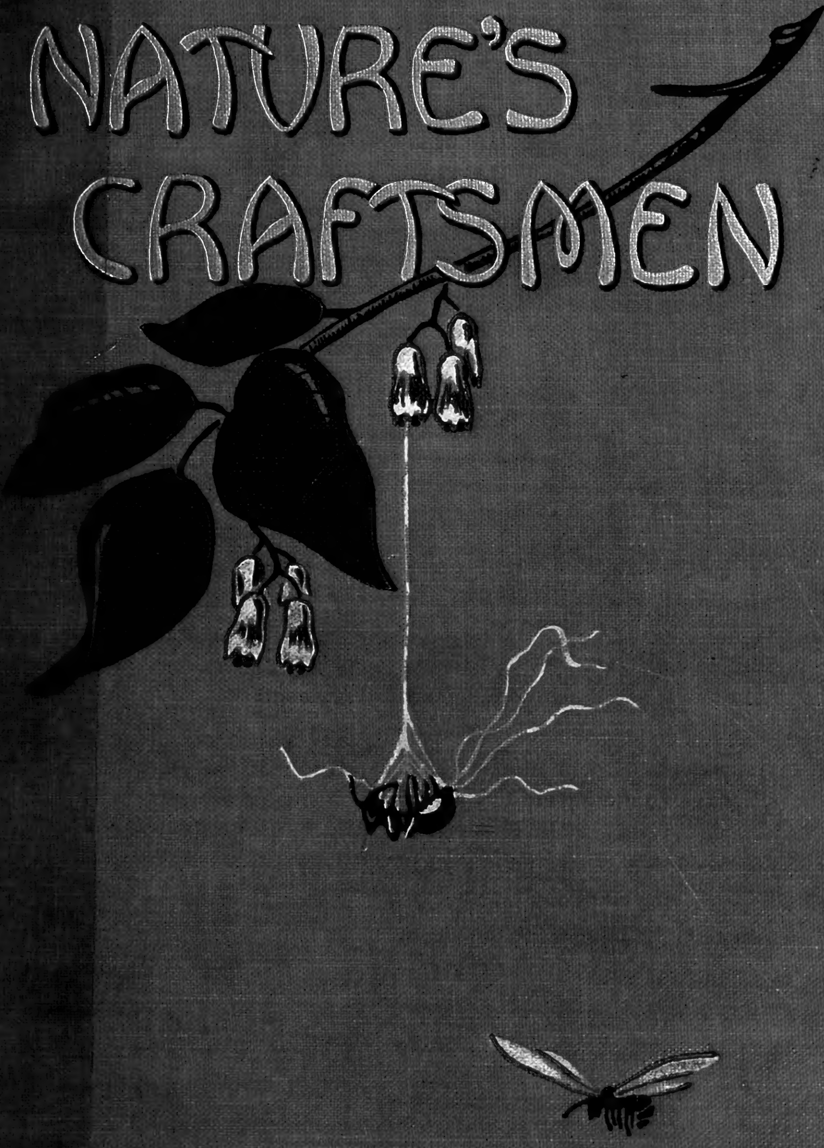
NATURE'S CRAFTSMEN



H·C· McCOOK

Emil Liljeblad
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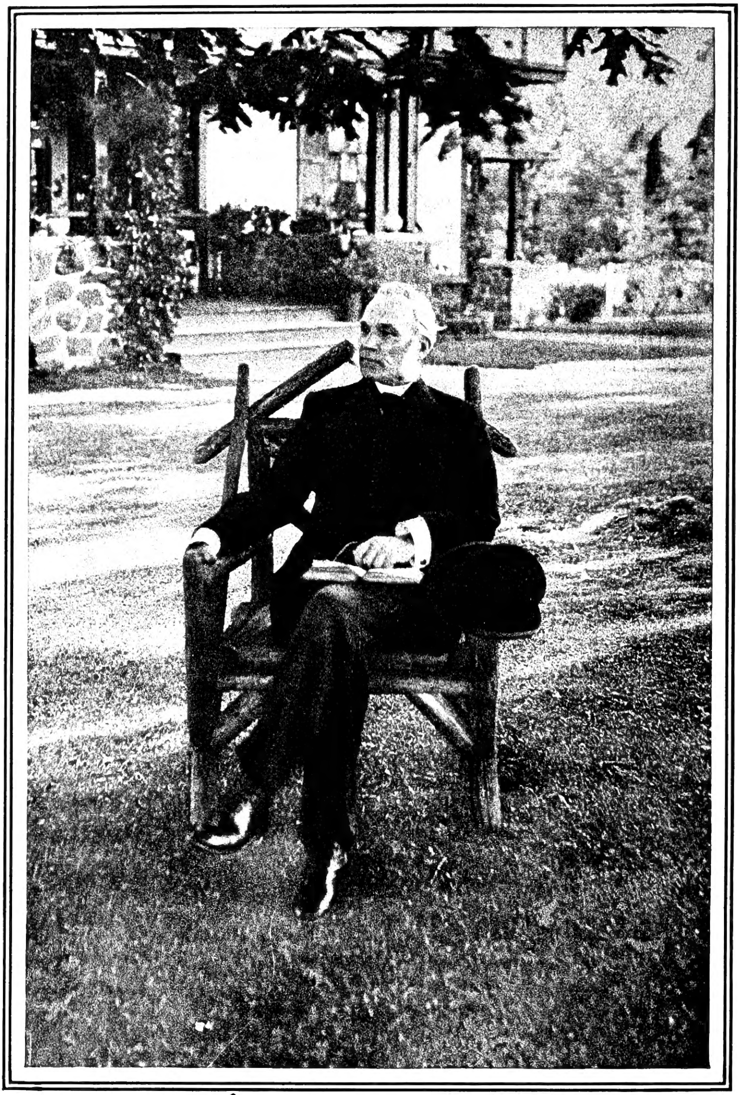

Henry C. McCook

NATURE'S CRAFTSMEN

POPULAR STUDIES OF ANTS AND OTHER INSECTS

BY

HENRY CHRISTOPHER McCOOK

AUTHOR OF
"AMERICAN SPIDERS AND THEIR SPINNING WORK"
"THE AGRICULTURAL ANT OF TEXAS"
"TENANTS OF AN OLD FARM"
ETC. ETC

ILLUSTRATED FROM NATURE

HARPER & BROTHERS PUBLISHERS
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1907

Published March, 1907.

TO

ELEANOR

WHOSE LOVING SYMPATHY AND CARE, NEVER WEARYING,
HAVE MADE IT POSSIBLE TO PREPARE THESE
STUDIES FOR THE PRESS

CONTENTS

ILLUSTRATIONS

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ILLUSTRATIONS

ILLUSTRATIONS

PREFACE

THIS book is an outgrowth from a series of nature articles printed in *Harper's Magazine* during the last four years. They were so well received that the writer was asked to put them into form for permanent publication. For the most part, the papers deal with popular phases of insect and aranead life, and their themes are drawn chiefly from the author's own specialties, ants and spiders. Outside of these, however, the products of some original studies have been given, as with certain wild bees, with water-striders, caddis-flies, wasps, and ant-lions.

A number of new chapters have been added. The magazine articles have been revised, enlarged by new material, and otherwise changed, it is hoped for the better. Parts of three of the new chapters have been taken from articles printed in the *Forward*, of Philadelphia, and for such use thanks are due the editor and publishers.

Free use has been made of such work of other entomologists as served the writer's purpose, knowing that naturalists are ever best pleased when their contributions to the knowledge of nature are best known. But as far as desirable in a work of this sort, credit has been given for published observations not original with the author.

PREFACE

From one view-point — yes, from two — *Nature's Craftsmen* may be called a popular book. It is as free as it can well be made from embarrassing technical terms, although like all other objects the creatures whose history is here given have and must have names, which must be learned, even as our own. Moreover, as the author believes that science need not be and should not be divorced from literature, he has tried to write his histories in attractive and agreeable style. Further, the book may be called "popular" in that it deals with phases of natural life that come most easily into common thought and interest. Otherwise the writer has aimed to make *Nature's Craftsmen* a thoroughly scientific study within its chosen field. That it will be found wholly free from errors is too much to hope. But the writer may claim that he has given due care to make his work accurate, and within its limits of good authority.

These pages represent many years spent in sundry parts of our continent in delightful contact with our little brothers and sisters of the Insect World. If some measure of the author's pleasure and advantage in field-work shall come to his readers, he will be well content. And if hereby any shall be won to study in His works the Author of all, he will have reached his highest aim.

Brookcamp, Devon, Pennsylvania,
***April,* a.d. 1906.**

PART FIRST

STUDIES OF ANT LIFE

NATURE'S CRAFTSMEN

CHAPTER I

THE ROYAL MOTHER OF ANTS

"WHAT kind of ants are flying ants?" This question is often asked by persons who fancy that there is a distinct species of ants that have wings. Most known ants are "flying ants" in their ancestral origin. The males and females are born with wings, which the males keep until death, and the females soon lose. Indeed, the females deliberately unwing themselves by divers contortions of the body, strokes of the feet, twisting of the wings, and rubbing against near-by objects. That nature-gift which we call instinct, that teaches wasps and bees to keep their wings, which they will need in their mode of life, prompts the mother-ant to put off her wings as useless appendages in her underground and flightless career.[1]

A complete formicary contains one or more fertile queens, workers of two or more castes, and young males and females. The last are sometimes called "virgin queens," for they are the predestined royal mothers of ants. Both sexes are carefully attended by workers of

[1] Some ant genera, however, are truly apterous, as *Eciton*, *Dorylus*, *Leptogenys*, and *Tomognathus*.

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the community, who feed them just as they do the baby ants or larvæ. They remain within the home nest until nature, with vigilant concern to perpetuate the race, prompts to the swarming or "marriage flight." Usually the workers assist nature. One may see males and females being driven out of the nest and from the surrounding herbage by squads of workers, who pinch them with their jaws, and otherwise give them notice that their room is held to be better than their company.

During their nonage these winged members of the formicary lead a lazy and merry life. While studying the habits of the Agricultural ant of Texas, the author saw some of them enjoying an outing upon the large circular pavement or plaza which surrounded the central gates of an immense formicary. Their visits to the outer air were not frequent; but they were plainly made for exercise and the benefit of the sunshine. One female was seen swinging, with evident gusto, upon a grass-stalk, not unlike a youth on a turning-bar.

On another plaza a bunch of young queens were having a joint outing, a sort of picnic which they heartily enjoyed. A large pebble near the gate was the chief sporting-ground. This they would ascend, and facing the wind, would sit erect upon their hind legs, taking as veritable a rampant posture as any heraldist could wish. Several of the queenlings would climb up the stone at one time; and then ensued a playful passage at arms for position. They pinched one another with their mandibles and chased one another from favorite spots. One was reminded of a group of boys sparring for place upon a big rock, or a bevy of girls in a game of "tag." So universal and natural is the impulse to play among the young of all living creatures, from an ant to man.

Thus the brief youth of the winged dependents of the formicary is passed (as far as now appears) in idleness and pleasure. But at length the time comes when they must go forth from their native city, to return no more. It would seem a sharp change and a most radical one; but nature has prepared the adventurers for it. Commonly the marriage flight occurs during the summer or early autumn. On a warm evening of a September day one may see multitudes of newly exiled male and female ants fluttering above the surface of the earth, the mass rising and falling as the members weave to and fro as in the mazes of a dance. Again, solitary winged females may be seen rising from the foliage surrounding an open formicary or from near-by plants, and flying away until lost to sight, or until they drop to the ground, where they may locate their "claim" for a new city.

Strange stories have been written and told of the immense numbers that escape in the swarming season from myriads of ant-hills, darkening the air, and covering several inches thick the surface of rivers and lakes, and even of the sea. Some accounts may be exaggerated; but enough facts are known, of which there is no doubt at all, to justify belief of most of them. The author has seen a swarm so vast as to shade the earth like a light cloud, and details of far larger swarms will be given in the next chapter. When one considers that these myriads of creatures are, up to this point, supported wholly by the labor of the workers; and that in addition thereto the care and nurture of the numerous larvæ; the excavating of galleries and rooms for the extension of the community; defensive and sentinel duty, and foraging for supplies, all are wrought by the same class —he will quite unite with Solomon in holding up the ant as a model of industry. But he who would find an ideal commonwealth, wherein are no non-producing classes and individuals, and where all work for the community, must go elsewhere than to an ant-hill.

After the marriage flight, the males soon perish. Most of them fall victims to birds and insects of various sorts; but such as escape these enemies hide under stones, or in hollows of the ground, or underneath shrubbery, and, being unable to provide for themselves, soon die. Their mandibles, which are the implements of war and industry among emmet tribes, are usually rounded, feeble, and unsuited for active service.

It seems a cruel transition, from being communal favorites and objects of unceasing care, to a state of exile and abandonment to death. It is another form of that harsh dealing with the useless members of society that one sees among their hymenopterous cousins, the bees. But the active savagery of the beehive appears in the formicary as neglect. The result in each case is the same; and perhaps the short, sharp method of the bees with their drones is the more merciful of the two. Nature, as operative in these vital atoms, having secured the perpetuation of the species, casts aside the individual when the one function for which he was provided has been performed. It is another example of Tennyson's large deduction:

> "So careful of the type she seems,
> So careless of the single life."

Every female and worker is furnished with two strong, movable jaws, or mandibles, hollowed inside like the palm of a hand and with toothed edges. With these they gather food, defend themselves against foes, open out homes in wood, as do the carpenter ants, or excavate galleries underneath the earth's surface and rear mounds upon it, as do the mason ants. As soon as the home-flitting is over, they settle upon the ground or on a tree, and first of all begin to "undress." They know—although one can only wonder how—that their wings can be of no use in the new life before them, while burrowing in the ground or tunnelling in the fibres of wood. Therefore, they rid themselves of those gauzy encumbrances.

This act of unwinging, or deälation accomplished, the queen—for she now may be truly ranked as a founder

PLAYGROUND OF YOUNG ANT QUEENS

Circular disk, or plaza, above the formicary of the Agricultural ant of Texas, eleven feet in diameter, and from it roads diverge to facilitate foraging, harvesting, etc.

of a house, although without a following—makes for herself a nest in a small cave in the ground or in a slight hollow in a tree. Therein she lays several eggs, from which a small brood of worker-ants is hatched, since the needs of the formicary first require workers. The eggs which produce males are not hatched until later. Whether, as in the case of bees, ants are able to develop queens from ordinary worker larvæ by special food and treatment is not positively known, but is hardly probable. Lord Avebury has shown that eggs are occasionally dropped by workers, who are really undeveloped females, and which always produce males.

While the first brood is maturing, the queen attends to all domestic duties. She is a fair type of the primitive human princess. She cleans up the house; digs out a new room for a nursery, if need be; washes and cleanses with her tongue her infant progeny; feeds them in the way common among ants, by regurgitation, drawing there for upon her own reserve of stored substance; and, in short, nurses and nourishes them until they are full-grown ants.

Then they are set to work for themselves. Their first duty is to assist in nursing their younger brothers and sisters. They take to this without instruction and while they are yet callow antlings. As they become a little toughened and hardened, they are pushed out-of-doors to help the queen mother gather food. By-and-by they are strong enough to assist in house-building, and begin digging out new galleries and rooms. Thus the work goes on and enlarges as the colony grows.

All this time the queen continues to lay eggs. There is need for an immense number, for there is great loss of life in an ordinary ant-hill. The daily exigencies of service among these little creatures are extremely severe. All sorts of enemies lurk in the way to devour them. The feet of passing beasts and human beings crush multitudes.

These frequent losses have to be made up by the fertility of the royal mother; and ere long it becomes necessary for her to devote herself wholly to increasing the colony. Foraging for supplies is abandoned. Household work, domestic service, nursery duty, are gradually given up, and the workers of the growing community take those tasks upon themselves. The queen is restricted to the function of motherhood. Therein lies her supreme claim to sovereignty.

This is a typical case of the course of founding an ant community; although herein also nature asserts her love of variation. In some cases, at least, especially in large communities, the workers seize the fertilized young queens and conduct them into the nest, where they are adopted, assigned quarters, and add their quota to the communal forces.

The ant queen's subjection to her subjects is not reached without resistance on the part of her emmet majesty. But resistance is useless, and she becomes in the end subject to the powerful house which she has reared around her. She is confined closely to the interior of the formicary, and wherever she goes, through chambers and halls, is attended by a circle of workers known as "courtiers"—a name that has a large and dignified sound. But the courtiers are simply a body-guard; and their chief office is to restrain the liberty of their sovereign within the bounds prescribed by the communal needs, and to look after the eggs when they are dropped. Almost necessarily this phase of ant life must be observed in artificial formicaries alone. Therein one may watch the courtiers surrounding the queen in a circle, attending her during all her movements. The circle never ceases to close around her as she passes from place to place.

A QUEEN ANT AND HER CIRCLE OF ATTENDANTS
Drawn from a sketch made from a scene in an artificial ant nest

Sometimes the queen, falling into a fit of stubbornness, will attempt a course different from that which her court prescribes. Then one attendant gently nips a leg and gives it a little push; another closes the mandibles upon the body and gives it a slight pinch; a third tenderly seizes a quivering antenna and draws it to this side or that. The whole body-guard meanwhile closes around the queen, and by pushing her and obstructing her path diverts her course, or quite turns her around, her huge body, several times as large as a worker's, moving sometimes readily, sometimes with sullen resistance. Thus at last the courtiers carry their point. Perhaps this sort of courtier-nagging is not unknown in the palaces of human sovereigns.

Once a queen escaped from the surface-gate of one of my formicaries. Not a courtier was in sight. She was free! Off she ran, as though intending to have a good romp and enjoy her freedom. But she had reckoned without her host, for she had gone but a little way when her body-guard pursued and seized her, somewhat roughly, and immediately began to pull her backward towards the gate. She resisted sturdily, but at last gave way, and was drawn down the opening into the royal domicile. Poor queen! Certes, there are some drawbacks to the dignities that hedge about an emmet throne.

The courtiers maintain their circular sentry while the queen is laying eggs. When they are laid, a worker catches up the tiny white pellets and pulls them to one side. Then they are borne away into the nurseries, wherein all eggs are set aside, and watched and cared for by the workers who have the special charge of that department.

From what has been written it appears that the name "queen," as commonly applied by entomologists and others to the fertile female of hymenopterous insects, such as bees, wasps, and ants, is misleading to the general reader. The functions of the ant queen seem to be limited to those above described—namely, first, the mason or carpenter-work and other labors necessary to establish the original nucleus of a formicary; and, subsequently, the increase of the colony by depositing eggs. There is really no headship analogous to that which the word "queen" expresses among men.

The entire administration of the community appears to be in the hands of the workers. All changes, such as emigration to a new nest, or wars of defence and offence, or the extension of the public works, are directed by them. These movements appear at times to be spontaneous in an entire community, and the reasons for them are often beyond human ken; but sometimes they plainly lie in special annoyance, inconvenience, danger, or necessity.

Every ant seems to be a law unto itself, and preserves independence of action in all things. The only sovereignty which it recognizes is that of personal influence and example, which create a potent social atmosphere or environment. When this becomes effective upon the individual worker, it is urged forward in the line of labor, apparently wholly independent of other rule or restraint than that which its task imposes. In fact, the proverb which, many centuries ago, described the wise workers of the ant-hill as "having no guide, overseer, or ruler," has been proved by modern myrmecologists to be literally true.

It would be more appropriate, therefore, to speak of an ant community as a pure democracy than an absolute monarchy. The queen is simply the mother of the home; the source of all life and prosperity, because of her power to produce offspring. Her life is guarded and regulated by a view single to the interests of the community, and, as far as can be seen, not at all with regard to the dignity and office of the royal mother herself.

How long may an ant queen live? In their natural habitat some queens doubtless have short lives; but by

A WANDERING QUEEN FORCED HOME BY HER COURTIERS
Courtiers dragging an ant queen back to her quarters

reason of the protection afforded them, and the seclusion enforced by the workers, they probably live much longer than other members of the community. Within artificial surroundings they attain a comparatively long life. The oldest emmet queen known to science was one preserved under the care of Lord Avebury, better known as Sir John Lubbock. In the winter of 1881, during a visit to this distinguished naturalist at his country-seat, High Elms, Kent, the author for the first time saw this venerable sovereign, living in the ingenious artificial formicary which had been prepared for her. She was then in the prime of life, as it afterwards appeared, being seven years old.

In the summer of 1887 Sir John was again visited, this time at his town house in London. After greetings he was asked about his royal pet.

"I have sad news to tell you," he answered.

"What? Is the queen dead?"

"She died only yesterday. I have not had the heart to tell the news as yet even to my wife."

Having offered my hearty condolence, I asked to see the dead queen. Sir John led the way to the room where his artificial nests were kept. The glass case which contained the special formicary in which the old ant had lived was opened up. Lying in one of the larger open spaces or rooms was the dead queen. She was surrounded by a crowd of workers, who were tenderly licking her, touching her with their antennæ, and making other demonstrations as if soliciting her attention, or desiring to wake her out of sleep. Poor, dumb, loving, faithful creatures! There was no response. Their queen mother lay motionless beneath their demonstrations.

"They do not appear to have discovered that she is really dead," remarked Sir John. Afterwards he wrote me of another queen which died at the age of fourteen years. The ants dragged her body about with them when they moved, until it fell to pieces.

CHAPTER II

ANT QUEENS AND THE FOUNDATION OF FORMICARIES

IN the former chapter the reader has been given a general view of the life of a queen ant. The subject is of such wide interest, and bears so closely upon the whole economy of ants, that it will now be taken up more in detail, especially with a view to the manner of founding a community.

Let us begin the history at the point where the young adult females or virgin queens await in their native formicaries the period at which their real life-function is about to begin. Heretofore they and their winged male associates have been beneficiaries in the home nest, wholly dependent upon the workers for food, and for other attentions. They can preen the soft hairs and bristles that clothe their bodies, and otherwise attend to their personal toilet. But they are still subject to the watch and discipline of the worker castes, who are the emmetonian soldiers, policemen, builders, purveyors, nurses, and laborers.

