little sunshiners,[3] under which name several distinct species are popularly confused. If they are not familiar to the adult members of the population—who may have forgotten them—they are quite well known to the children, among whom survives a superstition that if one of these golden-glossed beetles be killed rain will inevitably fall. As the children are advocates for perennial sunshine the active little beetle is always allowed to go free. These beetles appear to differ from the great majority of the family in being at least partially addicted to a vegetable diet.

[1] Carabus. [2] Cychrus rostratus. [3] Amara

BOMBARDIER-BEETLES.

[illegible] little bombardiers, so called from their power to produce a report accompanied by a bluish vapor when pursued by an enemy. [illegible] contact with the air. In the photograph which is not from life two bombardiers are being pursued by the violet ground beetle, [illegible]

Among these ground-beetles are a number of cave-dwellers[1] found in the great caverns of Europe and North America. These, having no occasion for sight, are blind, and some of them have lost not only their eyes but the optic nerves as well. But the loss of sight appears to be compensated by a finer development of the sense of touch, for they are fully as active as those that have sight. Other blind beetles of this family are found living under deeply imbedded stones, and have never been found above-ground. We have a native genus[2] whose members live under stones and in deep crevices, and some of these show great diminution in the size of the eyes. Two other of our native species[3] live under stones on the seashore, between tide-marks. As the tide comes in they do not trouble to run up the shore out of its reach; they merely retire under stones and allow the water to cover them. This behaviour is made possible to them by the possession of a couple of air-sacs within the hind-body which hold a sufficient amount of air to sustain their respiration until the tide goes out again and sets them free to prey

Photo by] [*P. H. Fabre.*

THE GOLDEN GROUND-BEETLE.

This beetle is common in France—where it is known as the gardener—whence it often makes its way to English markets in crates of vegetables. Like the other of its family, it is voracious, and destroys large numbers of noxious insects in fields and gardens. Other inhabitants of the soil also fall victims to it, as in this case, where a party of "gardeners" have set upon a large earthworm and are tearing it to pieces.

upon certain little sea-snails they find among the seaweeds that have been washed ashore.

One of the finest of the members of this family is a beetle which, borrowing from its scientific name,[4] we may call the beautiful searcher. It is rare in this country, but is found in the New Forest and a few other localities. It is broad in proportion to its length, and of a beautiful dark bronzy-green or violet-black; the wing-covers each bearing three rows of minute pits, and having the remainder of the surface delicately grooved in two directions. Owing to its rarity here we cannot claim for it that it is a very valuable member of the British fauna; but on the Continent an allied species is more abundant, and its activity in the interest of the timber-grower is so patent to all that it is acknowledged, and care is taken not to destroy it. It haunts the oak- and pine-woods, which suffer so severely from the attack of the caterpillars of the processionary moths[5] that large numbers of trees are absolutely killed through the loss of their foliage. The caterpillars

[1] Anopthalmus. [2] Trechus. [3] Aëpus marinus and A. robinii. [4] Calosoma inquisitor. [5] Cnethocampa.

of this moth spin an extensive web of silk on the trunk, under which several hundred of them pass the day, marching out in procession in the evening to feed upon the leaves of the tree. The grub of the beautiful searcher is an active creature, something like a lady-bird grub, dark coloured and flat backed when not overfed. This grub searches for the tents of the processionary caterpillars, and entering behaves like a wolf in a sheep-fold. Caterpillar after caterpillar he attacks with his sharp jaws, and gorges until his skin is inflated and tight. If several of the beetle-grubs have got into the same tent there may come a time when all the caterpillars have been consumed. Two searcher-grubs may be making a meal of the last caterpillar, and when it is finished the larger or stronger of the beetle-grubs may finish by eating his brother.

One other species of these ground-beetles must be mentioned, because it affords an illustration of one way in which many useful Insects are protected from more powerful enemies. This is the little bombardier-beetle,[1] quite a small member of the family measuring only 10 mm., if we leave legs and antennæ out of the account. Its head, fore-body, legs, and antennæ are brick-red; the wing-covers, which only hide two-thirds of the dusky hind-body, are blue-black. It is found lurking under stones on river margins and seashores. Nothing very definite appears to be known as to its ways of getting a living, except that it is said to attack other Insects, like most of its family. Without having had any opportunity for observing it in its haunts (it is a very local Insect), we venture the suggestion that it will be found to feed principally upon snails. The suggestion is based entirely upon its build. The hind-body is narrow and almost cylindrical, the fore-body and head not more than a third of the width of the hind-body, and appear to be planned for their insertion into snail-shells. But the peculiarity that has made the bombardier famous and given it both popular and scientific names, is its power of producing mimic explosions accompanied by a smoke-like vapour of evil odour. Most of the members of the family have glands at the tip of the hind-body from which when attacked

Photo by] [*E. Step, F.L.S.*

BIG-HEADED BROSCUS

A common ground-beetle of more robust build than the species of carabus. Its less graceful appearance is due to the breadth of the head and fore-body. Its colour is a uniform black, and it is represented four times the size of life.

[1] Brachinus crepitans.

they eject a caustic and ill-smelling fluid, with the object of disgusting a pursuer. In the case of the bombardier, this fluid rapidly volatilizes on exposure to the air, and goes off as a bluish vapour. Its emission is accompanied by a cracking sound. Dufour describes the odour as similar to that of nitric acid, and says that litmus paper reddens on being exposed to its fumes. One can imagine the effect produced on its pursuer by such a discharge, which can be repeated. Cooper, quoted by Stephens, has recorded that one specimen "performed the operation no less than thirteen times in rapid succession"; and Rolander says it is capable of twenty discharges. The volatile fluid if brought into contact with the human skin causes a burning sensation, and makes a red mark, which afterwards turns brown.

Photo by] [*E. Step, F.L.S.*

BEAUTIFUL SEARCHER.

One of the prettiest of the ground-beetles, but unfortunately rare in this country. In both grub and perfect stages it preys upon noxious Insects. An allied species on the Continent wages war upon the destructive processionary caterpillars. Twice the natural size.

Mosquitoes and Gnats.

When a townsman goes into the country and takes a rest on a flowery bank, he sometimes gets bitten by a gnat. The part of his anatomy selected by the Insect for experimental borings is usually either the ankle, the temples, or the back of the neck. The so-called "bite" of the gnat is a stab from a stiletto, and the instrument being perforated the Insect is able to suck a drop of blood through it. The stab itself is nothing—a mere pin-prick, but the Insect appears to inject a minute drop of some liquid, probably for the purpose of thinning the blood and making it flow more freely. But with some temperaments it does more than this—it produces a smarting, burning sensation, and around the puncture the flesh may swell up into a large inflamed bump. When there are symptoms such as these the victim is assured that he has not been bitten by an ordinary common gnat—it must have been a mosquito, such as one reads of in books of foreign travel. No British Insect could be so malignant! To such a sufferer the statement that the Insect sometimes dies as the result of its indulgence in human blood will be read with satisfaction—it is so like the finale of Goldsmith's *Elegy* on the dog who "to gain some private ends, went mad and bit the man." In the result we know on good authority that:—

"The man recovered of the bite;
The dog it was that died."

Even man may have in his blood some microbe that is deadly to blood-sucking flies as well as to dogs. Naturally, we only look at the matter from our own point

THE GRUB OF THE COMMON GNAT.

In the first photograph the grub is seen floating to the surface of the water to take in a fresh supply of air. In the second photograph the hinder extremity is shown on a larger scale, exhibiting particularly the breathing-tube, which is thrust into the air. Through its tissues will be seen the channel through which air passes to the air-tubes, which extend throughout the body.

of view; but it is possible that some of us who are badly tormented by Insects may in return cause serious mortality among our little persecutors.

But the point we wished to make plain is this—that gnats *are* mosquitoes, and that mosquitoes are only gnats translated into Spanish. This will be unconvincing to the people who think it is more interesting to be bitten by mosquitoes than by common gnats; just as they would be rather pleased to tell you they suffer from arthritis, but are ashamed to confess to so vulgar a complaint as gout! Let it also be understood that these terms—gnat and mosquito—are general, like butterfly and moth, and do not indicate any particular species. We have in this country alone about a dozen species of gnat, and they do not all belong to one genus, or even to the same family. From the popular point of view it is unnecessary and rather absurd to distinguish between species of flies that appear so much alike that only specialists can separate them; but there are marked differences in the early stages.

Photo by] [*H. S. Cheavin, F.R.M.S.*

HEAD OF FEMALE GNAT.

The head of the female is here shown on a scale of thirty times the actual size. The sucking extremity of the long proboscis is shown, with the accompanying lancets by which the incision in the victim is made.

The common gnat[1] has an aquatic grub about a third of an inch long, with a swollen fore-body and a long, slender hind-body of nine segments, but no legs. It has the peculiar habit of hanging, as it were, from the surface-film of the water, head downwards. It is enabled to do this—in spite of its being heavier than water—owing to its possession of a tube which starts off at an angle from the eighth segment, and ends in five flaps. This tube is in connection with the internal air-tubes, by means of which Insects get their blood supplied with oxygen. When the gnat-grub dives into the depths of its stagnant pool or water-butt, the tube is closed by the five flaps meeting in a point; but when it is feeding head downwards at the surface the flaps are spread out and lie upon the surface, in such manner that they form a shallow funnel which at once admits air for respiration and buoys up the grub. The head bears a number of delicate lashes by whose movements microscopic food is directed to the mouth.

After incessant feeding and several changes of skin, the grub becomes a chrysalis. It now bears some resemblance to a minute tadpole, for its head and fore-body are conjoined like the head and body of the tadpole, whilst the long, slender hind-body of the gnat resembles the tail of the tadpole. The gnat-chrysalis has what may more fitly be called a tail consisting of two lobes at the end of the hind-body, which

[1] Culex pipiens.

it uses as paddles for propelling it through the water. There is no longer any air-tube at this end of the Insect, but from the back of the large portion there stands out a pair of curved trumpet-like tubes which serve the same office. The reason for the removal of the respiratory tubes from one end to the other is that this is the part of the chrysalis that comes nearest to the surface of the water. Another reason will appear directly.

When the wings of the future gnat are formed within the chrysalis-skin, the hind-body is extended and laid along the surface. Then the skin between the two trumpets splits and the fore-parts of the gnat emerge. The chrysalis-skin becomes a boat, and the critical operation of emerging from it in an erect position without the use of legs or wings is undertaken. A slight puff of air would blow the gnat over and probably make a fatal ending to the performance. But usually the legs are withdrawn successfully, a pair at the time, and rested on the water; the wings are spread and dried, and the hind-body is withdrawn from the boat. After a short rest the fully-developed gnat is able to join its companions in flight. But it will be seen that unless the position of the breathing-tubes had been changed when the Insect became a chrysalis, this delicate final metamorphosis could not have taken place.

This is the common gnat of which one or another species is found nearly all over the world, and is the true mosquito. The sexes are easily distinguished by the fact that the female has comparatively simple, thread-like antennæ with short side-branches, whilst those of the male are distinctly bushy with frequent whorls of very long branches. The female gnat in preparing for the continuance of the species stands on the water with her fore-legs resting on some slight floating support, and her hind-legs crossed behind her. Into the angle thus formed she deposits her glutinous oval eggs to the number of about a couple of hundred. They all stand

Photos by [*A. Leal*

GNATS.

In these two photographs the distinctions between the sexes are shown clearly. The upper figure is that of the male with heavily plumed antennæ, and longer and more slender hind-body. The comparative simplicity of the female antennæ is evident in the lower figure. The attitude of the legs is not natural, but dictated by the necessity of getting them into the small field of microscopic vision

erectly and adhere one to another, so that finally they form a tiny, boat-shaped mass, which floats safely on the water, and the emerging grubs, a few days later, have only to push open a sort of trap in the floor to find themselves in the water.

The proboscis or piercing and sucking organ of the gnat is to the unaided eye a simple instrument, and we have spoken of it as a stiletto; but viewed through the microscope it is seen to be anything but simple in its structure, for it has no fewer than seven separate parts. Two of these are the lengthened upper and lower lips, which form a protecting case for the more delicate cutting needles. This outer sheath does pierce the skin, but having a sort of knee-joint it partly doubles up to allow the needles to enter, whilst by pressing its lobed tips against the skin it steadies the action of the other parts, which are a modification of the jaws of biting Insects. Now the reason why the male gnat or mosquito does not attack man and other animals is not necessarily that it is of more peaceful disposition, but rather that it has not the power—the piercing and cutting implements are undeveloped.

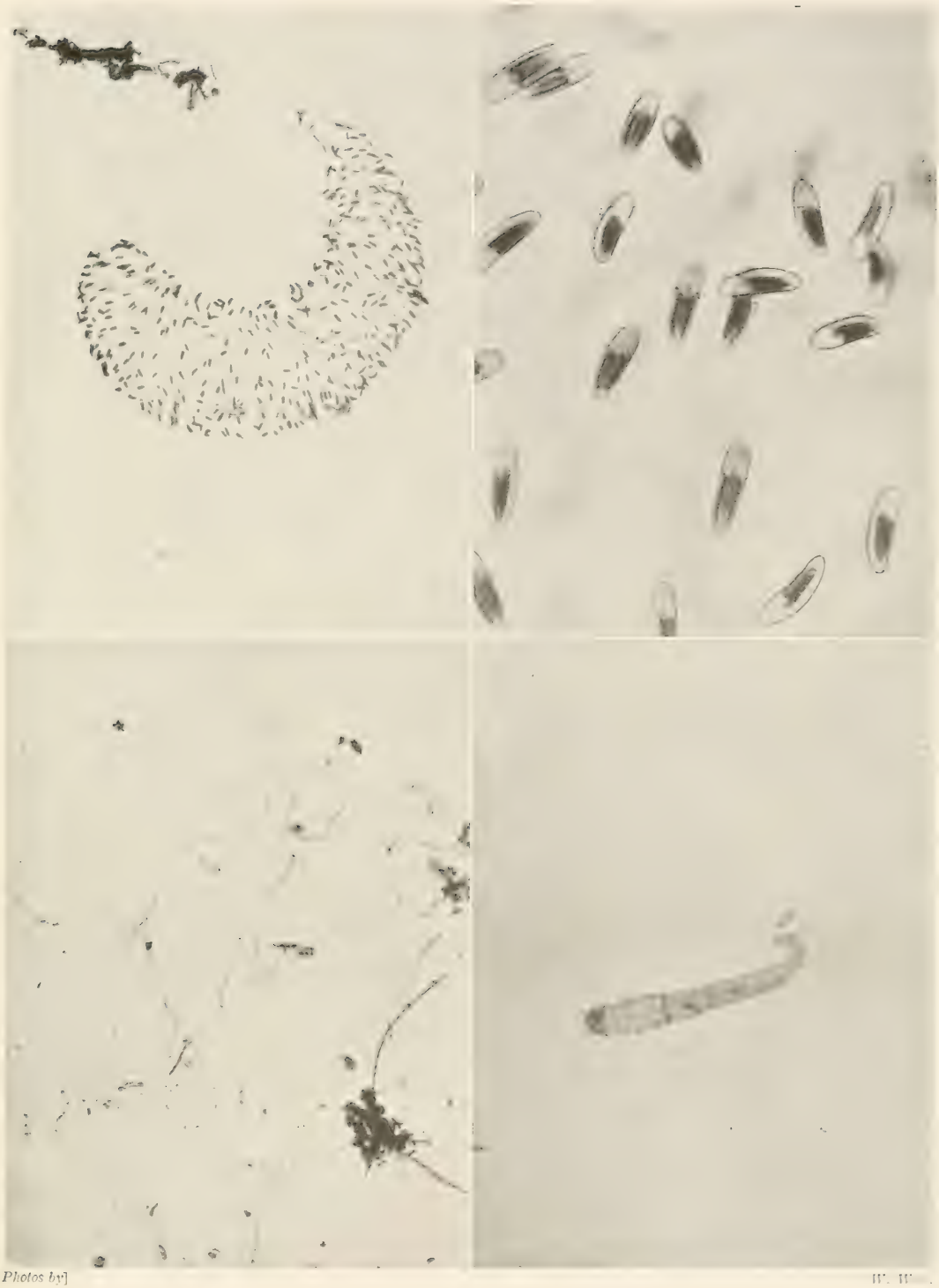
Photo by [*H. S. Cheavin, F.R.M.S.*

THE GNAT EMERGES.

When full development is almost reached, the gnat-chrysalis floats, back upwards, at the surface, and its skin splits behind the head. The gnat wriggles partly out, gets its legs out, and balancing itself on the tips of these, withdraws its long wings and the hind-body. It has to maintain itself in this precarious position until its parts are sufficiently firm for flight. Magnified about ten times.

Although our common gnat can make itself exceedingly unpleasant through the irritation and disfiguring swellings produced by its blood-sucking, it has not yet been detected as a carrier and transmitter of disease; but a member of the same genus,[1] the brown mosquito so prevalent in Southern India, is the transmitter of elephantiasis. Several allied species, but belonging to another genus,[2] are the carriers of malaria, which they accomplish by sucking up the germs with the blood of an already afflicted person, and inoculating a healthy person with them when they take another meal. The parasite runs through its course of development in the body of the anopheles mosquito and stores the Insect's salivary glands with a fresh stock of germs for dissemination.

[1] Culex fatigans. [2] Anopheles.



Photos by] W. W.

EARLY HISTORY OF THE HARLEQUIN-GNAT.

The female chironomus deposits her eggs in a mass attached to a water-plant. By the absorption of water this soon becomes a little blob of jelly, as shown in the first photograph, enlarged twelve times. A few separate eggs are shown on a larger scale in the second photograph. In the third, the eggs have hatched, and the tiny bloodworms issued from them are seen magnified twelve times. The last photograph shows a single newly hatched bloodworm seventy-five times its actual size.

Photo by] [*E. Step, F.L.S.*

THE CACIQUE.

The huge wings, which span six and a half inches from tip to tip, are coloured deep blue with white spots. They are highly polished and give brilliant reflections. The photograph is one-fifth less than natural size.

Another genus [1] includes the mosquitoes that are necessary agents in the propagation of yellow fever, which can only be transmitted by their unconscious aid. Here an interval of twelve days is necessary between the biting of a fever patient and the attack upon a healthy person, and during that period the germs absorbed pass through certain stages which make the mosquito an efficient distributor of the disease to all whose blood it samples. It was the discovery of the facts concerning this species that enabled the United States Commission to extirpate yellow fever from Cuba, and a few years later the experience thus gained made the completion of the derelict Panama Canal works possible. It was a case of Gulliver against the Lilliputians; but no military conquest recorded in history is fit to be compared with it. The French Panama Company had from fifteen to eighteen thousand labourers at work, and annually lost between sixty and seventy per thousand from yellow fever and malaria. At length, after fifty millions of money had been spent, the task was abandoned as impossible under such difficulties. Recently, Colonel Gorgas, with the experience gained in Cuba and the assistance of a staff of reliable helpers, cleared up the belt of land through which the canal was to run, abolishing the breeding places of the gnat, screening every water-vessel, and fumigating every house with sulphur and pyrethrum-powder. The enemy, whose minuteness and abundance made its conquest to appear an impossibility, was routed. Yellow fever became practically extinct in that region, and the Panama Canal is an accomplished fact.

The victory over the malaria-gnat was, in a sense, more difficult, because its early stages are passed in clean water which, of course, cannot be sacrificed. But it is more under control because the gnat rarely flies farther than two hundred yards from its breeding pools; and if the inhabitants are dosed with three grains of quinine per day, their blood is rendered poisonous to any malaria germs that may get into it.

[1] Stegomyia.

Commonly confused with the gnats are the harlequin-flies,[1] whose aquatic grubs are well known as "bloodworms" in stagnant waters and the mud-banks of rivers. The perfect fly may often be seen flying up and down our window-panes; and when at rest it may easily be distinguished from a true gnat by a trick it has of raising its first pair of legs from its support. The true gnats commonly raise the hind-legs under similar conditions. The eggs are laid in gelatinous masses, as shown on page 375, attached to anything at the margin of the pond. From these hatch out very minute "bloodworms," which ultimately attain a length of about an inch, and are distinguished from ordinary gnat-grubs by their blood-red colour.

Butterfly Beauties.

Among the grandest of the known forms of butterflies are the members of a genus that is confined to Tropical America. Fabricius more than a hundred years ago named this genus morpho, to indicate their beauty of form. To beauty of form are added brilliance of colour and magnificence of size. Although in expanse of wing measured from tip to tip they are surpassed by the bird-winged butterflies of the eastern tropics, in total wing area there is not much difference, for whilst the bird-wings have these organs long and narrow, in the morphos they are very deep. But in proportionate expanse of wing relative to the size of the body, whose muscles have to work and control those wings, the morphos take the first place.

Photo by] [*Step, F.L.S.*

THE DIDIUS.

The colouring of this species—which measures six inches across the fore-wings—is a beautiful pale blue with darker margins to all the wings.

[1] Chironomus.

The prevailing tint of the morphos is a brilliant sheeny-blue of varying shades on the upper surface of the wings; but on the under sides we have various tints of brown and white, to render the Insects less conspicuous when they are at rest with the upper sides pressed together over the body. Some of them have longer wings than others, and these are noticeably high-flyers, habitually taking altitudes between twenty and a hundred feet above the earth. Those with deeper wings fly lower, and even descend to the ground to suck the juices of ripe fruit that has fallen. The high-flyers never descend to the ground.

The life-history of these Insects may be very briefly indicated generally, as it is impossible here to enter upon a description of the fifty or so species individually. The eggs are globular and translucent, smooth or with slight ornamentation of the

Photo by] [*E. Step, F.L.S.*

THE MENELAUS.

A Brazilian species measuring six inches across the fore-wings. All the wings are entirely blue, with the exception of the inner margins of the hind-wings, which are brown. The smallness of the body in comparison with the wing area is specially noticeable in this and the next photograph.

surface. The caterpillars are in shape much like those of our purple emperor, with a forked tail, and the head divided in the middle. Some of them are conspicuously coloured with red, yellow, black, and white, and clothed with spines. These colours are doubtless of the nature of warnings to birds that they are not palatable; for although night-feeders, they congregate in open positions in the day, as though conscious that their vivid colours will protect them from interference. A further protection is found in the spines, which break off and enter the skin when the caterpillar is carelessly handled. How secure they are in their exposed resting positions is shown by the fact that the caterpillars of a common Brazilian species[1] will congregate in a cluster of a hundred or more on the trunk of a tree, and those

[1] Morpho achilles.

Photos by] *[E. Step, F.L.S.*

THE VENUS

Though smaller than the foregoing species, this Central American morpho is quite as beautiful, the upper side being a brilliant glossy blue, with bands and spots of white. The under side, shown in the lower photograph, is a fine combination of spots, blotches, and rings in chocolate and white. From tip to tip of the fore-wings the measurement is five and a quarter inches.

of another species[1] hang together as a red bunch on the twigs of their food-plant. They change into stout, oval chrysalids with divided heads.

Although these butterflies are highly esteemed in collections for their size and magnificent colouring, and have consequently been much hunted by assiduous collectors, Kaye says that some of the woods—the morphos are purely forest Insects—in South Brazil teem with them, just as Bates described them at the time of his exploration of the Amazons country to the north. The latter says: "Morphos are among the most conspicuous of the Insect denizens of Tropical American forests."

We will content ourselves with brief notes on the species whose photographs appear as illustrations. The difficulty in referring to them is that they have no popular names; but as the scientific names are mostly derived from those of persons,

Photo by] [*E. Step, F.L.S.*

SULSKOWSKY'S BUTTERFLY.

The beautiful under side of this comparatively small morpho is shown in this photograph. Its colouring consists of a marbling of pale brown and brownish-white, diversified with ring-spots. The upper side is pearly pale blue, with brown tips to the fore-wings and little tails to the hind-wings. It measures four and a quarter inches across the fore-wings.

real and mythical, these will be more or less familiar words to the general reader.

The Venus[2] is a Central American species which measures five and a quarter inches across the spread fore-wings, which are of a brilliant glossy blue with a broken band of white across the middle and a line of six smaller white spots between it and the hinder edge of the wing. The hind-wings are of similar colours, but here the white band is unbroken and the smaller spots are more or less crescent shaped. The under side is a beautiful arrangement of irregular spots, blotches, and eye-marks in pale chocolate and white. The cacique[3] measures six and a half inches across, and is of deep blue with a row of white spots near the margin of the fore-wings; whilst the inner margins of the hind-wings, which lap the body of the butterfly,

[1] Morpho epistrophus. [2] M. cypris. [3] M. cacica.

are brown. The didius[1] measures six inches, and is almost wholly of a beautiful "moonlight" blue; the exception being the dark-coloured margins of all the wings and the brown inner border of the hind-wings. Menelaus[2] is similarly self coloured without the dark outer border, but the inner margins of the hind-wings are brown. Sulskowsky's morpho[3] is comparatively small, measuring little more than four inches across. It is of the pale blue suggestive of mother-o'-pearl, with brown tips to the fore-wings, two little tails to the hind-wings, and two red dots above them. On the under side it is marbled with pale brown and brownish-white, and has several conspicuous eye-spots. The ega[4] is a Colombian species, measuring four inches and a half, and is purplish-blue.

