NATURE BIOGRAPHIES

CLARENCE MOORES WEED

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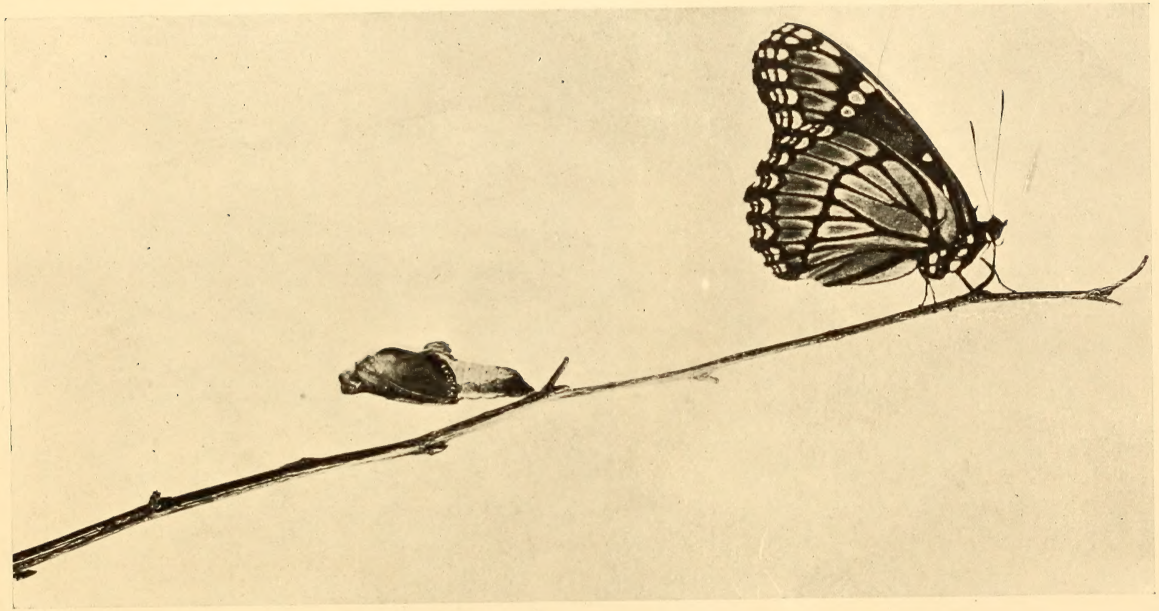

1. The Viceroy Butterfly and its Empty Chrysalis.

Frontispiece.

NATURE BIOGRAPHIES

THE LIVES OF SOME EVERY-DAY BUTTERFLIES: MOTHS: GRASSHOPPERS AND FLIES

BY

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AUTHOR OF "TEN NEW ENGLAND BLOSSOMS," "LIFE HISTORIES OF AMERICAN INSECTS," ETC.

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To

The Little Lady that Helped

NOTE.

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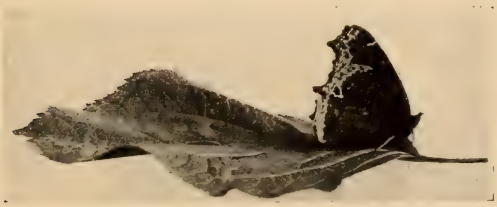

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THE MAKING OF A BUTTERFLY.

To the Greeks of old as to the moderns of to-day and many enlightened people in all the intervening ages, the making of a butterfly has ever been one of the most wonderful things in this wonderful world. The secret by which an unattractive, sluglike caterpillar is in the course of two brief weeks transformed into the most ethereal of the children of the air, on whose translucent membranes Nature has delighted to paint such delicate and beautiful colours, seems likely ever to remain a mystery of mysteries. Were we able to understand it "all in all," then should we get at the secret of creation just as surely as would Tennyson had he known in its completeness that famous "flower in the crannied wall."

In its external features the life of a butterfly is sufficiently familiar to many people. It starts with an egg laid by the mother insect upon the leaf of an appropriate food-plant. The egg shortly hatches into a tiny caterpillar, that begins this second stage in its life-history as an elongate larva, strange in form and void of any resemblance to the parent from which so shortly before it came. The larva feeds and grows. In a few days its

skin is stretched on account of the increase in size, for with insects and related creatures the skin is not continually increased from growth within itself. Instead of this a new skin is formed beneath the old one, and the latter is sloughed off — much as a snake from time to time casts its scaly covering.

In this moulting process the skin upon the head splits apart along the middle line of the upper surface, and the break is continued straight backward through several of the body rings. By various more or less violent movements the caterpillar manages to withdraw its head from the old covering, and then to escape entirely, leaving the cast skin — an *exuvium* the naturalists call it — at one side. In the case of many species, the caterpillar, after resting awhile for parts of its new covering to harden, calmly eats its exuvium, presumably that the presence of the latter may not be a sign to some bird or other enemy that a caterpillar is in the neighbourhood.

The larva is now much larger than it was before. After recovering from the stress of moulting, it again begins to devour the food-plant, feeding more ravenously, and continuing to eat, with intervals of rest, for about a week. Then it has so increased in size that another moult is necessary, and this is gone through with in the same way as before. During the next three or four weeks this operation is repeated twice or thrice — making a total of four or five moults during the period from the egg to the full-grown caterpillar.

After the last of these larval moults the caterpillar feeds for a week or ten days. Then apparently the prodigious appetite it has shown throughout its life becomes satisfied, for the insect becomes restless and wanders about. It is searching for some sort of shelter where it may

spend the quiet pupal period, when it will be utterly helpless to escape the attack of its many enemies. Having found a sheltered corner of a fence, or some similar situation, it proceeds to spin a silken web upon the under side of the chosen board, in which a little later it entangles its hind feet and hangs downward preparatory to becoming a chrysalis. The bare outline that I have thus given would apply to many species of butterflies. Among

FIG. 2. — Monarch Butterfly at Rest upon a Poplar Twig.

others, it fits the beautiful Monarch Butterfly,[1] so familiar of every one who goes afield from midsummer until autumn. The eggs of this regal insect are deposited on the leaves of milkweed, upon the substance of which the resulting caterpillars feed from the time of hatching until they become full grown. For the remainder of this account of the making of a butterfly I wish to describe this species in particular, because I have been able to get the accompanying photographs to illustrate the description.

[1] *Danais plexippus* Linne (*D. archippus* Fabricius).

The full-grown caterpillar of the monarch butterfly is a good-sized black and white insect about two inches long, and of the general appearance shown in the picture (Fig. 3). It spins — sometimes upon the under surface of the milkweed leaf, sometimes elsewhere — a little mat of silk in which it entangles the hooked claws of its hind feet. Then it lets go with its fore feet, and hangs downward with the front end of its body curled upward as in Figure 4. In this position it remains for some hours — perhaps a day — the body-juices gravitating downward and causing a swollen appearance on the lower segments. Then the skin splits apart again, and it is wriggled off by the contortions of the body. When it finally drops away, there is left a strange-looking creature, broader below than above, whose appearance is shown in the picture (Fig. 5). This is a transition stage that lasts but a very short time: soon the form is entirely changed, so that the broadest part is above instead of below. The

FIG. 3. — Caterpillar feeding upon Leaf of Milkweed.

FIG. 4. — Caterpillar hung up for the Change to the Chrysalis.

definite outline of the chrysalis is soon taken on, the outer tissues hardening into a distinct covering. The

FIG. 5. — The Transition Stage.

FIG. 6. — The Chrysalis.

insect now looks like Figure 6: in colour, it is a beautiful green with wonderful golden spots upon its surface, and a few black spots just below the black cremaster by which the chrysalis is connected with the web of silk upon the leaf. The black spots, the cremaster, and the white silken web are plainly shown in the picture.

FIG. 7. — Chrysalis, showing Butterfly ready to emerge.

In this quiet chrysalis the insect remains for nearly a fortnight. Then the structure of the forthcoming butterfly begins to show through the thin outer covering (Fig. 7), and you know that the period of the chrysalis is nearly ended. If you

keep watch you will probably see the sudden bursting of the outer envelope and the quick grasping of its surface by the legs of the newly emerged butterfly (Fig. 8). Its wings at first are short and crumpled, bearing little resemblance to those of the fully developed butterfly. But as it hangs there with one pair of legs holding to the empty chrysalis and the other

FIG. 8. — Butterfly just out of Chrysalis.

FIG. 9. — Same, a little Later.

to the leaf above, the wings rapidly lengthen, hanging limply downward as the body-juices penetrate the veins. A little later they expand in the other direction, the hind wings reaching full size before the front ones, as may be seen in Figures 12 and 13. Finally both pairs of wings are fully expanded, and the butterfly is likely to walk to the top of the support, where it rests for an hour or two while its tissues harden, before it attempts to fly.

Such, in brief outline, is the process by which a butter-

fly is made, so far as it is to be determined by external observation. But these are only the visible results of invisible internal processes, of the nature of which we could scarcely hazard a guess from the most careful outward scrutiny. To learn of these internal developments many specimens in different periods of growth have to

FIG. 10. — Butterfly with Wings nearly Full Length.

FIG. 11. — A Front View, still Later.

be sacrificed to the microtome and microscope, so that by careful study the variation in the structure and position of the minute cells of which the insect is composed may be determined. During recent years great progress in such knowledge has been made, so that we have a fairly complete idea of the method of development, although we do not know, and perhaps shall never know, the "all in all" of the marvellous process.

It is probable that ever since men have studied nature

critically, there have been attempts to explain the way in which a butterfly is made. Nearly two centuries ago, Swammerdam, the great Dutch naturalist, studied very carefully the development of butterflies and other insects. He found that if he placed in boiling water a caterpillar that was ready to pupate, the outer skin could easily be removed, revealing beneath the immature butterfly with its legs and antennæ. This led him to believe that the process of development was simply a process of unfolding; that is, as Professor Packard has put it, "that the form of the larva, pupa, and imago preëxisted in the egg, and even in the ovary; and that the insects in these stages were distinct animals, contained one inside the other, like a nest of boxes, or a series of envelopes, one within the other, or, to use Swammerdam's own words, "*Animal in animali, seu papilio intra erucam reconditus.*"[1] This was called the *emboitement* or incasement theory, and for nearly a hundred years it was held by naturalists to be correct. Early in the nineteenth century, however, it was discredited by Herold, who studied carefully the development of butterflies; but it was not until 1864

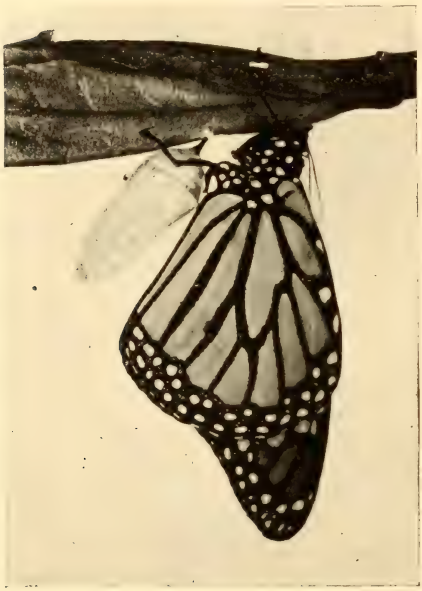


FIG. 12. — Side View, Front Wings not fully developed.

[1] Text-book of Entomology, p. 641.

that it was definitely replaced by another and much more convincing theory propounded by Weismann, the great German zoölogist.

By careful studies, in which the modern methods of microscopic research were employed, Professor Weismann found that instead of the organs of the adult butterfly being present in the caterpillar, they really result from the breaking down of the various tissues of the larva, followed by a remarkable process of rebuilding, in which the starting-points are certain germinal buds or "imaginal disks."

FIG. 13. — Side View, a little Later.

FIG. 14. — The Empty Chrysalis.

This theory has entirely replaced the incasement theory in the minds of naturalists. The germinal buds appear very early in the life of the insect, sometimes even before it hatches from the egg. They remain with little change throughout the growth of the caterpillar. Just before the period of pupation, the various organs of the larva are broken down by the action of the blood corpuscles, the result of their destruction being a creamy mass which is immediately utilized for the rebuilding of

the tissues. During the process of destruction of the larval organs the germinal buds remain intact, and simultaneously they begin to grow by building themselves up from the creamy material surrounding them. In this way the buds develop in a short time into the various organs of the butterfly.

THE VICEROY BUTTERFLY.

THE Viceroy Butterfly[1] is a familiar insect throughout most regions of the United States. In appearance and habits it reminds one of the larger monarch — which in truth it mimics — being found in open fields and meadows, especially along small willow-bordered streams. In such situations it sails leisurely about, stopping now and then to sip nectar from a flower, or perchance to deposit an egg on the tip of a leaf upon a willow or poplar twig. In the late summer months it often flies under apple trees to sip the juices of the decaying fruit.

If the egg upon the willow leaf happens to have been laid by one of the first of the season's butterflies, it hatches in a few days — generally a week — into a tiny caterpillar that gnaws a hole out of the side of the egg-shell, and after it has escaped turns round and eats the remainder of the shell. Probably, as Mr. Scudder has suggested, this peculiar meal is taken to prevent the presence of the empty shell from notifying some enemy — perhaps an ant, possibly an ichneumon — that a young caterpillar is in the vicinity. After this dry repast, it is ready for more succulent food, and this it finds right at hand in the leaf it is resting upon. Here it feeds, eating

[1] *Limenitis disippus* Godart.

the sides of the leaf near the tip, but letting the denuded midrib remain. When its appetite is satisfied it retires to the lower surface of the leaf, where it rests motionless upon the midrib. Throughout the day, when its enemies could easily see it if it moved, it remains quietly on its resting-place, feeding chiefly under cover of darkness. In about a week it moults, eating the cast skin, and soon begins again to devour the succulent leaf tissues.

FIG. 15. — Viceroy Caterpillar feeding on Poplar Leaf.

These young caterpillars have the curious habit of fastening a few bits of leaf together by means of silken threads, and then fastening the bunch to the denuded rib of the leaf. Such little packets are shown in Figure 18 on the lower left-hand leaf, and in Figures 15 and 16 near the middle, behind the vertical leaf stem. To explain this I want to quote from an admirable essay by Mr. Samuel H. Scudder, whose studies of butterflies have done so much for our knowledge of these beautiful creatures: —

FIG. 16. — Same, Another View.

"Soon after birth," writes Mr. Scudder, "when it has eaten but a very few swaths down the leaf, the little fellow constructs a small and loose packet from minute bits of leaf and other rejectamenta, loosely fastened to one another and to the midrib, close to but scarcely touching the eaten edge of the leaf; and as fast as the leaf is eaten, it removes this packet (continually added to until it becomes almost as big as a small pea) farther and farther down the midrib away from its perch, always keeping it near the eaten edge. It should be noted that it is so loosely attached (the bits of leaf at all possible angles) that it is moved by the least breath. Meanwhile the caterpillar has been growing larger and more conspicuous, and thus in greater peril from its enemies. There are two possible services that this odd packet may render. A spider wandering over a leaf and observing its motion may seize it, and thinking it has a prize, hurry away with it and leave its architect unharmed. This seems to me rather a strained suggestion, for a wandering spider would probably proceed to investigate it on the spot. Another explanation seems more probable. It should be remembered that the leaves preferred by these creatures as food are mostly such as are easily shaken by the wind, and as the caterpillar moves with the leaf and with all the surrounding leaves (in a continual fluttering in the case of the trembling aspen, and to a less degree in the other food-plants) this of itself is

Fig. 17. — Young Viceroy Caterpillar resting on Poplar Leaf.

a protection to it, as it would more readily escape observation as an object distinct from the leaves, all being in motion together; but on the more stable leaves, like the willow, the motion in a feeble wind would not be sufficient to be serviceable, and here, at least, the packet comes into play. An object in motion among others at rest is a noticeable thing; a fact well recognized among animals, as a host of them show when they fear being seen. This packet attached by loose silken threads moves, as stated, with a breath of wind, and so would *distract attention* from its architect near

FIG. 18. — Viceroy Caterpillar resting on Poplar Twig.

by, who has taken pains to place it at the farthest remove from his perch, while still (to avoid undesirable steps) on his daily track. If this be really its object, it is surely one of the oddest devices in nature."

The caterpillars of this early summer brood continue to feed and grow, moulting twice more, at intervals of a week. As they become larger the two spiny horns just back of the head become more conspicuous, and the general colour becomes a peculiar mottled combination of greenish olive and gray, the darker colour being at each end and the lighter in the middle, as may be seen by reference to the accompanying pictures of these caterpillars. When the insect gets too large to rest in comfort and safety upon the midrib of the leaf, it spends its days upon the twigs, resting quietly for hours, head downward, in such positions as are shown in Figures 18 and 19. The colouring of the insect is such as to suggest a bit of bird dung, and the resemblance is made more marked by its form and the attitudes it assumes. This resemblance, probably, proves a source of protection from some birds and other enemies.

FIG. 19. — Viceroy Caterpillar resting on Poplar Twig, Another Position.

When the larva becomes full grown, it spins a web of silk upon the bark of the twig, upon the leaves of which

it has been feeding. In this it entangles the hooked claws of its hind legs and hangs downward in the position shown in Figure 20. Here it remains for a while before the skin along the back splits open and is wriggled off, leaving the insect suspended in the peculiar form shown in Figure 21. This transition stage is of short duration:

FIG. 20. — Viceroy Caterpillar hung up for Pupation.

FIG. 21. — Transition Stage between Larva and Chrysalis.

very soon the definite form of the chrysalis is assumed (Fig. 22).

The colours of the chrysalis are very much like those of the larva — such a mottling of gray and olive-green that the creature still resembles a bit of bird dung. The most peculiar thing about the shape of this stage of the insect is the large projection on the middle of the back.

The pupa state lasts only about a week. Then the

butterfly emerges, hanging on the empty chrysalis or the adjacent twig, until its wings are of full size. Then it walks upward toward the tip, where it is likely to rest an hour or so, as shown in Figure 23, before taking its first flight into the new and airy world into which it finds itself born. The forsaken chrysalis still hangs — an empty tenement, perfect in outward form, with only the cracks along the front to indicate where the occupant escaped (Fig. 25).

The butterflies that thus appear in August belong to the second brood of the season. They remain upon the wing for some time, laying eggs during the later days of their life on the same kinds of food-plants that they developed upon. These eggs hatch into little caterpillars, that feed upon the terminal parts of the leaves, in the same way that the earlier brood did. But

FIG. 22. — The Chrysalis of the Viceroy Butterfly.

when they are about one-third grown, they do something that was not done by the preceding generation — they build special houses in which to spend the winter. This is so curious and interesting a fact in the life-history of the species, that I want to quote the original account of it, written by the late Dr. C. V. Riley, for one of his classic reports on the Insects of Missouri: —

FIG. 23. — Viceroy Butterfly, Back View.

"The larvæ of the autumnal brood," writes Dr. Riley, "when about one-fourth or one-third grown, build for themselves curious little houses, in which they pass the winter. First and foremost — with wise forethought and being well aware through its natural instincts that the leaf which it has selected for its house will fall to the ground when the cold weather sets in, unless it takes measures to prevent this — the larva fastens the stem of the leaf with silken cables securely to the twig from which it grows. It then gnaws off the blade of the leaf at its tip end, leaving little else but the midrib. Finally, it rolls the remaining part of the blade of the leaf into a cylinder, sewing the edges together with silk. The basal

portion of the cylinder is, of course, tapered to a point, as the edges of the leaf are merely drawn together, not overlapped; and invariably the lower side of the leaf forms the outside of the house, so as to have the projecting midrib out of the way of the larva, as it reposes snugly in the inside. The whole, when finished, has somewhat the appearance of the leaf of a miniature pitcher plant (*Sarracenia*), its length being .50–.65 inch and its diameter .11–.14 inch.

"These curious little cases may be commonly found upon our willows and poplars in the winter time. I have

FIG. 24. — Caterpillar resting on Hibernating Case.

examined hundreds of them, and although they are invariably built upon the same plan, they vary greatly in the degree of perfection which the architect attained; and this is especially the case where they have been built in confinement. The blade on the tip piece is sometimes gnawed off right down to the rib; at others it is left almost as broad as the tube. Sometimes it is bent over the orifice; at others not. They are also much more irregular and ungainly when made with broad leaves, such as those of the silver poplar, than when made from the more narrow leaves of the willow. These autumnal larvæ have also another peculiar habit; they exhibit a tendency to build from the time they are hatched, and will always eat the leaves from the side, gnawing large

holes and cutting along the sides of the midrib. They commence at the tip, and as they work downward toward the base, they collect the débris into a little bunch, which they fasten with silk to the midrib. When the hibernaculum is finished, the seam is perfectly smooth, and the whole inside is lined with silk. The larva having completed its work, composes itself for the winter, with the hind end toward the orifice. Here it remains till the catkins are in bloom the next spring, when it retreats from its house and commences feeding. Not the least wonderful part of the phenomenon is that it is only the autumnal brood of larvæ that form pitcher-like houses to live in during the inclement season of the year, the summer brood having no occasion to shelter themselves from cold."