They have an eye even to their constitutional exercise; for Huber has told us of certain carpenter-ants, both male and female, that under escort of workers left their arboreal chambers, and from the middle of the afternoon until midnight promenaded the neighboring branches, like a bevy of boarding-school girls on their daily walks under their teachers' ward. They re-entered their rooms, to appear from time to time, until the final separation from the parent nest, to which this formal parad-

MARRIAGE FLIGHT OF ANTS
Worker ants urging males and females to leave the home nest

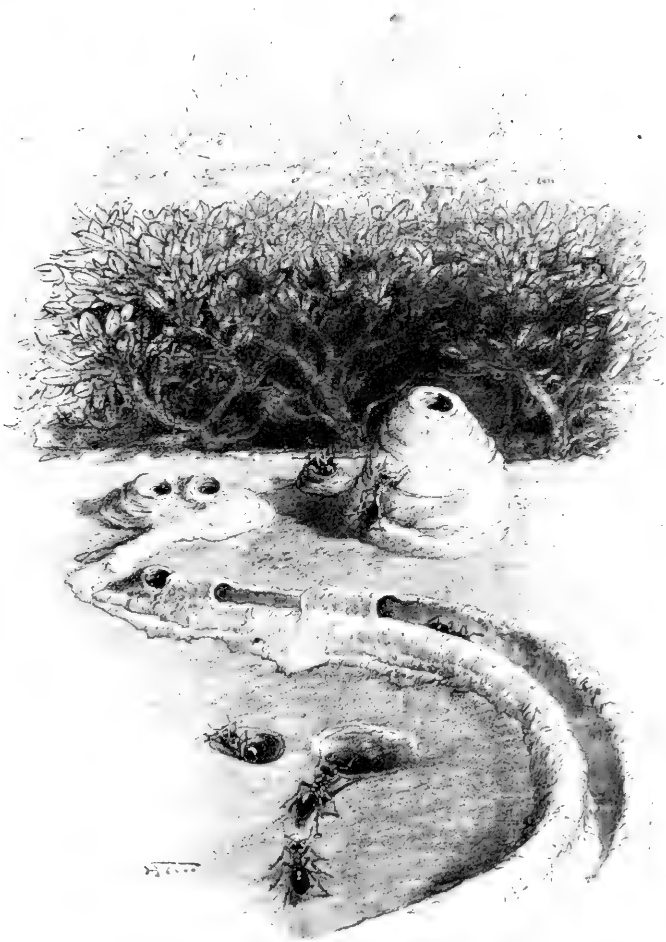
ing was preliminary. It is not known that the virgin females of any species take part in the domestic economy,[1] and that this is true of the males is almost certain. To them it is, or seems to be, the heydey of life; yet one sex is on the verge of a laborious career and life imprisonment, the other of his extinction.

A warm dry season seems to be required for a marriage flight or swarming of ants. The period varies with the latitude and the species. Enough time must be allowed for a goodly number of the sexed forms to mature. As these seem to come on later than the workers until the community is established, the season must be well advanced ere the first flight occurs. Some species will begin to cast off their dependants in the latter part of June. Late August sends out great numbers; and September and early October are favorite months.

The workers know the proper time for leaving the nest, and in part, at least, determine it by exciting the male and female adolescents to depart. They certainly make preparations for the exit, opening the formicary gates, urging their wards to the surface, and nagging them to take flight. Thus urged, they mount the mound, if there be one, or climb up the surrounding foliage, to which points the workers pursue them with their expulsive affection. Some even offer them nourishment for the last time, a sort of stirrup-cup, ere they set forth upon their aërial journey.

The usual bustle that pervades the community shows that it is in high holiday, and that there is a general consciousness that a rare event is at hand. The workers fairly throb with self-importance, their pent-up energy

[1] A few instances have been cited of the virgin queens taking some part in the communal industries; but the rule is as here given.



SURFACE MOUNDS OF A MASON ANT (LASIUS)

Works thrown up on a garden path in May, when the ants are enlarging the formicary for the growing community

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causing their bodies to vibrate like a shaky vessel driven by a huge engine. They act much as they do when rushing in line or column to a battle-field.

The winged forms share the common agitation, and tumble and crawl over one another, and spread their gauzy wings that quiver and give forth a faint crackling sound, and flash in the sunlight with iridescent colors, as though Iris had looped upon them tiny bits of her veil. And now, as if by one impulse, the emigrants begin to take flight. Singly, in pairs, in groups, in mass they rise, and flutter above the surface, rising or falling, or weaving in and out of the swarm seemingly in purposeless confusion.

Sometimes I have seen two or three centres of migration several feet apart, as though they were neighboring and fraternal nests of one species, or one widely extended colony. In either case one is amazed at the vast numbers that pour out of the open gates, as if some Cadmus of the insect world had called by magic an army from the ground. If the nest-site happen to be on well-known ground he will wonder all the more, for the presence of such a multitude would never be suspected by anything actually seen. Whence have they come? Where and how have they been kept?

The swarm reaches several feet above one's head or swings around the face, so that one may readily see the male lovingly escorting his companion, who is several times larger than himself. At times, the swarms will sink almost to the surface, when the lovers may be seen dropping from the mass and continuing their courtship on the grass.

The course of a marriage flight is regulated by the direction and force of the wind. It has no relation to the parent nest, to which none of the outgoers appear to return of their own motion. Nor, indeed, have they the power or ability to do so. In this respect there is a wide difference between winged ants and their cousins the bees and wasps. With the latter, wings are essential to the common life of hive or nest, and are instruments of transit to and fro on communal errands. They therefore have the gift of locating the home and returning to it on wings. But ants are given wings simply for preserving the species, and these organs of flight are used for that alone. This includes the ability to bear the female to a fitting spot wherein to found a new community. She escapes from the hurly-burly, and sees her home nest no more.

As for the males, their life-mission ends with or soon after the marriage day, and nothing in nature seems to be kindly concerned about them. They are waste matter in the world of life; like Falstaff's recruits, mere "food for powder"; that is, prey for ant-destroying creatures, or flotsam and jetsam before the undulations of winds which drive their dry carcasses to and fro.

Sometimes there is more or less uncertainty in an ant community as to the exact period for the marriage flight. At least, a difference of opinion would seem to arise between the ruling caste and the winged dependents. On and near the grounds of Mrs. Mary Treat at Vineland, New Jersey, were some nests of the Sanguine slave-makers (*Formica sanguinea*), in which I became much interested during several visits to that lady, during which we jointly studied the manners of several species. The winged forms began to emerge about the middle of June, and three days thereafter the interior of the glazed

AT PLAY IN THEIR PARK
Young queens of the Agricultural ant romping on a pebble

frame which had been placed over the colony was alive with them. Upon removing this cover the excitement greatly increased. Workers, red and black, mistresses and slaves, came out in such vast numbers that they literally covered the backs of the winged members—pushing, pulling, carrying, hurrying them into the underground passages, thus promptly deciding that their wards were not yet ready for that outside world upon whose unknown experiences the callow things seemed so eager to rush.

A few days thereafter virgin queens were seen now and then wandering beyond bounds. But the attendants quickly had them back into the formicary, usually leading them by an antenna. The males, too, were objects of solicitude, and were kept in until the time for the grand exodus arrived. I have suspected that, notwithstanding this vigilance, a queenling of exceptional enterprise occasionally would escape, and go solitary to her destiny.

On the eleventh day after the appearance of the sexed Sanguineas, preparations for the flitting began. Early in the morning the slaves (*Formica subsericea*) commenced to throw aside the embankments which they had piled around the edges of the frame, and to excavate beneath it. Several openings were thus made to the principal apartments. The Sanguine mistresses now became very active. Numbers passed rapidly along the lines of black workers. They occasionally stopped to assist; then proceeded to another group as if to encourage and inspect the work, and again disappeared within. This continued until about the middle of the day, when a large number of the Sanguineas joined their slaves in the trenches. Several large apertures were soon made beneath the east and south sides of the frame.

Now came sundown, and the queenlings, with their partners and escorts began to issue from the gates. Five wide doors had been opened, through which streams of insects with agitated wings were flowing. Many excited workers hung around the doors. They were not hindering the exit now, but forwarding it. And the outgoers seemed eager for the change. They mounted blades of grass and stems of plants and from thence took wing. The foliage of the trees in the thick grove hindered free and continuous flight, and soon the leaves were alive with the winged throngs. They were watched until the deep evening gloom prevented observation.

Next morning all was quiet at the nest. The wild rush of the marriage flight had ebbed as rapidly as it rose. The slaves were closing the doors and restoring the embankments. Beneath the glass the large covered apartments, a day before so full of life, were vacant. In one corner, which had been used as a sort of kitchen-midden, was a good handful of cast-off wings. After the flight the workers had sallied forth, seized the females within reach, dragged them into the nest, and established them as associate queens. Scouts were still out hunting for such recruits; and every little while one would be brought in—now led by an antenna, now dragged by a leg, and again carried bodily in a worker's jaws, which clasped her captive, whose form was bent like a letter C, her abdomen thrust beneath her porter's forelegs. And always, ere this capture, the queenling had been dispossessed of her wings.

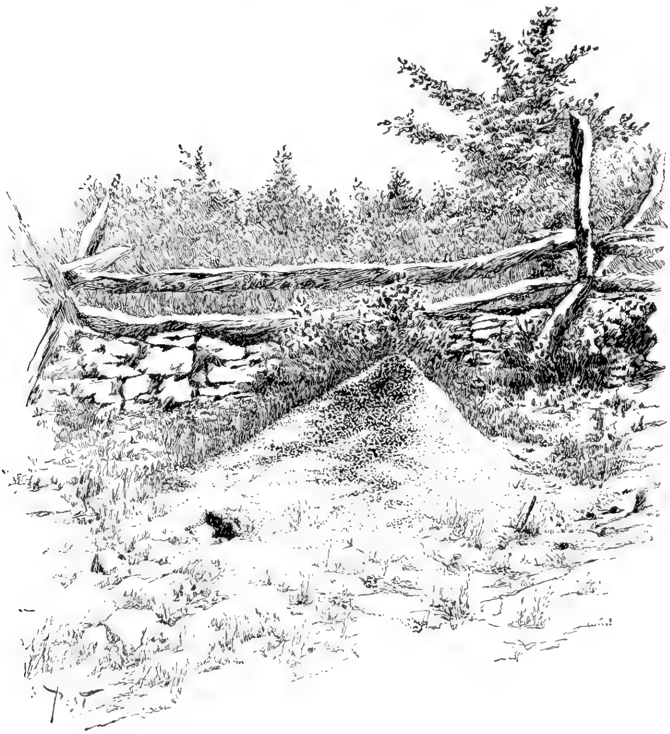
And now, what next? I knew, said my informant, from former observations that a marriage flight would soon be followed by a sally of red soldiers in martial column to some negro colony, which they would assault and plunder, and kidnap the young. For this sight I remained, and witnessed it, greatly to my satisfaction, though much to the ill-content of the glossy black ants (*Formica subsericea*) whose home was raided. But the story of slave-making ants must wait for another chapter.

The natural impulse which starts the marriage migration from parent nests seizes multitudes in a neighborhood at the same time. As a result, in sections where the normal increase is not hindered by tilling the ground, immense numbers of flying ants will be abroad at one time. The contingents from various formicaries are driven together in masses until the united swarms include myriads of individuals.

The natural hostility existing between different species, and even between separate communities of the same species, seems then to be suppressed. It is a time of peace, as wedding events should be; and herein (if this be habitually so) nature surely works for the preservation of species. There is no proof and little likelihood that the barriers between species are broken down at these great mass-meetings by alien alliances. But the outputs of multitudes of nests are massed in a common swarm, and drift together before the wind, or take a common course in flight. This phenomenon has always been seen with wonder, as something most unusual, and reports thereof have commonly been largely discounted or wholly doubted.

I have seen many large flights, but no such swarming myriads as have amazed observers. But from what I have seen, I can readily conceive how such hosts could be assembled. Moreover, I have indubitable accounts of such phenomenon from personal witnesses and personal acquaintances whose word and the accuracy of whose observation are beyond challenge. A few examples will well enough illustrate this feature of the life of emmet queens.

A remarkable swarm of ants that crossed Hollidaysburg, Pennsylvania, on September 13, 1876, was reported to me by a correspondent. I referred the matter to a citizen of the place, the Rev. Dr. D. H. Barron, a gentleman of learning and discretion, who made a thorough examination and report. The ants, in the course of their flight, had come in contact with mechanics at work upon the tower of a new court-house, and newspaper accounts said that they had been assaulted vigorously. These men were visited, and communi-



A NEST OF MOUND-MAKING ANTS OF THE ALLEGHANIES
Surface nest, showing mound three feet high, and twenty-five feet in circumference at base

cated the following facts: The day was clear, warm, and calm; the ants came between 10 and 11 A.M., from the direction of Chimney Rocks, a ridge of the Alleghany

Mountains southwest of the town. They came in "swarms so thick that one could hardly see through them." They struck the building at a height of about one hundred and twenty or one hundred and twenty-five feet, and "assaulted" the men. Whether the attack was a bite or sting they could not tell, but it was something uncomfortable. The ants were of two sizes, some larger, some smaller. One of the men had saved specimens which proved to be males and females of *Myrmica lobicornis* Nylander. This species can inflict a painful sting; but the ants probably attacked the workmen simply in self-defence—that is, the men happened to obstruct their flight, and vigorously brushed off the insects that lit upon them, which in turn becoming irate, the females applied their stings. Such a vast horde as this swarm contained must have been composed of the winged inmates of many formicaries on the mountain-side.

A similar account was given me in 1884 by Mr. B. S. Russell, of the rufous or thatching ant (*Formica rufa* var. *Americana*), whose nests then occupied the rolling prairie country lying between the Cheyenne and the James River, in Dakota. The ants appear in the spring, with the first vegetation, and by hay-harvest, the latter part of July, the flying ants are seen. The swarms are very annoying to the inhabitants. A person driving or riding over the prairie will find himself suddenly in the midst of one of these hosts. The insects settle upon the body, and creep into the openings of the clothes. A swarm settled upon the house which my informant was then building, and the carpenters were compelled to leave it while in the act of shingling the roof. In the hay-field, the harvesters are often obliged to stop to fight off the winged hosts, and those in charge of the hay-wagon abandon for the time the stack which is being hauled to the barn, on account of the annoying creatures. The same is true of the grain harvest which comes later, the appearance of the swarms continuing throughout August and into September.

The ants, however, do not sting, my informant averred. The nervous irritation produced by contact with such numbers is the chief annoyance. Some horses show great excitement under the visits of the swarms, to which the more stolid mule is quite indifferent. These flying ants do not get angry when beaten off, and rush at and follow after the parties attacking them, as bees do. They whirl round and round in dense masses, alight upon an object within their path, but show no sign of hostility, or wish to pursue human or other animals who approach them. The family of ants to which this genus (Formica) belongs, has no members possessed of true aculeate organs. The so-called "sting" is really produced by the insect "biting" or abrading the skin with its mandibles, and then ejecting formic acid from its undeveloped stinging organs into the wound. The smart of the acid is quite severe. All this may have changed in the last twenty years,[1] but the facts are given above as they then existed.

Mr. W. C. Prime, well known as an author and editor, described for me and subsequently published the account[2] of a swarm of ants seen by him on Lonesome and Profile lakes, two small waters in the White

[1] See my paper on this ant in *Proceedings*, Academy of Natural Sciences, Philadelphia (1884), p. 57 sqq.

[2] *New York Journal of Commerce*, September 24, 1886. See also *Proceedings*, Academy of Natural Sciences, Philadelphia.

Mountains of New Hampshire. The trout that inhabit these lakes feed upon various insects that hover over or sink upon the surface, and of whose habits they seem to have a tolerably correct notion. But there are certain annual visitations of insects which bring the trout out in unusual numbers, among which is the swarming of ants in marriage flight. The one described occurred Monday, September 6th. The wind fell flat calm at noon. Then Mr. Prime, while fishing on Echo Lake, became aware of the presence of the ants. Having become especially interested in the subject by a conversation with the author during a casual meeting in Florida the previous winter, he gave up fishing and began observations.

He rowed completely around the lake and across the middle. There was no spot on the entire surface which was not more or less thickly covered with winged ants. He repeatedly counted the number on a square foot of water. The lowest count was five, the highest nineteen. He made a rough but sufficiently exact estimate of the lake surface as containing two million square feet. Taking the lowest count of ants per square foot, there was therefore not less than ten million lying on the water, and the actual number was probably several times greater. Estimated from the average number per square foot, the total would reach the enormous figure of twenty-four millions! This is only the beginning of the myriads.

In the afternoon Mr. Prime found Profile Lake equally covered with the insects. The lakes are three-fourths of a mile apart. The boats of the pleasure-seekers, rowing in all directions, had swept the ants into windrows, thick masses of dead insects stretched up and down and hither and thither on the surface. The trout were feeding along the edges of these windrows, generally in groups. Ten, twenty, fifty fish would be half out of water at the same instant within a square rod. The ants did not reappear the next day. All of the millions that fell into the lakes became food for other animals. Those which the trout did not get, the innumerable inhabitants of the water ate when they sank.

These ants appear at about the same date every year and in the same numbers. The trout are fond of them, and feed ravenously upon them, as they do on the gnats, which also come in annual swarms. But, though there may be millions on the water, the fish do not touch them if they lie still and seem dead, as trout demand living objects for food. As an ant struggles on the surface among its dead companions, it attracts the eye of the fish, which rises and takes it. Mr. Prime kept no specimens, and one can only guess at the species represented. Many of them may have been of the same species as the Alleghany Mountain swarm just described. At all events, we have an authentic account by a careful and competent observer, which amply authorizes the fugitive stories of the incalculable numbers of flying ants seen in swarms from time to time in various parts of the world.

We have thus considered the ordinary, or at least the most usual, mode by which the queen ant is sent out qualified for her duty of founding a new family. Dispersed in the marriage flight, and thereafter borne by personal impulse and the force of the wind, she makes a suitable lodgement and begins at once to prepare her initial nest. But in some cases the conditions of dispersal are different. The outpouring of numerous winged forms, the excitement among the workers, the massing upon the ground, the ascent of neighboring plants, the nagging of males and females by their escort —all these are the same as heretofore described. But both males and females take flight separately, and seemingly without regard to one another.

For a moment the queenlings would poise themselves upon their perch, spread their wings, sway them back and forth, and then rise in the air. Their manner showed no mark of the feebleness and uncertainty of inexperience, except, in some cases, a slight tendency to a zigzag course for the first few yards. The flight was thereafter, and commonly from the first also, strong

A MARRIAGE FLIGHT OF WINGED CARPENTER ANTS and in a straight course. The insect first rose to a height of about twenty feet, which was soon increased to forty, fifty, and even sixty feet, and this latter height was maintained until the form was lost to sight. I was able to follow the voyagers in several instances to a distance of more than three hundred feet, before they disappeared, at which time they gave no sign of alighting. Others settled at a distance of sixty to eighty feet. Some flew into trees near by, which might be the upping-block for a second venture, or the undressing-room for deälation, in which case the ground must be reached. The flight was in every case solitary, and was in all directions, although generally in the course of the breeze. This method of dispersing the winged males and females by single and separate flight I have observed in several species. In such cases the meeting of the sexes and the marriage union must have taken place in the air; unless we infer, against current belief, that it preceded the flight.

We are now to trace the first active steps in founding a new ant settlement. If the ant is by instinct subterranean, she makes a small cave or burrow in the ground, wherein she lays her first eggs. If the queen is a carpenter ant, she makes her initial cave in wood, doubtless availing herself at the outset of a convenient knot-hole or the boring of a beetle or other insect. The stages of progress may be illustrated best by giving the history of some examples carefully observed. The late distinguished naturalist, Professor Joseph Leidy, turned over to me three fertile queens of the Pennsylvania carpenter ant (*Camponotus herculeanus* var. *Pennsylvanicus*) collected by him. One was taken August 9th in a chestnut log; the others August 14th in the stump of a chestnut-tree. They were enclosed in small cavities about an inch in diameter, within which the queens had sealed themselves by closing up the original opening, and from which, as a nucleus, they must have cut out their resident-room and nursery. When they sallied forth to obtain food, as they may have done (for I have often observed queens wandering solitary), they must have removed the plug, or "door," and restored it upon reentrance. However, it is quite within the bounds of probability that a well-fed queen can live without additional food for a number of days after setting up housekeeping, and this is doubtless the usual course.

In these nesting cavities were found the white, oval, or cylindrical eggs of the species; larvæ of various sizes, from those just out of the egg, 2.3 millimetres long, to full-grown, about 10 millimetres; cocoons or enclosed pupæ; and in one case a callow antling, which was of the dwarf caste, as all the larvæ and cocoons also appeared to be. There are three castes in a formicary of Camponotus, the worker-major, the worker-minor, and the minim, or dwarf. We may infer that the latter caste is the one which is first produced in rearing a family.

It has been conjectured that the imperfect nurture given to larvæ, under the above circumstances, might account for the appearance of small workers first in order. Whatever may have been the fact in the remote origin of these castes among ants, it is certain that when the formicary has been fully peopled with workers, and the food supply is unlimited, the severa' castes continue to appear. Minims, minors, and majors, not only abound among the mature insects, but are found among the larvæ and cocoons. These distinctions are a permanent feature of the ant economy. The fact is, in some genera, the workers have also remarkable differences in structure, as of the head, for example, in Pheidole and Pogonomyrmex. This appears to show that differentiation into castes is regulated by something other than the food supply.

Females of Camponotus, when fertilized, go solitary, and after dispossessing themselves of their wings, begin the work of founding a new family in some convenient bit of dead or living timber. This work they carry on until enough workers are reared to attend to the active duties of the formicary, such as procuring food, tending and feeding the young, and enlarging the domicile. After that, the queens generally limit their duty to the laying of eggs.

A series of valuable observations was made upon an ant queen by Mr. Edward Potts, a member of the Philadelphia Academy of Natural Sciences, in accordance with the author's suggestions and directions. The ant was afterwards taken into the author's possession and many of the observations were confirmed. June 16th, Mr. Potts captured a carpenter queen (*C. pennsylvanicus*) running across a house-room floor, late at night. He placed it in a bottle, but forgot to examine it until five days later. The ant was then alive, and had laid six or eight eggs in the otherwise empty bottle. These eggs, in their various stages of development, she continued to attend for about fifty days. A pinch of white sugar, moistened every evening with a drop or two of water, was the food supplied. At feeding-time, the mother would quit her otherwise unremitting watch over the eggs and larvæ, to press her mouth for a moment into the sweet fluid, her labial and maxillary palps meanwhile rapidly vibrating with pleasure. She was not prolific, but one or two eggs were added to the original stock from time to time, until about August 15th, making the highest number counted, nineteen of all ages.

The larvæ were at first scarcely larger than the eggs, and only distinguishable upon close observation by the slight grooves between the body segments and the ill-defined head. They grew gradually at first, and afterwards more rapidly, finally reaching a length of about one-quarter-inch, when they began to spin their cocoons. On the morning of July 20th, the first larva was surrounded by a single layer of web, within which it could be seen working. By evening the pupa-case was so dense that the larva was hidden. On the morning of the 21st, the second larva was covered, and the third by the evening of the 22d.

On the evening of August 11th, a worker was running about the bottle and already essaying its ministrations upon the undeveloped eggs, and the next series of larvæ, quite as big and much heavier than itself. Thus we had the period of thirty days, June 20th to July 20th, occupied in the development of the first eggs and the fulfilment of the larval stage. From July 20th to August 11th, twenty-two days, were spent in the pupa state.