Pond-Bugs & Sea-Skaters.

Everybody knows the slender little bugs known as ditch-skaters[5] that flit over the surface of fresh-water ponds and ditches with the motion of a racing skiff with outriggers, except that it is spasmodic instead of being continuous; but it is not so well known that there are closely related species who spend their lives on the not always tranquil surface of the ocean. The ditch-skaters are remarkable for their long, narrow bodies, and their long, thread-like legs, which make some of them look like spiders skimming the surface of the pond and never getting wet.

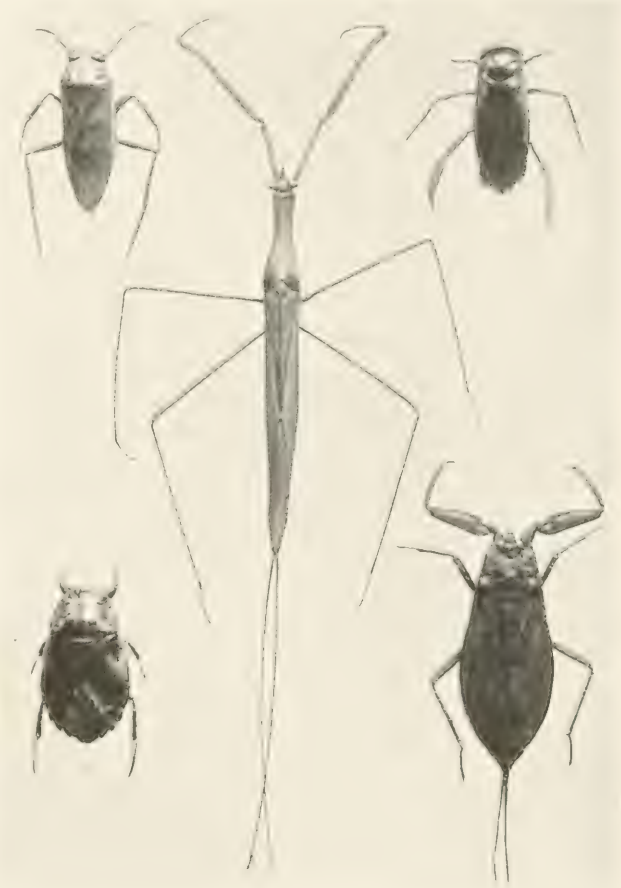


Photo by [*H. Bastin.*

A Group of Pond-Bugs.

In the centre is what we may call the stick-Insect of the pond, though it is not related to the stick-Insects proper. Above, to the left, is the well-known boatman. In the opposite corner is the equally common but flat-backed corixa. Another common species is the naucoris, in the lower left-hand corner; and opposite to it is the familiar water-scorpion.

The first pair of legs are very short in comparison with the second and third pairs; and the object of the difference is to provide a pair of limbs with which the skater can take hold either of a water-plant or of its prey. The middle pair cover a considerable extent of water surface, and they help materially to buoy up the body, and by their action row it along. The hinder pair do this also, but they are held in a more backward direction and are used more for steering. The whole of the Insect, legs as well as body, is covered with a fine velvety down, scarcely

[1] Morpho didius. [2] M. menelaus. [3] M. sulskowskyi. [4] M. ega. [5] Gerris.

visible to the unassisted eye, which holds a film of air and so prevents the Insect getting wet, even when submerged. A section made across the hind-body would show that it is boat-shaped, the sides being continued slightly over the back to form bulwarks as it were.

SEA-SKATERS.

These remarkable little Insects—actually only half the size of their photographs—live entirely on the surface of the ocean, often many hundreds of miles from the nearest land.

In one species, known as the water-gnat,[1] the general form is much like that of a stick-Insect on a very small scale. One-third of the entire length of the trunk consists of the head, which is drawn out to an inordinate length, and the eyes arise from the hinder half of the head. All its legs are long, and its antennæ are proportionate to them; so that the superficial likeness to a stick-Insect is complete. Two of these skaters will be found illustrated on page 162.

Built on somewhat similar lines to the ditch-skaters, but very much larger, is the ranatra,[2] which might well be passed over as a length of broken reed-stem. It is not in the habit of skating over the surface, but lies quietly below with its long respiratory tube reaching to the surface, and for short periods ranges along the bottom in quest of food, mainly the grubs of other Insects. A near relation is the very dissimilar water-scorpion, and another is the gigantic belostoma, with whose histories and habits we have already dealt (see pages 24 and 161).

Photo by] [*E. Step, F.L.S.*

GIANT WATER-BUG.

This huge Insect, allied to the water-scorpion of our ponds, is a rather formidable native of South America and Trinidad, which catches fishes and frogs with its mantis-like fore-feet. Natural size.

What one may call the sea-skaters[3] more nearly resemble gerris than they do the last-mentioned; but the hind-body is so greatly abbreviated as to look as though the major part of it had been bitten off by some other denizen of the deep. A number of species are known from various parts of the ocean surface, where it gets sufficiently warm for Insect life; but so far no species have been found

[1] Hydrometra stagnorum. [2] Ranatra linearis. [3] Halobates.

[*By Theo. Carreras.*

THE STICK-INSECT OF THE POND.

Floating on the surface of the pond is the [illegible] and for similar purposes. The terrible [illegible] with [illegible] a strong contrast with the former species, though closely related. They are engaged in seizing nymphs of one of the mayflies. All the Insects are shown twice the natural size.

with wings, so that they may be presumed to spend their entire existence, generation after generation, on the surface of the sea, often many hundreds of miles from the nearest land. Their eggs have been found attached to a floating bird's feather, pumice, and cuttle-bones, but in some cases the female carries her eggs about until they hatch. The *Challenger* naturalists were constantly finding these sea-skaters in the towing nets, both in the Pacific and Atlantic Oceans. They are sometimes found on shallow water near the shore. They are believed to shelter from storms by retiring to a sufficient depth to be clear of the agitation of the surface waters.

Just as the pond-skaters get a living by sucking the juices of aerial Insects that have had the misfortune to fall into the pond or ditch, so the

Photo by] [*H. Main, F.E.S.*

LACE-WING FLY.

These exceedingly graceful and delicate Insects are among the most valuable of the gardener's allies, laying their eggs where the green-fly are thickest, that the resulting grubs may feed upon the pest. The wings are green and lace-like, and the conspicuous eyes brilliant. Slightly enlarged.

sea-skaters are believed to subsist chiefly upon the juices of small animals recently dead that float upon the surface of the sea. Also like the pond-skaters, they are found in little companies on the sea. But the nearest approach in form to the sea-skaters among fresh-water bugs is supplied by a species native of North America and the West Indies,[1] whose hinder legs suggest a distinctly gouty tendency, as indicated in its scientific name. In this species the middle pair of legs are of great length, and the first pair very short. The antennæ of the male are developed into prehensile organs with which to hold the female. The species whose photograph appears on page 382 is Mullenstorff's sea-skater.[2]

[1] Rheumatobates bergrothi. [2] Halobates mullenstorffi.

Lace-wing Flies.

Among the familiar objects of what we may term garden entomology, one of the best known is the green lace-wing fly or golden-eye. It is not a fly in the true sense—a creature with two wings only—for this has four, and they are nearly equal in size. It is more nearly akin to the ant-lion fly, the caddis-fly, and the dragon-fly, than to the house-fly and the hover-fly. It will be noticed that the wing is weak in structure and not capable of powerful flight, there being only one strong nervure, just within the front border. Although the rest of the wing is entirely covered with a network of fine veins that has suggested the appropriate name of lace-wing, there is nothing sufficiently substantial to indicate swift or prolonged flight. So we find the lace-wing fluttering silently through the air as lightly as a snowflake. The common species,[1] to which we particularly allude, is a delicate green in colour, the wings transparent and shining, but the most striking features are the prominent eyes, which to appearance are of shining gold. From this circumstance the Insect is also known as the golden-eye. There are a great number of species known, and of these fifteen are natives of Britain, but the differences between them are such as appeal more to the specialist than to ordinary readers, and a statement of the life-history of the common species will apply generally to the group. Some of the species give off a very unpleasant odour, which has earned for them the alternative name of stink-flies.

Photo by] [*H. Main, F.E.S.*

THE GRUB OF THE LACE-WING.

This active little creature has a fine pair of sharp-pointed jaws with which he impales many green-fly and through which he sucks them dry. This beneficent activity continues for a month. Three times the actual size.

The eggs of the lace-wing are laid in an extraordinary manner, so that few persons seeing them for the first time would imagine they were what they really are. They are like the finest conceivable of entomological pins, half an inch long, with seed-pearls for heads. The early naturalists, indeed, imagined they were the fruit of some kind of moss, and classified them as such. In most cases they are sufficiently far apart to keep their stalks quite distinct, but in some species they are so close that the stalks unite. The lace-wing will at times afford us a demonstration of the way in which these remarkable footstalks are contrived. When about to lay, the tip of her hind-body is brought into contact with the leaf or shoot she has selected, and a minute globule of gum is attached. Then, elevating her body to the full

[1] Chrysopa perla.

extent possible, the gum is drawn out into a thread of gossamer, which hardens on exposure to the air, and becomes stiff enough to support the egg, which she attaches to its extremity. In so doing, she is doubtless taking precautions against her eggs being eaten by some other Insect, it may be against the grubs of her own kind, for they are all of a voracious character and are not free from the imputation of cannibalism. It has been noted that, where the eggs are sufficiently close together, the first hatched-out grub will cling to its egg-shell and watch for the emergence of its brothers and sisters, catching and eating them as they appear. In the ordinary way the grub crawls down the hair-like stalk of the egg, and finds itself quite close to a flock of green-fly.

The grub is, roughly speaking, not unlike the lady-bird grub in shape, with six active legs and a somewhat flattened body. Its jaws are so constructed that when not in use they may appear to be four in number, but for practical purposes the two parts on each side of the mouth unite to form a sharp-pointed tube. The grub impales a succulent green-fly between the points of its jaws and sucks, when the whole of the green-fly's contents are drawn into the mouth through these tubes and the empty skin is cast aside. These jaws are hard worked, for the life of the grub is passed in a continuous picking up of green-fly, emptying them, and casting away the empty skins. With this constant supply of food, our grub increases in size rapidly, and twice it has to cast its skin to get one allowing of greater expansion, until, in less than a month from its emergence from the egg, it reaches the limit of its growth, and sets about arranging for its future state. It seeks a suitable crevice, and there fabricates a silken ball or cocoon just large enough to contain itself. In this it lies without change all through the winter, and not until the spring does it cast off its last grub-skin and enter upon the chrysalis stage. The marvel is that in the confined space it should be able to get free from its old integuments. As it is, the chrysalis is packed up in what looks like a very uncomfortable position, and if one did not know one might imagine that in the final stage the Insect was bound to be a cripple. The legs and wings and long antennæ are not all fixed up in a general wrapper and immovable as in moth chrysalids, but are separately cased and folded along the front of the body. A remarkable feature is the provision of a pair of jaws which are different from those it possessed as a grub, and different from the mouth-parts of the perfect Insect. They are indeed temporary developments to

Photos by] [*H. Main, F.E.S.*

COCOON AND CHRYSALIS.

The lace-wing grub, having finished its course as a destroyer, spins a cocoon in which it passes through the winter still in the grub stage and becomes a chrysalis in the spring. In the latter condition it is provided with a pair of jaws specially for cutting off the upper end of its cocoon before the emergence of the complete lace-wing fly. Three times the actual size.

Page [illegible] — *H. Moss, F.E.S.*

Page [illegible] — *F. Step, F.L.S.*

EGGS OF LACE-WING FLIES.

The egg-laying of the lace-wing flies is a most [illegible] character. Each egg is attached to the summit of a hair [illegible] and [illegible] the [illegible] appear [illegible] quite separate [illegible] in the first of these photographs. In the second photograph, of another species—the hairs coalesce in their lower part, which causes the eggs to come close together. In the latter [illegible] could be seen through the egg-shell.

Photo by] [*H. Main, F.E.S.*

LACE-WING FLY.

Having escaped from the chrysalis-skin, the lace-wing fly seeks some place where it can hang vertically until its wings have fully expanded and hardened, before attempting flight. One and a half times actual size.

be used once only and then abandoned. A little before the lace-wing fly is ready for emergence from the chrysalis wraps, these jaws become operative, and the chrysalis cuts with them cleanly, nearly all around one end of its cocoon, leaving a small uncut bit to serve as a hinge to this lid. Then it pushes up the lid, and still a chrysalis, crawls out into space, where it can straighten its doubled-up body. It uses its legs, and with them clings to some vertical surface where its body and wing-buds can hang down. This is an essential item in its proper development, to allow the fluids of the body to flow down into and expand the wings; but first the chrysalis-skin has to be split, and the mature Insect walks out. It retains the vertical position until all its parts have attained to full expansion, and are sufficiently hardened to permit of flight.

Horned Beetles.

Some of the most striking among the multitudinous species of beetles owe their conspicuousness to a sort of copying of the antlers of deer, antelope, and rhinoceri. Of course, regarded from a structural point of view, these growths are in no sense homologous with those of the four-footed beasts that they call to mind. In some cases the antler-like growth is an excessive development of the jaws, as in our largest native species—the stag-beetle.[1] In other species, which are suggestive of the rhinoceros, the jaws have nothing to do with this counterfeit resemblance, one horn being sometimes an outgrowth from the front part of the head, and another, or perhaps others, from the fore-body, which is sometimes so greatly developed forward as to make the head appear very small by comparison, or scarcely to appear at all.

It is noteworthy that these enormous growths are, as a rule, restricted to the male sex; and this led years ago to the confident generalization that they were sexual in purpose—that by means of them the male beetle was in the habit of

[1] Lucanus cervus.

detaining an unwilling female. So far as our stag-beetle is concerned that was a reasonable explanation, and it was backed by the assertion of some observers that they had seen the great jaws so employed. The reason for its being reasonable is that the jaws move freely in a horizontal plane, and can be used to hold a female in their grip. But in many others the horns are more or less vertical in position, and moreover are fixed outgrowths from the head and fore-body. The small amount of movement possible to the head is not sufficient to be of any value in this connection; whilst even if the tips of two horns of this sort could be brought together, their polished and tapering ends would prevent the holding of anything between them. A notable example of horns vertically opposed is seen in the Hercules beetle, whose portrait is reproduced on page 1. The well-known European rhinoceros-beetle [1]—which, by the way, is not nearly so good a rhinoceros as some of the tropical species of copris—illustrates the apparent uselessness of the horn by arching backwards from the front of the head over a scooped-out area of the fore-body; and there are many examples of a similar arrangement of these ornaments.

Several of the photographs we give as illustrations show that, in most cases, these growths do not offer suggestions of any way by which they could be useful, either for holding females or for fighting other males for the possession of females. It is true that the North American stag-beetle [2] is stated to use its horns in courtship, and there seems no reason why our native species should not do the same. So also might the splendidly armed chiasognathus (see page 4) of South America, whose jaws exceed the combined length of head and body, and are set with sharp teeth all along the inner margins—the fore-legs having a similar armament. This beetle has the reputation of being pugnacious, and prone to open wide his jaws in presence of a possible foe, but Darwin found on putting his finger between them

Photo by] [*E. Step, F.L.S.*

HEAD OF A WOOD-BORING BEETLE.

In this example of a horned beetle, the "horns" are due to a great development of the jaws. The antennæ also are so long and stout that they merit the popular term horns, so frequently applied to antennæ. The photograph is nearly four times larger than life size.

[1] Oryctes nasicornis. [2] Cervus elephas.

that their muscular power was not sufficient to inflict any pain. The jaws of the female are quite small in comparison.

Until naturalists have devoted more attention to the habits of the great horn-bearing beetles of other countries, which *may* throw some light on the uses of these outgrowths, we are compelled to regard them as being merely sexual adornments for the purpose of gratifying the æsthetic sense of their females. One might easily imagine that our native typhæus beetle[1] by rotating its body on the short central horn marked out the circumference of its tunnel with the two side horns; but we are not aware of any observations that would justify such an explanation of their existence.

Photo by] [*E. Step, F.L.S.*

TYPHÆUS BEETLE.

One of the dung-beetles or scarabs. It sinks deep pits in the earth, in which it stores rabbit dung for the food of itself and its grubs. Only the male is adorned with the three spines, which are not head ornaments but outgrowths from the fore-body. The photograph is four times the natural size.

The Old Lady.

Many butterflies and moths are the bearers of remarkable names, and it is not always an easy matter to guess how these names were suggested. In some cases the reason for the name is obvious in some conspicuous mark or colour, or in some habit of the Insect. Old lady, however, appears at first sight to need some special explanation as the name for a moth. Yet, if one comes upon this species in the day-time with the fore-wings closed over the hinder pair, as shown in our photograph, and the observer is old enough to remember the fashions of mid-Victorian days, he will get an idea. There is the upper part of the lady of those days who had passed middle age, and covered her back and shoulders with a flounced cape, scalloped along the lower edge, and the scallops bordered and fringed. This must have been the origin of the present name. At an earlier date the moth was referred to in books as the great brown bar, in allusion to the broad band that crosses the wings from front to back; and later as old maid.

A singular trait of this rather large moth[2] is its liking for houses. Many moths are attracted into open windows at night owing to the rooms being lighted up; but the old lady rather comes in during the day in order to find an obscure corner where she may rest. There she may be seen day after day for a week or more; but it must not be assumed that she does not fly during this time. There is reason

[1] Geotrupes typhæus. [2] Mormo maura.

Photos by

HORNED BEETLES.

The lower photograph is of a scarab allied to the typhœus on the opposite page. Here again it will be seen that the horns are a part of the fore-body. It is possible that they may assist in giving form to the mass of dung scooped up by the shovel-like head. The upper photograph is of the centaur, from West Africa, and in this case the front, backward-curving horn is on the head, the second and forward-curving one from the fore-body. The upper photograph is one and a half times, and the lower four times the actual size of the beetles.

for believing that having selected a suitable resting-place she returns to it day after day. We have turned such specimens out of the house, and had good evidence that the moth seen in the same place next day was the one turned out the day before. Some years ago, an entomologist named Reading, believing this to be the case, deliberately marked certain individuals and turned them adrift, only to find that they returned to the house. Often it is not a single moth that has been found clinging under the cornice, or behind curtains, but six or more huddled closely together. Summer-houses, stables, and sheds, as well as dwelling-houses are favoured by them, any structure with a roof appearing to satisfy them. The colouring consists of various shades of dull brown, which harmonize well with the shadows where they rest.

In spite of its familiar habits, it is by no means a well-known moth. Its period of activity as a winged Insect is in July and August, and in some years it is much more abundant than usual. It begins life as a dingy brown caterpillar of rather large size—that is, about two inches in length when full grown. There is a series of oblique paler stripes along each side, and the spiracles are made distinct by their red and black colour. Young caterpillars may be found in the autumn feeding on various weeds. They pass the winter in sleep, and when they emerge from hibernation in spring they change their food, showing a preference then for the new shoots of various trees, such as sallow, birch, and hawthorn. When full grown—about the middle of May—the caterpillar spins a slight cocoon, and turns to a glossy red chrysalis. In the course of a few hours, however, the red is not visible, and instead of the glossy surface showing, the creature is coated with a blue-grey powder, probably some form of wax. In July development is complete, and the chrysalis-skin splits to release the moth. Our photograph on page 395 shows a number of these moths in an overlapping cluster, spending the day in a dark corner of a passage, from which they flew off in the evenings and returned in the mornings. It is probable that in this matter they may be guided by scent, the place where they have once settled having acquired some subtle aroma from their bodies. The red under-wing moth has also been observed to return to a day-time perch again and again after spending the nights away. This habit, it must be understood, is quite distinct from that of the tortoise-shell butterflies and the queen wasps that come into houses in autumn and sleep through the long winter.

Photo by] [*E. Step, F.L.S.*

ANTÆUS BEETLES.

This photograph illustrates the difference between male and female in the matter of horn equipment. The male, to the left, has three curved horns arising from the fore body, and apparently of no use except for ornament. The female, to the right, is without even a vestige of such adornments, and appears to be as well off without them. Natural size.

Social Wasps.

There are a large number of wasps of various kinds that inhabit these islands, but most of them are known only to the few entomologists who make a special study of the order[1] of Insects to which all the wasps belong. The many that are unknown to the general public are solitary wasps—wasps of which the females laboriously construct a nest of some sort which is provisioned with food, an egg laid upon it, and the nest closed up. The social wasps form communities, often consisting of many thousands of individuals, who not only provide a habitation for their progeny, but watch over and nurse these from the moment they escape from the egg until they reach the winged stage, preparing their food for them, and actually putting it to their mouths.

It is generally thought that the common wasp is a well-known Insect, but this is not the case. There are, in fact, few Insects that are so little known—even by those who organize clubs for their destruction and put a price upon the head of every queen-wasp. The wasp as it presents itself to the imagination of these well-meaning people, and the wasp as known to those who have studied its life-history and habits, are two entirely different creatures. Like all prejudices of long standing that have come to us from the dark ages and have left their mark upon our language, this false estimate of the wasp is dethroned with difficulty. Except for one short period in its life, when the wasp undoubtedly does act in a way that arouses the murderous resentment of greedy man—the wasp has at least equal claims with the bee and the ant to be included in the list of Nature's moral exemplars. But that one lapse not merely wipes out its record of good deeds, it prevents people seeing the possibility of its ever having had a reputable past. Let us state the facts, and leave judgment to the fair-minded reader.

Photo by] [*E. Step, F.L.S.*

THE OLD LADY MOTH.

The resemblance of the closed brown wings to a lady's flounced and fringed mantle of ancient fashion has suggested the name in all probability. In spite of its large size, its colouring makes it very inconspicuous, and in consequence it is not very well known. Natural size.

A queen-wasp of one of the common sorts,[2] for whose dead body our local wasp club has offered a reward, creeps out in spring from the dark, sheltered corner where she has been sleeping through the cold days of winter. She had only thrown off her chrysalis wraps in the autumn, and after a day or two of rest in the nest, to allow her new black and yellow corselet and her limbs to become firm, she set out for her virgin flight. The activities of the nest were over for the season. The workers who had spent their winged existence in the unresting search for food for the helpless grubs in the combs, had now nothing to do. All the grubs had spun silk covers over their cells, and had turned to chrysalids. The old queen—the mother of the entire community—was dead of old age, and no eggs had been

[1] Hymenoptera. [2] Vespa vulgaris, or V. germanica

Photos by] [*E. Step, F.L.S.*

EARLY STAGES OF THE OLD LADY.

The upper photograph shows the full-grown caterpillar of the natural size. The eggs are laid in August, and a little later the young caterpillars may be found feeding on low-growing plants. The chrysalis is at first red and glossy, but soon becomes dull with a coating of bluish "bloom."

laid in the cells for some time. So the workers went off to enjoy themselves during the very short spell of life still left to them. They knew that with the first night-frost of autumn the older and weaker of them would die. It was their last chance of a brief spell of enjoyment unfettered by the responsibilities of sisterhood. So they sallied forth to a neighbouring plum-tree where the fruit was bursting its skin with over-ripeness. They had laboured long for the fruit-grower and his kind, killing millions of noxious Insects to use as food for the grubs in the combs, and now for once they had only pleasure to think of. The newly emerged virgin princess went with them, and feasted royally upon the sweet juices of Victoria plums. It was there she met her husband, a smart young drone from a neighbouring nest. Although smart, he was, perhaps, not over-wise. After a brief but happy time together, he must venture to explore a bottle that was hanging from a branch. Whether it was the odour of sweetness that came from the bottle, or the sight of hundreds of other wasps inside, struggling to drink of the liquid it contained, she could not tell; but he insisted on going, and paid for his rashness by getting drowned. It is to be feared that the princess was not greatly concerned at this loss. Wasps and bees, and, indeed, most Insects, set but slight value upon their males. The responsibilities of parentage, and the toils consequent thereon, are discharged by the females.

After she had feasted sufficiently on plum-juice, the princess flew into the open window of a house, and her song as she flew around attracted the attention of a woman, who made various attempts to strike her down with a bread knife. If the princess had been waspish in the dictionary meaning of the adjective, she could have alighted on the back of her neck and stabbed her persecutor. But she had no wish to use her defence unnecessarily; so seeing some open book-shelves near at hand, she flew to the top of a book labelled *Man's Place in Nature*, and crept back into the shadows behind it. Here

Photo. [*W. West.*

OLD LADIES ROOSTING.

[illegible] Old Ladies [illegible] to [illegible] the top-most [illegible] and return to the same [illegible] day after day. About Lake [illegible] [illegible] for a week or more [illegible] It is presumed that these were the same individuals, as in other cases old birds have been distinctly marked [illegible]

she thought she would rest awhile till that irascible woman had calmed down. There, clinging by her jaws to the fore-edge of that particular book, she went to sleep, and as nobody in that family wanted to read about man's place in Nature, she continued to sleep all through the winter. It was not until the incidence of the domestic upheaval known as "spring cleaning," when the books were taken out of the shelves for their annual dusting, that she was disturbed. The duster swept her from her hold, and she fell to the floor unnoticed. Bruised and stiff she crawled away, and after brushing and shaking the dust off her wings and corselet, and washing her face and hands, she climbed out of the window into the spring sunshine, which soon made her feel alive again. Then she remembered a dream she had dreamt during her long winter sleep. According to her dream she was to be a queen, and to reign over a populous city of her own foundation. It was time she set about her dream's fulfilment.

