SECT BEHAVIOR

PAUL GRISWOLD HOWES

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INSECT BEHAVIOR

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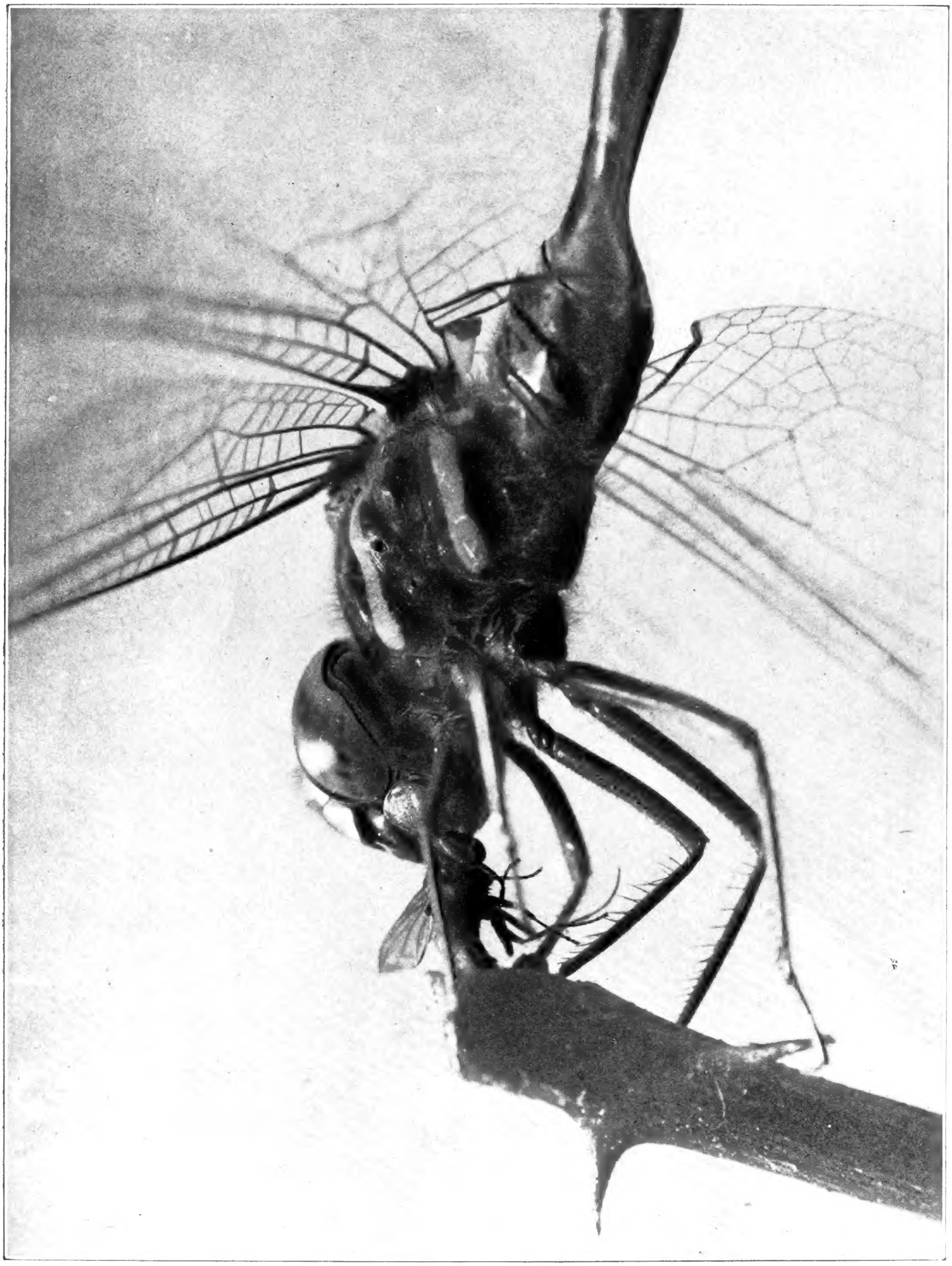

"They hover over the expanse below, occasionally swooping down upon creatures of lesser bulk"
Æschnid dragon-fly feeding upon a house fly. Much enlarged

Insecta
H.

INSECT BEHAVIOR

BY

PAUL GRISWOLD HOWES

WITH ILLUSTRATIONS FROM PHOTOGRAPHS BY THE AUTHOR

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TO

MY MOTHER

WHOSE FAITH AND ENCOURAGEMENT

HAVE PAVED THE WAY

THIS BOOK IS FONDLY DEDICATED

PREFACE

IN preparing this little volume my object has been to produce a work written in a light enough vein to be entertaining to the reader, however casually interested he may be in insect life, but at the same time, one that is in every way scientifically accurate.

In the chapters which follow, I have endeavored to describe as vividly as it lies within my power to do, various phases of insect behavior which I have been fortunate enough to observe and record during many years spent in active field work.

Chapters II to VIII inclusive, treat exclusively of South American insects, studied in the jungles of British Guiana, and while they are interesting species, whose habits have heretofore remained unrecorded, they possess no more wonderful life stories than our insects of the Eastern States, whose habits, for the most part, make up the remainder of this book.

Wherever one searches in the world of insects there is something new to be found. Perhaps only an unrecorded habit, or a slight problem to be solved, yet each problem leads to another, and soon one is led unconsciously into the depths of the study. Once in, there appears to be no way out, and I for one do not wish to retrace my steps to the freedom I knew before the fascination of this study laid hold of me.

If this book leads others into the world of insect study or, in some measure, brings home to the reader, the same fascination that these life stories hold for the author, then its object will be fully realized.

For the use of chapters II to VIII inclusive, which originally appeared in Volume I of Tropical Wild Life in British Guiana, I am greatly indebted to the New York Zoölogical Society, and to those magazines who have published other chapters as separate articles, and have now given their consent to their use in this book, I wish also to acknowledge my grateful thanks.

Last but not least, to Lillian Carey Howes, upon whom has fallen the main burden of preparing my manuscript for the printer, I make grateful acknowledgment.

PAUL GRISWOLD HOWES.

Stamford, Conn.,
January 1, 1918.

CONTENTS

CHAPTER		PAGE
I	The Insect World at Close Range	19
II	The Black Reed-Wasp	27
III	Larval Sacrifice	33
IV	The White-Footed Wasp	40
V	Paralyzed Provender	46
VI	The Forest Shell-Wasp	53
VII	The One-Banded Dauber	60
VIII	The Blue Huntress	68
IX	Controlled Pupation	77
X	Cannibal Wasps	85
XI	The Sphecid's Duty	91
XII	The Original Paper-Makers	95
XIII	Insect and Other Strategists	102
XIV	Observations on Ants	109
XV	The Sight of Insects	125
XVI	How the Greenbottle Does its Duty	129
XVII	Some Insect Experiments	134
XVIII	The Cecropia Moth	143
XIX	Nature's Way with Undesirables	147
XX	Spittle Bug Spittle	151
XXI	The Life of the Thread-Legged Bug	154
XXII	Trailing a Bee to its Lair	160
XXIII	Camouflaged Insects	164
XXIV	Living Examples of the Geological Past	169
	Index	173

LIST OF ILLUSTRATIONS

FACING PAGE

Æschnid dragon-fly preying upon a house fly . . . . . *Frontispiece*
A centipede greatly enlarged 21
Grasshoppers fighting 21
Staphylinid beetle preying upon a fly 22
An assassin bug laying her eggs 24
A handful of vegetation at close range 26
A photograph made under asparagus plants 26
Plough furrows are as mountain ranges to the insects 31
A greatly enlarged hemipterous insect 31
Male black reed-wasp guarding nesting tube 33
Female black reed-wasp arriving at the tube 33
Glass tube removed from box, showing plugs, egg and spiders 33
Old nest of wasp used by the black reed-wasp 33
Stages in the larval sacrifice 35
Newly transformed pupa of the roach-killer 35
Spider used as provender by the white-footed wasp 40
Cocoon of white-footed wasp 40
Tangle of reeds and razor grass in British Guiana 40
Two common bugs which do great damage to squash vines 49
Open nest of the forest shell-wasp 56
Open nest and larva of the forest shell-wasp 56
Newly emerged one-banded dauber 65
Suspended hatching egg of the forest shell-wasp 65
One-banded dauber working upon her nest 65
Four types of nests made by the one-banded dauber 65
Spider prey and egg of the blue huntress 68
Pupa of the blue huntress showing T-shaped jacks 68
A queen paper wasp at her nest 72
A cabbage butterfly depositing an egg . . . . *following* 76

		FACING PAGE
Cocoons of ichneumon parasite of cabbage butterfly larva		76
Male and female paper-wasps hatching in July		81
Paper-wasp worker with unusually large pellet of paper		81
The cannibal's nest layed open		85
A cannibal wasp at her nest		85
The cannibal and her diggings		86
A complete lead model of the cannibal wasp's burrow		86
A wasp of the sphecid's size compared to a rove beetle		88
Sphecid wasp dragging a paralyzed cicada to her burrow		88
Common cicada, upon which the sphecid wasp preys		88
Comparative wing expanse of cicada and sphecid wasp		90
Hole in cicada through which the young sphecid entered		90
Young sphecid wasp two days old feeding on its host		90
Queen paper wasp in the act of depositing an egg	*following*	92
Photomicrograph of eggs of the paper wasp	*following*	92
Paper wasp cells showing young and silken cocoon-caps		95
Life size nest of paper-wasp		95
Cells of the paper-wasp with caps removed to show young		97
Paper wasp cells in section showing larva and pupa		99
Epeira insularis, an orb-building spider, laying eggs		102
A spider using a cicada's shell as a hiding place		104
An example of spider strategy		104
The fishing net of a hydropsychid and its maker		106
Ants surrounding and pillaging a larger one	*following*	108
Brown ants transporting aphids to their underground nest	*following*	108
Actual debris gathered up after an ant battle	*following*	108
Carpenter ants tending their aphid "cattle"	*following*	108
Paralyzed and dying South American leaf-cutter ants		111
A group of dead ants all linked together		111
Carpenter ants proceeding to battle		113
A severed head of an enemy clinging to a dead ant		113
A train of South American army ants		113
Leaf-cutter ants with heads and abdomens eaten away		113
Young brown ants carefully tended by their nurses		115
Young brown ants brought up beneath a sun-warmed stone		115

FACING PAGE

A snowy tree cricket singing 118
The typical dragon-fly face 120
A robber-fly with its prey 120
Photomicrograph through the eye windows of a fly 122
A harvestman . . . . *following* 124
Egg mass of the greenbottle fly . . . . *following* 124
A greenbottle laying eggs upon the head of a dead bird 127
Greenbottle laying eggs in the bill of a starling 127
Young greenbottle flies at work 129
Skeleton of a muskrat cleaned by young greenbottle flies 131
Test tubes containing foods liquefied by young flies 131
Nest of the mound-building ants 134
Cecropia caterpillars twenty-five days old 138
Cecropia caterpillar casting its skin 138
Caterpillars of the cecropia just after the second cast 138
Eggs of the cecropia on an apple leaf 138
Female cecropia moth 143
The full grown cecropia caterpillar 143
Newly completed cocoon of the cecropia caterpillar 143
Squash flower opened to show nectar cup 147
How the honey bee reaches the nectar in a squash flower 147
A beetle at the entrance of the nectar cup 147
Fertilized blossoms of the squash plant 148
The yellow gaping throat of a squash flower 148
Foamy dwellings of immature spittle bugs 150
Growth of the spittle mass 150
A dried spittle mass and the mature insect 152
Huge spittle mass found in the jungle of British Guiana 152
A thread-legged bug laying eggs 154
A stampede of thread-legged bugs 156
Greatly enlarged head of the thread-legged bug . . . . *following* 156
A characteristic attitude of the thread-legged bug . . . . *following* 156
A thread-legged bug casting its skin 157
Spring-tails in their tiny world 159
Spring-tails showing spines upon their bodies 159

FACING PAGE

A tiny solitary bee resting between journeys 161
Making a plaster cast of the bee's burrow 161
Entrance to the bee's tunnel showing surroundings 161
Model of the bee's nest made from a plaster cast 163
Interior of the bee's burrow showing cell and food 163
Excavating the cast of the burrow 163
Caterpillar of a geometrid moth which resembles a twig . . . *following* 164
Caterpillar which mimics the excretia of a bird . . . . *following* 164
Chrysalis of the mourning cloak butterfly 168
Cochlidiid caterpillar which mimics a leaf-bud 168
Thread-legged bug in its original environment . . . . . . *following* 170
Poison spines of the Io caterpillar . . . . *following* 170
Wood lice or pill bugs 173
A thysanuran or bristle-tail 173

INSECT BEHAVIOR

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CHAPTER I

THE INSECT WORLD AT CLOSE RANGE

NOT so long ago my world was commonplace; even dull at times. Tranquil and uninteresting, until one day a tiny voice broke the silence of my study. It led me from my dusty chimney corner, dropped me suddenly into the new and fevered world of insects, and there it left me.

Who can tell how long this new world had lain before me unnoticed, a world of tiny people within our own big world, fighting out their destinies beneath our very feet? I found it a land of marvels and excitement, where great geographical upheavals are but momentary matters; where changes, rivaling those wrought by a million years in our environment, occur from day to day, a land where there is no uniformity of change. I found disorder and repose walking hand in hand, neither more of one than the other, yet much of both. I stopped; marveled, became fascinated, with this land so new and mysterious, into which I could step without effort, from my study door.

There were jungles, immense ones, rank and tangled, grown with gigantic trees whose bark was an armor of thorns. Myriad life inhabited them, and a thousand different creatures prowled about hunting one another. In the tree tops, along their swaying trunks and in the tangles below, every living thing was fighting for existence. Were our ears attuned to the vibrations of this jungle, a terrifying sound, dwarfing all others, would reach them, a grinding of life between myriad jaws, merciless, endless, for such is life in this new world.

Such an existence in such a forest is beyond our comprehension. It is the exception to survive long here. Each species preys upon, or fights to exterminate the next. There are serpents of great length and colossal rodents that comparatively dwarf a mastodon, which add to the excitement of life. It is fortunate that the creatures peopling such a world possess little if any intelligence. Indeed it is possible that they were purposely deprived of it lest they fear to venture forth.

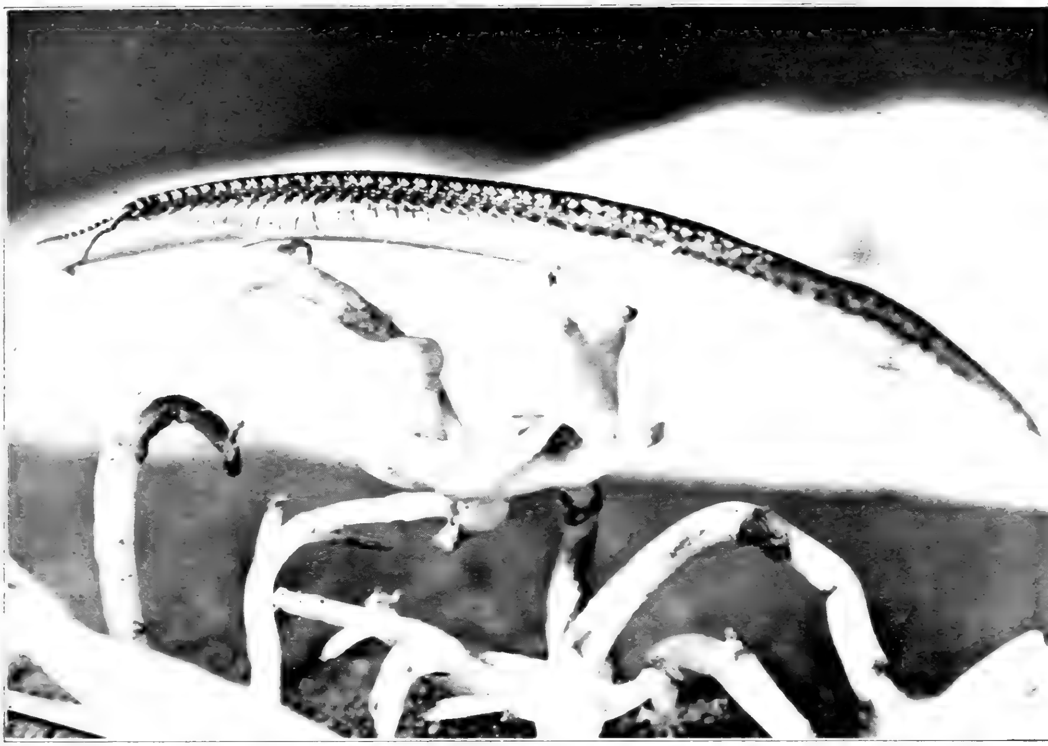
Now this jungle may flourish into a great wilderness, a forest whose real floor the sun never reaches. Here among the buts of the trees, weird creatures are encountered. Ugly crab-like things that suck the blood of others, minute horny creatures and indescribable crawling ones whose life story and functions nobody yet knows.

Above the dead fallen stems that cover this tomb life, a second group of living things is encountered. Larger creatures capable of utterances of a harsh nature, hard shelled beasts and triangular-bodied ones that emit disgusting odors.

One night the jungle flourishes, green and rich with swaying, surging life and energy, but the next night it has vanished. Every tree has fallen by some mysterious hand; millions of creatures perish and all is confusion. What has occurred claims a greater toll than war, yet, as we shall see, it is by no means a miracle.

Beyond the vanishing jungle lies a country of another type, the like of which no human being has ever seen.

Imagine a series of parallel mountain ranges, three hundred in number, of great length, with as many narrow valleys lying between. The country is nearly barren yet strangely rich in soil. At great distances some green thing finds courage to lift its head, standing



"Minute horny creatures and indescribable crawling ones whose life story and functions nobody yet knows"
A centipede greatly enlarged

"A land of tiny people, within our own big world fighting out their destinies beneath our very feet"
Grasshoppers fighting

out like a palm in an oasis, giving its mite of shelter from the sun. Lying about in no order, one sees great boulders, some rounded, others with jagged dangerous edges and many bearing white wounds as though a giant hammer had tried to cleave them.

There is a scarcity of animal life here just as there is a scarcity of vegetation, but one or two creatures revealed by the hunt are interesting.

One possesses a bony orange head that glistens like polished armor. It is armed additionally with heavy curved tusks, working sidewise with great strength, but for all this war-like apparatus its body is fat and pudgy. Such a hypocrite could be attacked from behind with safety. The creature rolls about aimlessly and one is forced to wonder how it obtains its food.

Another is a hairy eight eyed creature, possessed of as many agile legs that carry it rapidly from place to place. It lives in damp caves beneath boulders, darting out upon the unwary. In the seclusion of its cave it sucks its victim's blood casting out the skeleton as a warning to others.

We pass on. The journey brings us through another jungle of immense fruit trees bearing large objects resembling cocoanuts and thence to a lake of great extent, backed up by a group of mountains. Over the water one sees large flying creatures, with tremendous eyes and slender, plated bodies. They hover over the expanse below, occasionally swooping down upon creatures of lesser bulk, whom they consume greedily.

In front of us there are slimy flats sloping toward the lake. Puffs of tainted air lead to the discovery of a mass of carrion near the water's edge. Here is something of interest.

Upon the manna a multitude of animals are gorging. Most of them are similar in body, being long, fleshy and alert. They appear to be fighting greedily for the repast upon which they are exuding a strange fluid to assist digestion. They move continually about by means of grapnels which enable the animals to progress either forward or backward by repeated contractions of their muscles.

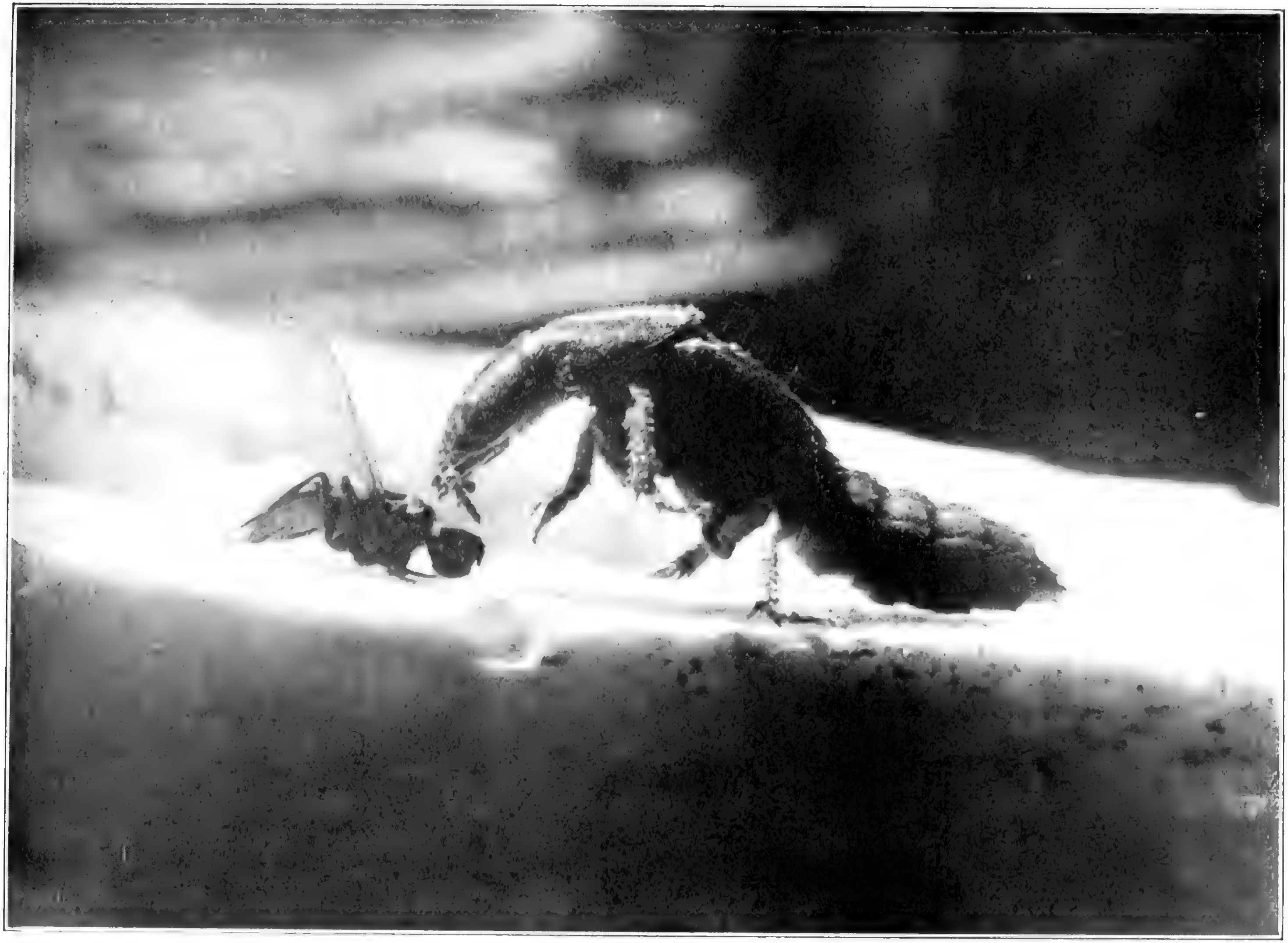
Other animals are attracted by the odor of decay and from far and near they come to seek the cause. Some to their advantage, others to their detriment, for a cannibal lies in wait for them.

It is a powerful animal, slender and supple-bodied, with a coat of glossy bronze velvet. It is perhaps the most active of all the weird creatures that we have come to know, moving like a flash in response to stimulæ. It could not exist were patience a necessity, at least one is so impressed upon observing it.

There are many tunnels twisting into the carrion, excavated by other creatures, and one of these the cannibal selects for its abode, until the flesh becomes too dry to act as lure. In this grewsome cave the creature rests, its eyes roving and its whole body ready to spring at an instant's notice, which it does upon all who venture within its range. Indeed we have found a veritable dragon in this creature so fiery and ready for battle. Its prey is helpless before the onslaught and its teeth sink easily through armor.

Leaping upon the back of its victim, the dragon tears deep into its body, grinding flesh and skeleton, sucking every drop of blood until the broken creature curls, dry like a leaf. In a few seconds the unlucky one has disappeared before our eyes. A minute ago we saw a living creature come to the carrion to stay its appetite. Next we heard a crunching noise and saw a splash of blood. Now there is nothing but the retreating cannibal and we gaze dumbfounded at the spot where the scene was enacted.

From the lake we journey on, through a wide and heavy section of woodland, on our way to the desert that lies beyond. As we go we have many weird experiences and see many curious sights, but lack of time prevents their proper observation. We must reach the



A powerful animal, slender and supple-bodied with a coat of glossy brown velvet

Staphylinid beetle preying upon a fly

desert at once, lest we arrive too late to see the pitfalls of the desert lions.

At length the broiling sands are reached and none too soon. The lions only build their traps at certain times of the year and few signs of them are encountered. A search reveals four pits, however, placed in the neighborhood of a colony of burrowing creatures common to the desert.

The pits are deep conical excavations in the sand, so cunningly constructed as to compel admiration despite the clumsy makers, who walk backwards in preference to forward.

At this time the lions are still youthful and being grotesque and cumbersome of body, must therefore secure their prey by strategy. Each individual excavates a pitfall, cone-shaped as we have seen. At the apex of the cone, which is deep in the ground, the creature conceals itself with only the sabre-like, sand-colored mandibles protruding.

Let us watch from a safe distance the methods employed. We have not long to wait, for a constant stream of animals are pouring in and out of their burrows near by. Many keep at a safe distance; others escape more through good fortune than intelligence, but at length a stupid individual arrives at a pit and heedlessly places one foot over the edge.

At once the footing crumbles and the poor animal starts on its journey. Once, in its frantic struggles, it appears to regain the lost footing, but seeing or expecting this, the lion hurls a multitude of rocks from below, which once more start the sand sliding and the victim meets its death in merciless, waiting jaws.

Now we might travel on and on, from the desert to another valley, lying between inspiring mountain chains, thence to a dried up ocean bed, across a great river into more jungle and so on, indefinitely, witnessing an endless series of geographical and living wonders that would soon bewilder us.

We can go no further now. Our expedition into the new world must needs come to an end. Before we return home, we are, however, to witness the approach and arrival of a new period. We are to see with our own eyes and in a very short time, the temporary death of this curious land.

The period, which is a glacial one, comes rapidly and is marked by great frosts, capable of killing an entire jungle in a single night. With each successive frost, countless millions of creatures perish, the weakest dying at once, the stronger surviving for a slightly longer period. Lakes and oceans freeze solid from surface to their depths, valleys and mountains are buried with snow and in an incredibly short time, perhaps a month or two, life in this lately flourishing land through which we have traveled may be cold and dead.

A glacial period has come, transforming the land into a desolate waste. It has apparently carried all life before it.

A fertile earth today, a barren moon tomorrow, such is this new world within our own!

* * * * * * *

Let us now see just what this new world is and where our travels have led us. We have barely looked into its treasure house of wonders, but for all that, we have learned something and our eyes have been opened to its possibilities.

Its geography is our own, more minutely seen, analyzed as it were into its smallest parts. To study its wonders one must lose sight of all large unimportant things. Real mountains, lakes, deserts, objects that make our geography, all must be ignored. They are too evident to be considered and to bother with them as a whole would be like hoarding something without value.

If we examine a great painting closely, we see only a mêlée of mean-

Another strange creature of the insect world
An assassin bug laying her eggs
Enlarged six times

ingless strokes; dabs of color placed together like the patches of a crazy quilt. So we may liken this new, or insect world, to these strokes and dabs that collectively make the painting. In a word the new world consists of the particles that, heaped together, compose the mountain, the valley and the desert of our own.

When we were coaxed from our study by the excitement of discovery, we stepped across the lawn into a field of waving hay. It was bordered with a heavy growth of weeds and other vegetation. Stopping to analyze, we found a jungle of the insect world. At the other end of the field the farmers were already swinging their scythes—thus the jungle vanished in a day.

We journeyed on to another field, so recently turned over by the plough that vegetation had only appeared at intervals. There were three hundred furrows, mountain ranges to an insect. There were stones bearing plough wounds, a few drassid spiders under them and here and there a fat white grub rolling helplessly about.

Next we passed through a patch of asparagus with its rounded fruit. Beyond this a clear little puddle was sighted over which dragon flies hovered, occasionally swooping down upon smaller insects. The far bank of the puddle was composed of sand and stones heaped together like conglomerate, but in front was a muddy flat upon which some frightened creature had dropped its animal prey.

In the flesh of this unfortunate we found a swarm of maggots, young flies whose duty it is to liquefy such objects and return death to life. Beneath the carrion a rove beetle lay in wait for unwary mother flies who came to lay their eggs in the game.

Leaving the pond for pastures new, we crossed a sandy field. Here several ant lions had made their pitfalls to entrap blundering ants, in whose formic acid they find nourishment and a pleasing flavor.

And so we might travel on and on, endlessly were it not for winter. Frosts are messengers of death in the insect world. Each drop of the mercury reduces its myriad life until at length there is nothing left. We witness the coming of the frosts, then the snows, exterminating all the little people that we have learned to know, for with winter comes the temporary death of their world. A queer little world that may be a fertile earth today and a barren moon tomorrow.

"Immense jungles grown with gigantic trees whose bark was an armor of thorns"
A handful of vegetation at close range

"Great fruit trees, bearing objects resembling cocoanuts"
Photograph made under asparagus plants

CHAPTER II

THE BLACK REED-WASP

Trypoxylon cinereohirtum, Cam

WHERE man has felled the primitive forest, obliterating nature's labors of half a thousand years, he leaves a wound that is long in healing. Just as a wound in the flesh leaves a scar that stands out distinct from its surroundings, so the forest heals its injury with a new vegetation, distinct from itself, but a mask nevertheless to the ghastly wound lying beneath.

We call the mask second growth. It is made up of trumpet trees, weakly shoots from fallen forest giants, great waves of razor-grass, briars, various types of undergrowth and here and there a patch of canes whose hollow stems are the natural nesting sites of the black reed-wasps.

Abandoning their natural habitat for the advantages afforded by Kalacoon,[1] they flocked to our hospitable board, setting up their abodes in our pen-holders, in spools, nail holes, in the handle of my shaving glass, and, in fact, in anything that suggested a hollow tube with a tiny diameter.

To the general rule among Hymenoptera[2] the black reed-wasps are an exception. That is to say, they are neither social, in the usual community sense of the word, nor are they solitary. They came in mated pairs in search of nesting sites, inspecting all the best holes

[1] A laboratory in the jungles of British Guiana where the author encountered the subject of this chapter.

[2] An order of insects including ants, bees, wasps, etc.

in the house with great care and deliberation. Like so many newly married couples, filled with the enthusiasm of a novel project, they roamed about among the improved property that Kalacoon offered. To facilitate my studies of their life history, I placed several pieces of glass tubing, three or four inches long and a quarter of an inch in diameter, about the laboratory. I inserted the tubes, which were closed at one end, into pasteboard boxes, leaving the open end of each projecting, so that the entrances were in plain view, but the main part of the passages were quite dark, within the boxes. Thus I made conditions in the tubes exactly like those in the reeds that the insects naturally chose for their nests.

They were an instant success, and within an hour or two, all were occupied by enthusiastic couples. In the glass nests, I could watch everything that went on. All that was necessary for me to do in order to observe the occupants' behavior; was to remove the box covers, and replace them when I had finished.

True to the tradition of wasp history, the female proceeds with the hard labor of nest building and providing for her family. The male, while he never actually takes part in the work, sits menacingly in the entrance, during his mate's absence, guarding the nest from intruders of the same species that are ever-ready unbidden to acquire a partly prepared home. He shows great interest in the work, following the female into the tunnel, watching closely whatever she may be doing and squeaking continually in a high pitched key by vibrating his wings. This is a common habit among many wasps during work hours, but the species in question emits this strange little rasping sound during almost all of its occupations. I interpret it as an expression of pleasure or well-being, like a man who whistles at his job. The sound is never heard during fright or anger, but of this I shall treat in another chapter.

Upon occupying a tube, the female's first procedure is to place a plug of solid mortar in the end of it, doubtless to prevent parasites and ants from entering. This plug is two millimeters in thickness and composed of wet, light gray clay. It dries in a few hours, hardening into a tough cement. Next to this, a second plug, one millimeter in thickness, is placed, containing more moisture than the first and of a much darker shade. This is followed by a third one of the same description, placed five or six millimeters in front of the second plug, so that there is an air space between them which holds moisture in the nest. The tube is now provisioned with small spiders of different species, varying from five to eight in number, which are paralyzed by the wasp's sting and brought in one by one. They are packed tightly into the tube by the insect's broad head which is brought into use as a sort of ramrod. The tube is a tiny muzzle-loader, into which she packs her living wads without mercy.

Upon the side or apex of the last, and usually the largest, spider's abdomen, she deposits a milky-white, bow-shaped egg, two millimeters in length. It is less than one-quarter as wide as long and closely resembles a sausage. The spiders and the egg are now enclosed in a substantial cell averaging twenty millimeters in length, by the insertion of a double plug of mortar, six millimeters in thickness, half of damp, dark-colored clay and half of the hard lighter material. The nest is now abandoned by the parent wasps who often start immediately to provision a second one.

In two days the egg hatches, bringing to light a yellow-white grub of thirteen segments. It commences feeding at once upon the spiders, a process which may be observed under the lens as a series of ripples or waves, commencing just behind the head and continuing the entire length of the body,—one wave being completed or spent, before the following one sets in. It grows rapidly, but very steadily, increasing each day in the same ratio until the last twenty-four hours of feeding, when it gains somewhat less than during the previous days.

In all, the larva or grub is full grown in four days from the time it hatches.

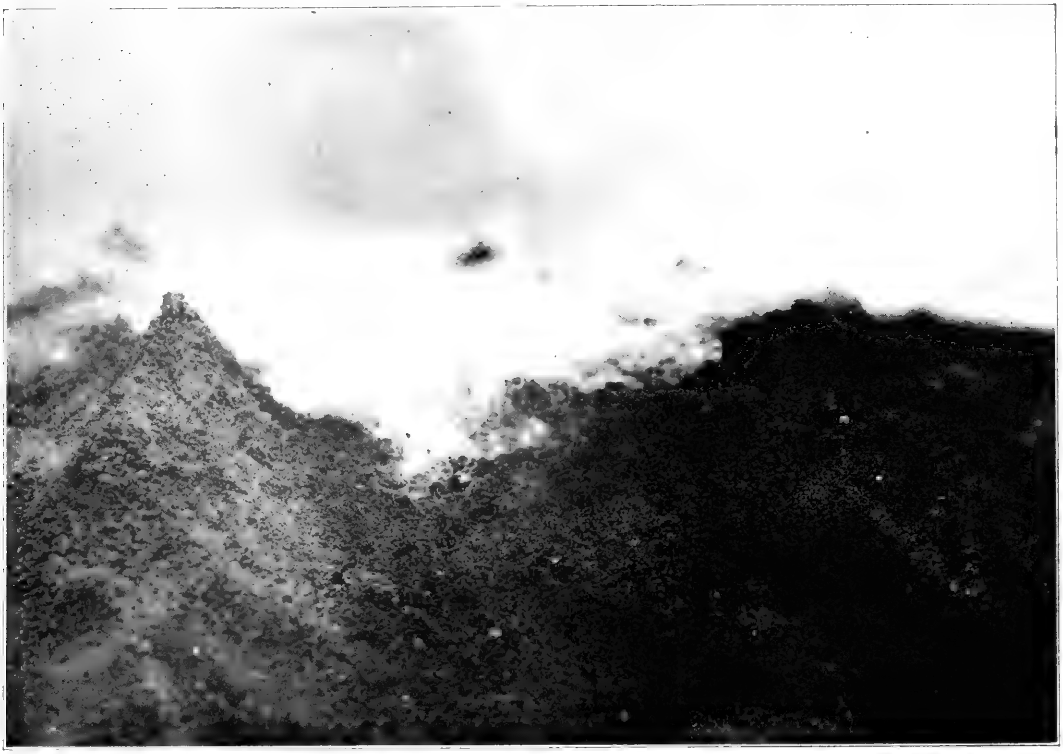
Upon finishing its meal, which lasts continuously for four days, the larva spins a flimsy net work of silken threads inside of which the cocoon proper is spun. This inner cocoon resembles a tiny torpedo, rounded at both ends and ten millimeters in length. It is very neatly constructed of delicate silk and coated all over the interior with a brown varnish that hardens in contact with the air.

Within this delicate cradle, ten days later, the budding wasp undergoes pupation—that wonderful process described more fully in the following chapter—by which the footless grub is transformed from a low and ancient form, to the highest order of modern insects. The actual change from gorged grub to a neatly folded, but colorless wasp is affected in ten days, but it still has three hundred and twenty-eight hours of confinement separating it from the light of day, hours which must be passed quietly, lest injury result.

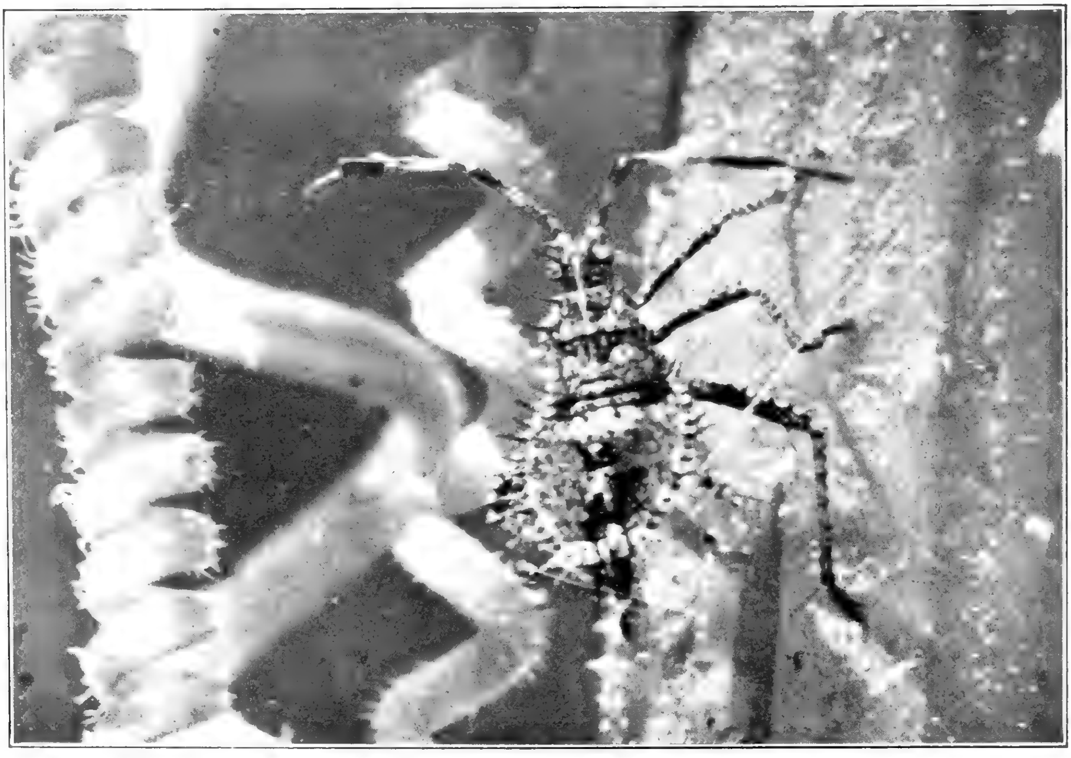
As the hours go by, color at length flows through its body and appendages, transforming opaque yellow to glistening black. Then comes the final gift of nature, the power of motion. The nascent creature, moist with birth, bursts its cocoon, gnaws through the plug of mortar and issues into the outer world a perfect insect. Only thirty-eight days have passed since I placed the tubes in the laboratory, and since the parents of this new creature arrived, realizing their destiny.

There is an interesting problem to solve concerning the black reed-wasps. Their nests vary considerably in number of cells. Some are complete with one, others contain two, but the majority are complete only after an egg has been laid upon the stores in three separate compartments. The question arises, How will the wasps emerge as perfect insects without disturbing one another?