The manner of the newly fledged worker was nervous and far from soothing, especially to the well-grown larvæ, who evidently much preferred the mother's care to that of the elder sister. This antling was not seen feeding from the sugar, but upon one or two occasions made osculatory advances towards its mother as if seeking nutriment from the maternal fount, to which it became accustomed during its wriggling larvahood. It constantly climbed over the eggs and larvæ, apparently nipping them with its mandibles, but not moving them to any purpose, and making no well-defined attempt to feed them, as was done by the parent ant. It plainly added awkwardness to inexperience, or was defective in instinct. The mother would caress the larva by sundry pats, with her antennæ, upon each side of the face, when, if hungry, it would lift up its head under her mandibles, placing its labium against hers, at which time a flow of liquid down the larval throat was seen.

As the queen's labors increased, she was less given to move her charges from place to place, though they were not allowed to remain long quiet. The maternal inclination to tend and dandle one's offspring seemed vigorous even in her emmet bosom.

The moisture necessary to cleanse and refresh the larvæ was apparently supplied from the salivary glands and tongue of the care-taker, who examined them one after another, moistened the dry places, and kept the egg and larval skins flexible. The queen was careful of the eggs, standing nearly all the time with her head over the little heap, occasionally picking them up to move them a quarter of an inch or more to one side. She was thrown into a great excitement of solicitude by a fly attracted by some crumbs within her domicile. She sprang fiercely at the intruder, and raged around her narrow compartment, seizing a group of eggs, as if to escape with them from a threatened danger. Then she replaced them, as if recognizing the impossibility of getting away; or, it may be, soothed by reason from her needless fear. Her demeanor indicated strong maternal solicitude; and how like our own mothers and wives!

When ovipositing, the queen stood up high upon all three pairs of legs; the abdomen was thrown downward and forward between them, and the head bent back and beneath almost to meet it. The egg was then about half protruded. Considerable muscular action was visible throughout the abdomen, and when presently the egg was posited the ant straightened herself out with a visible air of relief. She forgot all about the egg, which was left for several minutes while she attended to other matters. At last, accidentally touching it with one antenna, she picked it up and carried it to the family quarters, where the worker found it and placed it in the group of the older eggs. An evident intent at classifying the eggs and larvæ was remarked, these having been kept separate, as far as the narrow limits would permit. This separation of the various stages of larval growth may be regarded as a common trait of all emmet species.

On August 13th, another worker was released from its cocoon. The female appeared to assist in the delivery, as she was seen standing over the neophyte, who seemed to be weak, its femora bent forward, the tarsi and tibiæ still nearly reaching the end of the abdomen, indicating the manner in which the legs were folded in the cocoon. Immediately after release the mother gave the young imago nourishment.

At this date there were in the formicary, beside the mature ants, two full-grown larvæ, very fat; two half-grown, and several smaller ones, with the eggs in different stages of development. The two oldest were then evidently about ready to spin into pupæ.

August 14th, one of the two full-grown larvæ was partly overspun, but so thinly that its motion was readily seen through the case. The other larva seemed quiescent, but examination with the lens showed muscular action in the posterior segments of the body. This state of comparative torpor was thought to immediately precede the act of spinning. At this date the workers had become less nervous in their motions, and the female had resigned most of her labors to them, resting much of the time quietly in one place.

August 16th, the third worker had emerged, and was at once quite at home in attending to its duties. The second grown larva was then still uncovered and quiescent. Close observation was required to show that it breathed, and it made no other visible motion.

These observations establish, or confirm, the following points: (1) The manner of depositing the eggs, which, as well as the larvæ, are cared for by the queen until the workers mature. (2) The stages in the development of the eggs and larvæ are partially noted. (3) The time required for the change from larval to pupal stage is about thirty days. (4) About the same period is spent in the pupal stage, the entire period of transformation being about sixty days. (5) The work of rearing the first broods of Camponotus begins the latter part of June or early in July. (6) About twenty-four hours are spent by a larva in spinning up into a cocoon. (7) The ant queen probably assists the callow antling to emerge from its case. (8) Not only larvæ, but occasionally also the antlings, are fed by the queen. (9) The young workers, shortly after emerging, begin their duty of nurses, caring for the eggs and tending the larvæ.

Such is a fair type of the mode of founding an ant colony. Details will vary with conditions, with species, perhaps with individual temperament. But, on the whole, the reader can picture the prevailing process. Thenceforward, the course of progress is subject to the exigencies of life; but under favorable surroundings the workers will increase, and will gradually take over all communal affairs which will multiply as the primitive house-cave enlarges. The queen becomes a mere agent for laying eggs, with a life-history which the opening chapter uncovers.

CHAPTER III

INSECT HERDS AND HERDERS

IT seems an amazing instinct that sends slave-making ants upon predatory raids to recruit the domestic laborers of their commonwealth by mature and larval captives of other species of their own family. But even more surprising is the instinct which leads ants to appropriate to their own uses insects of another order and of wholly different habit, and to create for them a natural and wholesome environment. Yet this is what the naturalist finds.

An ants'-nest is somewhat like certain French villages that serve as social centres and domiciles for the inhabitants, from which every morning workers radiate to the surrounding fields, wherein they earn their livelihood, and to which they return at evening. The formicary is the emmet home. The foraging-ground lies outside. Hence ants become great wanderers, and may be seen, often as solitaries, moving about in circuitous and greatly involved paths. In the course of these wanderings they will be seen climbing trees, shrubs, and bushes. Here is one mounting, let us say, the stem of a rose-bush.

"Alas!" exclaims some rose-culturing reader, "do I not know that act too well. Have I not often seen those mischievous mites thronging and preying upon my favorite plants?"

Thronging, yes; preying upon, no! Look more closely! Your rose-bushes are infested by certain small insects known to entomologists as aphides, but to you by the homelier name of "plant-lice." They, not the

ANTS COLLECTING HONEYDEW FROM AN APHID HERD

roses nor the bushes, are the objects of the ants' attention. They are the so-called "ant-cows," and if you like you may see the milking!

As one case will give a fair measure of the whole range of habit, I ask readers to follow me in a special study made of this mode of feeding among the mound-making ants of the Alleghanies (*Formica exsectoïdes* Forel), whose vast communities, centred within their large conical mounds, has been described in the preceding chapter.

We take our stand before this large mound, which is astir with thousands of insects hurrying to and fro in the various industries of the commune. Issuing from and crowding into the gates or circular openings that skirt the base are two columns of workers. Their fellows hover around the doors, bent upon their several duties. But these columns keep up a steady march and countermarch without visible diminution of numbers, and without cessation day or night. One column stretches off to the southwest, and disappears at intervals under flat stones. It reappears, crosses the tops of similar stones, intersects the lines of workers busy about the surrounding hills, and penetrating the jungle of grass beyond, is finally distributed among a number of young trees not far distant. The other column leads off in a straight line to the southeast for a distance of eight rods to a large oak-tree which stands by a stone wall that parts the wood tract containing the "ant city" from a field. Leaving the well-marked road at the foot of the oak, the column stretches along the trunk and is distributed among the branches.

A portion leads off upon one of the lower limbs, which overhangs the stone fence. Stand atop of the wall and look carefully among the twigs and branchlets. You have the key to the movements of the promenaders upon the avenue beneath.

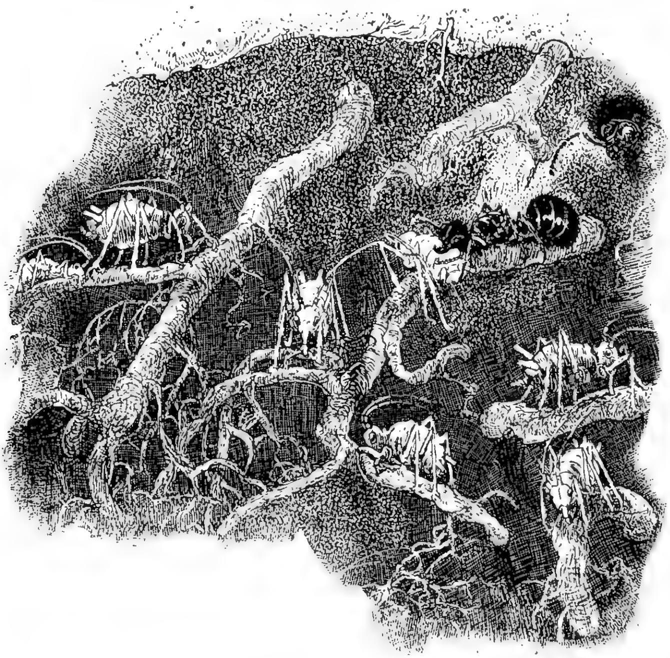
At various points vast numbers of aphids are clustered. They clasp the branches with their feet. Their abdomens are slightly elevated, their heads are depressed, and their beaks, which are a sort of suction-pump, pierce the tender bark, and tap the sweet sap coursing within. This is the natural food of aphids, and appears to undergo some change in transit through them that adds to its toothsomeness. But what has this to do with our ants? Wait. Note this worker. It approaches an aphid and fixes its attention upon the apex of the raised abdomen. Do you the same, and you shall see a minute drop of transparent liquid exuding. You have barely noticed it ere it has disappeared within the ant's gullet! After a few moments' waiting, again a droplet forms, which is also quickly lapped by the attendant ant.

A longer interval must elapse ere another globule shall form, and you will grow impatient. The ant will hasten matters for you. See! She is gently stroking with her antennæ the back of the aphid. Now on one side, now on the other, the delicate organs are gently drawn again and again. What does this mean? Why does your cat purr and curl contentedly in your lap when you stroke her fur? Why does your dog bend his head and stand still with such a seeming of muscular relaxation and physical content when you stroke his head? Or, to get nearer home, why does the male of the human species (and some of the females as well) yield his head with such unutterable satisfaction to the deft manipulation of a loved hand, with or without the comb? Can you tell why? Then you know why the ant strokes the aphidian back, which is covered with papillæ or minute hairs. She has learned from her own experience "how good it feels," and is promoting the aphidian complacency by an approved method.

And now another droplet of the sweet liquid is forming, yielded by the aphid to the deft diplomacy of the emmet. That liquid is the entomologist's "honeydew," and you have seen an ant milking her cows! All over the tree, like scenes are occurring between hosts of foraging ants and aphids.

The ant laps honeydew from the aphid; the aphid pumps sap from the tree; the tree draws moisture from earth and sky, and earth and sky receive rain from the sea. Thus the circle of life runs, and ants, like other tenants of the earth, derive their nurture from Father Neptune.

Our aphid shifts her position, and passes along the branch towards the trunk. Its first attendant had left,



PORTION OF AN ANTS'-NEST
A broken section of earth, showing aphids domesticated upon roots of plants

seemingly from mere fastidiousness, and afterwards several ants had enjoyed the sweet refection. As the aphid moves away, it receives antennal salutes from sundry ants, as though they were challenging its disposition or resources; but it is allowed to pass on. Its abdomen is now at normal size, but the bodies of many of its fellows are rounded out from fulness, and, one would think, must feel uncomfortable. The ants, however, are fast relieving them, and their own abdomens are undergoing a noticeable change. They swell and elongate until the folded membranous bands which unite the several segments thereof are pushed out into straight, white, transparent ribbons by the distension of the crops into which the honeydew first goes. At length the abdomens are so full that they become semi-translucent, and the burdened honey-gatherers turn towards home.

These "repletes," as they have been called, compose the descending column upon the tree-trunk, and their swollen abdomens with their whitish bands show in sharp contrast with the small, roundish, black abdomens of the ascending ants. At the foot of the tree a most interesting scene awaits the observer, to which the writer was thus led: Among the workers thronging the avenues radiating from the hills to various trees, the number of home-bound repletes was seen to be out of all proportion to those descending the trees from the feeding-grounds. Moreover, many workers were returning home without swollen abdomens. If they had not been foraging, what then? Or had they simply been more abstemious than their fellows? Led by these reflections to follow the repletes down the tree-paths with greater care, some of them were seen to disappear at the roots. This led to a discovery which the reader is now prepared to share.

Let us clear away these dead leaves as noiselessly as may be. Turn back gently the sod at the angle of this bulging root. You have exposed a cavity whose occupants, after their first flutter of surprise, will return to the business at which they were disturbed. In fact, they were drawing rations, live civil pensioners in wartime. And "pensioners" they have been called. Note the scene before you. The floor of the cavity is pierced by openings into galleries that evidently communicate with the central nest, more than a hundred feet away. Around these openings are huddled numbers of ants. Some try to escape down the galleries, and some are opposing or hindering them. Others are engaged in drawing or bestowing the honeydew ration. The process is a curious one. The replete is reared upon her hind legs, her fore legs out-stretched and her head elevated. A pensioner in like attitude faces her, with jaws lifted up against her jaws. Presently a droplet of honey-

A WORKER ANT DRAWING A RATION OF HONEYDEW FROM A REPLETE dew appears upon the replete's mouth, hanging to the maxillæ beneath. It has been forced out of the full crop by muscular contraction upon its enfolding sac, and is immediately lapped by the expectant pensioner. You may see two or even three ants thus feeding at once from the same replete. This is substantially the process by which the larvæ and antlings, the wingless queens, and the winged females and males are fed.

The repletes, as a rule, made no objection to this process; but at times one would show anxiety to break away without parting with her treasure. The pensioners would occasionally solicit a ration with their antennæ; and once a replete was seized rather violently as though to coerce a gift. After the feeding the repletes dashed into the galleries and disappeared through the mass of legs, heads, and black abdomens of workers, all apparently engaged as above.

A chief significance of the behavior here described is the view which it gives of the public economy of an ant republic. It seems to show a general movement which has much the appearance of a division of labor. Those members of the community engaged in building and in the internal economy of the formicary appear to leave the collecting of food, for the nonce, at least, to others of their fellows, not only for the dependants of the nest, but for themselves. Content with satisfying the simple wants of nature, they leave their work and visit the vicinage of the feeding-grounds to get food from the superabundance of those who have the duty of foragers. The points of contact are well chosen for this purpose, forming as they do a series of stations between the foraging-field and the nest. As many of the repletes are plainly overloaded, no loss is wrought to the commune by relieving them.

Besides, it seems probable that the instinct which urges repletes to gather store for the larvæ, nymphs, and other dependants, might prevent them from yielding a part of their store to their fellow-workers after the nest had once been reached. It may be supposed that the surplus honeydew would be kept for individual delectation, and thus the builders and sentinels be compelled to leave their work and forage for themselves. Therefore the general movement to arrest the repletes at the stations near the foraging-grounds is clearly for the public good.

The habit as here described prepares us to see how important to ants might be the domestication of aphid herds. That this is accomplished any one may readily satisfy himself by turning up flat stones in a field or woodside on a warm spring day. He will see groups of ants clustered upon the under part of the stone or in the excavated rooms and galleries in the matrix or pit beneath. Along with them he will see bunches of aphides. Great excitement will at once ensue, and the agitated emmets, each seizing an aphis in her jaws, will plunge with it into the underground galleries. Soon both ants and aphids will have disappeared.

These aphid herds, as seen in early spring, are plump, and show signs of having weathered the winter in robust health. Evidently they had been well cared for by their emmet mistresses, whom they had doubtless repaid by draughts of honeydew. And this care extends also to the attention to their physical health and comfort, by which they are brought up from the cooler subterranean parts to the warm and dry vicinage of the stone,

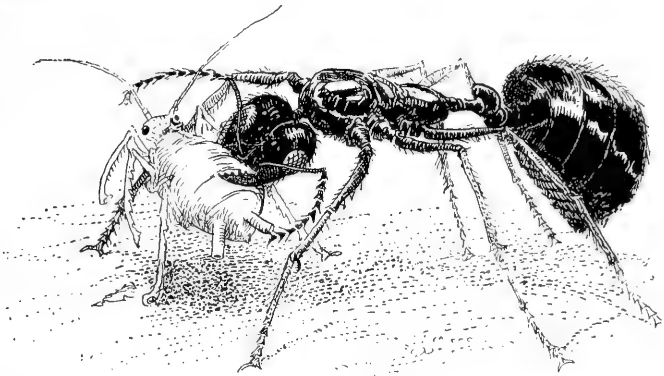
ANTS'-NEST UNDERNEATH A FLAT STONE
A herd of aphids brought up for an airing, or perhaps for "milking"

which, lying upon the surface, absorbs the heat of the sun.

Multitudes of aphids subsist upon roots of plants. Indeed, it is here that they are most destructive to the horticulturist. From this habit it appears how much easier it would be for ants, who are also subterranean in habit, to acquire the instinct of domesticating aphids for the sake of their sweet and nourishing excretion, and of bearing them from point to point, as they do their own younglings, and giving them generally the same care.

But the herding instinct has gone yet further than transferring the aphids from their native quarters to those of the ants. It has gone further even than taking the eggs of aphids raised upon roots within the formicary limits, and rearing from them milking chattels. Lord Avebury has shown that ants have taken aphids' eggs from the leaf-stalks of plants outside their nest where they had been laid in the autumn; have transported them to the interior of the formicary, where they were protected from the severity of the weather and other dangers; have tended them through the winter months, and then brought out the young, and replaced them upon the food-plant natural to them! Similar facts have been repeatedly observed by Professor A. S. Forbes, of this country. He found ants tending the aphid eggs as carefully as their own. They even carried them over the winter season, to that end bearing them below the frost line. They would explore the vicinage of growing corn until they found the sprouting kernel, then mine along the growing shaft and put the aphids upon it. This clearly suggests, if it does not closely approach, that human ability to rear and keep herds which our race has held in such honor that it has called its kings "shepherds of the people," its religious teachers "pastors," and even the Supreme Deity "The Shepherd."

Another feature of this herding habit deserves notice. At times one may observe that the aphids clustered around the axils of leaves or twigs on some plant, have been enclosed within or surrounded by a light wall or shed of mud or wood-dust composite. This is the work of attendant ants who have brought up particles of leaves, flowers, and decayed bark and pellets of soil from the ground, and thus, as one may say, have enfolded their flock. It is interesting to note in ants this behavior, which suggests the presence of a sense of communal propriety in food-yielding aphids; and—what seems to be a natural sequence therefrom—an



AN EMMET SHEPHERDESS CARRYING ONE OF HER APHID FLOCK

impulse to protect their interests from intruders by a process which, to say the least, reminds one of our own way of secluding domestic herds within folds, stockyards, and corrals.

This habit especially marks—though not limited thereto—a small black ant (*Crematogaster lineolata*), which has the odd fashion of doubling up its abdomen above its thorax as it walks, thus winning for itself the popular name of "turn-belly."

Aphids are not the only insects thus utilized. Afield, the larvæ of certain butterflies that yield an agreeable secretion are attended and solicited in the same manner as aphids. So also are some honey-yielding leaf-hoppers. Cocci and beetles are preserved within the nest, and if not reared are at least domesticated and adopted for the sake of certain animal products that they yield, and which serve as food. Both these insects, like the aphids, may be seen in the early spring flocking together in a warm corner of an ants'-nest beneath a stone. On being disturbed, the ants seize them and run into hiding precisely as they do with aphids. But the story of these other "ant-cows" must for the present remain untold.

CHAPTER IV

THE DAINTINESS OF ANTS—TOILET HABITS

IF there be truth in the old saying, cleanliness is next to godliness, insects are but one remove from piety. As tidy as an emmet—is more truthful than most proverbial comparisons. Who ever saw an untidy ant, or bee, or wasp? The author has observed innumerable thousands of ants, has lived in his tent in the midst of their great communities, and watched them at all hours of day and night, under a great variety of conditions, natural and artificial, unfavorable to cleanliness, and has never seen one really unclean. Most of them are fossorial in habit, digging in the ground, within which they live; are covered with hair and bristles, to which dirt-pellets easily cling; they move habitually in the midst of the muck and chippage and elemental offal of nature—yet they seem to take no stain and to keep none.

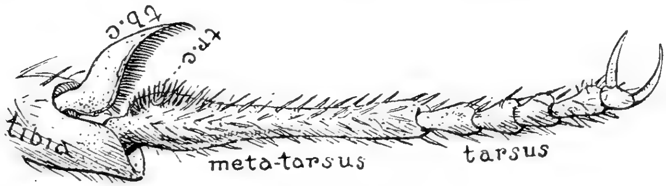
This is true of other insects. Take, for example, the interesting families of wasps. Many burrow in the earth to make breeding-cells for their young. Others, like the mud-daubers, collect mortar from mud-beds near brooks and pools to build their clay nurseries and storehouses. Some, like the yellow-jackets, live in caves which they excavate in the ground. They delve in the dirt; handle and mix and carry it; mould and spread it, moving to and fro all day long, and day after day, at work in surroundings that would befoul the most careful human worker—yet do not show the least trace of their occupation.

Of course there is much in temperament and training. There are women who remind us of insects in their faculty of moving unmarred amid the current defilements of daily duty. They will pass to the parlor from kitchen, nursery, or sewing-room with no adjustment of toilet but a discarded apron or turned-down sleeves, yet quite sweet and presentable. But there are women, high and low, and men innumerable, of a different pattern. With insects, however, the type of dainty tidiness is the absolute rule. There are no exceptions; no degenerates of uncleanness, as with men. Temperament is wholly and always on the side of cleanliness; and training is not a factor therein, for it is inborn, and as strong in adolescents as in veterans. How has nature secured this admirable result?

If the reader were told that ants possess brushes, fine and coarse tooth combs, and other toilet articles quite after the pattern of our own, he would probably think he was being gulled. Yet it is even so. Let us take an inventory of these. To begin with, the body is covered more or less closely with fine pubescence, corresponding somewhat with the fur of beasts. This is interspersed with bristles and spines, which are sometimes jointed, and are so arranged as to aid materially in keeping the body clean. Particles of soil cling to this hairy covering, but it is a protective medium, holding the dirt aloof and isolated from the skin surfaces, so that it can be readily shaken off or taken off. The brushing, washing, and combing of this hairy coat constitute the insect's toilet-making.

One of the efficient toilet articles is the tongue. Around the sides of this organ curves a series of ridges covered with hemispherical bosses. The ridges are chitinous, and thus by greater hardness are fitted for the uses of a brush. When eating, this structure rasps off minute particles of solid foods, thus fitting them for the stomach. For toilet uses it serves as both sponge and brush, and takes up bits of dirt not otherwise removed. In short, ants use their tongues as dogs and cats do, for lapping up food and licking clean the body. One is continually reminded, as he watches the tiny creatures at their toilet, of the actions of his cat and dog at the fireside.