Photo by] [*E. Step, F.L.S.*

A Queen-Wasp.

Lately awakened from her long winter sleep, the queen-wasp looks about her for a suitable site for the foundations of her future city, whose first walls and comb she builds without aid. As she is one of the underground builders her choice will probably fall upon a mouse's tunnel in which she can excavate a roomy hall. Four times the actual size.

All the sunny hours—they were not many—of that April day she flew about and sought the ideal site for a wasp-city, but could not find it. In the afternoon she crawled beneath a piece of loose bark on a dead oak-tree, and went to sleep for the night. The next morning she found that the tree itself had many tunnels in its decayed wood, where beetles or other boring Insects had once excavated; and one of these led to a quite roomy hollow in the centre of the trunk. But on reaching this hall, she found a hornet-princess in possession. The hornet-princess was a sort of cousin, and confided to her that at last she had found a suitable place for the foundation of *her* city. So the wasp-princess retired, and resumed her search. After a weary round of explorations that came to nothing satisfactory, she had the good luck to find the entrance to a mouse's tunnel in a hedge-bank, and she could tell from the absence of any mousy smell that it had long been vacant. So she explored it, and found that a short distance along the tunnel there was a little hollow, which could be rounded and made larger by a little hard work. So she set to work at once upon the roof, digging out pellets of earth with her jaws and carrying them outside, through the tunnel. After considerable labour she came

upon what she had hoped to find. She laid bare a small portion of a tough brown root that ran horizontally through her roof. That was enough digging for the time. Going outside into the open air, she carefully took her bearings of the entrance-hole, and then set off on her wings. A short flight brought her to a long stretch of oak fencing which had absorbed a lot of sunshine, and was warm and dry. Here she set to work with her jaws again, shaving off the finest possible films of wood from its surface, and grinding this up in her jaws, and mixing it with saliva until she had a little pile of wood-pulp. With this she flew home, and spread it out evenly in a band around part of the root in the roof. Incessant journeys follow, and pellets of wood-pulp innumerable are brought home, to be worked up into coarse but thin paper, with which she constructs a sort of stickless umbrella depending from the band on the root. Then under the umbrella she constructs her first comb. There are only a few cells at first, and these are quite shallow when she lays an egg in each. Then she sets to again excavating to make her royal hall larger and more regular in shape. She adds to the edges of the umbrella and makes it broad above and narrow below. Then an outer umbrella protects this balloon-shaped bag open at the bottom. The eggs hatch, and food must be obtained for the grubs. This she gets by flying out and pouncing upon almost the first Insect she sees—fly, butterfly, or moth. Having secured a prize of some sort, she quickly severs the wings, legs, and head as being too hard for her purpose; she carries off the trunk and masticates portions, with which she feeds the grubs from her mouth to theirs.

A Queen-Wasp's Nest.

The pretty little nest here shown is the unaided work of the queen, and serves as a shelter for the small brood that occupies the few cells of her first comb. When the grubs have developed into wasps they are found to be all workers, and at once rel [illegible] rebuilt again and again to accommodate broader and more numerous combs. Naturally the nest should have been suspended in a bush, but a roof of some sort often serves instead. About one-third of the actual [illegible]

It should be stated that the cells are built only on the under side of the comb, and with their open ends downwards and apparently, the grub keeps its hold of the fixed egg-shell to enable it to retain a position in the open cell. It rapidly increases

in bulk, and its fat sides fill the space. As the grub grows, the mother-wasp builds up the cell walls, making them hexagonal in form like the wax cells of the honey-bee, and also begins other cells around them in which more eggs are deposited. The first batch of grubs become full fed, and then each spins a papery cap across the mouth of its cell, and throwing off its last grub-skin, becomes a chrysalis. In about four weeks from the day the first few eggs were laid an equal number of worker-wasps emerge from the cells. After resting quietly for awhile, in order to let their new integuments harden, these workers take up the duties of nurse, caterer, and builder. The wasp-princess is now a queen with a select circle of subjects. The new arrivals, without any instruction, know how to enlarge the nest-hall, to build new combs, and to spread out additional layers of paper walls to increase the warmth of the dwelling, and so hasten the development of the second batch of larvæ. There is no need for the queen to do any of this work—anything, in fact, but to lay eggs; and as soon as her worker-daughters—imperfect females—can construct more cells she is ready to supply the eggs. The old cells, too, which were the cradles of these workers, have other grubs in them already. Soon, with fresh batches of wasps emerging frequently from the combs, there is a considerable population. All these new arrivals are workers, until late in the summer or early in the autumn no males or perfect females are produced.

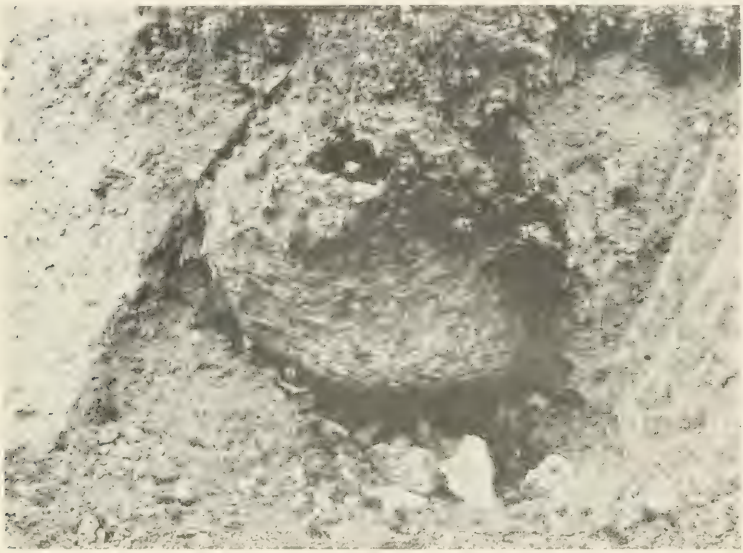


Photo by] [*J. Holmes.*

Underground Nest of Common Wasp.

A bank has been partly cut away to show the nest in position. It hangs suspended by a paper strap to a tough root. The hole near the top is an accidental tear made by the excavator. The entrance to the nest is underneath, not visible in this view.

A noteworthy example of the wasp's readiness to cope with unexpected difficulties came under observation last summer. The nest was built in the bank of a rock-garden, and only two or three inches from the entrance-hole was the netting of the tennis-court. We had noticed with some surprise that, though home-coming wasps flew through the meshes without hesitation or difficulty, the streams of outgoing wasps made a sharp turn to the right or left to avoid the net. We could not understand the reason for this difference, but evidently it was a real trouble, for one day we noticed three workers hanging to the net by jaws and feet, and *revolving round the twine* the better to cut it through. Before long there was a hole in the net immediately opposite the entrance to their nesting-hole, and the out-

Photo by] [illegible] F.R.S.

THE QUEEN'S WINTER SLEEP.

This queen-wasp in autumn discovered what [illegible]ic consid[illegible]red a suitable pl[illegible] with her jaws upon th[illegible] threads of a netted curtain, sh[illegible] furled her wings a[illegible] folded her legs in front. Then locking her jaws, she depended solely up[illegible] hung to [illegible] throughout the winter.

going wasps had no longer to turn sharply on going out. Detractors of the wasp would contend, probably, that this was done from a desire to damage human property, as usual; but there were hundreds of square yards of the netting, and it was curious that the only place cut was immediately facing their doorway. We covered the gap with another piece of netting, and next day that was cut through. A second supplementary piece was served in the same way, and satisfied that the damage had been done to meet a real need, we forebore to give them further trouble.

Wasps appear to be very sensitive to cold, and with the exception of the newly emerged females, who take care to hibernate in some sheltered retreat, all the community die off in autumn. By this time the wasp-nest has largely increased. Time after time the industrious workers have had to enlarge the hole in which the nest hangs. Then to allow room for the enlargement of every comb by the

Photo by] [*J. Holmes.*

STAGES IN A WASP'S LIFE.

The extreme right-hand figure of the lower series shows a newly hatched grub, and the next four figures show stages in growth until it is full fed. The next two show the newly formed chrysalis, all white excepting the eyes. The two extreme left-hand figures show, from above and below, the chrysalis when the wasp is ready for emergence.

addition of new cells to its margins, the inner layers of the paper walls have had to be cut away and new layers added to the outside to keep up the previous thickness which is necessary in order to maintain the warmth of the nest. New combs have had to be built until there are from six to ten of them, suspended one from the other. The cells that contain grubs destined to develop into perfect females and males are much larger than the others which have produced the smaller workers.

During the period of great activity in the wasps' nest, when thousands of grubs have to be fed several times a day, there is little fruit ripe enough or sweet enough to tempt the wasps. There are strawberries it is true, but for some reason the wasp does not appear to touch them. We have had two average-sized nests under a bed of strawberries, but we could never detect a single wasp eating the fruit. It may be that the strawberry is too acid for their taste, but our impression

BUMBLEBEE-WASP — THE RHINOCEROS-BEETLE

[illegible]

is that at this period the wasp is too busy catching Insects to serve as food for the grubs to have much time for the indulgence of its own appetite for sweets, though it does sip at the jam-dish when it visits our breakfast table to steal shreds of ham from our plates. We have little doubt that the grubs are fed entirely upon an animal diet; at midsummer flies are the chief item upon their *menu*. It seems remarkable that in an age when great efforts are being made to minimize the pest of flies, at least as great endeavours are made to destroy the wasp, which is the most effectual check upon the multiplication of the house-fly and the bluebottle.

If the fruit-grower feels that he *must* destroy wasps, the most sensible time for him to do so is just before the fruit has attained sufficient sweetness to attract them. To kill them in spring is to deny himself the great advantage of their wholesale destruction of Insect pests.

Photo by] [H. Hamlin

THE QUEEN ON HER COMB.

The queen-wasp is the sole egg-layer in the community. As soon as the workers have [illegible] new comb she goes over it and lays an egg in each cell, gluing the egg to the cell-wall. Th[illegible] all horizontal, and the cells open downwards.

Certain of our social wasps build their paper cities in trees and bushes; others chiefly in the ground, but occasionally in trees and sheds. In the former group are included the tree-wasp,[1] the Norwegian tree-wasp,[2] and the rare tree-wasp.[3] The second group contains the two common wasps[4] and the red-spotted wasp.[5] The hornet,[6] our largest wasp, prefers a hollow tree or the shelter of a house-roof.

Mr. Chas. Oldham, F.L.S., at a recent meeting of the South London

[1] Vespa sylvestris. [2] V. norvegica. [3] V. arborea. [4] V. vulgaris and V. germanica. [5] V. rufa. [6] V. crabro.

Entomological and Natural History Society exhibited two collections of small stones that he had obtained near the entrances of wasps' colonies, and which the members of these had removed when making and enlarging the cavities in which they built their nests. He said that if these stones are too heavy to be removed, they are allowed to gravitate to the bottom of the cavity, only the loose soil and stones not too heavy to carry being removed. The weight of some of the stones lifted was, in proportion to the size of the wasps, very large, and that those exhibited closely approached the limit, was shown by a heap being found at a few inches from the entrance to the nest. These heaps consisted of stones all about the same size, apparently very near the limit of the weight which a wasp was able to support when on the wing, and so they had been compelled to drop them just outside the nest-hole. The stones of lesser weight, and the particles of earth, which had also to be removed from the cavity, were not in the heap, and were, presumably, carried to a further distance, just as are the general refuse, dead grubs, etc.

Photo by] [*H. Main, F.E.S.*

INTERIOR OF NEST SHOWING FIRST COMB.

In this photograph a similar nest to that on the opposite page has had its paper walls removed to show the first comb. The original cells contain chrysalids and are capped. Above them newer cells have grubs in them, and in more recently added cells at the top eggs may be seen. Combs of later construction will be flat and horizontal.

The talus of stones around a nest of Vespa germanica began some two inches from the lip of the hole and covered roughly an area of a semi-circle of two feet radius. They decreased in number with the distance but there was no apparent decrease in their size. Frequent observation of this nest showed him that most of the wasps got away with their burdens, but that those with larger stones nearer the limit of the capacity of their bearer failed to take wing properly, and landed somewhere within the above area and had, after many vain efforts, to relinquish their burdens.

The nodules were weighed and compared. Ten flint nodules gave an average of ·33 grm., and twenty chalk nodules gave an average of ·35 grm. They were probably drier than when brought to the surface. Six of the wasps were captured

NEST OF A TREE-WASP

[illegible] rocks to find shelter for the nest, which it should be ex[illegible]

Photo by] [*W. Bagshaw.*

THE MAGPIE-MOTH.

The conspicuous colouring of the magpie-moth—spots and bands of black and yellow on a whitish ground—indicates that it is not good to eat. As though conscious of this fact the moth exposes itself freely everywhere.

and weighed immediately after death, and their average weight was ·076 grm. The average weight of the thirty stones was ·347 grm., and, therefore, was 4·5 times the average weight of the wasp. Similar observations were made by him on a colony of Vespa vulgaris, and it was found that in the case of that species the average weight of these stone nodules was 3·7 times the average weight of the wasp, a difference, no doubt, due to the wing area of the last-named species being less than that of the first. In this connection it should be remembered that the weight is always carried in the jaws of the wasp.

The Magpie-Moth.

Every possessor or frequenter of a garden knows this moth, though it may be under the name of gooseberry-moth or currant-moth,[1] these alternatives indicating two of its special preferences in the way of food whilst in the caterpillar stage. But although it becomes specially noticeable when it attacks our fruit-bushes, it is a pretty general feeder, and among other things often abounds on the Japanese spindle, or garden euonymus, which is frequently grown as a garden hedge. The reason for its being so well known to those who are not particularly interested in observing Insects is that in all its stages it is at no pains to hide itself; instead, it seems to thrust itself upon our attention, and the gardener who suffers from its depredations cannot plead that the mischief went forward without his knowledge. The pretty caterpillar, striped and spotted with black and red on a ground of creamy white, is a most noticeable pest, and carries on its nefarious work fully exposed in the light of day. Even the black, glossy chrysalis, with its bright-yellow bands, is prominent through the slight veil that is spun up on leaf or paling; and the strongly marked black, white, and yellow moth flaps along lazily as though conscious that it has not an enemy among birds, beasts, or reptiles. There is no effort at concealment here; whether the moth settles on leaf or flower, tree-trunk or garden-fence, it is equally conspicuous. In the light of the theory of

Photo by] [*E. Step, F.L.S.*

THE EMERGENCE OF THE MAGPIE.

A caterpillar had spun its flimsy cocoon under the rail of a fence, and changed to the shiny chrysalis, which is ringed with yellow on a black ground. This can be discerned dimly in the deep shadow of the rail, but the moth that has just escaped from the chrysalis and the cocoon is fully exposing itself whilst its wings are expanding and hardening.

[1] Abraxas grossulariata.

warning coloration there is no mystery about it so exposing itself. It has been found by numerous experiments with birds, lizards, and monkeys in captivity to be objectionable as food, and the Insect acts as though conscious of the fact, freely exposing itself.

It is one of the family of geometers, to which we have already referred; and it is usual throughout that family for the caterpillars to be coloured in harmony either with the foliage upon which they feed or with the branches upon which they rest, and of which they appear to be twigs. The chrysalids, too, are hidden away among dead leaves on the ground, or spun up between leaves on the food-plant. The moths themselves are so cryptically coloured that when they settle on tree-trunks, etc., they are lost amid their surroundings. In the case of the magpie-moth there are none of these aids, because the Insect being objectionable in all its stages and not sought for as food, there is no chance of protective resemblances being developed. We have said that it is the rule for geometer-moths to be protected by such devices: the magpie is an exception that really does prove the rule. Like the tiger-moth, it varies to an extraordinary degree in a state of nature. The other members of the family vary considerably in the breeding cages of the entomologist, but such variations are seldom found in the collecting net. It is not that they do not occur in the wild state, but when they do, if the variation is at all in the direction of rendering the Insect more conspicuous, that individual will be snapped up by an enemy and have no chance of perpetuating the variation. Such is the working of natural selection: always tending to fix and perpetuate variations that tend to the good of the species by weeding out variations in the other direction. In the case of the magpie-moth, varieties, so long as they retain their warning colours—which are well understood by insectivorous creatures as an advertisement of inedibility—can perpetuate the varying tendency, because the particular arrangement of their colours is of no moment. So long as they retain the black, white, and yellow they are equally protected. If any varieties were to appear that lacked these warning colours, though the moths were still inedible, they would surely get killed off or so maimed as to be unlikely to leave descendants.

EGGS OF THE MAGPIE-MOTH.

These eggs were laid in captivity. In a state of nature the female magpie-moth lays her eggs singly, and is careful to deposit one only on each leaf. They hatch in a few days.

The young caterpillars may be found in August, but are not then very noticeable on account of their small size. After feeding for two or three weeks, they retire from public view by spinning up the edges of a leaf and hiding within it. When the leaves fall in autumn that particular leaf does not go with the others, because it has been attached to its twig by a few threads, and in this cradle the

caterpillar passes the winter. When the new leaves are expanded next year the caterpillar resumes its feeding, and becomes full fed about the end of May. Then it spins a flimsy cocoon, and changes to the yellow-banded black chrysalis, from which the moth emerges in July or August. In suitable seasons the young caterpillar is sometimes able to attain to its full growth in the first year, and becomes a moth in the autumn.

The clouded magpie,[1] which is our only other representative of the genus, is a much less common Insect, and it is probably not so thoroughly inedible as the magpie. It has not been experimented upon in the same way; but though it has the warning coloration it is not so strongly and obviously marked. The body is yellow with black spots, but on the white wings the markings are blotches of yellow-brown and clouds of grey. This colouring—apart from feeding experiments with birds, etc.—would lead one to suppose that it would be less hurtful than merely uninviting as food, for it appears to rely upon a protective resemblance more than upon warning colours. It haunts the edge of the woodland, and may be seen sitting with expanded wings on the leaves of dog's mercury and other low plants. When so seen it is not likely to be suspected of being a moth by those who are unacquainted with its peculiarities. It will be passed by as the dropping from a wood-pigeon squab in the branches above. That is exactly the appearance presented.

Photo by] [*H. Bastin.*

THE MAGPIE-CATERPILLAR.

This white caterpillar, spotted and blotched with red and black, is a most conspicuous as well as destructive Insect. Like those of the moth, its colours advertise the fact that it is inedible, and for that reason it is not careful to hide itself. Twice the actual size.

The caterpillar, which feeds chiefly upon wych-elm, is greyish-white, which becomes yellowish on the back, where there is a black central line and a broken one on each side of it. The spiracles are black, and there is a yellow line below them. It will thus be seen that in this species the caterpillar is more warningly coloured than the moth, and the presumption is that it is more inedible in the earlier stage than in the perfect state. In a few other geometer-moths protection is obtained by a similar likeness to bird-droppings.

[1] Abraxas sylvata.

THE TIMBERMAN.

A couple of males are engaged in combat, whilst a female awaits the result. In these contests the magnificent antennæ—which may be four times the length of the body—are often disfigured by breakage. The lower part of the picture shows the grub in its tunnel, and the chrysalis of the male with its antennæ folded down the sides and up the front. The Insects are shown two and a half times the actual size.

Photo by] [*E. Step, F.L.S.*

THE COBBLER.

This wood-boring beetle is common in the pine-growing districts of the Continent, and is occasionally found in this country. The photograph is that of a male, and shows the actual size.

The Timberman.

We have already described several species of long-horned beetles (see page 193), and remarked upon the general characters and habits of the family. It is a noteworthy fact that all these beetles, whose relationship can be established at a glance by reason of the great length of their antennæ, should agree so closely in habit in their grub stage. At this period they all obtain their food by boring into timber, cutting cylindrical tunnels from the exterior towards the heartwood of the tree, and eating all that they cut away. The grubs are all much alike in form, though differing, of course, in size, according to the dimensions attained by the respective species when they come to full beetle-hood. They are white and soft, somewhat flattened above and below, and are widest just behind the head.

The species to which we desire to refer now is rare as a British beetle, restricted to the north of these islands, and its chief locality certain woods at Rannoch, where the males may be seen flying with their extraordinarily long antennæ extended backwards. It is known locally as the timberman,[1] and it is interesting to note that equivalent terms in other tongues are applied to it in Sweden and Lapland, where it occurs also. It is said that the reason for this name is to be found in its usual trick of carrying its antennæ so spread that they resemble the arms of a pair of compasses, with which it appears to be making measurements. The females are not so well endowed with these ornaments as the males, in accordance with the rule prevailing among beetles respecting such adornments. It may be surmised that in this matter the females have little cause for complaint as their antennæ are usually twice the length of the body; but it is no unusual circumstance for those of the male to be four times the length of his body. We ought perhaps to

Photo by] [*E. Step, F.L.S.*

RING-HORNED PALIMNA.

The palimna is a common wood-boring beetle of Malaya. Its uniform mottling of black and grey gives it a pretty appearance, which is rendered more graceful by the length of the antennæ, which are of the same colours as the body but disposed in rings. Natural size.

[1] Acanthocinus ædilis.

qualify this statement by adding that this may be their length when the male has but recently made his first public appearance. After he has met with another of his sex, probably a rival for the good opinion of a female, these antennæ may be seriously damaged. The beetle-hunter has to deplore this tendency of the males to fight and spoil the good looks of their rivals, for it makes it a difficult matter to secure a perfect male specimen for the cabinet. In spite of their great length, these antennæ consist only of the same number of joints as in many long-horned beetles, whose appendages do not show any disproportion to the length of their bodies. The disparity is attained by the lengthening of each of the ten joints. Each joint has the forward half light coloured, and the hinder half dark.

The beetle attacks various trees, but shows a distinct preference for pine. It is most frequently obtained from the stumps of felled trees, because in the decaying of the large cut surface these are more easily explored by the collector; but the Insect does not restrict its operations to these useless remains. It also pays attention to standing timber, but there is reason for believing that though the wood is sound and useful, the process of decay has begun before the beetle considers it fit for its purpose.

The grub makes tunnels of considerable width, and when approaching towards full size it turns these in the direction of the circumference of the stem, so that it finishes its labours not far from the exterior, where as a beetle it may have little boring work in making its escape. It then constructs a sort of cocoon of gnawed fragments of wood, in which at the beginning of summer it changes to a chrysalis. In this stage the sexes may be distinguished already, for the long antennæ of the male, curved down each side, have to be curved again and brought up in front and over the head, as shown in our drawing. It remains in this condition for a few weeks only, and then the perfect beetle throws off the chrysalis-skin. But it is in no hurry to make a public appearance. It lies quietly in its cell, apparently, for nearly a year, and does not emerge into the open air until the summer following.

Photo by [*E. Step, F.L.S.*

FORTUNE'S LONG-HORN.

A fine wood-borer with metallic blue-green colouring. The photograph represents it of the natural size.

It has often been captured in coal-mines, sometimes at very great depths below the surface, and the explanation is to be found in the fact that it has found its way into these regions as a grub in the interior of timber used for propping the roof of workings.

Two larger beetles of similar form and habit may—borrowing from their Latin

names[1]--be known as cobblers, the long antennæ having suggested to their sponsor the wax thread of the shoemaker. These beetles, though plentiful in the pine-growing districts of Europe, are of only rare occurrence in this country. We give a photograph of the male sartor, and it will be seen that though his antennæ are more than twice the length of his body, they are proportionately much shorter than those of the smaller timberman. The antennæ of the female are much shorter. Another character of the males in these and some other long-horned beetles is found in the greater length of the first pair of limbs. An allied species[2] is recorded as having emerged from a piece of furniture known to be fifteen years old; and the evidence went to show that the grub was at work in the wood before it was worked up. Other cases point to the probability that the grubs of these long-horned beetles may extend their existence—under similar unnatural conditions—over twice that period of time.

African Locust.

This species appears to have its headquarters in East Africa, whence its surplus broods, numbered by billions, overflow into the surrounding country, usually taking a northerly direction. They migrate in clouds, so vast that daylight is obscured.

Migratory Locusts.

The story of what man in all the ages has suffered from the ravages of vast armies of locusts would fill a goodly book. From the earliest times they impressed man with his impotence pitted against a foe individually despicable but, when associated in untold millions, irresistible. Not relishing defeat at the hands of so insignificant a creature, some of the ancients took to magnifying him in their imagination; and so Pliny tells of a locust which was three feet long, and had legs so strong and well-toothed that they were used as saws. The Arabians, who suffered much from the locust, pictured it as being endowed with some of the attributes of the strongest, swiftest, and most dangerous of other animals. It

[1] Monohammus sartor and M. sutor. [2] M. confusus.

THE ASHY LOCUST.

[illegible] migrate in great swarms, this is probably the one that is most frequently referred to. Its range extends [illegible] Natural size.

THE MIGRATORY LOCUST.

One of the species celebrated for its devastating incursions from the earliest days. It is a native of South eastern Europe and Turkestan, and does not extend so widely in its migrations as some of the other species. Natural size.

had the head of the horse, the eyes of the elephant, the neck of the bull, the horns of the stag, the chest of the lion, the belly of the scorpion, the wings of the eagle, the thighs of the camel, the legs of the ostrich, and the tail of the serpent. The locust hordes were to them the avenging armies of the great God. They were believed to lay ninety-nine eggs, and to be restricted to that number because, if they laid a hundred, their progeny would consume the whole earth and all its contents.