FIG. 25. — The Empty Chrysalis.

Another interesting thing about these cases, pictures of which may be seen on page 11 and in Figure 24, is that in the north, they are nearly always made near the ground, where they are commonly protected by the snow during a large part of the winter.

The caterpillars in spring feed upon the catkins of the willow or the poplar, a fact that probably helps to limit the food-plants to these two genera. They utilize the winter home as a resting-place during the day, and the habit of retiring to them is continued long after

the catkins have given place to the leaves. The characteristic position assumed, with the head end bent downward, is shown in Figure 24.

After a few weeks of feeding in the spring, the caterpillars transform to chrysalids, and soon change again to butterflies, thus completing the yearly cycle of the species.

THE AMERICAN TENT CATERPILLAR.

One of the best examples of a tent-making insect is to be found in the common American Tent Caterpillar[1] of the orchard and highway. In July the eggs of this insect are laid in masses of two hundred or more, which more or less completely encircle the twigs of apple and wild cherry trees (Fig. 26). They remain unhatched until early the following spring; then the tiny caterpillars gnaw holes in the egg-shells and crawl out. When they first emerge they huddle together on the empty egg mass, often covering it with a slight silken web, as shown in Figure 27. They may remain here for some days, in which case they produce a noticeable tent (Fig. 28) enclosing the egg mass; but generally they soon migrate to a near-by fork in the twig. From the time of hatching they spin wherever they go a

Fig. 26. — Egg Mass of Tent Caterpillar, with Slight Web on Left Side.

[1] *Clisiocampa americana* Harris.

silken web. When they have congregated on the forked twig they spin a web over as well as under themselves, and this web thus becomes a sheltering tent. The colony of small caterpillars busily

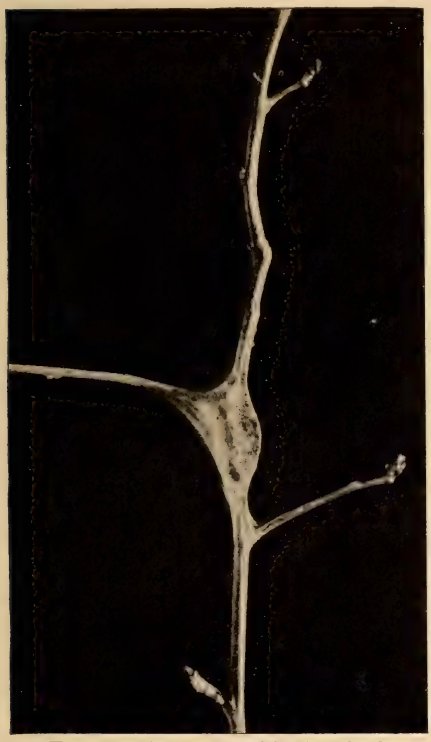


FIG. 27. — Egg Mass with More Web over it.

FIG. 28. — Miniature Tent enclosing Egg-ring.

spinning the threads of the tent is illustrated in Figure 29.

From the shelter tent they have thus provided, the caterpillars march along the twig to the unfolding leaves. Upon these they feed, returning to shelter again when hunger is satisfied. To go out and come in, the little

architects have left one or more openings which serve as doorways. They remain within the tent at night, and much of the time in rainy weather. New layers of silk are added to the outside of the tent as the days go by.

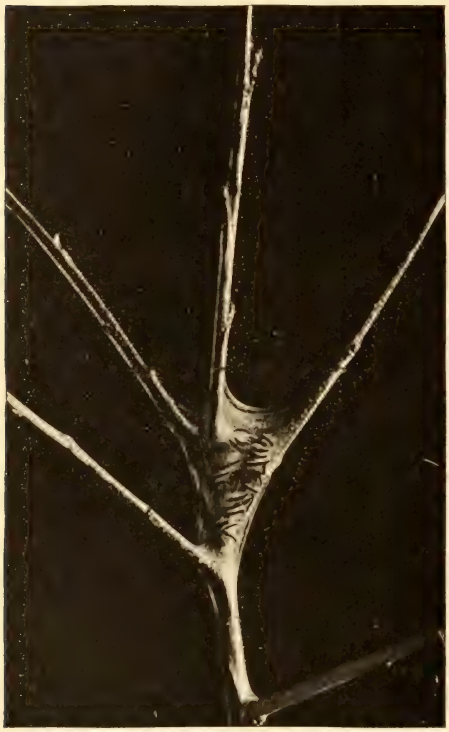


FIG. 29. — Young Colony of Tent Caterpillars.

It commonly happens that the first tent is made near the end of the branch in the fork of a small twig. In such cases the food supply beyond the tent is soon exhausted, and it is difficult to enlarge the shelter, because there are but the two branches to build it upon. Consequently, it can only be a flat tent, with little room inside.

To avoid these difficulties the caterpillars, as they grow larger, often migrate down the limb to a place where three or more branches go off in various directions. Here a new and more commodious tent is built, doors being left in suitable places. This home now becomes the centre of a new area of leaf destruction as the caterpillars crawl along the various branches to feed upon the foliage.

The most critical periods in the lives of caterpillars are the moulting periods. The insects are then sluggish

and unable to defend themselves by wriggle or flight. Of course these tent caterpillars utilize their shelter during these dangerous days, so that on the inside of a large tent you may always find the cast skins of the different moults that the larvæ have passed through.

FIG. 30. — A Terminal Tent on Two Branches.

As the caterpillars go back and forth from shelter to food and from food to shelter, they travel along the same paths day after day. As each crawls, it spins the ever-present thread — perhaps originally designed to guide it back to the nest. The addition of thread to thread along the route soon develops a distinct white ribbon of silk, which marks the pathway, and serves as a foothold to the marching larvæ. In trees having large colonies of caterpillars, these silken bands along the trunks and branches become very conspicuous.

It is an interesting sight to see these caterpillars at work adding new layers to the nest. A considerable number of them assist in the operation, some on the outside, others just inside the outer layer. They walk rapidly back and forth, spinning as they go the silken thread. Each of the caterpillars on the outside may be seen attaching the end of its thread to the bark of the twig at one end of its line of march, then promptly turning and repeating the action at the other end. They are careful not to carry silk across the openings of the doors and thus to close them. Sometimes these openings are at the top of the tent, as in Figures 32 and 33; sometimes they are at the bottom, as in Figure 31.

FIG. 31. — A Terminal Tent with Door at Bottom.

In about six weeks from the time of hatching the caterpillars become full grown. Each is then nearly two

inches long, with a hairy body ornamented by a distinct white stripe along the middle of the back, on each side of which are numerous short, yellow, longitudinal lines, rather irregularly arranged. The sides are partially covered with paler lines, spotted and streaked with blue, while the lower surface of the body is black: the general appearance is represented in Figures 34 and 35.

FIG. 32. — A Flat Tent with Doors at the Top.

Sometimes two or three colonies of the nearly full-grown caterpillars will unite in making a large tent at the base of the lower limbs of a tree. Such multiple colonies result from the fact that the nests higher up have not room enough to accommodate the caterpillars as they approach the full size. So each colony migrates down the limb to build a nest in more commodious quarters. As one colony migrates down one limb, another may be coming down another limb, and the two combine to build at the base. Of course it would rarely happen that these colonies would thus move at exactly the same time, but the result

would be practically the same if they came at nearly the same time.

The tent, whether made by one colony or more, is too small for all the caterpillars to remain in it and spin their cocoons. Most of them crawl down the trunk of the tree and wander over the ground, seeking a safe shelter for the next stage of existence. When they find a satisfactory situation — such as the under side of a board, beneath loose bark, or in the cracks of a fence — each spins an oval silken cocoon within which its body becomes short and thick (Fig. 36) before it changes to the quiet pupa state. Two or three weeks later it emerges as a brown moth.

FIG. 33. — Flat Tent with Caterpillars entering Upper Door at the Right.

The appearance of the male tent caterpillar-moth is shown on page 22. The males are considerably smaller than the females. These moths are nocturnal, flying only at night, and are to be found throughout the greater part of July. The females deposit the eggs upon the

twigs of trees, and soon die. As already stated, these eggs remain unhatched until the following spring, although the tiny caterpillars are fully formed within the egg-shells long before the advent of winter.

FIG. 34. — Tent Caterpillars at Rest on Tent.

Now let us consider for a moment what advantages the possession of the tent gives the caterpillars. Do they derive substantial benefit from it, or is it merely a useless device?

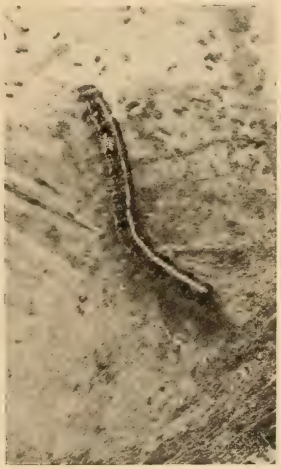


FIG. 35. — Full-grown Caterpillar on Tent.

To answer these questions we should consider the lives of the caterpillars in at least three relations, namely: first, their relation to cold; second, their relation to rain or snow; third, their relation to insect and vertebrate enemies, especially birds.

The relation of tent caterpillars to cold is an important one. Entomologists who rear caterpillars know that in warm weather they grow rapidly, while during cold

spells they grow little, or not at all. Now the animal heat in two or three hundred caterpillars is considerable, and if it can be confined to a limited space, it must make quite a difference in the temperature as it is felt by the larvæ themselves. These caterpillars develop during a period when the nights are commonly cold and the days are often damp and chilly. They hatch in early spring, generally as soon as the first leaves of the earliest trees begin to expand, and become almost or quite full grown by the first of June. It seems probable that the tent is of decided value in preventing radiation of animal heat from within and the entrance of atmospheric cold from without, thus increasing the temperature in which the larvæ live.

FIG. 36. — Caterpillar shortened for Pupation.

FIG. 37. — Tent where Several Branches fork.

That these caterpillars are sensitive to heat and cold is shown by the way in which they congregate on the outside of the nests during the warmer hours of bright days. One may often see large numbers of them thus taking their sun-baths.

The American tent caterpillars feed normally upon

the leaves of apple and wild cherry trees. These are two of the earliest trees to push out foliage in the spring. The closely related Forest Tent Caterpillar — which does not make so complete a shelter tent — feeds generally upon oak and maple leaves which are comparatively late in pushing out. The caterpillars of the latter species

FIG. 38. — Caterpillars enjoying a Sun-bath.

are correspondingly late in hatching. So there is a good reason why the apple and wild cherry caterpillars are in greater need of a shelter tent than are the others.

The relation of these caterpillars to storms is also important. In the spring of 1898, just after the caterpillars had hatched, and before they had time to build their tents, there was in central New England a heavy and long-continued rain-storm. Directly afterward I examined a considerable number of tent caterpillar colonies

and found that the only survivors were those congregated on the under sides of the egg masses, where they were not subjected to the washing effects of the rain. The destruction of caterpillar life during the storm had been enormous. Just such storms are common in April and May: unless the shelter tent protected them, the caterpillars would be

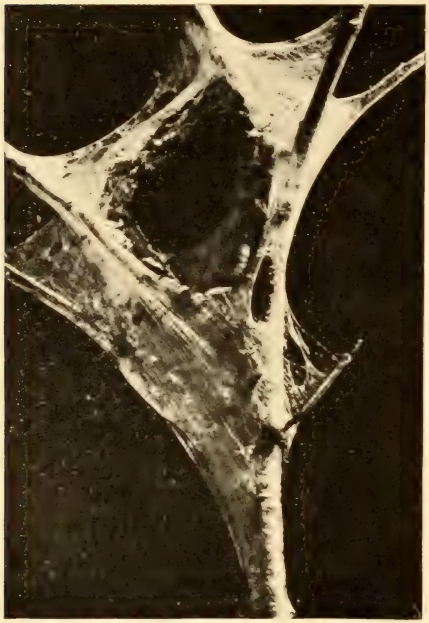


FIG. 39. — Tent injured by Hail-storm.

FIG. 40. — Tent raided by Birds.

constantly exposed to the danger of being washed away. And even a well-developed tent does not always protect them from hail-storms: Figure 39 shows the havoc such storms cause.

In what ways does the shelter tent protect this caterpillar from its host of living enemies? It greatly reduces the period of exposure to the attacks of predaceous beetles: some of the larger species of these — notably

the caterpillar hunters of the genus Calosoma — would be likely to devour any caterpillars which they came across in their wanderings, but they would not be likely to enter the tent for them. It also prevents, to a considerable extent, the attacks of many birds, although not all of them. And it makes the attacks of wasps and parasites more difficult during the moulting periods.

But the tent is by no means a complete safeguard against all enemies. Some birds, like the cuckoos and the Baltimore oriole, have learned to make holes in the web, and to tear out the larvæ concealed within, while some ichneumon flies appear to have learned how to enter the nest for the purpose of depositing their eggs.

Fig. 41. — Caterpillars killed by Disease.

It has just been said that the Baltimore oriole and the cuckoos feed upon these larvæ. In Figure 40 a nest is shown in which holes have been made by one of these birds for the purpose of extracting the caterpillars. The orioles are more likely simply to pierce the skin of the caterpillar and to extract some of the body contents, while the cuckoos swallow the insect whole. In the stomach of the black-billed cuckoo dozens of these caterpillars have been found.

This difference in manner of feeding may help to determine whether a given caterpillar's nest has been

raided by oriole or cuckoo. If there are many dead and mutilated larvæ on the branches near the tent, it was probably an oriole. If the caterpillars are gone, and there are no such remains, it was probably a cuckoo.

There is one sort of danger, however, to which the colonial lives of these tent caterpillars render them peculiarly liable. This is the ravages of bacterial diseases. These diseases attack many insects, especially caterpillars. They are very contagious, so that if one larva in the colony becomes infected, the others are likely to suffer, because in the crowded quarters of the tent it is inevitable that the germs shall spread.

FIG. 42. — Caterpillar, showing Effect of Disease.

That this is no imaginary danger is shown by many observations. In New England, in 1898, there was a culmination of an outbreak of the orchard tent caterpillar that had lasted many years. The chief agency in reducing the outbreak was a disease which appeared during damp weather in May and early in June, and killed nearly all of the larvæ. On every tent the dead and decaying larvæ could be seen by scores (Fig. 41), and as a result, there were very few nests to be seen in 1899.

A RURAL IMPOSTOR.

In tropical countries, as every one knows, there are many insects that mimic their surroundings. Wonderful tales are told by travellers of cunning creatures which so closely resemble leaf or twig or bark, that it is impossible to distinguish them. But it is less generally known that in our own fields and woods there are many examples of such mimicry fully as wonderful as those of the tropics. In this brief sketch I wish to bring to light one such impostor.

Over a large part of the eastern region of the United States, the fields and roadsides are overrun by the sweet fern, a low-growing shrub familiar to every one who has rambled through a New England pasture. It is a vagrant plant, not at all choice as to its habitation, speedily taking possession of any unused land. It serves as host — presumably an unwilling one — to quite a list of insects that find good feeding grounds upon its leaves. One of the most interesting of these is a strange caterpillar — a caterpillar in disguise, for it is strikingly different from its kindred.

Now caterpillars in general are smooth and cylindrical creatures, having well-rounded bodies, although many of them are clothed with hairs to avoid tempting the

greedy appetites of birds. But this insect is in effect at least a sweet fern leaf, and a sweet fern leaf has a very different appearance from that of an ordinary caterpillar. The leaf is long and narrow, with many pointed teeth along each side the midrib, and of a dull green or brownish colour, commonly having a rusty appearance. These

FIG. 43. — Sweet Fern Caterpillar at Rest. (On lower side, near middle.)

peculiarities the caterpillar has copied so successfully that your chances of finding one of the larvæ by searching the sweet fern branches in the field are considerably less than those of the person who hunts for a needle in the proverbial haymow. Even on a small branch on which you know the specimen is resting, it requires sharp eyes to see it. It is one of Nature's puzzle problems in which you are to find the caterpillar.

When you succeed in distinguishing the insect from

the surrounding leaves, you should examine it closely to see in what ways this remarkable resemblance has been brought about. The first thing you are likely to notice is that each of the rings of which the body is made up, instead of being round in outline as in other caterpillars, is nearly triangular in cross-section. On each side of the median line the back of the ring has been developed into a pointed projection of the form of one tooth of the serrate sweet fern leaf. The repetition of these projections along the whole length of the caterpillar's body has rendered the resemblance to the leaf, as a whole, very striking. You will notice also that the head is small and angular, making a suggestive tip to the counterfeit leaf, while the under side of the body is flattened, and the legs are inconspicuous.

The colour of the caterpillar also helps it out in its mimicry of the leaf. The foliage of the sweet fern is dull green or light rusty brown, there being nearly always many leaves of the latter hue upon the plant. The caterpillar is generally of this brownish colour, although the precise tint varies considerably.

If these sham leaves were constantly moving about, their shape and their colour would profit them little. For birds know that true leaves do not wander from place to place upon a plant, and a bird seeing such a wanderer would be likely to peck at it to see what it is made of. Now to a caterpillar a peck is as bad as a swallow: if its skin is pierced, its day's work is done. So you will find when you keep your caterpillar under observation that it will assume a certain position and remain rigid and quiet by the hour, apparently sleeping through the day. After the friendly shades of night have fallen, it will probably wander about and feed freely upon the

foliage, for then it is safe from observation by the eager eyes of birds. But when day returns, it will again become quiet.

The position commonly assumed by this caterpillar is to take hold of the stem with the pair of feet at its posterior end, and to hold the body rigidly out at the same angle that the leaves make in their attachment to the stems. Very often this position involves such a resistance to the force of gravity that you wonder how the insect keeps its front end in position for so long a time. If you look carefully, however, with a lens or reading-glass, you can see a silken thread extending from the mouth to the twig; this is the secret of the fixed position, for this thread holds the head in place.

FIG. 44. — Sweet Fern Caterpillar. (On the right-hand vertical leaf, but practically indistinguishable.)

How did this wonderful adaptation come about? Not so very long ago the answer would have been that the Creator made the caterpillar so, in order that it might escape from its enemies, and additional strength would thus be given to the famous argument from design. Now, however, we simply cite it as another instance of the strange results of the centuries of struggle for existence through which the species has passed. In so doing we by no means deny that the Creator made the insect as we see it, but we simply say that the method of its perfection has been through the action of the

laws of natural selection. For the mystery of life is as inscrutable as ever; we are merely learning, step by step, a little about the ways in which it manifests itself.

When the caterpillar becomes full grown, it makes a cocoon from the leaves surrounding it, fastening them together by silken threads. Within this, it changes to a pupa, to change again later to a beautiful little green moth, which is called by entomologists *Aplodes rubifrontalia.* It belongs to the large and interesting family of geometers — the Geometridæ, or Phalænidæ.

A DEVASTATOR OF FORESTS.

It is comparatively seldom that man has an opportunity to learn what would happen if, so far as forests and their enemies were concerned, the delicately adjusted "balance of nature" did not exist, so that tree-feeding insects had free opportunity to increase to the limits of their food supply. Probably when the good people of Massachusetts let the Gypsy Moth Caterpillars spread over the land, opportunities of this sort will not be so lacking as in the past and at present. Occasionally, however, a species gets beyond the control of its natural enemies even now, and is able to work its will upon the forests, apparently unchecked by any agencies. A notable instance of this kind was the recent outbreak of the forest tent caterpillar[1] in New England and New York, during which thousands of acres of woodlands were defoliated, and an immense number of valuable trees were destroyed. Maple woods were especially affected, but nearly all sorts of deciduous trees were also attacked.