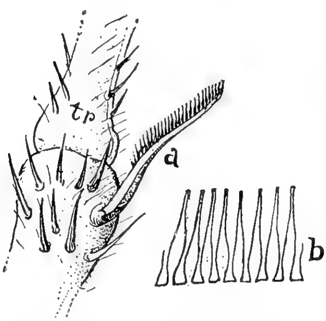
The tibial comb or fore-spur is another toilet implement, unique in form and function. This is a real comb,



PART OF AN ANT'S FORE LEG, SHOWING ITS TOILET APPARATUS

which might well have served the inventor of our own combs for a model, its chief difference being that it is permanently attached to the limb that operates it. It has a short handle, a stiff back, and a regularly toothed edge. It is set into the apical end of the tibia of the fore legs, upon which it articulates freely (tb.c), thus giving the owner the power to apply it to various organs. Placed along the edge are about sixty-five teeth of equal length, except towards the apex, where they are shorter. They are pointed at the free end and enlarged at the base, are stiff but elastic, and spring back when bent, as do the teeth of a comb.

The efficiency of this instrument is greatly increased by an arrangement of the tarsus, opposite whose base it is placed. That part of the leg is so shaped that the curved outlines of the tibial spur when pushed up against it fit into it. It is furnished with about forty-five teeth, coarser and more open than those just described. Thus ants have the useful arrangement of fine and coarse toothed combs which for toilet uses are practically united in one instrument. A further contribution to the toilet paraphernalia is a secondary spur, a simpler form of that on the fore legs, set upon the tibiæ of the second and third pairs of legs. Moreover, the mandibles, or upper jaws, which are palm-shaped and serrated, are used freely, especially in cleaning the legs, which are drawn through them while loosely held between them. In this action there is a salivary secretion that moistens the members, and furnishes a good substitute for those "washes" which are valued by men and women as softening the hair and making it more pliable. Indeed, one might almost conjecture that it is also the emmet equivalent for our toilet soaps!



TOILET ACCESSORIES OF ANTS
(greatly magnified)
a, secondary spur or comb
b, teeth of tibial comb

There are no pastes and powders among these toilet articles—at least as far as known—but the repertoire, it will be seen, is tolerably complete: fine-tooth combs, coarse or "reddin'" combs, hair-brushes and sponges, washes and soap!—and all so conveniently attached to the body and working-limbs, which are arms as well as legs, that they are always literally "on hand" for service.

Ants have no set time for brushing up. But certain conditions plainly incite thereto—as when they feel particularly comfortable; as after eating, or after awaking from or before going to sleep. The keen sense of discomfort aroused by the presence of dirt incites to cleansing. Often one may see an ant suddenly pause in the midst of the duties of field or formicary and begin to comb herself. Here is a mountain mound-maker (*Formica exsectoïdes*) driven by the passion of nest-building to the utmost fervor of activity. Suddenly she drops out of the gang of fellow-workers, and mounting a near-by clod, poses upon her hind legs and plies teeth, tongue, and comb. For a few moments the aim of being is centred upon that act. Around her coign of vantage sweeps to and fro the bustling host of builders with all their energies bent upon reconstructing their ruined city. She combs on unconcernedly. From top of head to tip of hind legs she goes, smoothing out ruffled hairs and removing atoms of soil invisible to human eyes. Her toilet is ended at last. A few leisurely finishing-strokes and she rises, stretches herself, calmly climbs down her pedestal, and is immediately infected with the fervor that lashes on the surging throng around her, and is lost in the crowd. Meanwhile, other workers have dropped out of the lines, and may be seen here and there at their ablutions. Thus it goes in the field, as one may easily see if he have tact and patience.

But artificial nests give the best opportunity for careful observation, although one must allow for the unnatural surroundings.[1] No doubt with ants, as with man, artificial conditions of society induce greater attention to personal appearance. Thus the author's imprisoned ants would invariably be drawn out from their underground lodgings by the light and heat of lamps at night. They would gather in clusters against the glass of the formicary next the lamp, and after some preliminary jostling and skirmishing for position would begin to wash themselves. Slight elevations, afforded by irregularities in the surface, were favorite seats. The modes of operating are so various that it is difficult to describe them, much more to fix the attitudes with the pencil. But typical poses at least may be described.

In cleaning the head and fore parts of the body, the insect often sits upon the two hind legs and turns the face to one side. Then the fore leg is raised and passed over the face from the vertex to the mandible—that is, from the top of the head to the mouth. Meanwhile the head is slowly turned to expose both sides to manipulation; and if this is not satisfactory the position is reversed and the opposite leg brought into play. In

[1] These notes, and the sketches upon which the illustrations are based, were made chiefly from three species in confinement—the Agricultural ant (*Pogonomyrmex barbatus*), the Florida Harvester (*Pogonomyrmex crudelis*), and the Honey ant of the Garden-of-the-gods (*Myrmecocystus hortus-deorum*).

"doing up the back hair"—as one may say—the head is further dropped and the leg with its movable spur-comb, which has free play like a comb in a human hand, is thrown quite behind the vertex, and moved forward again and again through the tufts of hair growing there. In these and other cleansing movements the leg will be

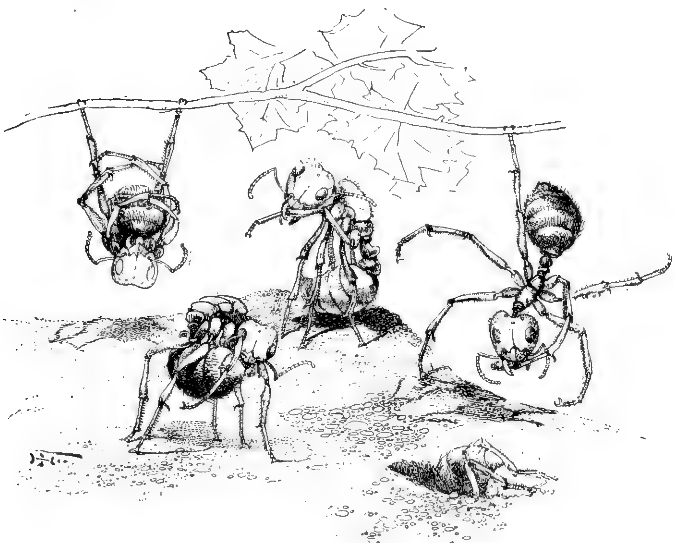
COMBING THE HEAD AND THE BACK HAIR

drawn through the jaws at intervals, to moisten it or to wipe off the dust caught in the comb. The action reminds one of the alternations of pussy's paw between mouth and neck when washing the back of her head and ears.

Cleaning the abdomen and the stinging organs at the apex, which is surrounded by circles of hairs, places the ants in grotesque attitudes; although herein also one notes a miniature of the ways of domestic animals. For example, the hind legs will be thrown backward and well extended; the middle pairs set nearly straight outward from the thorax and less extended, so that the body is nearly erect. The abdomen is then turned under the body and deflected upward towards the head, which at the same time is bent over and downward. The body of the ant thus forms a letter C, or nearly a circle. Meanwhile the forefeet have clasped the abdomen, the tarsus passing quite around and beneath it, and the brushing has begun. The strokes are directed towards the tip of the abdomen, which is also sponged off by the tongue. Occasionally the leg is rubbed over the head after being drawn through the mouth, and so again to the abdomen. One ant was seen cleansing its abdomen while hanging by the hind legs from the roof of the formicarium. The abdomen was thrown up and between the legs, as a gymnast on the turning-bar throws his body upward between his arms. The head was then reached upward, and tongue and forefeet were engaged as above described. Another emmet acrobat was caught in the act of cleansing its legs while hanging by one foot, the under part of the body being towards the observer.

During these toilet actions the formicarium presented a most interesting view, especially in the evening, when the table-lamps were lit and the ants had been fed, and a general "washing-up" was in progress. But one of the most interesting features was the part which the insects took in cleansing or "shampooing" one another. This was a new and pleasing revelation in life habit. It was unexpected, but after-experience showed that nature has taught these little creatures the value of co-operation in such matters among fellow-communists.

Ants are particularly liable to attack of parasites—a danger increased by imprisonment. As these enemies pass from one to another, and thus become a common peril, every individual has an interest in the personal health and habits of his neighbors. This is shown in the friendly offices here described. We may easily think of men as saying, "My neighbor's premises are untidy; he lacks the means and the disposition to keep clean; he is infected—what is that to me?" But citizens of an emmet commune are apt to be superior to such selfishness, and seem to feel instinctively—at least so to act—that the pernicious habits and personal misfortunes of the individual highly concern his fellows and the public. Perhaps this is fortified by a natural amia-



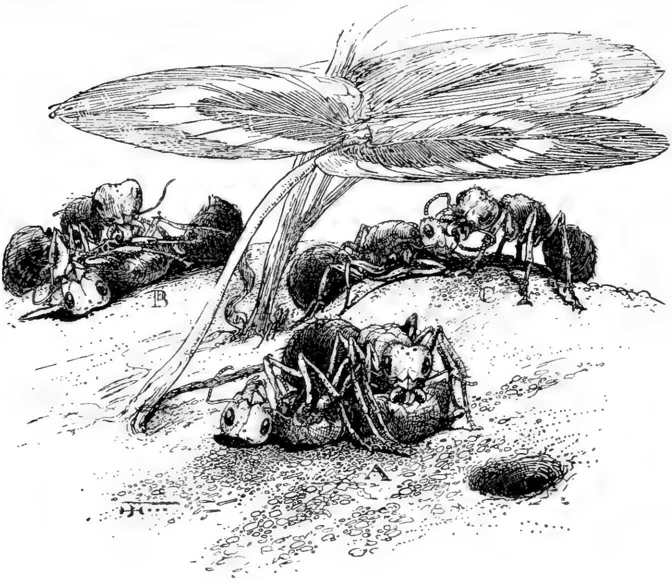
ODD TOILET ATTITUDES

Ants cleansing the legs and the stinging organs bility that delights to give pleasure. And what a pleasure most animals feel in manipulation of the hair and body! The now popular art of massagerie appears to be naturally practised by ants, doubtless antedating by ages the habit of men. But we forbear. This is anthropomorphic! It may be well to explain that these shampooing ants are not wholly disinterested in their kindly acts, for it has been suggested that they may obtain some sort of nourishing material from the bodies which they treat.

Let us peep into this group snugged up against the warm glass side of the formicary. They have finished their evening meal of sweets; have drunk, after their fashion, by lapping water from moistened wood, and most of them are busy at their toilet. And here is one receiving a sort of Turkish bath! A fore leg is held up, which a fellow-worker is sponging with her tongue, moving gently with "the lay of the hair" from thigh to foot. Then the mouth is passed steadily over the body; next the neck is licked, then the prothorax and head. Now the friendly operator leaves, and her comrade takes up the toilet service for herself.

Note another couple. The cleanser has begun at the face, which is thoroughly brushed, even the jaws being cared for, which are held apart for convenient manipulation. From the face the operator passes to the thorax, thence to the haunch, and so along the first leg, along the second and third legs in the same manner, around to the abdomen, and thence up the other side to the head. Another ant approaches and joins in the friendly task, but soon quits it. All this while the attitude of the cleansed ant is one of intense satisfaction, quite like that of a family dog when one scratches his neck. The insect stretches out her limbs, and, as her friend takes them successively into hand, yields them limp and supple to her manipulation. She rolls slowly over upon her side, even quite over upon her back, and with all her limbs relaxed presents a perfect picture of muscular surrender and ease.

The pleasure which the creatures take in being thus brushed and "sponged" is really enjoyable to the

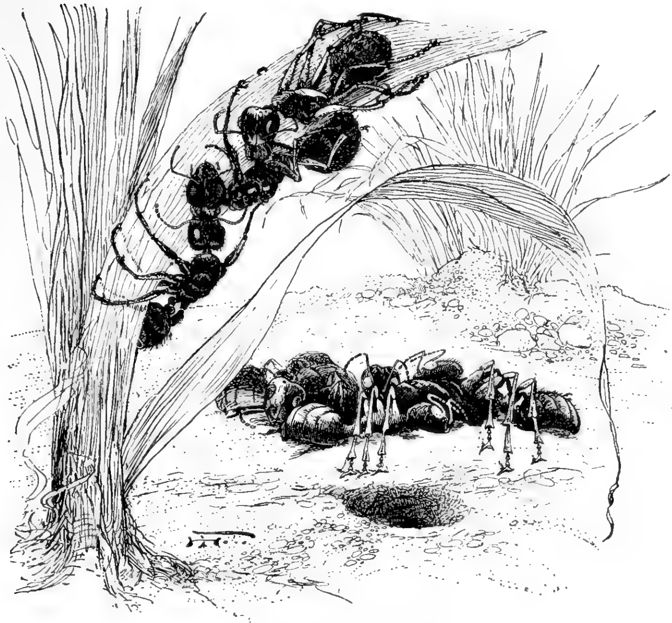


ANTS GIVING A FRIENDLY TONGUE BRUSH TO THEIR FELLOWS
A, cleaning the abdomen; B, the legs and sides; C, the mouth parts

stander-by. The author has seen an ant kneel down before a fellow and thrust forward its head, drooping, quite under the face, and lie there motionless, thus expressing as plainly as sign-language could do her wish to be cleansed. The observer understood the gesture, and so did the supplicated ant, for she at once went to work.

The acrobatic skill of these ants was fully shown one morning in the offices of ablution. The formicary had been taken from its place, where it had become chilled, and set on the hearth before an open fire. The warmth was soon diffused through the nest, and roused its occupants to unusual activity. A tuft of grass in the centre of the box was presently covered with them. They climbed to the top of the spires, turned around and around, hanging by their paws, not unlike gymnasts performing upon a ladder. They hung or clung in various positions, grasping the grass-blade with the third and fourth pairs of legs, which were spread out at length, meanwhile cleansing their heads with the fore legs, or bending underneath to comb and lick the abdomen. Among these were several ants, and in one case a pair, engaged in washing and brushing a fellow-ant. They clung to the grass, having a fore leg on one side of the stem and a hind leg on the other, stretched out at full length, while the cleansed ant hung in a like position below, and reached over and up, submitting herself complaisantly to the process. As the progress of the act required a change of posture by either or both parties, it was made with agility.

These toilet operations usually preceded and followed sleep. For ants, of course, must sleep; and all the tokens of repose appear in them which are common to sleeping animals. Their sleepy ways may be illustrated by the behavior of a group of twenty-five or thirty Agricultural ants in a glass formicary. They had been lured by a gas-lamp upon the table from underground



AN ACROBATIC BATH
Brushing and sponging a fellow-ant—a group of sleeping ants below

galleries and cells where they spent most of their time, and grouped themselves in little clusters next the light. Some occupied corks, clods, and pebbles placed for them, for they like slight elevations. Others clung to the surface of the glass a little above the ground; but this was not a secure retreat, for they would soon drop off when they fell asleep, whereat, with a drowsy air and crestfallen seeming, they sought more secure positions. Most of them were cuddled down upon the surface. Some squatted upon their abdomens; some lay upon their sides; some stood a-tiptoe on their hind legs against the glass. Some crouched upon the earth, piled one atop of another. There was a constant agitation in the clusters, and frequent changes of position occurred.

While the ants of one group were sleeping, others would be at work, and these would stalk among and over the sleepers, vigorously jostling them at times. Again, new members occasionally joined a group, and, in their eagerness to get close up to the heat, crowded their drowsy comrades aside. Ants at work in the galleries would drop the pellets they carried, push into a group of sleepers, and presently themselves be sound asleep. This rough treatment was invariably received with good-humor, as are like jostlings during waking and working hours. The fact must be set to the credit of emmet amiability, as—from the stand-point of higher animals at least—the circumstances peculiarly tend to irritate the temper. Of course, however, some of the sleepers would be aroused. They changed their positions a little, or gave themselves a brief combing, and resumed their nap—unless, indeed, they were satisfied, in which case they stretched their limbs and yawned in the approved manner of the *genus homo*.

The length of time given to sleep varies according to circumstances and, perhaps, temperament. The big-headed soldiers of the Florida Harvester seem more sluggish than the smaller workers. Their sleep is longer and heavier. The longest period during which individuals were observed to sleep is three and a half hours. But then with most ants sleep was broken up into several naps, longer or shorter, by incomers and intruding laborers. We may infer that the sleep of ants may be prolonged for three hours. They may sleep longer in natural site and under ground. Certainly in confinement they commonly take much shorter naps.

During sleep the ant's body is quite still. Occasionally may be noted a regular lifting-up and setting-down of the forefeet, one leg after another, with almost rhythmic motion. The antennæ also have a gentle, quivering, apparently involuntary movement, almost like breathing. The soundness of slumber was frequently proved by applying to the sleeper the feather end of a quill. The feather tip is lightly drawn along the back, stroking "with the fur." There is no motion. Again and again this action is repeated, the stroke being made gradually heavier. Still there is no change. The strokes are directed upon the head, with the same result. Then the feather is applied to the neck with a waving movement intended to tickle it. The ant remains motionless. Finally the sleeper is aroused by a sharp touch of the quill. She stretches out her head; then her legs, which she also shakes; steps nearer to the light, yawns, and begins to comb her antennæ and brush her head and mouth. Then she clambers over her sleeping comrades, dives into an open gangway, and soon has said "Good-morning" to another tour of duty. Be it well noted, however, that she has gone to work, as she and all her fellows always do, not only rested, but with her person perfectly clean! And this rôle, in its general features, and certainly in its result, may be alleged truly of the toilet habits of all insects.

COMBING THE ANTENNÆ

CHAPTER V

KIDNAPPING ANTS AND THEIR SLAVES

CHARLES DARWIN, in his *Origin of Species*, confesses that he first approached the subject of slave-holding ants in a sceptical spirit. "Any one," he observes, "may well be excused for doubting the truth of so extraordinary and odious an instinct as that of making slaves."

But Darwin was to find that slavery among ants is not as odious as his philanthropic feelings had colored it. It is of an Abrahamic type, constituting a family or community of equals. It does not suggest the chattel slavery which human greed developed in modern times. In fact, it can only be called slavery by a strained metaphor. Certainly, there is kidnapping of an aggravated kind, with the conflict, slaughter, and maiming, the wreckage of homes, the disruption of communities, and the mimic reproduction of spoliation and woe that we associate with the sack of cities in human wars or slave-hunting raids in Africa.

But after the first assault of the plundering host and the domestication of the kidnapped victims, every odious feature disappears. The larvæ and pupæ are the main captives, and those spared to be reared as auxiliaries are cared for with assiduous concern. They grow up to be free and happy citizens of their new home.

They are completely "naturalized." Their privileges and general treatment are precisely those of their captors. Their state is substantially that which would have resulted had they been reared in the home of their birth instead of their adoption. If one would seek a human analogy for their condition, it is not to be found in that of the war-captives of ancient times sold into individual bondage, or of the chattel slaves of recent days. We find it rather in the state of those who were transplanted in mass to chosen sites, and established therein by conquerors ambitious to found great cities like Alexandria and Cæsarea Philippi. These expatriated captives were endowed with the privileges of

A SLAVE-MAKER RETURNING FROM A RAID CARRYING AN ANTLING, AND WITH A SEVERED HEAD CLINGING TO A LEG freemen and citizens, and their youth and children grew up to know no other country.

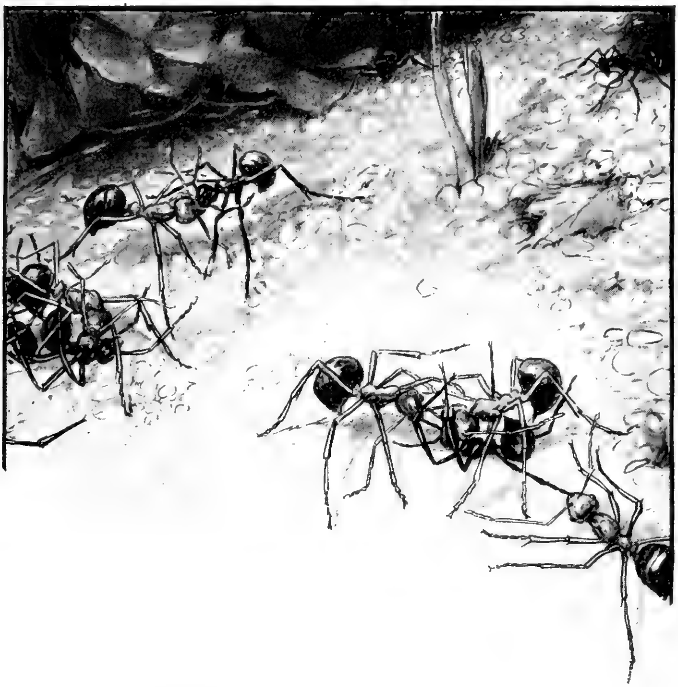
One hundred years ago a Swiss naturalist, M. Pierre Huber, the distinguished son of an eminent father, made the discovery of what he called mixed or "compound nests" of ants. These embraced two species, of which one, the Rufescent ant (*Polyergus rufescens*), was dominant; the other, the Fuscous ant (*Formica fusca*), was in a subject or servile condition. The Rufescent ants—which Huber named "Amazons" and "Legionaries"—were found to be a military caste, making raids upon neighboring formicaries for the capture of larvæ and pupæ, which they brought home, most of them probably to serve as food, but many to be reared as workers. The affairs of these mixed communities were conducted in the usual emmet way, with one striking difference. The Fuscas, or "negroes," did all the work of construction, of foraging, and of feeding the family, including the Amazons themselves, their queens, and young winged males and females. The sole function of the Amazons was to fight and plunder, and they controlled the succession and citizenship of the commune. In the course of his studies Huber found another species, the Sanguine ant (*Formica sanguinea*), having the same habit of kidnapping other species, but with some decided differences in manners, and that some compound nests contained two slave species.

This is a bare outline of a series of facts which have been noted and published in greater or less detail by various observers, especially the distinguished countryman of Huber, Dr. August Forel. They form a unique chapter in the history of animated nature, some of whose pages will interest the general reader. Recent studies of ants show the tendency of many different species to make common interest in one vicinage. But the best-known species with claim to be ranked as slave-makers are still those of Huber's classical discovery, or their close American kin. It is interesting that two species are found widely distributed in the United States—one, *Polyergus lucidus*, the Shining Slave-maker, closely related to, and the other, *Formica sanguinea*, subspecies *rubicunda*, the Sanguine Slave-maker, differing little from, their European congeners—and that these should have developed here the remarkable habit that distinguishes them there.

Let us follow one of these species upon a kidnapping foray. As the hour approaches for the adventure, the raiders issue from the city gates and assemble upon the rounded exterior. As numbers increase, the excitement grows. They move back and forth, around and around, in a sort of maze, as though engaged in preliminary evolutions. Frequent challenges pass, by crossing antennæ or striking them smartly upon the forehead. Legs jerk nervously. Abdomens throb, rising and falling rapidly. There ascends a faint, crackling sound from the agitated mass which covers the hill, that one fancies may come from the sharp contact of numerous moving insects, whose hard, chitinous skins are as veritable armors as those which compassed the frames of ancient warriors. But perhaps, as Professor Wheeler suggests, it is a real stridulation that one hears, the sound of tiny abdominal cymbals that emmets carry, and whose raspings, indistinguishable in the individual, are audible in the mass. Has the pygmy army, then, not only its silent antennal signals, but its music, too, to stir up martial ardor and give stridulant calls to soldierly movements?