There are many records extant of locust visitations in the south and east during the historical period, without falling back upon legend; and even in our own time the story of our kinsfolk's struggle with these Insects in Cyprus and South Africa is sufficient to satisfy us that the older records do not exaggerate the ruin and devastation these creatures caused. The great Darwin, who was in no sense prone to exaggeration, tells us how, in the year 1835, being just arrived at Luxan, in South America, "we observed to the south a ragged cloud of a dark reddish-brown colour. At first we thought that it was smoke from some great fire on the plains; but we soon found that it was a swarm of locusts. They were flying northward; and with the aid of a light breeze they overtook us at the rate of ten or twelve miles an hour. The main body filled the air from a height of twenty feet to that, as it appeared, of two or three thousand above the ground; 'and the sound of their wings was as the sound of chariots, of many horses running to battle': or rather, I should say, like a strong breeze passing through the rigging of a ship. The sky, seen through the advance guard, appeared like a mezzotint engraving, but the main body was impervious to sight; they were not, however, so thick together but that they could escape a stick waved backwards and forwards. When they alighted, they were more numerous than the leaves in the field, and the surface became reddish instead of being green: the swarm having once alighted, the individuals flew from side to side in all directions."

Mr. Carruthers, in the year 1889, made observations on a swarm that passed over the Red Sea, and estimated its extent as equal to two thousand square miles. By ascertaining that each locust weighed a sixteenth of an ounce, he arrived at an estimate of the total weight of the swarm being 42,850 millions of tons! A second swarm of equal or greater extent was observed the following day. When we took possession

of Cyprus—described as the brightest jewel in the British crown—it was soon discovered that the great drawback to its prosperity consisted of the enormous swarms of locusts that almost perennially devastated it, and rendered cultivation impossible. During the year 1881, the organized conflict against this enemy resulted in the destruction of sixteen hundred millions of egg-cases, weighing thirteen hundred tons. But this wholesale destruction of eggs appeared to have little effect, for only two years later it was estimated that over five thousand million egg-cases were deposited. Finally, however, the scourge was practically wiped out by the ingenious device of Signor Matthei, who, noting that the swarms always proceeded across the island in the same direction, suggested the erection of nearly upright screens across their course with trenches at the base. A band of polished leather was fixed across these screens and formed an impassable obstacle, for their feet cannot cling to a smooth surface. The winged Insects could, of course, save themselves by flight, but the main object of the plan was to destroy them in the young stage, when they have not attained to egg-laying powers. As they fell in thousands they were shovelled up and burnt in heaps; or stamped down in the pits.

The Cypriote plan did not succeed to any appreciable extent in South Africa, where the extent of country over which the *voetgangers* (as the Boers term the early wingless stage) march is too extensive. But quite recently another plan has been attended with complete success. This consists in setting apart a broad band across their route, and, after excluding the domestic grazing animals from it, sprinkling its vegetation liberally with Paris green. The voetgangers feed on the

Photo by] [*H. Bastin.*

WANDERING LOCUST.

The most universal of the migratory locusts in its range, which takes in our own country, the Continent, Arabia, Afghanistan, and Northern India. It is believed also to visit South America. In India it is known as the north-west locust, that being the direction from which its swarms arrive.

march, clearing off every scrap of herbage as they advance, and they did this on the treated strip, eating the Paris green with the vegetation, with the result that the locust pest in South Africa may now be considered a terror of the past.

There are several kinds of these scourges. The migratory locust of science[1] is not the most important of these, as its range is said to be limited to South-eastern Europe and Turkestan. An allied species, the ashy locust,[2] is of wider range, extending throughout Europe and Asia, from the Atlantic in the West to China in the East. The wandering locust[3] is even more universal in its tours. It has visited us in England, takes in Africa, Cyprus, Persia, Arabia, Afghanistan, and Northern India to its eastern limits. There is a record of a swarm invading a ship in the Atlantic when twelve hundred miles from the nearest land, and it is believed to be one of several species of the same genus that are migratory in South America, which, it has been suggested, may have been its original home. In India it is known as the north-west locust, that being the direction from which it arrives. In the earlier wingless condition, when it is known as a hopper, it is very destructive in the dry plains of the Punjab, where it breeds. In the vast swarms in which they come these locusts exhibit a great difference of colouring from that assumed when they settle down to the business of sowing the ground with billions of their eggs. The swarms have been described as red clouds, and this colour is due to the fact that the Insects in their nuptial dress have a rosy tint; but when they settle, this brightness is dulled to a yellowish-grey tint, which harmonizes better with the soil. Often their clouds have descended on unsuitable places for their egg-laying, such, for example, as a railroad, with the result that millions are destroyed by the rolling stock, whilst their mangled remains, making the rails slippery, soon bring the railway service to a standstill, and not infrequently have derailed the trains.

Photo by] [*F. Noad Clark.*

EGG OF A BUTTERFLY.

The eggs of butterflies show considerable variety of form and sculpturing. The example shown is the egg of the white admiral, which is of a beautiful pale-green tint, and is laid on the leaves of sallow in July, hatching about a fortnight later. It is magnified twenty times.

With the extremity of their hind-bodies the females bore holes in the earth, and leave in each a package of eggs, which are all glued together. Mr. E. P. Stebbing, F.L.S., tells us that "Areas in which these egg masses have been deposited look for all the world as if a heavy shower had recently passed over them, the soil being pitted with small holes as if made by heavy raindrops. From these eggs eventually emerge little black wingless hoppers, at first small and helpless and quite unlike one's notion of a grasshopper or locust, but rapidly developing by a series of moults or casting of the skin. Some few days after hatching, the little 'hoppers' pack together and move down into the cultivated lands in well-ordered battalions and brigades and divisions, in which formation they spend the

[1] Pachytylus migratorius. [2] P. cinerascens. [3] Schistocerca peregrina.

Photo by

SILVER-WASHED FRITILLARY.

The example photographed is a male, slightly enlarged, to show the scent organs, or androconia, t
cross the middle of the fore-wings. The larger scales that cover these parts are connected with special
which they appear to derive an odorous fluid which they disperse. Diverse odours have been dete
are believed to be employed for charming the females

rest of the wingless portion of their lives devouring the crops. Another species[1] appears to have its headquarters in East Africa, from which its superabundant broods, billions in number, migrate in a northerly direction. Mr. W. L. Distant describes such a migration of this species he witnessed at Pretoria in 1890. He says, in his *Naturalist in the Transvaal:* "On the morning of May 11th, our attention had been directed to myriads of locusts flying near the hills, and some few stragglers were found in the town; but shortly after noon the air was darkened, as swarms only to be computed by billions came with a rushing sound over our heads and across our path. The light was obscured as with clouds of dust, whilst to walk through the flitting Insects reminded one of the driving snowflakes at home, as the pale hyaline wings and not the dark tegmina [wing-covers] are observable during flight. Stragglers continually fell out of the ranks, and we heard them drop on the iron roof of our dwelling. . . . The ground was thickly covered, and at sunset most of the flight had probably settled for the night. The heaviest portion of the main body, which might be described as the centre of the army, crossed us in about half an hour, but the flight continued long after and before. Their extraordinary numbers could be appreciated by the non-observable effect of their immense losses. Myriads were trodden under foot, our Kafir workmen collected them for food, the poultry of Pretoria gorged themselves on their bodies."

Photo by [*W. Bagshaw.*

THE TONGUE OF A BUTTERFLY.

The so-called "tongue" of the butterfly is a very long trunk, kept coiled like a watch-spring when not in use, but extended for sucking the sweets of flowers. For the trunk is pierced throughout its length, and is formed of two interlocking halves which are seen partially separated in our photograph.

The Story of the Butterflies.

Although in the butterflies and moths, which together constitute the scaly-winged order[2] of Insects, we have the highest development of the race so far as beauty is concerned, viewed from other standpoints they are seen not to have the premier position. Indeed, in none of the systems of classification of Insects, ancient or modern, is such a position given to them. Such priority has usually been accorded either to the ants, bees, and wasps from their superior intelligence, or to the beetles from the perfection of their external parts and the superior mechanism of their joints. But to the non-classifying members of the human race, poets, painters, and moralists, the butterfly has been the Insect *par excellence,* probably because in this type of Insect the phenomenon of metamorphosis was first known. The imagination was captured by the marvellous evolution of the magnificently painted and jewelled creature, like a flying flower for beauty and brightness, from a "disgusting worm" whose sole concern in life was to minister to an insatiable appetite. In this was seen a picture of man, grovelling and of the earth, earthy, who, when his span of

[1] Pachytylus migratorioides [2] Lepidoptera.

eating and drinking was over, lay in his narrow cell (chrysalis) from which his soul escaped in due course. So to the ancients the butterfly was adopted as a type of the soul, and the one word Psyche served for both. Psyche, the nymph, indeed, was always portrayed by painter or sculptor in human form, but with the wings of a butterfly.

As a rule when Insect metamorphosis is referred to it is the life-history of the butterfly that is in our thoughts, for here it is best exemplified, the creature being unconcealed in all its stages, and therefore patent to the least observant. We may have observed the small tortoiseshell-butterfly laying her greenish eggs upon the leaves of stinging nettle, and shortly afterwards seen the same nettle plant clustered with small caterpillars clothed with short spines. Curiosity aroused, we watch their progress from day to day, see them casting their skins at intervals and coming out of them larger each time, until they have reached their full stature. Then we see them suspended by their tails from the branches and leaf-stalks, and observe the last caterpillar-skin rolled up to and off the tail, and the strangely shaped grey chrysalis revealed, with the points along its back tinged with gold. Finally, we see the head end of the chrysalis split, and the butterfly climbing out with the aid of its weak, thread-like legs, and its soft and crumpled rags of wings hanging limply. But what a change is evident in an hour! The wings have expanded, and are resplendent on the upper side with dull red and yellow and black and spots of blue. And the wings having been fanned a little to make sure that the motive muscles are in working order, away sails our butterfly in the June sunshine, a thing of perfect beauty.

Photo by] [*H. S. Chewin, F.R.M.S*

SCALES FROM A BUTTERFLY'S WING.

The colours and patterns on the wings of butterflies and moths are due to the arrangement of innumerable scales of microscopic proportions. In some cases the scales are themselves coloured, but the colour effects are sometimes merely optical, due to the reflection of light by delicate ridges and striations on each scale. The few shown in this photograph are magnified thirty six times.

Now, unless our ancestors far back had watched this process they could never have imagined that there was any connection between the caterpillar and the butterfly. There is not a single point of external form or structure that could suggest such an amazing possibility as that the one would develop into the other, or that the eggs laid by the butterfly would not hatch directly into small butterflies again as the eggs of birds hatch into birds. If they had examined the mouth of the caterpillar and found the cutting-jaws, and the several other parts fitted for the tearing and mastication of vegetable matter, and compared it with the long, trunk-like formation of the butterfly's principal mouth-parts, they would have found no

helpful analogy. Further, there is not an atom of suggestion in any external part of the caterpillar of the relatively enormous wings, so beautifully clothed with scales that are so minute they look like dust. Who could imagine either that the six poor little bow-legs on the fore-part of the caterpillar would develop into the long and graceful appendages of the butterfly, or that the insignificant little ocelli would be supplemented by the magnificent compound eyes of which the butterfly's head appears to be mainly composed. No wonder if contemplation of this complete metamorphosis should give rise to the theory of metempsychosis—the belief that in the apparently lifeless chrysalis stage the soul of some other creature entered into the Insect and gave it the additional glories of the final stage.

Photo by *E. Step, F.L.S.*

BUTTERFLY CATERPILLARS.

These are caterpillars of the swallow-tail butterfly, the fine Insect that, so far as Britain is concerned, is found only in certain parts of the fen districts. The colour scheme is an alternation of black and orange rings.

The eggs of butterflies are very variable in shape and ornamentation. Some are ninepin-shaped, some like codlin-apples reversed, others hassock-shaped. The sculpturing usually takes the form of ribs and fluting. The colour varies, not only according to species, but with the age of the egg. Some species deposit their eggs singly, others in batches.

The caterpillar consists of thirteen segments besides the head, but the full number cannot be made out often without dissection, owing to the hinder two or three being united. The first three segments behind the head bear each a pair of tapering, curved and jointed legs, and these segments constitute the fore-body;[1] the remaining ten form the hind-body.[2] Segments three to six of the hind-body bear thick, unjointed, and fleshy feet, which are of a temporary character, and are not represented in the later stages. At the extremity of the body there is a pair of similar nature distinguished by the name of claspers. These feet and claspers are used for locomotion and for clinging to the food-plant, the true legs as a rule being used only for steadying the edge of the leaf whilst the caterpillar eats it. The true legs end in a minute claw; the free ends of the feet are fringed with hooks, which enable it to take hold so readily and so tenaciously.

The head at once appears as distinct from the body owing to its horny character. On each side of the mouth may be seen six or fewer tiny clear spots, which are

[1] Thorax. [2] Abdomen.

Photo by] [*E. Step, F.L.S.*

THE WHITE ADMIRAL.

One of our most beautiful butterflies, photographed in the act of imbibing nectar from the flowers of the musk-mallow. It is a woodland species, like the larger purple emperor, which it resembles somewhat in its markings. These are finest on the under side, which is shown here. Slightly enlarged.

imperfect eyes, or "ocelli." From the character of the optic structures beneath them it is considered that the visual powers of the caterpillar are very poor. Its principal sense organs appear to be the very small antennæ, which may be found one just outside each of the cutting mandibles. The spinning organ, through which it produces the silk threads by which it suspends itself before changing to the chrysalis, will be detected as a projection from the lower lip. The spiracles, or breathing pores, will be found to the number of nine along each side—one on the first segment behind the head, and one on each of the segments four to eleven.

The greater part of the caterpillar's interior is taken up by the enormous stomach and digestive organs. The slender tubular heart runs along the middle line of the back, and the nervous system along the floor of the body. There are also, however, rudiments of the future wings, which may be seen by dissection of a full-grown caterpillar. These are just beneath the second and third segments of the body, and perhaps explain why these two segments are without spiracles. When about to become a chrysalis, the caterpillar in most cases spins a pad of silk to which the chrysalis can fix itself by hooks at the tail end; it also in many cases spins a girdle of silk across the middle of the body, the two ends being securely fastened to the material upon which the chrysalis is to be suspended.

Photo by] [*Lumsden.*

How a Caterpillar Clings.

The true legs of the caterpillar just behind the head are used chiefly for manipulating its food. The thick, soft legs near the middle of its length are of a temporary character and do not reappear in later stages of its existence. One of these pro-legs, as they are called, is shown much enlarged to reveal the fringe of hooks which enable it to take hold so readily and tenaciously.

Having so secured itself, and thrown off the last of its caterpillar-skins, the chrysalis is revealed. The wings, the long legs, the antennæ, the large compound eyes, the long trunk, are all to be seen laid along the under side, but covered by a hard skin, which is formed by the pouring out of a fluid when the caterpillar-skin is thrown off. This hardens by exposure to the air, and glues down all the appendages, forming a thin shell external to them. Now, although these organs are formed in a sense at this stage, they are not properly developed; they are, so to speak, merely sketched in, and the mass of the body contents is in the condition of a creamy fluid due to the breakdown of much of the caterpillar's internal organization. The butterfly, subsisting upon a little liquid food, manifestly does not require the enormous digestive apparatus of the caterpillar, that had to extract its nourishment from leaves. The caterpillar was a creature of no sex—though some

investigators have found the beginnings of sexual organs by dissection—and the generative system has got to be built up. So with other systems—the Insect has largely to be made up afresh from the materials of the caterpillar. Even the scales which clothe and give pattern and colour to the wings have all to be developed. The number of scales on all the wings of one of the large South American morphos has been computed at a million and a half. They are flattened bags containing fluid or air, and are of a similar nature to hairs, into which indeed they gradually merge. It is these scales which give colour and pattern to the butterfly, sometimes by a true pigment inside the scale which shows through, sometimes by an optical effect produced by the microscopic ridges and grooves on the surface of the scale. Each of these scales is attached to the wing by a footstalk, which fits into a receptacle excavated in the wing-membrane, one row of scales overlapping the footstalks of the next row, a manner which may be said to be copied in the tiling of a roof. In addition to the scales which cover the greater part of the wings in both sexes, there are special long slender scales (termed androconia) which are peculiar to the wings of the males, and these are believed to cover glands which are the source of scents produced for the purpose of charming the females. It has been proved by experiment that various butterflies have their own distinctive odours, which are either stronger in or restricted to the males.

Photo by] [*E. Step, F.L.S.*

RHINOCEROS-BEETLE AND ITS FOE.

[illegible] a uniform brown. Both insects are shown of the natural size.

The antennæ of a caterpillar are very small and inconspicuous organs; in the butterfly they are developed to great length, and either have their free ends clubbed or they are thickened a little short of the tip. Another remarkable development of the perfect butterfly is the proboscis, which is always of great length. It is kept coiled in a flat spiral close to the head; but when the butterfly visits flowers it is unrolled, the tip is inserted in the nectar of the flower, and the sweet juices are sucked up it. This proboscis really consists of two tubes, each with a concave inner face, and these faces so interlock by their edges that they form a third or central tube.

A Burrowing Wasp.

We have already given some account of wasps and bees that bore shafts into the ground, terminating in nest-cells to which they bring their prey in order that it

may serve as food for their young during the helpless grub stage. There is a family of wasps, represented in this country by two small species, but which in warmer countries includes some of the largest and most powerful of the wasps, whose limbs are stout and well formed for digging, but they adopt methods different from those of the miners. They burrow in the earth, but they construct no definite shaft. They make proper provision for the welfare of their progeny, but they make no cells. They are hairy wasps of black colour save for several relieving spots or bands of red or yellow, true to the wasp principle of advertising their dangerous character to all whom it may concern. As usual, the females, who do all the work, are much larger than the males. Several of the larger species are found as near to us as France, where they have been studied by Fabre and others. Unfortunately, they have no English name by which to distinguish them from other wasps, but we will call them beetle-eating wasps,[1] though it must be understood that the beetles they destroy are always in the grub stage, and that it is the wasp's grub that does the eating.

Now it is remarkable that these beetle-eating wasps should restrict their attentions to the grubs of a particular family of beetles—at first sight not so remarkable, when we remember that other of the solitary wasps show similar exclusive preferences for particular kinds of prey; but in those cases the selection takes place in daylight, above-ground. The marvellous thing in connection with the beetle-eating wasp is that her victims are hidden from sight underground. They are all grubs of leaf-horned beetles, such as the rose-chafer, the rhinoceros-beetle, etc., each species of beetle-eating wasp keeping to one genus of beetles. These grubs are large and fat, not very active, and lie on their sides, feeding upon decaying vegetable matter underground. Now the task for the beetle-eating wasp, flying over the ground, is to determine where one of these beetle-grubs is feeding below. As they were hatched from the egg underground, there is no clue afforded by the entrance to a burrow, and the task of the wasp seems to be as hopeless as that of the self-styled water-diviner, who claims by a special sense to be able to locate hidden underground water-channels. Whether the beetle-eating wasp is the possessor of a special sense for her purpose we cannot say, but it looks much like it.

Photo by] [*E. Step, F.L.S.*

YELLOW-FACED BEETLE-WASP.

Thickly clothed with long hairs, this yellow-spotted black wasp suggests a parallel with burly carpenters of the bee tribes. Its sagacity in discovering its hidden prey is remarkable. Natural size.

The curious habits of these wasps were made known as far back as 1840, when an Italian entomologist named Passerini published an account of the yellow-faced beetle-eating wasp.[2] He found that the mother-wasp hunted for the fine large grub of the rhinoceros-beetle,[3] which is common on the Continent in spent-tan, and when found placed an egg on its chest. When the egg hatched, the tiny wasp-grub

[1] Scolia. [2] S. flavifrons. [3] Oryctes nasicornis.

Photos by [*Harold Bastin and Hugh Main*

NESTS OF POTTER-WASPS.

These nests are made by species of eumenes—the two upper and right-hand lower examples by our native heath potter, and the other by a Jamaican species. The material is clay, tempered by a glutinous fluid from the wasp's mouth, in which grains of sand and small bits of stone are embedded. One of the photographs shows an empty nest with the hole through which the wasp escaped after coming to full development.

at once bit the beetle-grub between the sixth and seventh segments of its body, and buried the first three segments of its own body in that of its victim. In this position the wasp-grub sucks and sucks until nothing but the skin of the beetle-grub is left ; but by that time the wasp-grub is full fed and able to transform itself into a chrysalis, from which in due time the wasp emerges. Now, in this case the task of the hunting mother-wasp may be comparatively easy, for the spent-tan in which its victim is found may lie in a heap on the ground where the tanners have thrown it out of the tannery pits ; but in other cases it does not appear so easy.

In more recent years, Fabre has investigated the operations of the two-banded beetle-eating wasp,[1] who selects the grub of the rose-chafer beetle[2] for the food of her young. These grubs are mostly found deep in the nests of the wood-ant, where they feed upon the decaying vegetable matter of which these structures are composed. However, the wasp finds it, and as the chafer-grub is a large one, and by its movements might easily destroy the egg of the wasp, it is necessary to kill or render it insensible. Fabre lays great stress upon the necessity of rendering it helpless without destroying life, in order that its body may not putrefy ; but the Peckhams, who have paid special attention to all matters relating to wasps, differ from Fabre in this matter, and say it does not matter if wasp-victims are killed outright, they serve the intended purpose all the same. Fabre says that a struggle ensues, the chafer-grub wriggling to prevent the wasp getting its weapon into the desired spot—the centre of the nerve-ganglia that control the movements of the chafer-grub ; but ultimately the wasp is successful, the nerve mass is stung, and henceforth the grub is as one paralyzed, alive but incapable of movement or feeling.

THE HEATH POTTER

One of the smaller of our native wasps who makes her cells—shown on page 423—in the form of a broad-based vase with a short neck and turned-out lip. Each cell, made of clay, is furnished with a stock of small caterpillars and a single wasp's egg.

The cavity that the chafer-grub had made for itself to lie in serves for the cell of the wasp-grub, and the single egg is laid on the under surface well behind the legs. It hatches, and the young wasp-grub pushes its head through the skin of its victim and gradually clears out the rich contents of the hind-body, and when this part is gone it pushes its head further inside and attacks the more forward parts, until the empty skin is left.

Another species[3] of these beetle-eating wasps chooses the grubs of two related species of chafers[4] more akin to our cockchafer. The eggs are laid in August or September and hatch about two days later. When full fed the wasp-grub spins a cocoon inside the empty skin of its victim. In this stage it passes through the winter, and in spring becomes a perfect wasp ; but it does not emerge from the earth until early in June.

[1] Scolia bifasciata. [2] Cetonia aurata. [3] Scolia interrupta. [4] Anoxia.

Wasps as Potters.

That the common wasps which come too freely into our houses in late summer are competent paper-makers is a familiar fact to most people. But it is, perhaps, not so well known that all wasps do not follow the same industrial vocation. There are wasps who work only in such plastic material as clay or mud, as well as some who are more masons than potters.

One of these—the heath potter-wasp[1]—may sometimes be found constructing its nest on heath-plants. It is a small black and yellow creature differing from the ordinary wasps, among other things, by its hind-body being connected to the fore-body by a thin waist as long as the fore-body. Its nest takes the form of a low, round-bellied vase with a short neck and turned-out lip, and is made of clay tempered with the wasp's own cement, supplied from the mouth. It consists of a single cell, and before the mouth is closed it is stocked with small caterpillars—which are believed to be stung to keep them quiet—and the wasp's egg. Sometimes the vase is placed upon a broader surface than the twigs of a shrub afford, and in that case it loses a little of its grace, the bottom being flattened to give it a better hold. The wasp's egg is not deposited on the living food store, but is suspended by a thread from the roof.

Photo by] [*E. Step, F.L.S.*

YELLOW-PAINTED POTTER.

This large species is a native of Borneo, and well illustrates the general form of these potter-wasps, though the present species [illegible] The [illegible] wasp. Four times the natural size.

The wood potter[2] and the apple potter[3] embed small stones into the walls of their nests, so that they have the appearance of having been built up of stones with clay to hold them together. The apple potter occurs in the South of France, and Fabre, apparently describing this species, says that the fourteen or sixteen small caterpillars with which the nest is provisioned are only slightly affected by the stinging (if they are stung), for they are able to use their jaws and to kick out, as it were, with the hinder part of the body. This power of movement would make them dangerous company for a delicate egg placed among them, or even for a newly hatched grub. Here, then, is the reason why the egg is suspended. Should it be struck by the movement of one of the caterpillars it would swing out of the way like a pendulum; whilst the newly hatched and tender grub can feed in safety

[1] Eumenes coarctata. [2] E. arbustorum. [3] E. pomiformis.

from its swinging perch. A remarkable point in this connection, showing how several items are correlated, is the way in which the egg-shell splits up on hatching. From the point of attachment of the suspensory thread it splits into a sort of ribbon, which in effect lengthens the thread and enables the grub to get nearer to its food. The clawed potter,[1] though it fashions a less regular vase, provides three cells in the interior, each of which has its egg and its store of caterpillars. An Indian species[2] makes the mistake of constructing its nest with walls so thin that a parasite readily pierces them to lay its eggs. For this reason only two wasps were reared from a group of five cells, the parasites having destroyed the other three.