If the nest is to shelter three insects, the cell farthest from the



Plough furrows are as mountain ranges to the insects



"Above the dead, fallen stems that cover this tomb-life, a second group of living things is encountered"
A greatly enlarged hemipterous insect

entrance will naturally receive the first provisions collected, and, it would seem, in due time, the first egg deposited. The remaining two cells would receive their respective contents in the order of their position, but the first egg laid, naturally hatches before the others. The grub reaches maturity, pupates and is ready to emerge sometime ahead of its sisters in the other cells. What happens then? Does the issuing wasp burrow its way out through the cells in front, upsetting in its passage the vital conditions of solitude that surround the younger insects? Does it burrow through the clay plugs, separating each nursery, and as a final act of vandalism, leave the nest open, exposing its younger sisters to the first parasite?

So it would seem, but such a course would be contrary to all the laws of nature. She does not destroy her children needlessly, yet I wonder what happens in such nests as that of the black reed-wasp, whose oldest child seems farthest from the door to freedom!

Perhaps the parent wasp is gifted with the power of laying eggs that require varied terms of incubation. In the first cell provisioned she lays an egg that requires three days to hatch, in the middle cell one that requires two days and in the outer cell the egg hatches in a day and a half. The theory would straighten out the difficulty very nicely. The insects would emerge in turn without disturbing one another and all would be well, but a theory is no better than a guess. Moreover a little careful observation of the glass tubes yields the correct and simple answer to the question.

I watch a wasp entering one of the tubes carrying a spider which is held tightly beneath her body. She enters, stores the game, squeaks about it to her watching mate, and is off again in search of a second victim. She does not rest after placing eight spiders in the tube, yet this is the maximum number for a single cell. Instead, the work continues during most of the day without interruption.

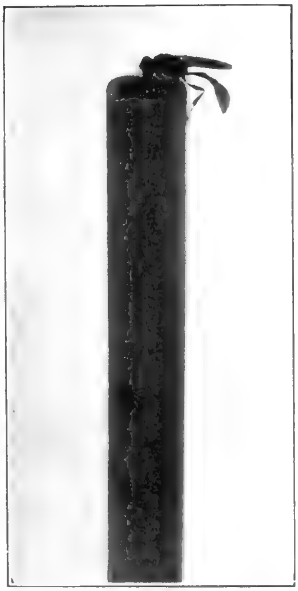
In the afternoon I open the box containing her nest. The tube contains twenty spiders separated into three little groups by half partitions of clay. Upon the abdomen of a large spider in each group she has deposited an egg. Now I close the box and await her return. She arrives laden with a tiny ball of clay in her mandibles, enters the nest for a moment and then flies off minus her burden.

At the end of an hour the operation has been repeated twenty times. Now she commences to close the entrance with the same material. The job requires ten more loads of mortar, but it is completed rapidly. By evening she has left the nest, I presume for good and all, and for the last time I pry into her secrets.

It is all very clear. In a single day she has accumulated the entire amount of provisions necessary to provide her three offspring, and separated them into distinct groups. Further she has constructed half partitions that keep the stores separate, but still permit her to pass from one end of the nest to the other. Thus she is enabled to deposit her three eggs in different departments of the nest, all on the same day. The laying over, she has only to finish the half partitions with a few loads of clay, plug the entrance and her work is completed.

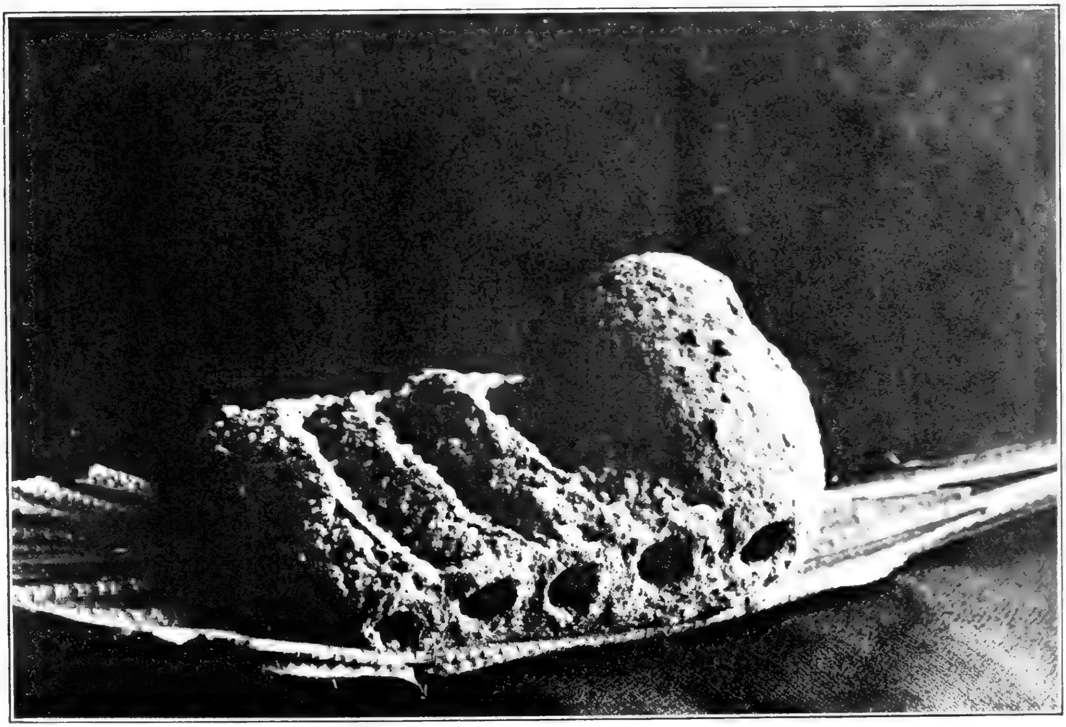
She deposited all her eggs within an hour and they are safe in isolated cells. The three will pass through their metamorphosis or life history, as one. They will eat and grow and pupate together, and issue into the world almost at the same moment. Thus the black reed-wasp solves the problem very simply. She brings her offspring into the world as triplets!

Male black reed-wasp guarding nesting tube



Female black reed-wasp arriving at the tube

Glass tube removed from box, showing plugs, egg, and spiders



An old nest of a jungle mud-wasp, the empty cells of which were used as nurseries by the black reed-wasp

CHAPTER III

LARVAL SACRIFICE

IT is strange what a vast array of facts are disclosed through the study of the unintelligent invertebrate. I am thinking particularly of insects, dominant creatures of the earth, into whose life-secrets and lore man, through his wretched span of years, may scarce become a trespasser. They are set apart, almost in another world, vastly wise and ruled by an iron discipline that has wrought their world empire of today. My attitude toward the insect is that of a pupil under a great master, who, unable ever to reach the altitude of his mind, must be content to set forth his simplest teachings. No matter where I look, my master is there, a superior being who appears to have risen far above me. From his instinctive throne, he looks down pityingly upon my intelligence, I who must put two and two together and work my poor brain so hard to understand his simplest problem.

Words fail to tell adequately of what I see in the world of insects. Then again there is much that I fail to understand anyway, as a consolation for the missing words, but occasionally I have just a faint glimmer of what is transpiring before my eyes. Thus I shall skip briefly over the life history of a wasp I call the roach-killer, Podium rufipes (Fabr.), to the subject of this chapter.

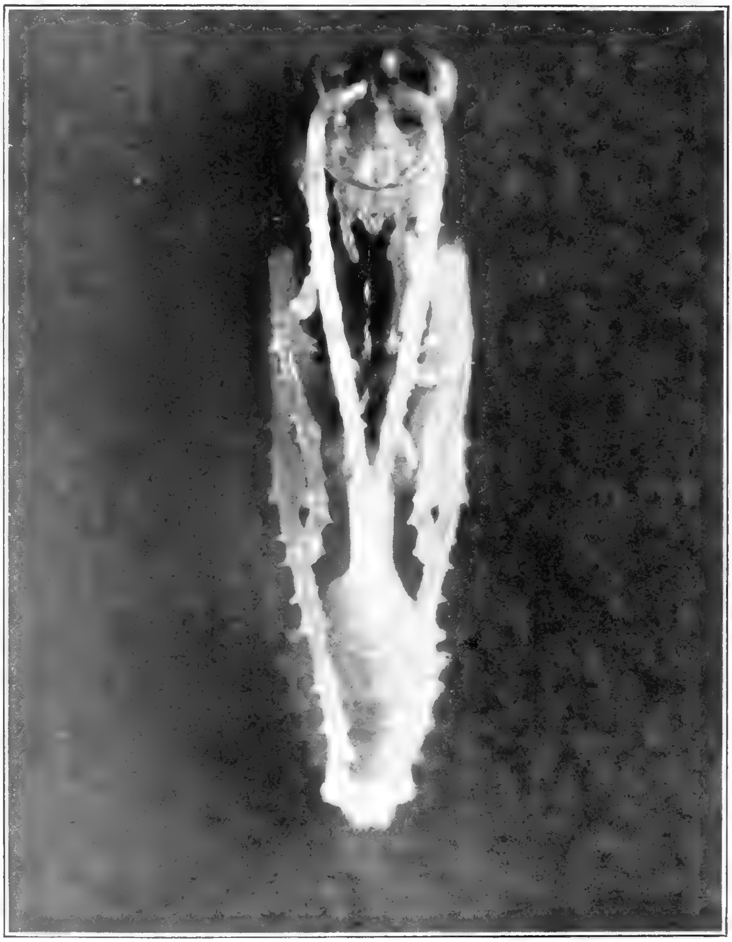
The roach-killer is a solitary mason wasp, who has taken advantage of man's intrusion into her domain. His houses and buildings afford safer quarters for her nest, which originally she cemented to the concave sides of stumps or forest trees. Now she has partly abandoned the old sites for the immovable wooden shutters of tropical civilization, where her rough red columns of clay stand for years as monuments over the birth beds of her offspring.

The nest, a single column of clay, two and one-half to four inches in length and close to three-quarters of an inch in diameter, consists of a series of V-shaped layers placed side by side. The entrance to the nursery faces toward the ground. Inside it is divided into several ten by twenty millimeter cells, never exceeding four in number, which, compared with the exterior, are quite smooth and polished.

Here is an interesting fact; if the wasp has chosen her original habitat among the stumps, she abandons it when finished as an inconspicuous gray blotch that blends nicely with its surroundings. In the forest she finds no red or orange clay for building material. The swamps yield a rich brown and the brook banks a shade of gray. The nest is of necessity somber in color. On the other hand, the nests placed in the shutters of houses were all of rich, orange-red clay, collected from a nearby excavation in the trail. They were conspicuous objects to say the least, but the wasp quickly covered her fresh paint with a neatly arranged layer of termite's wings, cast off spider's skins and other bits of refuse. At first I put the occurrence down as accidental, but careful examination leads me to believe that it is a regular habit of the wasp, in view of the fact that not a square millimeter of the underlying clay showed through the veil. When the nests were finished they appeared old and disused.

Each cell is usually provisioned with four wood roaches. Upon the last one placed in the cell a single white egg, with a yellow median line, is deposited. It is thrust under the fore leg of the roach, where the leg joins the insect's body. It is a tender spot where the young wasp, two days later, may easily bury its head in the creature's flesh. The number of roaches in a cell varies according to their aggregate. Thus a cell may contain two medium and one

Stages in the larval sacrifice, showing gradual changes from larva to pupa. (Life size)



Pupa of the roach-killer just after transformation from the larva. Greatly enlarged very large insect, or six small ones, and while there is variation in the number of victims, the total bulk and food value of each cell's contents remain the same.

Two days after the egg is deposited and the cell sealed up with clay, the young roach-killer hatches. It is but a tiny grub of thirteen segments, two millimeters in length, rather transparent and concerned only with its mouth and digestive tract. For two days it gorges, selecting only the tenderest, juiciest parts of its victims, leaving the legs and other less nutritious parts untouched. On the fifth day of its existence, it returns to these left-overs, going over and over them until all nourishment is gone.

One hears the glutton plainly at its feast. Sip-sip-sip, comes the rhythmic sound. Its entire body throbs in unison as the greedy creature dives deeper and deeper into the grab-bag of the roach's anatomy. In five days the feast is over. The wings, egg cases, shells of the heads and thorax, together with the hard limb skeletons of the roaches are left uneaten in the end. They lie about the cell in fine disorder as lasting evidence of the grub's revelry.

Immediately upon finishing the repast, the larva constructs a network of silken threads, just enough to prevent its rolling about. Within this cradle, an inner cocoon is formed, composed of threads much more densely spun, and finally coated within, with a reddish brown fluid that hardens in contact with the air, into a brittle skin. The process of spinning and coating requires eighteen hours for completion, after which the larva excretes the waste from its five-day gorge in a single mass at one end of the cocoon.

Spinning over, there comes a ten-day pause in the creature's activity, during which time we shall witness the Larval Sacrifice. This process, known as pupation, is in many respects the strangest and most wonderful of all physiological transformations that take place in the insect world. We will see the grub, which in reality is but the ancestral form of the wasp, transformed by what we might call a "second birth," from its lowly worm-like body into an utterly different and highly specialized member of the topmost order of modern insects.

We have traced the larva from the time the parent wasp deposited it as a tiny egg upon the roach's body. We have watched its growth from day to day and observed how it tackles one victim, consumes it, searches out a second, then a third and fourth: how it eats the tender portions first and returns later to coarser fare. Its actions are almost those of a creature conscious of its life and appetite, which thinks only of its stomach and so many good things to be consumed. But the minute the repast is over, and the cocoon spun, we see this energetic and ravenous bit of life cease all outward activities.

From young to full-grown larva, the creature is, in a measure, master of itself. It moves about in the cell of its own accord, feeds itself copiously and rests if need be, but thereafter it must surrender to an incomprehensible power, an invisible surgeon who will anesthetize the grub, tear down its old body and bring forth a new and better creature from the havoc of his scalpel.

During the operation, many of the larval organs and tissues are entirely done away with, and at the same time many parts of the new insect are derived from them. There is no spilling of blood, no suffering, no consciousness of what is taking place within the larval skin. From the exterior we see nothing to hint of what is transpiring. All is serene during the ten days that the operation requires for completion.

This strange process of "second birth" (I have no adequate term for it), is unknown in creatures other than insects. From the blood and tissues of the horse, the fœtus is produced, and eventually born. It arrives quite like the parent except for minor details. Without radical changes it feeds, lives and grows to maturity. In the chicken we have the egg, then the young, different at birth from the parent, but rapidly growing to resemble it, upon the addition of food to the youngster's stomach. In the wasp we have an egg, followed by a grub that is unable, simply by eating, to become like its parent. Something more radical is necessary, a complicated bit of surgery which will knock down the larval house and raise an imago from the ruins!

Thus in ten days after the larva spins its cocoon we see a slight shrinking of the body. A depression just off center follows. There is a tremor, ever so slight, then slowly the whole perfect insect unfolds from the grub like a nascent flower from its bud. It may require a million years for processes of evolution to become established into a train of events, yet here in the course of a few days, by watching this wonderful transformation from grub to pupa, we have actually witnessed the ancestral form sacrificing itself to a modern one!

The processes that bring about such radical changes in the insect are known as histolysis and histogenesis. The former covers the breaking down and disintegration of the larval tissues and the latter the building of the new body, in part independent of the old material. There is little known of these strange performances, yet it appears to be the general belief that for the most part the perfect insect is developed chiefly from the skin cells of the larva. Therefore, I shall set forth what I have been able to gather through the logic of observation, about this point. I make my statements guardedly—simply as facts that appear to have been overlooked.

A yacht is built and launched. She serves admirably as a pleasure craft and is quite satisfactory for that purpose. War is declared. She is commandeered by the government for patrol duty and must be altered to meet new requirements. She is dry-docked, fitted with guns, more powerful engines are installed, and lastly she is painted the battle color. Later the craft appears once more upon the water. Altered tremendously, the old hulk still serves the fundamental purpose. It is much the same with the insect. The larval wasp is commandeered by nature. She must be fitted to meet new conditions in order to perpetuate her race. Thus the task devolves upon histolysis, the wrecker, and histogenesis, the builder.

During the period of larval growth, from the time it hatches until the provisions in the cell are entirely consumed, the grub rids itself of no waste matter whatever. Unlike the larva of the butterfly that excretes every few minutes as it eats during the days of its worm life, the young wasp waits until its stores are gone and its cocoon spun before passing off the waste of its five-day gorge. Even then it waits another day before finally depositing it in a single mass at the lower pole of the cocoon. A few days later pupation takes place.

In the days which pass, between excretion and pupation, no foreign matter appears within the cocoon. The insect is motionless: its cradle, save for the hardened mass at one end, is scrupulously clean. I remove this mass, float it out in a little water and subject it to a thorough inspection under the microscope. It contains bits of chitin, hairs and fragments of claws, all, however, fragments of the deceased roaches. There is nothing unusual in the array, no bits of larval anatomy, no fragments of the grub itself. What then becomes of the material that histolysis is supposed to dispoil? Are the skin cells all of the grub's anatomy that serve to build the wasp?

I cut open the body of a grub, three days after the cocoon is spun. The greater part of it runs through the incision as a smooth, pasty liquid, amorphous in every way. At eight days, I open a second grub. Now it is partly paste, but mostly wasp!

The laborers of histolysis are not altogether wreckers then. They are concerned more with tearing down the old timbers, removing the rusty nails, puttying the holes and handing them back to the equally skillful employees of histogenesis, who in turn rebuild the house along more modern lines.

Twenty-four days after pupation the insect issues from the cocoon, drills a neat hole through the wall of its nursery and emerges into the sunlight a perfect insect. Behind her, she leaves a few, very tiny pellets of white excreta. These are the rusty nails from the old structure. They are all I can find of the larval body that is not incorporated in the new.

Fruit from the tree of instinctive wasp-love, the newborn insect is only an atom in the world, but what a bundle of unsolved mysteries to the humble student of her secrets! At her "second birth," she becomes her own mother! Not content with skin cells alone as building material, histolysis and histogenesis have rebuilt the Huntress from herself. She flies into the world with a fresh coat of paint, remodeled, a thing brought up to date, but somewhere underneath, lie the old timbers, reshaped and sawn to meet the new plan!

CHAPTER IV

THE WHITE-FOOTED WASP

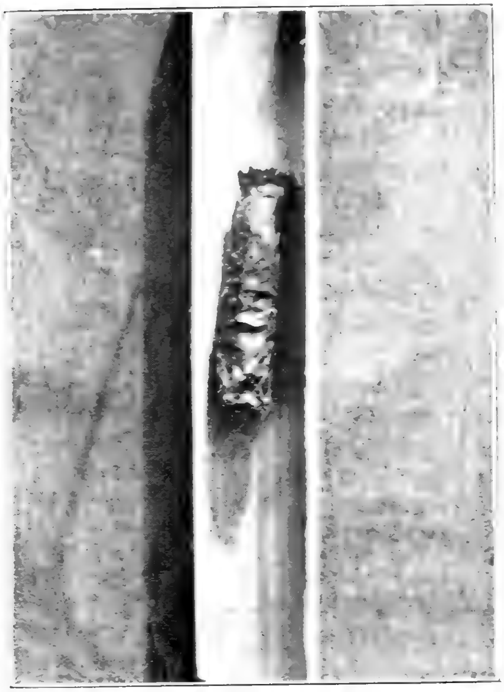
Trypoxylon leucotrichium, Rohmer

AN alert business-like insect, deep steel blue with a white band encircling each of her hind tarsi, the white-footed wasp is readily recognized. She inhabits the hot open trails where bamboo grass has been slashed in clearing, leaving here and there a severed hollow stem hanging in mid-air and supported by the plant's shriveled leaves, which catch among other foliage. These hollow tubes supply the insect's favorite nesting sites, unapproachable from below except by winged enemies.

The reed which the wasp had chosen had been severed by a knife slash so that its end was sliced off at a gentle angle. It hung four feet above the ground in a heavy patch of bamboo grass with its open end pointing toward the earth. Several other open reeds of the same character surrounded it, appearing to me very much the same. Not so to the wasp, however, she differentiated at once, and upon returning from her journeys, flew directly to the reed of her choice. There was no uncertainty in her approach, no repeated trials to find the proper entrance. A straight, single flight from the outer world to her tube marked her arrival. What a contrast to the clumsy one-banded dauber who wastes her precious time!

I first found the white-footed wasp gathering a ball of soggy clay in a pitfall trap in the trail leading to the forest. Several of these holes had been excavated and for their intended purpose of catching frogs, toads and the smaller rodents they were perhaps less produc-

Species of spider used as provender by the white-footed wasp.



Nesting reed of white-footed wasp opened to show elaborate cocoon.

Tangle of reeds and razor grass in British Guiana. In the ends of these reeds, when cut or broken, the white-footed wasp makes her nest.

tive than they were of wasps. The pits, after a rainfall, often contained several inches of water. When bailed out, a pasty layer of clay would be left in the bottom of each. This material, a ready made mortar, proved attractive to a number of wasps, which used mud in the construction of their nests. Tiny little reed-wasps, medium-sized ones, big blue huntresses, daubers and a dozen others collected at this abundant public property. Here, side by side, they gathered their building material, all laboring in a great common design for the welfare of their race in the future.

The wasp brought several loads to her tube, scraping it up from the floor of the pitfall and carrying in it little globules to her doorway. Once within, a high-keyed squeaking and buzzing would continue until the clay was thoroughly kneaded into a safety plug at the upper end of the reed. Her trips between nest and pit were continued for nearly an hour, like a hod-carrier laboriously plying between mortar box and masonry. After many trips back and forth she disappeared, returning in a little less than half and hour with a limp, paralyzed spider.

The victim, a medium-sized creature, was richly colored and patterned in various shades of brown. Its body was quite small, measuring six millimeters in width, but the legs, all of which were intact, were long and rather cumbersome to the wasp. With her burden she flew directly to the entrance of her nest. She alighted with difficulty, then turning about and grasping the spider by one of its palpi she endeavored to enter the reed backwards. All went well for a time. The victim's cephalothorax and fore legs caused no trouble, but its abdomen caught at once upon the sharp edge of the reed, which tapered almost to a point. From this point the spider would not budge—and what is more, was in great danger of being punctured. Had the wasp pulled too hard it certainly would have been impaled on the reed and ruined for future use.

Here I witnessed a most skillful performance. Clinging to the interior of the reed with only her two posterior claws, the wasp lowered the spider very carefully and deliberately until its entire body swung free in the air. Here, clasped tightly in the wasp's strong mandibles, it was held by its two front legs, and rotated, so that its abdomen came into the position so lately held by the cephalothorax. Then walking backward up the tube the wasp succeeded in bearing her victim to its last resting place.

As I have already stated, the wasp seeks out spiders which, although of moderate size, possess long, slender legs, and there is a simple significance in her choice. The wasp's nest is a hollow reed whose smooth perpendicular walls end abruptly in space. Her front door gapes in the void and must be approached from below. The spider's body alone is considerably smaller than the diameter of the tube. Thus were the wasp to choose a short-legged victim it would drop from the nest at the instant of release. The long legs of her spider are doubtless burdensome, yet they are a necessity to the success of her work. In drawing them into the reed, their legs fold back between abdomen and reed, filling the intervening space so nicely that the entire creature remains wherever the wasp places it.

Four of these spiders are allotted to each of the three cells, which are separated as the wasp provisions them, with plugs of clay three millimeters in thickness. Upon the side of the largest spider in each cell, a three-millimeter egg is deposited. It is slightly bowed, just enough to fit the curve of the spider's abdomen, slightly elongated at one end and about the color of skimmed milk.

The three cells vary considerably in size. One measures three inches, another two, and the third is an inch and three-quarters long. For these differences I can see no reason. So long as there are three cells in the tube the wasp is apparently quite satisfied to place her divisions at random.

The egg hatches in forty-eight hours, resulting in the characteristic wasp grub of thirteen segments. It commences feeding at once upon the stored spiders, first drawing off the soft parts, and later returning to less delicate food. During the first day of its life the larva grows only two millimeters. On the second and third days it averages five millimeters each. On the fourth day it goes back to two, grows eight on the fifth and finishes with a growth of one millimeter on the sixth and last day of its meal. The spiders are now entirely consumed and the grub measures twenty-six millimeters in length.

Without pausing for a moment to rest, the full-grown larva now sets about to lay the foundations of its elaborate cocoon. The insect is awkwardly placed at the outset, living as it does in a cell whose perpendicular walls are several times its own length, but fortunately at this period of its life it is endowed with an unusually tacky skin. This stickiness serves a special purpose, enabling the grub to remain safely in the top or center of its cell without the slightest danger of tumbling down to the mortar plug separating it from the cell below.

From its lofty position and in total darkness, the grub first throws out several bands of silk, fastening them in various places about the reed walls. It makes no choice of its own, but simply fastens each successive thread to the first point of contact. Some of the strands pass to points above the spinner, some below, and still others across the middle of its body to the wall beyond. At length the grub finds itself more or less enclosed in a delicate silken net through the strands of which it may still poke its head.

Thirty or forty new threads are now extended from the top of the growing cocoon. They emerge from various points in a circle, and are fastened to the cell wall above. The larva now returns to its original network, within which it spins a firm torpedo-shaped covering, slightly wider than its own body, nineteen millimeters in length and open at the upper end. Through this opening a ring of silk is spun, two millimeters in height, with a scalloped edge, the point of each scallop forming one of the thirty or more strands extending above the cocoon. The open top is now closed and reinforced with silk, the strands crossing and recrossing in every imaginable direction so that the cocoon now appears in the shape of a stubby cigar with an inverted parachute at one end. The strings of the parachute extend above, where they are fastened to the reed, thus suspending the entire cradle in the center of the cell.

The cocoon is now strongly supported from above. It hangs perpendicularly in the hollow reed, head up, and no matter how the larva thrashes about, there is no danger of falling. Two or three hours after the last silken thread has been spun, the grub continues its work, this time coating the entire inner surface of its cradle with a transparent or slightly yellowish fluid. A certain amount of this is brushed directly upon the walls as it oozes from the creature's mouth, but for the most part, the grub expectorates it upon its own ventral surface. From here it is caused to flow over its entire body by a strange series of muscular contractions. The operation is repeated over and over until the writhing creature is thoroughly moistened by the secretion. As the grub expands, contracts and turns its segments, the liquid becomes incorporated with the silk of the cocoon, wetting it thoroughly on the outside.

It is a varnish with strange properties that the larva employs,—a sort of cement which will adhere only to certain objects. When secreted it is transparent or nearly so. It amalgamates at once with the silk and hardens in contact with the air into a skin, purplish brown in color and brittle, like the inner covering of a peanut. Strange to say it does not adhere to the larva, nor turn color until compounded with the other material of which the cocoon is made.

The entire process of spinning and varnishing requires two full days. The grub then expels a large pellet of waste, the accumulation of six days of feeding, in the bottom of the cocoon. This hardens rapidly into a solid cake in a few hours. Sixteen days later pupation takes place.

Now comes the period of absolute quiet during which time the insect receives its color, which appears first in the eyes and gradually flows throughout the body and its appendages. The process requires some fifteen days. This is followed by a six-day period before the perfect insect emerges, to lay the cornerstone of a new generation.

CHAPTER V

PARALYZED PROVENDER

IN the black chambers of a solitary wasp's nest lie six growing youngsters. They are grayish, maggot-like creatures, each consisting of twelve rings or segments surmounted by a more or less bony or chitinous head that in turn supports a pair of sharp incurved mandibles. Their bodies are plump and pudgy; they possess no adequate appendages for locomotion and in the light their skins glisten, as if moistened with liquid.

Each will eventually become a wasp, an active dominant creature with a delicate taste for nectar. But that is far off in the insect future, perhaps some forty days hence. They are concerned now only with the meals that are set before them, spiders that the parent wasp has selected as dainty provender.

In each cell of the nest the mother insect deposits her bowed egg among the mass of spiders that are paralyzed by her sting. She hunts them abroad in the forest or among the fallen leaves in the sunny trails, discovers their hiding-place and swoops hawk-like upon the unfortunates. There is a struggle, perhaps, a short one; the wasp's sting soon finds its mark, plunges home, and in an instant the spider lies limply upon its threshold. The victim is not dead, instead it is only plunged into a state of paralysis that instantly binds the muscles fast. It cannot move again in self-defense, cannot command the power of its legs. It is still a living thing unconscious of life. Thus, slightly quivering from the shock and poison, it is borne to the victor's nest, deposited roughly in a cell with several other equally unfortunate ones, sealed forever from the light of day and abandoned as helpless living flesh for the young wasp to gorge upon.

In order to understand what has just taken place, let us examine the victim's anatomy and structure. In outward form spiders are divided into two distinct parts—the cephalothorax and the abdomen. We are concerned chiefly with the former, which is the first division of the creature, the head and thorax, as it were, combined in one. The central nervous system of the spider is, for the most part concentrated in a mass of ganglions clustered about the œsophagus. The œsophagus is a tube through which food passes from the mouth to the stomach. It lies in the central portion of the cephalothorax. That part of the central system lying above is the brain, from which the optic nerves and those of the biting and poisoning appendages arise. Lying below the œsophagus is the ganglion from which the nerves of the legs and palpi emerge.

Now, strange as it may seem, the wasp knows the above paragraph by heart. She was an anatomist long before man. She understood spiders long before man understood himself. Her teacher was instinct, an immortal master. Thus in stinging her spider she is like the master surgeon. With a single tiny wound above, with a single lance below, she accomplishes the desired end. Into the spider's nervous center instinct guides the wasp's poisoned dart. With precise strokes she reaches the ganglions of her victim and spills her venom. Henceforth no external outrage, however great, may be transmitted to the brain; no volition in return will command the forces of protest and defense. Like a party on a broken wire, the spider lies helpless with the central office paralyzed!

In preparing provender for the cells, the methods employed by the majority of solitary wasps are more or less the same. Yet the sting-poisons of different species produce two widely different effects on the victims. Both are doubtless forms of the same affliction; one, the commonest type, acts instantly, as I have just described. It causes complete paralysis throughout the muscles that control walking, biting, excretion and all exterior movements of the cephalothorax, abdomen and its appendages. The respiratory system appears to be all that is left uninjured.

The second form, which is much more rarely met with, is a gradual type, commencing with the deadening effect of heavy sleep, finally giving place to paralysis, some time after the victim is stricken by the sting. Let us observe the two cases in question. As an example of the first we have a medium-sized spider that has been stung by the white-footed wasp. Of course different kinds of spiders are selected by different species of wasps. But this is of no consequence, and will not affect the essential facts of our observation. If the creature is a spider it matters not in the least whether it be Gasteracantha, Filistata, Micrathena or any other jaw-splitting species. Spiders are the common prey of many solitary wasps, a fact which is sufficient.

The victim lies limply upon its belly in the cell. Enclosed in a tomb of solid masonry, it is abandoned by the mother wasp to its fate. Upon its flank lies the glistening egg of the slayer. Thus the unconscious living incubator awaits the pleasure of the maggot. Its legs are limp and motionless, its palpi equally still. To all intents and purposes the dejected object is dead, but there is still a flutter of life in the outraged body. An occasional shudder, barely discernible under the lens, a labored rise and fall of the abdominal walls evidences the tiny spark still unquenched.

In two days the young wasp emerges from the egg, glues its mouth to the plump spider and commences to draw the victim, drop by drop, into its own body. In twenty-four hours a shriveling sets in. Like a punctured balloon in the sky, the spider shrinks before the maggot's onslaught. Later, in order to taste sweeter fare, the

As they appear at close range

Two common bugs which do great damage to squash and pumpkin vines. Both the insects shown above are immature, the lower one being the common squash-bug in its dotted youthful costume

Enlarged four times

ravenous object plunges its head within the breach. It drinks, munches and revels in the spider's anatomy; eats from the inside to the out, chews up the bony walls, continues through the cephalothorax and finally consumes the legs. Then finding no more it pauses. After five days of orgy it is time to digest. Thus the spider is eaten alive, but from the first there is never a sign of protest, never a twinge of pain.

As an experiment, I secured several other spiders paralyzed by the same wasp whose grub I have described at its meal, and subjected them to various tests. One I denude of its legs, clipping them off at different lengths, thereby cutting through eight different nerves. From the second I clip the palpi, severing the nerves, and into the abdomen of the third I thrust a slender needle. Throughout these gross indignities the spiders lie quite motionless. There is no contracting of leg stumps, no drawing in of injured palpi, no quiver of punctured body. There is no response, no feeling in the creatures.

Such is the first condition of paralysis. We find it in a host of victims. The white-footed wasp, the blue huntress, the black reed-wasps and many others go in quest of the spider, another wasp takes frog-hoppers, still another, locusts, and there are many others that I will not mention. They are a merciful crowd. Under the respective jaws of their grubs, the victims lie completely paralyzed, relieved from the tortures of gradual execution.

The second form of paralysis is, as I have stated, much more rarely met with. At the present time I know of only two wasps that afflict their prey in this manner, but they will do very well as examples. One is the roach-killer (Chapter III), which stores her earthen cells with wood-roaches, the other, a tiny, unidentified wasp that supplies her maggots with a cricket each. Her nest is a hollow reed lying upon the ground, the end of which she plugs with a great quantity of wood—little chunks of charcoal from the cane burnings, bits of reeds, tiny twigs and woodchips barricade her doorway. Therefore, for convenience sake, I will call her the lumberess.

The modes of life of the two insects are in most respects widely at variance. They build individual types of nests, provision them differently, choose different situations for the home site and go about their respective businesses in separate ways. It is important, however, that the two have a single habit in common. The roach victims of one and the cricket prey of the other are affected in the same manner by the stings of the two insects.

I have before me two crickets of the lumberess and a dozen roaches of the roach-killer. These I collected from the sealed nests of the insects. Therefore, to the best of my knowledge they have been stung by the two wasps. I find in the victims a physical condition entirely different from that existing in the spiders paralyzed by the white-footed wasp. So differently are they affected that I do not consider them paralyzed at all.

The roaches are capable of moving every pair of legs, they can turn the head from side to side, also move all the mouth parts and their antennæ. But strange to say they lie motionless unless I touch them with a needle or the tip of my pencil. I place one of the roaches upon its feet. It lies absolutely still as though dead until I touch one of the protruding appendages at the posterior end of its body. As I do so it jumps forward without much effort, in the act, using each pair of legs. Now it waves its antennæ back and forth for a few seconds, wriggles its mouth and settles back into its torpor. With the crickets I try a similar experiment with the same result. Much the same thing appears to take place in these victims as one observes in a sleeping dog, whose foot has been tickled with a straw. It is quite peaceful and unconscious, yet its nerves and muscles respond automatically to rid the animal of its annoyer.

Certainly then, the insects are not paralyzed at this time, any more than a sleeping dog, for paralysis means the loss of power to contract the muscles, an accomplishment of which both the roaches and crickets are still capable.

Twenty-four hours later I experimented again upon my subjects with a result similar to that of the previous day. I let another twenty-four hours pass. This time, at the touch of my pencil point, the insect responded with a jump far less energetic than before. Every hour now brings a weaker reaction; at length there is little or no response to my efforts.

The sting of the roach-killer and that of the lumberess thrust their victims into painless sleep. The poison's action is not unlike alcohol. At first a powerful sleeping potion followed by a gradual, ever-increasing tying of the muscles, until they cease to move at all. Such is the second condition of paralyzed provender.

Let us now endeavor to discover the causes leading to these two distinct types of paralysis as we have observed them in the prey of solitary wasps. Having already glanced at the spider's anatomy, it will be well for the sake of comparison, to look into the anatomy of the roach. In the first place the two belong to different phyla; one is an arachnid, the other an insect. Therefore they will differ physically.

In the spider we find the ganglions clustered about the œsophagus, concentrated into one particular section of the body and easily accessible. In the roach they are spread, more or less, throughout the insect. There is a brain, three pairs of ganglions in the thorax, followed by six pairs in the abdomen, a problem indeed for the wasp who would paralyze such a complicated creature.

I have not been fortunate in observing either the roach-killer or the lumberess in the act of stinging their prey, but here is what I believe to be the case in view of the facts: To reach the isolated nerve centers at the outset, to bring instant and complete paralysis to her victim, the wasp would find it necessary to drive her sting into as many different places as there are ganglions. Judging from the condition of the prey it is a feat quite beyond either the roach-killer or the lumberess. Therefore they must depend upon one or two thrusts to stun the insects. As the sting plunges home it ejects a tiny drop of poison which gradually spreads throughout the victim's body, bringing on, in due time, the gradual paralysis that we have observed.

Gradual paralysis would appear to be dangerous to young wasps. They are very tender creatures. A cricket or roach thrashing about within the cell would soon cause fatal bruises, but nature has looked out for them nicely. If undisturbed, the roach and cricket lie quietly enough. Upon their lower surfaces lie the wasp's white eggs, but they are motionless. In forty-eight hours the wasplets emerge, tiny creatures, three millimeters in length, whose baby mouths do not disturb the sleepers. In another day they begin to really chew their hosts, but by this time paralysis has set in.

There is no significance in the two types of paralysis. They are present in the spider and the roach, simply because of the physiological difference existing between the two. Thus the grubs of the roach-killer and the lumberess and those of the spider hunters live much the same. One is as safe in its respective cell as another, so there we shall leave them.

CHAPTER VI

THE FOREST SHELL-WASP

Zethusculus hamatus Zav

HOW early one thing begins to support another in the jungle! Even the infant, thread-like air root, new born from the parent liana, sustains a spiral of fairy moss and later a tiny emerald wasp's nest, fashioned from the ribbon of the sporophyte. The great cool jungle reminds me of a jig-saw puzzle, the pieces of which are its life, entwined and ingrown, each using another for its own particular success and to complete its part in the great green picture. A giant liana supported by a still greater tree; thread-like offspring supported by the liana, fairy moss living upon the thread-roots, wound in its turn into the hoop-like walls of an insect nursery. Here at least are five fragments of the great puzzle we see fitted together.

The nursery which belongs to the shell-wasp of the forest reminds me of two algæ-grown snails, one clinging to the slender stalk, the other to its sister's tapering shell. In reality, the two shells are the cells of the nest fashioned from the ribbon-moss which grows upon the air-root. It is very delicate material. One must look sharply in order to see that it is a thing separate from the mere thread that supports it. Peeling off the ribbon, the wasp winds it into little hoops, one upon the other, and cements it together with her own personal glue. The building material, when dry, is tough and quite waterproof. Some twenty hoops, half a millimeter in width, complete each cell, and the freshly made nest gives off an emerald sheen.

In each cell a stumpy, slightly bowed egg is laid, two and a half millimeters long and a third as wide. It is yellow in the center, fading to a transparent white at either end. The yellow center is in reality the young wasp, and the transparent end, the extremities of the film-like egg shell. The eggs are laid one at a time, that is to say, the wasp deposits in one cell, waits for it to hatch, then provides the young with sufficient food to bring it to maturity and plugs the cell with moss before laying the second egg.

Its chosen prey is doubtless small caterpillars, for I found three uneaten heads in a cell containing a full-grown larva. The egg is attached to the roof of the cell by its posterior end near the back, and hangs downward. Thus the young wasp hatches with its head in mid-air.

The mother wasp guards her cells closely during the period of incubation, often resting within the cell containing the new laid egg. She crawls to the entrance on the roof of the nest, then turning round, backs in, clinging to the underside of the roof. Her head peering out, with its antennæ waving here and there, adds to the illusion of the nest being the shell of a snail.

The two nests on which this life history is based were found on May 14, in the deep forest. One of them I lost, but let us go back to that day and the remaining nest. If I leave it upon its swaying air-root for further observation, I will probably never find it again. It blends perfectly with the emerald surroundings, a tiny object in a part of the forest that I have visited but once. Therefore I will carry it home to the laboratory just as it is, and put myself in difficulties at once.

The first cell contains a full-grown larva and the second is empty, save for a single, freshly deposited egg. The larva is quite satisfactory. It has finished its meal of caterpillars and will soon pupate, giving me much desirable information and no trouble. But what of the egg? If true to the rule, which is usual among solitary wasps, it will become a hungry living grub in forty-eight hours, how then shall I feed it? I have not given the parent wasp a chance to store provisions for her larva, yet I am responsible for the orphan.

The young of solitary wasps are fed on a variety of material, but spiders and caterpillars seem to be most frequently chosen as provender. This I know from experience gained in the examination of a great many nests. In the light of the present difficulty it may prove a valuable bit of knowledge. The victims are stored within the cells in a paralyzed condition from which they never awake. If they were killed outright, they would soon putrefy in the cells, contaminate the budding wasps and turn the healthy nursery into a colony of lepers. Therefore instinct, the great teacher of insects, guides the wasp's sting only into the victim's nervous centers. The creature so treated, passes into a comatose condition and lies powerless to move or struggle while the young wasp sucks at its viscera. This, then, is my grewsome course: I must catch, artificially paralyze and present living food to the shell-wasp's grub if I am to rear the orphan successfully.