Amid this seething mass the slaves are moving. They are the glossy blacks that Huber's Amazons most affect for servitude—the Fuscous ants of a close American variety (*Formica subsericea*). Some of these are placidly at work on the daily round of duty. They carry out earth pellets and bring in supplies, apparently as separate from the warlike commotion around them as if they were a sect of protesting non-combatants. Others run about under the feverish agitation that stirs the mustering combatants, whom they frequently salute. Indeed, they seem at times to be egging them on, like women of a martial kraal or clan cheering their fighting kindred to foray and fray.

At last the muster is complete. Mysteriously but effectively the signal "Forward!" is given, and the column moves from the hill. There is no regular alignment, but a show of solidarity, a holding of the ranks within close compass and touch—a "route-step," in fact. There is no general; there are no subordinate officers; but such is the sympathetic unity that they seem to move in response to one will and command. If every warrior is a law unto himself, the law so binds and animates and compels all alike that the ends of an organized cohort are served. This emmet army actualizes the proverbial picture of military absurdity—an army wherein all are brigadiers! The function of commander lodges in the whole column. It owns a corporate leadership, a telepathic control. Here, also, Solomon's description of ant operations is accurate: there is no guide, ruler, or overseer. And this communal generalship has therein no note of anarchy. Without discord or division it guides directly and steadily to the common weal. A few Fuscans may accompany the column or escort it



A SLAVE-MAKERS' RAID—FIGHTING ON THE OUTSKIRTS

beyond the home bounds; but for the most part they remain on duty in and around the formicary, which at once takes on its wonted aspect of peaceful industry.

Assault, battle, and pillage follow quickly upon the sortie. The objective point of the march is not far away. With ants, as with men, there are variations in the fortunes of war, and disappointments and failures befall. The scouting may have been defective, or the tactics of the threatened community may have thwarted the enemy, or the defence may appear too formidable for the attacking force, which must return empty-handed. But we are here following a typical successful assault of our American Sanguine Slave-maker, as the author has seen it.[1] A hundred yards distant is a Fuscan village. The route thereto lies across the edge of a grove, over a foot-path, along a fallen tree, under whose shelter and shaded by tufts of grass is the devoted commune. It is feeble in numbers, and there is a bare show of defence upon the outskirts as the freebooters hurl themselves upon the hill and plunge into the open gates. The villagers flee at the first onset through unassailed or secret passages. Some run the gantlet through the assaulting ranks. All who can, carry a part of the family treasures—eggs, larvæ, and pupæ. Like their brobdingnagian brothers of the human race when disaster befalls, their first care is for their offspring. The fugitives mount into near-by clumps of low wood-plants, whence they look down upon the devastation of their home—with what feelings? For one must suppose that the midgets *do* feel, though sometimes he would fain hope otherwise.

Meanwhile the invaders issue from the gates, bearing in their jaws the Fuscan young, and occasionally an adult. They take the home trail, but not in ordered ranks. It is go-as-you-please now, the "route-step" of marching soldiers. They are welcomed back by their black confederates, who receive the captives and take them—their very own sisters, perhaps—into the domestic quarters. The soldiers hurry back to the scene of

[1] I have never seen a foray of the Shining Slave-maker (*Polyergus lucidus*), but her method is substantially that of the Sanguine ant.

action, for their work is not yet finished. The greed for larger citizenship, as insatiable as in American or Canadian frontier towns, demands more captives, and the squadron musters for another raid. Soon they are off in solid column, their course bent towards a negro city several rods distant. It is a large and flourishing formicary, and at once arouses to repel the invaders. The peaceful industrial commune is transformed into a camp of belligerents. Videttes push out from the city bounds. Sentinels stand alert at every gate. Workers hastily barricade galleries and close up doors, while nurses gather the young into interior rooms for concealment or readier escape.

Already the battle rages. The Fuscan videttes have met the Sanguine scouts, and, ant to ant, have begun "the tug of war"—a phrase that is literally true of an emmet conflict. Hosts of irate blacks pour out of the formicary and hurl themselves upon the red marauders, who join the issue with equal valor and greater skill. Soon the border is covered with a confused mass of struggling combatants. The red helmets and corselets of the invaders distinguish them from the black armor and slighter forms of their adversaries. But here and there groups are balled together in such a tangle of interlocked jaws and limbs that only the fighters themselves can tell friend from foe. The toothed mandibles, or upper jaws, are the chief weapons, and with these wide open the ants rush together. If opposing jaws are interclasped in the contact, the fight is likely to be long, and another weapon is brought into play. The abdomen is curved upward, and jets of formic acid—a sort of chemical "hand-grenade"—are thrown from the nozzle of the poison-glands into mouth and face. Thus our little brothers of the ant-hill have a long priority in this mode of warfare.

Sometimes these duellists are allowed to fight to the death unmolested, and many such hand-to-hand combats are seen, especially on the fringe of the field, as the thick of the fray sways closer to the formicary. Oftener the duel draws others into its vortex. A passing red warrior seizes a leg of the black combatant, and a black, rushing into the battle, stops to clasp the red foeman's antenna. Thus the fight thickens into a group, from which now and then a pair may drop away to form another centre of conflict.

The slave-makers are not always victors; but in this case they succeed in entering the besieged city and capturing many larvæ and pupæ. As they trail homeward with their booty, one may occasionally see a warrior bearing her prey and dragging along a trophy of battle in the shape of a severed black head, whose unrelaxed jaws still cling to its foeman's leg. The plunderers do not always return scot-free. The pillaged villagers will sometimes follow and harass the rear of the column, pounce upon stragglers, and succeed in rescuing some captives. Erelong the fugitive Fuscans return from the jungle of grass and ferns whither they had fled with their young, and come up from the cavernous recesses wherein they had been barricaded, and the life of the commune is reorganized. Their little ones, for whom all had ventured and many had yielded life, grow up in their ravishers' city, and ere the season ends may be cheering on their captors to another raid upon their native village. Alas! crude nature is not a Peace Society, and nothing is more purely "natural" than war. Our hope

SLAVE-MAKERS, WITH THEIR PLUNDER, LEAVING A SACKED CITY for the reign of "peace on earth" can hardly rise from the sovereignty of "the natural."

What is the reflex of this habit upon the slave-making ants and their subjects? Ought we to expect that social laws and customs which influence so powerfully the human species should work analogous results upon ants? Let us see. In the case of Polyergus there appears a dependence upon the slaves which is almost absolute. The Shining Slave-makers on the raid, in assault, in combat, and in the capture and rapture of the young of subject species show immense animation and persistence. But they take no part in the domestic economy of the formicary. The construction of galleries and chambers, the nurture of their own young from egg to antling, and the care of their young captives, the garnering of supplies, and the support of their queens, winged males and females, are wrought by the slaves alone. The deterioration has gone so far that the Polyergus warriors will not feed themselves, but depend upon their servants for both food and feeding! It seems astounding and incredible that any creature should be reduced to such an abnormal state; but experiments show that when these warriors are placed in artificial nests without their usual attendants they will starve amid abundance. Let slaves be introduced, and the scene changes. With the instincts of a philanthropist and a nurse—or, shall we say, of a born servant?—the black laborers take the Amazons in hand, rescue from death those who still live, clean up the house, and set affairs agoing comfortably.

Turning to the Sanguine ants, we find a condition wholly different. The red warriors are workers also.

They bring to building and other home work the energy shown in fighting. The nest architecture of Polyergus has the characteristics of its slave; or, if there be two subject species, shows typical traces of both. The architecture of Sanguinea bears her own individuality crossed with that of her slaves. The theory that institutions founded upon kidnapping and slavery must impair the quality of their supporters here breaks down. Or, shall we fall back upon Darwin's view that the slave-making habit, which has reached its ultimate in Polyergus, is in course of development in Sanguinea, and has not had time to reach its inevitable results? At all events, Sanguinea is a normal ant in warlike and industrial instincts, to which have been added kidnapping and adoption of alien species.

With Polyergus and Sanguinea alike it is noteworthy that no fertile queens or virgin queens and males of their subjects are reared within the community; only their own are tolerated. The increase of the working citizenship is made from captives introduced as larvæ and pupæ and reared under an environment created by the captors. These prudent creaturelings may well suggest to us a lesson as to the influence of motherhood and the value of home and civil surroundings in forming the character of childhood and the habits of mature life.

What effect does emmet servitude have upon its subjects? The writer, at least, has never been able to note any effect. The Fuscous and Schaufuss ants—the only two species observed by him—have precisely the same manners in compound as in native nests. The slaves of the Amazons retain their fighting instincts, and are not reduced to mere workers. They seem to transfer with absolute loyalty the normal devotion shown by ants to the commune and its young. As slave parents are not permitted, and servitude is not transmitted from parents to offspring, one cannot know what changes might have been wrought in course of time under other conditions.

But in one respect ant-slavery appears to have reacted upon species living near slave-makers, by developing greater caution and cunning in protecting their homes and probably less courage in defending them. In sites free from kidnapping ants the Fuscans make such extensive nests that they seriously damage lawns and gardens. Their architecture and demeanor show that freedom from fear of special perils which marks a community dwelling in perfect confidence and continued security. On the contrary, Fuscan colonies in the vicinage of slave-makers tend to lessen or omit exterior elevations. The dumpage from interior workings is scattered broadcast. Gates are fewer and concealed.

Once, watching a Sanguine army assaulting a Fuscan colony, the author chanced to see, a short distance from the scene, a Schaufuss worker (*Formica schaufussi*) moving back and forth in a way that aroused curiosity. Knowing this to be an enslaved species, he directed attention upon the solitary ant. She was putting finishing touches upon the closure of her formicary door. A tiny pebble was placed. A few pellets of soil were added. Then she walked away, took a few turns as though surveying the surroundings, and cautiously came back. The coast was clear! Next she deftly crawled into the small, open space, and, from the movements inside and occasional glimpses of an antenna-tip, it was seen that she was completing the work of concealment from within. At last her task was done, and all was quiet. Just then a single Sanguine warrior, apparently a scout or a straggler from the invading army near by, approached the spot. It walked over and around the nest, which was indistinguishable from the surrounding surface. It sounded here and there with its antennæ, passed over the very door into which the Schaufuss ant had disappeared, and, although its suspicions were apparently aroused, it moved away at last.

The observer confesses gratification that the Sanguine depredator had been baffled, and that the instinct of home protection had proved too much for kidnapping cunning. Perhaps this feeling was also "anthropomorphic bias"?

CHAPTER VI

AGRICULTURAL ANTS

FROM remote antiquity men have believed that ants are harvesters of grain. Thus much, at least, of the farmer cult they were thought to possess. On few matters of natural history is ancient literature so accordant. Virgil, in his *Æneid,* compares the departing Trojans to swarms of harvesting ants invading fields of yellow grain.

Early English writers accepted this fact solely on the testimony of antiquity. Milton's lines will be recalled in the matchless account of the creation of living things, placed in the mouth of Raphael. The Angel, with zoological accuracy, places the Hymenoptera at the head of the orders of insects:

> "First crept
> The parsimonious emmet, provident
> Of future, in small room large heart enclosed;
> Pattern of just equality perhaps
> Hereafter, joined in her popular tribes
> Of commonalty."
>
> —*Paradise Lost,* Book VII., l. 484 sqq.

Milton doubtless wrote better than he could have known at that period, when he found in ants a pattern of a just, equal, and provident society.

Thus the record ran without break until the close of the eighteenth century, when Gould, an English clergyman, who had made some admirable studies of British ants, raised a note of doubt. He found no harvesting ants in England; therefore he challenged the accuracy of antiquity, Solomon included.

Doubt has a bacterial quality of dissemination and multiplication, and erelong the ancient belief in harvesting ants was reversed. Latreille, at the head of French entomologists, declined to "be so weak as to perpetuate the popular error." The Swiss Huber, the incomparable historiographer of ants, as charming in style as accurate and original in observation, "relinquished the opinion." The English Kirby, a high authority in entomology (and, like Gould, an Anglican clergyman), cautiously concurred in the prevailing doubt, and opined that an extraneous interpretation had been fathered upon Solomon's words.

Even that noble work of sacred scholarship, *Smith's Bible Dictionary*, in the American edition of 1868, apologized for Solomon as "adapting" his language (Proverbs vi. 6–8; xxx. 25) to the common belief that the kernels carried by ants into their nests were used for food instead of for building material.

Here and there was heard a note of dissent, harking back to the early faith. Thompson, the American missionary, in his now classical work, *The Land and the Book*, and Moggridge, of England, in his delightful studies of the harvesting ant of southern Italy, gave testimony that ought to have prevailed, but failed to reverse the popular opinion. It is quite true, although not the current belief, that science is conservative towards well-rooted notions, and often inhospitable to the new and radical. Thus it came about quite naturally that the old belief in harvesting ants was not re-established until the publication in 1880 of my book (now out of print), entitled *The Agricultural Ant of Texas.*

The author's interest was awakened by a number of old manuscripts placed in his hands by the eminent hymenopterist Ezra T. Cresson. They were written by Dr. Gideon Lincecum, of Texas, and had been kept in the archives of the American Entomological Society, but under the shadow of serious doubt as to their accuracy. Nevertheless, the papers impressed me as having a basis of truth, and in the summer of 1877 I visited Texas, prepared to investigate and, if possible, solve the old question which science had negatived, but which had thus again been raised: Do ants harvest grain? And, if so, what are their agricultural habits?

Camp was made in a live-oak grove on the Barton Creek hills, three miles southwest of Austin, in easy reach of numerous nests of the insects to be studied. The tent door was a half-dozen steps from several large communities, and the tent itself was a gangway for the busy creatures. They are large ants, about the size of our common black Pennsylvania carpenter ants (*Camponotus Herculeanus-Pennsylvanicus*), and of a uniform bright mahogany color. There are two forms of workers, the worker-major and worker-minor, the former being seven-sixteenths, the latter five-sixteenths of an inch long. The females and males are winged, the former ten-sixteenths, the latter eight-sixteenths of an inch long. The males, as is usual among ants, are drones, and, like the females, are dependants. At the pairing season they leave the gates, to return no more. A tuft of reddish hair beneath the face gives the ant its

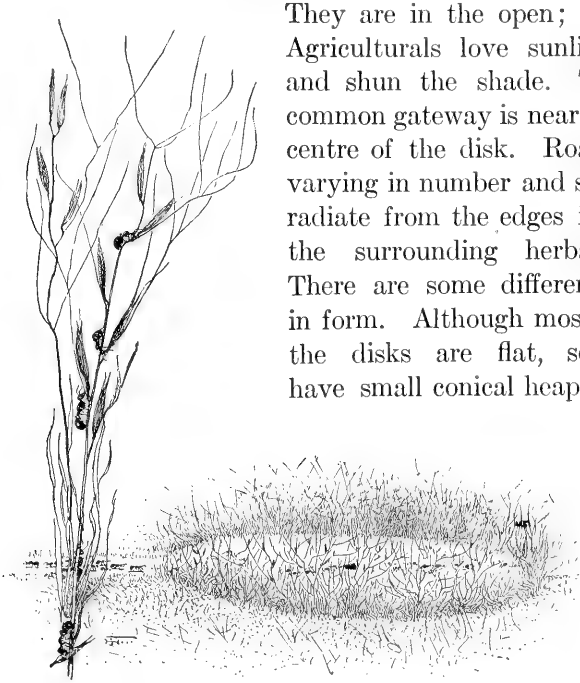
SCENE IN A HARVEST-FIELD—ANTS HARVESTING BUFFALO-GRASS

scientific name—*Pogonomyrmex barbatus*—literally rendered, the bearded beardy ant.

The workers compose the bulk of the emmet population, and they are in enormous numbers. They are not secretive in habit, and were everywhere in evidence. They were found along the roadsides; they were met in all parts of Austin, in the streets, on the trodden sidewalks, in gardens and yards. Even in the open court of the hotel there was a community in full activity.

Through the cement joints of stone slabs the workers had cut a gateway, into and out of which they went all day long. In such sites, of course, the native emmet industry was modified, but in the open and untilled spaces about our camp the natural habit appeared.

As if to invite observation and challenge assail of foes, the Agricultural ants have plainly marked their city bounds. Here on the grassy opens surrounding camp are smooth, flat, circular, verdureless spaces of various sizes, some as large as twelve feet in diameter. They have three noteworthy features in common. They are in the open; the Agriculturals love sunlight and shun the shade. The common gateway is near the centre of the disk. Roads, varying in number and size, radiate from the edges into the surrounding herbage. There are some differences in form. Although most of the disks are flat, some have small conical heaps of



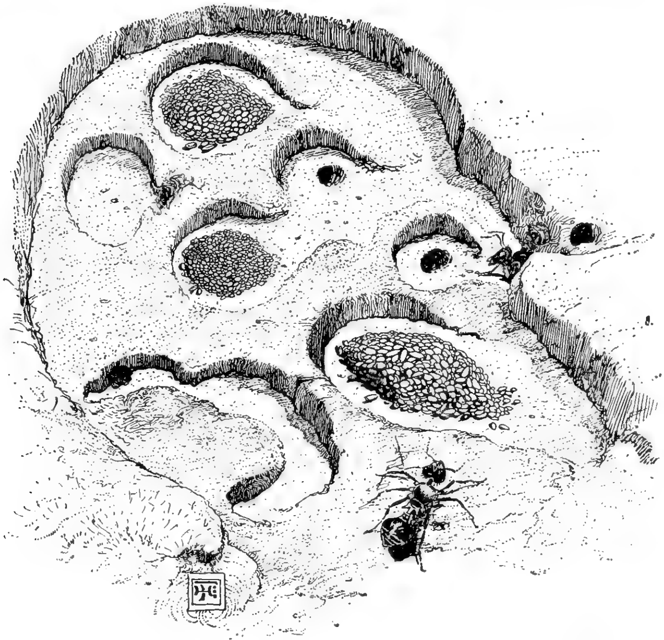
A DISK COVERED WITH A CROP OF ANT-RICE
A single stalk shown at the left

gravel piled around the gate, which apparently have been brought up from the excavated galleries and granaries underneath. Occasionally one sees a decided truncated cone raised in the centre of a circle, with the gate piercing the dish-shaped top.

Another striking variation appears. Most of the flat disks are wholly without vegetation, but here and there are nests whose circular pavement around the gate has a bordering band covered with two species of grass, *Aristida oligantha* and *Aristida stricta,* known as ant-rice, or, more popularly, needle-grass. That this is permitted by the ants is plain. No other plant is thus tolerated, and their seeds are gathered and stored with others in the underground granaries. Moreover, it is quite within the ants' power to keep their disks clean. They were often found established in a thicket of wild sage, daisy, and other vigorous weeds, with stalks as thick as one's thumb and standing several feet high. This rank growth, quickened by the fat soil and semi-tropical sun, is as thoroughly under the control of our Barbati as are the cleared fields amid the woods under the settlers' control. Not a plant is allowed to intrude upon the formicary bounds; and, although often seen, it was an interesting sight, after pushing through the high weeds, to come upon one of these nests, and observe the tall, tough vegetation standing in a wellnigh perfect circle around the edge of the clearing. The weeds had crowded up as closely as they dared, and were held back from the forbidden grounds by the insects, whose energy and skill could easily limit their bounds. Certainly, ants capable of such work could readily have cleared away growing stalks of the Aristida, In fact, after the seed has ripened in the late summer they are said to clear away the dry stalks in order to make way for a new crop. It is this that justifies the reputation of Barbatus as a farmer. She has not been seen—so far as the author knows—sowing the seeds, but she permits them to grow upon her formicary bounds, and afterwards utilizes the product.

The extent to which the Aristida is preserved appeared by a glance over the landscape. On all sides one saw circular belts of that grass rising above and easily distinguished by its yellowish stalks and blades from the prevalent surrounding herbage, and exactly marking the sites of formicaries on which they stood. No other plant was tolerated. The belts were as sharply marked as fields of Indian-corn in the midst of meadows or wheat-fields. About one-third of the formicaries in sight were thus covered. The Aristida is thus a "raised" crop in the sense that it is exclusively permitted.

If the gathering, threshing, and storing of seeds warrant the name "agricultural," our Barbati have a clear title thereto. To make a proof of this, let us direct attention upon this large nest. From its border on all sides radiate roads as smooth and clear as the disk itself. There are seven of them (the number is commonly less), of varying lengths, one over three hundred feet long, forking towards the point where it is lost in the wild grass. All are much wider where they enter the disk. Standing by one of these roads, we see a double column of ants hurrying along, one outward bound and unladen, the other home-bound and carrying seeds of various kinds, mostly of buffalo-grass (*Buchloë dactyloides*). We must play footpad in the interest of science and rob some of the grain-bearers. A light tap upon the back causes the little carrier to drop her burden. After a moment's pause, in manifest surprise and perplexity, she scurries across the pavement and disappears within the gate. The next porter is not so placid. She drops her seed, but, rising upon her hind legs, stands rampant, with quivering antennæ and wide-



HORIZONTAL SECTION OF AN AGRICULTURAL ANT'S NEST
Arrangement of rooms and granaries shown.

open jaws. This highway robbery goes on until a small paper box is filled with plundered seeds.

Now we must follow the outgoing column. Robbing ants is easy, but this is hard work. One individual must be chosen, marked, and followed as she pushes out along the main road, turns into a narrow side trail, and at last plunges into the forest of surrounding grasses. With head bent towards the ground, antennæ out-stretched and in continual agitation, every pose and movement showing intense eagerness, the worker passes from point to point, now to this side, now to that, now around and around, but always pushing farther into the grassy jungle. It is a severe trial of one's patience to follow her movements. Stooping over on hands and knees, or prone upon the face, crawling slowly along with eyes fixed upon the eager insect, one was sometimes led a tiresome chase.