Several wasps of the genus trypoxylon construct nests much after the same pattern as those mentioned. One of these is referred to by Bates in the account of his natural history exploration of the Amazons. He says, "Their habits are similar to those of [the mud-daubers]: namely, they carry off the clay in their mandibles, and have a different song when they hasten away with their burthen from that which they sing whilst at work. One species [the white-footed potter[3]], which is a large, black kind, three-quarters of an inch in length, makes a tremendous fuss whilst building its cell. It often chooses the walls or doors of chambers for this purpose, and when two or three are at work in the same place their loud humming keeps the place in an uproar. [The gold-faced potter[4]], a much smaller species, makes a neat little nest shaped like a carafe, building rows of them together in the corners of the verandahs."

THE GOLD-FACED POTTER.

This small Brazilian wasp constructs its clay-cells in the shape of water jars with a distinct neck and well-formed mouth. It is one of the species that appear to prefer the vicinity of human beings for their nests; and it will build a row of these carafes in a corner of the verandah.

In Hawaii several species of mud-wasps[5] construct single-celled nests similar to those of eumenes, but more cylindrical than spherical. They are fond of making these in a leaf that has been curled up already by a spider to serve as a nursery for her young ones, and in addition the young of a certain species of snail like to crowd into the same refuge; so that, as Mr. R. C. L. Perkins tells us, you may find a curled leaf occupied by these three kinds of tenants at the same time.

Two European species of agenia (one of them British) make vase-like nests, which they hide in tree-hollows, wall-holes, and similar places. The black agenia,[6] which is found in the South of England, contrives a nest much like a wide-mouthed bottle, but it is not so accomplished in the potter's art as some of those we have mentioned, for it does not appear to have learned the secret of kneading its materials with saliva, and so its pots have not the proper permanency. For this reason they are not placed in exposed situations, where the weather would soon crumble them. The little wasp has learned that such material would not be waterproof, and so she takes care to line the nest inside with a coating of glaze, probably supplied by her mouth, which serves to keep the contents dry. The cell is provisioned with spiders which are paralyzed by biting instead of stinging, and their legs are broken. An American species[7] builds its clay cells in the shape of little barrels, which it hides under prostrate trees.

[1] Eumenes unguiculata. [2] E. conica. [3] Trypoxylon albitarse. [4] T. aurifrons. [5] Odynerus. [6] Agenia carbonaria. [7] A. bombycina.

Photos by, [illegible]

CONICAL AND APPLE POTTERS.

These names are suggested by the shapes of the hind-body in the two species whose photographs appear above. Below is a cluster of cells made by the apple potter, which uses clay in which it embeds small bits of stone, so that they look more like the work of a mason than of a potter. Stones of suitable size and shape have to be sought for, and when found are carried in the potter's jaws.

Photo by] [*E. Step, F.L.S.*

A Bornean Potter.

Several related species of potters are found in the Far East. They make pots of clay much after the style of our heath potter, storing them with caterpillars.

An East Indian wasp[1] makes clay pots like those of eumenes, and stores them with stung caterpillars. The pots are attached to wood. Of an allied species,[2] Sir Richard Owen complained that it obliterates Egyptian hieroglyphics by plastering its cells among them. Some thousands of years ago, when an ancient Egyptian was being converted into a mummy, one of these wasps had the fortune to be wrapped up with him. When, in later times, Dr. Birch, of the British Museum, unrolled the wrappings of that mummy, the wasp came to light, to prove that this potter was an ancient Egyptian also.

The Humble-Bee Fly.

We have already mentioned how the naturalists of a century ago saw in the mimetic resemblance of a species of drone-fly a special intervention of Providence to enable the fly to slip into a bee's nest unnoticed, in order that it might lay its eggs there, and so bring about the ruin of the unoffending bee-colony. As we then pointed out, one of the weaknesses of the argument is that the drone-fly is in no sense an enemy to the bee, but a distinct friend. Had they pitched upon the humble-bee fly[3] as their recipient of special Providential favour there might have been something in it; though even then it would have been hard to understand why the industrious bee should have been victimized in order that a mere parasite brood should thrive.

The humble-bee fly is got up to resemble one of the smaller humble-bees, and the likeness is achieved mainly by the dense pile of silky brown hairs that covers the body, and by the long, bee-like "tongue." But there can be little doubt that this livery is not intended to delude bees, but rather to deceive the enemies of flies into the belief that this fly is some kind of a bee—therefore, provided with a sting, and better left alone. As a matter of fact, though the humble-bee fly does victimize humble-bees, it appears to be more of a nuisance to the solitary mining bees. Dr. T. A. Chapman has made careful observations upon its behaviour towards andrena and to the tower-building wasp odynerus. From these observations it appears that the female fly does not enter the nest of the bee to lay her eggs, but, whilst still on the wing, flings her egg as it were against the bank where the bees are mining. Proximity is apparently enough, and the newly hatched grub probably attains its goal more safely than if its mother attempted to place the egg upon its victim.

The Black Bottle-maker.

This little potter wasp, which may be found in Southern Britain, constructs its nest in the shape of a wide-mouthed bottle; but it is not so accomplished a potter as some others, and its work does not stand exposure to bad weather. It is placed, therefore, where it will not be fully exposed, and it is lined with a coating of glaze.

Later Dr. Chapman found both the grub and the chrysalis in the cells of a mining bee.[4] The grubs at first sight, owing to their form, might be mistaken for those of a bee, but an examination of the head shows it to be that of a two-winged fly. It has a very delicate skin through which are seen masses of fat, and through

[1] Rhygchium nitidulum. [2] R. brunneum. [3] Bombylius major. [4] Andrena labialis.

these runs the dark digestive system. It has a very small, retractile head, armed with bristle-like jaws. Its feet are reduced to six stout bristles. As the cell containing the chrysalis was empty, save for the cast grub-skin, it appeared that the fly-grub had eaten the grub of the bee. The chrysalis is much like that of the ghost-moth. On the head are five spines, which represent no corresponding parts in the head of the perfect Insect, and are seen to be special developments to assist the chrysalis to make its way through the clay-stopping with which the mother-bee had sealed up the mouth of its cells. There are numerous bristles and hooks on the various segments of the body, which give the chrysalis leverage to push its head-

Photo by] [*E. Step, F.L.S.*

THE HUMBLE-BEE FLY.

A two-winged fly whose form and thick coat of long hairs produces some resemblance to a small humble-bee. It lays its eggs in the vicinity of the nests of solitary bees, where the resulting grub enters a cell and feeds on the grub of the bee. The fly is shown four times its actual size.

spines through the clay, and to help it in climbing through the burrow, which is from six to ten inches deep.

It is quite a common thing for moths which spend the chrysalis period in wood or earth to have the way made easy for their exit as moths by the caterpillar preparing that way before it becomes a chrysalis. But in the case of a fly-grub there are no organs that will enable it to do this office, and the circumstances of its pupation makes such provision unnecessary. The case of bombylius is quite exceptional, and no other fly-chrysalis appears to be

called upon to do such work, and consequently is not fitted with the tools for the purpose.

There is one other point in which this Insect appears to have borrowed ideas from the bees upon which it preys. In order to avoid fouling their nests, which would probably bring about the destruction of the race, the bee-grub does not void any of its waste, but retains it in the hinder part of its intestines until it attains to the winged condition, when it is either left in the empty chrysalis-skin or discharged after leaving it. A similar arrangement is met with in the ant-lions, and here again in the case of the humble-bee fly.

Stag-Beetles.

Of the more than three thousand species of beetles that are to be found as inhabitants of these islands, the stag-beetle [1] more than all the others has impressed

Photo by] [*H. Bastin.*

MALE STAG-BEETLES.

A series of specimens photographed side by side to show the great variation in size and the development of the jaws that is found in this species. The females exhibit a similar range of variation in size.

itself upon the popular mind. Though it is restricted in its range to the south, the figure of the male often seen in books has become so familiar that most people know its name when they see it for the first time. Here, just one item in the structure has served to make the Insect notorious, and this is the huge development of the mandibles which are reminiscent of the antlers of a stag, and so have suggested a distinctive popular name, which has been accepted and latinized by the learned men who act as scientific sponsors for all living things. In one respect the name is not a good one, because it relates to the appearance of one sex only: it is the male alone that has this great development of its jaws. Although the female has got a strong pair of these organs, and for food-getting purposes a more practical pair than her mate, they are only in fair proportion to her size, and, therefore, are not noticeable; so that a novice might easily mistake the two sexes for separate species. In the photograph of the two sexes (page 431) it will be seen that

[1] Lucanus cervus.

[E. Step, F.L.S.

THE STAG-BEETLE.

[illegible] here represented by the two sexes, is a convenient example of the high development of the exterior attained by the beetles, every part being protected with hard, horny armour connected by tough but supple joints, which allow perfect freedom of movement of the limbs and other parts.

with the development of the "horns" of the males there has been a corresponding increase in the size of the head and all its parts, eyes and antennæ included. In truth, the comparison will show that the difference extends to the entire Insect, for not only is the female considerably the smaller of the largest specimens of both sexes, but her fore-body and her wing-covers are much more rounded than is the case in the male, and the legs are smaller.

Photo by] [*H. Bastin.*

STAG-BEETLE GRUBS.

The grubs are shown feeding in a decaying tree, where they are engaged for several years. The trees attacked are chiefly oaks and willows, but the timber is mostly in a decaying condition before the eggs are laid upon it. Occasionally they attack the roots of trees still living.

We have referred to the "largest specimens" because there is very great variation in this respect in the species. You may come across males that measure two and a half inches from the tip of the antlers to the end of the wing-covers; another may measure less than half that length. A similar disparity may be found in the size of the females, some of these being very small indeed. The colour, too, varies from a bright chestnut to a brown that is scarcely to be distinguished from black.

The possession of the "horns" by the male has led to a large amount of theorizing and conflicting statements. Their chief use appears to be that of sexual ornament, though they may be useful on occasion to retain the female where there is tolerable uniformity in size between the pair. It is stated that the males fight fiercely between themselves for possession of some desirable female, but we have never seen one of these conflicts. It is tolerably certain, however, that though they may indulge in a duel, they cannot well hurt one another. Put your finger between the horns of a full-sized male, and induce it to

close them upon your flesh. You will then know that they have insufficient muscular power to make the slightest impression upon the armour-clad bodies of their rivals. It is possible, too, that they scare off birds by assuming a proper attitude and distending their mandibles to the full extent. A common attitude with the male when at all alarmed is to raise the head and fore-part of the body by stiffening the fore-legs, and then distend the jaws and spread wide the antennæ. There is a "come on if you dare" air about him, which, no doubt, serves the purpose for which it is assumed; but it is mere bluff.

The well-formed wing-covers protect a pair of long, transparent wings of a pale-brownish tint, so long that they have to be doubled over as well as folded to get them underneath. The wing-covers take no part in the work of flight, being merely held up over the back to allow free play to the wings. The flight does not strike the observer as being business-like, but rather as slow and aimless. In the districts where the beetle is plentiful they may be seen in flight in the evening in June and July. They frequently blunder against persons and get their hooked feet entangled in the hair of ladies, who become greatly alarmed, and expect to be eaten. At such times they are fond of flying around oaks in quest of mates. They settle also to feed upon vegetable juices, which the female easily obtains by crushing shoots and leaves with her short jaws. The male may also do this with the teeth or tines of his horns, but these organs are ill-adapted for such work, and he probably feeds at wounds which have been made by females, or on free-flowing juices. The tongue in both sexes is adapted for sucking fluids, its four branches being thickly beset with golden hairs.

Photo by] [*H. I*

CHRYSALIS OF STAG-BEETLE.

The grub hollows out a space among the wood-fragments to serve as a cocoon, and changes to a chrysalis. It will be seen that the long, antler-like jaws are pressed to the under side, now uppermost. The chrysalis-skin is thrown off long before the perfect beetle leaves this cell.

In the larval stage the beetle feeds upon decaying wood, usually oak or willow; only occasionally upon the roots of living trees. They are occupied in this work for about four years, but only a short period is spent in the chrysalis condition. In this stage the large horns of the male are bent under and lie pressed to the under surface. The grub is much like that of the better-known cockchafer, of a whitish colour except the red-brown head, and with the hinder extremity of the body much enlarged. When about to enter upon its next stage it makes a sort of cocoon of wood-fragments in which to lie. In exploring decaying stumps for beetles in the spring, the collector frequently comes upon stag-beetles that have already assumed

Photo by] [*H. Main, F.E.S.*

THE KENTISH GLORY.

The photograph represents the finely marked female moth. The male is much smaller and less brightly coloured, though it has fine antennæ. Natural size.

the perfect form, but are in a lethargic condition, in which they remain until June, when they make their way out into the public view. In this emergence the males precede the females by several days.

Attention should be drawn to the remarkable form of the antennæ, which characterizes three families of beetles, and reaches its highest development in the cockchafer and its immediate allies. In the stag-beetle the last four joints are very broad in one direction, so that they look like a kind of brush with a long handle. It is probable that these differently shaped terminal joints are the seat of some special sense, but what that sense is has not yet been determined.

The stag-beetles are a numerous family, there being nearly six hundred species known from various parts of the world. There are only two other British species, neither of which is sufficiently known to have had any popular name bestowed upon it. It must be confessed that the scientific men have tried their best to make up for the deficiency by giving both fine-sounding names with a fair number of syllables.[1] The word dorcus applied to one of these is evidently from the Greek for an antelope, but it is not easy to see why it is so called. It is about an inch long, and much like a diminutive stag-beetle, except that the mandibles of the male are only as large as those of a female stag-beetle. In both sexes the colour is black, and there is no difference in size except that the hind-body and wing-covers are broader in the female. The grub is somewhat similar to that of the stag-beetle, and feeds internally on the wood of decaying willow, beech, and oak. The French call it *La Petite Biche.*

The third species, whose scientific name signifies the wood-destroyer, is a smaller Insect, little more than half an inch long, shining black, minutely pitted on the fore-body, which has its front part cut away abruptly and forming five small tooth-like projections. The little head ends in a curved upright horn suggestive of that of the rhinoceros in the male; but in the female it is much shorter and straight. On the wing-covers the little pits are larger and run one into another. The grub, which lives in decaying ash, willow, and other trees, is somewhat like that of the stag-beetle, except that its hinder parts are not swollen—it is indeed narrower there than behind the head.

Photo by] [*H. Main, F.E.S.*

EGGS OF KENTISH GLORY.

The large eggs are laid along the twigs of birch-trees, usually in a double row. At first green, they change in tint to purple-brown. They are here enlarged to twice the natural size.

[1] Dorcus parallelopipedus and Sinodendron cylindricum.

Photo by] [*H. Main, F.E.S.*

KENTISH GLORY CATERPILLARS.

These stoutly built caterpillars are green, with oblique whitish stripes along the sides. They are shown here slightly enlarged. It will be seen that in a general way they resemble the seed-catkins of the birch, which are included in the photograph. It is probable that this resemblance may be of some protective value.

Photo by] [*H. Main, F.E.S.*

YOUNG CATERPILLARS.

When very young the caterpillars of the Kentish glory cluster together around a birch twig, with their fore-parts raised. As they get larger they separate and feed singly.

The Kentish Glory.

Although in general appearance this splendid moth resembles the eggers, the very considerable difference in the caterpillar shows it is not closely related, and the authorities have erected it into a separate family. If the photograph of this caterpillar is compared with those illustrating the article on eggers (page 246), it will be seen that, quite apart from the absence of hairy covering, the Kentish glory caterpillar is quite different in form, tapering to the head and having a pyramidal elevation on the last segment but one, which suggests a resemblance to the caterpillars of the hawk-moths, a likeness increased by the oblique white and creamy stripes along the sides. It is coloured green, paling to a whitish tint on each side of the central dark-green line. It attains a length of about two inches, and in appropriate localities it may be found feeding on birch from the end of May to July. When newly hatched they are black, but after casting their skins the black becomes greenish, sprinkled with minute black dots; later they become distinctly green, and the black dots are restricted to the lower surface. In the young condition a number of the caterpillars will cluster together on the twigs of the birch, presenting a peculiar appearance with their fore-parts raised from the twig. As they get larger they separate, apparently to avoid becoming too noticeable. When full grown they construct a rough dark-brown cocoon on or just under the surface of the ground, and spin up moss and vegetable debris into the structure. Here they change into blackish chrysalids, with rough points on the segments, which enable them to wriggle out of the cocoon a few days before the moth emerges in the following spring.

Photo by] [*H. Main, F.E.S.*

NEWLY EMERGED.

The Kentish glory has just escaped from the chrysalis and cocoon at the base of the tree, and has climbed up a twig, there to hang until the wings have expanded fully.

About April the small, tawny-brown males fly in sunshine seeking the larger, paler-coloured females, who sit about on birch or heather until after dark. It is a forest and moorland species, in the former frequenting the open places where there is sufficient light for the birch to flourish. Its old name of Kentish glory[1] was probably given to it from its occurrence in Darenth Wood, near Dartford, that former paradise of the London

[1] Endromis versicolor.

entomologist, whose glories (in a double sense) have long departed. Tilgate Forest, in Sussex, was also a stronghold of this moth, but it is by no means so plentiful as it was, except in parts of Scotland and Worcestershire. The female measures nearly three inches across the wings, and the male about two inches and a quarter. The large, purplish-brown eggs are laid in double rows along the twigs of birch.

Photo by] [*H. Main, F.E.S.*

THE LEAF-CUTTING BEE.

One of the clever and industrious bees that disfigure our rose-bushes by cutting out oval and circular pieces from the leaves, wherewith to line her burrows, and divide them into nursery-cells.

Upholsterer Bees.

Some Insects exhibit a tendency to luxury in their surroundings. Many there are that finish off their cocoons with a delicate, polished, silken lining so that the chrysalis shall not be in danger of injury through any roughness of the part that lies next to it; but a select few to which we propose to devote a small space, rely not upon their own secretions for this purpose, but import hangings from without. Let us first, however, briefly refer to two or three of the former class among bees. Under the head of carpenter-bees we have already mentioned several species that bore into bramble-stems and divide the burrow into cells by building up partitions across it. The little solitary bees of the genus prosopis, however, that excavate their nests, some species in the stems of brambles and other plants, and some in the earth, form cells by lining the burrow with a fluid secretion from the mouth which hardens into a delicate tissue, not unlike gold-beater's skin, but finer. There is reason for the use of this material in the fact that the provision for the food of the future grub is more liquid than is usual in the case of the solitary bees. This food

Photo by] [*H. Main, F.E.S.*

THE WORK OF THE LEAF-CUTTER.

A rose-leaf, of which four leaflets have been cut by the bee. Sitting astride the edge of the leaf, the portion desired is cut through by her jaws, and when completely severed she flies off with the piece to her burrow, where it is curved and adapted to the form required.

consists of pollen to which sufficient honey is added to enable the bee to knead it into a pasty lump. Prosopis is without the usual pollen-collecting apparatus on the hind-legs; and for this reason it was long suspected to be of parasitical habits. But though parasitism has been shown by Mr. R. C. L. Perkins to be indulged in by some of the numerous Hawaiian species, the charge does not lie against our native species. It is now shown that they are of rather primitive organization, and have to bring home their pollen and honey mixed—in their interiors—and regurgitate it for the storing of their cells. The mixture being more liquid in character, the cells are lined to make them waterproof for the holding of it. For the purpose of laying on the lining secretion, the tongue is specially developed into a somewhat triangular organ, broad in front.

In the neighbouring genus colletes, although the bees make their burrows in the ground, their cells are lined with the same material. They are less primitive than prosopis, and have the legs well clothed with hairs, but they have a similar shaped tongue, and mix a good deal of honey with their pollen. They bring home a great quantity of pollen on their legs, but this is mixed in the cells with so much honey that, according to Shuckard, the mass ferments, but is nevertheless consumed by the grub without any ill results, the more liquid portion being consumed first, the more solid later. Speaking of the upholstery work, this author says: "The beauty with which these cells are formed transcends conception. Each consists of a succession of layers of a membrane more delicate than the thinnest gold-beater's skin, and more lustrous than the most beautiful satin. In glitter it much resembles the trail left by the snail, and is evidently, from all experiments made, a secretion of the Insect elaborated from some special food it consumes, and by means of its bilobated tongue, which it uses as a trowel, it plasters with it the sides and the bottom of the tube it has excavated to the extent necessary for one division. As this secretion dries rapidly to a membrane it is succeeded by others to the number of three or four, which may be separated from each other by careful manipulation. It then stores this cell, deposits the egg, and proceeds to close it with a covercle of double the number of membranes with which the sides are furnished, and continues with another in a similar manner, until it has completed sufficient to fill the tubular cavity, which, after closing the last case similarly to the rest, it stops up the orifice with grains of sand or earth."

Photo by] [*H. Bastin.*

A Leaf-cutter's Cell.

A single cell detached and enlarged to show how the leaves are curved and folded to get the form required. The photograph is about three times larger than the actual size.

The carder-bee[1] is one of the upholsterers that go abroad for their materials, and her decoration takes more the character of tapestry. She is a larger bee than those just named, her body half an inch long, and the spread of wings an inch.

[1] Anthidium manicatum.

Photo by] [*H. Main, F.E.S.*

THE NEST OF THE LEAF-CUTTER.

The leaf-cutter has sunk several shafts in decayed wood, and in two of these she has formed and provisioned her cells of rose-leaf. From this and the previous photograph it will be seen that each cell is made separately, and about a dozen pieces of leaf separate one cell from the next. Twice the natural size.

She is too large for bramble-stem exploration, and does not appear to relish hard, manual labour such as is involved in digging a shaft in the earth; so she looks out for the disused tunnel of some other Insect, such as the musk-beetle or the goat-moth, and appropriates it to her own use. This is the Insect to which Gilbert White refers in the following passage, though he did not know its name:—"There is a sort of wild bee frequenting the garden-campion for the sake of its tomentum, which probably it turns to some purpose in the business of nidification. It is very pleasant to see with what address it strips off the pubes, running from the top to the bottom of a branch, and shaving it bare with the dexterity of a hoop-shaver. When it has got a bundle, almost as large as itself, it flies away, holding it secure between its chin and its fore-legs."

In addition to the plant mentioned by White, the carder-bee gathers her cotton-wool from the corn-cockle, the quince, and other plants with downy leaves and stems. With this she lines the cavity selected for her operations, and forms

Photo by] [*H. Bastin. Photos by*] [*H. Main, F.E.S.*

EGG. GRUB. CHRYSALIS.

In this series of photographs is shown what the cells of the leaf-cutter bee contain at different periods. Before the cell is closed an egg is laid on the mixture of pollen and honey upon which the grub is to feed. In the second photograph the full-grown grub is shown in its cell after having disposed of the food-supply. The third photograph shows a cell cut open after the grub has changed to the chrysalis.

her cells in it, coating the inside of the cells with cement to enable them to hold the pollen-honey mixture with which she next stores them. This is the only British species, and here it is restricted to the southern parts of England, but there are others on the Continent. Fabre has described the work of one of them[1] which forms its nest in hollow reeds, much after the fashion adopted by our species. The grub, before pupation, constructs a cocoon of its own excrement connected by silk. At one end it is provided with a perforated conical extension, which Fabre surmises to be for the admission of air. Two other species utilize empty snail-shells for nesting places. One of these[2] only uses the broader body-whorl of the shell, shutting off the narrower portion by a wall of resin collected from plants. The other[3] uses the narrower whorls and leaves the body-whorl vacant; in consequence it sometimes happens that a species of osmia builds her nest in the mouth of the shell and blocks up the carder-bee. As the latter is ready to leave its cell before the osmia has completed its transformations, it dies a prisoner in its cell.

[1] Anthidium diadema. [2] A. septemdentatum. [3] A. bellicosum.

RUBY-WASP AND MASON-WASP

The Mason-wasp builds temporary towers to exclude enemies from her nest. In spite of this precaution, the Ruby wasp succeeds in getting access to some of the cells and introducing her eggs. Her grubs destroy those of the mason, sometimes eating the egg before it hatches, and then consuming the food that was stored for the mason-grub consumption. The Mason-wasp is shown above, and the Ruby-wasps below. All considerably enlarged

But the bees that are most fully entitled to the name of upholsterers are the leaf-cutter bees.[1] These have long been known, not only to naturalists, but also to everyone who has grown roses, for every rose-garden furnishes evidence of the skill with which these bees cut out circular and oval pieces for the lining of their cells. Sometimes the foliage of one particular rose-tree is specially attacked, and the rose-grower who takes pride in the general perfection of his plants—leaf as well as flower—is rather emphatic in his denunciation of the "pest" that has wrought this havoc. All the leaf-cutters, however, do not select rose-leaves for their purpose; the species that do so mostly are Willughby's leaf-cutter[2] and the patchwork leaf-cutter.[3] The first-named usually makes its nest by boring deep wells in the soft wood of an old willow, and sometimes instead of rose-leaves selects those of the laburnum for its depredations. The manner in which most of the species work has been well described by Shuckard. He says: "Having fixed upon the preferred plant, rose-bush or laburnum or sallow, or whatever it may be, it alights upon the leaf, and fixing itself upon the edge, it holds it with three legs on each side, then using its mandibles as the cutter of silhouettes would his scissors, and just as rapidly as he cuts out a profile, does this ingenious little creature ply the tools it is furnished with by nature. The oval or semicircular cutting being thus speedily dispatched, with the legs still clinging to the surfaces, the Insect biting its way backwards, the piece cut off necessarily remains within the clutch of the legs, and, when about falling, the rejoicing labourer expands her wings and flies off with it with a hum of delightful triumph, the cutting being carried perpendicularly to her body. In a direct line she wings her way to

Photo by] [*H. Bastin.*

NEST OF LEAF-CUTTING BEE.