A search for caterpillars of the proper description is entirely unsuccessful. They must be minute, soft, and without hair upon their bodies or the youngster will die of indigestion. Moreover it is the off season for them and unlike the wasp I cannot find them by the sense of smell. Therefore as an experiment I substitute spiders for the proper diet of span-worms. Spiders are abundant and easily paralyzed.

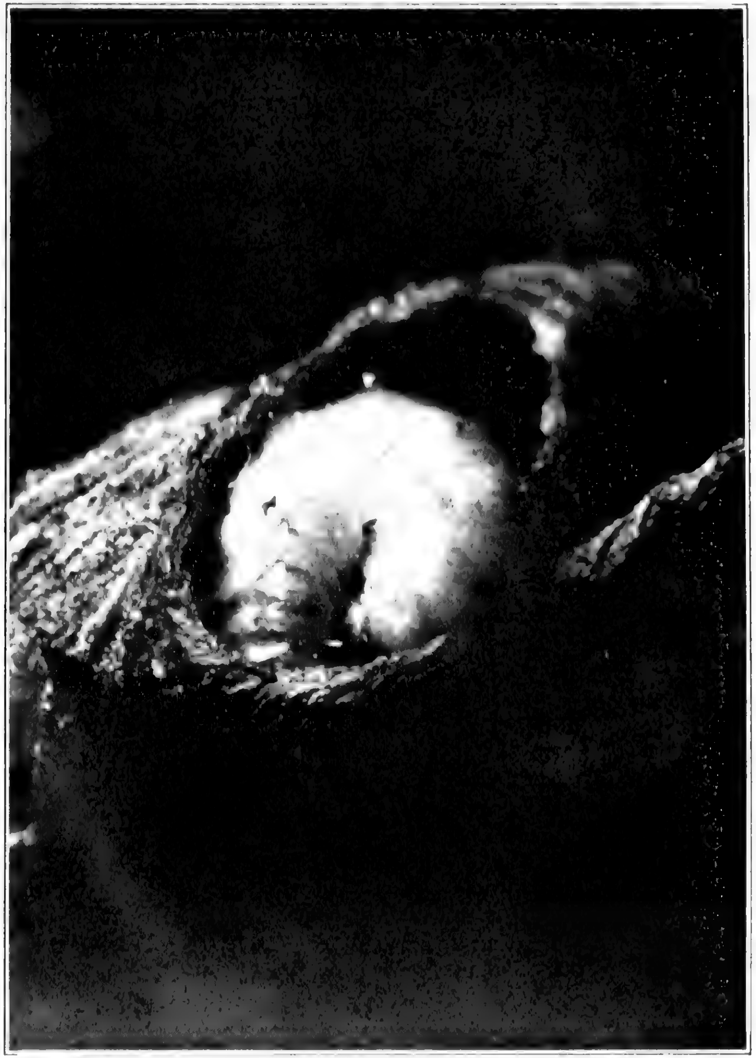
The nervous system of a spider is concentrated in a mass of ganglions gathered about the œsophagus. It lies in the cephalothorax, or in that section of the creature which is foremost, there being but two divisions.

I secure my first victim from its web in the window corner. It is a long-legged creature with a good plump body, soft and unprotected. With a little chloroform, I anæsthetize it, just long enough to keep the creature quiet. As soon as it is still, I clip its legs off quite short, then with a very slender needle I stab the cephalothorax in two places, once from above, once from below. My object is to reach the ganglions mentioned above, thereby injuring them with my needle and producing a sort of paralysis in the spider. The experiment works well enough. The victim quivers for a moment, then lies motionless. With my crude sting, represented by the needle, I have imitated as closely as possible the methods employed by the parent wasp in preparing food for her offspring.[1]

Now I place the spider in the cell just under the suspended unhatched egg of the wasp and await developments. In two days the young wasp emerges from the shell, and hangs head down, still attached at its anal segment to the cell wall. For several hours I keep close watch, during which time it pays no attention to the paralyzed spider. It scorns my work and the repast I have prepared and hangs helplessly, its mouth sucking rhythmically at the air. Now I move the spider so that one of the stab wounds in its body comes in contact with the larva's mouth. It responds frantically, like a creature dying of thirst, to the liquid that oozes from the wound. It fastens itself by the mouth to its victim and there it clings like a suction pad, its entire body rippling as it drains the spider's life.

Much to my surprise the experiment is crowned with success. In a few hours a change is noticeable in the larva—it has grown and gained in strength. At length it pulls away from the walls of the cell and settles among the spiders I have provided. It is an experiment especially prolific in answering abstract questions and suggesting others. It proves that all larvæ are not entirely dependent on one certain article of diet. Doubtless a given species is invariably supplied by the parent with the same kind of food, yet we have posi-

Nest of the forest shell-wasp swinging like two snails upon a slender air-root. Enlarged four times



Opened nest and larva of the forest shell-wasp. Enlarged seven times

tive proof that such a condition is not imperative. The larva has no more abhorrence for the spider than for its natural diet of caterpillars. If the mother wasp but knew the truth she might store her nest with the ever abundant spider in years of caterpillar scarcity.

Further, the experiment points out that in the wasp's victim, paralysis may be brought about by the thrust of the dart unaided by its poison. It is the stabbing and injuring of the ganglions that produces the effect, at least in the case of the spider.

Is the poison of the wasp a potion for prolonging life in the stores, rather than an agent for producing paralysis? Do wasps that attach their eggs to the cell walls, leave the doors open until the young wasps hatch, for any particular reason? These are questions that the experiment suggests. But let us go back to the insect's life history.

At birth the young wasp measures two and one-half millimeters. It is a milky white grub of thirteen segments counting the head, which is a round bead-like affair. As it feeds and increases in size the distinction of the head decreases. At first the head is nearly the same diameter as the body itself, but the latter soon takes on flesh and grows many times its original size, so much more rapidly than the head that it soon greatly surpasses it.

I continued to feed my orphan for five days, which is the average length of time spent gorging by the Guiana grub. During this time it consumed several small spiders that I paralyzed and placed before it, reaching in the end a length of seven millimeters and turning a pale yellow color, much like clouded or partly sugared honey.

Now the grub lies motionless for three days, when a pellet of undigested bits of spider is deposited in the cell. No cocoön of any kind is spun; instead it lies upon the bare hooped floor of the nursery, apparently quite contented. All wasps rid themselves of what waste has accumulated during larval life in this manner, a short time prior to pupation, the majority placing it in the lower pole of the cocoon, where it acts as a solid plug. When the waste matter is expelled the grub often loses its original color, which is due only to the sewage showing through its transparent skin. In the case of the shell-wasp, it changes from a clouded honey color to white, slightly tinged with yellow. It also becomes more opaque.

Ten days after excretion the insect pupates. Then comes another wait of three weeks before the final wasp issues from its cell.

During these twenty-one days, the pupa receives its finishing touches—at first, when the transformation from the larval state takes place, there is no dark pigment in the body. It is yellowish white and rather translucent. Color appears first in the eyes, which turn light lavender, then brown and finally black. Next, the pigment appears in the remainder of the head. Then, as though coming through some hidden tunnel below the flesh, it appears as a mere dot of dark fluid in the center of the thorax. Slowly the dot expands, throwing out arms of color which later combine and fill the entire thorax with pigment, like a rocket that unfolds its display in the sky. Next the slender petiole of the abdomen becomes clouded. This soon gives place to darker color while its recent cloudiness appears in the abdomen itself. At length the entire insect turns black save for the three small orange-yellow patches on its abdomen.

This general dullness is due to the pupal skin in which the finished wasp is now resting. We see it through this delicate membranous covering which is immeasurably thin, and fits the insect as closely as her own external skeleton. Under the transparent covering the insect appears dull, but otherwise quite normal except for her wings. Her legs and antennæ are of proper length, her head and body neatly proportioned, yet her wings are but a third the natural size. They are hollow appendages intricately folded and held in place by the wing bags of the membranous covering. Later with the pupal skin of which they are a part, these bags are shed, releasing the true wings, which unfold to their full extent under a pressure of liquid which flows into them from the wasp's body. Later the liquid is withdrawn and they dry as thin, brittle appendages.

When the pupal membrane is cast the wasp requires at least another day to rest and gain strength for her emergence. She does not issue into the world in the wet, weak condition of the butterfly, to rest and dry in the sunshine before flying to seek her mate. Instead she makes her toilet within the cell and waits for full strength before emerging. Then, everything ready, with knife-like mandibles, she cuts a neat round hole through the mossy wall and casts herself to the lot of fate.

We see her as she emerges, all glistening with the youth of a new generation. A scant forty days have passed since the mother wasp fashioned the emerald nursery upon the swinging air root.

CHAPTER VII

THE ONE-BANDED DAUBER

Sceliphron fistulare (*Dahlb*)

THE physiological phases of the dauber's life history naturally adhere to a set of invariable rules—the egg hatches in a certain length of time, the larva feeds until the spiders in its cell are consumed and in the course of certain definite periods the insect pupates and emerges. Her nest is of clay, her provisions spiders, but otherwise, in the remainder of her nesting activities, this wasp is a creature that follows no rule. Her nursery may be but a single earthen cell or it may boast a group of twelve. It may be fastened to a twig, to the side of a house, to a sheltering stone or on the edge of a narrow shutter slat—one nest is a long flat object humped at one end with additional cells and decorated with strips of variegated clay, another is top-shaped; still another is but a single gray cell, half circular at one end and quite round at the other. They vary endlessly according to the energy and taste of the individual builder, therefore I cannot describe any one nest as the usual type—I may tell only of the building of a cell. It may be the first room framed in an elaborate plan, or the completed nest of the dauber, but my remarks will apply to any nest.

Upon a brick pillar supporting the laboratory the wasp laid the corner-stone of her nest. Twelve loads of brown mud, tamped out into flat pies, side by side, sufficed for the foundation. The material was carried in little round pellets weighing one-tenth of a gram. They were borne in the wasp's mandibles from a moist spot in a flat clearing nearby. Each pellet was tamped and arranged with great care, during which time the wasp buzzed continually and held her abdomen at the end of its long petiole high in the air, as a balance weight to the lowered head on the other end. The forelegs were used as much as the mandibles, thus her dumbbell-like body swung pivoted upon the central pair of legs.

When the foundations were laid she proceeded with the cell itself, bringing thirty loads of mud per hour. In a little over two hours the cell was complete, a neatly rounded tube, thirty millimeters long and sixteen millimeters in diameter, the result of some sixty-five loads of mortar.

In fashioning the tube, the first few pellets were deposited side by side and raised into a semi-circular mound, or half disk stood on end. Here again the work was accomplished with her mandibles and forelegs. The clay was pinched up between the tarsi and then shaped principally with the mandibles, which acted like a pair of flattened tongs. When the disk was finished the successive loads of mud were pressed against its inner surface, usually at one side and then moulded into a narrow ridge running around its circumference. Thereafter each pellet was fashioned into a ribbon of plaster placed against the side of the preceding layer. When the job was finished these individual layers were quite visible so that the separate rings of which the nest was constructed could easily be counted.

In coming to her nest the wasp often experienced great difficulty in locating it. She would approach the brick pillar with her mortar pellet, circle the column once and then alight, as a general rule, some distance above or below the nest. A thorough inspection of the spot to which her general sense of direction brought her, would follow. This inspection never extended beyond one or two bricks at most. Finding the cell missing, she would take wing, circle the pillar once more and alight in a new location. Sometimes this performance was repeated over and over, until at length she would come by chance upon the brick supporting the object of her search.

Different species of wasps vary greatly in degrees of accuracy in finding their nests. Some experience no difficulty whatever, others have slight trouble, while still others spend at least one-third of their nesting period searching for the elusive keyhole. So true is this among solitary wasps that they might be divided into several groups in the order of their respective accuracy. One group would contain the wasps which build their nests in the ends of hollow reeds. The home doorway may be in the midst of a dozen others, yet the owner flies directly to her own threshold without an instant's hesitation. The long black reed wasp [1] and the white-footed wasp [2] would be shining examples of this enlightened group. Again we have such wasps as the red-legged digger [3] who locates her tunnel in the ground only after a series of circular flights in the air above it, much as a carrier pigeon does upon release, before turning in the homeward direction. In the third group, the one-banded dauber might head the list of blunderers who find their cells only after a search, sometimes of great length, with the loss of much valuable time and energy.

I do not believe that sight is an important factor to be considered in any of the above cases. Most insects do not see such small objects as their nests clearly from a distance. It is, to some extent, a sense of smell, after the main journey has been accomplished, but they rely chiefly on a sense of direction. Some have it more highly developed than others, just as the Indian finds his way in the forest unaided by compass, where another individual, a white man, would fail or perhaps blunder through to his camp. The one-banded dauber flies accurately enough to her brick pillar, but lacks that balanced

[1] An unidentified species of Trypoxylon.
[2] Trypoxylon leucotrichium (Chap. IV).
[3] A species of Sphex.

sense of direction that lands the white-footed wasp in a single flight at her doorway.

In the wooden shutters of the laboratory, I found further evidence of the dauber's stupidity. For a nesting site, she had selected in this case the narrow edge of a slat, situated midway between the top and bottom of the shutter. Below her site were a dozen other slats, each affording a building plot similar in every way to the one she had selected. Above her were as many more. This made her work difficult; as it finally proved, too difficult for her limited sense of direction. She laid the foundation of her nest in a maze of sites, each exactly like those above and below, and in the end her design perished. Her pellets of mud were deposited upon four different slats, one below the other, until four different cells, three inches apart, commenced to take form. Arriving laden with her ball of mud she would fly to the general location of her original foundation, but to distinguish which slat among so many similar ones supported her original masonry was quite beyond her. Thus she worked, vainly endeavoring to finish her nursery in the usual space of time, laboring the while on four widely separated cells! Eventually she abandoned the job in despair, and indeed it must have been discouraging. To return, hour after hour, laboriously carrying that heavy mortar to a house that refused to grow, might easily discourage a stouter heart than the dauber's.

That she concentrated her efforts entirely upon four slats was an interesting fact. It gives us some idea to what degree of perfection her senses of smell and direction are developed. The first slat bearing evidences of her workmanship was situated twelve inches above the fourth and lowest one. Now as the wasp always returned, with her pellets, to one of these four, it is logical to suppose that her sense of direction was developed accurately enough to bring her within twelve inches of the actual location of her nest. Observation of the insect whose nest I found upon the brick pillar strengthened this evidence. This wasp never returned directly to her nest at the outset, but at the same time never alighted with her burden more than a full twelve inches from it. From such a position she would walk about in a zigzag course, until at length the brick bearing the nest was reached. Once this "home brick" was located, the insect would walk straight to her nest. The dauber returns to the general locality without much difficulty, but actually to reach the cells she must feel about with curled antennæ, and depend upon smell rather than a mere sense of direction.

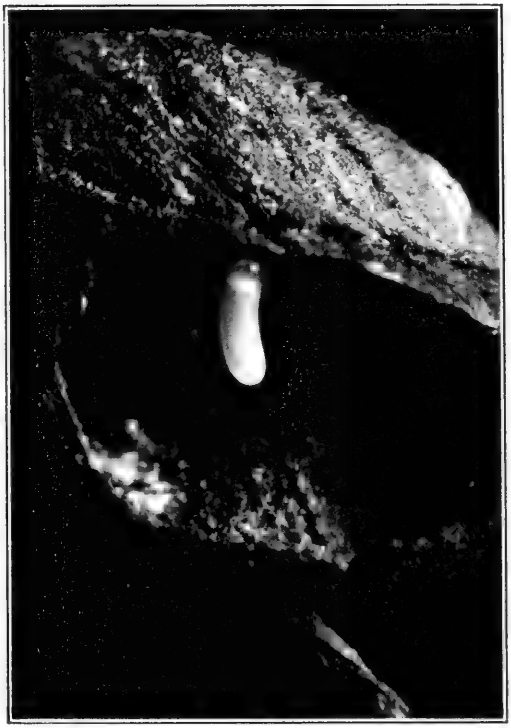
To build a cell, including its foundation, requires between seventy and eighty loads of mortar. The freshly made nursery weighs about seven and two-thirds grams, but by the time it is ready to receive provisions, evaporation has reduced it to three. From these figures I conclude that to build a nest containing ten cells requires some seven hundred pellets of mud. In accomplishing her task the tireless, energetic mason carries 1,000 times her own weight in mortar and fashions it grain by grain into the abode for her progeny.

In storing her cells, the dauber shows a varied taste. I have before me two open cells. One contains two large fat spiders that easily fill the storeroom, the other is stored with a variety of victims, nine in all, including many grades of size and color. In these two cells I have at least two genera and five different species of paralyzed spiders.

Upon the side of the abdomen of the largest one in each cell, the wasp deposits a pale yellowish white egg, then she seals the nursery entrance with a few pellets of mortar and abandons the nest for good.

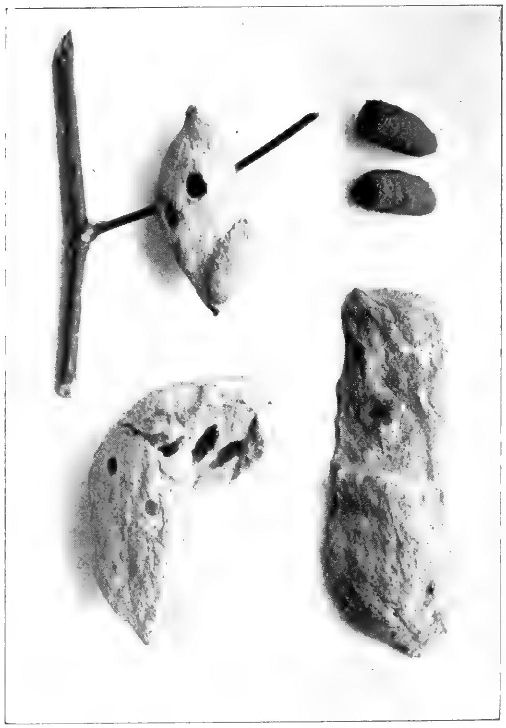
In seventy-two hours the egg hatches, or I should say, comes to life. Here is a strange process. Watching the erstwhile egg through the lens, a spasm suddenly takes place within its film-like shell, which is nearly transparent and allows a fairly clear view of what takes

One-banded dauber freshly emerged from her cocoon. Enlarged twice



Suspended hatching egg of the forest shell-wasp. Enlarged seven times

One-banded dauber working upon her nest. One-third natural size



Four types of nests made by the one-banded dauber. One-third natural size place within. This spasm is a sort of pumping wave, similar to the movement in a big fire hose under pressure from the engine. It starts at the anterior end of the egg and traverses its entire length, fading out as it reaches the opposite end from which it started. Thus does the new-born take its first mouthful of liquid food from the spider. There is no actual hatching and crawling forth from the egg, no empty shell behind the larva. Instead, its mouth appears first to eat a tiny opening through the film that encloses it, after which the grub finds its mouth flat upon the spider's abdomen. As the pumping spasms continue, each one representing a swallowed mouthful of spider substance, the nursling increases very gradually in bulk. In a few hours after taking its first draught of foodstuff, the egg-film apparently splits along the center of the larva's back, one end of the breach traveling in either direction, exposing the actual skin of the young wasp. The breach spreads like a drop of oil upon water, only much more slowly, but twenty-four hours after the first spasm not a vestige of film remains. It appears to have been absorbed into the larva's body. Under the lens it vanishes slowly before my eyes, yet I cannot see where it goes, and when the process is over I can find no trace of it, either on the larva or its spider host. The grub is a living dialyzer through whose delicate skin the egg-film appears to osmose. In other words, I believe that the film is absorbed into the insect's body in minute particles in much the same manner that food passes through the walls of the œsophagus to reach the distributing corpuscles.

It is possible that the larva eats the egg-film, but if so it is drawn into the mouth so gradually and with such skill that it is impossible to detect the operation. Therefore, I suggest that the process may be akin to osmosis. The action is so gradual, so smooth and uninterrupted that I can think of no other way to describe it.

At first the young wasp lives only on liquid foods. During the first few hours of its life its mandibles are of a very rudimentary character, in fact scarcely distinguishable until the grub is a day or more old—and are developed gradually to be in readiness later when substantial parts of the spider must be eaten. The fact that at birth the grub possesses no adequate appendages for chewing suggests an interesting question: How does the tender creature make the first incision through the mature wall of the spider's abdomen? Perhaps the parent wasp pricks it and uses the minute drop of fluid that oozes from the wound as mucilage with which to secure the position of her egg.

The grub feeds for six days—during this time it goes about its meal in a thorough manner so that in the end not a hair of the stored spider remains. Further the larva has changed greatly in size. At birth it measures four millimeters, now it is seventeen millimeters long and ready to spin its cocoon.

Spinning is a laborious process requiring three whole days. A slight network of silk is first thrown about the cell, within which an inner cocoon of a far more substantial character is then constructed. It is somewhat longer than the grub, torpedo-shaped and reddish brown in color, which is due to the varnish, so commonly employed by the larvæ of Hymenoptera, showing through from the inside.

The cocoon is in no way remarkable, in fact it is quite simple. I have seen other larvæ build more elaborate ones in a day, yet the dauber requires seventy odd hours for so simple an operation. Its nature is sluggish from the outset, and throughout its immature life it is slow about its affairs. The egg requires three days to hatch, the grub feeds six days, therefore it logically follows that spinning should be a leisurely process. Consequently, the grub takes its time and is none the worse for it.

Seven days after spinning, pupation takes place. The creature now lies motionless in the usual quiet state that accompanies this condition. Colorless and stately, lying upon its back with folded arms in its tomb of masonry, the pupal corpse awaits a reincarnation that in twenty days brings forth a perfect insect.

Stupid affairs of the wasp world are generously heaped upon the dauber. Before me lies an oddly-shaped nest of her making which I have opened for inspection. It contains twelve cells and as many cocoons, ten of which have been burst open by the young wasps who, alas, lie dead and shriveled in their cells. Their heads face the mortar-plugged doors of the prison, which bear marks of frantic efforts to escape, yet each has died of starvation, unable to reach the outer world.

Herein lies the reward of stupidity. The dauber, whose life seems made up of errors, chose for her nest the first mortar that she chanced to find. It was not soft gray mud from a puddle, or the sandy orange surface of the clearing, but a pasty yellow clay. It kneaded admirably when soft and fresh but in hardening turned to rock. The offspring grew normally within, spun their cocoons and passed successfully to finished insects, but were unable to emerge. They hammered and gnawed and scraped at the mortar; the nest bore evidence of the effort put forth, but all in vain. The mortar resisted and the young wasps died. Thus on the very eve of their emergence the dauber's offspring were obliterated by her stupidity. I wonder, even if there were a tiny glimmer of intelligence in her little dome, whether she would see the error of her ways?

CHAPTER VIII

THE BLUE HUNTRESS

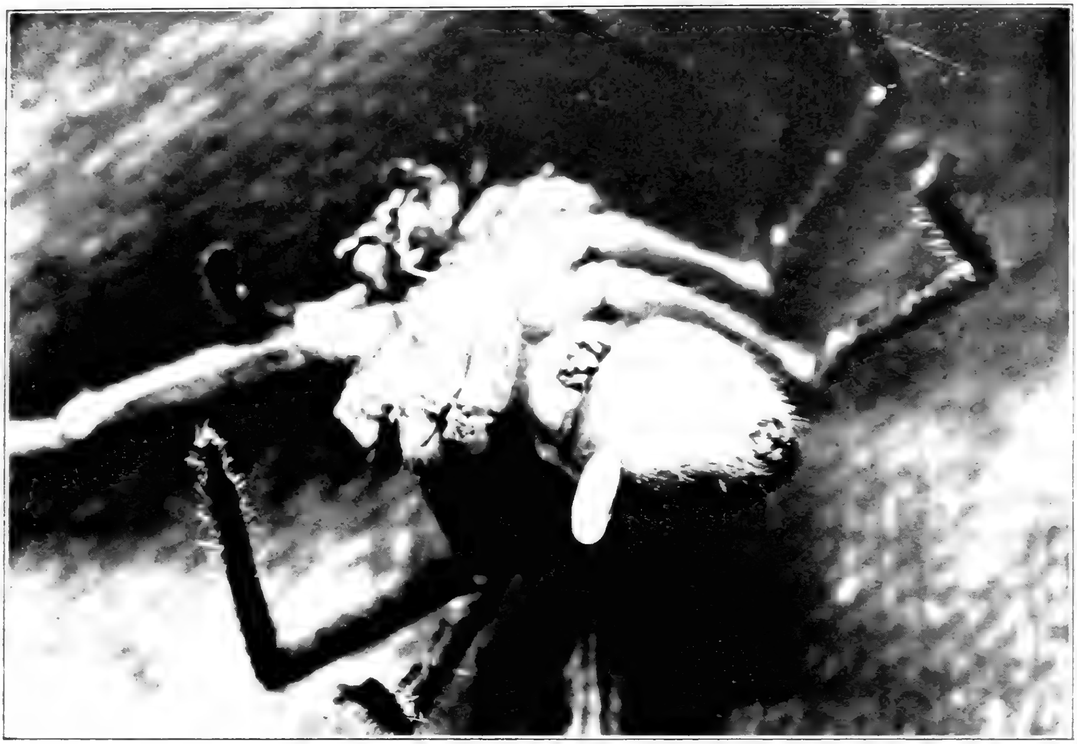
Chlorion neotropicus, Kohl

CLOSE to the out-house, whose rough frame supports the nursery of the blue huntress, lies a heap of rich red-orange clay, thrown up from a pit on the trail to the forest. It attracts a dozen busy mason-wasps who arrive from far and near to gather up the pliable, ready-made mortar and bear it away to their nests. We are concerned only with a single member of the laboring crowd. She is at once distinct in size. Her rich metallic color attracts our attention and holds it over eleven less comely ones.

The cement which she is gathering is pliable like putty, but filled with tiny bits of stones that make its contents similar to that of very fine concrete. These tiny stones, which are large rocks to the insect, lend themselves admirably to the needs of her nest. They lend a rough, rugged appearance to the three-celled nursery, but form an impregnable barrier against a host of enemies.

The building material is laid on in irregular heaps. They dry very rapidly as the work progresses, giving the nest the appearance of a bit of fairy hill country covered with a thousand disorderly loads, spilled helter-skelter from as many tiny dump carts. The wasp cares little for outside appearances, which are of no account. She is concerned chiefly with finishing the interior, which is a far more serious matter.

Within, the cells are quite as smooth as they are rough without, a condition necessary in view of the delicate contents they are to



Spider prey of the blue huntress, showing egg of the wasp attached to its abdomen. Greatly enlarged

Pupa of the blue huntress, showing T-shaped jacks, which support the creature's abdomen, thus protecting its legs. Greatly enlarged

shelter. The slightest projecting bit of stone work, even a sharp grain of sand overlooked, might injure the tender bodies of the insect's offspring. Thus we see her tamping a tiny pebble or a bit of hardened mortar, until it sinks into the smooth wall of the chamber. Over and over, she inspects her work, scraping, brushing, tamping, until the cradle bears no resemblance, except that of color, to the coarse, sticky substance from the pit. Her nest reminds me of a callow suburban home, terra cotta and jagged stones. Her taste is not cultured, but we may excuse her quite readily. She specifies these droll materials for a vital reason.

The huntress is a skilled worker—she is a prodigy, requiring but a single tool to fashion the mortar nursery. The tip of her abdomen is a veritable tool chest all in one, a universal appliance with which the work is done. True, she gathers and carries material with her mandibles, but the house itself is wrought by the last segment of her body. It is a modeler's gouge, with which she measures the cells, decides their contour, smooths their walls and fashions the entrances. Throughout the building one finds tiny, triangular indentures, where the tool has left its impression.

The finished nest consists of three tubes, placed one upon another. They are open at one end, where the entrances are slightly funnel-shaped like the mouths of flower vases. The tubes or cells measure thirty-four millimeters in diameter. There is variation to a slight degree, but the measurements are the average of several nests. The insect works energetically, completing the work in five days. One cell is constructed, provisioned and an egg deposited, before a second one is commenced.

As soon as a cell is finished, the wasp sets out in search of provisions with which to assure the successful life of her offspring. She travels the open sunny trails, or the dark floor of the forest. One is as good as another, provided there are dead leaves or fallen branches that shelter her prey from less agile creatures than herself. We see her alight upon the ground and search diligently under every leaf and branch that chances in her path. Her antennæ are curled over, so that the end of each forms a perfect loop. She thrusts them ahead of her and depends upon their sensitive pores to locate the big tawny spiders that constitute her prey. She is always nervously alert, her body tense and ready at an instant's notice to spring back out of danger. As she works, her big, steel blue wings quiver continually as though with excitement over the possibilities of each new leaf and shelter that she explores.

Her course is irregular. Here she searches for perhaps a minute, followed by a longer investigation some fifty feet away. Now the hunt leads her back to the starting point and later to the intervening ground, which is searched minutely. At other times she walks in a zigzag fashion for a great distance, even though unsuccessful in the end. It is a surprise to me that she finds her elusive and protectively colored prey at all. You wonder why? Then search among the leaves for the spider that serves to provision her nest. You will scarcely find one, even in a whole day's hunt, yet the huntress is a dominant insect, seldom defeated in her quest.

At length the spider is found lurking beneath a brittle leaf. Her antennæ telegraph the information to a tiny brain and instantly the wasp springs back as though surprised. A second later she recovers and thrusts herself into the spider's den. Her body bends under her so that the deadly sting protrudes almost beyond the head. At the first movement from the spider, she springs back again with quivering wings. The manœuvre is repeated over and over until her prey is at length forced unconsciously into a convenient position. Then, like a flash, she is upon the unfortunate. Her sting plunges deeply into the creature's nerve center and instant paralysis results.

The spider is not killed outright. In that case it would decompose and become dangerous fare for the young wasps. Instead, it is simply paralyzed. It will never move again to protest, or protect itself. Perhaps it may react automatically with a slight quivering of the legs when touched, but henceforth it will yield to whatever fate has in store for it. The victim will awake from unconsciousness only as a part of another living creature, when spider substance has been eaten to build the body of a wasp.

The spider is a larger creature than the wasp herself, yet she manages to fly laboriously to her nest, carrying her victim by one of its palpi, clasped between her mandibles. To gain access to her nest, she must enter the outhouse through a slatted window, the lowest part of which is three feet from the ground. Once she missed the opening and tumbled with the spider headlong to earth. She was undismayed by the fall, never once relinquishing her hold, but I was struck by the difficulty she experienced in starting once more for the opening. It required the combined strength of legs and wings to drag the creature up the perpendicular wall of the building to the slats of the window.

Once within, the spider is dragged to the waiting cell, where it is left with head facing the entrance. A yellowish white egg, projectile shape, is now deposited upon the side of its abdomen. This accomplished, the wasp returns to the outside of the nest. Now comes a thorough personal clean-up before continuing. The forelegs are drawn through her mouth and rubbed briskly over her head and antennæ. The hind legs are used in cleaning the wings and abdomen and during the process the wasp stands almost upon her head. In a few minutes she is clean and bright. Doubtless the scrubbing refreshes her, as a bath puts new vigor into a tired man who has worked faithfully for his family and returned home with the sweat of labor still upon him.

But her work is not over with the storing of the spider. She has yet to close the cell with a seal that cannot be easily broken. The job must be done with care, and quickly. A flaw, ever so tiny, in the masonry, may jeopardize the helpless inmates. Wasplets are tender morsels, fine fare for many a parasite. The huntress must guard the results of her labor. I watched this interesting process, which required an hour from the time the spider was dragged into the cell. It was only a tiny doorway, ten millimeters in diameter, yet during those sixty minutes, thirty loads of clay were brought to the nest and packed with minute care into the entrance. The tiny trowel and scraper, the tamper and smoother, all combined in the tip of her energetic little body, must have been worn indeed when the task was finished. But there was no sign of fatigue. In fact, I believe she rejoiced at the close of a day, well spent in the interests of her race, without a thought for her own spent body, for such is the great spirit, altruistic even though unconscious, that rules the insect world.

The last cell provisioned and sealed, the wasp abandons her nest. She deserves a rest and a feast of nectar. Henceforth, nature will take charge of her offspring that she may spend her declining days unburdened.

Within the cell, the egg hatches in forty-eight hours. In place of the tiny albumen filled projectile, we have a soft white grub. It is footless and quite unfitted for anything but the consumption of food. It possesses no sting like the parent huntress, and could not compete in battle with the most primitive insect, yet it feeds, immune from danger, upon the spider that lies limply within the cell. Like a foundling, the wasp in its infant state is reared by a foster parent. Like the child, it lives only upon liquids, drawing them from the huge bosom of its spider wet-nurse. As the draining goes on the spider's body shrivels accordingly. In forty-eight hours the pap is exhausted, but now the grub is strong enough to partake of solid food.

A queen paper wasp at her nest
When in the spring she lays the cornerstone of a new empire she has not a single worker at her disposal. Enlarged seven times

Its mandibles are capable of masticating what remains of the feast. In short, it sips the cream first and eats the porridge afterwards.

After five days of continuous gorging, the larva treats itself to a short rest before spinning its cocoon. During the five days, the spider has vanished so completely from the cell that only a microscope reveals a few uneaten hairs. These adhere to the larva's tacky skin, and thus escape the stomachward journey. I have never seen such a hog! Long after the feast is over, when the dishes have been licked clean, so to speak, the glutted one continues to Fletcherize upon the air.

The act reveals how hard and fast are the instinctive rules governing the insect's behavior. The larva hatches upon the spider's body. As soon as its mandibles become strong enough, they commence to tear and chew automatically. A bit more or a bit less provender in the cell is of no consequence whatever. Once started, the jaws continue to work for a certain set length of time that allows for variation in the bulk of the stores. Thus, if the spider be a bit large, it will be consumed readily enough. If a bit small the larva will simply continue, as I have said, to Fletcherize upon the air until the time limit set upon the active period of its mandibles is up. The insect is an automaton, a slave to a power that is not intelligence.

As an experiment, I introduce two spiders into a cell where one is the normal provender. The larva consumes nearly all of the feast, grows to an abnormal size, but eventually dies. This would appear to contradict the existence of an invariable set of rules governing the insect's life, but such is not the case. I have interfered in the normal course of events and artificially changed those rules at the outset by doubling the amount of provisions in the cell. The wasp's life is like a chemical compound, the ingredients of which correspond to these rules and depend upon one another for the ultimate result. Thus if we alter the quantity of one ingredient the desired result is not obtained.

The experiment has in no way disproved that the creature's life progresses by hard and fast rules. On the other hand, it confirms the statement, and further, points out that each rule depends upon the invariability of another for the ultimate success of the wasp. It also tells us that feeding is governed by the amount of provisions in the cell. Each mouthful stimulates a certain number of strokes from the mandibles. Thus, when the normal provender is consumed by the larva, it still continues to chew until the stimulus is gone. In the cell containing two spiders, the poor wasplet found no end of good things. It ate one spider. Its mandibles continued toward the limit of their working hours and came bump into the second spider. The stimulus was renewed, and its jaws commenced to work again, eventually dragging the unfortunate larva into death at the hands of indigestion.

Thus we see the reason for hard and fast rules among insects. They are entirely dependent upon them for their existence. Even so slight a variation as my experiment provided, proves this to my satisfaction. I varied the rule in one small particular with the result that the larva was led unconsciously to its own destruction.

To go back; the larva upon finishing its spider rests for a short period before commencing its cocoon. This rest may be necessary because there is nothing else to be done until the spinning fluid of which the cocoon is to be made, commences to flow. Once started, a network of strands is thrown across the cell. They pass for the most part under the spinner so that the grub rests upon a net, stretched midway between the top and bottom of the chamber. Later, upon this preliminary support, a neat tubular cocoon is spun. It is rounded at both ends, grayish yellow in color, glossy and rather transparent. It measures eight by seventeen millimeters, and only partly fills the roomy cell. As a final touch the interior is lightly coated with a pale, smooth varnish. The cocoon is finished in two days, after which the larva excretes a mass of waste matter in one end. This accomplished, it lies quietly awaiting pupation, which follows in eight days.

The pupa is yellowish white and beautifully folded so that its remarkably long posterior legs do not extend beyond the tip of its abdomen. Its head is armed with four spikes. Upon either side of four of the six abdominal segments there is a "jack," or protruding T-shaped support, and protruding from the opposite sides of the lateral segment is a pair of club-shaped appendages.

At first I took these strange objects to be the remains of ancestral legs. I thought them inherited rather than acquired characters, but continued observation of the pupa within its cocoon proved the contrary. They have been acquired in order that the insect's heavy abdomen may be kept leveled or centered within the cocoon, no matter how it is shaken about or turns of its own accord.

This is very important to the insect. It is not that the pupa would be injured by contact with the cocoon wall, but rather that the weight of its own abdomen, which is joined to the remainder of its body by a very narrow waist, would have to be borne by the creature's tender legs. In such a case they would become partly crushed and, owing to their great delicacy at this period, would not develop properly. When the legs have become strong and have received their steel-blue pigment, all the supporting appendages shrivel and are completely lost. This takes place three days before the huntress emerges from her cocoon. The supports are inflated with a watery fluid which disappears as soon as a breach occurs in the pupal skin. One may be cut off without seriously injuring the wasp, but the removal of all causes deformed legs owing to the abdomen sagging upon them.

Emergence from the cell as a perfect insect takes place twenty-one days after pupation. If the parent wasp lived she might witness the home building of her children, thirty-eight days after she deposited them as eggs in cells of her own workmanship.

A cabbage butterfly depositing an egg
This common white insect is responsible for enormous annual loss, its offspring destroying great quantities of cabbage throughout the summer months. Like many of our pests it is an introduced species

Fortunately the cabbage butterfly's offspring are held in check to some extent by paper-wasps. Their chief enemy, however, is a tiny Ichneumon fly which deposits its eggs in the cabbage caterpillar. Later its young burrow out through the skin of their host, spinning small cocoons about the dying and depleted caterpillar.

CHAPTER IX

CONTROLLED PUPATION

THERE is a tree in the Guiana forest which, for lack of a better name, I call the vermilion-nut. This tree ranks high in the scale of giants. It towers above one, reaching more than a hundred feet above the forest floor, where it throws out its rather flattened boughs that bear a thick mass of foliage, and in April, a vermilion fruit. This fruit is lime-shaped, two inches in length by one and one-quarter inches wide, and consists of a moderately tough pubescent vermilion shell, guarding the soft, greenish inner pulp that surrounds the true nut. The pulp is soft and quite sweet, but incipient, and the nut is as hard as a fresh almond and slightly over twice as large. Even to botanists its name is unknown.

Troups of howling-monkeys make daily visits to these trees, gorging themselves for hours on the juicy pulp and throwing the shells, bearing their teeth marks, to the ground below. One must either lie upon the back or suffer a cramped neck to observe them feeding in the top-most branches. Even then they are often screened from one's sight by the masses of heavy foliage that characterize the vermilion-nut.

Other animals find the food to their liking also. Agouti, smaller species of monkeys, and a host of wild bees feed daily beneath the everlasting twilight of these branches. One might spend a year studying the creatures that feed upon the fruit, which is often scattered abundantly among the rotting vegetation on the ground for a hundred feet in every direction.

In the latter part of April, I came upon a band of howlers feasting in one of these trees. They were easily one hundred and twenty-five feet from the ground, yet quite unconscious of the dizzy height, they reached here and there for the fruit, seldom clinging to the branches with other than the hind legs. They ate with great relish and greed, plucking far more than they could possibly eat. Consequently many nuts were dropped quite untouched, and wasted. Curious as to the quality of the fruit, I picked one up and split it apart. To my surprise it contained eleven light yellow maggots, that writhed about actively and tried to escape from their late prison. They had eaten the soft pulp entirely away, leaving only a mass of brown excreta and the inner nut, which was free and rattled about when I replaced the shell which had been cut away. Thus, by chance, I discovered the subject of this chapter in its strange cradle among the tree-tops, where it has doubtless fed in its larval state since the first vermilion-nut blossomed in the branches of its parent. This is a new species of fly belonging to the family Trepetidæ, and the genus Spilographa.

When and how the mature insect deposits her egg within the nut is beyond me. It would be necessary to live in the loftiest branches to ascertain such a fact. One glance at a vermilion-nut tree would stand as evidence of its infeasibility. One thing we do know; the insect is a fly, as shown by the larva, a typical fly maggot, with eleven segments, counting the head. It tapers from a well-rounded segment at the posterior end, almost to a point at the head, which is supplied with two hooks turned downwards like the claws of a cat. It is transparent yellowish white and through its entire body one may trace a pair of respiratory tubes with one set of openings in the head and the other in the last segment of the body. These orifices, two in front, two behind, stamp the creature as a young or larval fly.