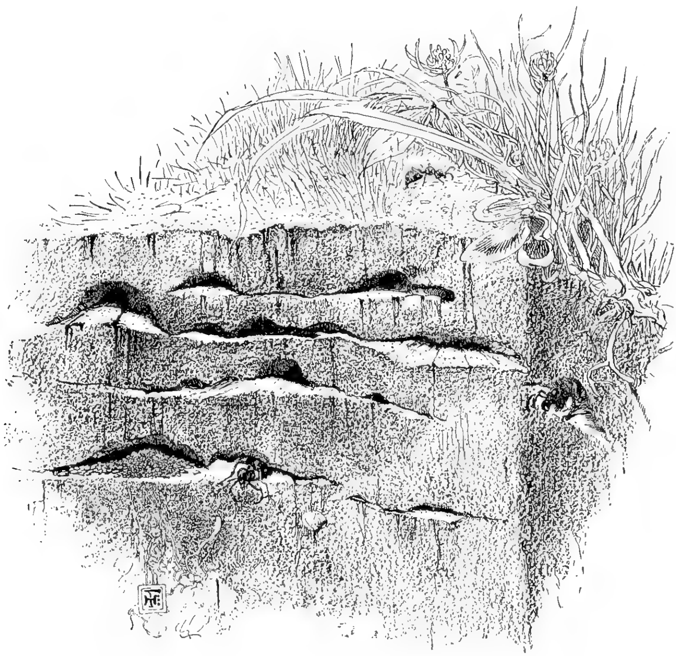
All this while the harvester at intervals applies her mouth to various objects upon the ground, most of which are dropped seeds. From seed to seed she goes, feeling, handling, turning, rejecting. Why this fastidiousness? It is quite like a shopping excursion! The abandoned seeds seem precisely like those which her plundered sisters were carrying. Is this merely fickleness? Or indulgence in the natural gratification of examining, testing, choosing? Or is she seeking, and sensitive to some quality beyond human ken?

At last a satisfactory seed is found. It is lifted from the ground with the strong mandibles or upper jaws, turned, pinched, adjusted, balanced. This is done by the jaws and forefeet usually, but sometimes aided by the point of the abdomen. Stiffening out the legs, the body is elevated, and the abdomen swung underneath until the apex touches the seed in the jaws. Thus braced, the load is the better adjusted, and the insect moves away. She is a good forester, with a true sense of direction, and starts straight homeward. Many obstacles are to be overcome ere she reaches the open trail—pebbles, clods, bits of wood, obtruding rootlets, fallen stalks of grass, and weeds as huge to her as tree-trunks to the woodman. They were scarcely noticed when the ant was empty-handed. But they are troublesome barriers now that she has a load quite as thick, twice as wide, and half as long as herself.

It is interesting to watch the strength, skill, and rapidity with which the little porter swings her burden over or around, or pushes it beneath these obstacles. Now the seed has caught against the herbage as she dodges under a too-narrow opening. She backs out and tries another passage. Now the sharp points of the husk are entangled in the grass. She pulls the burden loose and hurries on. The road is reached at last, and progress is easy. Holding the grain in her mandibles well above the surface, the ant breaks into a trot, and a pretty fast one, and, without further interruption, except the elbowing of her fellows, gets safely home. There are variations from this behavior, more or less marked, but this is a typical example of the mode of ingathering an ant harvest. The work is wholly individual, at least as the author saw it. There is no working in gangs, no overseers; each ant is a law unto itself. But thousands of individuals are on the harvest-grounds, and the aggregate of their labor is great.

Meanwhile other workers are issuing from the gates bearing what seem to be seeds. Curious! Are these creatures working at cross-purposes? Here at one side of the disk they are dumping their loads, and quite a heap has already been formed. Let us look at them. They are not seeds, but husks! This is a kitchen-midden, and inside those gates the work of husking the grain is going on. What a merry "shucking-bee" it must be!—to quote a pioneer phrase. Boxes of this chaff and refuse are collected as another step in our inquiry.

The last step in our field investigations remains. The interior of one or more of these formicaries must be explored. It is the most difficult task of all; for these



CROSS-SECTION THROUGH AN AGRICULTURAL ANT'S NEST
The storied arrangement of galleries and granaries underground

Agriculturals are "embattled farmers." Peaceful industrials as they are, when aroused to defend their possessions they are terrible adversaries. They merit their popular name of "stinging ants," for they have a barbed sting whose wound is more painful than that of bee or wasp or hornet. Laborers could not be hired at double wages to dig up the nests, and the investigator, gloved, mufflered, booted, padded, with openings to arms, and neck and legs heavily wrapped, had to wield pick and spade and trowel, as well as sketch-book and note-book, and attend to the plaster-casting by which the rooms and galleries were fixed and thus accurate outlines secured.

Briefly, the interior formicary was found to be a series of large chambers arranged in irregular stories like the Roman catacombs, and connected at many points by tubular galleries leading to the central gate. Some of these caves were used as nurseries for eggs, larvæ, and antlings; some were occupied by the winged queenlings and males, and by the fertile queens. But many were granaries. Nearest the top were unhusked seeds, such as the ants had been seen gathering. Farther down were store-rooms of naked seeds, and these were identified as ant-rice, needle-grass, buffalo-grass, and various oily seeds or nuts, such as had been taken from the workers in the field, and whose shells had been found in the kitchen-midden. The demonstration was complete as far as field observation could go. *Pogonomyrmex barbatus* is a true harvester, a veritable "Agricultural ant"!

The excavation was necessarily slow, since the purpose was to study the interior architecture and collect material. This required to be done piecemeal and most carefully, constantly guarding against the falling in of the soil. Only a few feet in depth were therefore accomplished, but this sufficed. In one nest, however, fortunately exposed by a deep cutting, the galleries and chambers were traced to a depth of fifteen feet. One may imagine the enormous work involved in carrying the formicary to such a depth, or even much less, beneath the space covered by a circle ten or twelve feet in diameter.

The strain of such use upon the ants' working-tools—the mandibles—must be great. How does it affect them? An interesting fact developed from examinations of the mandibles of many specimens. The normal jaw has well-defined teeth, sharp and hard. The jaws of workers showed all stages of abrasion, from a pointless long tooth to absolute toothlessness.

This is seen elsewhere in the insect world. The teeth and dentations on the outer side of the tibia of fossorial

EXAMPLES OF ABRADED DENTITION OF THE MANDIBLES OF AGRICULTURAL ANTS

The first figure shows the perfect mandible

beetles are frequently worn to the extent of their entire disappearance; and the same is true of the mandibular teeth. The surface sculpture will in like manner disappear, the striations upon the back so wearing away by rubbing against stones and logs that they are readily known as second-season species. One wonders what becomes of these toothless ants, since their efficiency as masons must be impaired, and in a measure as harvesters and pioneers also. Perhaps they are detailed to the nursery departments? That would be quite humanlike!

Not the varied industries of agricultural ants in general communal service, but those directly associated with the harvesting habit, are those to which this chapter is especially devoted. And there remains only space to add that the last step in solving the query with which we started was left for home demonstration. A number of well-stocked artificial formicaries were taken from Texas to Philadelphia, and there, under constant observation, continued during many months, it was shown that the ants use for food various seeds, both oily and farinaceous, which they store in their granaries, and other seeds like them. Further study has disclosed that there are other harvesting species, widely distributed throughout the United States. Of these, special studies were made of the Florida Harvester, *Pogonomyrmex crudelis;* of a Pennsylvania ant, *Pheidole Pennsylvanica;* and the Occident ant, *Pogonomyrmex occidentalis*, Cresson.[1]

[1] The habits of the last-named species are described in my book, *The Honey and Occident Ants*, now out of print.

CHAPTER VII

HONEY ANTS OF THE GARDEN-OF-THE-GODS

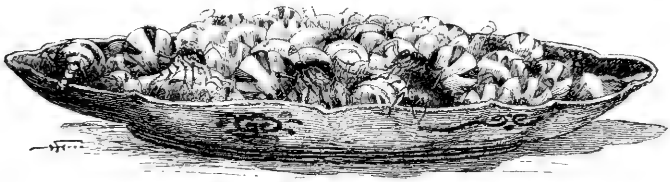
ANTS and bees are inveterate seekers of sweets. Both have found a way to lay by their gatherings against a time of need. The measureless diversity in unity that marks the course of nature appears in that these two kindred creatures have reached the same end by ways most diverse. The bee keeps her treasure in wrought honeycombs; the ant resorts to living structure. She has not only acquired the habit of aphisculture, but in a few species, at least, utilizes certain of her fellows as living honey-jars. The story of this habit as seen in the honey ants of the Garden-of-the-gods (*Myrmecocystus hortus-deorum*) is now to be told.

In A.D. 1832, Dr. Pablo de Llave made known the existence of Mexican ants some of whom have spherical abdomens filled with honey. His information and specimens came from a resident of Dolores, a village near Mexico City, who said that these honey-charged forms were there held to be great delicacies, being freely eaten and served at marriage and other social feasts.

This account greatly interested naturalists; but little more was known of the insect until 1879, when the author of this book left Philadelphia for New Mexico, where the ants were reported to abound, hoping to remove this long reproach from American entomology.

During a brief visit to the Garden-of-the-gods in Colorado, the honey ants were found nested upon the ridges. The trip to New Mexico was deferred; camp was made within the Garden, and study of architecture and habits was begun.

The Mexican species (*Myrmecocystus melliger*) had been reported as making no outer nest. The Colorado species, or variety, heaps around its one central gate a low moundlet of pebbles and sand, the dumpings from the galleries, halls, and rooms dug in the rock beneath.



A DISH OF HONEY ANTS AS SERVED AT MEXICAN WEDDING BANQUETS

These moundlets are not huge cones outfitted for nesting uses, but are the natural outtake of the mining gangs within.

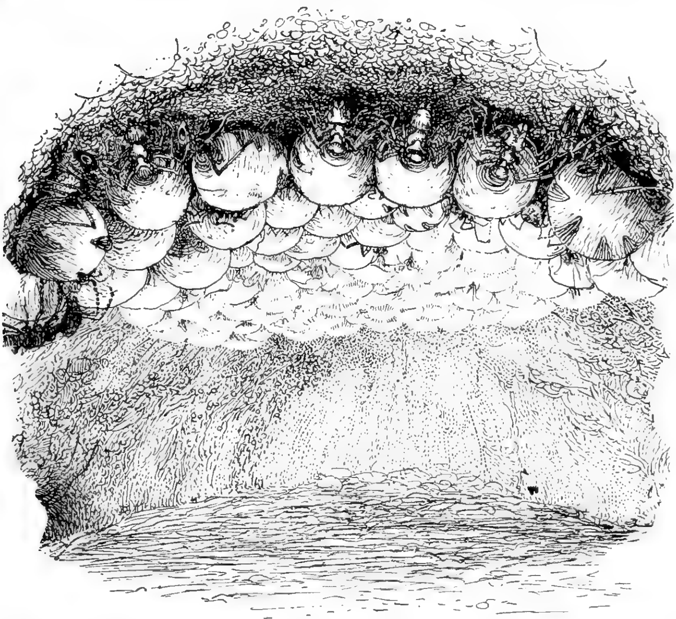
In form they are like a Turk's-head pound-cake, and are not above four inches in height, with a base girth of thirty-two inches. They have one main gate, a straight, tubular opening less than an inch wide, slightly funnel-shaped at the top. This cuts through the mound perpendicularly and is deflected at an angle more or less abrupt. Thence it leads into a series of branching galleries and rooms which in populous formicaries occur in stories. These inner chambers are vaulted spaces of irregular shape; are five to six inches long, three or four wide, rising from a half-inch to an inch and a half at the centre.

A nest upon the summit of a ridge, made in the friable red sandstone that there prevails, was chosen for thorough exploration. Its uncovering kept two men for half a week at work with chisel and hammer, including the time taken in measurements, sketches, and plaster casts. The nest-interior sloped towards the base of the hill, and occupied a space, in round numbers, eight feet long, three feet high, and a foot and a half wide. In other words, there were thirty-six cubic feet of rock fairly honeycombed by the series of galleries and storied chambers. All this was not only dug away, but was carried through the interlacing galleries, up the central gangway, and dumped around the gate. It is a busy underground scene that one's fancy calls up, not wholly free from that marvel which in primitive ages simple-minded men were wont to couple with mining-works and miners, and evoke therefor the aid of gnomes and the "swart faery of the mine."

However, it was not the wonders of the architecture that gave chief zest to this search. As the chisel, deftly wielded, uncovers this large room, a rare scene is in view. The vaulted roof is beaded with rich, amber-colored spheres, from beneath which protrude the yellow trunks and legs of living insects! These are the honey-bearers, whose rotund abdomens, with their stores of sweets, have made their species famous among the emmet tribes. As the light breaks in—the first these cavernous halls have ever known—a faint wave of movement stirs throughout the compact group of "linkèd sweetness." The shock of the income sunshine, and the confusion that has seized and scattered so many of their fellows, as their habitation crumbles about them, do not cause them to loose their hold upon their perch.

It could hardly be by chance that the roof to which they cling has been left rough and gritty, instead of being smoothed off as are the galleries. At least, so it is, and the fact aids the rotunds to keep their place.

The author has somewhat anticipated. When the delightful vision of one of those vaulted store-rooms, with its roof crowded with honey-bearers, had located and identified their nests, the first question that arose was, whence do the ants get their honey? The theory that the rotunds "elaborated" it was dismissed as a vain imagination. It was plain enough that they must be sedentary creatures, and that the bulk of the store within their immense abdomens must have come from



HONEY ANTS ASSEMBLED UPON THE ROUGH ROOF OF A VAULTED CHAMBER the workers, the true honey-gatherers. Of these there were three castes, the majors, minors, and minims, or dwarfs.

But whence do the workers get their supply? From the aphides, of course! Here experience failed to be a true guide, for in the whole vicinage there was not an aphis found. Even the wild rose-bushes, which there abounded, were barren of these familiar emmet herds. In sooth, neither aphides nor ants were found on our first day's search among the near-by shrubbery. The nests were as silent and apparently as empty of life as cemeteries. Throughout the day nothing living moved about them but the circle of sentinels that kept ceaseless guard just within the gate.

As this implied a nocturnal habit, a nest convenient to our tent was chosen for observation, and nightfall was awaited. The sun set at 7.30 o'clock, and the Garden began to darken, although the snowy summit of Pikes Peak was still aglow. Then a few ants appeared. They advanced to the top of the crater; they were followed by others, who swarmed upon it. They pushed out upon the gravelled slopes of the mound, the upper part of which was soon covered with yellow insects moving restlessly to and fro. There were no rotunds or semirotunds among these mustering squadrons; all were workers with normal abdomens.

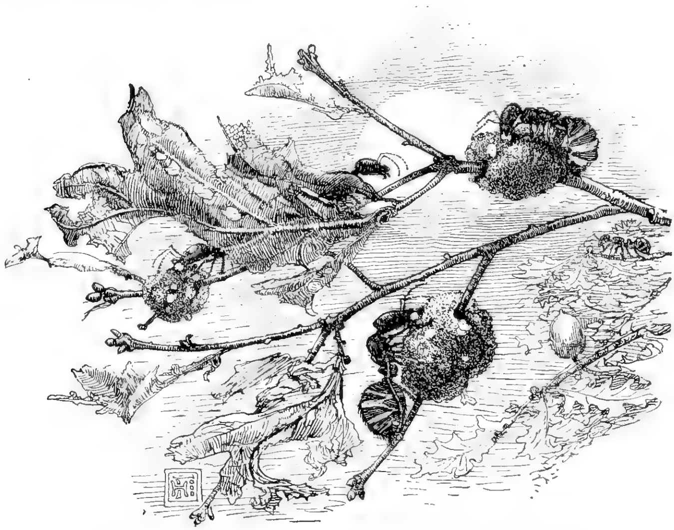
Presently an ant left the mound and started over the ridge northward. Another—several—a score followed. Soon a long column trailed along the ridge. It was so dark that it could be traced only by stooping close thereto; and a lantern had to be used.

Fifty feet from the nest the column descended the slope and entered a copse of scrub-oak, within which most of the ants were lost at once. A few were traced to a bush several feet within the thicket, but their secret was not unravelled that night. The next night also we were baffled. On the third night the ants were again out at the pale of day, and began to move at once, but at a slower pace, perhaps because the scent upon the track had been weakened by a heavy rain during the afternoon. There was no acknowledged leader. A dwarf worker held the van over most of the way; then a minor pushed to the front. But there was no proof of actual leadership at any time in any part of the line.

In seventeen minutes the ants reached a low tree or bush and were soon distributed over it. Their forms could be traced hunting trunk, branches, and leaves, but it was nearly three hours before the object of their search was found. This delay will not seem unreasonable if the reader will picture the observer wedged in among thick, low branches of a dwarf-oak, holding up a lantern with one hand and using the other to clear space for it, keeping motionless lest he alarm the timid insects and again fail of his quest. In the course of these slow investigations the end of a branch was reached upon which were a number of ants hovering around clusters of brownish-red galls. They moved from gall to gall, not tarrying long upon any one, and often touched them with their mouths. That was all that could be seen in the dim light at the distance one must keep. But it was enough. The secret was out! For even in the feeble lantern-light, as it played among the branches, the ants' abdomens were seen to be swollen by the sweets which they had lapped.

With an assistant's aid the branch was cut off without disturbing the workers, and was carried to the tent, and braced up within a pail of water to hinder the ants' escape. But they made little effort to leave, so intent were they upon their honey-gathering. They were kept in view during the rest of the night, and thus—and by many like experiments that followed—appeared the object of their nocturnal forays and the present source of honey-supply. What was it?

Some of the galls exuded minute globules of a white, transparent, saccharine liquid, which the ants greedily



NIGHT-WORKERS GATHERING HONEY FROM OAK-GALLS

lapped. This sugary sap issued from the several points upon the gall, which in some cases became beaded with six or more droplets. During the night one gall would yield at least three series, and this explained the flitting of the ants from gall to gall. The successive exudations invited frequent returns. Thus in emmet experience our proverb "as bitter as gall" must needs be modified; and for them also the well of Mara became a fount of sweetness.

Some gall-bearing twigs were put into the artificial nests. They received no attention. This led to more careful selection, and twigs having bleeding galls were introduced. These were instantly attacked and cleaned of their beaded sweets. Examination explained this difference in behavior. The favored galls were livid and greenish in color and soft in texture. They contained the immature forms of a gall-fly, *Cynips quercus-mellaria.* The neglected galls were all hard and of a darker color, with a circular hole near the base through which the mature gall-fly had escaped. The galls were all small, the largest being three-eighths of an inch in diameter. Thus our honey ants were shown to be garnering the nectar of galls whose flow was probably stimulated by the trituration of gall-fly larvæ.

The ant-honey stored within the rotunds has an aromatic flavor suggestive of bee-honey, and is agreeable to the taste. An analysis, made by a competent chemist, of the product of the Mexican species showed a nearly pure solution of sugar of fruits differing from grape-sugar in not crystallizing. The Mexicans and Indians have, or had at the period of these studies, several uses for the ant-honey. They ate it freely. The late Professor Cope, when in New Mexico, had a plate of rotunds offered him as a dainty relish. Dr. Loew reported that the Mexicans press the insects and use the honey at their meals. They were also said to prepare from it by fermentation an alcoholic drink. Another naturalist learned that the natives apply it to bruised and swollen limbs.

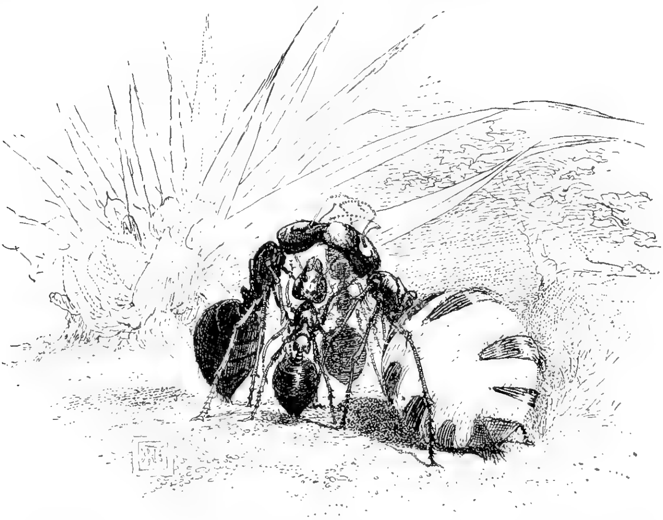
It has been suggested seriously that these ants might by culture attain the rank of bees as honey-producers. The difficulty of farming the colonies, and the limited quantity of the product, would prevent a profitable industry. The average amount of honey in a single rotund was by weight about forty (0.3942) grammes, a little over eight times (8.2) that of the ant's body. But counting the number of rotunds in a nest at six hundred —the utmost that observation would justify—the entire product would be only two-thirds of a pound troy, collected at the cost of all the honey-bearers' lives. Such results disbar these insects from the field of human industry.

Let us go back to the home nest. The time chosen for the foragers' exode was in all colonies the same, about sunset at 7.30 P.M. Always there remained a large force, some of whom were seen at all hours of the night on guard around the gate and patrolling the mound, even pushing their pickets beyond. The return home began about midnight and continued until the dayspring, between four and five o'clock. The incomers were challenged by the sentries, who guarded the approach with military vigilance. The antennal countersign was always exacted. One could not but wonder, as he saw the sharp arrest and the crossed antennæ, how keen must be the sense—the homologue, doubtless, of smell—by which recognition was made. As it is in human industries, there were plainly degrees of success among the returning workers, for some came with well-laden abdomens, and others scantily provided. Nor did size determine the measure of success, for some of the best-filled honey-bags were borne by the dwarf workers.

It had been assumed that the function of the rotunds was that of a store-room, a provision against a time of need for the family dependants. But the naturalist, while knowing the value of analogy and of circumstantial evidence, must seek "the sensible and true avouch of [his] own eyes." This was not easily had, although observations continued for more than four months on artificial nests taken from Colorado to the author's home. However, some progress was made.

It was proved that foraging workers, to which caste the rotunds belong, when returning as "repletes," were tolled by the sentinels and watchers. There was no such general levy of octoroi as seen at the gate of the mound-making ants, but enough to show that the habit was well fixed. From a gall-covered branch occupied by foragers a minim was laid upon her nest. She was much flustered, and failed at first to recognize that an unknown power, like the jinn of Eastern story, had borne her through the air to her own door. The watchers also showed surprise at so unorthodox an advent. But appetite quickly silenced speculation, and two dwarfs and a minor arrested the new-comer, and took toll from her mouth of the syrup with which her crop was charged. A worker-major put upon the mound was similarly treated.