In this case instead of soft decaying wood the tunnel has been bored in living wood—that of a small cherry tree, and packed with cells. Two separated cells are seen in the lower left-hand corner of the photograph.

[1] Megachile. [2] M. willughbiella. [3] M. centuncularis.

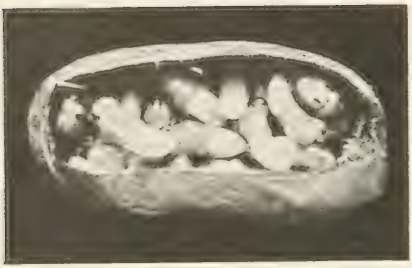


Photo by] [*H. Bastin.*

ICHNEUMONS.

A cocoon of the leaf-cutter bee on being cut open is in this instance found to contain a number of chrysalids of an ichneumon-wasp. The female ichneumon had contrived to deposit her eggs in the cell, and the grubs have lived at the expense of the bee larva, which has been consumed ultimately.

the receptacle, and arrived at the mouth of the aperture within which she has to convey it, she rolls it to its requisite tubular form and thrusts it forward to the bottom of the cavity. The first piece for the lining of the cell is always oval and larger in proportion to the succeeding ones, which, to the number of three or four, are semicircular, the first piece having an extra use to serve in forming a concave bottom to the cavity. Having completed the requisite manipulation for adjusting to shape the external lining of the bottom and sides of the first cell, she withdraws backwards, again flies off, and, as if she had traced a trail in the air, . . . back she wends to the same plant, and proximately to the spot of her recent triumphant exploit, renews the operation, but the result of which, this time, is to be semicircular. Home she flies again, and the arrangement within of this piece is different . . . for this is simply tubular, and so placed that it imbricates with its cut margin within the serrated edge of the first and the third, and in case of a fourth the fourth also is similarly placed, so that one laps within the other, the edges of two of these cuttings never being conterminous. The number of the cuttings is apparently regulated by the drier or moister condition of the substance in which the tunnel is drilled. Another duty has now to be performed, indeed that for which all the preceding labours were undertaken—the provision for its young, wherein it perpetuates its kind. . . . Having completed the requisite store of honey mixed with pollen, this is carried to the brush with which the under side of the abdomen is furnished, by means of the posterior legs. The honey and pollen are gathered from different kinds of thistles, whence it acquires a reddish hue and looks almost like conserve of roses, and the nest is filled with it within a line of its top; the egg is then deposited. . . . The cell has now to be closed, and the artificer, knowing that the transverse section of the cell is circular, again flies forth, and without compass, but with all the accuracy with which Leonardo da Vinci struck a circle with his pencil, to testify his mastery, cuts the leaf again in that form, and as surely: and three or four, or five or six times repeats the operation, returning each time with each piece, so many having been variously observed."

In the same manner other cells to the number of four or five are formed above the first, and any space remaining in the tube is filled up with earth. The bee

Photo by] *H. Bastin.*

A BEE PARASITE.

Ichneumons are not the only enemies from which the leaf-cutters suffer. Another bee—cœlioxys—to save the labour of nest making and provisioning, lays her eggs in the leaf-cutter's cells, and the young consume the egg and stores of their hosts. This is the bee that does the mischief.

Photo by *Mr.*

OSMIA CELLS IN BRAMBLE-STEMS.

The little bee known as osmia bores into the pith of dead bramble-stems, dividing the burrows into cells which a[illegible] and honey, and an egg laid in each cell.

then bores another tube, and repeats the process until her egg-supply is exhausted. When the grub has consumed its food-store, it spins a lustrous silken cocoon attached to the hangings of its cell, and undergoes the changes into the chrysalis and perfect bee.

Our other native species proceed in a similar manner, though some of them work in different materials. Thus, one[1] makes her excavations in the ground of banks, but lines them with rose-leaves; another[2] mines in sand, and sometimes uses the leaves of bird's-foot trefoil for her upholstery; a third,[3] like Willughby's leaf-cutter, makes hers in wood; a fourth[4] has been found nesting in the stumps of the broom. The common species, again, has sometimes been found to use the *petals* of the garden geranium, in which she appears to come close to the poppy upholsterer,[5] which lines her cells with the scarlet petals of the corn poppy. This bee is usually found in the neighbourhood of cornfields, and sinks her shafts in the firm earth of roads and well-trodden footpaths. Cutting semicircular pieces from the bright-red petals of the poppy, she uses them in much the same manner as the common species does with her rose-leaves, but instead of cutting small circles for capping the cells, she simply turns over the upper edges of the lining pieces to effect the closure.

Photo by] [*J. J. Ward, F.E.S.*

BUFF ERMINE-CATERPILLARS.

One of the smaller "woolly bears" that may be seen frequently in late summer or early autumn, hurrying across paths. It is a destroyer of many low weeds. Natural size.

Another species,[6] with labour-saving inclinations, usually appropriates a burrow of the earthworm, and as this is far too long for her purpose, she stops it at the proper depth with a plug of leaves, on which she builds up her cells. This labour-saving idea is appreciated by various species, who are not slow to avail themselves of any previously existing cylindrical hole of the right size for their nesting place. Bamboos used for the support of tall plants in gardens are frequently adapted to their purpose; screw-holes, pipes of small bore, and gun-barrels also come in handy to some individuals.

Ermine-Moths.

Included in the same family[7] with the tiger-moths are several white or cream-coloured species that are common by waysides and in gardens. From the fact that they are more or less spotted with black on their downy wings and bodies

[1] Megachile circumcincta. [2] M. argentata. [3] M. ligneseca. [4] M. versicolor. [5] Osmia papaveris. [6] Megachile albocincta. [7] Arctiidæ.

the name of ermine-moths appears to be a very appropriate one. During the day they may be seen sitting about on low herbage in exposed positions where such an exhibition seems highly dangerous in a world that contains many Insect-eating creatures. But the ermine-moths are not good to eat, and their conduct almost indicates a consciousness of the fact, as their colours make it known to the Insect-eaters.

The most familiar member of this group is the white ermine.[1] Normally its fore-wings are white with the faintest tinge of cream colour, scarcely evident except by contrast with the pure white hind-wings. Other specimens have the fore-wings distinctly cream coloured, and in others the cream has deepened to buff. Typical specimens have a great number of small black dots scattered over the fore-wings, and two or three on the hind-wings. The hind-body is yellow with a black spot in the middle of each segment and one on each side. The caterpillar is one of the "bears," and under its long, brown hairs the body is brown with an orange-red stripe down the middle of the upper surface. It is a general feeder on all kinds of plants whose foliage is close to the ground, whereon it may be found during August and September. It then spins up a slight and far from roomy cocoon into which it weaves its own hairs, and having changed to a dark-brown chrysalis, passes the winter and spring in that condition, the moth emerging in June.

BUFF ERMINE MOTH.

Similar in a general way to the white ermine, this moth has wings of some shade of buff, with the black spots differently disposed. Natural size.

A very similar moth is the water ermine,[2] which has all the wings white, with a black dot or two on the fore-wings. The yellow hind-body is white at the tip. It is not a common species, and is only found in the neighbourhood of marshes, where its caterpillar days are spent in feeding on the plants peculiar to such places, such as mint, willow-herb, lousewort, yellow loosestrife, flag, and waterdock. The caterpillar is dark brown, dotted with black warts, from which spring the spreading tufts of dark-brown hairs. It spins up in August. The cocoon and chrysalis are similar to those of the white ermine, but the chrysalis has a redder tinge. It remains in the chrysalis stage during the winter and spring, and the moth makes its appearance in June.

A third species is known as the buff ermine,[3] from the colour of the fore-wings being commonly some shade of buff, though it varies in one direction to cream colour and in another to light yellow. The hind-wings are usually paler. Several

[1] Spilosoma menthastri. [2] S. urticæ. [3] S. lubricipeda.

black dots are scattered along the front edge of the fore-wings, and others form a more or less indefinite oblique line extending from the tip to the hind-margin. There are a few (number variable) small, black spots on the hind-wings also. The hind-body is yellow with three rows of black spots. The caterpillar, which often tries to help us get rid of our garden weeds, is a brown, hairy creature much like that of the white ermine. It feeds upon all kinds of low-growing plants, spins up in August or September, and passes the winter as a red-brown chrysalis, from which the moth breaks out in June.

One further species must be mentioned. This is the muslin-moth,[1] in which the females alone have white wings, with six or seven black dots on each. The smaller male is entirely of a smoky-brown colour, upon which the darker dots are not very prominent. From this fact it is concluded that the muslin-moth is edible, and that the females, who expose themselves to view much more than the males, mimic the inedible white ermine.

Photo by] [*E. Step, F.L.S.*

WASP-BEETLE.

Conspicuously banded with bright yellow on a black ground and with a globular fore-body, the beetle, when walking on flowers and leaves, is frequently mistaken for a wasp. Twice the natural size.

The Wasp-Beetle.

Among the beetles of the long-horn family[2] which feed as grubs in timber is one that may frequently be seen in summer flying about flowers. Like others of its family its body is long, slender, and straight-sided, its legs and antennæ are long, and its colouring is black and bright yellow. The yellow is laid in narrow bands across the black, and the superficial appearance presented is that of one of the smaller species of wasp. The manner in which it moves its long legs in walking is very like the movements of a wasp, and it agitates its antennæ in precisely the same nervous manner as the wasp does hers. There can be little doubt that this close general resemblance to a wasp largely protects the beetle from being eaten by birds, for it must be remembered that the colouring of a wasp not merely gives notice of the fact that it is dangerous to meddle with it on account of its stinging powers, but that it is objectionable as food to most creatures at least. The strongly contrasted black and yellow, or black and red, wherever found as the predominating feature in the colouring of animals, may be held, *prima facie*, as presumptive evidence that the creature so coloured is inedible, or at least unpalatable. Creatures so coloured have the habit of boldly, sometimes ostentatiously, exposing themselves to the view of the natural enemies of their kind, as though fully conscious that the significance of such colouring is generally understood. Thus, the caterpillar of the cinnabar-moth, conspicuously coloured in alternate rings of orange and black, feeds openly all day in crowds on the ragwort, not troubling to hide itself under the leaves. The cinnabar-moth itself, simply coloured in black and crimson, flies lazily in sunshine, and the somewhat similarly ornamented burnet-moths sit on flowers in company as though there were no such creatures as Insect-eating birds.

[1] Diaphora mendica. [2] Cerambycidæ.

Photo by [illegible]

THE WHITE ERMINE-MOTH.

The moth is seen at rest on a bramble-leaf on the ground, the photograph having been tak[illegible] exposed, the white ermine rests as though conscious of her perfect immunity from attack [illegible] colouring advertises this fact to all concerned.

Photo by] [*E. Step, F.L.S.*

OBSCURE WASP-BEETLE.

Of similar form to the yellow-banded species, this is black marked with grey bands, and a large purple-brown patch at the base of each wing-cover. When walking on the bark of trees these patches make the beetle look like one of the wasps that have long, slender waists. Four times the natural size.

Photo by] [*E. Step, F.L.S.*

MULLEIN-BEETLE.

One of the wasp-beetles, but scarcely wasp-like. It is coated with yellow-grey scales and banded with black. It is found in Europe, but not in Britain. Four times the actual size.

But to return to our wasp-like beetle.[1] Although it has obtained the popular name of the wasp-beetle, the resemblance is not nearly so good as in some of the moths where, by losing their scales on emergence from the chrysalis, the wings also resemble those of a wasp and bring about a true likeness in details. Except when in flight, the wings of the wasp-beetle are kept in concealment beneath the wing-covers. And yet, the body of the wasp being more conspicuous than its semi-transparent wings, it appears to be sufficient that the wing-covers of the beetle should have a general colour resemblance to the wasp's body. Of course, without something unpleasant in its taste to back up its colouring, birds would soon learn, probably, to distinguish between the real wasp and its imitator, but the unpleasantness appears to be there. Experiments have been made in feeding Insect-eating birds and reptiles with these strongly marked Insects, and in the majority of cases they have been rejected. Sometimes, when impelled by hunger, an attempt has been made to eat one, but the offer of a second helping has been refused. Recently we supplied a wasp to a long-eared bat that we knew to be in a fasting condition. At first it was refused, but later it was eaten. The next day a second wasp was offered, but the bat refused to have it. A similar result followed the offer of the large yellow-underwing moth, whose hinder wings are banded with black.

The larva of the wasp-beetle is a long, whitish grub which, like the other long-horns, feeds in wood, apparently more in the branches than the trunks of trees. A few years ago our "den" became somewhat enlivened by the appearance of about half a dozen of these bright and active beetles, and for a week there were daily accessions to their numbers. The family were puzzled at this irruption, and fears were entertained that they might be infesting the furniture or woodwork of the house; but ultimately they were traced to

[1] Clytus arietis.

oak-billets that bore specimens of corky fungi. The beetle, which varies a good deal in the matter of size, makes its appearance in June, and in that and the following month may frequently be seen on the flowers and vegetation of the hedgerow. We have two other species, the greater wasp-beetle[1] and the obscure wasp-beetle.[2] The former is a better representative of the wasp on account of its larger size, but it is a rarer Insect. The third species is much smaller, and has no yellow bands, grey taking their place, and on the base of each wing-cover there is a large patch of purple-brown, which has the effect of making the beetle —when seen on a dark background —look like one of the burrowing wasps with a long, slender waist. The pretty mullein-beetle,[3] shown in one of our photographs, belongs to the same genus, but is not a native, though European.

It should be added that the coloured bands of the beetles are not due to pigment in the wing-cover itself, but to a layer of scales and hairs arranged upon it, as may easily be seen with the aid of a pocket lens.

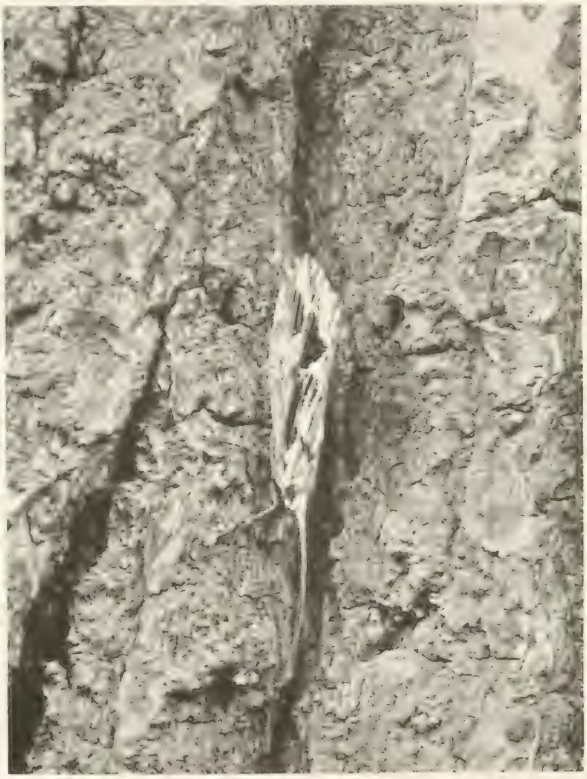


Photo by] [*H. Main, F.E.S.*

CADDIS-FLY AT REST.

The larger species of caddis-fly are on the wing only at night. During the day they rest on posts and tree-trunks with the wings folded closely to the body and the antennæ directed straight in front. Most of the species are dull coloured, but this is prettily mottled with black and grey.

Caddis-Flies.

Many a naturalist had his observing faculty first awakened on the margin of a pond or stream. He may have started as a boy catching "tiddlers" with a small net, and would then get interested in the very numerous and varied forms of life that he would bring up with every sweep of his implement. Among these would almost certainly be the grubs of some of the caddis-flies in their remarkable portable houses or "cases," and these in many instances have been taken home and installed in an aquarium, where their curious forms and the method of building them could be watched.

It is open to any reader who has access to a pond or stream, large or small, to do likewise—collect a number of these caddis-cases, and, placing them in an aquarium, to watch the development of the caddis "worms" into the hairy-winged caddis "flies." These Insects form a natural order[4] of their own, characterized by the possession in the final stage of four wings, which are more or less liberally

[1] Clytus arcuatus. [2] C. mysticus. [3] C. verbasci. [4] Trichoptera.

clothed with hairs. In this stage they come rather closely into resemblance with moths,[1] and in other days some of the species were for a time regarded as moths. The majority of moths have the mouth-parts developed into a long tube which can be coiled up after the manner of a watch-spring when not in use; but a few species of moth are deficient in this respect. Now all the caddis-flies resemble these aberrant species of moth in having their mouth-parts in a rudimentary condition. The wings are thin and semi-transparent, especially the hinder pair, which are larger than the fore-wings. As a rule they are of sombre tints, brown or black, though a few are prettily mottled with grey or white. In most cases they have long and tapering antennæ, and in some species these are several times the length of the body. They are carried standing straight out in front of the head, and close together.

Photo by] [*E. Step, F.L.S.*

SPAWN OF CADDIS-FLY.

The dark dots are the green eggs embedded in a cylindrical mass of jelly. Originally it was longer, nearly a half being doubled up behind the portion that is shown clearly. It was attached to the stem of an aquatic grass. Natural size.

In these islands we can boast of about a hundred and fifty distinct species, which are marshalled in seven families; but it is not necessary to enter into the technical distinctions between these Let us rather deal with the more interesting facts of their life-history in general terms. The female alights upon the water, or upon some floating leaf—she has been observed at times to enter the water—and deposits her eggs in a small mass of jelly direct into the water. As in the case of the eggs of the frog and toad, the jelly absorbs a great volume of water, so that in a short time it has become a cylindrical mass nearly four inches long, and half an inch in diameter. Such a mass includes four or five hundred green eggs. Upon hatching, the minute grubs make their first meal by consuming some of the jelly. They remain for two or three days about the jelly mass; then they set to work constructing a small case of any suitable material they find handy. They are born with the knowledge that protection from the numerous enemies the water contains is an essential of existence. Pretty little objects they are at this stage, as they roam over the weeds and the bottom. Spinning a tube of paper-like silk around the body, they attach foreign substances to it as they proceed. As they grow bigger the case requires to be enlarged to accommodate them, and this is effected in a very ingenious manner. All additions are made to the front end. The fore-body, to which the legs are attached, being the broadest part, additions to the case sufficient to surround this part will provide ample accommodation for the hind-body later. But such additions would soon make the case of unnecessary length; so the grub cuts off a portion at the rear each time it adds to the front, and keeps the same house for its use until it acquires wings, though before that time the case has been gradually remade entirely. The reason for this protection is found in the fact that the greater length of the grub is white and soft—conspicuous and unprotected, and offering

[1] Lepidoptera.

Photos by] [*E. Step, F.L.S.*

CADDIS-FLY AND CADDIS-CASES.

Above is a common caddis-fly on a scale of one and a half times the natural size. Below are two rows of the cases in which the caddis-worms reside. Each species has its favourite building materials and a distinct method of disposing them on the exterior of a silken tube. Those in the lower row are built mainly of sand, the three to the left of sand alone (plus the silk lining), and those to the right have a piece of twig added. One in the upper row has a snail-shell built in, and some species build of snail-shells entirely.

temptation to larger Insects of carnivorous nature, to say nothing of any fishes that may be in those waters. The head and fore-body, which have to be protruded in hauling the case along and in obtaining food, are dark and horny, as are the three pairs of jointed legs. Most species are feeders upon aquatic plants; but a few are themselves carnivorous. Apparently the grub stage is the only feeding time. The pupa has not the means of taking food, and it is probable that the rudimentary condition of the mouth in the winged Insect does not allow of indulgence in food.

After the winter the caddis-worm prepares for the chrysalis stage by spinning a silken grating across each end of its case, or by otherwise blocking up these openings. One species[1] at this period attaches heavy stones to its case, turns round inside, and thrusting its head out of the rear end, digs a hole in the bottom of the stream—it is found only in running water—and up-ends its case so that it becomes partially embedded with the heavy stones keeping it in position. When all is made safe in one of these ways, the last grub-skin is cast, and the chrysalis, with its wings, long antennæ, and legs folded down its sides, waits for the period of emergence. When this time arrives—in early summer—the chrysalis butts against the obstruction at the fore-end of its case and clears the way. It shoots up to the surface of the water, and uses its limbs to propel it to shallow water, where it wriggles ashore. Its chrysalis-skin splits and the caddis-fly walks out.

Photo by] [*H. Main, F.E.S.*

CADDIS CHRYSALIS.

The chrysalis has been extracted from its case. It will be seen that at this stage the parts of the "fly" are already well developed, the wings and antennæ being especially noticeable.

The mature Insects are seldom seen, save by the naturalist, for they are mostly night-fliers, but they may be found by day settled on tree-trunks and posts near water, where their sombre tints make them inconspicuous. One of our photographs shows one of the brighter species,[2] with mottled-grey fore-wings, at rest on a tree; its larger relation[3] is shown, with expanded wings, in another photograph. The latter species is the form most commonly seen at rest on trees and fences. A few of the smaller species may be seen flying in the sunshine above the surface of ponds.

Although the caddis-flies may be described as spending their earlier days in fresh-water, there are two or three exceptions to the rule. One is terrestrial, and two foreign species are found in salt-water.

Winter Moths.

Strange as it may appear to those townsfolk who believe that nature goes to sleep in late autumn and does not wake up again until spring, there are moths that wait until the beginning of winter before they break out of the chrysalis. Although one of these bears the name of winter moth,[4] it is not the only species to which it could be applied with fitness. After the British climate, the winter moth

[1] Micropterna sequax. [2] Phryganea minor. [3] P. grandis. [4] Cheimatobia brumata.

is probably the worst enemy that the fruit-grower in this country has to contend with; and anyone acquainted with its work might be pardoned for saying that its appearance in winter, when the nights are long, is only confirmation of his theory of its origin. The fruit-grower who knows his Insect enemies will tell us that, in order the better to escape his vigilance when she is engaged on her deadly work of laying eggs all over his trees, the female has got herself up to resemble a spider, and in this guise, under cover of winter darkness, she climbs up the trunk from the earth where the chrysalis has lain, and deposits her two or three hundred eggs in batches about the buds. She is an insignificant little creature, her wings reduced to a size that enables one to assert that they are there, but for all practical purposes they might as well be entirely wanting. But she has her six legs, and with these she can ascend quickly to the upper branches of the tree if the fruit-grower has not been laying a trap for her feet. This consists of a band of tar and grease around the trunk, which prevents her passage. At least it prevents the passage of the vast majority, but a few contrive by some means to get up above and lay their eggs, or the race would soon be exterminated locally. The male has well-developed wings, expanding to about an inch, of greyish-brown, obscurely lined and dotted with a darker tint.

Photo by] [*E. Step, F.L.S.*

MOTTLED UMBER-MOTH.

One of the commonest of the winter moths, it makes its appearance at any time between October and March, but chiefly in the last months of the year. The female is a wingless, spider-like creature.

When newly laid the eggs are greenish but become orange later. They hatch about April, when the buds are swollen preparatory to bursting and freeing the new leaves. The tiny caterpillars do not wait for this expansion, but bite through the bud-scales and bury their heads in the contents, and so destroy the bud. These are the buds that the tits are seen so industriously to pick off in spring in order that they can appropriate the grubs. The grower will not listen to this explanation, nor see the grubs on the trees: to him the birds are purely malignant pests who, for lack of other occupation, are bringing his efforts to ruin. As a matter of fact, birds who have to take their food in such minute portions have no time to spare for amusement: all their energies at this season are absorbed in filling the mouths of the dozen youngsters they have at home, to say nothing of their own physical needs. As the caterpillar gets too big for this work, and unattacked buds unfold their leaves, it spins two or three of these together and feeds under cover. All sorts of trees suffer from its depredations, but the destruction

Photo by] [*H. Main, F.E.S.*

DOTTED BORDER MOTH.

A near relation of the winter moth, but it does not appear until March. It is a female example, and it will be seen that though she has four wings, they are far too small to be of the slightest use in moving her corpulent body.

is more evident in orchards, where the caterpillars are more partial to members of the plum tribe than to apples and pears. Where the grease-band is not in use and the females have been allowed to climb the trees without let or hindrance, every leaf may be consumed, and the tree possibly killed. In spite of all watchfulness and application of grease-bands, females are found to get to the branches above and lay their eggs; and to many this has been a mystery. In the newspapers during November, 1913, much was made of the importance of a solution of this mystery on a well-known fruit farm, where the winged male was found to transport the coupled female to the branches. But this solution of the mystery had been found at least twenty years earlier, for in her Report on Injurious Insects for the year 1892, Miss Ormerod, giving particulars of ways in which the grease-band failed to meet the case, says: "Adding to this the difficulties arising from transport of the wingless females in connection with the winged males . . . it was plain that even to meet this one matter of prevention of egg-laying of wingless female moths, something more was needed."