The eggs are probably deposited when the fruit is still soft and immature or perhaps the scent of the tree's blossoms beckons to the insect. I can but surmise. Later the eggs give place to tiny wiggling larvæ, whose movements depend upon contractions of their muscles, for they are devoid of feet. They feast like gluttons upon the nascent flesh of the ripening fruit until it comes time to pupate.

From what we know of many other flies, we have seen that it is natural for them to pupate within the ground, or at least in a position from which they may work their way to the light of day when nature has transformed them into perfect insects. The larval flesh fly burrows below her carrion to transform in the damp soil beneath, the house fly in its bed of manure finds escape an easy matter, the mosquito transforms in the water, but what of our flies born within a tough-shelled nut in the highest forest branches? How are they to release themselves from such a prison after the feast is over? As we have seen, they reach the ground by falling, when the nut is plucked by some roaming monkey, or as it falls anyway when ripe, carrying its living burden earthward. But that is not answering the question. The larvæ must burrow into the forest soil to transform and issue successfully as a perfect insect. How, then, is this feast accomplished?

The nut which I cut open contained eleven larvæ. They appeared to be full grown and ready to pupate, at any rate, there was no more pulp left for them, and if they were hungry they must eat again that which had been digested once. No, they simply wiggled about frantically as though searching for an opening and swarmed to the hole I had cut.

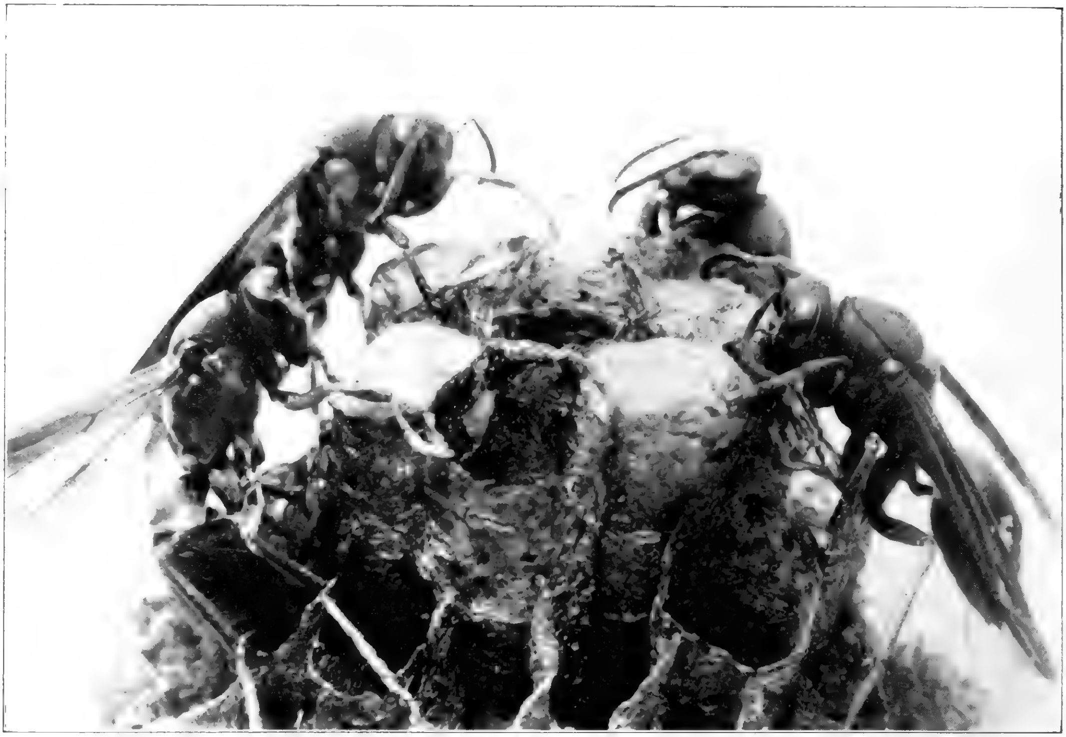
I remove two of them to tubes of soil slightly dampened. The remainder are locked once more in their prison. In the tubes conditions are, as nearly as I can make them, like those of the forest floor. The larvæ move here and there from fright in their new environment for a minute or two, but presently one thrusts its pointed head into the soil and commences to burrow. Soon it is followed by the other larvæ in their respective tubes. In twenty minutes all have disappeared below the surface.

Two days later I remove the material from the tubes in search of the larvæ. They have burrowed slightly over half an inch below the surface and all have transformed into little yellow kegs with ten red hoops running around them. Under the lens these hoops appear to be tiny bands of stitches like those in the cover of a baseball. In these pupæ we have convincing evidence that our fly naturally transforms below the ground, especially so in view of the fact that the larvæ left within the nut are still strictly larvæ in every sense of the word.

I remove two more of the imprisoned ones from the nut to freshly prepared tubes of earth. Two days later I have the same result from my experiment. Those within the tubes have transformed to pupæ, but those still imprisoned in the vermilion-nut remain in the maggot form. I keep the prisoners in their cell from April 20th until the 12th of May. Still there is no change from the larval form, yet any day I remove one to a tube of earth and forty-eight hours later recover it as a pupa! It is a strange condition indeed, but I think I see its significance.

When I open the fruit on the tenth day of May, I note that the true nut within has sprouted ever so slightly. Each day the cotyledons of the new tree are swelling within the shell that holds them, pushing upwards in response to the light above. Were the nut lying naturally upon the moist floor of the forest, the young tree's progress would be even faster. At length the pressure becomes too great for the nut's outer shell to bear. It yields to the vortex of a new life, splits open, and at the same time the imprisoned larvæ find the long-waited-for exit to the friendly mould of the forest.

Here is a condition among insects previously unknown to me. It is a remarkable adaptation to the condition of the creature's strange



Male and female paper-wasps hatching from the cells of a nest, in July. Enlarged four times

Paper-wasp worker with unusually large pellet of wood-pulp preparing to enlarge the nest. Enlarged four times habitat, that has brought about a deviation from the rule. In short, the young flies may hasten or postpone pupation at will! I would have hesitated to set forth such a statement, even as a remote possibility, were it not for my experiments that cannot be denied. One learns to expect the unexpected in nature, but who would go so far as to accuse her of running even so tiny a creature as this nascent fly, without a schedule? She is forced to surrender here to conditions self-imposed. If her children within the vermilion-nut lie imprisoned without food for a fortnight or more, it matters not. When release comes they are none the worse for their experience. If they are spilled roughly on the ground from a freshly broken nut a month before their brothers, so much the better. They have no set time for pupation. They will become flies just the same. Thus Nature has endowed them with ability to meet successfully, the strange circumstances in which she herself has placed them.

Let us see what has happened to the larva that has burrowed beneath the surface of the ground. Why must such an active creature entomb itself again upon being liberated from its original prison?

Unlike ourselves, animals or birds, insects pass through a series of stages, one might say, almost by jumps. At first we have an egg, quite helpless, but deposited with due care and forethought by its provident bearer. In a day or so, this helpless egg has become a ten-ringed maggot with a head, appendages for drawing in its food and possessed of a primitive but efficient set of organs. It is not an actual hatching as we see it in a hen's egg that has brought this strange creature into the world, but a fading of egg into maggot. There is no empty shell when the process is finished, no specter of the creature's former self. The process is like that of a moving picture, which fades before one's eyes from one scene to the next, which is widely different.

In its newly acquired form, the insect feeds, as we have seen, upon the vermilion-nut pulp, remaining unchanged except in size, until fate releases it upon the moist forest floor, when with a haste that is almost frantic it immediately imprisons itself once more, this time in the ground wherever it chances to find itself. Forty-eight hours later, we discover it as a tiny yellow keg, banded with red stitches, as though it had buried itself for good in a self-fashioned coffin.

Has the insect become so accustomed to the blackness of prison life that it cannot live in a world of sunlight? Must it live the life of a mole because it has only once seen the brightness of day? No, there is a far deeper reason than these, that sends it so hastily into the ground. It is about to undergo its last and greatest transformation, one during which it will be once more utterly helpless against the slightest odds. It must lie very still, as though in death, lest the beautiful process within be interrupted and the design shattered.

Up to now, the insect has resembled its ancestral family, less highly developed worm-like creatures of another day. Just as we have developed from less perfect creatures, so has the fly. Within the little yellow keg a wonderful change is in process.

At first the maggot, so recently an active definite creature, is seized upon by a host of nature's strangest forces. We cannot see them or give them any definite form. Nevertheless they are there, like a great group of wreckers, carpenters, masons, painters and decorators. The larva or maggot, the ancestral form, is torn down and reduced to a disintegrated mass of fluid. From this utter wreck of what was so lately a crawling, organized creature, the final insect is resurrected. From old tissues, new ones spring, from what was old and out of date, a more modern creature is erected. The yellow keg is no longer a coffin, but a factory wherein a host of raw materials are to be transformed into the finished product!

The process is comparable to tearing down an old-fashioned house and erecting a modern one on the old foundations. Much of the old material is used, and that which must be replaced by new, is burned or otherwise disposed of. So it is with the tissues of the maggot. From the old house we save the plumbing, the wiring and the kitchen range, which corresponds in the maggot to the reproductive glands, the nervous system and the heart, which are left intact, or at most altered and attended to.

At length it becomes time for the painters and decorators. Nature employs a vast army of these. In the keg, after ten days, the milky white and partly transparent, but otherwise perfect insect commences to receive its color. It appears first in the eyes with an influx of emerald green pigment studded with golden, microscopical dots, which are followed in forty-eight hours by the appearance of black patterns upon the legs and wings, due to more or less dense hairs upon these appendages into which the color gradually flows. Upon the back of the head there is a pattern of hairs and another of longer ones upon the thorax, while the abdomen likewise suddenly appears clouded with pubescence. Further than this no ground color or markings can be seen, owing to the color being much like the shell of the keg itself.

In another forty-eight hours, fourteen days after pupation, the fly emerges by splitting the head of the pupal keg in two equal parts. This is a simple operation, as the shell is not too substantial, but the new-born fly has yet another task, before it will be free. It has yet to dig a passage from its tomb to the light of day. It must be done quickly, lest the wings fill and dry too small and their usefulness be lost.

For this purpose the insect is supplied with a battering ram, which protrudes between the eyes at birth from the pupal case. It is a transparent sack-like appendage which may be expanded or contracted at will by the fly. It contains no apparatus of any kind, but is apparently the forehead of the insect capable of expansion. To watch the operation of this strange appendage is remarkable. First, it swells like a toy balloon when air is blown into it, until it protrudes two or more millimeters in front of the insect's head, pushing the sand or dirt in front of it as it increases. This is followed by a rapid deflation of the ram, which leaves an indentation into which the fly struggles with great effort. Now the first operation is repeated, the second indentation made and again the insect wedges itself into it. Thus, after an hour, if the fly is fortunate, it reaches the surface of the ground, where it rests for a time to recover its strength, before launching into a new and sunlit world once more to search out the vermilion-nut, this time as a nursery for its own offspring.

The cannibal's nest laid open
In the cell, two of the wasps may be seen, where they have been dragged by a third, to be eaten by the murderer's offspring
Enlarged four times

A cannibal wasp at her nest
In order to prevent dirt from rolling into the entrance, the miner alights at some distance and proceeds to the tunnel with great care
Enlarged four times. From a mounted specimen

CHAPTER X

CANNIBAL WASPS

Philanthus gibbosus

IN the glaring July sun, seething in a dizzy sea of rising heat waves, the cannibal wasps have built their city. The tennis court, but let us forget the human world, in the eyes of the insects, is a great sandy plateau, dotted in a hundred places, with tiny hills of sand that mark the excavations of their metropolis.

It is a barren land where mud huts bleach in a sun that knows no mercy and yet strangely enough, where the lives of its inhabitants are filled with endless work and gigantic energy.

If you can imagine a tropical climate without trees and where the creatures that people it possess greater energy than those of a temperate zone, then you will have a fair idea of the conditions existing in the topsy-turvy land of the cannibal wasp.

The insects are gregarious, but a separate burrow, or mine, is constructed by each female belonging to the general colony.

These tunnels are the homes of the wasps, mines in which the domestic duties are carried on. They are excavated in various fashions, twisting and turning according to the conditions of the ground. In all, the burrows may reach twenty-four inches in length, terminating in an elongated cell or chamber, twice the width of the passage leading to it. One or two short branches, also terminating into roomy chambers, may be found at various points near the end of the shaft. These cells are nurseries where the young wasps are reared and of which we will hear more later.

Beside the entrance hole to the burrow, a second tunnel, about two inches in length, is sometimes excavated, which serves as a sentry box, in which the insect rests and guards the entrance to the main nest. It is amusing to see a wasp from the colony lose its bearings and attempt to enter the wrong nest, when the rightful owner rushes from her sentry box and pounces upon the intruder. Then amid loud buzzings, which are doubtless oaths of a fearful nature, the two roll about until the intruder is driven off.

But let us go back to the building of the burrow, which is a gigantic task for so small a creature. She must be engineer, laborer, drill and steam shovel if her race is to survive, and this is no small burden for such delicate shoulders to bear.

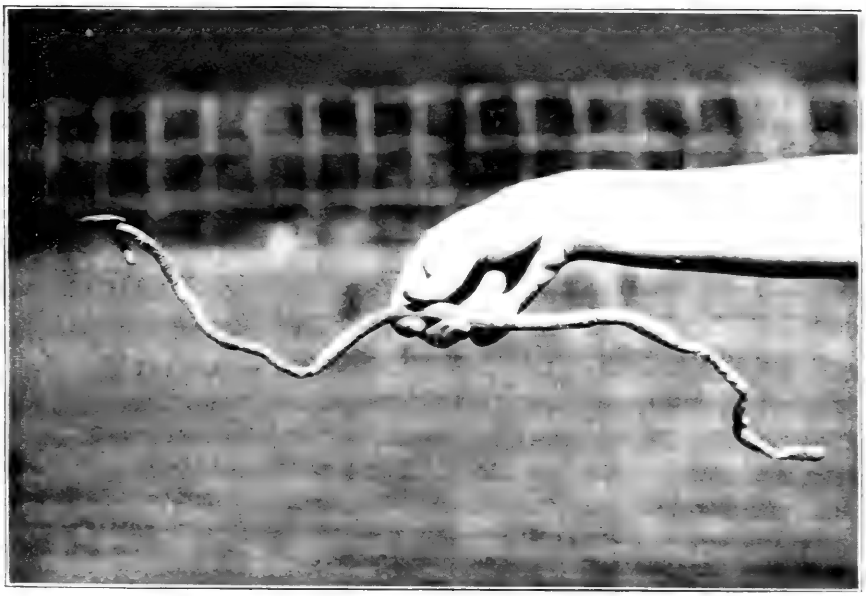
But in a wasp city there is never a complaint, never a strike for higher wages, but always a superb spirit of altruism and a wealth of strength that defends the race against extinction. In a way, instinct triumphs over intelligence here.

At the entrance, one finds a heap of dirt excavated from the burrow, which is carefully piled, in order that it will not run back into the doorway and double the labor of the well-planned dwelling.

On arriving at her tunnel, the miner alights at the far edge of the sand heap. From here she moves rapidly forward, kicking the sand back the while, thus forming a distinct trough leading to the hole. This clever method of approach is to prevent sand from rolling into the nest, which would be the case should she come blustering directly into the entrance.

To compare the weight of the sand heap with that of the wasp will be interesting. For this purpose the diggings from an average tunnel are scooped up and placed upon a delicate scale. It registers about two ounces. Now we place the wasp on the scales and find that its weight in the same measure, is one four-hundredth part of one ounce.

The cannibal and her diggings. In excavating her tunnel, the insect removes her weight in sand eight hundred times. Life size. From a mounted specimen.



A complete model of a cannibal wasp's burrow. This model, secured by pouring molten lead into a nest, clearly illustrates the shape of the tunnel with its extra tube cr sentry box at the left. One-third natural size.

In other words, the wasp in excavating, has removed her weight in sand eight hundred times. Now let us compare her work in proportion with that which a man would have to do to accomplish a similar feat. Taking a man weighing one hundred and fifty pounds and multiplying by eight hundred, which are the same figures used in the case of the wasp, we get one hundred and twenty thousand pounds, or sixty tons. The insect then removes the equivalent of sixty tons of earth to make her nest. This she does with no tools except her forelegs, and the gigantic task is completed in four days. Had we the same strength and endurance, the Panama Canal might have been completed in a week or two!

When the excavation is finished, the insect at once turns her attention to storing the subterranean cells with proper food for her offspring, and here we shall bring to light the cannibalistic instincts of these mining wasps.

The majority of the solitary wasps feed their young upon inchworms, spiders, flies, or insects of an entirely different order from themselves. But not so the miners; who in some cases deliberately hunt out members of their own family, paralyzing them with a drive of the sting and dragging them into the tunnels for their young to feast upon!

As many as a half-dozen victims may be packed into a single cell. Tiny humble bees, green and blue flower bees,[1] and sometimes unfortunate miners that have been executed for daring to place a foot in the wrong doorway.

In a week the cells are packed from end to end with victims of the cannibal's pitiless nature. The array is more gruesome than the corpses lying in a morgue, yet the insect gloats over her industry of murder, rushing eagerly in to inspect the contents of the cell, over

[1] Ceratinadæ.

and over, before laying her glistening oily yellow egg upon the mass of helpless flesh.

In two days the young cannibals wriggle from the eggs, footless, whitish maggots and helpless against the slightest odds. Yet nature has provided for them in such a manner that they may attach themselves to superior creatures, who must lie motionless and submit to their suckling mouths until the last cells of life pass into the bodies of the cannibals!

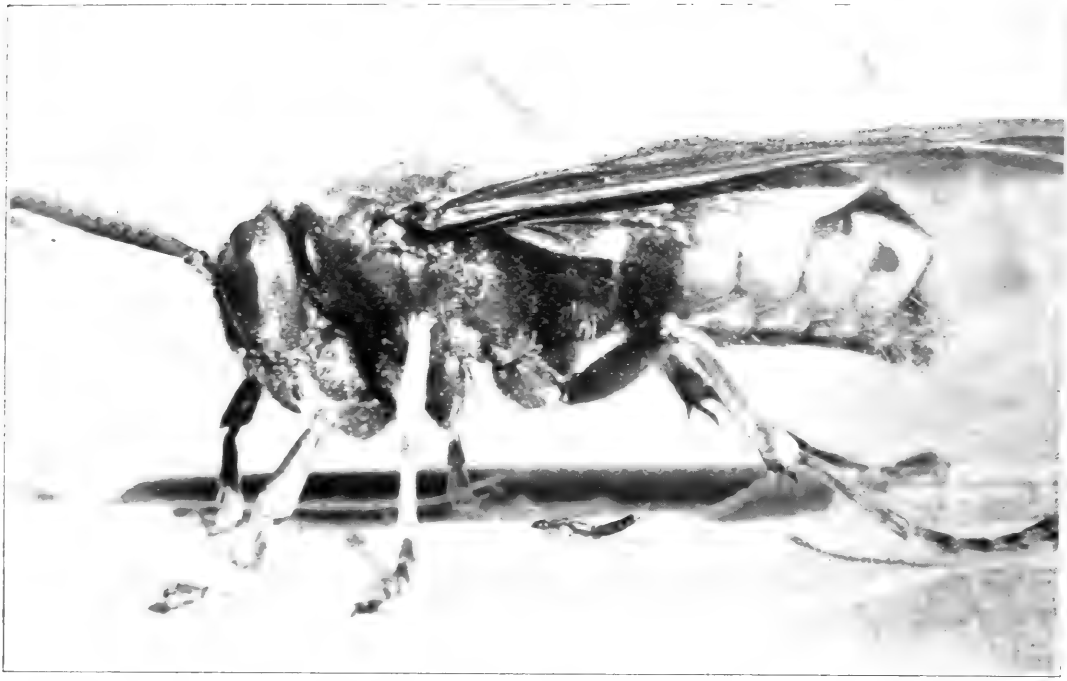
A single egg is laid upon the contents of each cell, and normally seven days are required by the young to gorge themselves into a state of torpor which lasts until the following spring. Then a wonderful transformation takes place. The motionless, fatty larva commences to assume a definite form.

Within its milky skin, disintegrated tissues and layers of cells have been whirled by nature's magic hand into definite parts and organs of the nascent creature. Legs unfold like budding leaves, a narrowing of the waist separates the thorax from the abdomen and delicate wings "sprout" from the center of the back.

Then comes color, darkening the head and thorax and throwing yellow bands about the abdomen, and finally comes the gift of motion, which leaves only a layer of earth between the cannibal, the sunlight and another generation of innocents to become her victims.

Crimes cannot always go unpunished. There must be justice, even in the insect world. This slaughter of the innocent flower bees must be avenged or regulated and nature's reprisal is cunning and severe.

There is another wasp-like creature, a true fly in reality, that plays her part in this gruesome drama. Nature has given her a flight that resembles a wasp's, to afford protection from minor enemies, but this is not the most remarkable of her gifts. It is her mission in life to hold these cannibals of the insect world in check, and she performs her duty with precision.



A wasp of the sphecid's size compared to a small rove beetle. Although four times life size in the picture, this insect is a formidable creature in its natural size. Note the tongs upon the legs which in the sphecid assist in carrying the prey.

Sphecid wasp dragging a paralyzed cicada to her burrow, after the homeward flight.

Common cicada, upon which the sphecid wasp preys.

While the cannibal is abroad in search of a victim, this creature, which we will call the checker-fly,[1] because of the peculiar pattern upon her abdomen, takes her life in her hands and slips into the den of the murderer.

Now to understand this action we must first examine a checker-fly in the laboratory. Dissection brings a wonderful fact to light. In the fly's abdomen we find no eggs, as one might expect, but in their place ten living larvæ! The microscope shows them to be whitish maggots clustered together in a ring, and through their transparent bodies one may see the expanding and contracting of embryonic muscles.

The checker-fly then gives birth to her young alive! But why? She is a lowly rung in the ladder of insect life, while the cannibal, a member of the highest order of insects, is gifted with nothing more unusual than egg laying!

The explanation is simple. When the checker-fly enters the burrow, she heads straight for the cell, in order to bear her young upon the meat stored up by the wasp for her own offspring. Thus she saves herself the trouble of providing a home and food for them.

We must know that the wasp is nearly four times as large as the fly and greatly superior in strength. Now should the fly and the wasp both lay eggs, the ultimate result would be at once apparent.

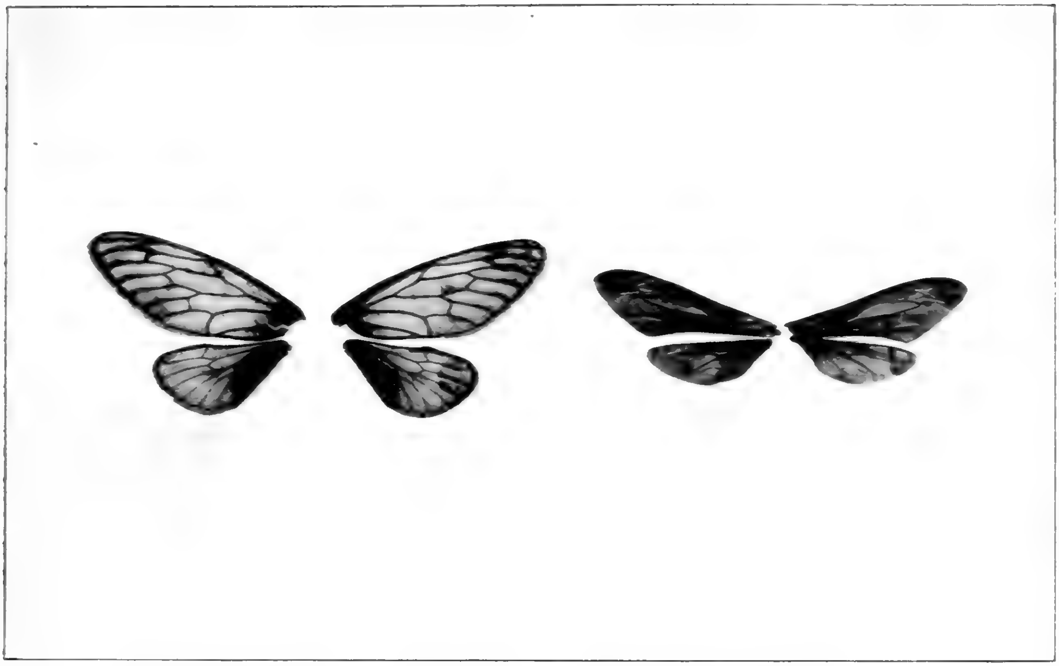
The eggs of both insects would hatch about the same time, but the young cannibals would soon grow much larger than the flylets. The strongest individuals survive, and were it not for nature's care in such matters, the young checker-flies would perish.

What takes place is plain. The parent fly bears her young alive and they start at once feeding and growing within the cell. In two days the wasp's eggs hatch, but the young checker-flies have now

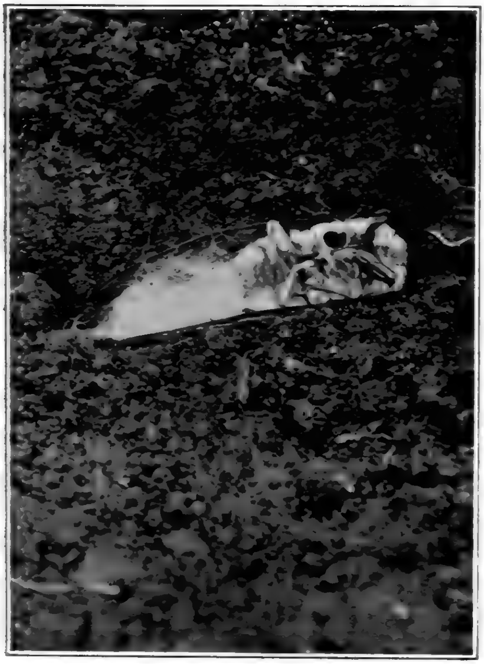
[1] A species of Tachininæ. This sub-family includes some of the most highly beneficial species of flies, such as the Red-tailed Tachina (Winthemia 4-pustulata), a parasite of the Army worm.

gained sufficient strength and size to push aside and starve the newborn wasps!

Thus nature modifies the birth rate of the cannibals, sending these checkered enemies to destroy them, lest some day they exterminate the useful little flower and humble bees, whose mission in life it is to blend the pollens of a billion blossoms and make our world a land of plenty.



Comparative wing expanse of cicada (left) and sphecid wasp (right)



Hole in cicada through which the larval sphecid entered its host

Young sphecid wasp two days old feeding upon a paralyzed cicada

CHAPTER XI

THE SPHECID'S DUTY

Sphecius speciosus

WHEN July has blended its last hot days into August and the air vibrates with the monotonous, irritating song of the cicada, it is then that one member of the insect world, the great golden digger, is hardest at work. Though the most formidable member of our eastern American wasps, being the largest, and possessed of a most powerful sting, it is perhaps more peaceable and less easily irritated than many of the smaller members of the Hymenoptera family.

Solitary wasps, of which the golden digger is one, are invariably more peaceful and easier to work with than social species, for a very simple reason. Solitary individuals are almost all preying species, creatures who require the services of their stings in paralyzing their victims. They reserve their poison and the energy required in injecting it, until it is time to gather provender for the coming generation of their kind. Such wasps sting in self protection only when captured, and scarcely ever in defense of their nests.

Social wasps and bees seldom, if ever, sting their prey and many of them are not even of predatory habits. The sting is therefore unnecessary in capturing or preparing food for their offspring and is used, as we know, chiefly in defense of the nest, which is the common property of a number of individuals.

The sphecid's service to mankind in killing countless numbers of the noxious cicadas makes this great wasp a popular one with those, all too few, who understand its highly beneficial function.

As in all insects, the wasp's first vital duty upon leaving its cocoon is to mate and deposit her eggs, which in due time are to bring forth the diggers of the following season. Her life story is most interesting.

Towards the middle of the day, when the cicadas are singing in every tree, the sphecid may be seen flying swiftly to a spot from whence a song is issuing. For a minute she disappears among the foliage, then suddenly the song ceases abruptly, giving place to a cry of agony and fright. The wasp has seized the unsuspecting cicada, and its terrible sting has been driven in, instantly paralyzing and throwing the unfortunate insect into a comatose condition, from which it never recovers.

The wasp and cicada will often fall to the ground together, struggling violently, the ill-fated bug giving vent to discordant death cries. From here the wasp carries its burden to the nest, which is often a difficult object to accomplish. The cicada is heavier than the wasp herself, which is a condition rarely met with among the preying Hymenoptera, and to carry the victim to the burrow often requires much time and patience on the part of the sphecid.

If the wasp and cicada fall from the foliage of a tall tree, all goes well. The wasp recovers before reaching the earth and flies to the nest without difficulty. Usually, however, the two strike the ground in a noisy struggle, where the sphecid accomplishes her work of paralyzing the cicada, often in a tiny cloud of dust. When this happens the wasp cannot lift her dead weight victim into the air. Try as she may, the precious meat will not budge from the earth and one wonders how the journey to the nest will be accomplished.

It has been stated that in such a case, the wasp drags the cicada overland, but this I have found to be untrue. The sphecid's course is very simple and interesting.

She drags her burden to the nearest tree, mounts to a distance of twenty feet or more and from this lofty perch launches herself

Queen paper-wasp in the act of depositing an egg which may be seen just emerging from the insect's body
Enlarged seven times

Photo-micrograph of eggs of the paper-wasp deposited at the bottom of the paper cells by the queen. Note the texture of the paper. Greatly enlarged

into the air with the cicada, which is now quiet and helpless. At first she tumbles like a wounded aeroplane, but at length recovers, rights herself and thus gains sufficient momentum to fly without halt to the nest.

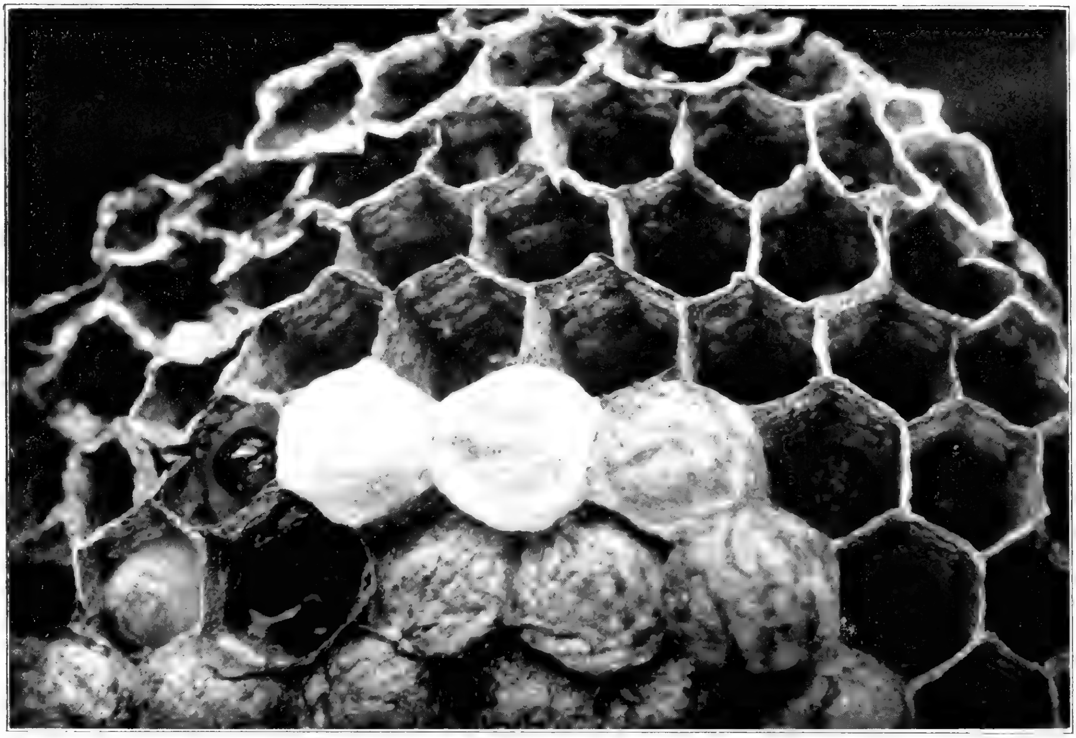
The nest consists of a sloping burrow, continuing under the ground for about eight inches in a straight line. A sharp turn is usually made at this point and the tunnel carried on for twelve inches more. At the extreme end there is an elongated cell, large enough to hold a single cicada. Branches from the main passage are often excavated, and occasionally one of the cells at the ends of these branches will contain two cicadas. It has been stated that these cells containing two victims bring forth much larger wasps than those containing one, and as the female wasp is much larger than the male, it was thought by a well-known entomologist that the cells containing the greater amount of provisions produced the females and those containing a lesser amount, the males. However, it does not seem probable that an insect possesses the power of distinguishing her eggs to the extent of telling which are to bring forth the males and which the females.

When a cell contains its store of cicada meat, a single whitish egg is laid under the middle leg of the victim. After this the burrow is closed up by the wasp and her duties are finished. The eggs hatch in two days, and the larvæ, as the young grub-like sphecids are called, start at once to suck the nourishment from the bodies of the cicadas, later entering the hosts' bodies, where they attain full size in seven or eight days.

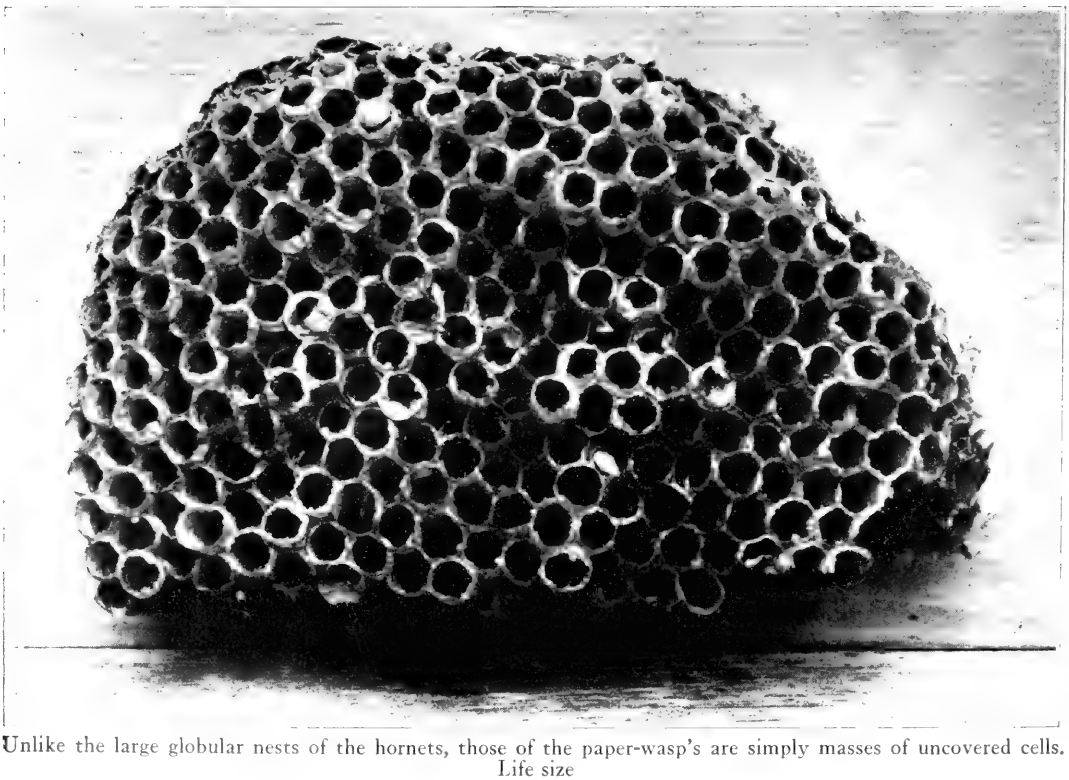
Now a rough cocoon is spun by each inside of its respective cicada, wherein it later transforms to a pupa, the stage corresponding to the chrysalis of a butterfly.

In this soft, helpless condition it remains all through the winter, until the following summer. Then, when the cicadas are calling once more, the long buried cocoon, from which the hollow shell of host has long since rotted away, splits open. Out crawls the powerful giant wasp, she brushes herself thoroughly and waits for strength to dig her way out.

In a few hours she has made her way laboriously to the surface of the ground. Here, all laden with mud and the sweat of her effort, she cleans and scrubs and rubs the dirt from her limbs. She draws her feet through her mouth and with this droll fluid polishes her eyes. Last, she scrapes her feelers clean, curls them back and forth, spits upon them, rubs them until they shine like metal. Having thus made her toilet, she is off, expert of wing at her virgin flight. She goes in a straight line out of sight, in search of a male to become her mate.



Cells of a paper-wasp's nest, showing heads of young insects, and silken caps spun at a later date. Four times life size



Unlike the large globular nests of the hornets, those of the paper-wasp's are simply masses of uncovered cells. Life size

CHAPTER XII

THE ORIGINAL PAPER-MAKERS

THE societies of the paper wasps,[1] like those of other social insects of the family, consist of three kinds of individuals, males, females and workers. The colonies only exist for a single season, the males and workers dying in the fall. The females or queens hibernate and each starts a new community in the spring. The queen is the largest in the colony and her one duty, after the first few weeks of spring, is egg laying. The males or drones are created for the one purpose of fertilizing the eggs of the queen and after performing this duty they are frequently killed and thrown from the nest by the workers. These so-called workers are, in reality, undeveloped females, who are unable to reproduce in a beneficial way, as their eggs invariably produce drones. Thus they are unable to assist in increasing the numbers of working individuals in the colony and the heavier work must therefore fall upon these otherwise useless members.

Let us start with the queen mother, the only survivor of last year's colony, who has safely passed through the winter in an impregnated and torpid condition and who must now lay the foundations of another great insect city.

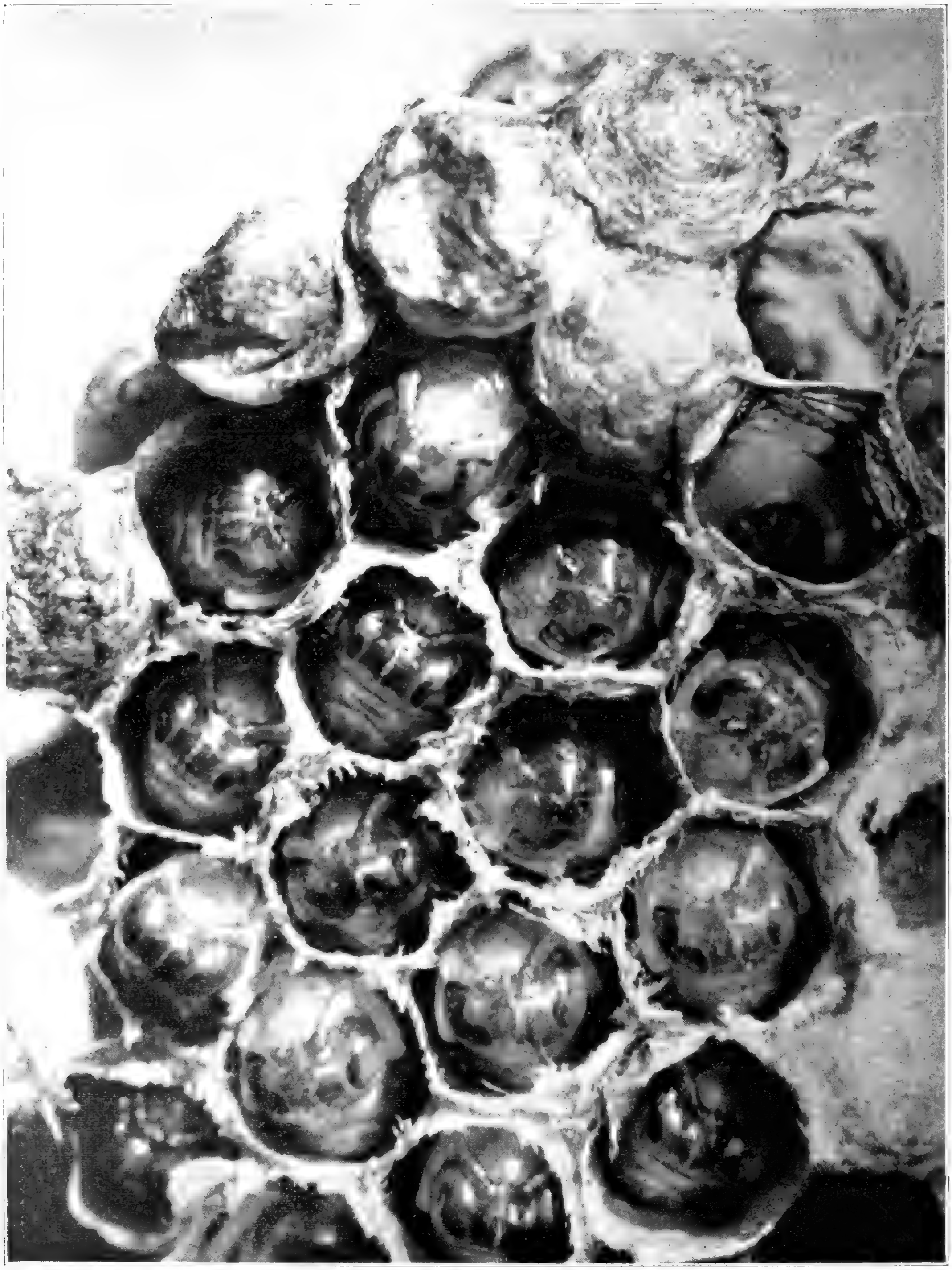
When in the spring she lays the foundations of her future empire, she has not a single worker at her disposal, and with her own hands and teeth she must lay the corner-stone of her future metropolis. She must herself build the first combs and produce from her own womb their first inhabitants, which in their infant state, she must feed and educate before they can assist her in the great design. At length,

[1] Polistes pallipes.

she receives the reward for her perseverance and labor; and from being a solitary unconnected individual, in the summer is enabled to rival the queen, who gave her birth, in the number of her children and subjects, and in the empire of which they are inhabitants. Even at this time, when she has so numerous an army of helpers, the industry of this creature does not cease; but she continues to set an example of diligence to the rest of the colony. If in any way the queen mother perishes, before the other females are hatched, the workers lose their instincts, cease their labors and die.