These forest tent caterpillars pass the winter within the egg-shells, the eggs having been deposited the previous summer in cylindrical masses that form complete circles upon the smaller twigs of a considerable variety of trees. The eggs are covered with a brittle

[1] *Clisiocampa disstria.*

substance which gives the egg mass a shiny appearance, especially in a bright light. The general shape of the "caterpillar belt," as it is called in some localities, is shown in Figure 45, the length of the belt varying from one-fourth to one-half of an inch; the diameter is usually one-fourth of an inch. The belt terminates abruptly at each end, although it is not as a rule squared off. The outside of the belt consists of a glistening, varnish-like, brownish or lead-gray material, which covers the eggs. When the eggs are first laid, and for some months afterward, this covering remains entire, but as the winter passes it becomes more and more broken, so that by spring it generally has a rather ragged appearance. By removing the covering the eggs will be found beneath, resting side by side at right angles to the supporting twig (Fig. 46). Each egg is a trifle longer than wide, and is covered with a reticulated network of the same varnish-like material that conceals the mass as a whole; this network serves to attach the eggs to the twig, and to each other. The eggs are of a dull gray colour, showing white in some places. When the caterpillars hatch they gnaw off a circular cap on the upper end of the shell, and come out through the hole thus made. Each egg is about one-twentieth of an inch long.

FIG. 45. — Egg Mass of Forest Tent Caterpillar.

The number of eggs in one belt varies from less than 150 to more than 225, the average being nearly 200. When the insects are so abundant that there is a partial exhaustion of the food supply of the caterpillars, the normal number of eggs are not laid, the egg-rings being much smaller than usual.

These egg masses are deposited in July, and remain unhatched until the following spring. The actual formation of the tiny caterpillars from the contents of the egg takes place, however, within a few weeks after they are laid. By a careful examination, the minute but fully formed larvæ may be found within the egg-shells any time between September and the following April. The caterpillars remain during this long period quietly confined within their narrow houses, but when the warm rays of the spring sun penetrate their abodes, they eat off the tops of the egg-shells, and come out ready to break their long fast upon the tender foliage of the expanding buds. They are then tiny creatures, scarcely one-tenth of an inch long, showing under a lens that the blackish body is thickly covered with rather long brownish, or grayish, hairs. They feed upon the unfolding leaves of the twig near where the egg mass was placed. In about two weeks each increases in size to such extent that the skin in which it came from the egg is too small for it. This skin then splits open along the back, and the caterpillar crawls out, clad in a new skin that had gradually been forming beneath the

FIG. 46. — Egg Mass, with Outer Covering removed.

old one. This skin-shedding process is called moulting: it is the general way in which insects provide for increase in size.

The caterpillars very commonly emerge from the eggs some time before the leaves of their food-plants push out. Under such conditions the tiny larvæ are likely to huddle together upon or near the egg mass to await the unfolding of the leaves. There seems to be considerable variation in the time of hatching, as larvæ of various

FIG. 47. — Miniature Tent with Cast Skins.

sizes may be found at any time during the latter part of May or in June.

Wherever they go, these little larvæ spin a silken thread which marks their pathway, although the thread is so slender that a single one is generally to be seen only through a lens, but in places where the larvæ congregate to rest when not feeding, a habit that they have, it becomes quite noticeable. It is especially so after moulting, for then one can often find on the end of a forked twig such a miniature tent as is represented in Figure 47, the cast skins being intermingled with the silken threads.

Soon after the first moult the caterpillars begin feed-

ing again, eating, of course, more and more of the foliage as they become larger. A week or so later they again moult, a process which is repeated twice, thereafter, at similar intervals. At the time of the later moults, the caterpillars are in the habit of congregating upon the trunks or larger limbs of the tree, often not far from the ground. Beneath the mass of larvæ there is an inconspicuous web, in which the feet are more or less entangled. The appearance of the caterpillars at such times is well shown in the photograph reproduced in Figure 50. At the end of about five weeks from the time of hatching from the egg, the forest tent caterpillars become full grown in this, their larval state. Each is now about two inches long and one-fourth of an inch thick. It is cylindrical in shape, with six jointed legs arranged in pairs directly back of the head, eight thick prolegs along the middle, and two prolegs at the hind end of the body. The head is dark bluish, and the body in general has a bluish appearance, more or less modified by the longitudinal series of marks and stripes. Along the middle of the back there is a series of whitish or cream-coloured marks of the shape shown in the picture on page 45. Along the upper part of each side there is

FIG. 48. — Another Tent with Cast Skins.

a broad blue stripe, bordered above and below by a narrow, irregular, yellowish white line. On the lower sur-

FIG. 49. — Cast Skins on Branch.

FIG. 50. — Caterpillars resting upon a Branch.

face the colour is bluish black. The whole body is sparsely clothed with rather short hairs.

These full-grown caterpillars are now ready to enter upon the next stage of their existence, that of the pupa, or chrysalis. This is a quiet stage, in which the insect

takes no food, and is unable to move about, and it needs to protect itself from its various enemies. Consequently, each caterpillar spins from certain silk glands in the mouth a shroud of silken threads, surrounding itself by an oval cocoon composed of several layers of silk, the outer ones much looser than the inner, with the hairs of the caterpillar intermingled with the silk on the inside layers. When this cocoon is first spun it is white, but the caterpillar soon colours it yellow with an excretion from the body.

Fig. 51. — Cocoons in Apple Leaves.

The caterpillars generally prefer some sort of framework to build their cocoons upon. They commonly choose the leaves of trees for this purpose. Sometimes a single large leaf will be used, its edges being folded over, as in the case of the cocoons in apple and currant leaves, shown in Figures 51 and 52; while at others, several smaller leaves may be deftly drawn together, as in the barberry leaf cocoon shown in Figure 53. If the insect happens to be in a pine tree, it will utilize the pine needles for this purpose, and even such delicate structures as the panicles of the smoke bush or fringe tree may serve the purpose. Where the caterpillars are numerous, the foliage of the trees is almost wholly webbed up when the cocoons are made, giving the trees a strange,

bunchy appearance. Many of the caterpillars, however, leave the trees, and seek shelter in other situations, such as crevices in the rough bark, beneath boards or stones upon the ground, in the crannies of a fence, along the clapboards, or beneath the gables of buildings.

FIG. 52. — Cocoon in a Currant Leaf.

Wherever the cocoon is spun the caterpillar inside of it soon changes to a pupa or chrysalis — an oval, brown object without legs or wings, able to move only by a feeble wriggle of its body. The pupa that is to develop into a female moth is slightly larger than that of the male. In this stage the insect takes no food, but its tissues undergo such remarkable changes that about ten or twelve days after the cocoon is made, a buff-brown moth emerges from the chrysalis and makes its way through one end of the cocoon. This is the adult form of the forest tent caterpillar. The male moths are slightly smaller than the females, as may be seen in Figures 54 and 55, in which the two sexes are represented by drawings, natural size. The feelers, or antennæ, of both sexes are feathery, but

FIG. 53. — Cocoon in Barberry Leaves.

those of the male are much broader, as well as somewhat longer.

The moths generally make their appearance during the latter part of June. Soon afterward the females deposit their eggs in masses of about two hundred each upon the twigs. The moths, having completed the cycle of life, die soon after the eggs are laid.

As a result of much patient watching, my assistant, Mr. W. F. Fiske, was so fortunate as to observe one of these moths depositing her eggs. He has recorded his observations as follows: —

"On the afternoon of June 27, three pairs of freshly emerged moths were found in the breeding cages mating,

FIG. 54. — Moth, Male.

FIG. 55. — Moth, Female.

and two of them placed, without separating, under a bell-jar with some green twigs of apple. At 8 P.M. one pair had separated, and the female was very active, buzzing around the interior of the bell-jar. Fifteen minutes later she had taken notice of the apple twigs, and was more slowly crawling over them. By 9 o'clock she had selected a site for an egg-ring, and had just begun its deposition. About a dozen eggs were laid at this time, in the form of a right triangle, one side forming what was to be one edge of the future egg-ring. On what would correspond to the hypothenuse of this triangle she was now busy depositing more eggs, making each row longer, and increasing consequently the width of the future band,

still keeping the general form of the egg mass the same. The placing of the first egg in each row is accomplished with some difficulty, and is also a matter of some delicacy, for if it is not placed correctly, the whole band may suffer; but after this is done, the remainder are easily fixed in their proper positions, the abdomen, which is stretched nearly to its limit, so moving that each egg slips into the space between the end egg on the row under construction and the corresponding egg in the row just completed. The eggs are laid at intervals of about half a minute, and after each is deposited there is a second's pause, followed by a little pile of bubbles of creamy whiteness, which rise around it and help to form the tough, protecting winter coat. It is very difficult to get a good view of the operation at close hand, on account of the position in which the wings of the moth are held, drooping and well covering the abdomen, and it cannot be stated with certainty whether the egg itself is deposited just before or just after the extrusion of the froth.

"The width of the band being decided upon, the rows are made of uniform length thereafter, and the girdle begins to take form. In the case under observation, as the moth was undersized, the band was a narrow one, and the number of eggs in each row was about seven. When the band was nearly completed, after about an hour's work, the moth was disturbed, and for the remaining distance the rows were anything but regular. Whether as a result of this break or otherwise, there were a lot of eggs left over after the ends of the bands were united, and these were deposited slowly and irregularly, with much preliminary feeling about on the lower edge of the band. This part of the operation required above an hour, or as long for the placing of a few dozen

eggs as it did for the construction of the girdle proper. The whole time, from the first observation until the egg mass was finally left, was about two and a half hours. The moth did not long survive the completion of the ring, but within a few hours, before it had been a whole day in its perfected form, it died."

A condition that has been repeatedly noticed during the last three years seems to indicate that in general the instinct of the moth teaches it to deposit eggs only on trees bearing leaves at the time the eggs are laid. When a maple orchard is defoliated one year, it is likely to escape the next year, unless it is invaded by caterpillars hatched on the surrounding trees. The moths that develop on such a lot of defoliated trees apparently fly to the surrounding trees that still bear leaves before depositing their eggs. Of course this habit is of advantage to the insect, for the chances of a sufficient food supply for the caterpillars are greatly increased by it. In some cases, however, the explanation is that the caterpillars completed the defoliation of the trees before they were full grown, and then migrated to new feeding grounds.

Like most moths the adults of these forest caterpillars are night-fliers rather than day-fliers. They are attracted by light after dark, and frequently fly through open windows into houses. Late in the afternoon they may also be seen when abundant, flying among the branches of the trees.

When the caterpillars are disturbed while feeding upon the leaves or crawling along the twigs, they have a habit of dropping downward, checking the fall by means of a thread spun from the mouth and attached to the twig. Thus suspended in mid-air they are very annoying to foot-passengers in villages, or to people riding along

shaded roads in town or country; for to find yourself suddenly confronted by a dozen caterpillars on the level of your face is disconcerting.

Even when not disturbed by man, a large proportion of the caterpillars drop down by means of the thread at one time or another during their growth: some are probably startled by the swaying of the twig in the wind; others by birds when alighting; in many cases the movement is probably induced by the exhaustion of the food supply, or, perhaps, by a migratory instinct. In any event, this dropping is very general, and as a result the caterpillars are continually to be seen crawling up the trunks of the trees; this is especially likely to be the case early in the morning.

Fig. 56. — Forest Tent Caterpillars at Rest. (Two of the American species are also present.)

When an orchard, grove, or forest in which these caterpillars have been feeding, is defoliated, the insects migrate to neighbouring trees, in a way suggestive of the

migrations of the army-worm. At such times they often appear in incredible numbers. Several cases are on record where in crossing railway tracks they have impeded the progress of trains by making the rails slippery as the bodies were crushed. One case which has been vouched for by the entomologists of the United States Department of Agriculture, after official investigation, is reported in these words: —

"The rails on the Carolina Central railroad were covered inches deep with caterpillars, so that for three days in succession trains were brought to a dead standstill, the driving-wheels of the engine slipping round as though the rails had been thoroughly oiled. The engineers were obliged to exhaust the contents of the sand boxes before crossing the strip of swamp from which the caterpillars seemed to come. The rails and cross ties were said to be obscured from sight, and the ground and swamps on each side of the track were covered with millions of the crushed caterpillars, and from the mass an unendurable stench arose."

During recent years there has been considerable discussion among the professional entomologists as to the best popular name for this insect. Its common name, forest tent caterpillar, is not very satisfactory, because the insects are as likely to be found in apple orchards as in forests, and they do not make tents in the complete sense that the nearly related American tent caterpillar does. Various substitutes for this name have been recently proposed, none of which, however, seem to me sufficiently satisfactory to warrant a change. Professor M. V. Slingerland of New York has proposed that the insect be called the forest tentless caterpillar; but the objections to this are, first, that it is not absolutely a tentless cater-

pillar, many of the caterpillars making in early life miniature tents, like the one shown in Figure 47; and, second, as Dr. L. O. Howard has pointed out, there are a great many other tentless caterpillars that feed upon forest trees.

Fortunately for man these forest tent caterpillars are preyed upon by many natural enemies, including insects, spiders, toads, and birds. Among the more important insect enemies are the tachina-flies and the ichneumon-flies. In the recent New England outbreak at least three species of Tachinids[1] were at work destroying the hosts of caterpillars. One of these flies is represented somewhat magnified in Figure 57 *a*: it looks much like a common house-fly, and is of about the same size. This fly deposits a whitish egg upon the skin of the caterpillar, generally after it is more than half grown. The egg soon develops into a tiny grub that burrows through the egg-shell and the skin of the caterpillar into the inside of the body. There it remains, absorbing the tissues of its host, and gradually increasing in size. In due time it becomes fully developed in this grub state, and breaks through the skin of the caterpillar. It is then a good-sized, white, oval, footless grub. The caterpillar has generally spun its cocoon before the parasite comes from its body, so that the parasite finds itself inside the cocoon when it gets outside the caterpillar. The grubs of two species of these Tachinid parasites

FIG. 57. — Tachinid Parasite of Forest Tent Caterpillar: *a*, fly; *b*, puparium.

[1] *Tachina mella* Walk, *Exorista futilis* O. S., and *Frontina frenchii* Will.

work their way through the cocoon and drop to the ground, while the other seems to remain in the cocoon.

The parasitic larvæ have now to enter upon the quiet pupa stage. For this purpose the outer skin turns brown, and becomes hard, forming a protective covering for the insect inside. This is called the *puparium* (Fig. 57 *b*). Within this covering the insect changes to a pupa, to change again about two weeks later into an adult fly.

After an outbreak of the forest tent caterpillars has continued for two or three years, these Tachinid parasites frequently become very abundant. They are often a chief cause for the cessation of an outbreak. In one New Hampshire town a year or two ago the people saw great numbers of strange flies swarming about the fields and pastures: they were probably these Tachinids.

Among the ichneumon-flies, the parasites of the genus Pimpla are the most abundant enemies of these caterpillars. The adult is a four-winged fly that deposits eggs in the caterpillars or the newly formed chrysalids after the cocoons are spun. Shortly after being laid the eggs hatch into minute grubs that develop at the expense of the chrysalids, finally eating up nearly all their substance. About two weeks after the eggs are laid, the parasitic larvæ change to pupæ, and soon afterward again change to adults.

These caterpillars are also subject to the attack of certain bacterial diseases which are often very destructive, especially during wet seasons. And sometimes when small they are killed off in enormous numbers, by late frosts.

It has frequently been pointed out that one of the greatest services which birds render to man is that of

concentrating their attack upon outbreaks of injurious insects. In this respect they are like a great standing army that, on short notice, can be mobilized upon any point where danger threatens. Although these forest tent caterpillars are protected from many birds by their hairy coverings, they furnish a good illustration of the value of birds in such emergencies. Careful observations upon this phase of the recent outbreak were made in Vermont by Miss Caroline G. Soule, who kindly com-

Fig. 58. — Cast Skins of Forest Tent Caterpillar.

municated to me the results. "A surprising number of birds were seen feeding upon the caterpillars, the list including robins, orioles, chipping sparrows, cat-birds, cuckoos, three species of vireos, cedar-birds, and nut-hatches. The latter were particularly useful, as they would stand by a patch of larvæ, lying close together below a tar band on a tree, and eat so voraciously, and with such an entire abandonment of self-consciousness, that I could go close and put my hand on them before they would fly. This experience was repeated several

times." During the last season that the caterpillars were abundant Miss Soule wrote: "I am almost sure the caterpillar has drawn the birds here; for in four summers I have never seen nearly so many as this year, though I have been observing birds for years. Too much cannot be said for the birds. The orioles and the red-winged blackbirds, especially, are stripping the trees of pupæ. Yesterday I saw orioles at work on a beech and an oak that had been badly eaten at the top, and I pulled down some of the branches and examined each of the many cocoons. Every one had the neat slit these birds make, and every pupa was gone. The baby orioles all learn to do this as soon as they can fly from one tree to another." A little later cedar-birds were seen flocking to the trees, opening cocoons and devouring the pupæ. On July 8, Miss Soule wrote, "The number of birds is really amazing, and the thorough work they do is delightful."

Regarding the birds that feed upon the moths, the same keen observer, in an admirable article in the *Springfield Republican* wrote: "Many cocoons gave the moths in July, and these little brown moths could be seen in great numbers flying about the maple, elm, apple, pear, ash, and other trees, laying their eggs near the tips of the twigs, — flying by daylight. Then the birds had another feast. Vireos of four kinds, flycatchers of three kinds, both cuckoos, robins, rose-breasted grosbeaks, tanagers, cedar-birds, cat-birds, orioles, red-winged blackbirds, martins, and sparrows fed on the moths as they had done on the pupæ and larvæ. Chipping sparrows became expert 'lofty tumblers' in their zigzag pursuit of the flying moths, and even the English sparrows had a brief season of usefulness, for they really ate some

of these moths, though they would not touch either pupæ or larvæ."

The Baltimore orioles were among the most efficient enemies of the caterpillars, destroying them in great numbers for their own food as well as to feed their young. These orioles are exceedingly useful birds, as they generally feed freely upon hairy caterpillars.

STUDIES OF WALKING-STICKS.

THE Walking-stick[1] has always seemed to me to occupy among our insects much the same position that the least bittern occupies among our birds. The latter has been well described by Mr. Frank M. Chapman as "a half-solved mystery," to be thought of "less as a bird than as a survivor of a former geological period, when birds still showed traits of their not distant reptilian ancestors." Both these creatures are extreme examples of that resemblance to surroundings which enters so largely into the make-up of the animal world, and they both have a well-developed instinct for keeping quiet to render more effective their peculiarities of colour and structure. The walking-stick seems, indeed, to have stepped from the pages of the books of Bates and Wallace with their stories of tropical mimicry, or at least to belong exclusively to the fauna of our Southern states, where it has for company the weird praying mantis. In Puritan New England it seems bizarre and out of place.

During last autumn these walking-sticks were unusually abundant in southern New Hampshire, and I took advantage of the fact to get some pictures. Better sitters

[1] *Diapheromera femorata* Say.

one could not ask for: they would remain quiet and "look pleasant" by the hour, so that time exposures could be made to one's heart's content. They were happy with only a bit of birch twig for support, and it seemed a matter of entire indifference to them whether they hung on with three legs or six, although they seldom utilized the latter number. A common position of the male is shown in Figure 60: the insect rests head downward, with the two front legs and the antennæ closely appressed and projecting forward as a continuation of the body. The termination of the head is not easily distinguished. Another position in which the front legs are not held so closely together is shown in Figure 59. The body is parallel with the twig, and the chief support is derived from the two hind and one of the middle legs.

FIG. 59. — Walking-stick, Male, resting with Head Downward.

The body of the female walking-stick is considerably larger than that of the male, but it attitudinizes in much the same way. A back view, in which it is clinging to

the support with its four rear feet and one front one, is shown in Figure 61. As will be seen, the other front leg projects forward beside the antennæ: on account of the larger body, the termination of the head is more plainly visible than in the male. Figure 62 shows a side view, in which five of the legs seem to be utilized for support, and one held out forward along with the antennæ, one of which is curled down in an unusual position.

FIG. 60. — Walking-stick, Male, with Head Downward.

When one has watched these queer creatures thus taking on attitudes, and holding them by the hour, it is interesting to study their structure to see in what ways they are adapted to their curious existence. One of the most remarkable things about them is the entire absence of wings. Another is the unusual development of the thorax: a little observation through a lens shows distinctly the three divisions of the thorax. The prothorax next the head is short and bears the second pair of legs near the middle of the under surface. The mesothorax is very long — the longest segment of the body — and bears the second pair of legs at its posterior end. The metathorax is a little shorter than the mesothorax and

bears the third pair of legs also on its posterior end. Then follows the abdomen with its nine short joints — all together just about equalling in length the three thoracic segments. The head seems but a continuation of the thorax, except for the large, well-rounded, projecting eyes which must give the creature a range of vision almost equal to that of the dragon-fly. The slender, many-jointed antennæ that project straight forward from the head are four-fifths as long as the body, and a little longer than the slender front legs. The latter show at their base a distinct and peculiar curve which enables the insect to bring them close together in front of the head; this curve may be seen in Figure 61.