Photo by] [*H. Main, F.E.S.*

MOTTLED UMBER-MOTH.

The male moth is shown at rest, as it may frequently be found on tree-trunks in winter. The caterpillar is very destructive in spring, alike to forest trees and those in the orchard.

The full-grown caterpillar is about three-quarters of an inch long and blue-green or smoky-brown, with a dark stripe down the middle of the back and whitish lines along the sides. When full fed it lowers itself to the ground by a fine silken thread, and enters the soil close to the roots, where it becomes a chrysalis. The moth emerges sometime between the beginning of October and the end of the year; it may be seen as late as February.

Another geometer-caterpillar of similar destructive propensities is that of the mottled umber-moth,[1] which may also be described as a winter moth, for it makes its appearance chiefly between October and December, and is sometimes found as late as March. The male moth is considerably larger than the winter moth, measuring an inch and a half across the variously marked, brown fore-wings. The female is entirely unlike a moth, for she exhibits no trace of wings. The pretty caterpillar is about an inch long with striped brown back and yellow sides and under side. It feeds upon forest trees, fruit trees, roses, etc., causing enormous damage to the young foliage in spring, and, as its scientific name indicates, often strips the trees completely. This is the caterpillar that hangs in hundreds from the branches in May, swinging on silken threads a couple of feet long.

Still belonging to the geometer family, though its stouter body and narrower wings give it something of the appearance of a noctua, is the small brindled beauty,[2] which makes its first appearance in February. It is the male that makes anything like a public appearance, for the female is again a wingless, spider-like creature that must be looked for on the trunks of oak-trees, where it is waiting for the male, or on its way to the branches for the purpose of egg-laying. These hatch in May, and the caterpillars grow to a length of nearly two inches, purplish-brown in colour, with raised black dots on the back. They feed chiefly upon oak in May and June.

[1] Hybernia defoliaria. [2] Apocheima hispidaria.

Photo by] [illegible]

WINTER MOTHS.

Three species are here represented. At the top are the male and female of the [illegible] from the chrysalis. It is one of the stout-bodied tribe of noctuas. In the middle [illegible] wingless; and below is the male of the dotted border moth, whose [illegible] male [illegible] shows [illegible].

More akin to the mottled umber, but unlike it in colour and markings, is the early moth,[1] which appears in January or February on hawthorn hedgerows after dark. The male has the fore-wings dark brown, with two lines and a central spot of a darker tint, and the hind-wings pale brown with a central dot, and a thin, dark line across them. The female has the wings too small to be of any use to her. The caterpillar is green, striped and spotted with white along the back and sides. It may be found in spring feeding upon whitethorn, blackthorn, and plum-trees. Another relation of early habits is known as the spring usher,[2] but as its time of appearance is February, it has about the same relation to the spring as the snowdrop has among flowers. The female is worse off in the matter of wings than the preceding species, so far as wings may be considered from the decorative point of view, a tuft of scales at the shoulders being their sole representation; practically she is no worse off than the others. The caterpillar is green, lined with yellow and mottled with brown. It is an oak-feeder, and may be found in April and May. Several other species leave the chrysalis at the same inclement season, and yet others between winter and spring, when few persons would suspect moths to be on the wing. The belief that such Insects are restricted to the warm nights of summer would soon be dispelled if the dweller in the suburbs or country towns would occasionally glance at the public lamps on his way home He would frequently see in winter, moths fluttering against the glass in a vain effort to reach the source of light within.

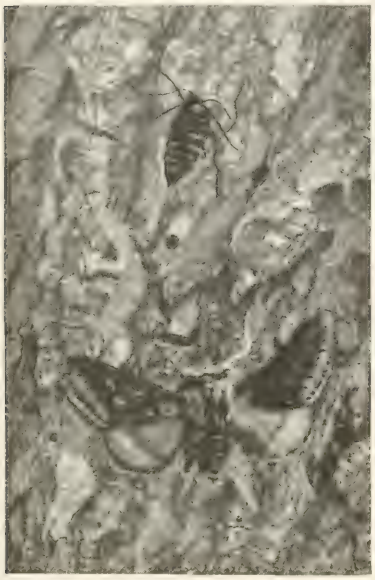


Photo by] [*E. Step, F.L.S.*

SMALL BRINDLED BEAUTY.

The two sexes of this moth are shown—the female the spider-like creature above. They make their appearance in February.

The Vine-Aphis.

There are those who think our Board of Agriculture and its predecessors have been on occasion too much inclined to get into a state of panic over feared importations of pests, as they did over the potato-beetle and the San José scale; and certainly writers of horticultural and forestry handbooks are too prone to describe as terrible pests Insects which, though known to spread ruin in other countries, have been proved by long experience to be negligible quantities here, thanks to our much-abused climate. Still, it is well to be always on guard, for we have a large body of evidence showing that a species that has never caused great concern in the place of its origin will often run riot when introduced to a new country and spread ruin far and wide. One need only mention the well-known results of the sentimental introduction of thistles, watercress, and rabbits from Britain to her Colonies at the Antipodes to illustrate the truth of this statement; and another striking instance is the introduction to Europe of an insignificant plant-louse from North America. This unsuspected introduction on American vines took place

[1] Hybernia rupicapraria. [2] H. leucophæaria.

at some date shortly before 1863, for in that year the peculiar disease caused by its presence was first noticed in France. In the same year the vine-aphis was found in vineries near London, but as it bore no evil reputation in the States, nothing much was thought of either discovery. In France in the next few years the disease spread rapidly, so that in thirteen years in one department (Vaucluse) the yield of wine from the vineyards had decreased by ninety per cent. It was not until 1868 that the connection between the vine-aphis and the vine disease was proved by M. Planchon. From that date to the present, although every means that science and practical horticulture can suggest has been put in operation against the enemy with good local results, it has continued to spread over Western and Central Europe and the Cape, and millions of acres of wine-producing land have been devastated. The European countries concerned formed a Phylloxera Convention, on whose advice the various Governments have adopted stringent laws for the destruction of all infected plants, and to stop the importation of further supplies of all plants that might possibly harbour the pest. There is food for thought here in the spectacle of nations with huge standing armies and fortified frontiers, who have taken all possible measures against aggression by their own species, being set at naught by insignificant Insects individually measuring about 1 mm.!

The Vine-Aphis.

To the naked eye this Insect[1] is not greatly unlike the wingless green-fly with which we are all so familiar, but under a good lens there are certain differences separating it from the true aphis. It comes nearer to the spruce-gall Insect, but instead of producing alternate generations on plants of different species, there is here a migration only between leaves and roots. In America the vine-aphis chiefly attacks the leaves, producing galls upon them, but in Europe the leaf-galls are comparatively rare, the attack being almost restricted to the roots, where tuberous, sausage-shaped swellings are formed, upon which the Insects will be found sucking

[1] Phylloxera vastatrix.

at the juices. As in the green-fly, there are several forms and conditions of the vine-aphis. Those feeding upon the roots are mostly wingless females of a pale yellow or dull-brown colour, with antennæ of three joints, rather short legs, and imperfect eyes. They attach themselves to newly formed roots, into which they thrust the fine proboscis, and suck at the sap. This causes the swelling up of the root, which bursts its bark, revealing yellowish masses of a lac-like material. The roots being unable to do their work properly, the upper shoots become stunted, the leaves turn yellow, the roots die, and there is an end of the plant. When the plant is dead the vine-aphis leaves it, and migrates to healthy plants within reach; so that one infected plant becomes the centre from which a district is attacked. During the winter these root-females remain inactive, but in spring they wander to newly formed roots, and each lays from thirty to forty eggs in several batches. These hatch in from five to twelve days, and the wingless young undergo several changes of skin; but they are soon adult, when they also lay eggs which in turn produce wingless females, and this process is in the main repeated six or eight times throughout the summer. About midsummer, however, there is some change. Some of the eggs produce individuals that develop wings and perfect eyes and longer legs. These crawl up the stems whilst still immature, and when their wings are developed and free they may fly away to infect other vines. This they accomplish by laying a few eggs on the leaf-buds or the under side of the leaf. These eggs are not equal in size, and they differ in character, the larger ones producing mature females, and the smaller mature males. Both sexes of these are produced solely for breeding purposes, for neither of them possess the means of feeding. They pair, and the females lay eggs singly under the loose bark of the vine. These eggs remain through the winter and hatch in the following spring, all alike producing wingless fertile females capable of producing other wingless females, and so on for several generations. The first spring brood may remain on the leaves and attack them, producing galls in the form of wart-like excrescences on the upper side of the leaf with an entrance slit on the under side. They produce young inside the gall, and these migrate to the roots.

Photo by] [*W. West.*

OAK PHYLLOXERA.

A few of the eggs from one of the circles shown in the next photograph, magnified to fifty times the actual size. They hatch in the course of a few hours after being deposited.

To minimize the destruction caused by this pest, and taking advantage of the fact that in America the aphis scarcely attacks the roots, vines are now being grown that have been grafted upon stocks of the American species, which have stronger roots and a more hardy constitution, owing probably to the fact that they have been cultivated for a much shorter period.

Photos by] [*W. West and E. Step, F.L.S.*

PHYLLOXERA OF THE OAK.

In the upper circle is seen a winged male showing marked differences of form from the wingless female below. The wings are twice the length of the body, the legs are long, and the antennæ long and banded. The lower inset shows a wingless female on the under side of the oak-leaf laying her eggs in concentric circles. When there is no longer room for her body in one cluster, she moves off and repeats the process near by.

The principal methods adopted in the warfare against the pest is the burning of the diseased plants, and the treatment of the soil whence they have come with bisulphide of carbon and gas-tar.

Another member of the genus [1] is found upon the oak. The female may be found on a discoloured patch of the oak-leaf where she has fed. Around her will be found two or three circles of eggs, which will hatch in a few hours and set up a cycle of forms which in about twenty-one generations results in the production of sexually mature Insects. This oak-leaf aphis, like the multitude of other oak-feeding Insects, appears to have no appreciable effect upon the tree, and is, therefore, totally unlike in character to its congener of the vine. One of our photographs shows a cluster of seventy-six eggs from which the female had departed when they were discovered, but from the seven eggs standing out from the outer circle it appears that she has only moved a short distance, and is engaged in depositing a second batch which already numbers seventy-one. The perfect sexual individuals of this species are produced in autumn, and possess no sucking rostrum, so can partake of no nourishment. The female lays only one big egg, which remains in a crevice of the bark until spring, when it produces a winged form which lays eggs on the under side of the oak-leaf. The produce of all these eggs are wingless, and each of them lays eggs in concentric circles, as shown in our photograph. The young hatched from these eggs are at first rather active, and move away from the egg-circle in quest of a feeding ground. They are dotted with small orange spots. On some young oaks every leaf is swarming with these Insects.

Photo by] [*E. Step, F.L.S.*

THE CICADA.

The most celebrated of the Insect musicians, whose powers were made much of by the ancient Greeks. The apparatus for the production of sound differs altogether from those of all other Insect musicians, as will be shown in further illustrations. It is shown with the wings expanded for flight.

Musical Insects.

Of a few Insect musicians it may be said that their power of producing sounds has been notorious from the beginning of time. Some have regarded these sounds as music, others as a wearying noise, and in all probability they will continue to be thus diversely regarded, according to the temperament or the condition of health of the hearer. The poets—and others—have made mistakes about this music. Some have thought the Insects had real vocal apparatus, others that the sounds were produced solely by rapid wing-vibration. But, as one would expect to find among creatures of such varied organization, a similar end is reached by different means. Some have a real vocal apparatus, though not connected with the mouth; but in most cases it is more akin to the action of lyre and plectrum. The list of Insect musicians is far too long to be dealt

[1] Phylloxera punctata.

with in detail: we can only pick out a few representative species and describe the nature of their sounds and how these are produced.

The Insect most celebrated for its song from antiquity is the cicada, concerning which the Greek poet Xenarchus wrote the ungallant couplet that has been quoted almost *ad nauseam*, possibly ever since it was written—

"Happy the cicadas' lives,
For they all have voiceless wives."

The cicada stands apart from all other Insects, indeed from all other animals, in the character of its musical instrument. It is not here a case of scraping one file on another, or a file on a drum. There is a special cavity in the trunk, divided into chambers by films of different character, and a specially delicate drum or tymbal, which is set vibrating by the Insect to produce the initial sound. These vibrations are caught up and intensified by the other membranes and the two shields which cover the entire apparatus on the under surface of the Insect. There is a special muscle which sets the tymbal vibrating, and these vibrations can be watched when the Insect is singing. Respecting the silence of the females, which attracted the attention of Xenarchus, it is not due to want of the apparatus, but to the fact that it is not fully developed. Hartman speaks of the music as the "marital summons from the males."

Photo by] [*H. Bastin.*

CICADA'S "DRUM."

The shield on the right side of a male cicada has been turned aside to [illegible] of the apparatus.

Speaking of the sounds produced by American cicadas, Darwin says that when the *Beagle* was anchored at the distance of a quarter of a mile from the shores of Brazil, "the noise thus made could be plainly heard on board." It will be noted that Darwin does not allude to it as a musical sound, but a noise, and in this he is perhaps justified by a remark of Bates, who was probably referring to the same species, for he was in the same region. Describing the "terrible discord" of mingled noises set up at sunset by birds and monkeys, the latter naturalist says: "Added to these noises were the songs of strange cicadas, one large kind perched high on the trees around our little haven setting up a most piercing chirp; it began with the usual harsh, jarring tone of its tribe, but this gradually and rapidly became shriller, until it ended in a long and loud note resembling the steam-whistle of a locomotive engine. Half a dozen of these wonderful performers made a considerable item in the evening concert."

There is, apparently, considerable difference in the character of the sounds produced by American cicadas and those of Europe. The ancient Greeks kept the latter in cages for the sake of their songs, and in this connection Kirby and Spence have a paragraph which is worth quoting. Cicadas, they declare, "seem to have been the favourites of every Grecian bard from Homer and Hesiod to Anacreon and Theocritus. Supposed to be perfectly harmless, and to live only upon the dew, they were addressed by the most endearing epithets, and were regarded as all but divine. One bard entreats the shepherds to spare the innoxious tettix, that nightingale of the Nymphs, and to make those mischievous birds the thrush and blackbird their prey. 'Sweet prophet of the summer,' says Anacreon, addressing this Insect, 'the Muses love thee, Phœbus himself loves thee, and has given thee a shrill song; old age does not wear thee out; thou art wise, earth-born, musical, impassive, without blood; thou art almost like a god.' So attached were the Athenians to these Insects that they were accustomed to fasten golden images of them in their hair, implying at the same time a boast that they themselves as well as the cicadæ, were *terræ filii*. They were regarded indeed by all as the happiest as well as the most innocent of animals."

Cicada's Musical Chamber.

The drawing shows what is underneath of the two covers seen in the preceding photograph. The jutting object to the left is part of the hind-leg. The large oval near the centre is the drum or tymbal, whose vibrations are the primary source of the sounds. Towards the left and lower than the drum is a tensely stretched membrane—the mirror—reflecting light and appearing many coloured.

The Romans appear to have differed from the Greeks in their appreciation of this music, for Virgil in his Georgics accuses his native cicadas of bursting the very shrubs with their noise, and he is supported by the comparatively modern Sir J. E. Smith, who says it "makes a most disagreeable dull chirping." In our own day, C. V. Riley, the late State Entomologist, thus refers to the seventeen-year cicada: "The general noise, on approaching the infested woods, is a combination of that of a distant threshing machine and a distant frog-pond. That which they make when disturbed mimics a nest of young snakes or young birds under similar circumstances—a sort of scream. They can only produce a chirp somewhat like that of a cricket and a very loud, shrill screech prolonged for fifteen or twenty seconds, and gradually increasing in force and then decreasing."

The order of Insects [1] which, next to the cicadas, has been most celebrated for the production of sounds, contains the crickets and grasshoppers; and these produce their shrill cries in quite another manner, the instrument being more akin to the fiddle and bow. Yet, even here, there is a great amount of variation in the method

[1] Orthoptera

THE TANANA.

A long-horned grasshopper of Brazil, whose notes are the loudest and most extraordinary produced by a grasshopper. The natives call it the tananá in allusion to its music, which resembles the syllables ta-na-ná, succeeding each other with little intermission.

of employing the same principle. In the three families, crickets,[1] long-horned grasshoppers,[2] and short-horned grasshoppers and locusts,[3] differences of structure necessitate differences in the fiddles and bows. The song of the house-cricket[4] is produced by the wing-covers of the male Insect. On the under side is a file, and as the two wings are vibrated the edge of one scrapes the file on the other and produces the shrill "crink-crink." Bates speaks of a species of wood-cricket (really a long-horned grasshopper) he found in the neighbourhood of Obydos, Brazil. He says: "The notes are certainly the loudest and most extraordinary that I ever heard produced by an orthopterous Insect. The natives call it the tananá, in allusion to its music, which is a sharp, resonant, stridulation resembling the syllables ta-na-ná, ta-na-ná, succeeding each other with little intermission. It seems to be rare in the neighbourhood. When the natives capture one, they keep it in a wicker-work cage for the sake of hearing it sing. A friend of mine kept one six days. It was lively only for two or three, and then its loud note could be heard from one end of the village to the other." The thin, parchmenty wing-covers are very convex, and give the resting Insect an inflated, bladder-like appearance. The inner edge of each wing-cover has a horny lobe near the base, and one lobe has sharp, raised margins, whilst the strong nervure of the other is crossed by fine, sharp furrows like those of a file. The two lobes being rubbed sharply one over the other, these instruments produce the sounds, and the parchmenty wing-covers and the drum-like space they enclose help to give resonance to them.

Andersson's Grasshopper.

In this South African species of remarkable appearance, the wings are not developed and the leaping legs are not used for leaping. The undeveloped wing-covers in the male are strongly grooved and ridged, whilst below them on the body there is a swollen plate with two or three hard folds. Over these various ridges and folds the thigh is rubbed, and the action results in a loud note. The specimen photographed is mutilated, so far as legs are concerned, but it shows the general form and the disposition of the hinder thighs.

The fact that these musical sounds are produced only by the males in most of the grasshopper family and in the cicadas will prepare the reader for the further statement that they are used in the courtship of the Insects, the whereabouts of the male being thus advertised to the female. There is reason to believe that some species which appear to be without musical calls of this character really have them, though the notes they produce are not audible to the human ear. The reason for this supposition lies in the fact that such apparently dumb species are provided, like the obviously musical ones, with ears—situated in the legs or the hind-bodies. The possession of ears by an apparently dumb species is good presumptive evidence that the species must itself produce sounds. It should be noted, too, that each species has its own particular notes, to which, no doubt, its ears are specially attuned. On this point Scudder, speaking of North American grasshoppers, says: "The

[1] Gryllidæ. [2] Locustidæ. [3] Acridiidæ. [4] Gryllus domesticus.

uniformity with which each species of stenobothrus plays its own song is quite remarkable. One kind[1] produces about six notes per second, and continues them from one and a half to two and a half seconds; another[2] makes from nine to twelve notes in about three seconds. In both cases the notes follow each other uniformly, and are slower in the shade than in the sun.' These, as in all the short-horned grasshoppers, produce their sounds by scraping the hind-leg over the projecting nervures of the wing-covers.

In a South African species[3] of this family, known as the flying gooseberry, there is an extraordinary development of the hind-body of the male, and the wing-covers are not used in sound production. The hind-body is inflated with air so as to become a great, pellucid bladder, in order to increase the resonance of the sounds the Insect makes by scraping the comparatively small hind-legs over a series of ridges which are placed on each side of the inflated abdomen. At night these Insects make a wonderful noise, according to Mr. Trimen. The file in this case, though owing to its position it does not show in the photograph, is so large and well defined as to be seen without searching for it.

Photo by

THE CICADA'S MUSICAL INSTRUMENTS.

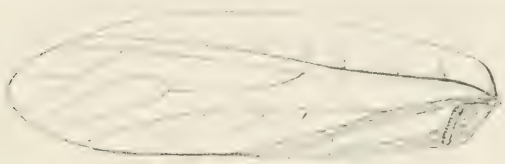
A view of the cicada from below. The legs have been removed, the [illegible] two semicircular covers to the apparatus for producing the loud notes [illegible] The position of these organs is indicat[illegible]

Another extraordinary example, Andersson's grasshopper, from South Africa[1] is wingless in both sexes and does not use its leaping legs for leaping. The thighs are greatly expanded, and on their inner face near to the base there are peg-like projections. Although there are no wings, there are incipient wing-covers, and these in the male are strongly grooved and ridged, whilst below them on the first segment of the hind-body, and partly overlapping the second, there is a swollen

[1] Stenobothrus curtipennis. [2] S. melanopleurus. [3] Pneumora scutellaris
[1] Trachypetrella anderssoni

plate with two or three strong and hard folds. Just behind it on the second segment is a prominent area whose surface is marked by very fine, raised lines. Both sexes have these arrangements, but in the male they are more highly developed than in the female. The thigh is rubbed over these sculptured plates, and the action results in a loud note. It is believed that the male can produce two distinct notes, one agreeing with that of the female, and one peculiar to its own sex. It is a very sedentary creature, and its colouring makes it appear like a clod of earth. When molested it does not rely upon its full powers of locomotion for escape, but upon its capacity for making a noise which will alarm its enemy.

The long-horned green grasshoppers[1] produce their music by means of the wing-covers alone, and as these only slightly overlap at their bases, the production of a considerable volume of sound seems at first sight not to be expected. Yet anyone who has heard one of these Insects giving expression to its joy, must admit that the volume of sound produced is marvellous. We have kept our native green grasshopper[2] as a pet, feeding it upon flies, and in the evenings it sang with notes that resounded through the house. In this family the ears are placed in the front legs, a little below the knee. De Geer pointed out long ago that an eye-like spot in the right wing-cover of the male was probably connected with the powerful note of this species. This area consists of a transparent film "resembling a little mirror or piece of talc, of the tension of a drum. This membrane is surrounded by a strong and prominent nervure, and is concealed under the fold of the left wing-cover, which has also several prominent nervures answering to the margin of the film. There is every reason to believe that the brisk movement with which the grasshopper rubs these nervures against each other produces a vibration in the membrane augmenting the sound."



Wing-cover of a Long-horned Grasshopper.
The darker portion is that which overlaps or is overlapped by its fellow wing-cover. The clear space is the drum whose vibrations give resonance to the sounds produced by the adjacent file.

The katydids, celebrated Insect musicians, which are described in a separate article, belong to the family of long-horned green grasshoppers.

We have already mentioned that the too-familiar house-cricket has, in the male, a musical file on the under side of each wing-cover; and this is a character which will be found throughout the family to which it belongs. In the mole-cricket[3] the musical organs are smaller and simpler than those of the house-cricket, and the note produced by them is a dull, jarring note which has been compared to that of the nightjar.

Mason-Wasps.

The mason-bees, described in a separate article, have their counterpart among the wasps. Though there is naturally some resemblance in their methods, there are also some differences. The species with the best title to the name of mason-wasp is a graceful little Insect[4] about half an inch long with a black body banded with yellow. For a building site it chooses the slope of a sandbank where the

[1] Locustidæ. [2] Locusta viridissima. [3] Gryllus gryllotalpa. [4] Odynerus spinipes.

LEAFING GOOSEBERRY"

[illegible]

sand is hard and firm, and therefore to be tunnelled with safety, though with great labour. Kirby and Spence tell us picturesquely that "its mandibles alone would be scarcely capable of penetrating [the hardened sand], were it not provided with a slightly glutinous liquor which it pours out of its mouth, that, like the vinegar with which Hannibal softened the Alps, acts upon the cement of the sand, and renders the separation of the grains easy to the double pickaxe with which our little pioneer is furnished."

The mason-wasp is both mason and miner. It bores a cylindrical cavity two or three inches deep, which branches below into three or four cells; but instead of sweeping away the pellets it quarries, as many mining Insects are careful to do, it uses them for building up around the mouth of its excavation a round tower, at first straight, then curved to correspond with the curvature of its own body. The purpose of this tower appears to be to make it difficult for any parasitical Insect to enter and lay eggs in the cavity during the absence of the mason-wasp when seeking provisions. It is only a temporary erection, and therefore it is not made solid; the stones of which it is constructed, though firmly connected, leave little interstices, as though the builder were anxious to make the material go as far as possible. The cells are furnished each with a number of small, green caterpillars, which naturally curl into a circle when alarmed. These, of course, are first stung, so that they have little or no power of movement. The egg is laid in the far end of the cell, so that on hatching the grub first attacks the caterpillar that was first stung.

Photo by] [*E. Step, F.L.S.*

THE MASON-WASP.

This clever little artificer has its body ringed with black and yellow. It digs a tunnel in a firm sandbank and builds a temporary tower of the excavated material. Four times the actual size.