The number of females in a paper wasp colony is quite considerable. They are hatched about the latter part of July or during the first part of August, at the same time and in about the same numbers as the males. In September and October, they fly from the nest and after mating, the males live but a short time. Of all the females, very few survive the winter to start the new empires when the vernal sun brings the insect world to life again.

To the workers falls the entire care of the young and other members of the colony. They must not only supply the food, which consists of honey and chewed-up insects, but they must also protect the nest from outside intruders. These neuters must be ready and willing at all times to do reconstruction work upon the rapidly growing nest. Almost daily there are new cells to be built, walls to be strengthened, openings to be closed and all manner of things which it is only proper for a worker to do. Of all these operations no other is so interesting as the process by which the wasp's paper is made. It is manufactured of wood pulp or other ligneous fiber, which is scraped by the worker from old weathered boards, fence rails and other unpainted wood which has weathered for a number of years. I once found a pole which supported a bird house, so thoroughly scraped by paper wasps and so frequently visited by them that it was kept in a roughened condition all summer. This pole must have supplied the pulp for



Cells of the paper-wasp with caps removed to show heads of pupæ nearly ready to emerge as perfect insects. Greatly enlarged many nests in the neighborhood, and even now is used year after year by insects of this family.

The tiny particles of wood fiber are mixed by the wasp with a glutinous substance, which is apparently secreted by the worker herself. She rolls the whole mass between her forefeet and masticates it with her mandibles, until a small gray pellet has been formed, and with this she flies to the nest. The pellet is then dropped in the proper place and left until a portion of it adheres to the edge of the cell in course of construction. When this has been accomplished, the insect draws the pulp from a ball or pellet, into a long thin line, to the opposite side of the nest. From here she returns to the starting point and, placing her tong-like jaws over the paper thread, closes them and simply walks slowly backwards away from the point of contact, thus flattening it out into a long gray ribbon, which is easily shaped in the form of a low hexagonal cell.

In this manner several layers of paper ribbon are applied, each layer above the other, until the cell is of proper depth. It is then ready for the delicate white egg which the queen lays, almost at its very bottom. The egg is fastened to the paper wall by a glutinous substance, which is probably the same secretion that is used in making the paper, and it is almost impossible to remove it, without leaving a portion of its tender shell adhering to the inner wall of the cell.

In the course of a few days the eggs hatch out into soft footless maggots, like all young Hymenoptera, and it is at this period of their lives that they are subject to the attacks of a very curious beetle parasite, known as the Xenos. The young of this insect is a tiny active creature which burrows into the body of the young wasp. There it lives, feeding upon the body of its host during its hypermetamorphosis. If it is to be a male, it transforms into a chrysalis and soon after this hatches out from the body of the wasp to live its short adult life, which lasts from fifteen minutes to three days. If a female, however, it never reaches the chrysalis state, but when the maggot host itself changes into one, the apparently immature Xenos pushes one end of its body out between two of the host's abdominal segments and there gives birth alive to a great many tiny beetles, in the earliest and most undeveloped stage of their lives.

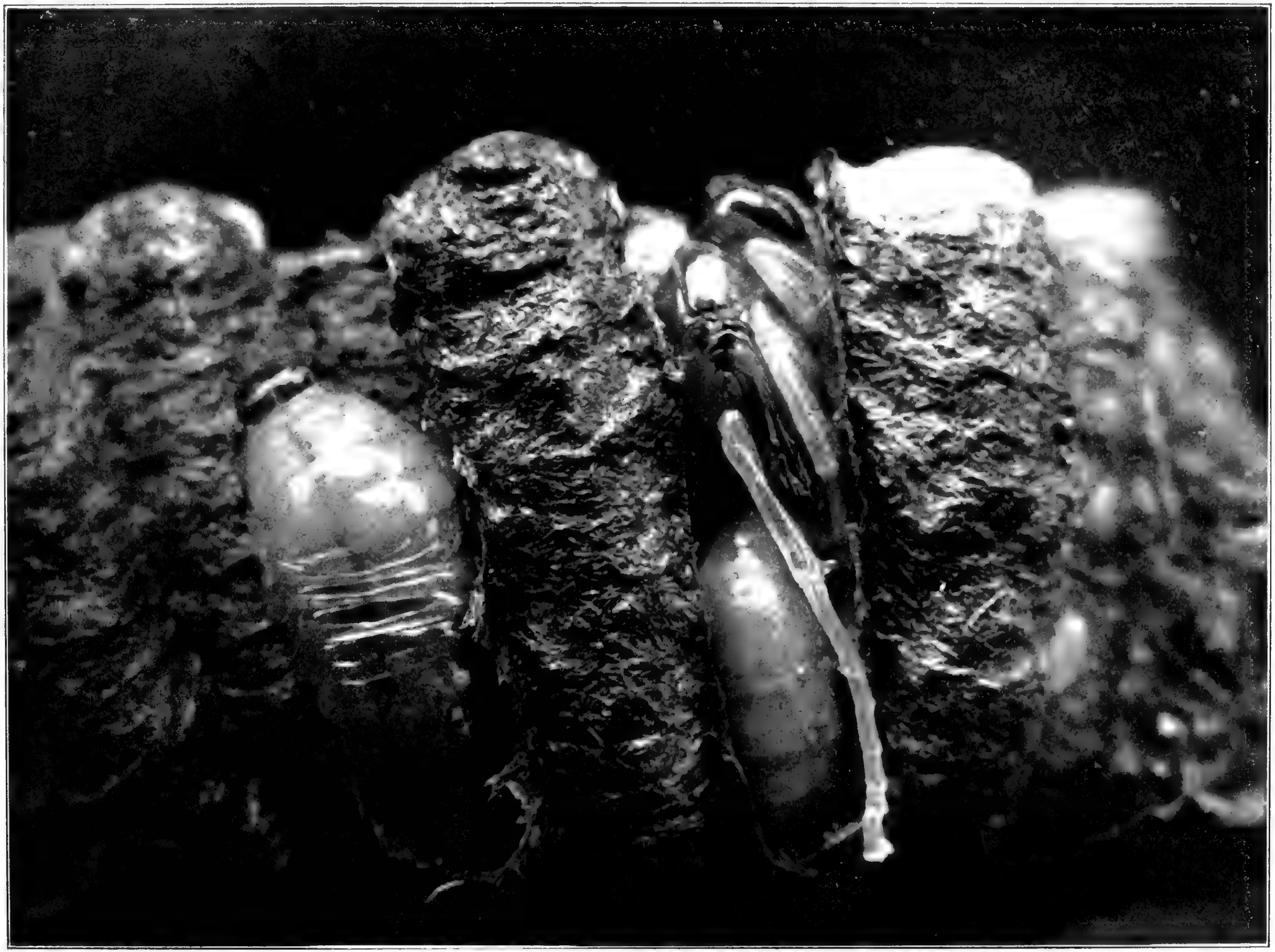
Owing to the position of the comb, when the young wasp emerges from its egg, it is suspended head downwards in the cell. It is, however, attached to the cell at its posterior end and remains so until full grown and ready to spin its cocoon. At this period it becomes detached but the bottom of the silken cocoon, which has now been spun, forms a capstone to the previously open cell and prevents the youngster from tumbling out. In this position the young wasp transforms to the pupal state, in which it remains for some time before issuing as a perfect insect to take up the work of the colony.

After this event the cell is thoroughly cleaned out by the workers and used over again by the queen. The entire period from the time that the egg is laid until the full grown wasp issues from its cocoon, is about five weeks; thus it will be seen that the same cells may be used several times during a single season.

The last brood of the year consists mostly of queens and drones and after these have been hatched the workers of the colony soon die. The inside of the cells may then be found to contain curious brownish skins, cast off by the chrysalids and which the workers did not have time to remove before the cold weather arrived.

Unlike the large globular nests of the hornets, those of the paper wasps are simply a mass of uncovered cells, ranging in numbers from fifty to three hundred. These are suspended by a single central stem from the undersides of large overhanging stones or from beams in old barns and sheds.

These insects are undoubtedly beneficial from the fact that they



Cells of the paper-wasp in section. Showing, at the left, a full grown larva and at the right, a pupa. The texture of the wasp-made paper is well illustrated. Enlarged eight times life size have been known to prey upon the destructive cabbage caterpillar [1] in the vicinity of Washington and also in Connecticut. Howard, in his "Insect Book," describes their actions as follows: "The wasps would hover above a plant and then alight and walk about it, but finding nothing, would continue to the next plant, and so on to the next. In the sunny center part of the field the cabbage caterpillars were exterminated, but in the shady portions next to a patch of woods, they were present in great numbers. Wasps do not see small objects clearly. They find their prey more by sense of touch than by sense of sight, and as they prefer the sunshine they unconsciously ignored the abundant caterpillars in the shade."

Kirby has left us the following extraordinary account of the manner in which the workers care for the young and helpless members of the community. These observations apply to the common yellow jacket or hornet, but many of the statements hold true in the case of the paper wasps, although I have not as yet been able to verify them all. "The workers are the most numerous, and to us the only troublesome part of the colony, upon whom devolves the main business of the nest. In the summer and autumnal months, they go forth by myriads into the neighboring country to collect provisions; and on their return to the common den, after reserving a sufficiency for the nutriment of the young brood, they divide the spoil with great impartiality; part being given to the females, part to the males and part to those workers that have been engaged in extending and fortifying the community. This division is voluntarily made, without the slightest symptom of compulsion. Several wasps assemble around each of the returning workers, and receive their respective portions. It is curious and interesting to observe their actions upon this occasion. As soon as a wasp that has been filling itself with the juice of fruits, arrives at the nest, it perches upon the top, and upon disgorging a drop of its sac-

[1] Pontius rapæ.

charine fluid, is attended sometimes by two at once, who share the treasure. The first drop being thus distributed, a second and sometimes a third is produced, which falls to the lot of the others.

"Wasps do not, as a rule, store up honey, but it is found in the cells of some European species as well as in those of America.

"Another principal enjoyment of the workers is enlarging and repairing the nest. They work with great celerity; and though a large number are occupied at the same time, there is not the slightest confusion. Each individual has its portion of work assigned to it, extending from an inch to an inch and a half, and is furnished with a ball of ligneous fiber, scraped by its powerful jaws from posts, rails and the like. The workers also clean the cells and prepare them to receive another egg, after the first has passed through all the stages of its life and is now a perfect insect working with the rest."

There is good reason for thinking that wasps have sentinels placed at the entrances of their nests, which, if you can seize and destroy, the remainder will not attack you. This has been confirmed by the author. If a nest of wasps be approached without alarming the inhabitants, and all communication be suddenly cut off between those out of the nest, and those within it, no provocation will induce the former to defend it for themselves, but if one escapes from within, it comes with a very different temper and appears commissioned to avenge public wrongs. In fact, very few incoming bees or wasps will attack the intruder. Perhaps it is because the insect who is returning to the nest sees what is going on about its home, while the one coming from inside the nest is confronted suddenly by an unusual form when it reaches its usual point of exit. It becomes alarmed not only for itself but for the safety of its colony. What follows is only too well known to the student of such insects. When the workers make their rush they are prepared to sacrifice their lives in the execution of their orders.

The first cold weather, after the queens have entered their winter quarters, produces an effect upon them similar to that which is produced upon the woodchuck and other animals subject to torpor. At first a partial benumbment takes place, but the insect, if touched, is still capable of moving its organs. As the cold increases, all the animal functions cease. The insect breathes no longer and has no need of a supply of air; its nutritive secretions cease, no more food is required, and it has all the external symptoms of death.

Thus we will leave the few survivors of a once great insect empire, perhaps huddled behind the picture moulding in our bed-room, insignificant now to be sure, but planning perhaps in their insect heads, every cell, every gallery, and every passage which is to be built when the new colonies are founded in the first warm days of April.

CHAPTER XIII

INSECT AND OTHER STRATEGISTS

INSECTS, like all other creatures of this earth, from sponges to man, must partake of food, for without it there would be no life. It is a simple thing to say, but for some insects of the lower orders, to procure their proper nourishing food would be quite a different affair, were they not carefully assisted by that almost intangible thing called instinct, taught in the school of nature. To be sure there are many of the higher insects, as the bees, ants and wasps, who are fortunate in possessing the power of rapid motion, unfailing protection and well-developed senses, and who would seldom be hampered in the quest of food, but how would the lower orders of insects fare, were it not for the marvelous stratagems that nature has taught them? Indeed, they would not fare at all, for if they were deprived of these instinctive strategic methods of obtaining their daily sustenance, such insect races would soon become a thing of the past. Should events of this nature come to pass, then even the balance of nature might be seriously affected.

Although many cases might be shown in which insects and their near relatives have been known to live by their stratagems, I shall endeavor only to describe the methods employed by four of the most interesting groups.

Through the long summer days these marvelous things are frequently before our very eyes, yet they pass unnoticed, so accustomed are we to neglect that which is the subject of daily occurrence. The webs of spiders for instance: What if we had never known of this marvel! Would it seem any more incredible to find an animal spin-

Epeira insularis

An orb-building spider laying her eggs. They are afterwards covered in a sphere of silk. Greatly enlarged

ning out long silken threads; weaving these threads into nets more perfect than any ever made by human hand and then suspending them with the best judgment where the wished-for prey is most abundant? Indeed it would not be more wonderful, but in this case, as in so many others, we neglect the actions of the tiny creatures, which in the larger ones would excite our admiration and endless attention. In fact, the minuteness of the creature renders web-building even more wonderful in the eyes of those who see nature as she really is.

The spiders might well be termed the kings of strategists, for their beautiful nets of glistening silk are among the most wonderful of creations. The spiders are divided into many groups, but the orb-builders, the platform-builders and those individuals who build no webs at all belong to the most interesting families.

The first group[1] constructs those exquisite geometrical figures, so wonderful and complicated and so common that we seldom stop to realize their beauty. They hang their webs in window corners, doorways, between branches of trees and in many other convenient situations where their prey is likely to be abundant. The silken threads which compose the webs of the orb-builders, are extremely sticky, consequently an insect seldom gains its freedom when once entangled in these death traps.

Many of the orb-builders sit motionless in the center of their webs while waiting for their prey, but the cunningest of them hide at a distance within a tiny bower of leaves, which are carefully shaped and then basted together with soft white silk by the spider. From the very center of the web, the creature spins two long delicate threads which run into the opening of the bower. These it clasps in its front feet and through them, the slightest motion of an entangled insect is transmitted to the hiding cannibal.

[1] Epeiridæ.

The platform-building group[1] constructs large stages of silk in all sorts of situations, but they are particularly fond of window-sills where their huge webs are often found. At one end of the stage a large silken tube is constructed in which the owner hides and from which it darts, upon seeing an insect alight upon the platform. The silk of these spiders is not so sticky and would seldom serve to entangle an insect; thus it will be seen that the platform-builders construct the flat white stages chiefly to attract their prey, that they may dart from their hiding place, seize and devour it at leisure.

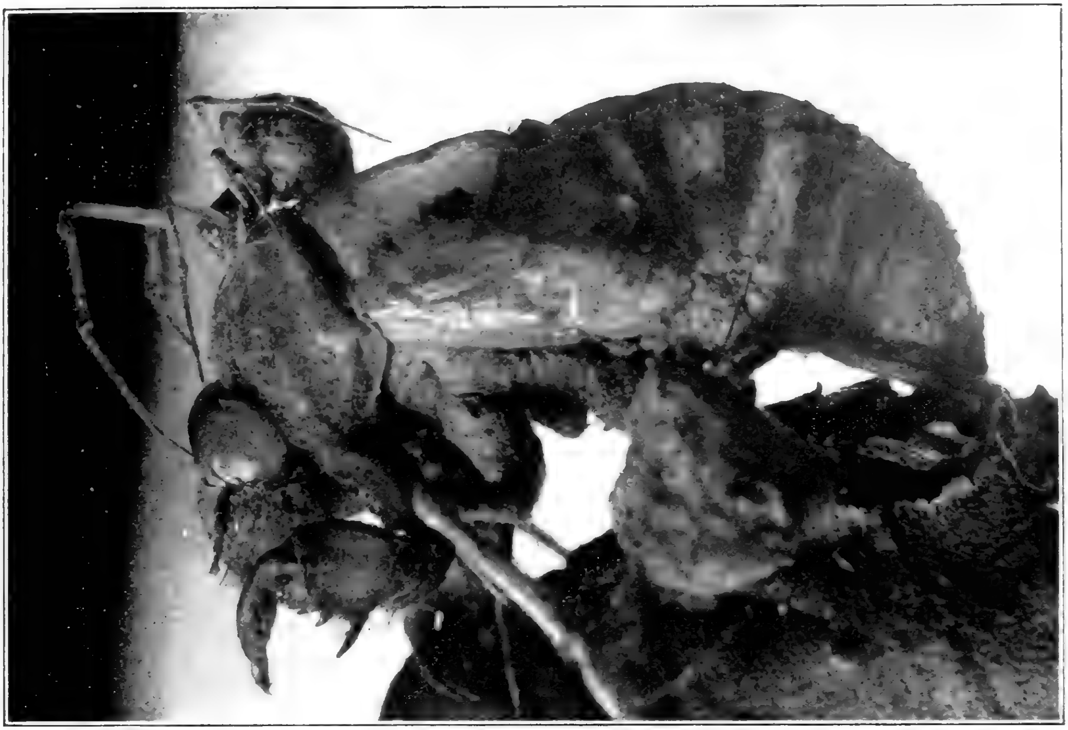
The third and fourth groups[2] embrace some of our largest and most powerful harmless spiders. These, however, do not build webs, but simply move about through the grass in fields or in other places frequented by their favorite insect food. In fact, they literally stalk their game, creeping up stealthily and then springing upon it from a distance of several inches.

Occasionally these spiders will construct a flimsy silken tube under a stone, but the majority dig deep burrows in the fields which they inhabit and their big hairy heads may be frequently seen squinting from the mouths of their subterranean homes.

One of the most interesting cases of insect strategy is the method by which the oil beetle[3] succeeds in placing its young within the nests of bumble bees, upon whom they are parasitic when young. The oil beetle is well named from the fact that it has the curious ability of discharging a noxious oily fluid when attacked by an enemy.

Towards the latter part of summer these big blue-bodied insects may be seen clumsily walking and tumbling among the early fall flowers which the bumble bees are sure to visit in their search for nectar. One unfamiliar with these two insects would not suspect the

[1] Agalenidæ.
[2] Drassidæ and Lycosidæ.
[3] Meloidæ.



1. A spider which used an empty cicada's shell as a hiding place while waiting for victims to enter its web

2. An example of spider strategy. The web of this spider, Agalena nævia, was watched from day to day for a period of two months. Ninety-eight insects were taken from the web, carefully dried and ground up, making in all, the pile upon which the spider rests. Only the day catches were removed from the web. The list of insects caught would include moths, butterflies, bees, wasps, flies, bugs, grasshoppers and numerous other orders. As an example of successful strategy in the capture of food it is unique

close relation which exists between their simultaneous reappearances, for the oil beetle is out on business which, unhappily enough, will prove detrimental to the welfare of the bee's future household. The beetle's reason for climbing among the flowers is to lay her eggs upon their blossoms; an intruder to be sure upon the property which in all nature seems justly and only that of the hard-working bees. In the course of a few days the beetle's eggs hatch out into tiny six-legged creatures, utterly unlike their parents. Later when the Bumble bee comes to gather her store of honey, these active little insects jump upon her back and, clinging fast to her hair, are carried to the nest, where first they eat the bee's own eggs and later the food which she has stored up for her young.

Another instance of the stratagems of insects in procuring their prey is that of a remarkable insect called the ant lion.[1] It is widely separated from the race of insects which includes the oil beetles, but it is perhaps the most interesting of all preying insect creatures. It is, in reality, the young of a certain nerve-winged insect, somewhat resembling a dragon fly. It is about an inch in length, and the outline of its body is more or less triangular, the widest point being at the tail end. It has six powerful legs and the mouth is supplied with two incurved jaws which give the insect a frightful appearance. Its sole food consists of the juices of other insects, particularly ants, but on seeing the lion for the first time, it hardly seems possible that it could ever secure a single meal. Its pace is slow and tedious, but worst of all it can walk in no other direction than backwards! What chance would it have with a nervous, fast-moving ant? It could not give chase, and to stay motionless would be equally ridiculous, for its grim appearance would be sufficient to impress upon all insect wanderers, the prudence of keeping at a respectful distance! The ant lion's appetite

[1] Myrmeleonidæ.

is tremendous and it will seldom partake of food unless it has first had the joy of killing it.

Here again the insect accomplishes by artifice what its ordinary unaided efforts would have been unequal to. It digs in dry loose sand a conical pit in the bottom of which it lies concealed, and there seizes those unfortunate ants which, chancing to stumble over the edge, are precipitated down the sloping sides into the lion's waiting jaws. Sometimes the ant is able to stop half way down, regain its footing and scramble madly for the top. No sooner does the ant lion perceive this than, shaking off its inactivity, it ludicrously shovels sand upon its head with its front feet and hurls it vigorously upon the body of the escaping ant. This heavy shower from below invariably starts the sides of the pit to slide under the unfortunate insect's feet and at length it is carried down to the greedy devourer in the bottom of the pit.

The methods employed by the ant lion in building its pitfall are extremely interesting and I must not fail to mention the fact that we have a species of this remarkable insect occurring quite commonly in the United States. Many accounts have been written of their curious habits, both in this country and in Europe. The following is an extract from a paper written many years ago by Reaum, and is an admirable description of an ant lion's energy in constructing its pit:

"Its first concern is to find a soil of loose dry sand, in the neighborhood of which, indeed, its provident mother has previously taken care to place it, and in a sheltered spot near an old wall, or at the foot of a tree. This is necessary on two accounts: The prey most acceptable to it abounds there, and no other soil would suit for the construction of its snare. Its next step is to trace in the sand a circle, which, like the furrow with which Romulus marked out the limits of his new city, is to determine the extent of its future abode. This being done, it proceeds to excavate the cavity by throwing out the sand in a mode

The fishing net of a hydropsychid

The maker of the snare is shown at the right. These creatures swarm in brooks. Greatly enlarged

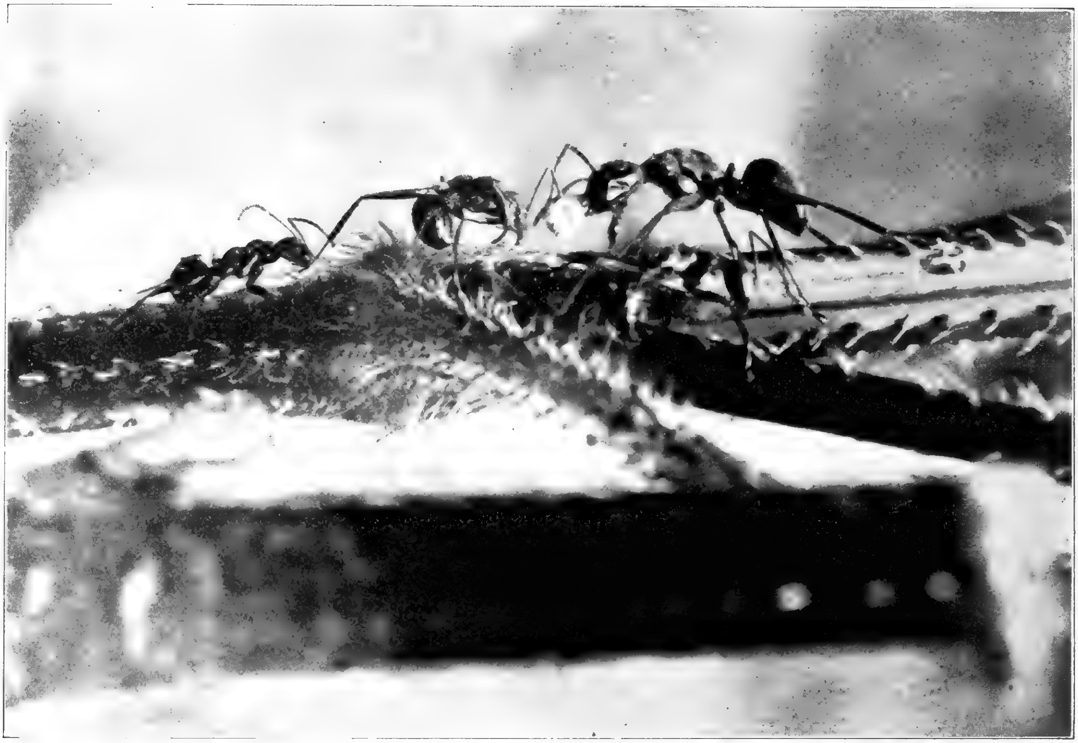
not less singular than effective. Placing itself in the inside of the circle which it has traced, it thrusts the hindpart of its body under the sand and with one of its forelegs serving as a shovel, it charges its flat and square head with a load, which it immediately throws over the outside of the circle with a jerk strong enough to carry it to the distance of several inches. This little manœuvre is executed with surprising promptitude and address. A gardener does not operate so quickly or so well with his spade and his foot, as the ant lion with its head and leg. Walking backwards and constantly repeating the process, it soon arrives at the part of the circle from which it set out. It then traces a new one, excavates another furrow in a similar manner, and by a repetition of these operations, at length arrives at the center of its cavity. One circumstance deserves remark—that it never loads its head with the sand lying on the outside of the circle, though it would be as easy to do this with the outer leg, as to remove the sand within the circle by the inner leg. But it knows that it is the sand in the interior of the circle only that is to be excavated, and it therefore constantly uses the leg next to the center. It will readily occur, however, that to use one leg as a shovel exclusively throughout the whole of such a toilsome operation, would be extremely wearisome and painful. For this difficulty our ingenious pioneer has a resource. After finishing the excavation of one circular furrow, it traces the next in an opposite direction; and thus alternately exercises each of its legs without tiring either!"

There is one other insect, a Caddice worm,[1] well worthy of a place among these instinctive strategists. This creature lives under the water. It is a true fisherman in every sense of the word, for it catches its food by constructing a silken net in the current of the stream which it inhabits. The mesh of this net is almost perfect in its symmetry, each strand of silk being fastened at a right angle with the one next

[1] Hydropsychidæ.

to it. They are funnel-shaped affairs and the insect is cunning enough to always place it so that the running water enters through the largest end, thus keeping the net tight and in one position. The insect spends the majority of its time under stones or pieces of old water-logged wood, visiting its net when in need of food, and finally leaves the water after many months, in the form of a filmy-winged insect known as a Caddice fly.

How marvelous it all is, that nature has supplied each and every one of her creatures, not only with a method of finding their proper food, but, as in the cases which I have just described, she has shown them how, by artifice, they may capture with ease and no loss of energy, their desired articles of diet.



Ants surrounding and pillaging a larger one bearing a pupa. Twice life size

Brown ants transporting aphids to their underground nest

One ant may be seen gently lowering an aphid to a waiting porter whose head protrudes from the ground. A third ant looks on from above. Enlarged twice

Actual debris gathered up after an ant battle
Note the mangled condition of the dead. About life size

Carpenter ants tending their aphid "cattle" upon the stem of a flower. Enlarged thrice

CHAPTER XIV

OBSERVATIONS ON ANTS

AS far back as one may search through the entomological literature of the past, there will be found records of ant behavior. Ever since man has been civilized to the degree of recording events, he has realized how wonderful is the highly organized social life of these insects.

So much has been said in fact, regarding their actions, that it has become difficult indeed to record anything new, and all but impossible to relate any of their known activities in a new enough manner to be entertaining.

It is strange, however, that no one has attempted to bring us face to face with ants in their daily life, in such a way that it is unnecessary to depend upon the imagination for the actual picture. Poets and artists have sketched them and sung their praises, scientists have gone minutely into the significance of their behavior, yet who has honestly given the camera its chance?

With this idea in view I have gathered together the material for this chapter. However meagre the results, they have been dearly bought by many failures and experiences that can be only realized by one who has worked in the field of insect photography.

Let us wander out for a time into the lowly world of ants, down among the grass and earth, or perhaps in the heart of some aged and broken tree of other days. Let us live among these creatures themselves, watch their activities and perhaps discover something new.

There, at the base of the old maple, where its trunk enters the ground, is a tiny pile of wooden pellets. Some five feet above, a carpenter ant[1] thrusts her head from a crack in the ancient bark. In her jaws is a bit of wood débris from the work of enlarging the nest within, where other individuals of her kind are cutting away the fiber with their powerful jaws.

The ant that we are watching is only a cog in the great machine that makes up the colony and her part of the work is simply gathering these wood chips and carrying them to the outside of the tree. Here she either drops or transfers them to other porters who carry them some distance away from the spot where the nest is being constructed.

Several porters are also assigned to the task of removing the pellets which are dropped at the base of the tree, and if we were to watch long enough, the pile which first attracted our attention would gradually be removed until no evidence of activities within the tree remained.

The work of enlarging the home may be carried on by ten individuals or a thousand, without affecting the regular routine of the ant city. As we watch the crack in the bark for the head of the porter with her endless wood pellets, other ants are seen hurrying in and out, ants of several sizes, bearing a variety of burdens. Occasionally one stops to give the characteristic greeting by crossing or touching feelers with a fellow worker, a sort of "Same Lodge," as it were, but the general appearance about the entrance is one of haste, and reminds me of the Grand Central Station a minute or so before the departure of a popular commuters' train.

Here is an ant bearing a tiny whitish grub-like object, dead but good eating nevertheless for the hungry ones within. Closely following upon her footsteps is a big powerful member of the colony struggling towards the entrance in the bark, with the entire springing leg of a grasshopper. It weighs as much or more than the ant herself and the spines upon it must have caused her no end of trouble, yet she has

[1] Camponotus pennsylvanicus.

South American leaf-cutter ants, paralyzed and dying after being attacked by a smaller species. Note the portions of leaves which the victims were carrying when attacked. Much enlarged

A group of ants, all linked together, but dead and motionless when the picture was taken. Greatly enlarged struggled on (who knows from where?) with that bit of food, faithful to her queen and colony.

Into the darkness of the nest she plunges, now assisted by another worker. She disappears through tunnels and alleyways and finally lands her dainty morsel in some store room far in the depth of the tree. All this she has done in utter darkness and it is strange that she should be able to work, unaffected, either by glaring sunlight, which she has just left, or the blackness of the nest.

Now let us look within the nesting tree and see the multitude of insect life that inhabits its endless tunnels and galleries. A complete colony contains one or two fertile queens, whose sole duty is the laying of eggs and without whose influence, the lesser personages of the tribe would soon lose their instincts and die. Besides these regal insects there are a multitude of creatures known as "Workers," undeveloped females in reality, upon whose shoulders the main labor of the community rests. Then there are the young males, and females, the weaker sex, to become royal mothers after they have left the old home in what is known as the "Marriage Flight" with the young males.

New colonies are started in this way by the younger generation, who at maturity are actually driven from home by the workers. The young males, however, never enter the new nest. Weak and unable to provide for themselves, they soon die of starvation or fall easy prey to their many enemies. Thus does Nature dispense with these useless members when the "Marriage Flight" is ended.

The young queens are independent, strong and well equipped to take care of themselves, as indeed they must be, for each must lay the foundations of a new colony. Their first action is to rid themselves of their no longer useful wings, which they do with enthusiasm, severing them close to the body with their own jaws! When this has been accomplished the fertile insect crawls into some tiny crack or cavity and lays her first eggs. This first brood of antlings must be fed and tended by the queen herself, until upon reaching maturity they are able to take up the labor for their sovereign. Brood after brood are hatched and reared and as each ant becomes a finished product she assumes her part of the responsibility. Thus, by the end of a season, the young queen becomes indeed a royal mother of a loyal army of supporters, workers and soldiers.

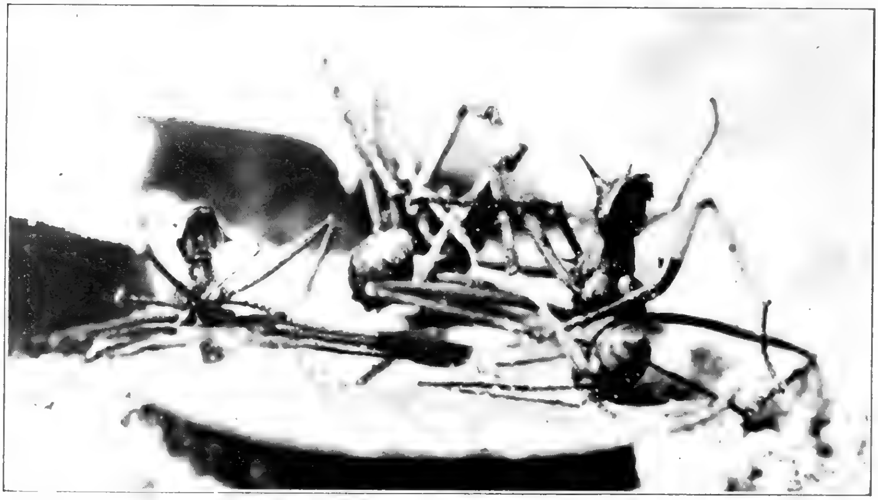
Interesting and wonderful are the ants known as the slave makers,[1] species that actually organize raids upon the nests of ants of another species for the purpose of stealing their eggs and kidnapping their young. At the start of such a raid, some little resistance is usually offered by the tribe that has been attacked, but owing to the sudden and unexpected nature of these bombardments, the slave makers are often successful. They are fearless and strong and quite willing to die, if need be, in attempting to secure an egg or antling from the pillaged nest.

Sometimes the defending insects will form a circle about the nest, which serves to keep the enemy off, until other members of the colony have had time to snatch up eggs and young and make for safety by some back door or passageway. But ants that have nearly made good their escape are often chased, cornered and robbed of their precious burdens by the alert and watchful slave makers.

When the raid has been brought to a successful end, the attacking party returns with its booty to the home nest where it is welcomed, perhaps cheered by the non-combatant members of the colony.

The supply of stolen eggs and young are now raised to maturity, after which in the case of one species, they become subjected to absolute slavery. The reflex of this habit upon the Slave Makers is just what one would expect; deterioration. The entire work of a nest is often put upon the shoulders of the slaves and in some cases, the war-

[1] Formica sanguinea and Polyergus rufescens, both slave-making species.



Carpenter Ants proceeding to battle. Dead specimens. Slightly enlarged.

Warrior Carpenter Ant with severed head of an enemy still clinging to it. Greatly enlarged.

A train of Army Ants. At least five hundred thousand individuals in the train.

Leaf Cutter Ants of South America showing heads and abdomens eaten out by a smaller species of ant. Three times life size.

riors of a colony will not even feed themselves, but depend upon the slaves to keep them from starving.

There is another species of slave makers, whose case is quite at variance with the insect mentioned above. This ant expends as much energy in home building and other work as it does in kidnapping. Consequently its home is in a healthier condition than that of its dependent, indolent cousin, even though its architecture is a cross between the ideas of slave and master.

But time will undoubtedly develop this ant into becoming more and more indolent, as it becomes more accustomed to depending upon its slaves. Indolence means the breaking down of its once strong home and instincts. Time may even obliterate it.

Let us leave these creatures already on the downward path to their fate. There are other ants to be considered, insects that have learned to better themselves.

There is a tiny family of true bugs, known as Aphids, often bright red or green in color, which gather in great clusters upon the stems and leaves of plants. They are equipped with a sharp sucking apparatus with which to draw the sweet sap from the plants upon which they live. Strange as it may seem, many kinds of ants have learned to extract the sweet liquid from the bodies of these little insects without injuring them in any way. This operation is performed by stroking the aphid very gently with the feelers and jaws. A stimulus is set up by the stroking, whereby the aphid exudes a minute drop of honey dew, which is greatly relished by the ant. So much have ants become associated with aphids that they are generally known as ants' cows, and wherever the little creatures are found clustered upon a plant, one is almost sure to see the attending ants fussing about and tenderly protecting them.

Under normal conditions, most of the aphids die as cold weather approaches, and this the ants appear to be aware of. With them they perform one of their most interesting habits. The first frosty wind that suggests the coming of winter, sends the ants scurrying to their respective herds. The tiny cattle are tenderly gathered up and born away uninjured to the ants' subterranean nests. Here they are placed upon exposed roots below the frost line, that the ant colony may enjoy a fresh supply of honey throughout the winter, when for the most part, the insect world is cold and dead.

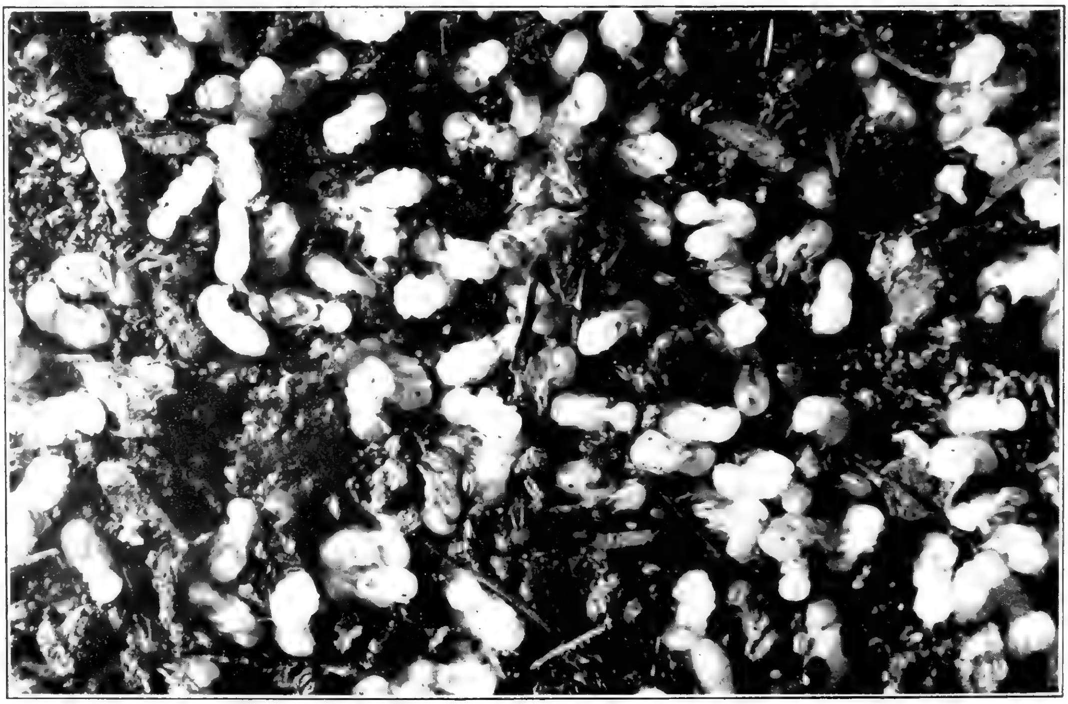
Even more wonderful is the fact that ants have been observed to gather the eggs of aphids in the fall, carry them into their nests for the winter and in the following spring, place the young cattle which emerge from them upon their natural food plants. Here they were allowed to remain during the summer in exchange for the honey-sap which they extracted from the plants.