FIG. 61. — Walking-stick, Female, Back View.

The middle legs are shorter and more robust, while the hind ones again are slender and nearly as long as the front ones. All the legs are so attached to the body that the first long joint extends sideways, and can even be bent upward at an acute angle. The legs are loosely

jointed, so that in the living insect the members of the same pair are seldom symmetrically arranged (Fig. 63). This is doubtless an important point, for the insects would be much more easily seen upon twigs if the legs were held in positions of bilateral symmetry.

FIG. 62. — Walking-stick, Female, Side View.

The more you look at one of these walking-sticks the more you are impressed with its wonderful mimicry of a bit of twig. The body surface has the shine of young bark, and minute irregularities on parts of its surface help out the resemblance. The colour, too, helps to the same end: it is a mottled brown or grayish green, much like the bark of little twigs of oak and other trees.

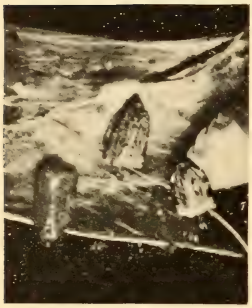
These walking-sticks are vegetarians, feeding upon the leaves of oak and various other trees. The females drop their eggs from the place where they are feeding: a considerable number were laid by the specimens in my vivaria, some of which are illustrated on page 58. They look like little seeds, and as a matter of fact, the part we see from the outside is simply a little capsule inside of which is the egg proper. Out of doors these eggs remain

upon the ground until they hatch the following spring, although it is said that sometimes part of them live over two winters before hatching.

During daylight these walking-sticks must be in constant danger of execution by birds, and presumably it is to escape such danger that they rest so quietly in one position for hours at a time. They are said also to fall victims to certain predaceous bugs that wander over trees and shrubs in search of caterpillars and other insects whose life-blood they may suck.

FIG. 63. — A Pair of Walking-sticks upon a Birch Twig.

THE CHOKE-CHERRY TENT-MAKER.



THE two species of tent caterpillars already discussed are often cited as examples of insects that spend an extraordinarily long period in the condition of the egg. With these species the eggs deposited in July do not hatch until the following April, so that nine months out of the twelve are thus passed. Were our knowledge of the insect world sufficiently complete, we should probably find many other similar examples. Even with the comparative ignorance of the present, such a one occasionally comes to light. One of the most interesting of the recently discovered examples of this is the case of the Choke-cherry Tent-maker, an insect that frequently becomes very conspicuous in early summer, on account of the pointed tents that it makes along fences and highways, and by the borders of the woods — wherever, in fact, the ubiquitous choke-cherry sends up its branches.

FIG. 64. — Early Stage of Tent.

The first indication that one

commonly sees of the presence of these insects is the webbing together, early in spring, of two or three of the terminal leaves of the small cherry bushes. These webbed leaves are not at all conspicuous, resembling at first the normal unfolding leaves at the tip of the twig. If you open them up, however, you will find inside a great number of tiny whitish larvæ, which will be disturbed by the unusual conditions as to light, and will rapidly escape.

FIG. 65. — A little Later Stage of Tent.

When you have thus found a young colony of these tent-makers, you will wonder where they came from. It seems probable that they recently hatched from eggs, but if you look carefully over the adjacent parts of the twig, you will be unable to find any indications of the egg-shells. In the case of some butterflies that deposit their eggs singly, the caterpillar on hatching eats up the empty egg-shell — so that no hungry enemy may discover that a young caterpillar is in the vicinity. But so far as I know this method is not adopted by the larvæ that live in colonies, so it seems improbable the egg-shells could

have been eaten by the tiny creatures that you find within the rolled leaves. The only thing to do is to extend your search farther afield: continue to examine the bark carefully from the tip of the twig toward the base, and just before you reach the ground, if your eyes are sharp, you will find what appears to be a bit of bark with a lot of little holes in it; it is slightly raised above the surrounding surface, although of nearly or quite the same colour. Through a lens you will readily see that this is an egg mass from which the larvæ have hatched. You can but marvel at the perfect adaptation shown by these eggs to the conditions of their life: were they on the upper part of the branch, many of the masses would be found by the eager eyes of birds, notwithstanding their resemblance to the bark; but down by the ground there is a bit of surface which is not so generally inspected by the birds, and this is where the eggs are placed.

Fig. 66. — A completely enclosed Tent.

In spring, when the leaves of the cherry bushes have pushed out, the eggs hatch into tiny larvæ that instinctively crawl up to the top of the branch, where they ensconce themselves within the unfolding leaves, sewing

their edges together by means of the silken threads that apparently are available from the time of hatching. They feed upon the succulent tissues of the shelter they thus construct, and within which they are to remain for the next few weeks. New leaves are added to the webbed mass from day to day, and before long the larvæ are able to bend good-sized twigs to their purpose, as seen in Figure 67, which also shows the way in which the leaves are eaten on the edge just inside the web. As fast as the leaves are eaten new twigs are webbed over and brought into position (Fig. 68), the tops being brought together in such a way as to form at last a veritable conical tent, a common form of which is shown in Figure 69. The silken threads must have remarkable strength to web and hold together the good-sized twigs that are often thus enclosed.

FIG. 67.—Tent showing the Way in which the Leaves are eaten.

Within this tent the larvæ pass their lives, gathering together toward the middle during the day, when they are not feeding, and enlarging the tent and feeding toward dusk or after dark. They moult from time to time as their growth requires, keeping well within shelter at these critical periods. If the food supply of the original bush becomes exhausted, the larvæ web up the surrounding grass and herbage; probably in search for another cherry bush. If one be found, they take possession of it. Each original colony commonly consists of a great number of larvæ, — probably more than a hundred, — and neighbouring colonies appear often to join forces in the operation of tent-making, especially after this wandering for food begins.

FIG. 68. — Tent showing Bending of Twigs.

These tent-making larvæ are rather slender, naked, whitish, wormlike caterpillars, without conspicuous markings except the blackish heads. Except for the tent, they have no means of protection against birds and other enemies. By working on the tent and feeding after dark they escape observation by birds, and in part, at least, the attacks of predaceous insects and parasites.

About five or six weeks from the time of hatching, the caterpillars become full grown, so far as this larval state is concerned. They now retire to the middle of the tent, where they unite to form a colony of cocoons side by side, the silken threads of the cocoons being more or less intermingled with the dried particles of excrement. Within these cocoons the larvæ change to pupæ, the quiet stage in which they rest and take no food. In about two weeks the pupæ wriggle out from the cocoons and reach the outer surface of the tent, where they hang until the dry outer skin of each splits apart and the small orange-brown moths emerge. The empty pupa skins, as they hang from the deserted tent, are shown in Figure 70.

Fig. 69. — A Completed Tent.

The moths are beautiful little creatures. They fly about at night, depositing their flattened masses of eggs upon the bases of the cherry bushes. When first laid these masses are distinctly yellow, but in course of time they lose their brightness, and take on the sombre brown of the surrounding bark. After about two weeks of winged existence the moths die, and for the next nine months the species exists only within these obscure egg masses hidden away at the bottom of the cherry bushes.

If you confine one of the cocoon masses — soon after the larvæ have pupated — within a glass jar, you will

be likely to get a lot of the moths, and in addition quite a number of four-winged flies, very different in appearance from the moths. These are Ichneumon parasites. You will notice that many of them have long ovipositors projecting from the abdomen. It was probably by means of this organ that the parents of these flies were able to penetrate the folds of the tent and lay their eggs on or in the larvæ or pupæ of the cherry twig-tiers.

FIG. 70. — Empty Pupa Skins projecting from Tent.

These moths belong to the family of leaf rollers, called Tortricidæ. It is a large family including many insects that feed upon the leaves of trees and other plants, most of the larvæ living within the rolled leaves of their food-plants. But some of them have found that other parts of plants besides the leaves are edible and so have changed their habits to take advantage of the discovery. The most familiar example of this is the larva of the codling moth which is so often found in apples, where it gets its food by eating the pulp of the fruit.

THE ANTIOPA OR MOURNING-CLOAK BUTTERFLY

During sunny days in spring, one may often see a beautiful purple-black butterfly, having a cream-coloured border along the outer margin of its wings, flying leisurely about, in the vicinity of woods and in the open fields. This insect is called the Antiopa or Mourning-cloak Butterfly; it is represented natural size in Figure 71. It has passed the winter in this adult condition, having found shelter in some retreat where it was not directly exposed to the storm and stress of the weather.

Fig. 71. — The Antiopa Butterfly.

When the leaves of the elm, willow, and poplar trees are nearly expanded, these butterflies deposit their eggs upon the twigs. These eggs are laid in clusters encircling the twigs, there being twenty or more in each cluster; their general appearance is shown

in Figure 72. In the act of oviposition, the butterfly keeps her wings spread out, moving the body and abdomen about as the placing of the eggs necessitates.

About two weeks after the clusters of eggs are thus laid upon the twigs of the food-plant, they hatch into small blackish caterpillars, each emerging from the egg-shell through a small hole that it eats out of the upper surface. They thus enter upon the second stage in their life-history — the larva or caterpillar stage. As soon as hatched, they crawl to the nearest leaf upon which they range themselves side by side, with their heads toward the margin of the leaf. They feed in this position, nibbling at the green surface of the leaf blade and leaving the network of veins untouched.

FIG. 72. — Egg-ring upon Willow Twig.

These caterpillars continue to feed in this manner for about a week, remaining side by side when feeding, and marching in processions from one leaf to another, as the food supply is exhausted. Wherever they go, each spins a silken thread on the surface traversed, so that the combination of all the threads makes a sort of carpet that serves as a foothold for the caterpillars. At the end of the week they moult or cast their skins, a process in which the skin of each larva splits open along the back, and the larva crawls out covered with a new skin that had been formed beneath the old one. This new

skin stretches somewhat after the caterpillar emerges, so that the insect is able to increase considerably in size. At the period of moulting, the caterpillars remain quiet for a short time, but they soon become active again and begin feeding with increased voracity.

During the next three weeks, this moulting process is repeated three times, the caterpillars becoming larger each time, and leaving their cast skins upon the denuded twigs, as shown in Figure 74. They soon scatter more or less over neighbouring leaves, but remain in closely associated colonies (Fig. 73). As they increase in size, they eat more and more of the leaf substance; when half grown, they devour all but the midrib and the side veins; but when they get larger, only the midribs are left.

FIG. 73. — Colony of Young Caterpillars feeding upon Willow.

The carpet web that they form becomes more conspicuous as the caterpillars develop, and often binds the ends of neighbouring twigs together, especially in those places to which the caterpillars retire for rest after feeding.

About four weeks from the time of hatching, these caterpillars become full grown (Fig. 76). They then leave the tree or shrub on which they have been feeding, and

scatter about, seeking some sheltered situation. Having found this — perhaps beneath a stump or along the under side of a fence — each caterpillar spins a web of silk along the surface. It then entangles the hooked claws of its hind legs in the silken web, and lets its body hang vertically with the head end curved upward. It remains in this position some hours before the skin along the back just behind the head splits apart and is gradually wriggled upward, until finally it is all removed and there hangs in place of the caterpillar a peculiar object having no definite form. But it rapidly assumes a definite form — that of the chrysalis (Fig. 77). This picture shows the shape and size of the chrysalis, which is of a grayish brown colour, different specimens varying somewhat in shade.

FIG. 74. — Cast Skins upon a Denuded Twig.

In this quiet chrysalis, the insect is apparently almost as inert as a mummy. If you touch it, it will wriggle a little, but otherwise it hangs there mute and helpless. On the inside, however, the tissues are being made over in such a wonderful way that in about two weeks, from the mummy case into which the caterpillar entered, there comes a beautiful butterfly.

The Antiopa or Mourning-cloak Butterfly.

When this butterfly first breaks through the mummy shell, its wings are very small, although its body, antennæ, and legs are well developed. By means of the latter, it clings to the empty chrysalis, while its wings expand. At first these wings are short, but as soon as the insect takes a position in which the wings hang downward, they begin to expand, and soon reach full length, but are more or less crumpled longitudinally, and the front wings are not so wide as the hind ones, hanging limply inside the latter, as shown in Figure 78. In a short time, however, they expand laterally and become full size, the butterfly still hanging to the chrysalis, as shown in Figure 79.

FIG. 75. — Half-grown Caterpillars feeding on Elm Leaves.

FIG. 76. — Full-grown Caterpillars.

After the butterfly has thus reached its full form and size, it crawls from the chrysalis to some neighbouring support, where it rests quietly for half an

hour or more. During the latter part of this time it exercises its unused muscles by slowly opening and closing its wings, until finally it flies away.

Fig. 77. — Chrysalis.

The caterpillars of the mourning-cloak butterflies are restricted to comparatively few food-plants. In regions where they are not especially abundant, they are likely to be found upon willow, poplar, or elm. In general, as many observations indicate, they are as likely to be found upon any one of these food-plants as upon either of the other two; but in certain localities where they become especially abundant it seems that they are more likely to occur upon the elm. On this account they have been called the Spiny Elm Caterpillars. There is considerable evidence to show that they prefer the American elm to other species of the genus, although in the case of willow and poplar there seems to be little if any preference as to the species.

Fig. 78. — Butterfly with Wings developing.

Miss Caroline G. Soule has seen the butterflies depositing their eggs upon the white and canoe birch, and it has been recorded as feeding in Labrador and Europe upon a species of birch. There is one record of the caterpillars having been found feeding upon the hackberry, and also one of their having fed greedily upon the leaves

of rose, and still another of their having almost defoliated a pear tree. Linden and nettle are also included in the European lists of the food-plants of this species.

It is evident, however, that all of these, except the three first named,— willow, poplar, and elm,— are to be regarded as exceptional cases, and that the normal food of the species is the foliage of a plant belonging to one of these three genera.

FIG. 79.— Butterfly hanging to Empty Chrysalis.

It has generally been supposed that this species is double-brooded in central and southern New England, the butterflies of the first brood appearing early in July. These are said to deposit eggs which hatch into caterpillars that mature into butterflies early in September. These butterflies live through the winter, laying eggs the following spring.

Unless the summer of 1899 was exceptional, however, this idea of the yearly history of the species will have to be modified, for during this season, in New Hampshire and Vermont at least, there was practically but one brood. Continual observations by Miss Caroline G. Soule at Brandon, Vermont, and by Mr. W. F. Fiske and myself in this state show that there was scarcely a trace of a second brood of caterpillars, for with all our searching in July and August we found but a single colony of larvæ. These were discovered on a willow at Durham, August 3. During the period when the second brood

of caterpillars are supposed to be at work, I travelled by carriage and on foot over hundreds of miles of roadway in southern New Hampshire and southern Maine, and though there was everywhere evidence of the presence of the first brood, none of the second were seen. During the same period Miss Soule was watching in northern Vermont, and Mr. Fiske took an extended trip through central New Hampshire. But save for the single colony mentioned, all our looking did not reveal a trace of the second brood. Nor was there a single complaint from correspondents of injury at the supposed time of the second brood, although many accounts of the depredations of the first brood were received.

FIG. 80. — The Spiny Elm Caterpillars.

In view of all this evidence, it seems safe to conclude that in northern and central New England, at least, a single brood is the rule rather than the exception. This involves the conclusion that the butterflies seen upon the wing early in autumn are the same ones that developed in July, and that these same butterflies remain alive through the winter and until, in the following May, they lay their eggs. Thus there is a

period of ten months of existence in the butterfly state, an extraordinary length of time for a butterfly to live.

To a large extent the butterflies disappear in August, and the question arises as to what becomes of them. Our observations lead to the conclusion that they go into summer quarters similar to those which they seek out for winter shelter. Apparently they fly about for a few days after coming from the chrysalis and then retire to cool woods, where under the side of a log or beneath the loose bark of a dead tree they settle down and to all appearances go to sleep. The instinct to remain quiet is very strong in these butterflies. In taking the accompanying photographs, I found that even shortly after coming from the chrysalis the butterflies when disturbed would fold their wings with the antennæ between them, and drawing the legs against the body would lie quietly on their sides for a long time; the position thus assumed by the living butterfly is shown on page 71. These same butterflies would also hang downward from a limb by the hour in the hibernating position as shown in Figure 82.

Fig. 81. — Butterfly in Resting Position.

In the cooler weather of early autumn, the butterflies come from their retreats and fly about in the sunshine. They are especially likely to be seen along the borders of woods or in open glades. At this time they love the sunshine, and will settle in a sunny place to bask in it.

On a springlike day early in November (the 8th) I came across one of these butterflies basking in the sunshine upon the ties of a railway track. It rested with its

wings wide open. On being disturbed, it would fly a short distance and then alight, and I was interested to notice that after alighting it would always turn about until the hind end of its body pointed in the direction of the sun, so that the sun's rays struck its wings and body nearly at right angles. I repeatedly observed this habit of getting into the position in which the most benefit from the sunshine was received, and it is of interest as

FIG. 82. — Butterfly in Hibernating Position.

showing the extreme delicacy of perception toward the warmth of sunshine which these creatures possess.

During the colder part of the year in bright weather when these butterflies are most often abroad, they commonly hold their wings open when they alight, but during the warmer summer days, they are more likely to rest with the wings closed.

When the warm days no longer tempt them abroad, the mourning-cloak butterflies seek shelter in many sorts of situations, — under loose bark, in hollow trees, under culverts and bridges, in woodpiles, in crevices of

rocks, or alongside logs lying on the ground. In such retreats they remain until the sunshine of spring again calls them forth.

The mourning-cloak butterflies subsist upon a considerable variety of liquid food which they suck through their long tongues. In spring, when they first come from their winter quarters, they visit the stumps of recently cut trees and suck the exuding sap, a habit which they continue whenever opportunity offers. Mr. Fiske has noticed that they commonly sip the sap of maple twigs where the squirrels have gnawed the bark. A little later they visit the willow catkins to suck the nectar secreted by these blossoms, and still later they hover about the delicate blossoms of the mayflower, or trailing arbutus, for a similar purpose. Probably many other flowers are thus rifled of their sweets, although this butterfly seems to be a less regular visitor to flowers than are many of its allies. A little later, when the aphides, or plant-lice, have become sufficiently abundant so that the so-called "honey dew" is to be found upon the infested shrubs, these mourning-cloaks sometimes sip the liquid sweet from the surface of the leaves. In April and May they occasionally visit the flowers of moosewood, and later in the season have been observed upon the blossoms of the common milkweed. From the time the early apples ripen these butterflies may often be seen beneath the orchard trees, sipping the liquids of the fallen and decaying fruit.

In Germany this butterfly is called *Trauermantel*, from the translation of which is derived the common American name, mourning-cloak. Its other common name with us, Antiopa butterfly, is derived from its Latin name, *Vanessa antiopa*. In England it is called the Camber-

well Beauty, from its having been found at an early date at or near Camberwell. A still earlier title adopted for it in England was "The Grand Surprise," given by butterfly collectors because at the beginning of the century, after a long absence, it appeared in considerable numbers.

In most books upon insects the technical name of this butterfly is given as *Vanessa antiopa.* In his recent writings Mr. S. H. Scudder has called it *Euvanessa antiopa*, although in one of his earlier books he called it *Papilio antiopa.* Questions of nomenclature, however, need no consideration in this connection, and I mention these names only for the guidance of any reader that may wish to study what has been printed about the species.

During the earlier years of our country's history many people regarded these caterpillars as "venomous and capable of inflicting dangerous wounds." Dr. T. W. Harris states that he had known people to cut down poplar trees around dwellings to prevent the presence of such dangerous caterpillars. But these insects are not poisonous, and may be handled with little fear of injury, although the sharp spines might perhaps penetrate the delicate skin of a child's hand.

The mourning-cloak butterfly is one of the most widely distributed insects in existence. Not only is it found in North America as far south as Bermuda, Florida, and Mexico, but it is also found throughout northern Europe, and in Asia and Japan. Consequently, as Mr. Scudder has said, it appears to be distributed "over the entire breadth of the northern hemisphere, below the Arctic circle as far south as the thirtieth parallel of latitude." This is an extraordinary distribution for an insect, and shows a remarkable power of adaptation to

the varying surroundings in which the species occurs. In the northern United States this is one of the commonest and most familiar butterflies.