After filling up the cell with from twenty to forty small caterpillars, the mason-wasp takes down her tower, stone by stone, and uses the materials for building up the mouth of the nest solidly. The building of this tower is, therefore, a fine example of economy of labour. Instead of dropping the material excavated from the hard sandbank, and having to collect it or similar material again for building up the entrance, she stacks it ready to hand, and in the doing of it contrives a shelter which protects her progeny from the insidious attacks of a deadly enemy.

The "deadly enemy" is the brilliant little ruby-tail wasp,[1] whose head and fore-body are blue or green in different aspects, and the hind-body red and gold, the entire body having a metallic polish that makes the little creature glow and flash in the sunshine. It appears to be chiefly against the ruby-tail that the mason builds her temporary towers; but wood-ants[2] have, in some districts, to be guarded against also.

Some of the mason-wasps carry their labour-saving ideas further, and look out for defects in human masonry. Where a chink has been left in the masonry

[1] Chrysis bidentata. [2] Formica rufa.

by a careless workman, they enter and enlarge it, making it symmetrical, as they would have done had they begun the excavation. Others adopt keyholes, nailholes, or any other perforations that are large enough, or can be made large enough by a little manipulation. In some cases it is the other way about, and they have to partially block up a crevice that would be otherwise inconveniently roomy. Whatever the mason's length may be its breadth is very little, and it contrives the burrows to have only sufficient "elbow-room." There are many inquisitive birds about with a taste for fat little grubs, and the smaller the entrance-holes to nests the safer for the defenceless grub. Ichneumon-wasps with long, slender egg-placers, and other parasitical Insects of their own order, have to be guarded against as far as possible; but the latter are the more subtle, and often succeed in introducing their own eggs to the utter ruin of the mason-wasp's plans. If the parasite does not begin by eating up the host, it devours all the provisions and allows the host to perish by starvation.

One species of mason-wasp,[1] described by Fabre, hangs its egg from the roof of the cell by a silk thread, a provision to protect the newly hatched grub from being crushed by movements of the score or more of small caterpillars that are placed inside after the egg is laid. From the egg-shell the young grub can reach down to its first caterpillar, and about twenty-four hours later, when this is devoured, the grub is believed to cast its skin and to be sufficiently strong to take care of itself among the only partially stupefied caterpillars. It eats them in the order in which they were stored.

Photo by [*H. Bastin.*

WASP'S NEST IN COTTON-REEL.

The wall mason-wasp—a different species from that shown in the previous photograph—has made use of an empty cotton-reel, and filled the hole with one of its clay cells.

Let readers who share the common enmity to wasps of all sorts bear in mind these facts about their utilization of caterpillars. Let such consider how long it would take them to hunt for and destroy ten dozen small caterpillars that are the exact tint of the leaves upon which they feed. This is the number that one species of mason-wasp will requisition for the provisioning of the cells in one of these interesting structures. Every such wasp that is wantonly killed means that number of caterpillars allowed to grow and to do incalculable damage to the choice plants of our gardens, it may be. Almost certainly, if a wasp is killed in our garden, it was there on a hunting expedition, and it is *our* garden that will suffer for our ignorant folly.

The wall mason[2] appears to be fond of proximity at least to human beings, for its nests are commonly constructed on the walls of houses, sometimes in the angles of the window-frames, but often on the seams of mortar between the bricks. She uses sand and mud, and mixes them with her own mouth-cement, which causes it to set like mortar. Sometimes she uses the "pointing" of the human mason or bricklayer, if this is not so rich in cement as to defy her jaws. Whatever the material,

[1] Odynerus reniformis.

[2] O. parietum.

she turns it into cylindrical cells, which are usually joined end to end, so that she gets a continuous round-backed ridge on the wall. Each of these cells she stocks with green caterpillars in turn as it is completed. Where she is engaged in her building operations, the ruby-tail[1] may usually be seen as an interested spectator, watching for her opportunity to bring the mason's labours to naught.

A little-known species,[2] found in the Mediterranean region, makes its nests in the earth, and connects them by a gallery two and a half inches long. It renders this gallery difficult of access to enemies by erecting a chimney-like porch after the manner of the first-named species. This precaution is very necessary in this case, because the cells are not provisioned and sealed up, but the grubs are fed more like those of the social wasps, by the mother bringing them food from time to time. This food consists of a paste resembling dried honey.

Photo by] [*E. Step, F.L.S.*

MASON-WASP'S TOWERS.

Two of the towers erected during the construction of the tunnel and underground cells. These are taken to pieces again to provide material for blocking up the entrance to the cells. Four times the actual size.

Ruby-Wasps.

In our account of the mason-wasps, we have referred to the destruction of their grubs by the interposition of the ruby-tails or cuckoo-wasps.[3] As there are many species of these, of which our own islands harbour about twenty, it appears desirable to give them more extended notice. They are all small Insects, and parasitic upon wasps and bees. But what they lack in size they make up for in brilliancy of colouring, and their metallic polish gleaming in the sunshine, of which they are so fond, makes them far more conspicuous than most Insects of their size. They are not gatherers of honey, pollen, or Insects for the sustenance of their progeny; but they take equally effective means to ensure the perpetuation of their species, though at the expense of distant relations.

The method adopted by the female ruby-wasp is to haunt the spot where a mason-wasp, for example, is provisioning a cell and is nearly ready for closing it. Then the ruby-wasp, taking advantage of the temporary absence of the architect, enters and deposits her own eggs—not one egg, as alone appears to be necessary, but a number which may be as many as ten. The object of this prodigality in egg-production is not clear, for, as far as observations have gone, only one appears to hatch and the others perish. The different species of ruby-wasp attach themselves, in most cases, to hosts of particular species. An exception occurs in the

[1] Chrysis ignita. [2] Ceramius lusitanicus. [3] Chrysis.

case of the commonest of them,[1] which, though specially destructive to the wall mason-wasp,[2] will lay her eggs in the nest of any species that comes handy. The spiny-footed mason-wasp,[3] which builds temporary towers to keep out these ruby-wasps as far as possible, is victimized by two species of the parasites,[4] and wherever this mason-wasp is plentiful these two ruby-wasps will be common also. Dr. T. A. Chapman, who investigated this matter many years ago, found that one-third of the grubs of the spiny-footed mason were destroyed by the grubs of the ruby-wasps. The two species effecting this destruction have different methods of attack. Neglecta appears on the wing in May at the same time as the earliest of the spiny-foots; bidentata does not show herself until about three weeks later, when the last of the spiny-foots are emerging.

If one of the first nests of the spiny-foot be examined a few days after it has been closed, it will probably be found to contain neither egg nor grub of the mason, but a grub of neglecta may be there instead feeding upon the green caterpillars, and it may be presumed that she has already eaten the egg or grub of the mason. By the time bidentata emerges, the mason-grubs that have escaped the attack of neglecta are full grown and spinning their cocoons. From various causes many of the burrows of the mason-wasp remain uncompleted, and the last-made cells are only protected by the wall of clay which she has intended to be only a dividing wall between this cell and another which she had purposed making. Bidentata is able to bore through this and get access to the cell. With her egg-placer she pierces the cocoon and lays her eggs inside; in some cases she has not this trouble, for the cocoon is not quite finished, and she can lay her eggs on the mason-grub with ease. The cuckoo-grub nips a fold of the skin in its jaws and, without cutting through the latter, sucks away all the substance of the mason-grub and grows rapidly, changing its skin four times, at intervals of only about two days. There is little save colour to distinguish the grubs of host and parrsite; the former is yellow and the latter white.

Photo by] [*E. Step, F.L.S.*

RUBY-TAIL WASP.

These tiny wasps—the photograph shows one four times larger than the actual size—are exceedingly brilliant Insects, the hind-body being bright red with a high metallic polish which flashes in the sunshine.

The Aphis-Lion.

The four-winged fly whose active grub is known as the aphis-lion[5] has been designated the brown lace-wing to distinguish it from the green lace-wing or golden-eye.[6] Most people would say it is the same thing with wings of another colour. Yet if the two are put side by side and closely examined there will be found points of difference which, in conjunction with some differences of internal structure and life-history, have induced naturalists to put them apart in separate groups.

In most species of golden-eyes the larva goes about openly upon plants where the aphis or green-fly abounds, and does his best to reduce the numbers of the pest. The larva of the brown lace-wing carries on the same good work, but possibly

[1] Chrysis ignita. [2] Odynerus parietum. [3] O. spinipes. [4] Chrysis bidentata and C. neglecta [5] Hemerobius. [6] Chrysopa.

to hide his operations from the gardener—who finds it difficult to believe in the existence of Insects that are friendly to him—he disguises himself by covering his body with the sucked-dry skins of his victims, until he becomes an entomological "old-clo' man." Nature appears to have given him decided help in this direction, for from each segment of the body there stands out on each side a fleshy process which supports about half a dozen bristles. These bristles spread out fan-wise, and keep the heap of rubbish from interfering with the action of the legs in walking. The curved jaws are sharp pointed and hollow, and when they have impaled an aphis, all its fluids are sucked through them. Then the thin, empty skin is tossed over the head and makes a little addition to the portable rubbish-heap. Delicate silken threads run through the rubbish and help to keep it together, but whether this is spun by the aphis-lion or borrowed from some wandering spider is not known. If we capture one of these aphis-lions, and carefully clear the rubbish off its back, we shall find that the Insect roughly resembles the ant-lion, though it is of more slender shape. When the aphis-lion has sucked dry as many aphides as it can, and feels that it has reached the limit of larva-hood, it spins a silken cocoon, and turns to a chrysalis; but just before the latter is ready to cast its skin and appear as a four-winged brown lace-wing it breaks through the cocoon. The wings are very delicate and finely netted. The long, fine antennæ are made up of many short, bead-like joints, so that an antenna looks like a minute necklace. The Insect flies with a weak, drifting flight, and when it settles on a leaf the four wings are folded in such a way that the body is completely hidden under a high, ridged roof that comes down right over the sides. In this country we have no fewer than eighteen species, whose differences are only of scientific interest; and the distribution of the genus is world-wide. Several allied genera come close to them in the winged state, among them the green lace-wings or golden-eyes.

Photo by [*E. Step, F.L.S.*

THE APHIS-LION.

The aphis-lion is the grub of the brown lace-wing. After sucking his victims dry he heaps their skins upon his back and carries them about, like an Indian brave with his trophy of scalps. In the photograph he is magnified four times.

Osmylus[1] in its winged state is very like the brown lace-wings, but is much larger. Its larva differs considerably in its habits, being semi-aquatic and living about the edge of the water, lurking under stones, in moss, or about the aquatic vegetation. Its jaws are converted into almost straight, hollow, sharp-pointed spears upon which it impales small Insects, and sucks their juices through the spears. It is remarkable as having no posterior outlet to the digestive system; the hinder part being modified into a spinning apparatus. In this respect it resembles the grub of the ant-lion. When full fed it forms a round cocoon in which it mixes grains of sand with the silk. Drepanopteryx[2] is much like a moth, and moth-like it has hooks for the locking of the fore and hind wings in flight. These are shown in the photograph on page 475.

[1] O. chrysops. [2] D. phalænoides.

The Book-Louse.

When one is turning over the pages of an old book the attention is frequently drawn to a minute, almost colourless, wingless Insect that runs along with comparative swiftness. This is the so-called book-louse,[1] a name we hardly like to use because of the misleading nature of its second half. Let us say at once, to put the reader at his ease, that the Insect known as the book-louse has no relationship to the personal vermin from which part of its name has been borrowed, nor does it resemble it at all in habits, or in anything but a very superficial likeness of form. Still, it has been mistaken for the real thing by many who, happily, have had no close acquaintance with the latter. We have several times been the recipients of specimens of the book-louse sent in carefully-packed sealed tubes accompanied by letters almost imploringly begging us to assure the sender that they were not samples of the loathed one, and asking for instructions how to get rid of such unpleasant-looking creatures. One such communication was from a lady who had recently changed her residence, and found that a certain room swarmed with these Insects which she thought were of the legitimately-detested species, and her object was clearly to obtain an opinion from us which would justify her in breaking her three-years agreement. Our report did not sanction such a course, though we hoped that eventually it relieved her mind.

Photos by [*H. Main, F.E.S.*

THE APHIS-LION'S COCOON

When the aphis-lion is full fed it spins a fl[illegible] cocoon of open network, keeping it [illegible] "old clothes" on the outside. The [illegible] to a chrysalis. The photographs show [illegible] to casting off the grub-skin. M[illegible] five time[illegible]

This little book-louse, though it causes great anxiety to the collector of Insects, may be regarded with unconcern by others. It is destructive without doubt, but unless it has such fragile things as Insects to exercise its minute jaws upon, it causes no appreciable damage. But if it gets into the tightly glazed drawers of the entomological cabinet—introduced perhaps on a specimen received from a less careful collector—it may work great mischief before its presence is suspected. The first sign is a little impalpable dust under one or more of the specimens. Then, if neglected, an antenna may drop off, and the wings begin to look shabby owing to the bright scales being eaten off the surface.

If we secure one of these miscreants in a shallow, glass-topped box, we can view him with a pocket-lens, and learn more of his appearance. The lens is necessary, for mature specimens are only about one-twentieth of an inch in length. With the aid of this instrument it will be seen to present a fairly close resemblance to a worker white ant. The internal structure is very different, but the book-lice[2] are included in the same order[3] of Insect-life as the termites. Like the workers of the latter tribe, the book-louse never develops wings, though a very similar allied Insect[4] does so. It has the same kind of soft integument as the termite,

[1] Atropos divinatoria. [2] Psocidæ. [3] Neuroptera. [4] Clothilla

and a proportionately large head. The only parts of the Insect which can be said to have a thick deposit of brown chitin are the jaws, which are made firm for biting. These take the form of a pair of stout, short shears, with the opposing edges well toothed. The head is adorned with a pair of long and very fine antennæ of many minute joints, which are kept perpetually waving. The fore-body appears to consist of two segments only, but this is due to the second and third having been united. As usual, it supports the three pairs of legs, which are remarkable for the stoutness of the thighs, though the shanks are very slender and end in the three-jointed foot and its pair of hooked claws. The hind-body is oval, the fore part only slightly narrower than the rear part, and giving the impression that the Insect does not suffer from any shortage of food. There really is no reason why it should, for it appears to feed upon any animal or vegetable substances from old books to household stores in the cupboards, or the dried "specimens" of the naturalist, be they plants, Insects, or larger animal remains.

Photo by] [*H. Main, F.E.S.*

BROWN LACE-WING.

The wings of the green lace-wing flies and the brown lace-wings are formed on the same plan. Although when in use they appear to us so flimsy, it will be seen from this enlarged view that the meshes of the lace are well knit. A strengthening rib extends along near the front edge, and a branch from it runs parallel with the inner margin.

The book-louse retains the same form throughout life. As there is no development of wings, and no alteration of the mouth-parts, there is no metamorphosis. The only changes—other than of size—that come to it is a darkening of the skin to a brownish grey as maturity is reached, an increase in the number of joints of the antennæ, and the development of simple eyes in addition to the compound pair.

There is one point in the natural history of this Insect that must be mentioned. All have heard of the "death-watch" that fills the superstitious with alarms. The ticking of the death-watch proper is the nuptial signalling—by a code older than the Morse—of the little wood-boring beetle[1] that drills pinholes in our most prized old furniture. The book-louse—which is also known as the lesser death-watch—makes similar sounds, though less loud. More than two hundred years ago, the Rev. W. Derham brought this fact to the notice of the Royal Society; but since his day there have not been wanting those who, because their ears may not have been rightly attuned to sounds so delicate, have denied his statements on the ground that the book-louse is too soft to produce a noise by rapping its head or other part of it against anything. But in spite of these denials, *the book-louse does tick!*

[1] Anobium striatum.

Photos by] [*H. Bastin*

TWO LACE-WINGS.

These Insects represent other groups of the lace-wing type. The upper one is osmylus, which is much like the mature form of the ant-lion; but its grub is semi-aquatic. The lower one, drepanopteryx, is at first sight like a moth, but closer inspection shows the lace-like structure. Observe the remarkable hooks by which the fore and hind wings are locked together for flight.

Most of the family[1] to which the book-louse belongs are small out-door Insects which, if seen at all by others than entomologists, are confused with the plant-louse, which they superficially resemble in size and general appearance. Most of these have wings, and there is, therefore, a slight metamorphosis in their development; but the Insects are active throughout life. They live upon dry refuse matter, both animal and vegetable, and various small forms of fungi found on decaying wood, bark, etc. The family is a small one, but we have about thirty representatives in this country, though none except the book-louse can boast of an English name. A number of species have been found preserved in amber. The females of this out-door group deposit their eggs in clusters of about ten on the under sides of leaves and, strange to say, cover them with a slight web. How this web is contrived by the winged Insect is not clear. It will be seen in our photograph on page 478, and it will be found, no doubt, to have some protective value.

Photo by [*W. West.*

THE BOOK-LOUSE.

A minute Insect—here shown on a scale of twenty-five times the actual size—that may frequently be found among old books, old papers, and neglected stores of various kinds, upon which it feeds. Its destructive powers are chiefly noticeable when it obtains entry to the store-boxes of the entomologist. In spite of its misleading name, it is not a parasite.

Mason-Bees.

The natural order of Insects[2] to which the bees belong stands pre-eminent for the cleverness displayed by great numbers of its members as workers in wax, wood, clay, paper, etc. In another article we have referred to the wasps who design pots and vases of artistic forms, and to the mud-dauber wasps that conceal their cells under massive knobs of mud of their own accumulation. The work of the mason-bee[3] is much akin to that of the mud-dauber, except that the bee uses grains of sand instead of mud, and fits and cements these together with her own saliva-cement. These Insects occur in the South of Europe, and Réaumur told their story many years ago. More recently, Fabre has paid much attention to them, making experiments that help to an understanding of the order of intelligence displayed. Réaumur told how the mason-bee, having decided upon the site of her nursery, carefully selects sand, grain by grain, for her building materials. These she glues together by means of a viscid secretion from her mouth, until they form masses the size of small shot, and transports them in her jaws to the building site. With a number of these, cemented by the same means, she constructs her foundations. Upon the latter she runs up the walls of a thimble-shaped cell, an inch long and half an inch in breadth. Before it is roofed in she becomes a gatherer of pollen and honey, with which she stocks the cell, and lays an egg in with it. On her return from one of these collecting journeys, she puts her head into the cell and discharges her gathering of honey. The pollen has been collected on the hairs of her lower surface, and to discharge this she gets into the cell backwards and cleans off the pollen in such manner that it falls to the bottom. When the requisite quantity of each of the two ingredients has been stored, she gets her head well into the cell and with her jaws works up the honey and pollen into a homogeneous paste; then lays her egg and seals up the top of the cell. The construction of a single cell takes the labour of two

[1] Psocidæ. [2] Hymenoptera. [3] Chalicodoma muraria

days to accomplish. But eight or nine cells are constructed, built one against the others, and then the whole of them are coated with a general mass of masonry. When finished she has a dome-shaped structure the size of half an orange. The outer coating of all is composed of grains of sand coarser than those previously used. It harmonizes well with the natural stone to which it is attached; or on a closer inspection might be regarded as an accidental daub of mud. But the masonry sets so hard that it is with difficulty explored with a knife-blade.

This building work is carried out in spring, and the solidity of the entire structure has evident relation to the fact that in an exposed position it has to protect the inmates from being dried up by summer's heat, and from being frozen by winter's cold, for it is not until the following spring that the young bees emerge. Then the hardness of the masonry presents no obstacle to them: their jaws are stout enough and sharp enough to pick it to pieces and clear a way large enough to permit of their exit. Yet Fabre found that their powers in this respect were somewhat limited. If the nests were closely surrounded by paper they cut through it as though it were part of their natural enclosure; but if the paper wall was so arranged that a clear space was left between it and the nest, they cut through the latter, of course, but did not know how to deal with the paper as a separate obstacle, and perished in this outer prison. The difference is due, probably, as suggested by Pérez, to the fact that in the larger space they do not know where to begin, whilst in the confined space of the cell they are bound to concentrate their efforts upon one spot—that immediately in front of them.

Photo by] [*W. West.*

PSOCIDS.

Out-door relations of the book-louse, scarcely known except to the few who make a special study of this small group. They are found upon bark, leaves, decaying wood, etc., and subsist upon dry refuse. Most of them have two pairs of wings. Those in the photograph are young individuals whose wings have not yet begun to appear. They are magnified twenty-eight times.

By marking some of these bees with paint and taking them away to a distance of four kilometres (that is over a quarter of a mile) before releasing them, Fabre found that their homing instinct was so good that they were back working on their unfinished nests next morning. But though their sense of locality was proved by this means to be very good, he found that when he transposed neighbouring nests they were unable to distinguish their own property, for a bee would unhesitatingly set to work at the substituted nest which now occupied the site of its own previous labours. If this spot was left blank by the removal of the nest only a slight distance away, the bee returned to the spot and showed great concern, but failed to recognize its nest though it had passed over it in its homeward flight.

Some of the results of Fabre's experiments were rather ridiculous, and showed that the bee does not modify its actions according to circumstances as honey-bees do. If he substituted a built and partially provisioned cell for one that had only just been commenced, the bee would proceed from that point in its operations at which it had left off, and would make the substituted cell much longer than necessary; yet when it had made the cell a third larger than the normal size it appeared to

realize the absurdity of its action and left off. If such a substituted cell was already provisioned but not closed in, and the nest taken away was beginning to be filled with honey and pollen, the bee would continue to pour provisions into the full nest and finish by laying an egg where there was one already.

It should be explained how Fabre was able to effect these alterations of the positions of nests. In the ordinary course they are attached to rocks, and to attempt to separate them from their base would almost certainly ruin the whole structure, and would at least make it difficult and perhaps impossible to re-attach them in such a way as would not vitiate the experiment by creating suspicion or aversion. One particular species of mason-bee with which Fabre experimented builds its nests on small boulders brought down by the Rhone in flood and scattered along its shores. Some of these were not too large to be handled, and these Fabre varied in position to suit his purpose.

Photo by] [*W. West.*

EGGS OF A PSOCID.

A cluster of eggs deposited upon a holly leaf. A remarkable thing about these and other psocid eggs is that they are covered with a slight web, probably for their protection. They are shown magnified twelve times.

Where it is possible to do so, the mason-bee selects an angle of the rock, as shown in our photographs on page 479. It is obvious that such a position gives greater security. The bee's object, no doubt, is to secure the firmer hold that the angle affords, and the consequent economy of labour and material; but there is the further advantage that the blob of cement is less obtrusive in such a situation than if attached to a plane surface from which it stands out, and is therefore less likely to be noticed by a possible enemy. We have elsewhere commented upon the wonderful industry displayed by the mud-daubers in accumulating the relatively enormous quantity of clay or mud required for one of their daubs, but it must be admitted that the industry of the mason-bee is greater. The mud-dauber selects moist material which she knows will dry into a hard, stony mass. The mason-bee uses dry, gritty stuff that has to be moistened grain by grain with her own adhesive saliva before she can carry a load to the scene of her building operations.

Although the hard cement of the mason-bee suffices to protect the contained grub or chrysalis against extremes of temperature, it does not ensure immunity from the attacks of parasites, who eat up the provisions and starve the grub, or even eat the grub itself. One of these parasitical intruders is the beetle trichodes, which we have described in a previous article (see page 310). Both Aristotle and Pliny describe the honey-bee as taking the precaution, when having to fly home in a strong

Photos by *H. Main, F.E.S.*

THE MASON-BEE.

This [illegible] a fracture [illegible] the [illegible], as it gives additional strength [illegible] the first photograph [illegible] In the second photograph the bee is seen adding to the thickness of the outer walls. Every bit of the material [illegible]

wind, to ballast itself by carrying a small stone. Réaumur supposes that in this matter these ancient authors were misled by seeing the mason-bee conveying one of the blocks of concrete she has constructed by cementing sand-grains together. But really in this matter they may have been misled only to the extent of mistaking the mason-bee for the honey-bee, for there is no doubt that the former lightens her labour somewhat and strengthens her building, by incorporating in it small stones. These have to be angular fragments or chips, such as are broken off larger masses by the action of frost. These are usually plentiful at the base of a natural rock face, and fragments that are small enough to be gripped by the bee's jaws are carried home and worked into her masonry. Sometimes the bee's masonry is attached to an old wall; but it has been noticed that in that case she is careful to attach it wholly to the stones of which the wall is composed, and not to the mortar that connects them. The wall may have been "jerry-built"—stuck together with a mortar composed of soft earth and spent lime—or the mortar originally good may have perished. In either case it would not make a reliable union with the new concrete. Possibly mason-bees in the distant past worked on such shoddy human foundations and found their work tumbling down before it was finished, and so those of the present day have inherited a prejudice against trusting to anything but solid stone—either the unaltered natural rock or the hewed stone incorporated in a wall. The remarkable thing is that with this suspicion of old mortar, they do not hesitate to use and adapt old work of their own kind. They will not only clean up, repair, and stock a mason-bee's nest that served its purpose in a previous year, but they will fight with one of their own species for possession of it.

Photo by] [*H. Bastin.*

MASON-BEE AT WORK.

A nearer view of the bee at work finishing off her masonry. The mouth of a cell proper is exposed at the top, and is being covered in by a mass of concrete that makes it less conspicuous.

THE END.

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