Among such masses of insects as people the ant world, one naturally finds a series of happenings, quite similar to the events in the world as we know it. Where great numbers of creatures are found living together, no matter what they are, or how low they may be in the scale of life, there are sure to be disagreements between certain members of the race. How these troubles originate is not for me to say, but it is true in the ant world, as in ours, that great upheavals often occur, usually between colonies of the same species. Starting perhaps between two or three individuals, these disagreements often end in general warfare between the two factions.

These ant struggles are true wars, where only death can decide the issue, for they fight hand to hand, or better, jaw to jaw, until one has destroyed the other. The battle is composed of hundreds of warriors, each fighting loyally and frantically until its last spark of life is extinguished.

Few people have been fortunate enough to witness one of these wars, yet by a strange turn of fate, the author came abruptly upon the tail end of a furious battle which had probably been going on during

Young brown ants tenderly cared for by their nurses. Twice life size



Young brown ants brought up beneath a sun-warmed stone. Twice life size most of the previous night. This fight took place between two colonies of carpenter ants,[1] in the eaves of an outbuilding and workshop. When the doors of the shop were opened in the morning great numbers of black, mangled bodies were seen upon the floor, covering an area nearly six feet in diameter. The creatures had been battling in the eaves above the door, and in the fury of the struggle had dropped to the floor below.

There were legs and feelers, several heads and broken bodies lying about in profusion, and here and there were little groups of ants, all dead, but still linked together in a death grip. Other mangled bodies still writhed in agony. There was one huge warrior with the severed head of an enemy still clinging to its feeler, and a few couples were still fighting furiously upon the floor.

One could hear a distinct clicking and snapping as the powerful knife-like jaws opened and closed upon the unfortunate victims. I even saw one little ant with every limb gone and its feelers both cut off, still bravely fighting upon its back, with a much larger and quite unharmed antagonist. Above, in the eaves, small groups of warriors looked down upon the aftermath, as though staring with satisfaction upon the scene of carnage which they had left.

It brought home to me, as no insect event has ever done before, how like us these creatures are! One offends, and the whole innocent race suffers, some only slightly to be sure, but others pay with their life and blood for the wrong of another!

The leaf-cutting ants[2] of tropical America during their foraging excursions are frequently attacked by a smaller species of ant that easily conquer them, thereafter eating out the abdomen and head of their captives. This pugnacious ant is a tiny creature, measuring

[1] Camponotus pennsylvanicus.

[2] These insects belong to the genus atta. They grow a fungus, Rozites gongylophosa, upon fragments of leaves, which serves as food for the colony.

three millimeters in length, and it is remarkable that they are so easily able to vanquish the large and powerful leaf-cutters that measure eight millimeters in length and possess long legs and powerful mandibles.

The method of attack is interesting. Grasping their large opponents by the middle of the tarsi, the minute warriors bend their bodies inward, and with head lowered hang on with great strength and force. Two or more attack the leaf-cutter at once and apparently put it into such a state of panic that no resistance is offered. It is probable that the leaf-cutters could easily rid themselves of these pests were it not for the fact that they are first beaten by their own fright.

Observation of this strange state of affairs, existing between these two species of ants, led to the following experiments, which I believe are worthy of recording. For the purpose of experiment, two vials of liquid were produced by grinding some of the dead leaf-cutters in a mortar, to which a few drops of boiled water were added. This was let stand for several hours before being strained for use.

For the first experiment a drop of solution, produced from the heads and bodies of the leaf-cutters, was injected into the body of a vigorous wasp, a creature many times larger and stronger than an ant. The insect immediately showed signs of stupor, twitched heavily and rubbed its forelegs over its head continually for several minutes, then recovered and flew to the window pane. A second injection of the same fluid, and a very heavy one, produced the same result, followed by recovery and the insect walking away when liberated! There is evidently no poison then, in the heads or bodies of the leaf-cutters, which, it will be remembered, are the only parts eaten by the smaller ants.

As a second experiment, a drop of liquid made from the thorax of the leaf-cutter was injected into a fresh wasp. This resulted in the insect's being completely overcome for perhaps half a minute, followed by part recovery, then a second spell of weakness, more severe than the first, violent twitching, then rolling upon the back. A second injection of the same fluid resulted in death within half a minute.

From the above it is plain why the attacking ants leave the thorax of the leaf-cutters untouched, as it contains material highly poisonous to the smaller insects.

Continuing the work of experiment, a solution was produced from the entire bodies of the smaller ants. A drop of this fluid administered to a wasp between the second and third pairs of legs produced immediate paralysis of these organs. Another injection given just in front of the forelegs produced the same result in that pair. Now, if the small ants are closely watched during their attacks upon the leaf-cutters, they will be seen to attach themselves first to the unfortunate insect's legs. Here they cling for a few seconds before gradually working their way towards the head of their prey.

At length they arrive at this point and remain doggedly clinging to the mandibles or mouth parts of the larger ant. From what we have observed the following is a possible explanation of what takes place:

The third experiment has shown that whatever part is injected with the small ant's poison, becomes subject to paralysis in a very short time. The smaller ant attacks the head of the leaf-cutter and the latter, as we have observed, makes no effort to use its mandibles upon its tiny persecutor. The smaller ant's course is plain. It attacks the leaf-cutter's head; paralysis of the muscles governing the mandibles and biting parts results and the larger insect can do nothing to protect itself against a number of the smaller ones, who soon drag it to their lair!

Before closing this chapter on various phases of ant behavior, that I have been able to record from time to time, it is fitting that I set down a few notes on the strange army ants of South America.[1]

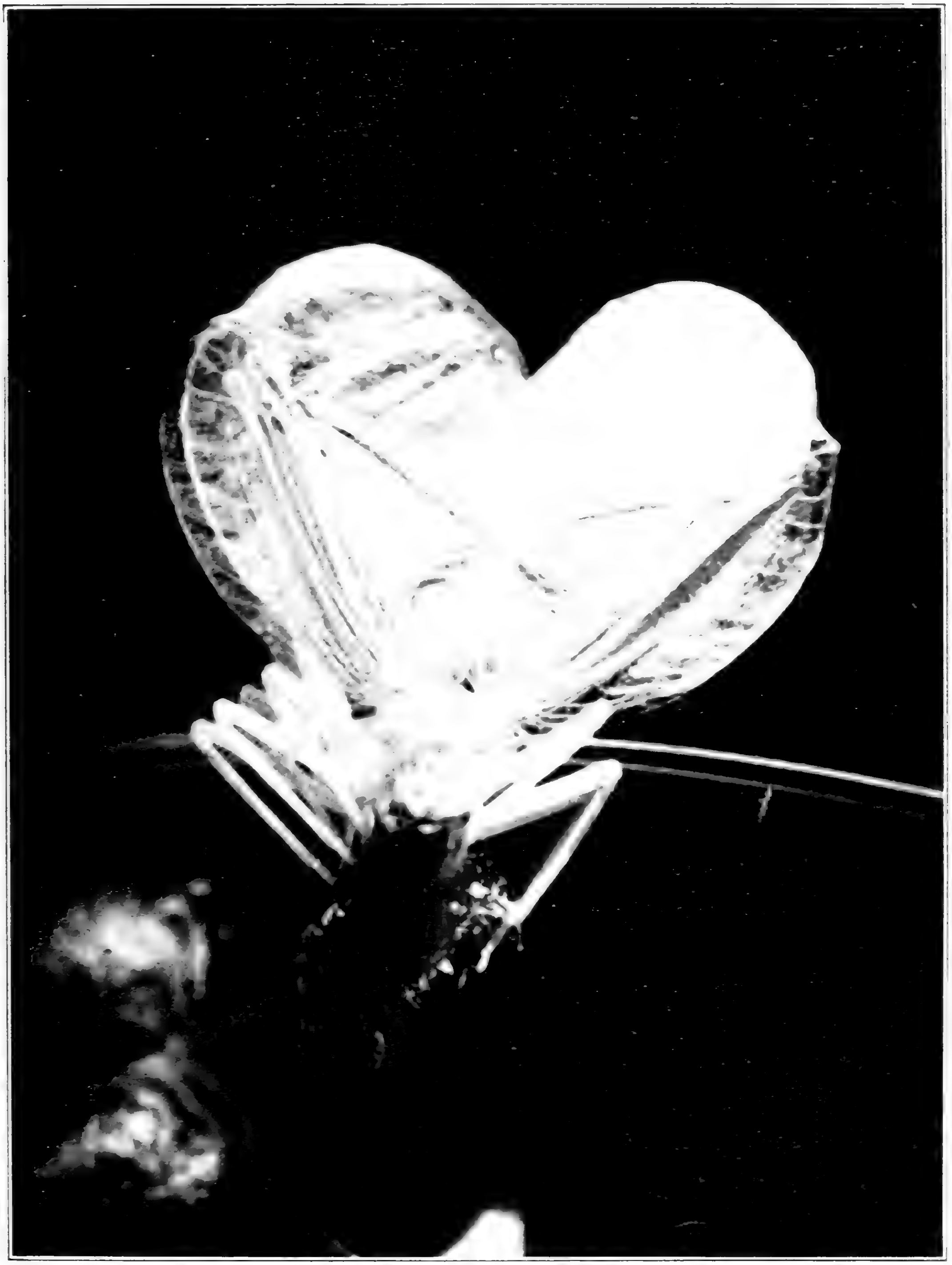
These insects roam the dimly lighted jungles in vast armies, traveling about from day to day like bands of gypsies. As they progress, carrying eggs and young with them, they hunt out and capture all insect life that chances in their path. The booty is torn to pieces and then borne to their nest, where the queen and nurses, with the tribe's precious eggs and young, together with a number of guards, remain in safety until the return of the warriors. Scouts are doubtless sent ahead from day to day, whose duty it is to find a safe shelter for the main army, which follows shortly afterwards.

At six o'clock one morning my attention was attracted by a long thin line of army ants moving hurriedly across the compound. Tracing their line of march I soon found them to be moving in a zigzag course to a hole underneath some blocks of concrete that had originally served as foundations. Evidently they had been moving for several hours, perhaps during the night, for a distinct path two inches or more in width had been trodden smooth by them.

Here and there a leaf or twig hindered their progress and at other places a depression in the ground called for the unnecessary expenditure of energy. To overcome these difficulties, a wonderful sense of duty was displayed by certain members of the tribe, who formed solid living bridges, over which the others passed. Sometimes but a few were necessary to bridge the obstacle, but in other places, dozens and dozens of individuals linked themselves together to form the bridge and complete the road as a smooth, comfortable highway for their tribe.

The ants traveled from five to eight abreast, never in a wider column, and the moving army reached from the concrete blocks clear across the compound and thence out of sight into the underbrush, a

[1] These observations were made in the jungle near Bartica, British Guiana, in May, 1916.



A snowy tree cricket singing
These insects produce their song by rasping their delicate wings together which causes them to vibrate and produce the sound

distance of at least three hundred feet. This is not unusual. They move thus for hours at a time and their numbers are enormous. I estimate that this particular army contained at least half a million individuals.

The Army ant remains in no regular home. They are a crowd of gypsies, that travel throughout their lives, living upon the land and carrying their possessions with them. In the line of march, one sees thousands of nurses carrying eggs, larvæ and pupæ. They are usually in the center of the column, guarded on either side by workers of various sizes and soldiers with tremendous heads and mandibles, shaped like elephant tusks and gleaming like ivory. Now and again a lieutenant rushes back along the line, sometimes charging through the thick of the column as though keeping order or searching for a member out of step that might hinder the march. All is magnificent order and system, like a huge splendidly organized army of soldiers, efficient to a man and disciplined into machine-like unity of action.

By mid-day the army was in its new quarters, encamped and ready for the next march or hunt. Meanwhile, until the order comes to move, there is much to be done. There are hundreds of eggs and young to be cleaned and cared for. They must be guarded and fed and kept warm lest injury result and the future of the tribe be endangered.

As they clean and brush the youngsters, the nurses gather in great clusters throughout the camp, one upon another, sometimes twenty deep and scattered everywhere among this living mass one sees the gleam of adolescent insects. All about them move other members of the clan, passing in and out among the company streets, each bent upon some important bit of work that collectively forms the superb organization before us.

They accomplish one great task at a time, eliminating and neglecting all others, which at other times would claim their attention. A harvestman[1] walks calmly about among the seething multitudes. He is undisturbed and quite ignored even by the soldier ants that surround the nurses and rest in clusters upon the walls of the cavern. A wasp has her burrow within the lines also, but she flies in and out, bearing prey for her wasplets at will. The entrance to her burrow is within half an inch of a solid phalanx of resting ants. Many others are moving hastily over the diggings thrown out from her nest, but none enters her domain.

They are a moral crowd indeed, these army ants. Tomorrow they may seethe forth in a terrible invasion and before them all insects will fall. They will be invincible, merciless, but the order of today forbids slaughter! Within their very camp other creatures move about at will, yet the ants obey that strange supreme command to rest. Fate is with the wasp and harvestman.

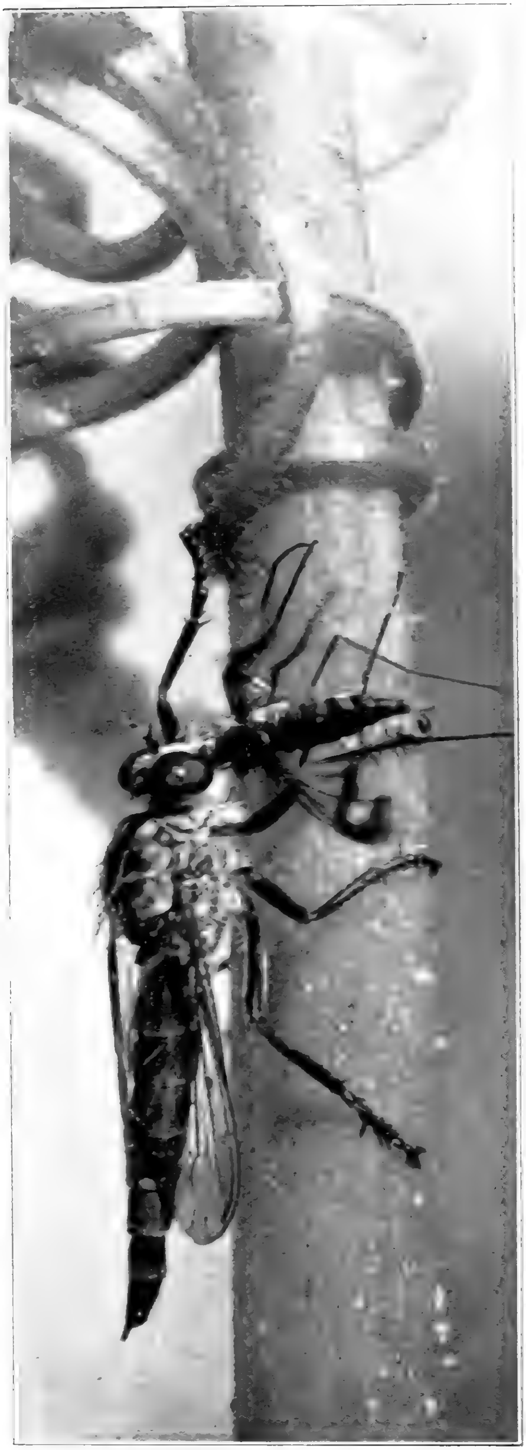
All is quiet and serene about the camp. There are no signs of outside activity until late in the afternoon. Then, about five o'clock, six lines of scouts issue from the cavern. One line travels out to the posts of Kalacoon house, another to the west, over the compound in the direction from whence the army appeared. Two more parties go to the south and again two to the west. Each of these lines extends for perhaps fifty feet. They form in single file, or at times two abreast, and occasionally a line may be seen returning, while others still advance.

These are doubtless scouting parties, searching out the ground to be hunted or traveled next. There are no warriors among them until late in the evening, and then only individuals scattered here and there by the wayside, taking no part in the activities of their brothers. The scouts are of two sizes, both, I presume, workers.

Within the nest, the nurses, and somewhere, hidden from the common horde, the queen still rests, attended by her special ants in

[1] A species of Phalangidea, commonly called Daddy-Long-Legs.

The typical dragon-fly face, showing the insects' highly developed eyes and negligible antennæ or feelers. Greatly enlarged



A robber fly with its prey. This insect is gifted with comparatively clear eyesight. Greatly enlarged

waiting. I wonder what the scouts have found, what they have noted and communicated in their mysterious way to the commander of this supreme army. It is growing dark without and the scouts abroad grow less numerous. One by one the stars appear and I wait as anxiously as an expectant enemy for the morrow and the outcome of the gigantic plan already formulating among those seething hordes in the encampment.

At dawn on the following day, I found the army at its work of slaughter. Walking by the forest trail, I was suddenly arrested by a strange sound. It was not the sharp noise of snake or lizard startled by my approach, nor the scratching of some hungry ant-bird. It was a faint, but steadily increasing crackling murmur, unlike all other jungle sounds.

Stopping to listen, with ear bent to the brush, my eye caught sight of a line of warrior ants. Their heads were huge rounded knobs, bearing curving mandibles far out of proportion to the remainder of their bodies. Glancing back along this line of soldiers, I soon understood the meaning of that strange cracking murmur, for there just behind these pickets rolled the main hordes of the army ants.

Hundreds and thousands, countless myriads of them rushing ahead behind their leaders. Some were in rows, others in bands, chains and semi-circles. Among them were warriors of two sizes, but these were outnumbered a hundred to one by the workers of the tribe, who rushed along with the others.

Every blade of grass, every stone and twig and leaf was searched and researched by these fierce creatures in their mad onward journey. They came to a large stump and seethed up it in a solid mass like thick flowing molasses; up one moment, down the next and on to another object, whatever it might be. Thousands of others mounted to the leaves of flowers and the foliage of small trees, sending down a shower of panic-stricken insects to the waiting crowds below.

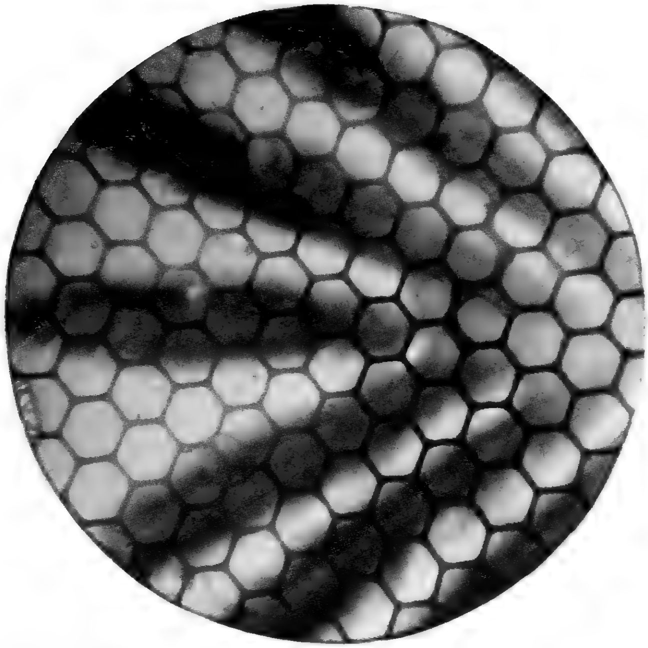
No living thing turned to give battle. Outnumbered a thousand to one none could combat such overwhelming odds. Ahead of the army rushed dozens of insects, driven from their habitats and fleeing like animals before a forest fire. Some would escape by a miracle, but the rule was a few short hops or springs and then death at the hands of the multitude. There were roaches and crickets, big caterpillars and beetles, ants of other species, bugs and huge centipedes and great numbers of spiders all fleeing for their lives.

Roaches and spiders were sought in particular. They appeared to be first choice. They were torn to shreds at once and carried away in still squirming pieces to the nests. Caterpillars, if hairless, were also in favor, then spiders, bugs and so on down the list to the less palatable creatures.

What I had heard at first was not the roar of the army itself, but rather the fleeing host of other insects driven from their lairs. I saw one large spider escape death by a hair's breadth, by jumping at the instant of capture from a leaf into the air and there hanging by a silken thread until the danger had passed. Other insects that occasionally escaped were crickets and grasshoppers, their powerful springing legs carrying them beyond the line of march. A curious fact was that the ants never crossed the more deeply trodden footpath in the center of the trail, consequently those refugees who were fortunate enough to pass this line, were safe, and escaped unmolested.

A large roach endeavored to escape by crossing the main front of the army. The creature made several powerful jumps, but each time it touched the ground in order to make another spring, its legs were grasped by the fearless ants until at length their added weight became too great for the roach to lift. In the end it fell, after a brave effort to be free, and was instantly torn to bits and carried to the rear.

Upon being captured and divided, the unfortunate victim is at once carried back through the lines to the temporary nest of the colony.



Photomicrograph through the eye-windows of a fly, of an external object, placed extremely close to the eye

A photomicrograph through the same eye, of the same object, moved a very slight distance further from the eye-windows, but not so far as to be out of focus when viewed alone

One sees an unbroken line of these returning warriors, each with its dainty bit of the spoils. If the captive is too large for one ant to carry conveniently, it is distributed in steaks and hams and then brought to the den by a dozen individuals. I saw one ant struggling towards the nest with a large span-worm. It was far too heavy for her to transport alone and, perceiving this, a second individual stopped to give assistance. After some difficulty, these two insects slung the worm between their legs, stretched it to its full length and by grasping it in their mandibles proceeded to the rear.

Another ant with the body of a wood roach was assisted by a worker who held the carrier's abdomen high in the air out of the way of her burden, all the way to the nest.

In observing the movements of the army I became so absorbed, that the ants surrounded me without my being aware of it. They threw their lines here and there through the jungle for a distance of two or three hundred feet in every direction, and while I was in no danger, I could not get beyond their rear guards without being attacked and severely bitten. As I crossed through them with all haste, they swarmed upon my shoes and socks, biting and stinging wherever they could get through to the skin.

The attack of these vile little creatures, whom I learned to hate worse than anything else in the jungle, was so painful and poisonous that I shall never forget it. It brought home to me, how horrible must have been the deaths of those poor black men of Africa, who, in punishment, were tied hand and foot and left in the path of the army ants!

It is a strange fact that many other insects were attracted rather than frightened away by the army's movements. There were various species of preying wasps, who, finding their favorite victims of caterpillars and spiders abundant, and already hunted from cover for them, were quick to take advantage of conditions. They would hover above the army like hawks, suddenly diving like lightning upon some dainty morsel with which to provision their nests.

Likewise there were flocks of birds, thus gaining a living at the expense of the ants who drove forth their favorite insects. Some were tiny species, impertinent and talkative and sombre in color, others were larger, decked with crests of snow white plumes. One learned to associate these birds and insects, for where a flock of one was heard the other was sure to be also.

For many hours I watched this army at its deadly work. Then at length the fury of their drive diminished. One by one the warriors made their way to the temporary den in the heart of a rotting forest giant and by afternoon no signs of activity remained upon the forest floor.

Would that I might have seen within that aged and broken tree, for there, no doubt, a royal banquet was in progress. Perhaps another, more fortunate than I, may some day tell us what goes on, when the tired warriors return laden to their queen. My notes are but a drop in the bucket, and the army ants have still much to tell us.

"A harvestman walks calmly about among the seething multitudes." (Page 90.) Greatly enlarged

The ivory-colored eggs, massed in the feathers or fur of the respective host, hatch within twenty-four hours. A cluster of greenbottle's eggs. Greatly enlarged

CHAPTER XV

THE SIGHT OF INSECTS

OFTEN we have wondered to what extent the sense of sight is developed in insects. It has been asked again and again. It has been argued from every possible standpoint, but for all that it has been answered slovenly, and in an unsatisfactory manner.

Casual observations of the insect world tend rather to convince us that its people are alert to movements and dangers, and therefore clear of vision. We observe the male of a species searching for his mate. Perhaps she is a foot or more away, hidden behind thick foliage. Her color blends perfectly with her surroundings, yet how easily after a move or two he discovers her and quickly greets her with his love.

Again we hear a tree cricket, shouting his melody into the summer night. Stealthily we creep up, step by step, to the spot from whence the tune arises only to have it cease abruptly at the instant of discovery.

And so we might sight a thousand cases where apparently insects' vision aids them in a successful life. The bug searching its mate, the cricket avoiding discovery, the fly escaping its everlasting and greatest enemy, the swat, and so on indefinitely.

But it is strange how modern instruments and facilities for proper study, knock one's pet theories in the head. They rather take the romance out of things. Surely they leave no room for imagination, but after all the truth is best.

Insects possess sight, it is true, but in most cases it is not in a highly developed state. In order to understand what follows we must first become acquainted with the typical insect eye.

It is not the organ we generally think of, as one sees it in the head of a man, a beast or bird, but a compound and vastly different object. It is true that upon examining an insect closely we observe two large eyes, one set on either side of the head, but if we were to magnify the outer shell or cornea of these protrusions, we would find that what appears to be a single eye is, in reality, made up of many hundreds of smaller facets or microscopical windows, the whole resembling in every detail the exterior of a piece of honeycomb.

Behind each of these facets is an independent eye element of a complex nature connected with the optic nerve, so that each tiny window sees that part of the external object that is directly in front of it. In other words, whatever the insect sees is separated into as many parts as there are facets. To begin with, then, we learn that insects probably see things in mosaic patterns.

Let us now take a fresh insect and place that part of its eye bearing these tiny facets, under the microscope. Through the instrument we observe a honeycomb sash, in which the cuticular windows are set, and which appear to be quite transparent.

By the aid of a photomicrographic apparatus, that is to say, an arrangement by which we may photograph through a microscope, we now mount a minute object so delicately in front of the already mounted eye, that by peering into one end of the apparatus, we may actually see an external object through the eye of an insect. We are, so to speak, inside the fly, looking out.

For this object a feather from the head of a humming bird was chosen. By reason of its very minute size and convenient fan-shaped structure it proved ideal to illustrate the qualities of focus in the insect's eye.

In figure 64 we see the result of the first photographic experiment,

Attracted by a special odor, the mother flies come to deposit their eggs. A greenbottle laying eggs upon the head of a dead sparrow.

The eggs are deposited away from the light, among the feathers, in wounds or in the mouth of the host. Greenbottle laying eggs in a starling's bill. Both much enlarged in which the feather was placed, the smallest fraction of an inch beyond the eye window. It is clear and in perfect focus, even showing the smallest scales of the feather in fine detail. In each successive experiment the feather was moved perhaps one micron further from the eye, the result being that its plumes rapidly lost focus until all detail was gone. This was in no way due to the use of a too powerful lens, as proved by the fact the feather remained in fair focus when by itself at a similar distance from the lens, only becoming blurred when viewed through the cuticular windows of the eye.

From these not over-difficult experiments we have the following facts concerning the power of sight in insects. In the first place they see objects in mosaic patterns. Objects are seen in clear focus only when extremely close to the eye. At greater distances, only the outline of the object is visible and beyond a few inches things doubtless pass into mere shadows with intervening patches of light.

Further the experiments tell us that an insect cannot always depend upon its eyes. To find its mate, and to sustain life, by securing food, it must rely upon the sense of smell. But what of the fly who even with its defective eyesight, still avoids your swat so easily? True, he cannot see you in clear outline, but remember that you appear to him as a gigantic shadow more reaching than that cast by a range of lofty mountains. When you make your swat, this great shadow topples toward him with fearful speed, but Nature has supplied the creature with eyes that exaggerate and a speed that excels a falling avalanche.

Now it might be argued that these experiments were not really performed with the actual eye of an insect, but simply with the outer coating of that organ, and therefore prove nothing. Perhaps, in part such a statement would be true, yet is it not the outermost window that governs the quality of sight? A man might possess perfect vision, yet were he to stand with his face against a dirty window his eyes would avail him nothing and he would be ignorant of the details of what passed without.

And so with the insect. I believe it is the glass in the tiny honey comb sash that governs its sight; and through these minute windows the photographs illustrating this article were taken. Whether we observe this through a microscope, as we have done, or with a hand glass or the naked eye, we will arrive at the same results that we have already seen by our experiments.

Doubtless some insects see more clearly than others. Crickets jump at the slightest movement of an object many feet away and appear to be so gifted. The robber fly [1] captures its prey upon the wing, darting after it as it passes by, but of all these creatures who use their eyes to advantage, the dragon flies are, in the opinion of the writer, the only insects who depend more upon their eyes than any other of their sense organs.

Dragon flies are primarily predacious creatures, feeding chiefly upon mosquitoes, gnats, house flies and other alert and winged insects. They dart upon their prey with the ease and swiftness of a hawk, often from a great distance, seldom missing their unfortunate quarry. A glimpse at the typical dragon fly race, strengthens the theory that they are possessors of accurate eye sight. The eyes are huge, covering two-thirds of the creature's head, while the antennæ or feelers, which are the usual sense organs of direction in insects, are scarcely noticeable, hair-like appendages. To connect these primary features with the creature's habits, can only lead to one conclusion—that the dragon flies are possessed of clear eye sight and are exceptions to the general rule.

[1] Asilidæ. See Fig. 66.

That which was but a mass of something dead and repulsive becomes the separate bodies of myriad living creatures
Young greenbottle flies at work. Life size

CHAPTER XVI

HOW THE GREENBOTTLE DOES ITS DUTY

Sarcophagidæ

AS we stroll by the roadside this bright morning, a breath of air brushes ever so slightly across our path. It is a breeze at first scented with blooming roses and wistaria, perfume gathered from who knows where, and born by chance to our nostrils. In an instant it passes on as mysteriously as it came, leaving us bewildered by its change to the offensive. It is no longer pleasing. Somewhere within, it hits a tiny blow that says decay. A moment ago we had forgotten that such a thing were possible, but we are awakened now quite rudely. Even today, when Nature displays her beauty in a thousand different colors and voices her mood in as many varied songs, there is such a thing as decay.

Exploring the realm of thought for a moment, we wonder why the shell of what was life, no matter how tiny, no matter how great, if left uncovered, offends us. There must be an explanation to this, for Nature does not create a condition or a state without a reason. Being human, and therefore curious, we hunt about with this thought in mind, first for the source of the odor. Its function we shall look into later.

Lying stiffly by the roadside, the result of human folly and ignorance we find the offending corpse, a tiny squirrel with lustrous coat, marred only by the wound that caused its death. A broken stick and an empty shotgun shell close by tell the story of the crime, sufficient evidence to convince if not convict.

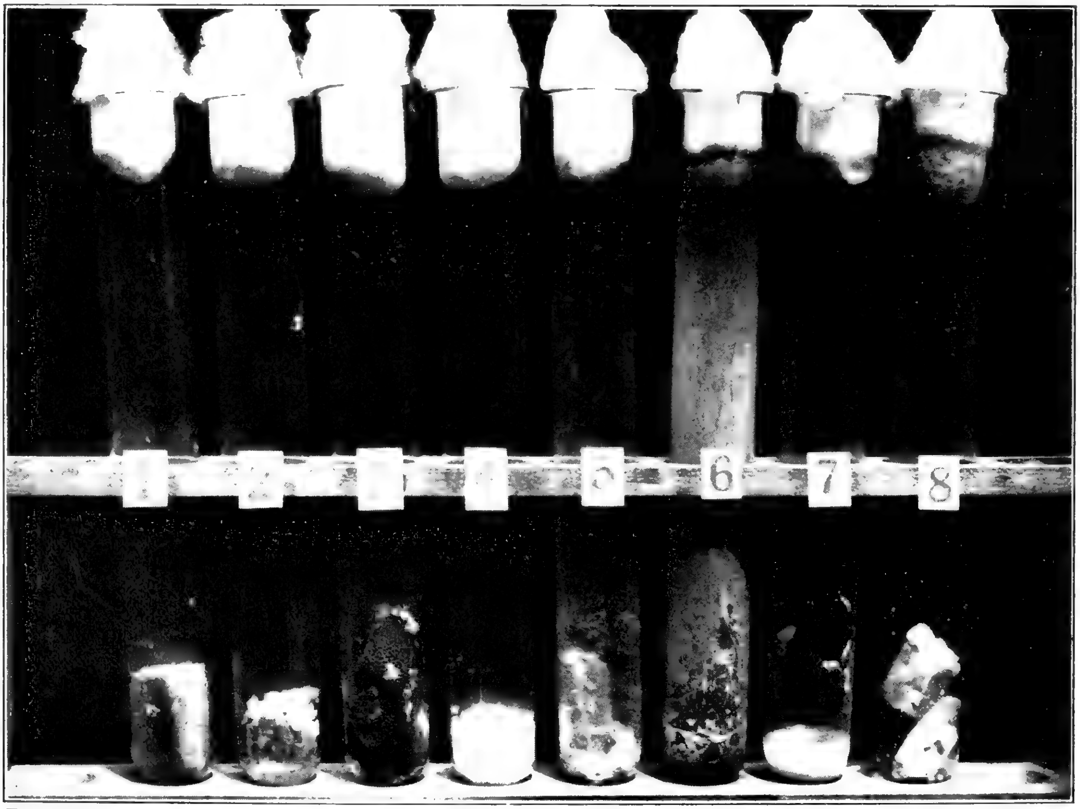
Turning over the little animal, we find a surging mass of maggots, a sea of life thriving upon death. They are the offspring of the greenbottle flies that hover about. Here indeed is food for thought. A repulsive sight perhaps, but let us forget about that part of it, in order to realize the beauty of what Nature is accomplishing.

Nature has long since learned that she cannot rely upon Man to restore the life that he has taken nor even to erase his crime by burying the corpse, yet she cannot tolerate the sight of death. If she did our land would be strewn with the mummies of ages. She cannot bury her creatures unaided. Instead she sends broadcast her tainted messengers, who marshal others to her aid. Thus we see her reason for the odor of decay.

Attracted by this special odor, the mother flies come from far and near to deposit their eggs, thus securing the future of their race. Hundreds upon hundreds, thousands upon thousands are deposited and hatched until a great army is mobilized upon whom Nature may rely. In a short time that which was but a mass of something dead and repulsive, becomes the separate bodies of myriad living creatures. Every atom of the squirrel disappears and becomes a part of a new life. True, the squirrel's bones remain, but they are mineral matter. They will go back into the earth where they belong and Nature will have restored her balance.

Examining one of the maggots, we find it to be a soft-bodied creature, milk colored, with a head somewhat darker than the rest of its body. It is tapered, like a kernel of corn viewed sidewise, the head appearing at the narrowest end, and is capable of a rapid rippling motion by contracting and expanding its muscles. At birth it is no larger than a flattened pinhead and at no time during its life is it supplied with mandibles or other appendages suitable for tearing or masticating its food. The mouth is soft and extremely minute; there are no sharp claws, no teeth. In fact it possesses nothing but two weak lips that could scarcely caress their host. How then does such

Skeleton of a muskrat
How the young flies clean up a dead animal, leaving only the bones which go back into the earth as mineral matter



From left to right the tubes contain, banana, coral fungus, boletus fungus, sugar, gluten, yolk of egg, white of egg and cheese. Each tube contains ten young greenbottle flies who were observed to thrive on these fresh-foods. Note liquification of foods in tubes 5, 6 and 7 a weakling surmount the difficulties of feeding upon the toughened corpse? To answer this we must experiment in the laboratory. Such a question cannot be decided by theory. We must secure the eggs of the fly, hatch them under various conditions and note what we can of their methods.

For our purpose, we place several dead objects in the sunlight. In a very short while there are a dozen flies about the game. Soon there are a thousand ivory eggs, and in a day, as many wriggling offspring. The first experiment is a huge success. We have a multitude of eggs and young. Let us gather some and continue.

In the laboratory we prepare twelve cubes of fresh raw beef, each weighing three grams. Six of these are placed in separate test tubes with cotton stoppers to prevent evaporation and a dozen freshly deposited eggs of the fly are added to each. The six remaining cubes of beef are placed under a glass bell as a control.

In a short time the inoculated tubes are alive with young flies and we notice that each individual is constantly surrounded by moisture. As the youngsters increase in size from day to day, the puddle in which each one feeds grows in proportion until at length after five days the meat within each tube is completely liquefied and about the consistency of thick cream. Under the glass bell conditions are totally different. Here the meat cubes are in exactly the same form as when placed there five days before. Perhaps they are slightly darker in color, but they are still in the form of cubes and quite as solid as ever. There is nothing which suggests a liquid state such as we see in the test tubes where the young flies have been feeding.

Continuing our experiments, we dip a piece of blue litmus paper into one of the tubes of liquefied meat. It turns almost at once from blue into a faded red. This is a simple chemical test which shows the contents of the tube to be slightly acid. We find that the same is true of the six inoculated tubes. Now in the human body there exists a ferment in the gastric juice known as pepsin, which in the presence of a weak acid converts proteids or tissue-forming foods into peptones, that they may be easily diffused through the membranes and used in the actual building and heating of the body. The strip of litmus has shown us the presence of just such an acid in each tube of liquefied meat.

Here then is the solution of the mystery surrounding the young flies' method of feeding. They are born without an equipment, suitable for actually chewing, but Nature has supplied them with a powerful expectorant capable of dissolving flesh into bouillon. Like so many drunkards, they drink their dinners, but their intoxication which comes only in the form of life, rids us of decay, a menace to our health and welfare.

From a chemical point of view, the young greenbottles digest their food in much the same manner that we do, but being unable to chew and swallow solids, they exude their pepsin first upon the food, converting it into liquid, which is then easily drawn into their suckling mouths and swallowed. Indeed it is a most admirable method, one that we would not be loath to mimic were our jaws undeveloped, our mouths toothless and our limbs unsprouted. So much for the young flies' method of assimilating their food.

Let us make the final experiments so that we may realize how this insect is of service to mankind. There are fifty thousand species of flies and we cannot condemn them all like the filthy house fly and the fever mosquitoes, which are recognized outlaws of humanity. In the ranks of this huge winged army we find insects doing good as well as bad, and the greenbottle is one of them.

For our experiment we procure a banana, two kinds of fungi, some granulated sugar, the boiled white and yolk of an egg, some gluten and a bit of cheese. It is a weird collection to be sure, but it will serve our purpose very well. We have now eight different food materials, fresh and wholesome in every particular, and varied enough, one would say, to suit the most fastidious taste. Such a free lunch should tempt the most abstemious.

During the day many greenbottles are attracted to the repast. They find the lure attractive and satisfying to their own mature appetite, but for all our trouble no eggs are laid upon the stores. This is indeed mystifying. Can it be that such excellent provender is unworthy of the fly's offspring? A curious state of affairs this, that such a puny creature must reject the fats, sugars, proteids and other nutrients capable of sustaining life in man himself.

Let us collect our foods and place each in a separate test tube, previously inoculated with a number of young flies. The youngsters are not half so particular as their parents. They feed happily enough on what we have provided and the tide of liquid rises rapidly in each tube. The egg, the fruit, the dry gluten, all but the sugar are consumed with relish by the maggots.

We have seen that the mother greenbottle ignores these fresh foods for the purpose of laying her eggs, but we know from the experiment just performed that her young will thrive upon them. Perhaps this is common knowledge between the fly and ourselves, yet she selects only putrefying matter in which to bear the fruit of her love, that our world may be saved from the menace of decay.

No doubt the greenbottles carry germs, no doubt they bring an occasional sickness to those who come in contact with them, but unlike the house fly, they are at the same time altruists, working for the public good. Like the street cleaner and the hobo, both are dirty, yet one is a menace, while the other rids us of one.

CHAPTER XVII

SOME INSECT EXPERIMENTS

YONDER near the forest's edge, a neglected, grass-grown wood path winds its silent way into the sombre, shaded depths of the virgin growth. In the center of the path stands a mound of dry, brown earth, protected from Nature's elements by the thick, dark foliage above. The mound is nearly three feet in diameter and stands some eighteen inches in height, for all the world like a miniature volcano in a setting of giant trees. Indeed, even the lava seems to be there, pouring downward in an ever-changing stream, as if impatient to destroy some tiny city at the mountain's base. But this is not the eruption of a fairy Vesuvius, which we are witnessing, nor is it even an unusual sight, but simply a great thriving insect city, wherein live some forty thousand mound ants[1] whose unceasing labors cause the whole metropolis to writhe lik streams of molten lava!