That the workers are fond of the honey which the rotunds carry was seen while excavating a nest. Some of the tense abdomens were accidentally ruptured. The excitement that racked the formicary, the martial ire and fervor to assail a foe, the instinct to save larvæ, pupæ, and other dependants, were suspended in the presence of this tempting delicacy, and amid the ruins of their home the workers clustered around their unfortunate comrade and greedily lapped the sweets from the honey-moistened spot. It was a pitiful sight, and noted to the disparagement of the ants, until the observer remembered that human beings have displayed



HONEY-ANT WORKERS OBTAINING HONEY FROM A HONEY-BEARER

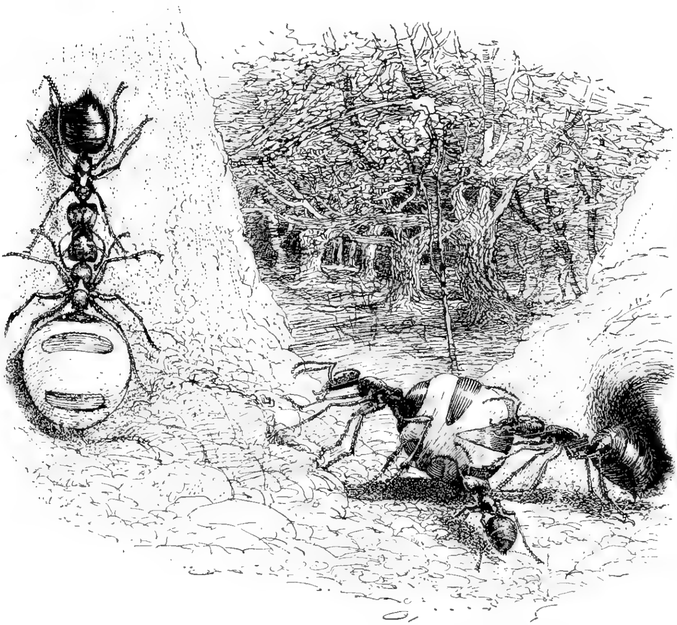
equal greed and ignoble self-gratification amid their country's wreck.

Over against this one may put a fact apparently more to the credit of our Melligers. From time to time the rotunds died in their artificial nests. The bodies hung to their perch for days ere the death-grip relaxed and they fell. Sometimes the attendant workers failed to note the change for a day or more, and caressed and cleansed them with wonted care. When they perceived the truth, and set about to remove the body, the abdomen was first severed from the thorax. Then the parts were taken to the "cemetery," that common dumping-ground for the dead which ants often maintain. The abdomens, with their tempting contents, were never violated. The amber globes were pulled up steep galleries, rolled along rooms, and bowled into the graveyard along with juiceless heads, legs, and trunks. Did this spring from an instinctive sentiment by which nature protects the living honey-bearer? At least, the workers seemed to draw a line between the use of the honey when exposed by accident and when held intact within the abdomens of the rotunds, whether living or dead. Was this an accidental incident or is it a specific trait?

That workers within the formicary feed from the rotunds as they do from repletes at the gates was seen in the artificial nests. Here is an example noted and sketched. The rotund stood with her head erect, her body elevated upon her legs at an angle of 45°, and regurgitated a drop of honey, which hung to the mouth parts. This was received by a major, who stood opposite and in like posture, and by a minim that stood almost erect and stretched up from below. Another major, attracted to the banquet, got her share by reaching over the back of the first worker and thrusting her mouth into the common "dish."

It added something to the inquiry that rotunds hold the place of dependants. The workers plainly rank them with the queen, virgin females, males, and larvæ. They were not fed, for their full crops guaranteed them against possible hunger. But the workers hovered about them as they hung upon the roof, cleansing them as they did the larvæ. In natural sites, when the honey-rooms were broken open and rotunds disturbed from their perches, workers of all castes ran eagerly to them and dragged them into the unbroken interior. Sometimes several united in removing one rotund. A single major was seen dragging a rotund by interlocked mandibles up the perpendicular face of a cutting, backing up the steep with her bulky protégé. Thus the behavior of the active class of the commune showed that honey-bearers are classed with dependants and receive care which cannot well be accounted for save by value attached to their stored food.

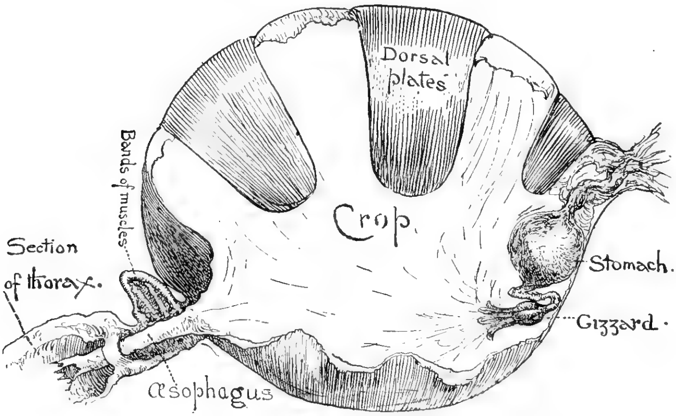
Hoping to prove beyond doubt the functions of honey-bearers, a number were placed along with work-



WORKER HONEY ANTS DRAWING HONEY-BEARERS INTO A GALLERY AND UP A PERPENDICULAR SURFACE ers in a nest, and all denied food. Some water was given, but otherwise their fast was unbroken for over four months. The plan was to force workers by hunger to go to their living store-rooms. But the perverse Melligers made the rotunds' lodgings within the heart of the nest, and no strategy could lure them into view. Yet during four months the workers, whose movements were observable, were in perfect health and in good condition. Indeed, they seemed more vigorous than their congeners in other nests, who were regularly fed. When the formicary was opened the survivors looked more like foragers returning from a banquet of oak-gall nectar than the victims of a four months' fast. The rotunds, too, were in good health; and, oddly enough, their abdomens, though somewhat diminished, seemed to have been but sparingly tapped! The complement of this experiment, a nest of workers alone, also denied food, came to an untimely end by accident.

The imprisoned honey ants uncovered many other interesting traits; but space permits the record of but one more—from the zoologist's stand-point, perhaps, the most interesting of all. Are the rotunds a separate caste? The question had been often asked, and the facts as observed required a negative. No sign of a separate caste appeared among the cocoons or callows. Accurate body measurements showed no difference between the workers and the honey-bearers except in the distended abdomen. The conclusion was reached that the worker-majors for the most part, and sometimes the minors, grow into rotunds by gradual distension of the crop and expansion of the abdomen.

The change of anatomy by which this occurs can easily be understood by lay readers with the aid of accompanying cuts. In ants, the alimentary or intestinal canal passes as a nearly straight tube through the thorax into the abdomen. There it has two special expansions, the crop and the stomach, which are united by the gizzard. The crop is in the fore-part of the abdomen; the canal opens

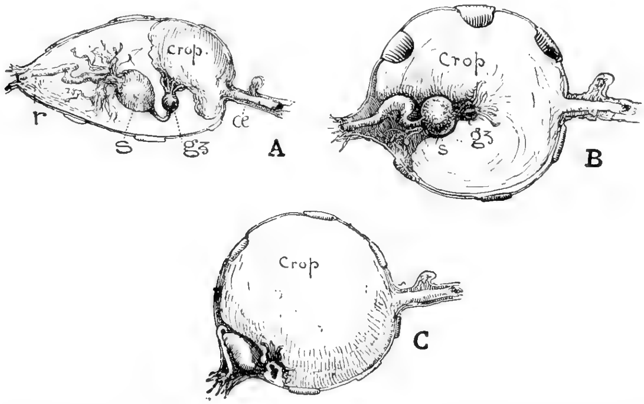


DETAIL OF THE ABDOMEN OF A HONEY-BEARER

directly into it, and therein the gathered nectar is first stored. Its elasticity, great in all ants, is highly developed in the Melligers, and it admits of immense expansion.

The walls of the abdomen which contain the above parts are composed of ten hard, chitinous, segmental plates, five dorsal and five ventral. These overlap one another, like roofing slates, from base to apex. They are set upon a strongly muscular inner membranous lining, which, like the crop, is highly elastic. In ordinary condition this inner coat does not show, and the ant's abdomen appears as a solid subcylindrical object. But in excessive feeding the crop expands, and, pressing upward and downward, forces apart the segmental plates at various degrees of separation, according to the amount of food taken. In the honey-bearer the three middle plates become wholly isolated, appearing as minute islets on the tensely stretched translucent abdominal membrane.

Meanwhile the backward pressure of the expanding crop forces the other organs before it, until they lie huddled together in the extreme end of the now rounded abdomen. It seems strange that creatures could live in such a condition, and in apparent good health. But so it is. Their habit is sedentary in the extreme, as they keep closely to their perches; but they can readily shift their positions, and when laid upon a smooth surface can move about with some celerity.



GRADUAL EXPANSION, FROM A TO C, OF THE CROP IN A HONEY ANT

The point here to note is the gradual stages by which a worker passes into the rank of honey-bearer. Large numbers were kept under observation, and finally dissected, and the progress from "replete" to "rotund," as shown in the illustrations, was well established.

CHAPTER VIII

A GUILD OF CARPENTER ANTS

THE warm, soft spring days fill air and earth and woods with multitudes of living things. Whence have they come? And whence came the hordes of black ants that have suddenly appeared on yonder great white-oak-tree beyond the brook at the edge of the grove? Did they come like the migratory birds? No; although some insects are great travellers. Surely they did not sprout into life like buds and grass and wild flowers? Not quite so; and yet something like that. They have been dormant during the winter. The cold suspended animation. They were frozen, but not killed.

One winter I was able to place in the museum of the Academy of Natural Sciences of Philadelphia a unique specimen—a large hill of the mound-making ants of the Alleghanies, *Formica exsectoïdes*. This could be done only in the dead of winter, when the great mound was frozen hard, and could be dug out and shipped without crumbling into the particles of soil from which it had been built up. It was a difficult undertaking, as the hill was brought from the mountains near Altoona; but it was accomplished.

Sometime after it had been installed in the museum a messenger came in haste to my house with an urgent appeal from one of the academy officials to hasten thither. My big mound was full of live ants, and hundreds of them were thronging the hill, and many had broken bounds and were pouring out upon the floor!

There had not been a sign of life in the hill when it was put up. But the warmth of the museum had gradually thawed it out, and therewith a horde of hibernating ants within. Naturally, as they woke up they looked about them, ant-fashion, to find something to do in their line of life. I had inferred that all the

CARPENTER ANTS REMOVING THE WOOD PELLETS CUT FROM A TREE colony had gone down for winter-quarters into the deep galleries beneath the surface, as far from the frost limit as possible, and that we had left them there. I was mistaken. The irruption of the mountain ants did the academy no harm, and the colony was soon extinct. But we had a good illustration of how ants in their natural habitat freeze up in winter and thaw out in spring.

In the spring we see our Pennsylvania carpenter ants [1] poking their black heads from beneath the loose bits of bark in yonder oak, and dropping pellets of fresh sawdust upon the grass beneath. They are making up for their winter inactivity by fervid energy. Their bodies fairly quiver with excitement as they move. They are clearing away the winter rubbish from their galleries, chambers, and halls, and are widening their premises for the increase of their community which the season is sure to bring.

They work rapidly. A heap of yellowish pellets the size of one's hat lies at the foot of the great trunk; and this would be much enlarged were it permitted to remain. Of course, the winds and the rains disperse and distribute the particles. But the ants themselves assist in this action. They seem to fancy that the freshly gnawed-out wood-dust will betray the whereabouts of their home, and so they remove it from the vicinage—an act of natural secretiveness. I have seen a gang of porters at the foot of a tree busily carrying the chippings and scattering them throughout the neighboring grass. Meanwhile the workers within the tree were rasping out the chiplets and dumping them

[1] *Camponotus herculeaneus*, subspecies *Pennsylvanicus*.

CARPENTER ANTS WORKING IN THE CORNER BEAM OF A FLOUR-MILL upon the rubbish-heap beneath. It seemed a waste of energy in pursuit of a vain imagination. Yet how should a human ignoramus like the observer decide that point?

I once carefully studied a large colony of carpenter ants that for several years had lived and wrought within the heavy corner beam of a flour-mill on the Bell estate at Bellwood, Pennsylvania. One gang dropped the pellets from a crack in the twelve-inch beam which opened into the nest. These fell upon a cross-beam, eighteen inches beneath, where another group of workers gathered them up and dropped them upon the stairway that led from the lower story, the nest being situated above the second floor.

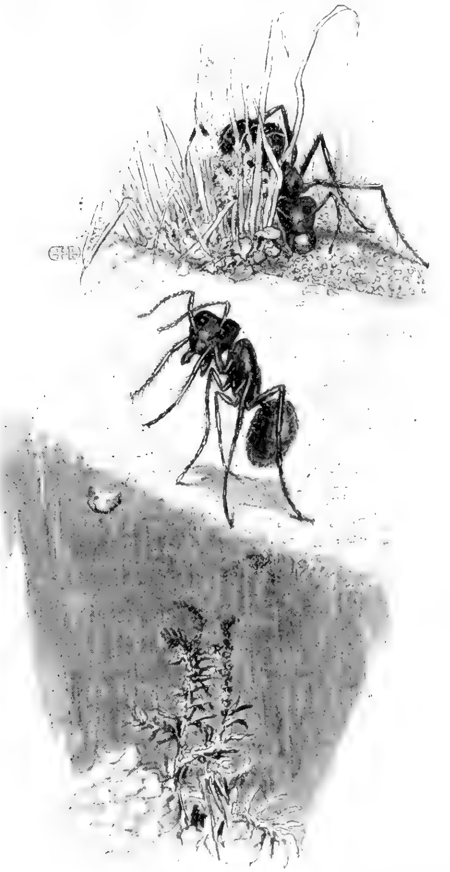
The miller, who had been about the premises for several years, said that when he first came the ants had a third gang detailed upon the stairway, several feet below, who cleared off the dumpage and dropped it to the floor. But as he swept the stairs daily, the emmets discovered that their detail for duty in that quarter was not needed, and withdrew it! Thereafter work went on as I saw it—the chippings cast from the cross-beam to the stairs were left to the manipulations of the miller's broom.

I have frequently found carpenter ants lodged in the shade-trees along city streets and squares, and there they have the same habit of secretiveness—or is it cleanliness?—practised by their country congeners. Near my home stood a maple much the worse for wear and tear, although not old. On one side, a few inches from the roots, was a small tubular opening hidden behind a bulging scale of bark. Out of this ants were dropping cuttings which formed a little heap upon the ground. Workers wrought upon this pile, carrying pellets piece by piece to the pavement curb and casting them into the gutter.

It was interesting and amusing to watch the little creatures in this act. Having reached the curbstone, the wee porter would rear upon her hind legs, poise herself a moment thus, then, bending forward, release or cast the chip from her jaws. The forefeet were used for this, being raised to the side of the face and placed against the pellet, which by a sharp forward motion was hurled away. Then would follow several similar movements, as though to brush from mouth and mandibles adhering particles of dust.

A gentle breeze, blowing at the time, lifted up the ejected cutting and carried it down the gutter, which for several feet was strewn with pellets. In some way these emmet porters seemed to have grasped the fact that the breeze aided the disposal of the chippage, which therefore need cause no further concern. One wonders whether they had any notion of the nature of this efficient coadjutor, and, if so, what they conceived it to be? Like many human toilers, did they work on with a dull subconsciousness that a sort of "Providence" had entered into their life, which behooved them to accept without further concern? One who lives much with these little brothers of the insect world can hardly help yielding to the fascination of such anthropomorphic musings, however idle they may be. Doubtless Mr. Burroughs is right in his stand against those who trespass upon the just boundary between truth and fiction in humanizing the actions of the lower orders. But theirs is an ancient offence, and strong indeed is the temptation thereto.

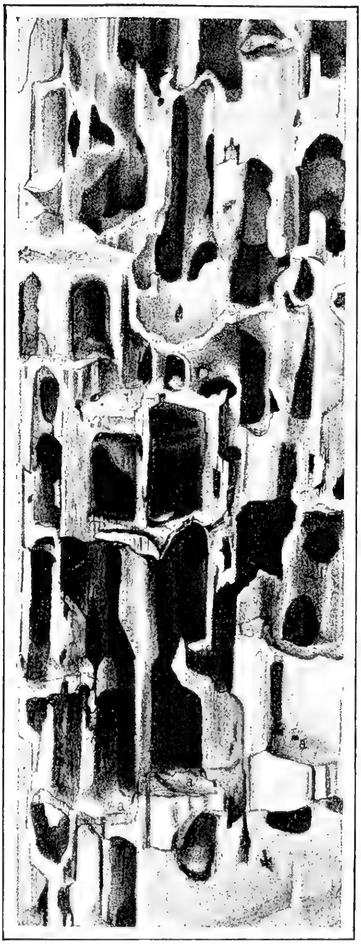
At all events, our rampant emmet porter there upon the stone curb's verge, committing her pellet of yellow wood-dust to the transfer of the wind and to the cavernous deep of the gutter, has plainly some idea of the situation. She knows her meets and bounds and the aidant features of the topography, and goes to and fro with the accuracy of a carter to his dump. That implies at least an automatic sort of intelligence. Moreover, the relations of these insects to the natural elemental forces seem to differ in temper from those that appear between them and the vital objects that beset them. For example, the winds, rains, and running waters are often rude invaders of emmet homes and preserves. In such cases the attitude of the sufferers appears



A CARPENTER ANT DUMPING A PELLET OF WOOD INTO A CITY GUTTER to be analogous to that of men in like misfortunes —not an angry outbreak of combativeness, but a more or less vigorous struggle with, or quiet submission to, the inevitable. Let an insect or other living raider trench upon their domain. That is quite another matter! The community is intensely excited. Every individual is violently pugnacious. It is a different quality of animation that one now observes. The dullest eye notes it. In short, the differing behavior of men towards a flood or a snow-storm and towards an assault of bandits one seems to see in diminished reflection in the behavior of ants under like conditions. It is this intuitive attitude towards the elemental forces, as hostile or friendly, and a corresponding acceptance of the same either as matters of course in an inevitable environment, or as casual, obtruding, or preventable forces in life, which has been suggested by our carpenter ants in accepting the alliance of the wind in the bestowal of the chippage from their arboreal homes. In the same spirit in which they adapt themselves to a beneficent attitude of the elements would they accept the reverse.

Let us return to our colony in the mill beam. What are the ants doing within? What sort of domicile have they wrought out? "If I could only peep inside!"

"So you shall!" responded the proprietor to my exclamation. And this was not badinage. A squad of carpenters—human carpenters this time!—was called. The corner of the mill was shored up bodily by great supports. A section about five feet long, including the inhabited part, was sawed out and a "splice" of corresponding size inserted. The exscinded part was carried into the open, and my coveted opportunity had come!



SECTIONAL VIEW OF THE INTERIOR GALLERIES, AND ROOM OF A CARPENTER ANT'S NEST

It is not often that a curious entomologist falls into the hands of such a liberal abettor.

The piece was sawed into two parts and carefully split open. Alas for the sacked city of the Camponotidæ! "Kill no ants needlessly!" was the order to the workmen.

"Do not distress yourself!" quoth the proprietor to the naturalist. "We would gladly be rid of all the pests. This is hard upon ants, but helpful to men!"

Nevertheless, only such specimens were taken as seemed needful sacrifices for the temple of science, and the others, a great company, were permitted to escape. As if by previous arrangement, they formed an irregular column, and the workers, who at once had seized larvæ and pupæ and eggs, marched away with their treasures into a near-by pile of logs, doubtless well known to them through sundry foraging excursions. Many winged forms, the males and females, accompanied or were carried by them. Their future was left to fate; it was their past that now concerned me.

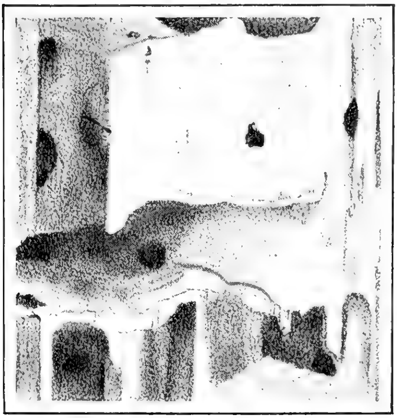
As the slabs were opened and divided into convenient blocks, there was exposed the work of from eight to ten years, and Camponotid architecture was probably never before so fully laid bare. A section more than two feet high by ten inches thick was fairly honeycombed, the cutting approaching at one point within two inches of the surface. A detailed description of the labyrinth of galleries, halls, and rooms is out of the question; but the specimen shown in the drawing gives a fair idea of the whole.[1]

One noticed first a crude but evident arrangement of the cells into stories and half-stories, as seen in the mounds and subterranean nests of the mason ants. The surfaces of the floors were uneven, but substantially upon the same level. Some of these stories seemed to have been formed by driving tubular galleries, which were gradually enlarged and finally blended. There was a manifest appearance of corridors or halls, running parallel in series of two, three, or more. These were separated by columns and arches, or by partitions cut very thin, in many places just broken through. At one spot a section of one of these was entirely enclosed, forming a triangular hollow chamber an inch and a quarter high and half an inch wide at the base. It looked like a miniature bay-window, and there was an entrance from the rear. Was this intended for

[1] The original blocks are preserved in the author's collection of Insect Architecture in the Museum of the Academy of Natural Sciences of Philadelphia.

a queen-room, or for a store-room for larvæ and eggs?

This section was the most thoroughly excavated in the entire formicary, and apparently had been the original centre of operations. There the solitary foundress queen had probably made first lodgment. As the community grew, work was pushed in all directions, terminating at the top in an irregular dome which, with its pendent columns, resembled the roof of a limestone cavern with its drooping stalactites This was, in fact, the ceiling or uppermost story of the formicary.



PROJECTING ROOM OVER A HALL: A BAY-WINDOW

The series of cavities that surrounded the centre and formed the outer works differed in general plan from those at the centre, inclining to large, open vaults rather than to compact series of chambers. It was as though the early era of the commonwealth had been dominated by one type of architecture, characterized by clustered chambers, and the latter era by another type, the vaulted or cavernous. One needs to keep a tight rein upon his fancy when such speculations arise; but, really, while studying the structure of this Camponotid commune, one could not forbear noting that cities of men show the same characteristic of crowded quarters around the old centres, and expansion at the margins.

Entrance to the formicary was had by circular and oblong doors pierced at irregular intervals in all sides of the beam. They opened for the most part into tubular, circuitous galleries communicating with the interior. A few entered immediately upon spacious vestibules. A vertical fissure in the beam several inches long appeared to be the main avenue of communication with the interior. At least, from this crack the workers cast the sawdust rasped from the inside. These openings served for ventilation as well as for entrance and egress.

Parts of this maze of vaults and chambers were blackened, probably by the formic acid exuded by the ants. Spacious as these quarters may seem (relatively), they must have been greatly crowded; for enormous numbers of larvæ, pupæ, eggs, and mature ants of all castes were housed within them. How many speculations arise as one pictures such a community carrying on its varied and complex duties—excavating and shaping roads and rooms, caring for queens and winged sexes, collecting eggs, nursing and feeding the larvæ, tending the pupæ, "policing" the quarters, etc., and all in what seems to us Cerberian darkness! What is the quality of the light that penetrates these cavernous domains and permits such work? Or is it controlled by the sense of touch alone? What must be the nature of a vital organism adapted to such a Plutonian career and equally and instantly to the free life in the sunny open wherein is wrought the foraging for communal supplies? For many and careful observations have never detected the slightest "shock" or change of manner in ants of any species in passing from the interior of their nests into the brightest sunshine.