As a rule, the caterpillars of the mourning-cloak butterflies are to be found only in occasional colonies, so that the damage they do attracts little if any attention. But sometimes the weather or other conditions are so favourable to their development that they multiply beyond this normal limit and are to be found in great numbers. At such times serious damage is often done. In this country such local outbreaks of the species have frequently occurred, generally, however, over very limited areas. So far as I can learn, the insect has never caused such widespread destruction as the forest tent caterpillar has recently caused in New England. In the tree plantations of the prairie regions of the West, these caterpillars are, according to Professor Otto Lugger, "very injurious, and sometimes denude whole rows of willows and poplars." The same observer adds, "They are still more fond of the leaves of elms, and I have seen them so numerous upon those trees in Michigan that branches were broken by their weight." In other regions of the West similar records have been made.

Like most other insects, the mourning-cloak butterflies have many natural enemies to contend against. From the moment the egg is laid until the butterfly dies, it is in constant danger.

Some of the eggs never hatch into caterpillars because a tiny fly, scarcely one-twentieth of an inch in length, finds the egg mass, and deposits in each egg another egg, the latter being microscopic in size. This tiny egg soon hatches into a maggot almost equally tiny, and the maggot grows by absorbing the contents of the

butterfly egg. In due time it changes to a minute pupa, later to a minute fly, like the one that laid the microscopic egg. This minute fly now gnaws a hole through the egg-shell of the butterfly and comes out into the world. The little creature that has thus developed at the expense of the egg of the butterfly is called an egg parasite. There are many species of these egg parasites, and they attack the eggs of many kinds of insects. The particular species that develops in the eggs of the mourning-cloak butterfly is called by scientists *Telenomus graptæ*. An account of the way in which these little flies oviposit in the Antiopa eggs will be found farther on in this book.

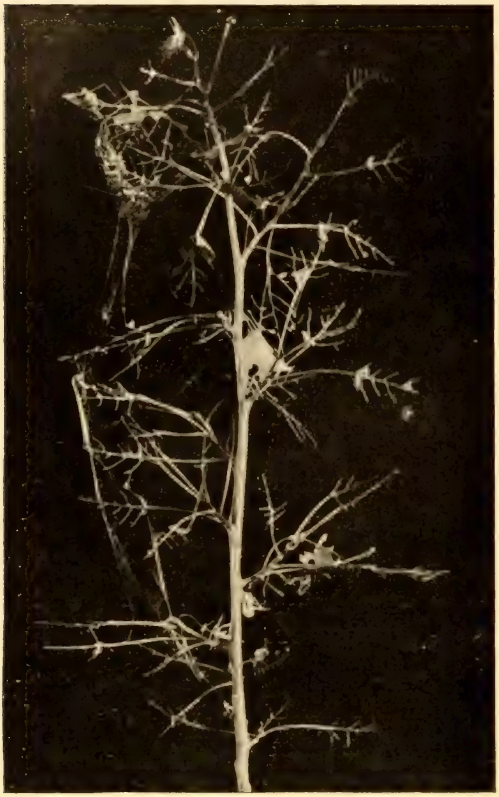


FIG. 83. — Poplar Twig defoliated by Antiopa Caterpillars.

After hatching from the egg, the caterpillars are subject to the attacks of various parasites. One of these is quite minute, not a great deal larger than the egg parasite. It is a tiny four-winged fly which deposits

many eggs in a single caterpillar. The eggs hatch into tiny maggots that grow at the expense of the caterpillar, finally killing it and changing to four-winged flies again. As many as 145 of these parasites have been known to emerge from a single dead caterpillar. These little flies are called *Chalcids* by entomologists.

There is still another group of four-winged flies, some of which attack the Antiopa caterpillars. These are much larger than the Chalcid flies and are called *Ichneumon-flies*. In the case of these, only one or two parasites develop in each caterpillar or chrysalis.

In addition to these various four-winged flies, there are certain two-winged flies, called *Tachinid Flies*, that develop at the expense of the caterpillars. In New Hampshire, during recent years, these appear to have been the most abundant parasites of these insects. An egg is laid on the skin of the caterpillar by a two-winged fly, similar in general appearance to Figure 85. The contents of this egg shortly develop into a tiny grub that burrows through the egg-shell and the skin of the caterpillar into the inside of the body. Here it remains absorbing the body substance of its host and gradually increasing in size. In a few weeks it becomes fully developed in this grub state. By this time the caterpillar has become sluggish from the effects of the parasite. If the branch upon which it feeds is disturbed, the other caterpillars are likely to crawl away, but it remains in its place. The caterpillars illustrated on the web in Figure 84 were parasitized specimens that thus remained after the others had crawled away.

Shortly after becoming full grown, the Tachinid grub breaks through the skin of the dying caterpillar and, falling to the ground, changes to a peculiar pupa; the outer

skin of the grub turns brown and becomes hard, forming a protective covering for the body inside. A week or two later the insect undergoes another change and emerges as a two-winged Tachinid fly, like the one that laid the egg some weeks before.

FIG. 84. — Parasitized Caterpillars remaining on Twig after Healthy Ones have left.

Besides those insects that develop on the inside of the bodies of these Antiopa caterpillars, called parasites, there are other insect enemies which attack them from the outside and devour them bodily. The most notable of these, perhaps, is a large beetle commonly called the *Caterpillar Hunter;* it is known to entomologists as *Calosoma scrutator.* This is a very active insect, with large strong jaws, that runs rapidly about in search of victims. In some cases it has been observed while destroying many of the Antiopa larvæ.

FIG. 85. — Tachinid Parasite. (Slightly magnified.)

In the Southern states a common reddish wasp — a species of *Polistes* — has been also observed attacking these caterpillars, and there are probably various other insects that destroy

them, although definite observations showing this have not been recorded.

The Antiopa caterpillars are such spiny creatures that comparatively few birds attack them. They are devoured, however, by the two species of cuckoos,— the yellow-billed and the black-billed,— and it is probable that they are sometimes killed by Baltimore orioles and various other birds. They are also greedily devoured by toads, but of course they do not often come within the reach of these useful animals.

Fig. 86. — Butterfly attacked by Maryland Yellowthroat.

Even the adult butterflies of this species have to be on the lookout for enemies. During the long months of their life many of them probably succumb to the attacks of birds or other creatures. I have seen but one such tragedy. While riding along a country highway with a bird-loving friend one spring day we saw a male Maryland yellow-throat flit by with a mourning-cloak in his mouth. The bird lit on a fence, from which I startled him so that he dropped the butterfly, a worn and faded, half-dead specimen that I photographed, and show in Figure 86. The places where the bird held the insect are probably indicated by the missing pieces of the wing.

In general, the most satisfactory remedy for these caterpillars is to cut off while they are still young the branch on which they are feeding, and crush or burn the

insects. After they become larger they may be shaken off and crushed. Or the colonies may be brought down with a torch, care being taken to kill the caterpillars that fall to the ground, as probably many of them will not be seriously injured by the flame. Jarring the limbs with a padded mallet will also be a useful way of bringing down those out of reach; or they may be brought down by use of a strong stream of water from a force pump or hydrant. They are also open to destruction through spraying with arsenate of lead or other forms of arsenical poisons.

FIG. 87. — Empty Chrysalis.

An interesting exhibition of popular ignorance occurred during a recent outbreak of these caterpillars when many owners of shade trees in a New England city applied bands of various sorts to the trunks of the trees to prevent the injury. Presumably this was done on the theory that as bands are successfully employed against canker-worms, they are equally good against other caterpillars. In the case of canker-worms, however, the female moth which lays the eggs is wingless, so that the bands prevent her from ascending the trees. But with the spiny elm caterpillar the parent insect that lays the eggs is a butterfly which can easily fly to the tops of the tallest trees. The eggs are deposited on the twigs by these butterflies, and the caterpillars remain in the close neighbourhood of the place where they hatch until they are full grown. Consequently, any banding of the tree is a waste of energy so far as this insect is concerned.

LOCUST MUMMIES.

Last autumn one could easily find a great many dead locusts attached to fences, the bark of trees, the sides of buildings, and in other elevated situations. Although dead they appeared to be alive, and it was only by touching them that one discovered that they were not only dead but so dry and brittle that they easily broke apart. Sometimes I found one just alive, so that when touched it would move a leg or an antenna, but was unable to jump away.

These grasshoppers were nearly all of one species — the large Carolina Locust[1] which was unusually abundant last summer. This insect is especially common along roadsides and in open grasslands near houses. It is the one most generally "flushed" as you walk along the country highway; at such times it flies rapidly in a more or less irregular, zigzag fashion, and generally alights a rod or two in front of you. When flying, its black under wings, with their cream-coloured borders, are very conspicuous; but the moment it alights, these disappear, being covered by the dusty-brown wing covers, which so blend with the soil that the insect is difficult to observe until it flies again.

The dead grasshoppers clinging to the trunks of trees and other things were generally dry and brittle. By

[1] *Dissosteira carolina.*

breaking them apart one could see that the body was more or less filled with a whitish substance which apparently had absorbed all the living tissues. It was because of the mummifying effect of this white material that the insects clung to their support so tenaciously long after they were dead.

These grasshoppers were the victims of a parasitic plant that had invaded their tissues and destroyed their lives. This plant is a fungus which reproduces by means of minute spores, so light as to float in the air, and so small as singly to be invisible to our unaided eyes. When one of these chances to fall upon a grasshopper, especially if moisture be present, it is likely to germinate by sending out a little tube. Should the spore be beside one of the spiracles or breathing pores of the insect, it would probably enter the body through this tiny opening. When it gets inside it continues to grow rather rapidly, absorbing the tissues and penetrating most parts of the body. The result is that the grasshopper is soon killed and its body mummified.

It is a curious fact that locusts affected by this strange disease are impelled to climb as high up in the world as they can get. Sometimes they will reach a position eight or ten feet from the ground. They very commonly crawl up the stalks of grasses and various herbaceous plants, especially goldenrod, as may be seen in the pictures herewith. Once one was brought me clinging to the fair white petals of a beautiful Blanche Burpee sweet pea; it was so striking a situation that I made the photograph which is reproduced in Figure 88.

The bodies of these mummified locusts are generally broken up by wind and rain before winter sets in. Late in autumn you will find them still clinging to their various

supports, but with many of them parts of the body are gone. The first storm of sleet and ice, however, generally breaks off such specimens, so that in winter you can seldom find any of the mummies in the places that knew them before.

Under favouring conditions of warmth and moisture, the fungus in these dead locusts will develop a crop of

FIG. 88. — Dead Locust clinging to Sweet Pea.

spores that will cover the insects with what looks like a fine white mould. It is by means of these that the disease is propagated.

These parasitic plants play an important part in the great drama that is sometimes called the *Balance of Nature*. Every species of animal tends to multiply to

an extent that would crowd the others out of existence. To counteract this tendency there are a host of agencies. In the world of insects, for example, species is set over against species in such a way that under natural conditions it seldom happens that one kind becomes overwhelmingly abundant. And when this happens Nature calls to her aid these parasitic plants which commonly make short work of the offending individuals.

FIG. 89. — Dead Locust clinging to Goldenrod.

Aside from the Bacteria, the most important plant parasites of insects belong to a group called *Entomophthoreæ* by the botanists. Most of them belong to the genus Empusa. In their structure these plants are allied to the moulds, but nearly all of them have the striking peculiarity that they can develop only upon certain forms of living insects. Every one has seen the Empusa that attacks the common house-fly; it is this plant that causes the dead fly to adhere to the walls and window-panes; the halo of white powder that commonly surrounds the insect consists of the reproductive spores of the fungus.

A striking illustration of man's indebtedness to these Empusæ in keeping in check outbreaks of injurious insects has lately been seen in Maryland, Delaware, and other North Atlantic states. In many regions in this

territory the growing of peas for canning is an important industry. Until lately there has been very little difficulty in raising the crop, few insects having become troublesome to the plant. In 1899, however, a plant-louse, or aphis, appeared suddenly on the vines over a large area, and soon destroyed much of the crop. In 1900 the attack was repeated with results that were almost equally disastrous.

Fig. 90. — Dead Locust clinging to Grass.

Even the entomologists at first were puzzled to determine where such enormous numbers of the plant-lice came from so suddenly. For some time it was supposed to be an undescribed species; it belonged to the genus Nectarophora, and the specific name *destructor* was proposed for it. It was later found, however, to be a species long known in Europe as *Nectarophora pisi*, and the careful studies of several official entomologists soon showed that the pests came to the peas from the surrounding clover fields, where they had probably been breeding unnoticed for many years.

In 1900 these aphides were suddenly checked during June by an outbreak of a fungous disease caused by *Empusa aphidis*. After its appearance in the infested fields this fungus spread from host to host very rapidly, and finally killed almost all of the plant-lice. This fact led to the suggestion that probably this disease usually keeps the pests in

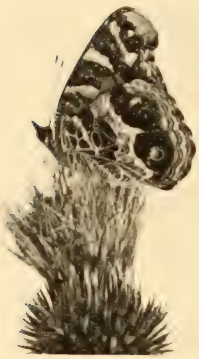
check, and that the reason there had been so serious an outbreak was because the weather conditions had been unfavourable to the spread of the disease, and consequently favourable to the unlimited multiplication of the insects. Professor E. Dwight Sanderson, of the Delaware State College, has stated the conditions observed in the following paragraph: —

"The chief natural factor in the control of the pest seems to be the fungous disease *Empusa aphidis*. The growth of this fungus requires slightly warm, wet weather, and is prevented by drought. April, May, and June of 1899, in Delaware, Maryland, and New Jersey, were altogether the driest for the past ten years, and with local exceptions this was true throughout the Atlantic Coast, Ohio Valley, and Lake Region. Following this, April and May of 1900 were almost equally dry, though in June the rainfall was much above the normal. In 1899 the fungus did not destroy any considerable number of the lice until about June 18, and from all accounts their destruction was most largely due to predaceous insects. In 1900 the disease appeared much earlier, destroyed large numbers of the lice, and their disappearance by the 18th of June was mostly due to it. In 1890 the lice were destroyed by this disease at Newark, Del., on clover by May 12. The rainfall of May, 1890, was above the normal at Newark, and the preceding winter was an unusually mild one, seemingly corroborating the view that a wet spring is favourable to the development of the fungus, which destroys the aphids on the clover and prevents them from becoming numerous enough to spread to peas."

It is the frequent recurrence of such experiences as this that convinces the entomologist that he ought to

have the fullest possible knowledge of the life-history and enemies of every species of insect, whether it may have at present any apparent economic importance or not. And so he is always making observations on as many of the insects of his region as he is able, knowing that all such knowledge has real value, and may at any time become of great practical importance.

CATCHING BUTTERFLIES WITH A CAMERA.



To paraphrase a famous saying in regard to hare stew: If you would catch butterflies with a camera, you should first get your caterpillars. For though caterpillars are not butterflies, they are butterflies in the making, and they will show you most interesting stages in Nature's manufacture of these dainty and exquisite creatures. This, however, is not my chief reason for giving the advice. You doubtless desire to make perfect pictures; and a perfect picture of a butterfly should show colour values and the details of structure — a result that is not to be obtained by the process of pressing the button. It is rather to be secured by a long exposure through a colour screen and a small diaphragm opening in a room where the light is not too bright.

FIG. 91. — The Painted Beauty Butterfly.

To make a picture under these conditions you must have a docile subject, and the butterfly afield is not a docile subject. You are fortunate if out of doors you get a snap-shot in focus,

and when you bring these day-fliers indoors, they will be attracted to the window as certainly as their cousins, the night-fliers, are attracted by a light. Under such conditions sweets and flowers are unavailing to hold their attention; the sunshine in the window is always calling.

But fortunately for the photographer, there is one brief period in a butterfly's life when it is so docile that it will pose for five minutes at a time. This is the period soon after it emerges from the chrysalis, when its wings are fully developed, but before they have hardened and become strong enough for flight. At this time the butterfly is perfect — every scale in its place, every spot of colour at its best; like a bride arrayed for the wedding, the beautiful creature is in the first flush of its perfection. And it will rest quietly upon a flower, a leaf, or a twig while you adjust the camera and expose the plate.

Fig. 92. — Caterpillar feeding on Everlasting.

Many people think that for indoor photography a studio with light from above is necessary. But for still life — such as flowers and butterflies — light from a side window can be used to equal, if not greater, advantage. In such pictures you want roundness and detail rather than flatness and lack of detail. The side light will give roundness, the degree of shadow being easily regulated

by white cardboard reflectors, and the long exposure will give the detail. In a room lighted by only side windows the accompanying pictures were taken, through a bichromate of potash colour screen and the smallest of diaphragm openings. The exposure varied from three to five minutes, the plates being orthochromatic and slow, or medium in sensitiveness.

FIG. 93. — Caterpillar Ready to Pupate.

FIG. 94. — The Chrysalis.

The larger butterflies are among the most interesting subjects for the would-be photographer of insects. It is a comparatively easy matter to get a set of pictures representing the life-stages of one of these creatures, if you are willing to devote to it the necessary time and attention. Suppose you wish to illustrate the life-history of the beautiful hunter's butterfly, which is also called the *Painted Beauty*. The caterpillars of this insect may be

found on the leaves and among the blossom heads of the common tall everlasting, a plant of the genus Gnaphalium. These caterpillars have the peculiar habit of making protective cases by gnawing off the woolly hairs of the food-plant and binding them together by silken threads. Within or beneath these cases the larvæ remain, feeding upon the substance of the leaves.

As the caterpillars approach maturity, they generally web together the upper leaves and the flower heads to make a sort of airy cell, in the middle of which they remain until full grown. Many of them at this time seem to care less for concealment than they did earlier, as their cottony coverings are more open.

Fig. 95. — Newly Emerged Butterfly.

When the caterpillar finally becomes full fed, it spins a mass of silk against the upper part of its cell, in which it entangles its hind legs and lets itself hang downward as shown in Figure 93. In a short time it wriggles off its caterpillar skin and hangs in the cell as a pupa (Fig. 94), where it remains unchanged for about a fortnight. Then the pupa skin splits open, the butterfly drops out, and

catches hold of the mass of leaves and blossoms with its legs, its body and the undeveloped wings hanging downward. In the course of the next half hour the wings expand until they are full size, the front pair being enclosed by the hind pair, as may be seen in Figure 95. Before long the unused muscles acquire more strength and the newly fledged butterfly walks to the top of the flowers, where it rests quietly for half an hour or so. It is now very docile and in an excellent mood for gratifying the whims of the photographer. Though it cannot always be depended upon to remain two or three minutes in a given position for you to get an exposure through the colour screen, it will do so often enough for a high average of good pictures. But it will not hold its wings open for you, coax it as you may.

FIG. 96. — Preparing to fly.

After about an hour of such rest the butterfly is likely to begin moving its wings, slowly opening and closing them to get the untried muscles ready for flight. Then the light of the window will prove too attractive for

longer quietude. After this you may succeed in getting a few good pictures, but the best mood of your model has passed.

FIG. 97. — Visiting an Aster.

There are many other butterflies that will lend themselves in a similar way to the uses of the photographer. The common mourning-cloak or Antiopa butterfly is a particularly docile subject, as is also the beautiful monarch butterfly. With those species that hibernate as adults, some attitudes will be held for a long time, even after the butterflies have moved about for a while. This appears to be an instinctive trait, due probably to the fact that in hibernation they remain quiet for months.

FIG. 98. — The Mourning-cloak Butterfly.

AN INSECT POTTER.

In the vast number of insects that live in the world a great variation is to be found in the manner of existence. As one studies these creatures he is led more and more to wonder at the marvellous contrivances and adaptations by means of which many of them are enabled to live. Even in a single group, such as that of the wasps, there is great diversity of habit: many wasps live in colonies in paper nests with which most people are familiar; others dig holes in the ground and live there; others take advantage of hollow stems in shrubs and herbaceous plants, and a few even build miniature houses on the outside of the stems of plants.

Among the insects that have the habit last mentioned perhaps none is of greater interest than the Fraternal Potter Wasp, called by the entomologists *Eumenes fraterna.* This is a pretty little thread-waisted insect, black except for creamy yellow markings on the body in the places shown in accompanying pictures. When straightened out, it is about three-fourths of an inch long.

These wasps are of special interest because they build the little earthen houses shown also in the picture. Selecting some small stem, preferably one having thorns upon it, the mother wasp brings tiny loads of sandy soil

which she cements together with her saliva, gradually building up a hollow earthen cell, nearly round, and about half an inch in diameter. Often the shape when completed is suggestive of a flattened jug, without a handle, but with a slight projection where the mouth of the jug would be; this is well shown in the lower cell in one of the pictures (Fig. 100).

FIG. 99. — Two Eumenes and the Cells from which they developed.