Among the numerous volumes which have been written upon insect life we seldom find one in which the ants are not credited as being the most marvelous of all insects. The actions of these creatures and the deeds which they accomplish would furnish sufficient material to fill many a volume of portly size, and indeed much has been written upon the subject. Marvelous is the manner in which they feed and care for their young and wonderful the loyalty of the subjects to their queen and their city. The storing of proper food for the winter and the capturing of Aphids or "Milch cattle," from which the ants extract a sweet nourishing liquid, are other interesting examples, all of which

[1] Formica exsectoides.

Nest of the mound-building ants
One-twelfth natural size

tend to strengthen one's belief in the intelligence of these industrious inhabitants of our world. But sooner or later, the very insect who, perhaps, by its marvelous actions, has held our rapt attention, or caused us to exclaim in astonishment, will display, but a moment later, such a ridiculous lack of logic that we are at loss to understand, and our belief in intelligence will be rudely shaken. But perhaps not permanently, for it is true that among nearly every large colony of these insects one will find an occasional example wherein an individual seems really to leave the beaten track of instinct in which its forefathers have traveled unwittingly for hundreds and hundreds of years.

Let us follow, for a moment, the movements of a single member of this colony of mound-builders, who is discovered laboriously endeavoring to drag the remains of a cricket many times its own size to the insect city, some twenty feet distant.

In the same circumstances, a man would have soon given up the task, for every twig, every leaf and every stone in the path played a part in hindering the progress of the hard-working insect. But the ant would not abandon such a dainty morsel of food, even had it been three times as heavy, and indeed she might have soon reached her destination had I not cautiously clasped the cricket by one of its antennæ or feelers with a pair of slender forceps. The ant was greatly troubled at finding her burden immovable, but she soon commenced to investigate, and finally, after some minutes, came upon the closed end of my forceps. Vainly she tried to free the insect from the grip of steel and finding herself unequal to the task, she soon made off in the direction of the mound. Now when perhaps fifteen inches away, the ant suddenly turned, as if by some idea or impulse which must be obeyed. Going straight to the feeler, which was still held by the forceps, she chewed it free with her powerful jaws and once more made off, this time in possession of her well-earned burden!

Of course it is probable that upon her return, the ant came by accident directly to that part of the cricket which was being held in the forceps. Nevertheless, it must be remembered that this time the ant freed her prize by chewing through the cricket's feeler, an action which had not, apparently, occurred to her when her journey was first arrested. Although this fact is not a very remarkable one, it is true that the ant was efficient in adapting herself to the circumstances, which were quite unusual. In such cases instinct is supposed to be deficient.

Now let us watch another ant, an inhabitant of the same mound, who is also struggling homeward, bearing the remains of some dry and lifeless insect.

After towing her burden backwards for perhaps twelve inches, the insect came upon a tall blade of grass, fully a foot in height, which was growing directly in her path. Here I expected to see the ant circumscribe the base of the stem, but what stupidity! Instead of executing this simple manœuvre, she climbed first to the top and finally down again upon the opposite side of the blade, probably with the idea that she had covered with ease a considerable portion of the homeward journey.

These two ants, which we have followed with their burdens, were undoubtedly children of the same queen, yet while one was quite competent under extraordinary conditions, the other lacked sufficient power of perception to have prevented herself from accomplishing a useless feat.

An interesting insect for experimental purposes is the Sphecid wasp,[1] the largest and most powerful of our Eastern wasps. This insect digs a deep burrow in sandy soil, at the end of which two or more elongated chambers or cells are constructed. In each of these, the insect places a single cicada or "Locust" that has previously

[1] Sphecius speciosus.

been paralyzed, but not killed, by the wasp's terrific sting. Now she lays an egg upon the breast of each of the unfortunate cicadas. When this has been done the burrow is sealed with earth and the young wasps feed upon the paralyzed insects until they reach what is known as the pupal state. In this form they spend the winter, issuing as perfect insects in the following spring. (See chapter XI.)

It is true that the cicada is larger and heavier, even than the powerful Sphecid, and it will readily occur to the reader, that to carry such an ungainly burden through the air, would be an extremely difficult undertaking. But here Nature has assisted the insect in accomplishing her function by supplying a pair of powerful upturned hooks or tongs, one of which is situated upon the under side of each of the wasp's back legs. These she squeezes against the cicada's sides and thus secures her burden during the overland journey to the burrow.

During the latter part of August, the writer captured one of these insects, together with a cicada, which it had recently paralyzed. The carrying hooks were then carefully removed from the Sphecid's legs and after several hours, the insect was replaced beside the same cicada which it had been carrying when captured. This was within a few feet of the burrow. Now a remarkable thing happened. The wasp paid not the slightest attention to the cicada, but flew rapidly away among the trees. This I had expected, but to my surprise she returned to the burrow within an hour, carrying another victim, apparently in her first and second pairs of legs. The cicada was suspended, tail down, in a line perpendicular to the wasp's body; the two insects forming the letter T while in the air.

This is a most remarkable case, as the Sphecid left the instinctive rut so minutely traveled by her ancestors and instantly adapted herself to the most extrinsic circumstances imaginable.

Equally interesting are the results of two experiments upon different species of the same group of insects, which were recently observed at close range by the author. These experiments are well worthy of note, from the fact that a vast contrast in adaptability was discovered between two insect species, so entirely identical in their anatomical structure and so closely related in their classification that they should have been equal to each other, even under the unusual circumstances in which they were placed. Yet in one of these experiments it was shown that a certain species possessed the power of instantly distinguishing between right and wrong, while the other made plain its inability to leave the beaten path of innate propensity.

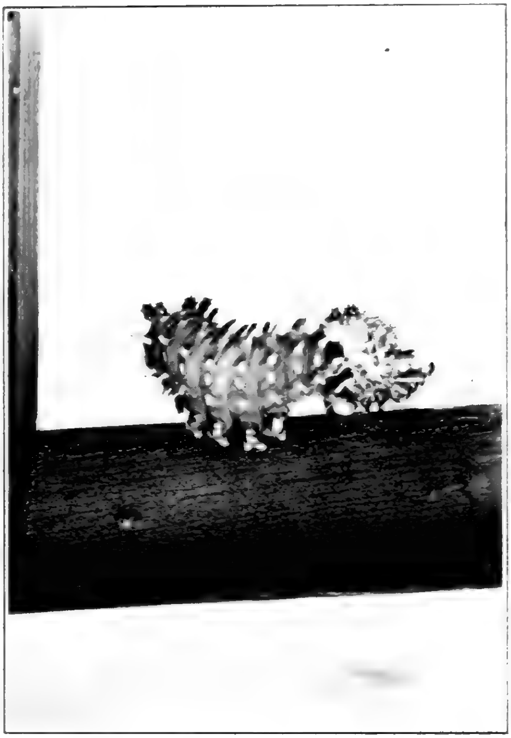
As I have said, the insects in question were both species of wasps; one the common paper wasp [1] and the other the common blue mud-dauber.[2]

Although they are much alike in structure, their habits are quite at variance, as we shall presently see.

The paper wasps are a social species; that is, they live in a colony, with a common den, which in this case consists of a group of paper tubes for cells suspended by a central stem from the undersides of overhanging stones or more often from old beams and timbers in barns or sheds. The paper for the nest is manufactured by the wasps from wood pulp, which is scraped from unpainted lumber and then mixed with a glutinous substance, which the insects possess. A large nest will contain in the neighborhood of three hundred cells, but the great majority are complete when one hundred have been constructed. In each of these cells an egg is laid by the queen and the young are fed by the other members of the colony until their period of helplessness is at an end. Their food consists of chewed up spiders and other insects, mixed with a certain amount of nectar, and is undoubtedly good. Thus it will be seen that the paper wasps are of a

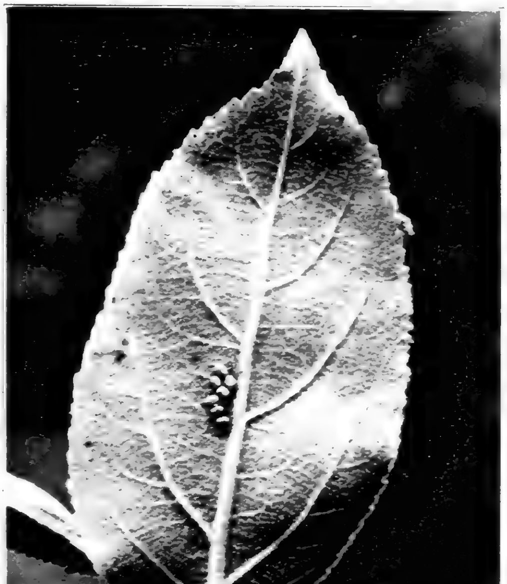
[1] Polistes.
[2] Chalybion cæruleum.

Cecropia caterpillars twenty-five days old. Life size



Twenty-six day old cecropia caterpillar casting its skin. Life size

Caterpillars of the cecropia moth just after the second cast. Reduced



Eggs of the cecropia moth on an apple leaf. Natural size

domestic turn of mind, and quite different in habits from their mud-daubing cousin, who is a restless, nervous creature of a solitary nature. This insect constructs from five to fifteen cells of rich grey mud, which, upon hardening, becomes quite substantial. The nest is placed in situations similar to those which the paper-making species select. Like the Sphecid wasp, the mud-dauber fills each cell with paralyzed insects, which in this case consist of small spiders. Then, after laying a single egg in each, she seals up the opening with mud and leaves the young wasps to shift for themselves.

For the first experiment, a mud-dauber's nest was selected which was discovered under the overhanging roof of an old woodshed. The affair consisted of ten cells, all but one of which had been sealed by the wasp, who, by the way, quickly appeared upon the scene, carrying a small, reddish spider. The burdened insect flew directly to the nest and after carefully inspecting her cargo, to make sure that it was in perfect condition and quite proper to serve as food for her offspring, she entered the remaining empty cell. To store these spiders to her satisfaction required quite some time, but when once they had been suitably placed our industrious insect lost no time in hurrying away to gather more victims. This manœuvre was repeated on an average of every seven minutes, but upon her tenth return to the nest, she carried a small pellet of mud instead of the usual spider. This she carefully placed upon the open end of the cell and after flattening it somewhat with her head and forefeet, flew off for more.

At this point I intervened in behalf of my experiment, and as a consequence thereof, the sealed portion of the entrance, and the spiders, were entirely removed from the cell. Within a very few minutes the wasp returned, bearing its second load of mortar, and this, as upon her previous visit, she cemented to the opening of the cell. Now the wasp thrust her head through the half-closed entrance and after apparently inspecting the empty interior, again flew away, this time, I thought, in search of a new supply of spiders. But this was not the case, as we shall see. I now left the immediate locality of the nest, fearing that perhaps my continued presence would alarm the subject of my experiment. In an hour I returned, only to find that the wasp had ignored the fact that the cell had been emptied and had completely resealed it without replacing the spiders or her egg.

In this case the insect clearly demonstrated her inability to notice even such a radical alteration as had been made in the cell contents during her short absence. She simply proceeded to accomplish a certain regular course of inborn events and, owing to the fact that it did not occur to her to alter any of these, even under the present circumstances, it is plain that there existed nothing in the form of intelligence, but simply innate muscular actions of a reflective or unconscious nature.

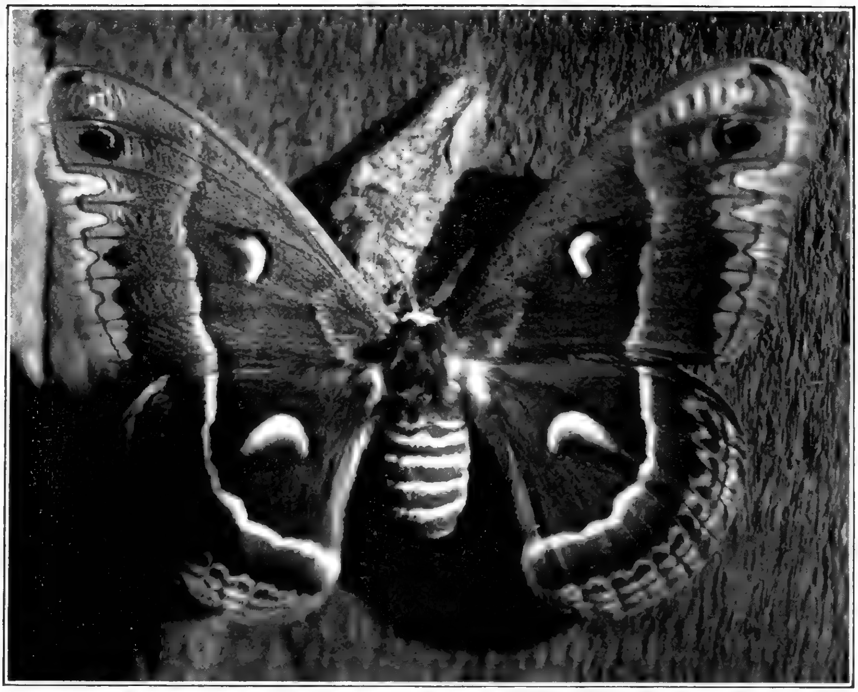
But now let us turn to the subject of my last experiment, which, it will be remembered, was the closely related paper-making cousin of the mud-dauber. As I have stated before, the paper wasps do not seal up their cells, nor do they even store them with nourishing food for the young. Owing to this state of affairs, it would, of course, be impossible to effect a similar alteration upon their nest as upon that of the mud-dauber. But the purpose of my experiments was not simply to place the two species in identical circumstances, but to discover, if when placed under extraordinary conditions, either would display in their actions any evidences of intelligence; or in fact anything which might give us better reason for believing that insects are sometimes governed by a power above mere instinct.

At the time of this experiment, the paper wasps were adding several new cells to the nest, which had grown too small for the rapidly increasing colony. These new cells were nearly finished; all but one, and of this perhaps a third had been constructed by the tireless insects. As I reached the nest, a wasp was seen working upon the unfinished cell, but she soon flew away in search of a new supply of pulp. When she had gone far enough to insure my feelings against her sting, the other members of the colony were quickly put aside and the cell was then suddenly finished by human hand, assisted by a small tube of greyish court-plaster.

In a few minutes the wasp returned and flew directly to the cell which I had so kindly completed for her. But she apparently considered my work as being far from the required standard, indeed she must have thought me downright fresh, for soon my carefully made cell of court-plaster was cut away from the nest and viciously ejected by the wasp, who was now in a temper to be respected.

On the following day I returned to the nest with another cell, but this time I had moulded it of papier-maché; thus it was identical in size, color and texture, with those which the wasps construct themselves. Once more the wasps were put out of the way, and while the one who had been allowed her freedom upon the previous day was again collecting pulp at a respectful distance, I cut away the cell which was now nearly finished, and fastened the papier-maché one in its place. Upon her return to the nest, the wasp displayed the same disgust at my inability to construct a cell, as upon the occasion of my original effort. Consequently the object of my labors met a fate similar to that which the first cell was subjected to!

How quickly this insect recognized the uselessness of these man-made cells, for indeed I had left them open at both ends. Yet her very near relative, the mud-dauber, was blind to the fact that her nest cell had been trifled with and her egg removed, which is an affair of much greater importance! But why these differences, even among insects almost of the same flesh and blood? That is what we do not know; it is a question for which we have yet to find an answer. But however that may be, it is evident from the results of the experiments which I have just described that in cases unlikely to be provided for by instinct, insects will occasionally adopt means whereby their objects may be effected. And if it be true, as we now believe, that all instincts arose through successive generations preserving habits which happened to be of benefit, then insects must gain knowledge from experience, which would appear to be impossible were they not gifted with a slight amount of intelligence.



Female cecropia moth. Two-thirds life size

Full grown cecropia caterpillar just before commencing its cocoon. Life size

Newly completed cocoon of the cecropia moth. Two-thirds life size

CHAPTER XVIII

THE CECROPIA MOTH

Samia cecropia

WHEN the first fireflies are sparkling here and there among the fresh dark foliage, and when the migrant warblers from the Southland have ceased to fill the evening air with their sharp clear voices, it is then that the great cecropia moths are on the wing, hovering silently among the newly opened blossoms, for it is the first real sultry night in June. During the day they have been creeping forth from their big winter-worn cocoons to dry their wings, long cramped and matted. But now it is night, it is time to venture abroad into a new world, perhaps to mate and to start a new generation, perhaps to enter the open net of an eager entomologist or perhaps to feed some hungry, prowling animal.

Soon after this first night of freedom, the female moth who has been fortunate in avoiding its enemies is ready to lay her eggs. These are deposited in small white clusters upon the underside of the leaves of our cultivated fruit trees. Unfortunately we cannot alter this law of nature and thus the cecropia must fall in our estimation, like so many other insects, wonderful and beautiful to look upon, but "Noxious" as the sentiment-lacking entomologist must class them. If the moths would confine their attacks to the larger trees, such as the apple or pear, the cecropia would do little or no damage, as the moths lay but a few eggs upon a single tree. However, when these occur upon a small currant or other fruit bearing bush, as they frequently do, it is but a very short time after the caterpillars hatch out before the foliage is entirely consumed. The bush is then ruined until the following spring.

Ten days after being deposited upon the food plant, the eggs split open in the center. One unfamiliar with the cecropia's life history would be very much surprised to see the tiny, black-spined caterpillars which emerge from them. At this age, they are jet black and scarcely a quarter of an inch in length. The body is armed with six rows of eleven and sometimes twelve stout spines, which, no doubt, are terrifying enough to their natural enemies. When about five days old, a tiny orange ring appears around the base of every spine. This is a sign that the larva, as the caterpillar is scientifically termed, is about to cast its skin. That is to say, it has grown too large for its birthday suit and therefore must have a larger one.

The cast is intensely interesting to watch, as the old dry skin may be seen to split, at first near the head and finally down the back until it reaches a point directly above the last pair of legs. At this juncture the larva simply crawls out, bearing a new suit of the brightest yellow, with steel blue spines, leaving the old black cast-off sticking to whatever substance the larva had fastened it to.

The cecropia caterpillar grows too large for its skin four times during its life, shedding each time, and the colors changing somewhat with every cast. The last moult takes place when the larva is twenty-six days old. The body color is then a beautiful deep foliage green and the spines are varied in orange, yellow, and the brightest imaginable blue. For eleven days after this cast the giant caterpillar goes on feeding as before, finally reaching a length of nearly five inches before starting to spin its cocoon. Indeed at this period of its life, it is hard to imagine that this great green worm could be connected in any possible manner with the tiny, black-spined larva of thirty-seven days before.

Although defenceless, the cecropia's protection is complete. Its green coloring mimics its surroundings closely. It is all but invisible at a distance, even to the human eye. To a bird, it is probably entirely so. When a bird comes upon one of these caterpillars at close range, it knows only too well that it is on dangerous ground, for the gaudy color of cecropia's spines actually serve to inform it that the creature contains poisonous ingredients and is not fit to eat.

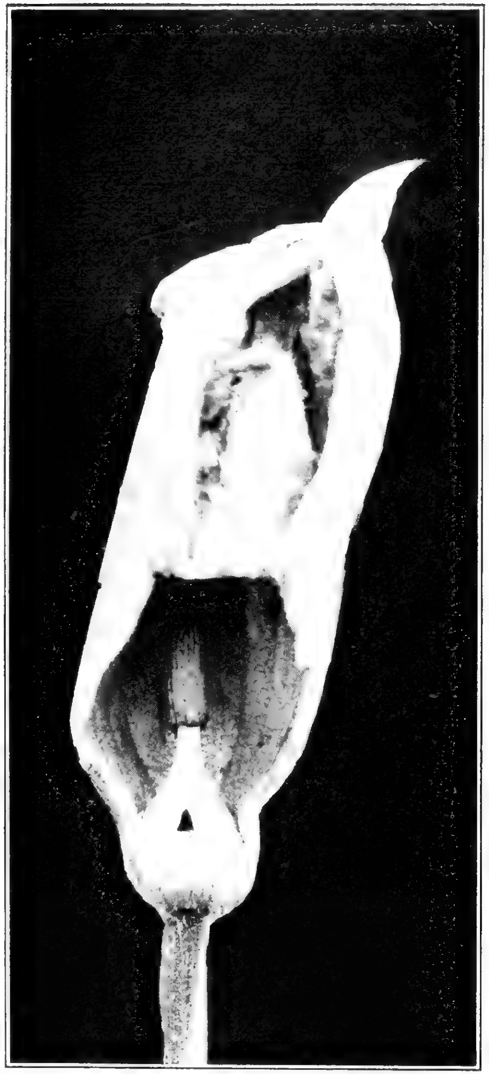
When the larva is ready for its cocoon, it crawls to some convenient spot in a corner, or under a piece of old lumber, usually in a more or less protected position, but never so that the moth would be hampered when hatching. When it reaches its final destination, from which the cocoon is to be spun, the larva becomes absolutely motionless, remaining so for many hours. This condition probably has something to do with the formation of the silk in the creature's glands. No doubt it is necessary for a certain period to elapse before the silk will flow freely enough to be spun into a cocoon.

When this period is over, the larva will suddenly be seen to stretch its head out as far as it can reach, then touching the object with which it comes in contact, it fastens the pure silvery silk to it. Now the insect turns its entire body with the exception of its last segment. Then, throwing its head back over the body, it pulls a thin silken thread from its mouth, fastening it again to the farthest point that can be reached at the back. This operation is repeated hundreds of times, in every direction, until at length the larva has completely covered itself. A second cocoon, much smaller than the first and more compactly constructed, is then spun within the first. The silk leaves the insect's mouth in a silvery liquid, hardening only when it comes in contact with the air. This turns to a deep reddish-brown about five days after the cocoon has been completed.

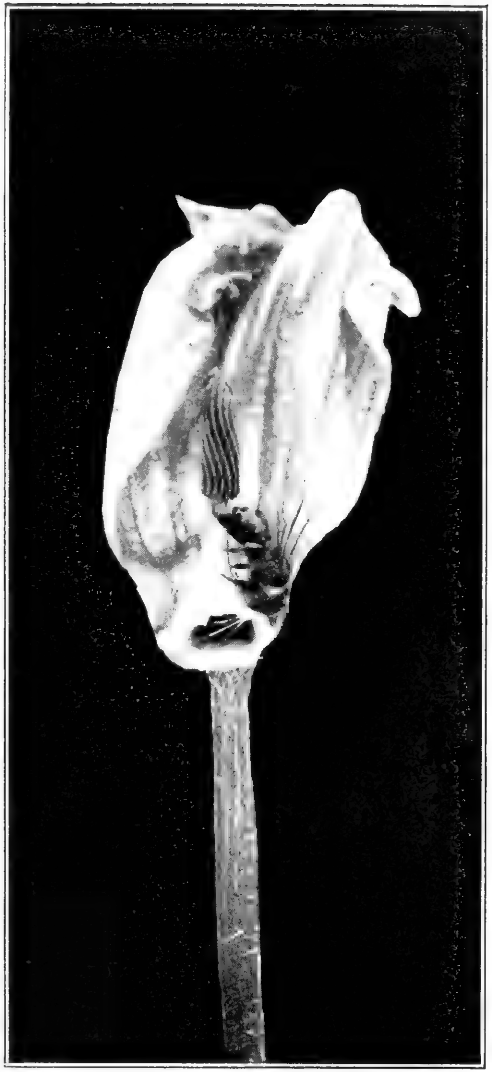
Inside the cocoon, the larva shrinks to about one-third its normal size. Then the skin begins to dry and becomes very brittle, finally splitting down the back and thus changing the larva to a pupa, or chrysalis, as this stage is commonly called. On the surface of the pupa, the wings and feelers, legs and eyes of the future moth are plainly visible through its reddish skin. In this form, the cecropia lies dormant for thirty-nine weeks in its silken tomb.

Then comes a day when the hot sun of summer strikes the cocoon. Within, the pupal skin splits open and the silk of the cocoon parts at one end. Its creator has excreted a few drops of fluid which dissolve the strands and thus liberate the insect. A glorious deep red and grey moth with feathery feelers and great clear eyes pushes itself to the light of day. Then, clinging to the edge of its weather-worn cocoon, this wonderful insect creation prepares itself for the world.

It stretches and expands its wings; waves them gently to and fro in the welcome sun, until the moisture of birth has disappeared. Then it rests for a time until the sun sets, a great glowing ball of crimson. When night falls over the land and the fireflies are once more upon the wing, the moth answers the strange mating call within. It flies away through the perfumed foliage of the first sultry night of summer.



Immature squash flower opened on side to show entrance to nectar cup. Life size



Squash flower with portion cut away to show how the bee's long tongue reaches the bottom of the nectar cup. Life size

A beetle at the entrance of the nectar cup finds its tongue too short to reach the honey. This carabid beetle feeds upon honey if obtainable. Life size

CHAPTER XIX

NATURE'S WAY WITH UNDESIRABLES

WEIRD and imperative upon the hazy early morning air floats the ephemeral perfume of the blooming squash plants. Yonder in the garden a long narrow line of them stretches out, from one end of the dew-drenched field to the other, their great yellow blossoms standing out in bold relief against the deep, rich green of their foliage. Weak indeed is that weird fragrance, from a human point of view, yet it is strong enough to bring the flower's insect admirers, the beetle and the bee, from far and near to their gaping yellow throats.

Simple enough to be sure, and as commonplace as any other cluster of color words, yet in that little paragraph about the squash, the beetle and bee, there lies a story, which is one of Nature's best.

A black, shiny beetle darted through the air, first this way then that, a carefree fortunate creature indeed, too simple to understand such a thing as care or worry. Once or twice it circled above the garden greenery, its filmy wings glistening in the sunlight. Then suddenly, as though pulled by an invisible cord, it wheeled sharply and flew straight into the mouth of a gaping yellow blossom. The insect had felt the call of that oddly scented perfume and it had proved irresistible.

Eagerly the beetle scrambled down the big yellow pistil to satisfy its thrust for the sweets which surely existed in the flower's hidden depths. But there was a rude surprise in store for him, for when he reached the bottom of the blossom the sweets were nowhere to be found. Search as the beetle might, there was nothing there, yet there was the odor, powerful and appetizing, unmistakably from a delicious nectarine fluid. Baffled and undoubtedly angry at being thus fooled, the insect turned and retreated in panicky haste to the outer air and a world of things more friendly.

Now, shortly after this incident, there came a honey-bee to the blossom, attracted by that same curious fragrance, or perhaps by the brilliant yellow coloring of the flower's petals. Down the pistil went the bee, as eagerly as the beetle had done but a minute before, until it reached the bottom of the flower. Then it quivered its wings and body nervously, as though something were absent that should have been there, but soon it settled down, contented and motionless, drinking in the delicious saccharine, from the flower's hidden storehouse. What a contrast to the excited clumsy beetle, who, just as Nature intended, would never taste those sweets or know the secret of their seclusion!

But why this apparent favoritism of Nature for the bee? Why should not the beetle also sip the honey? It is not favoritism. Such a thing does not exist in Nature. It is simply her method of protecting the flower from undesirable visitors and the beetle is one of these, as we shall presently see. But let us first study the flower for a minute, before going any further, that we may understand more clearly.

Plants are helpless inhabitants of our world, destined to spring from a seed and to spend their life just where that seed chanced to be dropped. But like most other living things, they must be fertilized before they may produce new seed that will grow and perpetuate their race. Their pollens must cross or intermingle, for that is the way plants are fertilized, yet they cannot move about, cannot come in contact, except by chance, so Nature is called upon to supply the means.

She has supplied two ways for the plant world. One the wind,

Fertilized blossoms of squash, turn rapidly into solid fruit. One-third life size

The yellow gaping throat of a squash blossom. Note the pin hole entrance to the nectar cup at the base of the pistle. One-third life size

which blows the pollen from one flower to the next, but the principal agents are insects and it is to the bee that the squash plant owes its existence.

At the bottom of the pistil within the squash blossom there is a tiny opening slightly larger than a pin hole, the only entrance to the hidden honey-cup which lies below.

Now, if we were to examine a honey-bee closely, it would be seen that the legs of the insect are broadly constructed and thickly clothed in a growth of powerful wiry hairs, while a short study of the mouth parts would reveal a strong triple tongue, long and very flexible.

When the insect crawls down into the blossom, it does not rush madly about after the method of the beetle, for Nature has long since taught the honey-bee the secret of finding the hidden nectar. It requires but a second or two to locate the tiny door through which it plunges its long tongue into the pure sweet honey. Meanwhile the insect's motions have shaken the pollen from its fastenings above. Down it comes in a yellow shower about the drinking bee. Some of it sifts in among the hairs upon the insect's thighs and here it clings until the next blossom is visited. Now some of it is bound to be brushed off each time the busy bee crawls within a blossom. Thus the pollens are blended and the flowers fertilized. In short, it is a fair exchange between two different kingdoms; the bee makes possible the offspring of the plant and the plant gives the honey for the offspring of the bee!

And now let us turn to the poor beetle, who alas cannot partake of the flower's store of nectar, try as it might. Unlike the honey-bee the beetle's legs are hard and shiny and bear no fuzzy hairs to which the pollen might stick. He is useless to the flower and therefore unwelcome. Yet were it not for Mother Nature, with her devices for protection, the beetle might drain the honey from the flower, fly away without a speck of pollen clinging to its legs, and thus accomplish nothing, save the downfall of the flower.

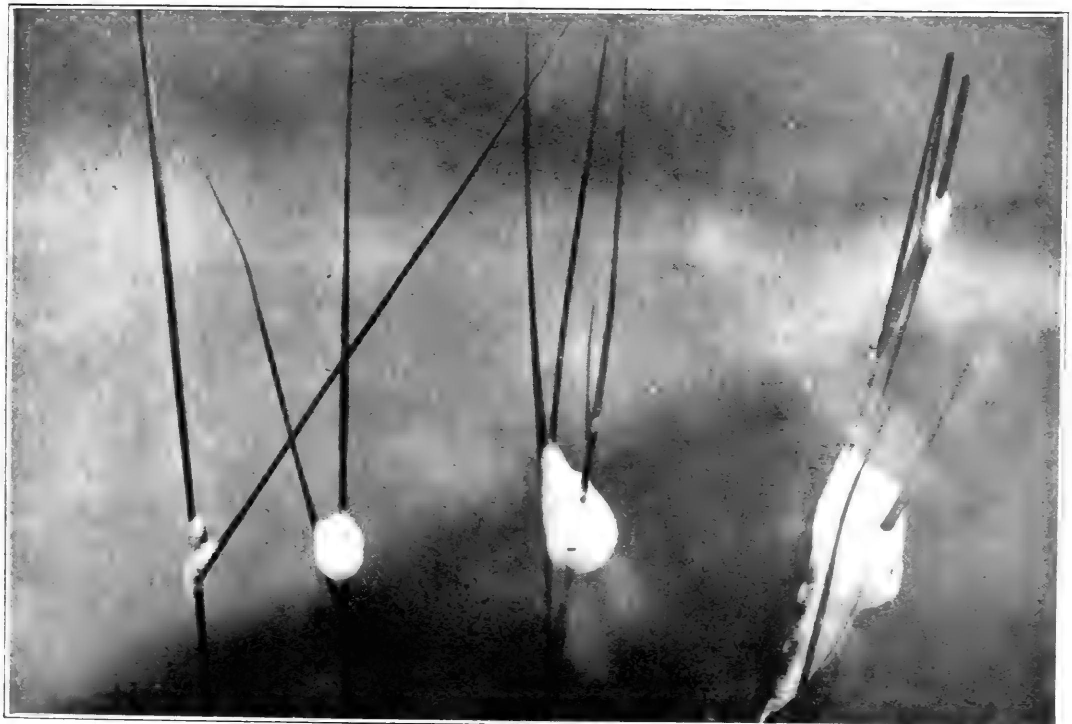
But the beetle has a short tongue indeed, as compared with that of the bee, and plunge it as he might into the pin-hole entrance at the bottom of the pistil, it could never reach the sweets in the bottom of the cup. Thus is the squash protected from such insects which would not give their services in exchange. He leaves the flower no wiser than he came, and the honey lies unspoiled and untasted in its cup, to await the coming of the friendly bee.

Of course there are certain insects, other than the many species of bees, who are so constructed by nature that they are able to obtain the squash flower's honey, but even these are beneficial in most cases. There are the Bombyliid flies, for instance, who resemble a bumblebee so closely that one unfamiliar with them would think twice before doing anything to arouse their possible displeasure! These insects possess a long flexible tongue like that of a bee, and although the hair is absent upon the legs, the body is so thickly clothed with it that it undoubtedly serves as an efficient carrier for pollen.

Many tiny crawling creatures of the insect world, small enough to insert their entire head or body into the nectar cup, would be serious factors for the plants to reckon with, had not Nature supplied them with numbers of stout hairs and spines of their own, over which the insects cannot pass. Nothing is overlooked. Nature is indeed a watchful mother.

There are few of us who would care to walk abroad upon a summer's morn down in the garden among the blooming squash, and see and watch these things until they knew the why and wherefore of it all. How many of Nature's secrets there are about us all the time, just like this little story of the squash, the beetle and the bee, only waiting for the one who cares enough to learn them.

These are not flowers, but the foamy dwellings of immature spittle bugs



Showing the growth of the spittle mass from foundation to the completed mass. Life size

CHAPTER XX

SPITTLE BUG SPITTLE

THERE are few country people who have not at one time or another during the summer months, seen curious, foamy masses clinging to the stems of grass or leaves, and created by the spittle bugs.[1] Yet how few have ever taken the trouble to look into these odd creations of the insect world, and how much of interest they have missed through their lack of curiosity.

Hidden beneath that foamy covering of tiny bubbles, lies an insect, insignificant to be sure, but as interesting in its daily life as the "Big Bugs" with which we are all familiar. Often these spittle masses occur by hundreds in our fields, but are overlooked because the insect knows enough to build its habitation where white clover blooms. In shape and color the foamy masses match the clover so perfectly that a casual observer does not notice the difference.

The spittle bug is, of course, primarily hatched from a tiny egg which is probably placed by the parent somewhere about the base of a stem of grass. A single egg is usually deposited upon each stem, although at times one will find exceptions to this rule. Such cases are proved by the occasional presence of several insects in a single mass of spittle. However, little or nothing is really known concerning the egg stage of the spittle bug, the above statements being simply the writer's own conclusions, drawn after considerable study of these creatures.

Our real intimacy with the spittle bug commences when, having left its egg-shell prison, it comes forth into the world in the form

[1] Cercopidæ.

of a soft-bodied, buff-colored insect, whose general appearance reminds one of a tiny submarine.

When the eggs have given birth to their curious children, the insects climb some distance up the grass stems, and here one may observe the most interesting of their habits—the formation of the spittle mass which has earned for the insect its name. When about to begin house building, the insect ejects a tiny drop of extremely sticky liquid upon the grass stem, into this mass it inserts the tail end of its body, which is fitted with a specialized apparatus for blowing bubbles. The apparatus opens slowly, allowing some of the sticky fluid to flow across its concave surface. Now the orifice closes slowly, while a slight pressure from within causes a tiny bubble to be blown. This does not burst, on account of its sticky covering, and as the process continues, thousands of these tiny spheres of mucus are manufactured, which eventually surround and completely cover the insect. The blowing apparatus in action reminds me of a gold fish's mouth, a continual opening and closing motion, but working, of course, to an entirely different end.

Thus the spittle bug hides itself away, safe from the hungry jaws of its numerous enemies.

It must be understood that when living in this curious dwelling the insect is not mature, but is in a form which corresponds to a caterpillar before it becomes a butterfly. Caterpillars feed upon the leaves and stems of various plants and trees, but just what composes the diet of the spittle bug is more or less a disputed question. This, and the reason for its manufacture of the sticky froth, are points which have been neglected by entomologists.

It seems as though either one of these unsolved mysteries might explain the other. The froth is extremely sticky and therefore acts as a trap for many tiny insects. In the insect world we find a great many species which live upon animal food when young, so why

A dried spittle mass and the mature spittle bug which has just emerged from it. Life size.

A huge spittle mass found in the jungle of British Guiana, fully ten times larger than the froth masses of our native insects. Life size.

should not the spittle bug be one of these, feeding upon the victims which it catches in its snare? In more than one instance, the writer has found a spittle bug in the center of its lair, clinging tightly to the body of some unfortunate insect.

In a large mass of spittle, one will occasionally find several of the insects living together in various stages of development. This, however, is unusual and in the great majority of cases but a single insect inhabits each mass.

Several days after leaving the egg, the insect stops feeding and remains motionless within its dwelling of bubbles for two or three days. At this period the spittle commences to dry up, leaving a cell about the spittle bug's body in which it undergoes the transformation to a perfect insect. Its old skin splits apart and slowly the mature creature pushes forth. She is a slender winged insect, longer and more agile than the form from which she has just risen. After brushing and drying herself she burrows through the dried white mass and soon becomes the mother of a new generation.

There are spittle bugs of many sizes, shapes, and hues, but this brief life history will suffice for most of them. Where they differ chiefly, is in the plant upon which they occur. Some blow their houses among the grass, others upon the leaf stems of basswood, and giant ones occur upon the needles of the long-leaved pines.

Wherever one goes in summer, providing there be vegetation, one finds these strange little creatures decorating the foliage with their sticky shelters of foam.

CHAPTER XXI

THE LIFE OF THE THREAD-LEGGED BUG

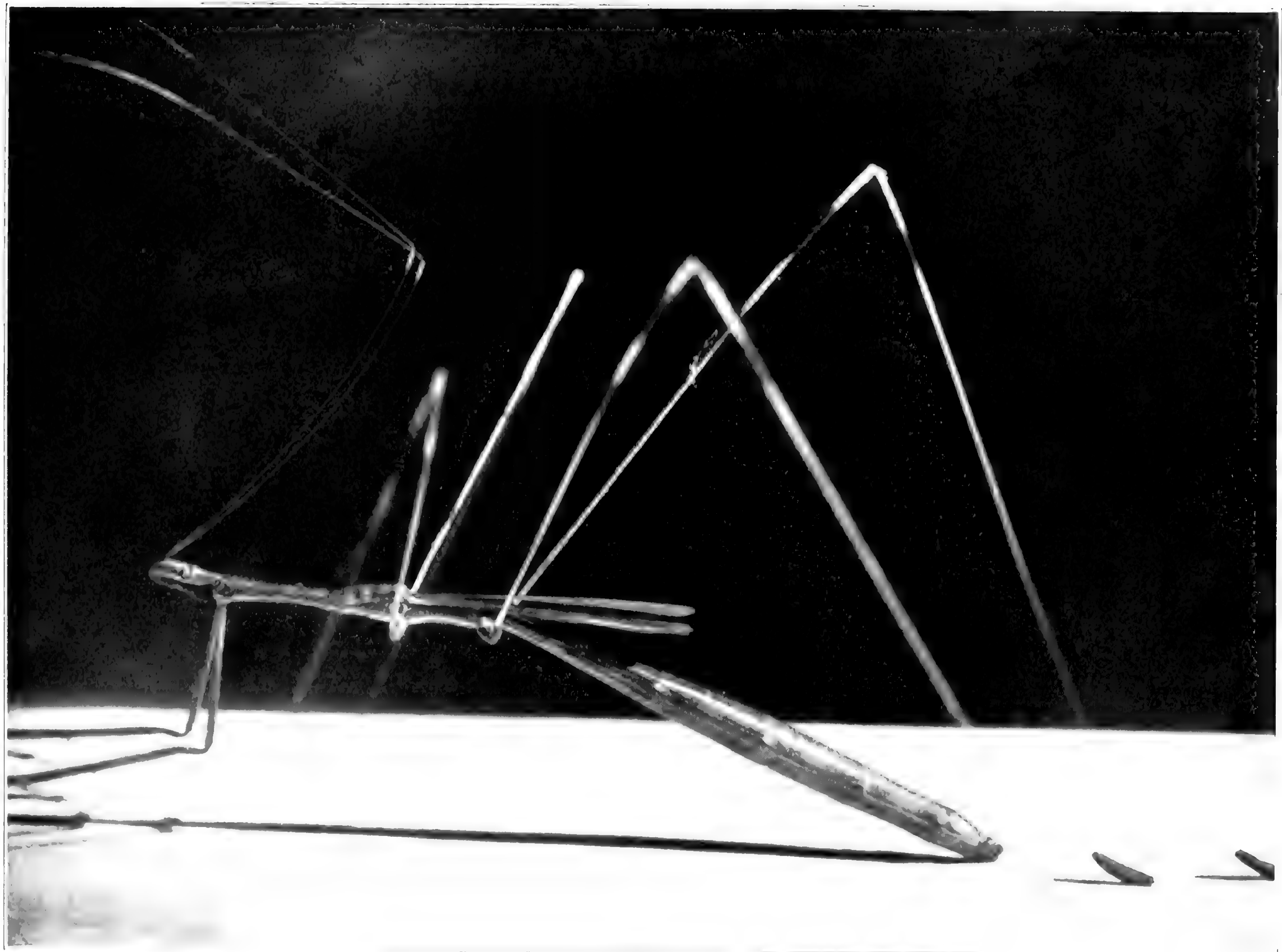
Emesa longipes

IT IS a musical night in mid-September, the zenith of the insect season. Far in the void, moist bands of mist pass slowly across the moon, raising and lowering the pale glow in the world about us, first obliterating, now bringing into clearer relief, shadows that melt away almost as we discover them. Dew is heavy on the grass tips. It sparkles in the silver light and adds its mite to September's fragrance, for each month has its perfume.