For what purpose does the little potter toil so diligently? For the same purpose that makes the lives of so many adult insects a round of ceaseless activity — that of providing for the young. When the cell is nearly finished, the wasp searches the leaves of trees and other plants for small caterpillars which after being paralyzed by stinging are brought to the little house upon the thorny twig. When enough of these are found, an egg is laid in the cell which is then sealed up.

In the case of some species the egg is hung from the top of the cell on the end of a tiny silken thread. When it hatches, the larva holds on to the empty egg-shell and reaches out to feed upon the caterpillars stored so abundantly just below.

The larva that thus feeds upon the caterpillars, placed in the cell by the provident mother, lives in darkness and alone except for the paralyzed caterpillars that await its devouring jaws. In due time it becomes full grown

in this larval stage, having eaten all the victims immured within its earthen house; then it changes to a quiet pupa, which shortly afterward transforms to an adult wasp that gnaws a hole through the side of the house and comes forth to build more houses, and provide for the next generation.

FIG. 100. — Eumenes and Cells.

Most of the wasps that build earthen cells for the development of their young place them in such shelter that they are protected from the rain. But this Eumenes, like the other species of the genus, builds habitually in exposed situations, commonly on plant stems, sometimes on rocks. Yet these houses of mud are unaffected by the rain that one would think might cause them to crumble. If you look at the cell through a lens, you see that it is composed of a great number of tiny pebbles, mostly quartz, cemented solidly together.

We owe much of our knowledge of the habits of Eumenes to the French entomologist, J. H. Fabre, whose *Souvenirs Entomologiques* have well been called "the most interesting and delightful of all entomological papers."[1] It was he who showed that the mother wasp obtains her cement for the walls of her house by selecting

[1] George W. and Elizabeth G. Peckham. Instincts and Habits of the Solitary Wasps. Preface.

particles of very dry dust and mixing it with her saliva. She thus forms a mortar that hardens quickly and holds firmly, despite the bluster of rain and wind.

Fabre's account of his discovery of the hanging egg and its subsequent larva is of such interest that I quote it in a free translation. Before he discovered how the Eumenes larva fed, he had made many unsuccessful attempts to rear it. He finally concluded that there must be some way in which the insect was kept out of the reach of the writhing mass of its victims.

"I had an ardent desire," writes Fabre, "to learn of the stratagem employed by the larva. I would not be rebuffed by the rarity of the nests, the pain of investigation, the heat of the sun, or the vain fracture of empty cells: I would see and I have seen. And my method was this: I made, with knife and forceps, a side window in the dome of the cell. Great care is necessary in order not to injure the occupant. When the opening is large enough to see the interior, I stop. And I found this condition: the egg is not deposited on the food; it is suspended from the dome by a thread, as fine as that of a spider's web. The delicate cylindrical egg vibrates at the least breath. It reminds me of the famous pendulum suspended from the dome of the Pantheon to demonstrate the earth's rotation. In a heap below is the living food.

"By opening a window in another cell we can see the second act in this marvellous drama. The larva we find is already growing. Like the egg, it hangs suspended, attached to the thread by the hind part of its body. But the thread is longer; in addition to the slender filament that held the egg there is a sort of ribbon. The larva is feeding; with lowered head it is devouring one of the

caterpillars. I touch another of the waiting victims with a spear of grass. It moves, as do its neighbours, and the Eumenes larva instantly withdraws from the mêlée. But how? To my surprise I find that what I took for a bit of flat ribbon attached to the thread, is a sheath, a scabbard, into which the larva retreats. And this is simply the empty egg-shell, transformed into a refuge for the larva when the writhing caterpillars below become dangerous."

When the larva becomes larger, it leaves the suspended shelter and feeds at will among the paralyzed caterpillars. And thus it is able to complete its growth and become a mature wasp to continue the propagation of the species by means of the strange set of instincts that have been developed through long ages of existence.

THE CAMERA AND THE ENTOMOLOGIST.

THE camera is like the human eye: it sees whatever its owner is interested in. If he love beautiful landscapes, it gives him pictures of them; if he love the fleecy clouds, it brings them down to him; if he love children and happy human faces, it gives them to him for his lifelong delight; if he love the birds, it transfixes them in their flight, yet leaves them to soar in the air unharmed. So it is not strange that every one nowadays must have a camera to enrich life and to give permanent record to its transitory phases.

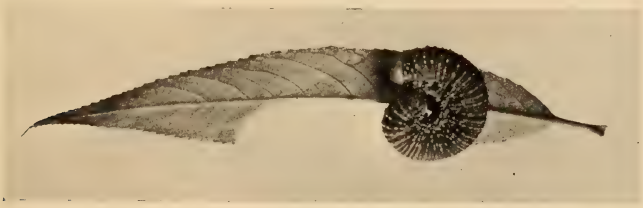


FIG. 101. — Larva of the Willow Saw-fly.

To the student of the teeming insect life that fills the outer world with such marvellous organisms, the camera may become of inestimable value. It enables him to picture phases of their existence so evanescent that it is hopeless to attempt to get accurate drawings of them, while it furnishes pictures in many ways more satis-

factory than the best of artists can make. It is always available, and there is comparatively little trouble in taking the pictures. Not every one can go a-birding with the camera, but most people who so desire can go a-bugging with it. And if the "bugs" are gorgeous butterflies or regal moths, the result both as to beauty and interest is not to be despised.

Fig. 102. — A Crane-fly.

Theoretically, the way to catch insects with a camera is to take it into the field with you and expose upon them as they rest upon the leaves or flit from flower to flower. This is entirely feasible, and many good pictures may thus be obtained. Such exposures, however, must be very short, and there are many things to interfere with getting the best results. While some phases of insect life — the flight of a swarm of butterflies, for example — are only to be taken by such outdoor exposures, more satisfactory results are to be obtained in the great majority of cases by bringing the insects to the studio where you can better control the conditions of exposure. The principal advantages you

thus have are the control of the light both as to intensity and direction, and the ability to use a satisfactory background. You also are thus able to rear the insect through the different stages of its life, and to get pictures of each phase of existence of the same individual.

FIG. 103. — Larva of the Polyphemus Moth.

Many successful photographs of insects have been taken by professional entomologists in insectaries that practically are simply glass houses, with strong light coming from all directions. In such situations the exposures are very short, and it is comparatively easy to get pictures of insects in all stages. The light effects, however, are usually flat, and the details of structure are frequently lacking. I greatly prefer a very different sort of a studio, and have taken most of my pictures in a basement room lighted only from one side by comparatively small windows, so curtained that the light is easily controlled. This, of course, involves longer exposures, which in turn give greater detail and much more satisfactory results. One great advantage of the

side windows is that the light effects are rounded rather than flat, so that the form of the insect or plant is more distinctly brought out.

There is also a decided advantage in utilizing a basement room, or, at least, one near the ground, especially in a building in which there are other occupants. The slightest movement of the specimens before the camera spoils the picture, and I have found that even on the second floor of a solid brick building the slamming of a door often caused such a jar as to set the leaves of a plant in motion. Under the most favourable conditions there are always enough chances of failure, so that one does not care to run this additional risk.

FIG. 104. — Larva of the Io Moth.

The length of exposure will depend, of course, directly upon the light at the time. I should prefer a room facing the north, where the light does not fluctuate so greatly through the changing position of the sun, but as yet I have had to be content with a room facing the east. From 9 A.M. to 1 P.M. the light in this room is quite sat-

isfactory, varying somewhat from hour to hour. The average exposure through the smallest stop and without the colour screen is about forty-five seconds. With the colour screen which is almost indispensable for red and red-brown tints, the exposure must be about five times as long. The best colour screen seems to be the ray filter, which contains a solution of bichromate of potash, and with which satisfactory pictures may be obtained of such difficult colours as the reds and browns of many butterflies. In my experience there has been no great advantage in using this screen on yellow, green, or whitish tints, while, of course, there is the obvious disadvantage of the longer exposure.

Fig. 105.—Caterpillar of Troilus Butterfly.

It is comparatively easy to get good photographs of the leaf-feeding caterpillars. Many of them feed mostly at night, resting by day in various characteristic attitudes. At such times they remain quiet for hours, so that one can focus and expose upon them indefinitely. Consequently pictures showing excellently the details of their structure may be taken; examples may be seen in the larvæ of the Polyphemus moth, the Io moth, and the willow saw-fly. By placing the caterpillars upon a plate of glass against a black background, one may get such pictures as that of the larva of the Troilus butterfly.

Many species of caterpillars construct for themselves habitations of various kinds. Like the nests of birds, however, these domiciles are exceedingly difficult to depict satisfactorily by any other method than that of

photography. They are generally made of very minute silken threads, the effect of which any line of pen or pencil fails to portray. But, under favourable conditions, perfect pictures may easily be obtained with the camera. Numerous examples of these may be found in the pictures of the nests of the American tent caterpillar and the cherry tent-maker in earlier pages of this book, as well as in the accompanying photograph of the web of the fall web-worm. In the original photographs one can see distinctly the different layers of silk of which the nests are composed.

Fig. 106. — Web of Fall Web-worms upon an Apple Twig.

All of these three last-mentioned insects are builders of communal homes, but there are large numbers of caterpillars that live singly rather than in colonies, and these also often construct protections for themselves. The camera portrays such domiciles in a very satisfactory manner. For example, the larva of the beautiful Atalanta butterfly lives in nettle leaves, the edges of which it rolls up and binds

together by silken threads. Such a leaf, as well as one that has been opened to reveal the spiny caterpillar, is shown in Figures 107 and 108.

FIG. 107. — Leaf Case of Atalanta Caterpillar.

The peculiar plant growths called *galls* are among the most interesting products of insect energy. These are of many forms, and often of very curious structure. They are generally brought about in this way: an egg is laid on or in the tissue of a leaf or bud; it shortly hatches into a tiny larva which feeds upon the surrounding tissue, and by its presence causes the plant to develop an abnormal growth.

FIG. 108. — Leaf Case opened to show Caterpillar.

The strange thing about galls is that each species of insect causes a peculiar and characteristic gall, so that on a single oak tree there may be a dozen sorts of galls, entirely distinct in appearance, each inhabited by a different sort of an insect. In due time the larva within the gall becomes full grown; then it changes to a pupa, and later again to an

adult. Very often there are multiple galls, each containing many insects.

Galls are often so complex in structure that it is difficult to get satisfactory drawings of them. But this fact need not trouble the entomologist who uses the camera. An example of these galls may be seen in the picture of the multiple goldenrod gall.

Fig. 109. — Multiple Goldenrod Gall.

In the case of many plant-feeding insects the injury done has well-marked characteristics which enable the entomologist to tell at once what species was at work, long after the depredators have disappeared. As a rule, it is difficult to represent such injuries by drawing or painting in a way that will enable one to identify them, but with the camera this is easily done. Take for example the two pictures of the apple leaves shown in Figures 110 and 111; these illustrate the work of the fall web-worm, the insect whose tent is shown in Figure 106. These caterpillars commonly build unsightly nests on the leaves and branches of a great variety of fruit and shade trees. When young they feed

only upon the green surface of the leaf, leaving such a network of veins as is shown in Figure 110, but when nearly full grown, they devour more of the leaf substance, eating out the smaller veinlets, but leaving the larger ones as shown in Figure 111. Now these are interesting and important phases of the life-history of this insect, and it is of a decided gain to be able to illustrate them so vividly when one wishes to monograph the species. Such a picture as Figure 112 also illustrates the same point: near the centre of the leaf, at the right of the midrib, is seen the remnants of a cluster of minute eggs, laid there by a good-sized moth. In due season these eggs hatched into tiny caterpillars that ate the green surface of the leaf from day to day; their feeding grounds are readily seen on each side of the egg-shells. But after feeding thus for a week, they migrated to new pastures on other leaves, their work remaining as mute testimony to their presence.

Fig. 110. — Apple Leaf denuded by Fall Web-worms.

Another sort of injury to oak leaves is shown in Figure 113, which illustrates the work of a small caterpillar that sews together adjacent leaves and then feeds within the shelter thus made. Sometimes this insect becomes

so abundant as to sew up a large proportion of the leaves.

If I were required to limit my use of the camera to any one phase of insect life, I should choose the transition stages between the larva and the adult. For these stages are so brief that it is difficult to get good drawings of them, and the insect is then in such a condition that it is impracticable to preserve it satisfactorily. But with

FIG. 111. — Apple Leaves eaten by Older Web-worms.

a camera one can focus upon a chrysalis about to disclose the butterfly, and when the insect comes out make a series of exposures that will give excellent pictures to show the curious process of wing development. Examples of this are given in the first two articles in this book.

Attention has already been called, in a preceding article, to the fact that beautiful photographs are to be obtained by taking advantage of the fact that when a

moth or butterfly becomes fully formed after emerging from the chrysalis, it rests quietly for about an hour to enable its tissues to harden preparatory to flight. In addition to the examples already given attention is called

FIG. 112. — Oak Leaf partially denuded by Caterpillars.

to Figures 114 and 115: the former represents the beautiful Cecropia emperor moth, resting upon its cocoon, and the other a back view of the handsome Promethea moth in a similar position, most of the cocoon in this case being hidden by the body of the insect. With most butterflies and moths such a view as this last is rather

difficult to get, as they commonly rest at this time with their wings closed, opening them only for very brief periods.

In attempting to get pictures of adult insects brought to the studio from out of doors, it is best to bring the

FIG. 113. — Oak Leaves sewed together by Caterpillars.

subjects in at least a day before you wish to photograph them, and to surround them with as natural conditions as possible. Thus they become so used to the new environment that they will remain quiet when you make the exposure. Good pictures of katydids and related insects may be often obtained in this way. Some-

times on rainy days you will find various sorts of wasps and bees resting quietly under the shelter of flowers. By careful handling, these may be brought to the studio and pictures of them secured.

FIG. 114. — Cecropia Moth resting on Cocoon.

One of the most successful photographs I have taken of an insect not reared in captivity is the crane-fly, shown in Figure 102, which wandered into the studio of its own accord. This insect looks like a gigantic mosquito; it is common in meadows and near water-courses during summer. Another such picture is shown in Figure 117; this dragon-fly had flown indoors in late autumn,

FIG. 115. — Promethea Moth resting on Cocoon.

having been chilled by the cold, and it was so stupefied that it would rest quietly while its picture was taken.

The camera can also be used to advantage in taking pictures of dead insects, not necessarily the unattractive illustrations of pinned insects, so often seen in entomological

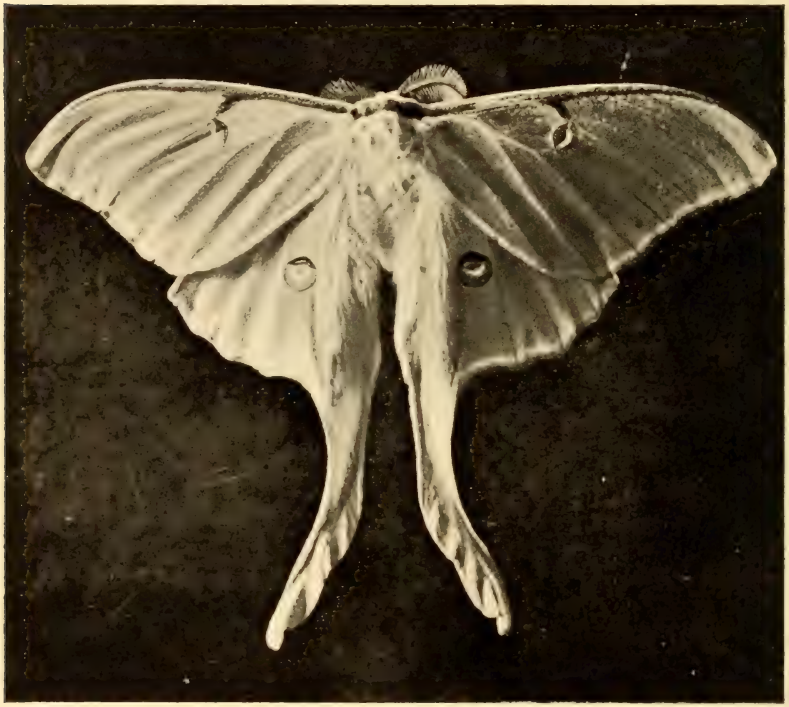


FIG. 116. — The Luna Moth.

bulletins, but rather pictures made from fresh unpinned specimens that similate the living insect. Such a picture of the beautiful Luna moth is shown in Figure 116.

These camera studies of insects require patience and perseverance for the most successful results. It is a comparatively new field of photographic activity, but one

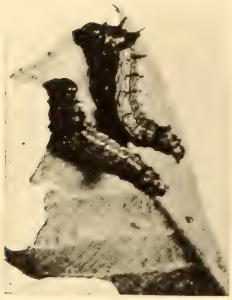
in which the naturalist will be richly rewarded. It seems certain that future books on insects will be illustrated chiefly by means of photographs, so that entomo-

FIG. 117. — A Dragon-fly.

logical literature will have a new and fresher interest to every one who loves even the ephemeral things of the outer world.

STUDIES OF INSECT PARASITES.

A PARASITE OF COLONIAL CATERPILLARS.



One day last summer I found upon an apple leaf a colony of small reddish caterpillars. When not eating, they rested together on the under surface of the leaf; when eating, they congregated along the outside and devoured the margins. The insects were recognized as young specimens of the Red-humped Apple Caterpillar, which, when full grown, is pictured above. They were brought to the laboratory in order to rear them.

Throughout their larval existence these insects remain together in colonies, feeding voraciously upon the foliage and denuding the branch as they proceed. On this account the injury they do is easily noticed, and when noticed the caterpillars are easily destroyed. If they are not destroyed, they descend to the ground when full grown, where

Fig. 118. — Part of Colony of Red-humped Caterpillars.

under leaves or other shelter at or just beneath the soil surface they construct fragile cocoons. In these they pass the winter, maturing the following summer into medium-sized brown and gray moths.

The caterpillars that I brought to the laboratory, however, were destined to have no such life-history. A day or two after I found them I noticed that the leaf on which they were was not being devoured; on looking at its under surface I found that every caterpillar had given place to a small cocoon formed inside its skin and having the head and legs of the larva still in position. It was, indeed, a strange sight; not one of the larvæ had escaped.

Fig. 119. — The Parasitized Colony.

It was easy enough to understand what had happened to my little colony. Sometime before I found them, a small four-winged fly had been among them. Perhaps she had thought herself lucky to find so many victims near together, so that she could dispose of so many eggs without the trouble of hunting out lonely caterpillars. At any rate she deposited an egg in each of the larvæ and then left the colony to its fate. Each egg shortly hatched into a minute maggot that fed upon the fatty tissues of its host, finally leaving nothing but the skin,

and thus reaching the limit of its food-supply. It then spun a cocoon around itself, the outside of the cocoon being consequently covered by the skin of the late host. The lower part of the skin generally splits apart longitudinally so that the cocoon rests upon and is attached to the leaf. Within this cocoon the maggot changes to a pupa, and a little later it again changes to an adult four-winged ichneumon-fly, which is called by entomologists *Limneria fugitiva*.

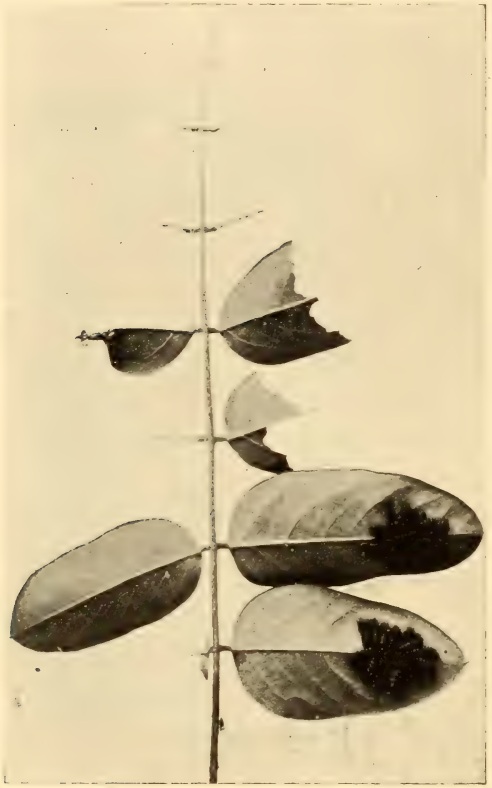


FIG. 120. — Colony of Io Caterpillars upon a Compound Leaf.

In choosing its victims this Limneria by no means confines itself to these red-humped apple caterpillars. Early in the season it very commonly attacks young American tent caterpillars, in the empty skin of which it makes its cocoon in the same manner, while later in the season it attacks the larvæ of the fall web-worm and various other species. It seems to prefer those species that live together in colonies.

The colonies of the larvæ of the Io moth are also attacked by this parasite, notwithstanding the spiny covering of the caterpillars. These Io larvæ feed upon the leaves of quite a variety of trees, shrubs, and herbaceous plants. The larvæ go to and from their feeding places in single-file processions. When not feeding they rest together on the lower side of a leaf in groups of a dozen or more. This habit is well illustrated in Figure 120, which shows a compound leaf on which the caterpillars have been feeding, while the colony has divided itself for resting into two companies of nearly equal numbers that have stationed themselves on two of the whole leaflets that remain. In Figure 121, a similar colony is shown, larger size, upon an apple leaf.

Fig. 121. — Io Caterpillars upon an Apple Leaf.

The habit of thus congregating is probably a help in preventing the attacks of birds, especially in the case of such spiny species as these Io larvæ. But it is a decided advantage to the Limneria parasites. With a colony of young Ios brought to the laboratory on a poplar twig I had just such an experience as I have recorded above in the case of the red-humped caterpillars. The skin of every larva in the Io colony shortly became occupied with a Limneria cocoon, showing that they all contained the parasites when they were found.

These Limneria larvæ do not always have things their own way, however. They are very commonly subject to the attack of another parasite that destroys them as they destroyed their hosts. So it often happens that if you bring in from out of doors a colony of the Limneria cocoons, the adult flies that come from them may be a species of Pimpla instead of Limneria. In this case the Pimpla is said to be a secondary parasite of the original host, that is, it is a parasite of the parasite. And not uncommonly there is a tertiary parasite that destroys the Pimpla larva as it destroyed that of the Limneria.

A PARASITE OF BUTTERFLY EGGS.

One bright May morning while I was walking along a picturesque byway with the Little Lady who helps me to see what is going on, we found a mourning-cloak butterfly in the act of depositing her eggs on a willow twig. She had already deposited about twenty eggs in a circle around the stem, and continued at work as we bent over her in eager observation. We saw a small gray hunting spider wandering around on the wings of the butterfly, apparently without her knowledge, for she paid no attention to him. After about five more eggs had thus been laid the Little Lady's hat brushed against the butterfly, which then flew away. The instant she had gone, we saw a tiny four-winged fly running excitedly about upon the eggs. I was delighted, for I saw that in all probability we were to have a glimpse of another bit of insect domesticity, — not unmixed with tragedy, — and I was not disappointed. For in a few seconds the tiny fly stopped over one of the butterfly eggs, held its body up vertically with its hind legs back

of it, and its other legs straightened out to hold the front of the body high up, and having inserted its tiny ovipositor through the egg, proceeded to deposit an egg of her own inside of the larger egg of the butterfly, that is, I assume that this was what happened, although of course it was impossible to see the smaller egg as it was laid inside the shell of the larger one. While thus engaged the antennæ of the tiny fly were bent directly downward to the egg beneath. In about a minute the fly withdrew its ovipositor, and after running around for a few seconds, again settled down upon another egg and repeated the operation. Soon it tried again on a third egg, and I saw that the domestic scene was likely to be continued for some time. So I quietly cut off the twig without disturbing the little creature, and sat down by the roadside, asking the Little Lady to keep the record that as timekeeper I dictated. This is her record: —

It required	"	94	seconds	to	lay	egg	No.	4.	Then	fly	moved	around	26	seconds.
"	"	120	"	"	"	"	"	5.	"	"	"	"	27	"
"	"	83	"	"	"	"	"	6.	"	"	"	"	20	"
"	"	92	"	"	"	"	"	7.	"	"	"	"	22	"
"	"	75	"	"	"	"	"	8.	"	"	"	"	40	"
"	"	90	"	"	"	"	"	9.	"	"	"	"	42	"
"	"	102	"	"	"	"	"	10.	"	"	"	"	15	"
"	"	120	"	"	"	"	"	11.	"	"	"	"	21	"
"	"	120	"	"	"	"	"	12.	"	"	"	"	18	"
"	"	60	"	"	"	"	"	13.	"	"	"	"	25	"
"	"	120	"	"	"	"	"	14.	"	"	"	"	25	"
"	"	60	"	"	"	"	"	15.	"	"	"	"	50	"

Thus the deposition of these fifteen eggs had occupied something over half an hour. By this time both recorder and observer were tired of sitting in the hot sunshine and we were also afraid the little fly would escape. So I sacrificed her to the cause of science, and later sent her to

Dr. L. O. Howard, the United States entomologist and our greatest authority on these tiny parasites, who kindly identified her as belonging to the species *Telenomus graptæ*, whose life-history was briefly outlined in the article treating of the Antiopa butterfly.

What interested me most in this bit of tragedy was the sudden appearance of the Telenomus fly upon the scene. As already stated, she was running over the eggs the instant the butterfly flew away, and very likely she had been there before and had not been seen because our attention was taken by the butterfly. How did this tiny creature, scarcely as large as a pinhead, happen to be present on that particular twig at that particular time? In the region there were hundreds of thousands of other twigs on which no eggs were being laid. Has the fly a perception of odour so keen that it can detect fresh-laid butterfly eggs at great distances, or does it light upon the body of the butterfly and rest there until she deposits her eggs?

A few weeks later I was in New York attending a meeting of entomologists and related this experience. When I had finished Professor C. W. Woodworth, the entomologist of the University of California, told of a similar experience years before in the White Mountains of New Hampshire. His Telenomus had been seen as mine had, engaged in ovipositing as soon as the eggs were laid.

A MOTH THAT FAILED.

Last October I found a large green Sphinx caterpillar upon the under side of a willow leaf. I put it in a box, thinking to rear it to the beautiful moth into which in the usual course of nature it would change. The box was

left in the carriage over night; when I came to look for the insect the next morning, it had escaped from its prison and was, I supposed, lost. But happening to look in the bottom of the carriage I found my prisoner in a hapless plight. It was resting on the edge of the mat, and was covered and surrounded with a mass of small white oval objects, most of them attached to the caterpillar, but many attached to the board on the bottom of the carriage.

The caterpillar was half dead, without sufficient strength to crawl away from the encompassing cocoons. For these

FIG. 122. — Sphinx Caterpillar with Cocoons of Parasites.

were the cocoons of parasites. The little creatures that made them had come from inside the caterpillar. Their previous history was simply this: one day, a few weeks before, a small black four-winged fly had alighted on the larva, probably as it was resting upon the back of the willow leaf, and had inserted beneath its skin, by means of a sharply pointed ovipositor, a large number of tiny eggs. I suppose that these eggs are deposited one in a place, so that they are scattered about different portions of the body, near the surface, but I have never been so fortunate as to see the fly in the act, nor have I read any record of any one else having done so.

The eggs soon hatch into tiny footless maggots that derive their nourishment from the fatty tissues of their host. They increase gradually in size for a short time. As they approach maturity they have the appearance of Figure 122 *a*. As is the case in general with the early stages of parasitic insects, the structure is very simple. As will be seen there are no signs of legs, the body consisting of segments, growing smaller toward the pointed head, and ending behind in a large rounded joint. The alimentary canal is simply a tube closed at the posterior end. There are no eyes, and the outer skin is uncoloured.

FIG. 122 *a*. — Larva of Microgaster Fly, much magnified (after Leuckart).

When these creatures are full grown in this their larval state, they all leave their unfortunate host at the same time, burrowing through the skin. As soon as they are outside, each begins spinning the delicate silken shroud that serves as cocoon, completing it within a few hours. Inside of these they shortly change to tiny pupæ, and a week or so later again change to four-winged flies. The latter are provided with sharp jaws by means of which each cuts off a lid from the end of the cocoon, and escapes.

The poor, half-dead caterpillar that thus became an unwilling sacrifice, giving up his own existence that a hundred or more lesser creatures might live, finally died and shrivelled up, never becoming the beautiful moth into which it might otherwise have changed.

People frequently bring me small yellow cocoons attached in loose masses to the stems of grasses, clovers,

and other herbaceous plants. Late in summer and early in autumn one may commonly find such masses in pasture fields and meadow-lands. An idea of their appearance may be gained from Figure 123, which represents them slightly magnified.

These cocoons have a history very similar to that of the cocoons upon the sphinx larva just described. The insects within them have developed at the expense of some grass or clover-feeding caterpillar, which they have killed, and then attached their cocoons to the nearest support they could find. Probably the larvæ of the common yellow Philodice butterfly are most frequently thus victimized, but cut-worms, army-worms, and other grass-feeding caterpillars often suffer also.

FIG. 123. — Cocoons of Microgaster Fly.

INSECTS IN WINTER.

One of the truisms of modern biology is that every species of animal exists by virtue of its adaptations to the conditions of its existence. The study of these adaptations forms a large part of the work of the latter-day naturalist, who is led again and again to wonder at the perfection of the adjustments that he discovers between animals and their surroundings.

In northern regions adaptation to climate is one of the most important problems that confronts each species. Those animals that like the birds can migrate quickly to warmer regions easily solve the problem, but those that must remain in one region throughout their lives find the solution more difficult. In the case of many of the insects there are four distinct stages of existence in which the winter may be passed, so there is considerable opportunity for variation as to the method of hibernation that may be chosen, through the action of natural selection, which must take into account not only the cold weather, but also the many enemies abroad during this period. For to these insects death may come at any hour between November and April. His grim messenger may ride on the wings of the wind and carry them far from food, so that if they survive until spring starvation awaits them. Or he may fall with the rain and wash them into pond,

lake, or sea, or come with the snow and bear them away in whitened arms. Or perchance he may choose the winter birds to carry his message, sending destruction through the beak of nuthatch, or woodpecker, or chickadee. And during the periods immediately preceding and following cold weather he may choose to do his errands, the myriad predaceous and parasitic insects that live only at the expense of the lives of unwilling hosts of their own class.

To contend with death in all these forms is no light matter. And were it not that each insect brings to the fray the unconscious wisdom derived from the experience of countless generations of ancestors, it were a hopeless one. But during all the ages each species has been adjusting itself more and more perfectly to its surroundings, increasing its means of protection from the primal elements, perfecting the disguise which conceals it from living enemies, or if these means avail not, increasing its rate of reproduction to such an extent that the 999 may perish and the one continue to propagate the species.

This long-continued struggle for existence has brought about many curious adjustments in the insect world. To our unseeing eyes the hosts of insects abroad during the summer months seem wholly to disappear when winter comes. The question as to where they go is often asked.

If we look about us to see where it is possible for insects to find shelter during winter, we see that at least the following locations are available: in the ground, or under shelter on its surface; in ponds, streams, and other bodies of water; in stumps, logs, and dead wood and plants of all sorts; in or on living trees, shrubs, and smaller plants; in galls; in fruits; and in occasional shelter provided by man for his own service.

Insects may hibernate in each of the four stages of their existence. As a rule, each species passes the winter in but one of these stages, although occasionally an insect will be found hibernating in two or possibly three stages. In general, the hibernating stage is the one in which the insect undergoes the least risk during the winter.

I. THE EGG.

When we consider the small size of the egg as compared with the other stages of an insect's life it would seem that there might be many advantages to the species in hibernating in this condition. And in truth a great many insects do utilize this stage for passing the long months of danger; excellent examples have already been discussed in the two species of tent caterpillars, the cherry tent-maker, and the walking-stick. And apparently the orders Lepidoptera and Orthoptera to which these insects belong contain a larger proportion of common species that hibernate in the egg state than do any of the others, except, perhaps, that of the true bugs — Hemiptera.

Fig. 124. — The Pine Locust, Male, slightly magnified.

In the order Orthoptera hibernation in the egg state is the rule rather than the exception. Besides the walking-stick already mentioned and the various species discussed in the following paragraphs, the cockroaches, praying mantes, black crickets, and tree crickets all hibernate as eggs. This is probably due to the com-

paratively large size of the members of this order and the eagerness with which they are devoured by birds, together with the fact that most of them depend for food upon herbaceous plants, and rely for protection upon their resemblance to these plants.

Most of our common grasshoppers, or locusts, hibernate in the egg state in the ground slightly beneath the soil surface. There is at least one species,[1] however, common in New England, that deposits its eggs in soft wood. One bright October day I happened to come across a fence beside a bit of woods, in the posts of which these locusts were busily laying their eggs. On the top of nearly every post was one or more of these busy creatures with her abdomen thrust down into a crack or crevice where she was depositing her bunch of eggs. The position then assumed is well shown in Figure 126, which was the only fairly successful result of several attempts to photograph one of the insects while ovipositing, the fact that they move their bodies constantly up and down making the taking of the picture difficult. The shape of the end of the abdomen in the female grasshoppers is shown in Figure 125; as will be seen it is pointed at the end, a fact which easily distinguishes this sex from

Fig. 125.—The Pine Locust, Female, slightly magnified.

[1] *Melanoplus punctulatus.*

the smaller males, which have the end of the abdomen rounded (Fig. 124). This species appears to have become adapted to life in open pine woods; it is coloured in mossy grays and browns that help to conceal it when upon the bark of trees or logs.

These grasshopper eggs, whether laid in wood as with the species illustrated, or in the ground as with most of the field species, remain unhatched until the following spring. During this long period they are subject to attack from a host of enemies, including birds, predaceous insects, and small red mites that feed freely upon the egg contents. Those eggs which are not destroyed before the latter part of the following spring hatch into young hoppers that feed upon the tender foliage of grasses or other plants.

FIG. 126. — Female Locust depositing Egg Mass.

These common grasshoppers belong to the family Acrididæ. They are chiefly distinguished from the Katydid family (Locustidæ) by their short antennæ, these organs in the latter being long and slender. The Locustids generally lay their eggs above ground, the precise situation varying with the species. Some of the typical katydids oviposit upon the twigs of trees, the eggs being flat, oval objects. The method of oviposition of the angular-winged katydid has been described by Dr. C. V. Riley in these words: "Selecting a twig of

about the size of a common goose-quill, this provident mother prepares it for the reception of her eggs by biting and roughening the bark for a distance of two or three inches. This bite is not gradual like that made when feeding, but is sudden and vigorous, the insect chewing and pressing the twig each side so as to form an edge. This operation is accompanied by a sudden nervous shake of the body from side to side, and lasts sometimes but two or three minutes, sometimes more than ten. When the operation is accomplished to her satisfaction, she clutches with her front feet the stem to be used, and anchors the middle and hindmost feet for the most part upon contiguous leaves or branches, and often quite wide apart. Then, if she has her head in an upward direction (for it seems to be immaterial to her whether the eggs are placed from below up or *vice versa*), she begins at the lower end of the roughened portion of the twig, and after fretting it anew with her jaws and measuring and feeling it over and over again with her palpi, as if to assure herself that all is as it should be, she slowly — with much apparent effort, and not without letting it partly fall several times — curls the abdomen under until the lower edge of the curved ovipositor is brought between the jaws and palpi, by which

Fig. 127. — A Common Katydid.

it is grasped and guided to the right position. It is then worked slightly up and down for from four to six minutes — all the time guided by the jaws, — while a shiny viscid fluid is given out apparently from the ovipositor. Finally, after a few seconds' rest or suspension of this work, the egg gradually rises, and as it passes between the ovipositor turns so that the one end appears almost simultaneously from between the convex edge with the other from the lower tip of the blades. The egg adheres to the roughened bark in an oblique position.

"After the egg is placed the abdomen is straightened out and the insect rests for a few moments, soon, however, to resume her efforts and repeat the like performance in every particular except that the second egg is placed on the opposite side of the twig and a little above the first one. The third egg is pushed in between the top of the first one and the twig, the fourth between the top of the second and so on, one each side, alternately. Thus these eggs are not laid as we might naturally infer, one over the other, but rather one under the other, that is, each succeeding pair having their ends thrust in between the tops of the preceding pair, the teeth at the end of the ovipositor helping to crowd the end into place."

The pine-cone willow-gall is described on a later page as the home of certain larvæ of two-winged flies. An examination of these galls in winter will often reveal another occupant; between the plates will be found rather large, elongate, yellowish eggs. These are too large to belong to either of the flies which commonly inhabit the gall. They are, in fact, the eggs of a meadow grasshopper (a member of this Locustid family), which has learned to take advantage of these galls as a place

for egg deposition. It is an excellent plan from the point of view of the grasshopper, for it is easy to insert the eggs, and they are safely protected through the winter.

In the order of true bugs — Hemiptera — there are many species that pass the winter in the egg state. With two of the largest families — those of the plant-lice and the bark-lice — this may fairly be considered the normal method of hibernation, while throughout the order it is common with many species.

If you look carefully through a hand lens at the twigs of apple trees, you will often find on the buds or at their bases small, black, smooth, shining, oval objects: these are the eggs of the apple aphis. They were deposited the previous autumn by the wingless female aphids, and will hatch the following spring into other female aphids. The latter will crawl upon the unfolding leaves, insert their tiny beaks into the tissues, and suck the sap. They develop rapidly, and in two weeks or so become full grown. Each then begins giving birth to living young, a process which continues through successive generations throughout the summer until in autumn a sexed generation is produced; the winter eggs are deposited by these.

A considerable variety of aphid eggs may be found in winter on the bark of willow shrubs. Some of these are deposited about the buds, in which case they may belong to one of several distinct species. Others are to be seen thickly scattered over the general surface of the bark, as shown in Figure 129; these are likely to belong to a rather large species of the genus Melanoxanthus. Generally these eggs are more or less covered with a whitish substance that makes them less conspicuous upon the light gray bark.

These plant-lice are attended by black ants until the very end of the season. Throughout last October, and even on sunny days in November, the ants were busily running about among the aphid colonies, caressing the insects with their antennæ as shown in Figure 128.

All of these aphid eggs attached to the surfaces of trees, shrubs, and plants are liable to many dangers. Unless they are securely fastened, they may be blown or washed away, or in time of sleet and ice they may be torn from their support. They also furnish a large percentage of the food of winter birds, like the chickadees and nuthatches. In a recent study of the winter food of the chickadee in New Hampshire I found that more than one-fifth of it consisted of the eggs of plant-lice. As many as 450 of these eggs were sometimes counted from a single stomach representing not more than one day's food. Probably only a very small proportion of the eggs that are laid in autumn survive to hatch in spring.[1]

Fig. 128. — Ants attending Willow Aphides.

On the bark of apple twigs one may commonly find small grayish or brownish scales about one-tenth of an inch long, shaped something like a miniature oyster

[1] In my Life Histories of American Insects I have given a rather full discussion of the hibernation of aphids (pp. 209–247); consequently I omit further reference to this interesting group in this connection.

shell. In colour they generally resemble the bark, so that it is easy to overlook them. This is the oyster-shell bark-louse, an insect that has long been known as a destructive enemy to apple trees.

If in autumn, winter, or early spring you remove one of these scales and examine its under surface through a lens, you will probably find small white objects which are the eggs of the bark-louse; they were deposited beneath the scale late in summer by the mother insect, whose shrivelled remains are to be found at the base of the scale.

FIG. 129. — Eggs of Aphides on Willow Bark.

Late in May or early in June these eggs hatch into little whitish, six-legged creatures with flattened bodies, barely visible to the naked eye. These crawl about over the bark for a few days. Then they settle down by inserting their tiny beaks through the bark, generally choosing twigs of the previous year's growth. When once settled, they remain in position and gradually begin to form the scale that is so prominent in autumn. As the weeks go by the scale enlarges until by the end of summer it is of full size. Then the mother insect fills it with her eggs and dies, her shrivelled remains staying in place to help protect the eggs through the long winter months.

Scattered here and there among the larger scales you are likely to find smaller ones of a different shape. These are the scales of the male insects.

In the great order Lepidoptera, a considerable number of moths hibernate as eggs. Typical examples are found

in the American and forest tent caterpillars and the cherry tent-maker discussed in previous pages of this book. Other examples are seen in the tussock moths of the genus Orgyia. The commonest species is the white-marked tussock moth,[1] the eggs of which may be frequently found during the fall and winter months upon the trunks and larger branches of elm and maple trees. They occur as whitish patches, easily visible some distance away; on closer examination these patches are found to consist of thin, gray cocoons, attached to the bark, partially covered with glistening white masses suggestive of a dried frothy substance. When broken open these masses are seen to consist of hundreds of small, white, spherical eggs, held together by the frothlike substance that permeates the whole mass. If the cocoon itself be pulled apart, there will be found within it an empty brown pupa case from which a moth has emerged. In spring these eggs hatch into the tussock caterpillars.

FIG. 130. — Eggs of Antiqua Tussock Moth.