Out there in the moonlit meadows and woodland, insect events rush on. Peace and war and industry are heralded, each sound, however tiny, fraught with meaning. All are working to one end. This droning insect music of summer is the battle cry of their race, each individual singing that he shall survive to perpetuate it.

By some the battle is lost, but over each loser a victor shouts his triumph and so the race goes on. Everywhere tiny wings vibrate with songs of life, while delicate odors emanate from quivering bodies, that strange mates may travel through the labyrinth of life, at length to meet successfully! At our very doorstep lies this world of insects, yet how little we understand and know its inhabitants.

Now on this very September night, perhaps the strangest of all these myriad insects is preparing to perpetuate her race. She is one that lays no claim to fame, for man has neglected her family history most completely. Unlike the housefly or mosquito, she is



Mating over, she hastens to her duty. A thread-legged bug laying eggs, two of which may be seen at the right of the picture. Much enlarged

of little account in our daily affairs, so the facts of her curious home life have never been chronicled.

Mating over, and perhaps feeling the paralysis of age creeping over her, tonight she hastens to her duty.

Among the weathered rafters of a shed, or perhaps an abandoned house, she deposits her tough black eggs. They are cigar-shaped with a slight flaring lip at one end and deeply fluted like a Corinthian column. One by one they are attached to the roughened surface of the wood. Sometimes but an hour, at others an entire day elapses between the laying of each, thus they rarely appear in clusters. Wherever the parent wanders from day to day, the eggs will be found, one by one in her path.

From early September until late October, the process goes on, until the first frosts of winter claim the declining creature, leaving only the dormant eggs as evidence of the parent's existence.

She is a grotesque object at best, this mother, slow and deliberate, with limbs as delicate as threads and a body scarcely more robust. Yet with all her physical shortcomings, she is a personality in her world.

She has left the common horde of insects and taken up her abode with man. Once, with other arboreal creatures of the clan she lived and died among the foliage, but now she finds human habitations to her advantage. Doubtless, in ages past, she was a dominant predacious insect of the air, a hawk in her world, dreaded by others less spry. Now, in her new habitat, after years of disuse, her wings are narrow and degenerate, scarcely capable of easing her fall when dropped from one's hand. Wings have ceased to be a necessity, but other characters, unknown perhaps in other generations, have been acquired. Her legs have grown to immense length with a tiny diameter of corresponding absurdity. The front pair have shortened and developed into spiked and jointed forceps, while the tips of the other four have become cleft like a cow's, all as we shall see for a purpose.

The thread-legged bug is extremely sluggish, every move being made very slowly and with great deliberation. Indeed they would make little progress in a lifetime, were it not for their habit of never resting. They are as active by night as by day and sleep is unknown.

In length the creature's body measures an inch and a half, while in width it is comparable to a sliver cut from a match. Two of the three pairs of legs are long and slender and the third pair, nearest the head, resemble a pair of arms bent abruptly at the elbows with hands bent backward towards the wrists. Upon these powerful tongs are rows of stiff hairs interspersed with an occasional sharp spike, which serve as meat hooks for the insect's victims.

The head is very minute, supplied with red, highly compounded eyes, which protrude in a ridiculous fashion, and a long bayonet which is hollow and used for sucking the juices from the creature's luckless victims.

Strange to say, flies and small bees form the thread-leg's chief article of diet. One wonders, in view of the insect's sluggish nature, how such agile objects can be captured. The original method, employed by the thread-legs of the past and those few who still cling to the ancestral home among the foliage, was doubtless to remain motionless, like the assassin bugs, where flies and bees abound. Drunk with the liquor of newly opened blossoms, they were easily fallen upon and devoured.

But what of food in the creature's new home, among the weathered timbers of its man-made dwellings? It is there to be sure, flies, and even tiny bees, searching for tunnels wherein to rear their progeny. In quality and quantity the supply is all that can be desired, but how

A stampede of thread-legged bugs, racing slowly through a spider's web towards an entangled victim. Twice life size

Greatly enlarged head of the thread-legged bug showing sucking apparatus. The two threads protruding from the creature's nose are its feelers or antennæ

A characteristic attitude of the thread-legged bug when at rest, is with head down and front legs or tongs stretched straight out in front. Twice life size

A thread-legged bug casting its skin just before becoming mature. Hanging head down, the insect draws itself out of the old covering. Note the eye, and degenerate wings. Enlarged twice to capture it? To us the problem would appear difficult. Not so to the insect.

Among the old beams and timbers, spiders have built their webs for generations. They have lived and died and abandoned their silken snares to whatever purpose they might serve. At first they grew heavy, grey with the dust of disuse. They served no second purpose and eventually collapsed.

That was long in the past, long before the thread-leg, abandoning its home in the foliage for an easier mode of existence, crept into the shelters of man.

Perhaps that first man-shelter, reached by the thread-leg, was as primitive as the insect herself, yet here she doubtless experienced a cobweb for the first time and found it to her advantage. Perhaps there was a fly entangled in the snare and no doubt she was hungry. Next day, another creature, entangled, kept her in the neighborhood of the abandoned web. Day after day her meals appeared, unbidden by nectar. As if by magic, she had simply to step forward and claim her prey.

She found herself peculiarly adapted to living in the web. Her long legs with cloven claws made travel easy, while deliberate, sluggish motions minimized the danger of entrapping herself.

Here at length, she was sought by the male. Here she mated, spent her reclining days and eventually died, leaving in her dormant eggs the seeds of a new habit, sleeping now, but one day to affect her entire race!

It is strange that the thread-legged bugs should abandon the world of sunlight and blossoms for their dingy abode among the spider webs, yet it is in keeping with their slow and indolent mode of life. Perhaps it is better to have one's food brought magically to hand than to work for it, even at the sacrifice of sunlight!

The eggs winter over in a dormant state, hatching sometime during the spring. A quantity carried to South America for experimental purposes poured forth their quaint inmates in the latter part of February, but in the North, May is doubtless the hatching month.

The young thread-legs are exactly like the parents, only quite transparent and scarcely over a quarter of an inch in length. They grow quite rapidly, casting off their old skin, like a caterpillar, several times before they become full grown, in August. At this time, shortly before paring commences, I have witnessed what I called "Stampedes." The insects congregate in hundreds about certain webs, which seem to be more popular than others. All goes well for a time, the individuals fraternizing with one another peacefully enough until some unfortunate creature from the outer world chances to drop into this snare.

The instant a victim becomes entangled, a most ridiculous stampede follows to see who will first reach and bear off the juicy morsel. The absurdity of this event is increased by the fact that the would-be stampeders cannot possibly move rapidly. The sight reminds me of that nightmare wherein I am in dire need of running, yet try as I may, I can move no faster than a snail.

When feeding, the creature holds its prey in the bend of its spiked forelegs at a safe distance from its head and body. Its sharp sucking tube is then thrust into the captive, whose life is rapidly drawn into the body of the thread-leg.

Flies, bugs and even bees hold no terror for this insect, who is immune from their bites and stings. From their position in the creature's outstretched arms they can reach no vital spots. A wildly darting sting, a poisoned fang or a tireless set of muscles are of no avail, and the thread-leg feeds at leisure.

Thus these strange creatures live their easy, toilless lives. They

Spring-tails in their tiny world. A white-headed veil pin at the right illustrates their comparative minuteness. Enlarged six times

The same group of spring-tails, lighted in such a manner that the tiny spines upon their bodies are visible. Note the minute snail inhabiting the same world. Enlarged six times have no enemies that I can discover, no work, no worries, and they require no sleep. From the hour of birth to the hour of death they idle away their time. Eating is their sole occupation, yet they remain one of the leanest creatures on earth!

CHAPTER XXII

TRAILING A BEE TO ITS LAIR

A TINY solitary bee,[1] with a yellow speck on each of her hind legs, winged her way to the sandy driveway, then after hovering for a second or two above a little hill of sand and pebbles, she dove straight as an arrow, into the hole in the center of the mound.

Near by there was another creature, a huge two-legged one, thousands of times the size of the bee, but that little insect excited the big animal greatly, so much so in fact, that he could not rest until he had seen the inside of the little creature's nest and found out the why and wherefore of her each and every fiercely energetic move.

But there was only difficulty and disappointment in store for the big creature, for in his haste to get at the secret, he tried to dig out the bee's home in the underworld and after following its curious winding course for a few inches, the sand and pebbles rolled into the opening, buried the unsuspecting insect and ended the matter, as far as that particular bee and her nest were concerned!

Some days later, however, another little mound much like the first one, only higher, appeared upon the drive close to the old site. Now it happened that the big interested creature also spied this second little heap of sand and stones. The sight made him rejoice, but he resolved to be more cautious, lest he destroy another home before finding out the mysteries going on within.

All that day and all of the next that little bee was watched, and each time that she came to the nest, her thighs were clustered with

[1] Colletes.

The tiny solitary bee resting between polen-laden journeys. Life size

Making a plaster cast of the bee's burrow

Entrance to the bee's tunnel showing general surroundings. Somewhat reduced yellow dust and each time she left the mound, that yellow dust was gone.

Here then was the first mystery, one which might be cleared before the nest was even touched, and one which was sure to prove interesting. When the little insect returned, for perhaps the fiftieth time that day, she was rudely surprised to find herself fast in the folds of a net which would not yield, instead of in the darkness of her tunnel. But she was not to be injured. Her only loss were those two yellow masses upon her legs and then she was free once more.

The yellow masses proved to be pollen, the seed germs of flowers, that yellow powder which one is sometimes dusted with upon brushing against a blossom. Even more interesting was the fact that the pollen was that of the goldenrod, and no goldenrod could be found within a quarter of a mile of the nest! Thus each time the insect returned with her burden of yellow dust, she had traveled half a mile.

But why does she take that pollen from the light of day and carry it far below the ground, leave it and then hurry off in search of more? Let us follow her into the nest and see.

When the little bee leaves the sunlight she does not go straight down, but follows a curious twisting tunnel, pitch black, and just large enough to fit her body. Maybe she would rather have it straight, but there are projecting roots, stones and many other objects too large for her to move, and even a bee cannot foresee these obstacles. She must, therefore, dig around them, hence the shape of the burrow, which is seldom twice the same.

At the end of this subterranean passage is an earthen cell, elongated and slightly larger in diameter than the rest. On reaching this little storehouse, for such it is, she removes the pollen from her thighs by means of her other four legs. Then she mixes the yellow substance with clear sweet nectar, kneads it into a honey-paste and tamps it down upon the previous layers within the cell.

What energy that little creature has to first dig that burrow, sixty times her own length, into the solid ground, then to fill the cell with pollen, which means hundreds of loads to be carried, kneaded and tamped into place. And even now she is not through, for there are eggs to be laid and perhaps other nests to be made and looked out for.

The egg is laid upon the honey-paste within the cell and after this the mother is through with that particular nest, for it is now sealed and deserted. Within, the young bee, a white legless creature, hatches and feasts upon the generous store of sweetened pollen which the mother has supplied. How long it feeds, someone else must say, but soon it transforms into a chrysalis, lies motionless for some weeks, perhaps months, then pushes its way through the earth to the world of sunlight, a perfect insect.

If it be a male, it mates and lives a life of ease, if a female, it has work to do, hard work and plenty of it, before an enemy or Jack Frost puts an end to its brief existence in our world.

How did the man find out all this? By watching, constantly and patiently, not by guessing. Nor was it tedious, uninteresting work; far from it, the big two-legged creature was sorry when the work was finished and the little bee had flown to pastures new.

But how did he know what that tiny subterranean passage was like, why did not the sand and pebbles fall into this one when it came time to explore its depths? New methods were used and caution triumphed, that is why.

When the bee had finished her work about the nest, she was not allowed to seal it. Instead it was filled with liquid plaster of paris, which ran down inside, filling every little nook and corner of the tunnel. Several hours later it had hardened like rock, and the man,


Model of the bee's nest made from a plaster cast. One-third natural size


Interior of the bee's burrow showing cell filled with honey paste. From the model. Twice life size


Excavating the plaster cast of the burrow. Photograph one-third natural size

with boyish enthusiasm and excitement, sat down upon the ground and very carefully chiseled the earth away. Every minute revealed a new twist or turn and every minute the excitement grew, as with an excavator of Pompeii, until the end was reached and the pollen found.

Then the perfect cast was laid upon a smooth pine board and its course traced upon the wood in pencil. With the aid of a gouge and a sharp knife, a duplicate of the original nest was modeled in the wood, showing every turn and every indentation just as the insect had made them. Then the board was brushed with glue and sprinkled with fine sifted sand, taken from the spot where the nest actually existed. To represent the pollen, a touch of powdered yellow felt was glued within the artificial cell, and it was finished a perfect model of the little creature's home.

Then it was photographed as an everlasting monument to the skill and energy of the tiny insect who designed it.

CHAPTER XXIII

CAMOUFLAGED INSECTS

BY Nature the art of camouflage has long been practiced. It is her way of affording protection to those of her defenceless children who might otherwise fall victims to predacious enemies. To us the word is a war-baby, coming from the battlefields of France. It has since been applied to an endless variety of things; most anything, which by nature of peculiarly applied patterns, is made to blend with its surroundings, and thus appear more or less obscure to the eye.

Among insects camouflage has been carried beyond mere arrangement of color pattern. We find creatures whose general outline as well as pigmentation mimics their natural surroundings to such a marked degree that it is often difficult to distinguish where habitat leaves off and where inhabiter begins.

This curious state of affairs has been developed through thousands of years by the process of selection. Individuals vary greatly in color and those fortunate ones matching their surroundings more closely, naturally survived longer than their less protectively patterned brothers. Thus, as time went on, the pattern of these selected individuals became dominant of the species, developed in some cases to a phenomenal degree.

A remarkable case of this kind is shown in Figure 109, of a caterpillar or larva which later transforms into a geometrid moth. In the larval state the insect bears a very close resemblance to a twig. Its habit of clinging to a real twig with its posterior "legs" and allowing the body to swing out, adds to the illusion. The head of

Caterpillar of a geometrid moth which resembles the twigs of the insect's food plant, thus gaining immunity from the attacks of its enemies. Twice life size

This remarkable caterpillar resembles the excretia of a bird so closely that only one accustomed to seeing it under all conditions, realizes that it is a living creature. Greatly enlarged the caterpillar resembles a leaf bud, while in color the entire creature is an exact counterpart of a rough apple twig, the plant upon which it naturally feeds. Thus complete immunity is secured from the attacks of birds and all enemies which depend chiefly upon sight.

A similar case is that of the slug caterpillar, Figure 110, of the family Cochlidiidæ. Its general color is leaf-green with some small amount of dark red near the head, which is pointing downward in the photograph. On the whole, to the casual observer, it is scarcely distinguishable from a swollen bud. Even more remarkable are the caterpillars which rely for their protection upon their mimicry of the excreta of birds, Figure 111. I have been completely fooled by these larvæ on more than one occasion. They frequently rest in the center of a green leaf and while conspicuous, never suggest a living insect to the uninitiated. In color, the upper and lower portions of the body are dark chocolate brown, banded through the center with pure white, which suggests the lime so often seen in the excreta of birds. The entire creature is highly glossed, which gives a fresh and moist appearance to the object, which makes no attempt to conceal itself, depending entirely upon its strangely camouflaged body for protection!

In the course of my field activities, I have run across a great number of cases where insects were curiously camouflaged to their surroundings. They are far too numerous to describe here in detail, but one or two are of particular interest.

In British Guiana, inhabiting the trails through the virgin forest, is a tiny species of thecla, a bright blue, angular-winged butterfly. Upon endeavoring to capture one or two specimens, I swooped with my net in the ordinary way, where several individuals were flying about chasing one another, but as I did so all of them disappeared as if by magic. In a few minutes they returned, one by one, apparently from the vegetation directly before my eyes. A second and third swing of my net produced the same results. Try as I might, between swoops, I could find no trace of my quarry until they returned to the trail of their own accord, yet they never appeared to go far away.

At length I decided to beat the surrounding vegetation, and upon doing so caught two of the butterflies. Examination revealed that the under side of the wings were bright green, which matched perfectly with the jungle leaves. I stunned one and placed it upon a leafy twig and turned away. In a minute I looked back and found the insect with great difficulty, so perfectly did it blend with its surroundings. When I swung my net, the insects had retreated to the foliage and although bright blue in flight, they instantly disappeared upon folding their wings when coming to rest among the leaves.

In the Andean jungle of Colombia, one finds strange transparent butterflies. Unlike our familiar species, they possess no scales and are therefore without color patterns. The wings are the color of clouded glass, but quite transparent. In flight they are easily seen, but upon coming to rest among the brown leaves which cover the forest floor, they become more or less invisible and are thus protected.

Placed upon a printed page, one may read through their wings as readily as through a piece of glass, only the body and veins of the insect being too dense for this purpose.

I once found a drinking place of these butterflies in Colombia. A huge moss-grown boulder, upon which a tiny stream of water continually fell, produced a popular saloon to which hundreds of these skeleton insects resorted. It was an interesting sight to see them gathered together in such numbers to the exclusion of other species. From a distance only their brown bodies and wing veins were visible, resembling a multitude of stick insects, clustered upon the water-soaked moss.

In a great many cases insects are not camouflaged as we understand the word. Many are bright and gaudy and attract rather than deceive the eye. In such cases, these bright spots, bands, spines and ground colors serve as warning signals to the enemies of the insects. They are protective measures of another variety employed by Nature for a double purpose. They are to protect the bearer against its enemies and at the same time the would-be sampler of insects in general.

Bright and gaudy colors are often a sign of poisonous qualities in an insect, or one whose blood lymph or other body fluids possess a disagreeable taste. In the light of the above statement it is interesting that many harmless and edible insects mimic in pattern those species who are really ill tasting or poisonous. Thus the great monarch butterfly is closely mimicked in color by another species.

The monarch (Anosia plexippus) is one of the most successful of insects. It is abundant and widely distributed, due in all probability to qualities that make it distasteful to birds and other enemies, in all stages of its life. Thus it has become a dominant species in the insect world.

To mimic such a species would be at once advantageous to other insects and, strangely enough, the viceroy butterfly (Basilarchia archippus) gains immunity from attack in this way, even though it is in all probability an edible species.

In South America I found a species of Heliconidæ, a medium-sized glossy black butterfly bearing rose-colored bands across the wings. This species, except in the contour of its wings, was closely mimicked by a species of Papilionidæ, inhabiting the same general locality. The former are supposed to be inedible or distasteful. Endless cases might be cited, like the above, especially among tropical insects, who are camouflaged, so to speak, to resemble something which is dangerous and to be left alone by birds, lizards and other enemies of the insects.

There is still another type of camouflage among insects worthy of mention, one which is doubtless effective in protecting absolutely harmless and passive creatures from being attacked and eaten.

We find, for instance, the chrysalis of a butterfly, a species of Vanessa. It hangs by a tiny silk-fastened stem under a protecting fence rail. Within the shell of the chrysalis, there is nothing but a mass of disintegrating tissues, a thick fluid, studded with globules of fat. It is neither caterpillar nor butterfly. It cannot thrash about from side to side or make a demonstration, there are no spines to pierce a would-be enemy, no wings by which the creature might take flight. It is as helpless now as so much custard, for the insect is in the process of change from one form to another.

Such is the actual condition of the pupal butterfly, but let us examine its outer covering. It is a frightful-looking object, armored, and covered with sharp spikes between which beady false eyes peer out. It is absolutely harmless but appears otherwise. To birds it is doubtless a thing to beware of, yet one tiny puncture of its brittle covering would reveal a delicious feast within!

Many insects are thus protected, ones that could not compete in any form of battle. They are given immunity from attack because they could not ward it off themselves. In the case of the transforming pupa, some such form of protection becomes a necessity. A butterfly in the making is as helpless as the egg from which it sprung, so Nature resorts to camouflage to terrorize the destroyers of her children.

Chrysalis of the mourning cloak butterfly. In this passive state, it gains immunity by means of its terrifying appearance. Much enlarged

Cochlidiid caterpillar which mimics the buds of its food plant. Much enlarged

CHAPTER XXIV

LIVING EXAMPLES OF THE GEOLOGICAL PAST

STRANGE as it may seem, the most ancient types of insects are still represented alive, in the world today. Unlike the ancient men and mammals of our planet, whose scanty history comes to us through occasional beds of fossil remains, insects provide us, through those which live today, with an actual glimpse into the great geological past.

Some of the creatures have undergone little change during millions of years. They are today almost what their ancestors were in those past ages, ancestors who roamed the prehistoric fields and forests, now buried deep in the crust of the earth.

That these insects still exist, almost unchanged, still primitive in their structure, shows that Nature does not always do away with her early experiments. She does not cause them all to become extinct in favor of more modern ones.

These primitive insects which still inhabit the world, are known scientifically as Aptera, an order which includes two suborders, the Thysanura and Collembola, commonly known as Bristle-tails and Spring-tails.

Aptera today are the most widely distributed of all insects. They are found in Europe, the Faroe Islands, Chile, Alaska, Joseph Land, the Sandwich Islands, the South Orkneys, Graham Land, the United States, and South Victoria Land. Some have been collected from the snows of frozen mountain tops while others are found at sea-level, or below, in caves and caverns in the hottest climates.

They are very delicate, often minute, soft-bodied insects, covered in some cases with microscopic lavender scales like those of a fish. Those belonging to the Thysanura possess strange forked appendages which protrude like long tails from the posterior segments of the body. These are in addition to the legs, and antennæ or feelers, and their purpose is not definitely known.

In Collembola the species are supplied with a catch, and spring, which upon release, hurls the creature bodily and automatically out of harm's way. They are also supplied with paired sacs, which are carried upon the ventral tube of the first of the six body segments. These assist the creature when walking upon very smooth surfaces and doubtless serve as breathing organs in addition.

As it is extremely unlikely that such delicate insects could be transported across seas and oceans, their remarkable geographical range, so wide and discontinuous, suggests their great antiquity. Doubtless in ages past, before our planet was in the process of change towards what it is today, there were no seas or channels separating the various countries included in the range of the Aptera. The United States and Europe, together with Chile and the more isolated islands, were probably one continuous continent. If not; why then should we find these identical little insects in each of those places today? That they are of very ancient origin is undoubted. It is what makes the Aptera so important and interesting to scientists today.

Geologists have found many fossil remains of these insects in very ancient strata of the earth's crust. A supposed specimen was unearthed from the Silurian deposits of New Brunswick, buried there during a comparatively quiescent period in the earth's history. At this time a great sinking of the land was followed by a relative rising, which affected wide areas in the northern hemisphere. Other remains found in Carboniferous deposits in France were of Aptera which lived in prehistoric forests of great exuberance, before they

Once, with other arboreal creatures of the clan, the thread-legged bug lived and died among the foliage. Twice life size

Poison spines on the Io caterpillar

This catterpillar, which later transforms into the Io moth, is splendidly protected from its enemies by masses of spines, each bearing a highly poisoned tip. The slightest scratch from one of these darts causes extreme pain, itching and great discomfort probably due to formic acid, a substance which serves as a protection to many insects

were buried to become our coal seams of commerce. Here and there a few others have been found in older strata but it is not until the Tertiary that their remains were found in any quantity.

During this period or era, the configuration of the earth was steadily approaching that of the present day, but there still existed a great equatorial ocean, while East India and Africa, Australia and Asia, North Europe and America were probably united by land connections. The faunas of the planet also approached their present state, and might have continued to expand more broadly, had it not been for a rapid lowering of the earth's temperature, which brought about a great glacial period.

Spring-tails of the present day live in moss, under logs or fallen leaves, in grass, on water, snow, or in almost any place that is sufficiently damp. Their mouth parts are hidden and very difficult to study, but the insects are doubtless vegetable feeders like their Bristle-tail relatives.

Millions of years ago the latter probably fed on water-soaked seeds or other vegetable matter of a starchy nature, but today they inhabit the houses of man, feeding upon the paste which keeps our wall papers in place, or upon the same substance, when it may be found, in the bindings of books upon our shelves. It is a strange habit indeed, to acquire upon one's Nth millionth birthday as a race!

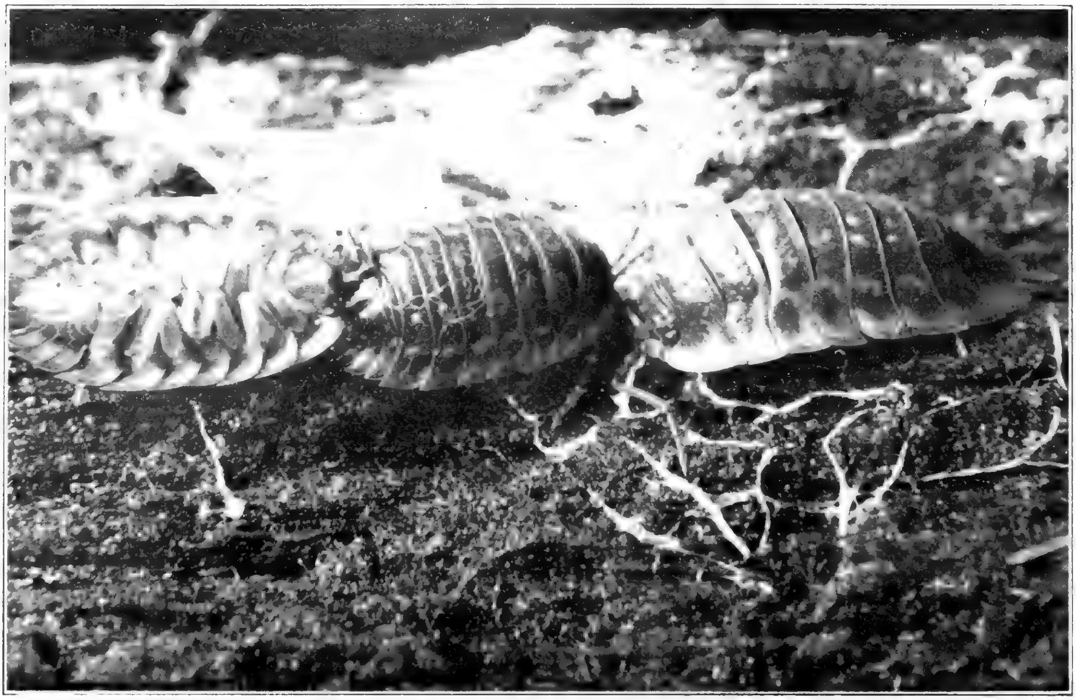
Another creature, still existing, whose kind may be traced like the Aptera, far into the geological past, is the inappropriately named wood-louse. In reality a terrestrial crustacean closely related to the land crabs and not an insect in any sense of the word, this little oniscus is familiar to everyone living in the country who has ever turned over a stone or log or a bit of decaying wood.

Members of the Isopoda are represented in all seas and lands, the wood-louse being the only land-loving representative of the order.

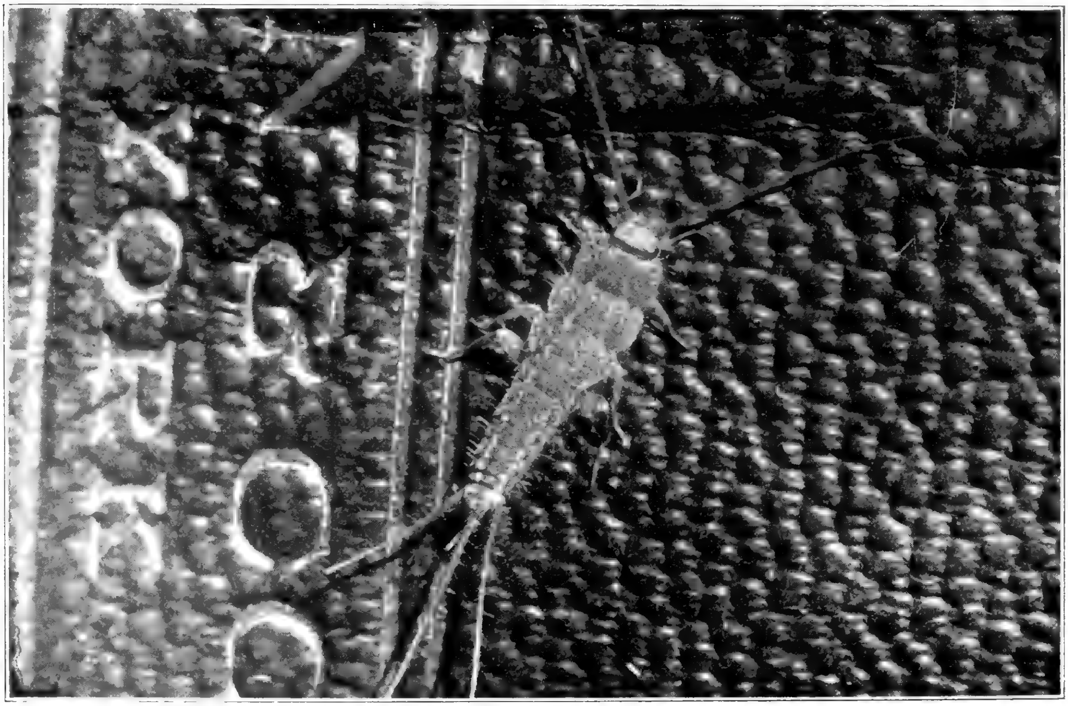
Hundreds of species are known in the world and they are perhaps one of the commonest creatures occurring in the United States.

The female oniscus carries her eggs in a pouch which covers the under surface of her thorax. The young are exactly like the adults except for the last pair of legs, which are lacking, and these are not acquired until later in life. The significance of this strange fact would be hard to discover, and like the life histories of so many of our tiny creatures, lies shrouded in mystery.

It is strange that these creatures and the Aptera, still progressing in our world today, have survived great upheavals of the earth, great changes of climate, great floods and glacial periods, and yet have come through unscathed to this modern century. Where great mammals, birds and reptiles of bygone ages failed and left us only fossil records of their existence, these tiny things succeeded and came, living into our day. They have been handed down to us by Nature as priceless heirlooms of our planet's ancient family.



Wood lice or pill bugs. Though commonly termed bugs, they are in reality terrestrial crustaceans related to the land crabs. Four times life size



A thysanuran or bristle-tail. A creature that has come down through the ages to eat the paste upon our wall papers and book bindings. One of the most primitive of existing insects. Enlarged three times

INDEX

A

Africa, 171
Agalenidæ, 104
Agouti, 77
Alaska, 169
Andean jungle, 166
Anosia plexippus, 167
Ants, South American army, 118, 119, 120, 121, 122, 123, 124
bite of army, 123
Carpenter, 110, 111, 112, 115
battles of, 114
cattle tending, 113, 114
Leaf-cutting, enemy of, 115, 116
poison of, 116, 117
Mound, experiment on, 134, 135
Slave making, 112
slave-making habit, reflex of, 112
Ant battles, 114
Ant birds, 124
Ant cows, 113, 114
Ant lion, 25, 105
Ants, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 134, 135
Aphids, 113, 114, 134
Aptera, 169
distribution of, 169, 170
fossils of, 170
Archippus, Basilarchia, 167
Asia, 171
Asilidæ, 128
Attadæ, 115
Australia, 171

B

Bartica, 118
Basilarchia archippus, 167
Battles, ant, 114, 115
Bee, bumble, 104
blue-flower, 87
green-flower, 87
honey, 148
humble, 87
Bees, 87, 148, 104, 160
Beetle, carabid, 147
oil, 104, 105
rove, 25
Xenos, 97
Beetles, 25, 97, 104, 105, 147
Birds, ant, 124
Black reed-wasp, 27
Blue huntress, 68
Blue mud-dauber, 138, 140
Bristle-tails, 169
British Guiana, 118, 165
Bug, spittle, 151
thread-legged, life history of, 154
egg laying, 155
food of, 156
stampedes of, 158
Bumble bee, parasite of, 104
Butterflies, invisibility of, 165
transparent, 166
Heliconidæ, 167
mimicry of, 167
monarch, 167
mourning cloak, 168
Papilionadæ, 167
thecla, 165
viceroy, 167

C

Caddice fly, 108
Caddice worm, 107
Caeruleum, Chalybion, 138
Camouflaged insects, 164
Camponotus pennsylvanicus, 110, 115
Cannibal wasps, 85
Caterpillar, cabbage, 99
cecropia, 114
cochlidiid, 165
protective colors of, 145
slug, 165
twig, 164
Cecropia moth, life history of, 143
Cecropia, Samia, 143
Centipedes, 122
Ceratinadæ, 87
Cercopidæ, 151
Chalybion cæruleum, 138
Chile, 169
Chlorion neotropicus, 68
Cicada, 91, 92, 136
Cinereohirtum, Trypoxylon, 27
Cochlididæ, 165
Collembola, 169
Colletes, 160
burrow of, 161
burrow, method of molding, 162
Colombia, 166
Controlled pupation, 77
Crickets, sight of, 128
tree, 125

Crickets, 49, 50, 120, 128
Crustaceans, terrestrial, 171

D

Daddy-long-legs, 120
Deposits, carboniferous, 170
  tertiary, 171
Dialyzer, insect, 65
Dragonfly, 25
  sight of, 128
Drassidæ, 104

E

East India, 171
Emesa longipes, 154
Epeiridæ, 103
Europe, 169
Excretia, of young wasp, contents of, 38
  method of, 28, 57, 58
Experiments, some insect, 134
Exsectoides, Formica, 112, 134

F

Faroe Islands, 169
Filistata, 48
Fistulare, Sceliphron, 60
Fly, bombyliid, 150
  checker, 89
  flesh, 79
  greenbottle, 129
    method of feeding, 131
    benefit derived from, 133
  house, 79
  robber, 128
  trepetid, life history of, 78
    erergence of, 83
    pigmentation of pupa, 83, 84
Flies, 78, 79, 83, 84, 89, 128, 129, 131, 133, 150
Forest shell-wasp, the, 53
  life history and habits of, 54
Formica sanguinea, 112
  exsectoides, 134
France, 170

G

Gasteracantha, 48
Geological past, living examples of, 169
Gibbosus, Philanthus, 85
Gongylophosa, Rozites, 115
Graham Land, 169
Grasshoppers, 122
Guiana, British, 118, 165

H

Hamatus, Zethusculus, 53
Harvestman, 120
Heliconidæ, 167
Histogenesis, 37, 38
Histolysis, 37, 38
Hornets, 98, 99
How the greenbottle does its duty, 129
Howling monkey, 77, 78
Hydropsychidæ, 107

I

Insects and other strategists, 102
Insect eye, anatomy of, 126
Insects, as pollen carriers, 149
  camouflaged, 164
  protective patterns, how obtained, 164
  sight of, the, 125
  warning signals of, 167
Insect world, at close range, the, 19
  geography, of, 24, 25
Isopoda, 171

J

Joseph Land, 169
Jungle, Andean, 166

K

Kalacoon, 27

L

Larval sacrifice, 33
Leucotrichium, Trypoxylon, 40
Living examples of the geological past, 169
Longipes, Emesa, 154
Lycosidæ, 104

M

Meloidae, 104
Micrathena, 48
Milch cattle, 134
Monkey, howling, 77, 78
Mosquito, 79
Moth, cecropia, 143
  geometrid, 164
Myrmeleonidæ, 105

N

Nature's way with undesirables, 147
Neotropicus, Chlorion, 68
New Brunswick, 170

O

Observations on ants, 109-124
Oil beetle, 104, 105
One-banded dauber, 60
Original Paper makers, 95
Osmosis, apparent of egg film, 65

P

Pallipes, Polistes, 95, 101, 138
Papilionidæ, 167

Paralysis, artificial of spiders, 56
meaning of, 51
Paralyzed provender, 46, 52
Pennsylvanicus, Camponotus, 110, 115
Phalangidea, 120
Philanthus gibbosus, life history of, 85
Plants, fertilization by insects, 148, 149
Plexippus, Anosia, 167
Podium rufipes, 33
Polistes, pallipes, 95, 101, 138
Polyergus rufescens, 112
Pontius rapæ, 99
Provender, paralyzed, 46
Pupation, process of, 35
controlled, 77, 78, 79, 80, 81, 82, 83, 84
Pustulata, Winthemia, 4, 89

R

Rapæ, Pontius, 99
Roaches, wood, 34, 122, 123
anatomy of, 51
nervous system of, 51
Rozites gongylophosa, 115
Rufescens, Polyergus, 112
Rufipes, Podium, 33

S

Sandwich Islands, 169
Sanguinea, Formica, 112, 134
Sarcophagidæ, 129, 133
Sceliphron fistulare, 60
Sight of insects, 125
Some insect experiments, 134
South America, 118, 165, 166, 167, 169
South Orkneys, 169
South Victoria Land, 169
Span-worms, 123
Speciosus, Sphecius, 91, 136
Sphecid's duty, the, 91
Sphecius speciosus, 91, 136
Spittle bug spittle, 151
Spittle, how produced, 152
Sphex, 62
Spiders, drassid, 25, 104
anatomy of, 47
nervous system of, 47
orb-building, 103
platform-building, 103, 104
Spilographa, 78
Spring-tails, 169

T

Tachina, red-tailed, 89
Tachininæ, 89
Thecla butterflies, 165
Thread-legged bug, the life of, 154
Thysanura, 169
Trailing a bee to its lair, 160
Tree cricket, 125
Trepetidae, 78
Trypoxylon, cinereohirtum, 27
leucotrichium, 40

U

Undesirables, Nature's way with, 147

V

Vanessa, 168
Vermilion-nut, 77

W

Wasps, accuracy of in finding nests, 62, 63, 64
ancestral form of, 36
appendages, use of pupal, 75
Black reed, life history and habits of, 27, 28, 29, 30, 31, 32, 49
Blue huntress, life history and habits of, 68, 69, 70, 71, 72, 73, 74, 75, 76
Blue mud-dauber, experiments on, 140, 141
Cannibal, life history and habits of, 85, 86, 87, 88, 89, 90
cannibalistic instincts of, 87, 88
characters, acquired pupal, 75
digger, Great golden, 91
egg film, osmosis of, 65
food, substitution of young wasp's, 55
Forest shell, life history and habits of, 53, 54, 55, 56, 57, 58, 59
Long black reed, 62
One-banded dauber, Life History and habits of, 60, 61, 62, 63, 64, 65, 66, 67
Paper, effect of cold on, 101
experiments on, 138, 139
food of young, 96
method of paper making, 96, 97
parasite of young, 97
life history and habits of, 138, 139
Prey, artificial paralysis of, 56
capture of, 70
stinging of, 47
provisions, significance of choice of, 42
Provender, preparation of, 47
pupæ, appearance of pigment in, 58
cause of dull color of, 58
Lumberess, 50, 51, 52
Mason, 68
Red-legged digger, 62
Roach-killer, 33, 39, 49, 52
sentinels of, 100
Solitary, food of young, 55
peaceful nature of, 91
Sphecid, experiments on, 136, 137
life history and habits of, 91, 92, 93, 94
method of carrying prey, 92, 93
toilet of, 94
squeaking, interpretation of, 28
sting poisons, effects of, 47, 48

Wasps, varnish, 44, 46
victims, forms of paralysis in, 48, 49
White-footed, life history and habits of, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49
sense of direction of, 62
wings, unfolding of, 58, 59
young, feeding stimulus of, 73, 74
method of feeding, 72, 73
starvation of, 67
varnish of, 44, 66
White-footed wasp, the, 40
Wasps, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 136, 136, 138, 139, 140, 141
Winthemia, 4-pustulata, 89
Wood-louse, 171
Worm, span, 123

X

Xenos, beetle, 97

Y

Yellow jacket, care of young, 99

Z

Zethusculus, hamatus, 53

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