Another of these moths, the Antiqua Tussock moth,[2]

[1] *Orgyia antiqua.* [2] *Orgyia leucostigma.*

seems commonly to choose a dried leaf hanging to a twig for her eggs. The egg mass of one of these insects as it was found upon an apple tree is shown in Figure 130.

Notwithstanding the immense number of species to be found in the three great orders that include the flies, the beetles, and the ants, bees, and wasps, it seems that very few of them pass the winter in the egg state. Apparently, most of them have found one of the three later stages more profitable for hibernation.

II. THE LARVA.

There is such infinite variation in the larval stage of insects that it is not surprising that many species have become adapted to hibernation in this condition. The proportion varies greatly, however, with the different orders. In the Orthoptera, which as already stated winter so largely in the egg state, there are very few that hibernate as nymphs, or immature forms. The most conspicuous examples are certain grasshoppers or locusts (Acrididæ), which may often be found in a half-grown condition. In the Hemiptera there are certain plant-lice that hibernate in a very early stage, and various other species pass the winter as nymphs, but most members of the order seem to hibernate either in the egg or the adult state.

When we come to the great order Lepidoptera, however, we find that many moths and butterflies utilize the larval stage for the purpose of hibernation. The examples of this are so numerous that I can cite only a few of the more interesting or familiar ones.

The beautiful butterflies of the genus Argynnis are

very common in summer, and attract much attention as they hover about beds of dogbane and milkweed blossoms. The way in which they pass the winter is of peculiar interest. The eggs are laid in August on the leaves and stems of violets; they soon hatch into small larvæ that as a rule have the instinct not to eat but to take a position on the underside of the leaf and to remain there until the following spring, a seven months' fast that seems curious enough. When the season opens, they feed upon the leaves of the violet, maturing into butterflies during June and July.

FIG. 131. — An Argynnis Butterfly.

Late in autumn and early in spring one of the best sorts of situations for the insect collector to search is beneath boards or pieces of wood of any sort lying upon the ground. Along fences and roadsides or in the grasslands he is thus likely to find a great variety of insects, including many of the smooth-skinned, soft-bodied larvæ which are commonly called *cutworms*. These larvæ hatched late the previous summer from eggs laid by night-flying moths. They feed upon grasses or other succulent plants until the approach of cold weather. Then they seek the shelter of the board or fence rail, or else burrow into the soil. When spring comes, the hungry, half-grown worms begin feeding again, eating grass or clover, or if some other crop takes the place of these, attacking that instead. After a few weeks of

this spring feeding, these cutworms become full grown. Making a cell in the earth, they pupate and soon emerge as dull-coloured, night-flying moths.

On the hanging leaves of oak, apple, and some other trees, one can often find the mines of some of the leaf miners (Fig. 132). Or in autumn when the leaves first fall such mines may easily be seen in the leaves upon the ground. A careful examination of such a leaf mine is likely to reveal a larval miner; for a large proportion of these insects pass the winter as full-grown larvæ within the mine in which they have developed. In spring they change to pupæ to emerge soon afterward as moths.

Fig. 132. — Mine of Leaf Miner in Apple Leaf.

Only a person with very sharp eyes need look for the winter stage of a common injurious insect called the *bud worm*. This is a tiny brown caterpillar that feeds upon the surface tissue of apple leaves in summer. When it passes its third moult, it knows instinctively that it is better to prepare for hibernation, even though the winter season may yet be distant. So it wanders to the bark of the twig or branch, and seeks some tiny crevice in the bark. Here it ensconces itself and spins a tiny case, or *hibernaculum*, just large enough to hold its body. The case is sometimes so covered with particles of bark that

it is very like the rest of the surface, and in general it is so inconspicuous that it can be found only by the most careful examination.

In spring the little caterpillars emerge from these hibernacula and seek the opening buds. They feed within these upon the tender tissues of the unfolding leaves, which they sew together more or less by means of silken threads. In six or seven weeks they become full grown as larvæ. They now pupate in a cocoon made of leaf and silk. About ten days later they again change to small moths.

In the development of this insect there have been many opportunities for the working of the laws of natural selection. In case the larvæ remained on the leaves for hibernation, what would happen? In case the larvæ spun their winter cases on smooth bark, or of colours which did not blend with the surroundings, what would happen?

I have found in the stomachs of chickadees, winter cases either of this bud worm or some other larva having a similar hibernating habit. Doubtless other winter birds — like the creepers, woodpeckers, and kinglets — also eat such morsels whenever they are to be found. What effect would this persecution have in perfecting the degree of concealment of the winter cases?

In the great order of two-winged flies, the Diptera, there are numerous species that pass the winter in the larval condition, although comparatively few of them are easy to find at this season. Those that live in galls are perhaps the most accessible; two examples will suffice for our present purpose.

The oval willow twig gall [1] is one of the most interesting

[1] *Cecidomyia salicis.*

forms of galls and also one of the most generally accessible. It is very commonly found over most of the United States and will be easily recognized from the sectional view in Figure 133. Generally it is nearly an inch long and not quite half an inch in diameter. The outside is of the reddish colour of the willow bark, becoming darker at the beaklike tip. This beak is brittle and easily broken off.

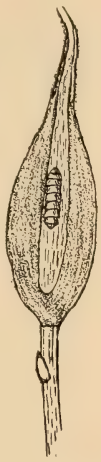


FIG. 133. — Sectional View of Oval Willow-gall.

If you cut open one of these galls vertically so as to disclose the middle, you will find the condition pictured. Beneath the outer bark is a mass of woody tissue which does not show the layer upon layer structure that a section of a twig usually reveals. Inside it there is a longitudinal channel with a smooth and fragile lining. If the gall has been opened carefully, and it is winter or early spring, you are likely to find within this channel a small, orange-coloured maggot, one-fifth of an inch in length.

This orange maggot is the proprietor of the gall. To serve its purpose the willow plant has built the gall and furnished the plant juices that have been its food. The maggot has also used the gall for its winter quarters, and had it not been disturbed would have pupated therein. If you keep a lot of these galls under observation in spring, and open one frequently, you may be able to see the pupa.

You will have noticed that the central channel is open clear to the tip of the cone. A little study will show you that this beaklike tip is evidently the remains of a blighted bud. When the pupa is ready to change to a fly it wriggles to the open end of the channel, and pushes part way

out. Then the pupal envelope breaks open and the small gnatlike fly emerges.

One of the most curious plant growths is the so-called pine-cone willow-gall easily found on the ends of willow twigs (Fig. 134). It looks a miniature pine-cone somewhat compressed longitudinally. If you cut through its vertical length so as to disclose the middle, you will probably find a sort of a tube in which is a small whitish larva, without legs or feet, and with no definite body divisions.

FIG. 134. — The Pine-cone Willow-gall with Dragon-fly resting upon it.

How did this larva come to be in this situation? And what is the origin of this remarkable growth on the willow stem? Obviously it is not the seed cone of the willow, for the seeds of the plant are scattered in spring from the ripened woolly catkins. Perhaps you can answer the questions better if you find out what becomes of the larva. This is not difficult. In early spring place some of the galls in a glass jar. Look at it occasionally; some day you will find some tiny two-winged flies in the jar. They look a good deal like mosquitoes. These are what the footless larvæ have developed into.

Now if out of doors these flies were let loose, and your eyes were keen enough to follow them in their flight, you might see some of them search out the

terminal buds of willow twigs and deposit an egg in each bud. The egg is very tiny, and it soon hatches into a larva almost equally minute, but in some way that we do not very well understand this larva is able to bend the energies of the twig to form a home for it. The bud starts to grow, but unlike the other terminal buds beside it it cannot push ahead as a slender graceful branch; instead it must stop and send its leaves out almost horizontally to form for this intruder a shelter and a food supply. So the leaves that else would take on so linear and delicate a grace, became the broad and clumsy scales of this monstrous cone. In the midst of all the larva lives, absorbing the plant juices which serve for nourishment.

The shelter which has done so much for it through the summer is obviously an excellent protection through the winter. So the larva remains in it unchanged until the approach of the following spring brings near the opportunity for the deposition of eggs for another brood. Then it changes to a pupa, soon to emerge as an adult fly.

This fly belongs to the family Cecidomyiidæ, which is composed of the gall-gnats. This species is called *Cecidomyia strobiloides.*

If you press apart the scales of the pine-cone, you are likely to find other pinkish larvæ snugly tucked away between the woolly surfaces of the scales. These are the larvæ of another gall-fly which has wisely learned to take advantage of the unused chambers of the gall. Its eggs are probably deposited while the gall is developing. In a single gall there will be a great many more of these *guest-fly* larvæ than of the original designer, for there is only one of the latter, while there are many of the former.

So it is probable that if you keep the galls in glass jars, you will get both species of flies, the most of them being guest-flies.

Of course the guest larvæ have learned that they could have no safer place to pass the winter than that where they have developed. Consequently they follow the example of the host species in remaining in between the scales as larvæ until the approach of spring. Then they pupate and soon emerge as flies.

Fig. 135.—The Oak-plum Gall.

This guest gall-fly belongs to the same family as the other. Entomologists call it *Cecidomyia albovittata.*

If you examine carefully the flies you rear in the jars, you are likely to find some quite different from the others. Their bodies are smaller and more compact, and they have four wings instead of two. These are parasites, upon one or the other of the Cecidomyias, perhaps both. So you see that even this elaborate summer and winter shelter does not keep them safe from all enemies.

The beetles form the great order Coleoptera, which includes many families and a vast number of species. The larvæ of many of these, especially such as burrow in the soil or in trees and logs, may readily be found during the winter months. Many of these require at

least two years to complete their development so that they must pass at least one winter in the larval condition. The beetle larvæ are not silk spinners, so they cannot make hibernation cases like those of many of the Lepidoptera; consequently they are seldom to be found save where they are protected by some other sort of shelter.

The easiest place to find the larvæ of the Hymenoptera in winter is in the numerous galls which they make upon various plants. The oak-plum gall[1] shown in Figure 135 will serve as an example of these. This curious growth develops on the outside of the acorn cup. In autumn it is of a bright red colour. Inside, it is of a spongy texture, with the larva in a little cell of harder tissue in the centre. The outer portion becomes denser as the season advances, so that in winter the gall is often very hard. The little black fly into which the larva matures generally emerges in April.

III. COCOONS AND CHRYSALIDS.

When we think of insects in winter, the forms which are most likely to come to mind are the cocoons with their contained pupæ. This seems at first glance the most natural way for an insect to pass the winter, yet were we to make a list of the winter stages of all the insects in a northern region, we probably should find that much less than half the species hibernate as pupæ.

This idea of the prevalence of the pupal stage of hibernation is probably due to the fact that several species of large and rather common moths pass the winter in con-

[1] *Cynips quercus-prunus* Riley.

spicuous cocoons which are often found. Thus the Cecropia moth winters over in the large silken cocoon shown in Figure 114 (p. 119). This cocoon is about four inches in length by two inches in breadth. It may often be found attached to the twigs of a great variety of trees and shrubs. If you cut it open, you will find that the outer wall of silk is tough and impervious to water; inside this you find a mass of more loosely spun silk, and lining the whole, another tough wall. Inside the latter wall you will find the brown pupa, with the dried remains of the larval skin crowded into one end of the cavity. Notice how firmly the cocoon is attached to the twig by the silken threads of which it is made up.

Fig. 130. — Caterpillar of Cecropia Moth.

By keeping some of these cocoons in a large box, one is likely to get the beautiful moths in May or June. As the season of emergence approaches it is worth while to keep the cocoons under daily observation so that perchance you may see the moth as it first comes forth, when its body is distended and the wings mere shoulder tufts. A small stick or other support should be provided, so that the moth can crawl up and let its body hang vertically. Then you may be able to see the expansion of the wings as the blood is forced into the veins.

One day last September a caterpillar of this Cecropia moth was brought to the studio. It was a strange-

looking creature with its immense body, covered with many warty projections, some of which were bright coral red (Fig. 136). I placed it on a fresh apple twig, of which it ate a few of the leaves, but the next morning it had begun the construction of its cocoon by drawing some of the leaves in toward the twig and covering them with silk. At first the caterpillar could be seen through the thin covering spinning its silken shroud, but soon the layers were so dense that it was hidden from view.

Fig. 137. — Cocoon of Promethea Moth.

Sometimes instead of a moth you may get from your cocoons four-winged ichneumon-flies. These are parasites which have destroyed the host and developed at its expense, while on the trees the cocoons are often torn open by the hairy woodpecker which devours the pupæ within.

An entirely different cocoon, which is often found upon the twigs of barberry, black cherry, sassafras, and other shrubs and trees, is represented in Figures 137 and 138.

This is the cocoon of the Promethea moth, a large and handsome species common in our Northern states. The cocoon is of special interest because it shows a remarkable instinct on the part of the caterpillar that constructed it. If you examine the structure of the cocoon carefully, you see that a leaf forms the framework on which the silken web was spun. Sometimes the leaf may have disappeared, but the impression of its midrib and principal veins is easily seen. Notice how cleverly it is attached to the twig by silken threads woven tightly around it.

Fig. 138. — Promethea Moth on Cocoon.

By keeping the promethea cocoons under observation late in spring or early in summer, you may be able to see the moths develop. Sometimes, however, you may get only a four-winged parasite for your pains.

Our commonest species of the large swallow-tailed

butterflies pass the winter in the chrysalis state. About gardens in which carrots, parsnips, or parsley have been growing one can frequently find during the autumn and winter months the chrysalis of the familiar black and yellow Asterias butterfly (Fig. 139). The rather handsome caterpillars of this species (Fig. 140) are frequently common upon the plants named during the latter part of summer. When full grown, they wander about in search of shelter for the chrysalis period. When they find a fence or a board loosely resting on the ground, they spin a silken mesh in which to attach the hind end of the body, and a silken girdle to go over the thorax; then they change to the chrysalis which hangs there naked and helpless during the long months of late autumn, winter, and early spring. It is not strange that during this period a large proportion of the chrysalids perish from the numerous enemies to whose attack they are exposed: birds, squir-

Fig. 139. — Asterias Butterfly on Goldenrod.

FIG. 140. — Caterpillar of Asterias Butterfly.

rels, and mice are among these, not to mention the various parasitic and predaceous insects.

It is fortunate for these chrysalids that to a large extent they have the power to conform their colour to that of the surrounding surface. In the summer time the caterpillars frequently seek the shelter of herbaceous plants to spend the chrysalis period; they then soon take on the green colour of the plant. Last summer I found such a chrysalis attached to the stem of a pigweed (*Chenopodium*); it is represented in Figure 141. The chrysalis was of the same glaucous green colour as the leaves and stems of the plant. The larva had spun its silken webs upon the stem

FIG. 141. — Summer Chrysalis of Asterias Butterfly.

and branches, a few threads going clear around to hold the rest in place. This was fortunate for the chrysalis, for much of the web had become loosened so that the support fell entirely upon the encircling threads; the condition is shown in Figure 142.

The winter chrysalids attached to dark, weather-beaten boards are generally of a dark grayish colour very similar to that of the surrounding surface.

Fig. 142.—A Nearer View of Same.

The beautiful Turnus swallowtail represented in Figure 143 also passes the winter in the chrysalis state. But as its food consists of the leaves of various trees instead of garden vegetables, the chrysalis is not so often found by insect collectors.

In the vicinity of a garden in which cabbages have been grown, a little search will nearly always bring to light the chrysalids of the common imported cabbage worm, the larva of the abundant white butterfly called *Pieris rapæ*. These chrysalids vary much in colour, those against a dark background being in general darker than those against a light background. In England the observation of this fact led to some of the most interesting experiments on the relation of the colours of insects to their surroundings. These chrysalids appear to be much more exposed to the attack of enemies than are

those of the insects which pass the winter in tough cocoons; and the mortality from birds and other enemies is probably proportionately greater. Instead of a cocoon there is simply a loop of silk to hold the front end of the body in place, and a flat bunch of silk against the support to which the hind end is attached. These chrysalids may be found on fence boards, the sides of houses, barns or sheds, under sticks or stones, in almost any situation to which the worm may have wandered before taking on the chrysalis condition.

Fig. 143.—The Turnus Butterfly.

Besides the variations in colour due to the background there is often a colour variation due to parasitism. By putting some of the chrysalids in a glass jar you are likely to get white butterflies from the healthy pupæ, and tiny four-winged flies from those infested with parasites.

The curious larvæ of the sphinx moths go into the ground in autumn, soon changing to pupæ that remain in the soil through the winter. By so doing, they escape many enemies that would rejoice over such a supply of food as one of these pupæ would furnish. This is true not only of the species that feed upon herbaceous plants, as in the case of the common tomato worm (Fig. 144),

but also of those that feed upon the leaves of trees. These pupæ lie in hollow cells in the earth without any sign of a cocoon or other covering.

FIG. 144. — The Tomato Worm.

There are various larvæ of the great family Noctuidæ — the night-flying moths — that have the same habit of going into the ground in autumn for the purpose of pupation. Perhaps the familiar zebra-caterpillar, which feeds upon cabbage, peas, and a considerable variety of other plants, is as good an example as any.

FIG. 145. — Larva of Datana Moth.

The larvæ of the hand-maid moths of the genus Datana, also hibernate as pupæ in the ground. The ministra, or yellow-necked apple-tree caterpillar, is one of the most familiar species

of this genus. One of these larvæ is represented in Figure 145 in the peculiar attitude it assumes when disturbed. These insects feed in colonies, devouring the foliage as they go, so that their presence is generally shown by the denuded branches of their food-plants. When full grown they descend to the ground and pupate in cells in the soil, remaining unchanged until early the following summer.

IV. THE ADULT.

Very few Orthoptera pass the winter as adults. Among these are the grouse locusts, which late in autumn or early in spring, as well as in mild weather during winter when no snow is on the ground, may often be found under the edges of stones, logs, or boards, or among the fallen leaves along the borders of woods. These insects hibernate in this adult condition, relying upon the shelter they find and their dull inconspicuous colours to enable them to escape from enemies.

Comparatively few butterflies pass the winter in the adult condition. Those that do seek shelter, on the under sides of twigs, in hollow trees, in wood piles, and various similar situations, many of which are due to the presence of man. Under the original conditions in which the butterflies developed as species, probably a large proportion of them passed the winter on the bark of twigs, branches, or trunk.

Most of these hibernating butterflies belong to one group; indeed in the Northern states a majority of them are to be found in two genera, — Vanessa and Grapta. One peculiarity of the butterflies of these two genera is that the upper surface of the wings is much more brightly coloured than the under surface. When

at rest, the wings are held vertically, the upper surfaces meeting and concealing each other, so that only the lower surfaces are exposed to sight. The general colour tone of the lower surface varies in different species, but in practically all of them it is grayish or brownish or blackish and has a curiously mottled appearance, suggestive of the effect of weathered bark or dead leaves seen at a little distance. There is, of course, an advantage to the butterflies in thus taking on the colour tones of their surroundings during the long period of exposure.

We have not enough precise observations to indicate that these butterflies choose their winter position with reference to the tint of the exposed surface of the wings. Such observations would be of great interest. That they may do so, seems probable. In Europe, as stated by Mr. S. H. Scudder, "Landois saw the butterfly, *Inachis io*, take up its winter quarters in an ivy, hanging from a branch by its hind legs, folding all its other legs on its breast and closing its wings. During a warm spell in the early spring it disappeared only, when the weather again changed, to return to the same spot and reassume its former position."

A good many species of the true bugs — Hemiptera — hibernate as adults. They may be found under loose bark and in the rubbish in fence corners and about stone piles. Many species of the two-winged flies — Diptera — also hibernate in this stage. Every one is familiar with the way in which house-flies and related forms congregate in attics through the autumn months. A little search in cellars and basements will also generally bring to light various mosquitoes that have sought out these places for their winter quarters.

Among the ants, bees, wasps, and their allies, hiberna-

tion as adults is a common experience. The wasps, hornets, yellow-jackets, and bumblebees are all good examples of this, while many of the ichneumon-flies and gall-flies also hibernate in the adult condition.

It is among the beetles, however, that the entomologist expects to find the largest number of species and specimens in his collecting from late fall to early spring. He finds the adults of this order in all sorts of situations. Beneath the soil, the click-beetles and May-beetles are resting in their pupal cavities, their outer tissues hardening preparatory to coming forth in spring. At the surface of the soil under shelter of many sorts are ladybird beetles and ground beetles, often collected together in great numbers, as well as a host of other sorts, scattered singly here and there. Under the bark of trees and logs are beetles of many kinds, while in rotten wood and among the fallen leaves in the forest there are many others.

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