Moreover the nest was located twenty-four feet above the ground, and all food and drink had to be brought thereto through the mill. This elevation and resulting vertical transportation are characteristic in forest nests, many of which are placed at far greater heights. That ants are ardently fond of water one may readily satisfy himself by experiment; but no way of approach to the mill-race was discovered except down the foundation logs, and no regular lines of travel to and from the stream were observed. And in this case, access to the natural supply of drink from rains and dews, was prevented by the interior location.

Their elastic organism and temperament the Camponotidæ share with insects of like habit; and in their general behavior while foraging, ranging, and skirmishing they resemble substantially their fellows heretofore described.

According to Professor W. M. Wheeler, the subspecies *Camponotus Pennsylvanicus* not only occurs from the Atlantic to the Pacific, and from British America to Texas (where the author has observed it), but extends over into eastern Asia, where it appears under three varietal forms in Japan, Burma, and eastern Siberia. In all this wide distribution it retains, as far as known, the same habits.

One point of especial interest remains to be noticed. In what rank must we place carpenter ants as insects injurious to man? Evidently such operations as above detailed cannot be carried on in the heart of a tree or log without damage thereto. The extent of damage, present and possible, cannot well be determined without a wide exchange of experiences. But something may be contributed towards a conclusion. Carpenters, lumbermen, and others who had lived and wrought in the mountain forests were questioned. One thought that the injury done was not serious, being confined to occasional spoiling of a saw-log. He had seen the ants for the most part in white pine (although they infest maple, cedar, and oak), and thought that they usually made entrance at a knot-hole or some bruised or shattered part. He had found the nests at all heights, and believed that when the ants build high the trees occupied are usually sound. He had seen one white pine whose top was so weakened by the ants, seventy-five feet from the ground, that it was broken off by the wind.

VIEW OF THE CEILING OF ROOF OF A CARPENTER ANT'S NEST

The miller's experience was either wider than his fellows' or he had been a more careful observer. He had often found the ants nested in trees at heights from ten to thirty feet. He had many times come upon the nests in logs, some formicaries six feet long, while managing a saw-mill. When making staves upon the mountain he had frequently noted the loss of the blocks by ant-cuttings. Usually the insects took hold of some decayed part of the tree, but often they attacked sound wood. This was the tenor of the testimony taken in the mountain region near Bellwood and Altoona. The most formidable case of injury—which I had not the opportunity to verify—was reported by a young farmer on Brush Mountain, who said that a tract of oak timber eight or ten acres in extent belonging to his father had been almost ruined by the black ants. This case stands alone among the many reported. As a rule, the attacks seem to be more annoying than injurious. One of the largest proprietors of lumbering interests, especially in West Virginia, has just written me that he does not think the operations of ants in standing timber entail serious loss. On the other hand, Professor Surface, the Economic Zoologist of Pennsylvania (1906), writes me that Pennsylvanicus "undoubtedly does a great deal of damage to trees, logs, and timbers of buildings by opening up the solid wood to contact with air and moisture, thus promoting decay."

But how stands the case with exposed structures of wood? Might not such excavations as represented in the section taken from the mill beam become dangerous, as, for example, in railroad bridges and trestles? We were then on the main line of the Pennsylvania Railroad, which had not yet entered the era of stone and iron bridges that now happily prevails. But the inspection of many wooden trestles showed no signs of dangerous impairment. However, while these facts were being communicated at a meeting of the Philadelphia Academy of Natural Sciences, Mr. Wilson, a well-known civil engineer connected with the railroad, stated that he knew of at least one case of a freight-train wreck caused by the break-down of a trestle weakened by carpenter ants. Recent inquiry at the office of the president of the road developed the fact that present-day engineers have so completely emerged from the period of lumber bridges that the only injuries of the sort known to them are those of the teredo, or ship-worm, whose legions make such destructive inroads upon the wooden piles used in sea-shore structures. But that is a matter for the student of mollusks, not of insects.

That our Bellwood grist-mill does not stand alone as an example of pernicious industry appeared in the vicinage of the author's city home. The late Judge Allison, an eminent jurist of Philadelphia, once sent me a section of an ant-eaten log, and later called to relate its history. It was a part of the beam which had supported the roof of the spacious porch of his suburban house. Persistent leakage in the roof led him to send for a carpenter, who found the cause in a large colony of Camponotidæ that had nested in the beam, and fairly riddled it for a space of several feet. The judge had often observed, while sitting on his porch in the cool of the day, ants ascending and descending the pillars.

He had mused upon their curious manners and moralized upon their industry and other fine qualities as described by his insect-loving neighbor. But here was a new phase of the subject, to him at least! He felt some scruples of conscience at dislodging such quiet tenants and breaking up the home they had so ingeniously and toilfully made. For although it was a case of manifest trespass, and the judgment of *delenda est* was doubtless right, yet he could not forget the saying, *summum jus, summa injuria.* Therefore he contributed his information and the vacant nest to the cause of science, in hope that the offering might in some degree compensate for the ruthless sack of the emmet city and home. He had rather in this case read the old judicial proverb, *transeat in exemplum!*—"let this be for an illustration"—than, "let it be for a precedent!" Happily the world has many such worthy spirits who can practise the grace of forgiveness even towards injurious insects.

CHAPTER IX

ANT-LIONS

A CREATURE that bears the joint name of the king of beasts and the queen of insects raises great expectations as to its quality. But the ant-lion has neither the social habit and wisdom of the ant nor the majestic appearance of the lion. In its perfect form, or imago, it is a graceful but plainly colored insect of the Neuroptera, or lace-winged order. In its larval state it is a most unattractive creature, with the fierce appetite of the dragon-fly larvæ.

It feeds largely upon ants, hence its generic title, Myrmeleon, the Greek form of its popular name. There are in all more than three hundred described species of the group Myrmeleonidæ, of which about thirty are in the United States. How many of these have the interesting habit of taking their prey which has attracted such general attention is not known, at least by the author. But the species whose manners are now to be described, and which is widely distributed in eastern America, is the well known *Myrmeleon immaculatus*.

It is the larvæ of this and like species whose doings have wrought the family fame. The dragon-flies best known to us, whom the ant-lions so nearly resemble, lay their eggs upon water plants, and the larvæ develop in the water, wherein they devour enormous numbers of water larvæ. This fashion they maintain as mature insects, only turning their energies against winged forms. But Myrmeleons lay their eggs in sand, and therein the larvæ, which is the true ant-lion, is hatched out, and at once begins its predatory career.

I have found these insects in Texas and Colorado, and as far east as New Jersey, and they abound along

IMAGO FORMS OF ANT-LION (*MYRMELEON IMMACULATUS*) the Atlantic coast. They prefer warm, sandy sites open to the sun. But I have seen them in a pine wood housed beside a fallen tree in and under which a colony of ants had made their nest. Thus cannily had they pitched their tent near their base of supplies.

Several specimens of *Myrmeleon immaculatus* brought from New Jersey to Philadelphia in midsummer (July), permitted me to study their habits at leisure. They were domiciled in a wide bowl filled with their native sand; and being in fine fettle disclosed some of their most interesting traits. The special feature for which Myrmeleon is celebrated in the annals of insects, is its manufacture, or arrangement, rather, of a trapping implement by which it gains its living. This is rare among the lower animals, being a marked human characteristic. The spider is conspicuous and almost unique among the inferior orders for this gift, its varied silken snares serving to take its prey, as traps and nets serve the human hunter and fisher. The only other example now remembered is the net-making caddis-worm, whose interesting habits are described in a following chapter.

The ant-lion's trap is a pitfall in the shape of an inverted hollow cone; and my captives showed quite perfectly their mode of work. Their pit was generally made by a backward movement along a spiral line which gradually closed upon the centre. One may make a good imitation of this by a rapid spiral movement with the point of a lead-pencil in a bit of dry, loose sand. The ant-lion while thus at work held itself just beneath the surface of the sand, its free progress through which was aided by the shape of the body, which is broad in the middle and tapers at both ends. Thus nature, in working out her vast projects, even in the lowliest forms of craftsmanship, well adapts her creatures to the conditions of their being. In the production of such forms one seems here to mark traces of the same quality of work that shapes a boat and ship to move through the waters and a plough to cut through the land.

The grains of sand were thrown forward as the larva pushed backward, and were continually tossed off by sharp jerks of the head upward and sidewise, and somewhat like the "butting" of a sheep or goat. As the larva progressed—or rather retrogressed—the sand was set in motion, a furrow was formed, and as the body rapidly ploughed round its shortening spirals, the small particles of sand dropped to the lower part of the fur-

ANT-LION LARVA CAPTURING AN ANT

row, and at last became a funnel-shaped hole two or three inches wide at the top and an inch or more deep. The size, however, varies with the size of the larva.

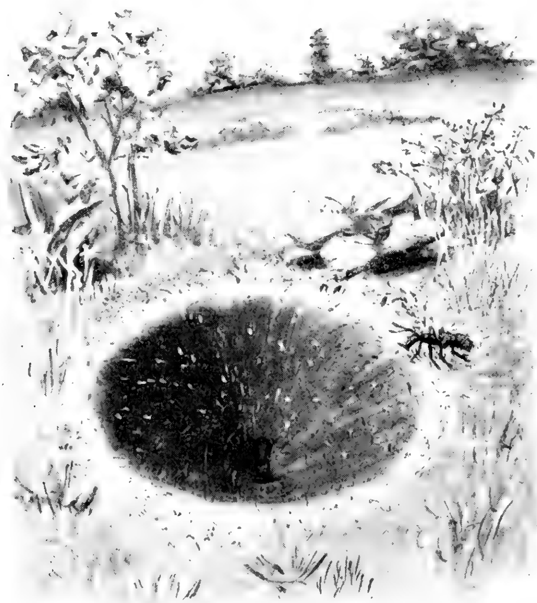
Myrmeleon had another way of making its pitfall.

It thrust its body into the sand, and began to toss from its head the grains that lightly covered it. Into the little hole thus formed the sand began to run; and as the insect continued to jerk the particles away the hole was enlarged, and a vortex caused by the sand running in from all sides, thus naturally forming a funnel-shaped pit.

Having prepared its trap in one or the other of these ways, the insect was ready for work. It took its place in the centre of the pit with only its head above the surface, and its long, strong, curved mandibles in sight. Then it began its patient watch for visitors, like the ogres of fairy-tales within their grim castles. The reader will remember that the large bowl within which these observations were made stood upon a naturalist's working-table. It therefore would have been a vain watch, and our ingenious trapper would have died in its den had not some one come to its aid. Hence its captor had to forage for supplies. Numbers of ants nested in the adjoining lawn; so many indeed as to be troublesome, and to justify one in somewhat thinning out their ranks. From time to time these were captured and put into the bowl.

There is a deal of the Paul Pry in emmet nature; and as the ants were placed upon the sand they went peeking and nosing about, as is their use and wont, waving their antennæ and challenging therewith every object in their way. But they did not seem to walk deliberately into the pit. They stopped upon the edge when they reached it in course of their rambles about the bowl. They waved their antennæ. Sometimes they reached a fore leg over the brink. Sometimes they retreated; sometimes they turned and began to walk about the pit. The agitation of the sand, slight as it was underneath the light tread of a small ant, generally, though not always, aroused the ant-lion to action. Then the head began its snapping jerks, and the sand began to fly.

It is the popular belief, justified indeed by statements of some nature-books, that the larva directly aims its



A BOMBARDMENT

volley of tiny bullets at the intruding insect when it comes to the edge, and also when it appears to be escaping from the pit. This seems to be without foundation in fact. The sand, as the author observed it, was thrown up precisely as when the trap was made, more or less violently, and so vigorously at times that it appeared to boil. This agitated the surrounding particles, which began to move towards the centre; and these setting in motion those above and yet above, at last withdrew those beneath the feet of the ant, which slid along with the tiny sand avalanche into the apex. There it was seized, unless, as sometimes occurred, it was fortunate enough to escape.

The ants often showed a strange fascination for the pit even after they had escaped therefrom. A large black carpenter ant was trapped and seized, but managed to get loose and rushed out of the pit. Then it paced excitedly around it, ran into it, and so in and out and around again and again, as though dazed. Meanwhile, Myrmeleon, no less agitated than the big carpenter, kept up a furious bombardment that fairly filled its pit with flying sand pellets. These were tossed up with force enough to cast them out of the bowl over the brim to the distance of several inches on the table—that is, from thirty to forty times the grub's own length and many times its height. Pellets as large as grains of rice were thus ejected. But they flew in all directions, on the side opposite to the ant or upon it or around it equally and indiscriminately.

My conclusion was, from many observations, that there was no direct aim, simply the usual and general instinctive movement, which, of course, was apt to reach anything within its compass. In short, the volleying was at haphazard, but as it was in all directions it was likely sometimes to hit the object of attack. But this seemed to be accidental, not of set purpose. In other words, the larva's weapon of offence was a vortex, not a volley. Instead of bringing down its prey by well-aimed shots of sand, as commonly believed, it cuts the ground from beneath its feet, and thus brings it within reach, a victim of the law of gravitation as directed by a skilful antagonist.

The use of the larva's long, curved, and toothed mandibles appeared in the act of seizure. The ants were held off at "arm's-length," so to speak, and were thrashed and jerked about until they were exhausted. Meanwhile efforts at defence were made futile by the captor, who held its victim out of reach of any vital part. A plucky little pavement ant (*Tetamorium cœspitum*) fell into the larval jaws. She has a sharp sting, and eagerly tried to use it, but was kept at such a distance that her poisoned lance wasted its force against the horny hooks that held her aloof. So also the formidable pincer mandibles of the Pennsylvania carpenter ant, by which she carves out her vast galleries, halls, and rooms in trees, and beheads her victim with the ease of a guillotine, were made useless.

This mode of disarming its victims was made more effective by the ant-lion's position just beneath the sand. A worker-minor of the carpenter ant that fell into the pit, was seized by a hind leg. She bowed her body to snap at her captor's head; but her jaws only grasped the gritty pellets that covered the ant-lion, and out of which its long hooks alone projected. When the juices of a captured insect have been sucked from its body, the dry shell is flung, or "butted," from the pit, and the larva resumes its watch.

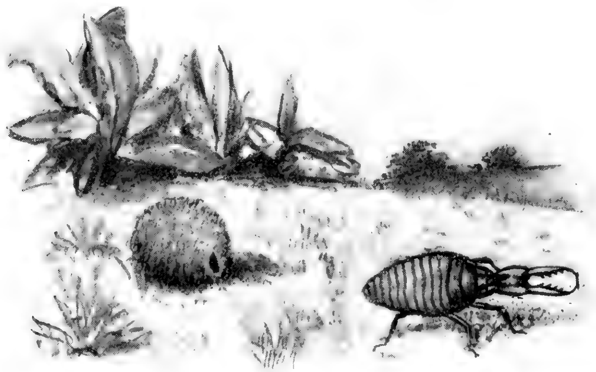
One point in the behavior of this group of ant-lions especially interested me. In the early part of last century a French observer told a remarkable story of the way in which a Myrmeleon larva got rid of pebbles too large to be moved from its pit by tossing with the head. The correctness of this statement was questioned, and I therefore put it to the test. Three pebbles, all larger and heavier than the larva, were dropped into the centre of a pit where they would be most inconvenient to the occupant, and likely to prompt her to remove them. The experiment succeeded perfectly.

The ant-lion thrust its head beneath a pebble and tried to toss it from the pit. Having failed in this, it tried another mode. It placed the end of its abdomen against and a little beneath a pebble, and began to push backward. A little time was taken to adjust the pebble so that its centre of gravity would be against the end of the body. Then the animal began to back out of the pit, pushing the pebble before, or rather behind it, up the side, and to a point a short way beyond the margin, where it was left. A small furrow was thus made in the sand, curved from the point of departure up the wall of the pitfall. The pebble was kept perfectly balanced during the entire movement, which was quite rapid and made with the ease and assurance as well as the celerity of an expert. All of the three pebbles were thus removed; and the experiment was repeated a number of times, always with the same result.

Some well-rounded bits were now dropped into the sand in order to increase the difficulty of balancing the load; but this made no difference in the larva's action. A round pebble was balanced and removed quite as readily as any other. That this task required no little acrobatic skill I satisfied myself by sundry experiments. My deftest efforts to push a pebble before the point of a pencil, *à la* Myrmeleon, were not an eminent success.

It was a curious and amusing spectacle—this odd little creature backing the accurately poised load, larger and heavier than itself, up the shelving sandy wall and out of its domicile, and then returning to put its house in order! Thus the correctness of the early observations of M. Bonnet were confirmed.[1]

Even the smallest ants introduced had great difficulty in moving over the wall of the pit, as the sand broke and rolled away beneath the lightest tread. One ant that escaped had a little ball of pellets attached to a hind foot as though caused to adhere by moisture or some viscid substance. Others had minute grains clinging to the delicate hairs of the body at many points. This raised the inquiry: Does the larva purposely secrete a



COCOON AND LARVA OF ANT-LION

sticky liquid that produces this effect, and thus aids in hindering the entrapped insect's flight? This seems more probable from the manner in which the larval

[1] See *Proceedings*, Academy of Natural Sciences of Philadelphia (1882), pp. 258–260.

cocoon is formed. When nature stirs within the ungainly grub the strange and resistless impulse to transform, it builds for itself a round cocoon in the sand. The gummy liquid silk which it exudes adheres to the grains and binds them together into a little ball. Herein the larva pupates; and thence the pupa issues, a graceful, winged insect. When food is plentiful the larva soon reaches its full growth and forms its cocoon. But if ants are scarce and it is scantily fed, the ant-lion's development is retarded, and the beautiful imago life postponed or never attained. This, indeed, is a law of nature that rules the development of all young creatures, man not excepted. The lack of fitting nurture in early life, whether of body, mind, or morals, can rarely be overcome in later years.

PART SECOND

STUDIES OF INSECT AND ARANEAD LIFE

CHAPTER X

HUNTING WILD BEES

MID-SEPTEMBER brings the mature glory of summer to the middle and northern Atlantic States. And here to our Brookcamp home, amid the hills of fair Devonside, has come an insect-loving friend for a field-day with the wild bees which just now he is studying. The weather has been erratic, pleasantly so for those who have scant charity for midsummer heats, but not so well for him who would range the fields in quest of creeping-flying things. For it has been unwontedly cool; and the sharp air has lulled the senses and weighted the wings of those children of the sun, whose vitality rises with the temperature and their activity falls with the mercury.

But happily for our plans, Apollo duly wheeled his chariot back into the caloric zone, and our morning broke clear and warm, though with a bit of lingering crispness that gave fine tonic for a lengthened ramble. So away we go, Mr. Fourcorners and I, he with his insect-net and killing-bottles, I to serve as a sort of scout to flush the game, and the two dogs as general inquisitors.

"But what a name! Really, now, is it—?"

Yes; really and truly it is "Fourcorners," though commonly spelled in a foreign way; but for brevity we will call him, if you please, Mr. Four. He is well worth your knowing, especially if you are caring much for bees. Down through the grove and across the brook we go to the fallow fields that lie between this wooded hill and the far southward wanderings of the stream along yon knobby glen.

Earlier in the season we might have sung literally with lovers of the old Scotch psalter—

> "In pastures green He leadeth me,
> The quiet waters by."

But not to-day! Here are, indeed, the quiet waters, but not the pastures green, for, in truth, they are yellow. It is a somewhat uncommon scene. This year the vast, untilled estate of "Devon Hills" around us has not known the sweep and burr-r-r of the horse-mower, and wild flowers and meadow-larks, spiders and grasshoppers have had unmolested sway. Thus it comes that a broad expanse of yellow golden-rod lies all around us, lightened up with clumps of the pale-blue and white aster [1] and the blooms of boneset,[2] wherein living things may range and hunt and nest after their own wild will and wont.

"This ought to be a fine field for our collecting," quoth Mr. Four.

Collecting wild bees? Surely that were a sport easily ended. A short horse is soon curried, saith the proverb; and I have never seen more than five species of wild bees around here.

Mr. Four smiled. He was well inclined to credit me with some knowledge of living creatures, but that trace

[1] *Aster puniceus* and *A. ericoïdes.*

[2] *Eupatorium perfoliatum.*

of conscious superiority which eye and voice betrayed showed me that I had blundered.

"Take them all together," he said, "social and solitary, we have at least five thousand species of wild bees; and I should count it a poor day's hunt if I did not get seven or eight to-day. And here is one of them!" he added, with a sweep of his net. "And one of the most interesting. It is Cresson's *Megachile mendica*," he continued, as he removed the bee from the net to the cyanide or killing-bottle, and thence—after a painless and almost instantaneous death—to his collecting-tubes.

LEAF-CUTTER BEE (*MEGACHILE MENDICA*) AT WORK UPON A ROSE-BUSH

Megachile, at least, the author knows; and his readers have had an inkling of her pretty ways, for she is one of our leaf-cutters. Last summer one chose the steps beneath one wing of our porch for the making of her nest, into which she would pass through the latticed screen atween the pillars of the floor. There was near-by foraging enough for the needed fabric, for her fancy lit upon rose-leaves. And they were everywhere around —yonder in the mistress's rose-garden, and there in the red-and-white ramblers that wellnigh cover the flag-arbor.

How deftly she does her cutting! Hers is indeed a fairy tread as she stands upon the velvety softness of the leaf, her body held up high by her outspread legs, and bends down her scissors-like jaws to her task. She clips the serrate edge and moves as on a pivot towards the midrib, leaving in her circuit a curved incision. Can that fragile floor uphold her weight? It does. The leaf hardly bends beneath her. Do the good fairies, indeed, put their shoulders inunder it—the tiny Atlases for this midget world.

Now a circular or semicircular bit is cut out, and, striding the gap, poised the while on fluttering wing, she balances the segment in her jaws and flies to her chosen nest-site. That may be in the butt-end of a hollow branch, in a cavity in a rotten stump, or, with some species, in a depression on the surface or a hole within the ground. The wee eremite seeks a space that shall be a little wider than herself. Good working room she must have; but not too much, else the tubular roll with which she is to drape the wall will not take and keep due shape.

Leaf tissue is dainty material to work therewith; but she manages to bend a cutting against the surface of her cave, to smooth it into place, and leave it there while she garners another piece and yet others, until she has hung a space the length of her body or more with overlaid bits of leaf that quite encompass the cavity. With feet and jaws, head and abdomen, she pulls, pushes, thrusts, and beats the pieces into place, trusting to their natural elasticity to get and keep their set into the concavity of her chamber. As three or four layers of these leafy drapings must be made, there are busy times before mother Megachile, and back and forth she flies between rose-bush and rose-den.

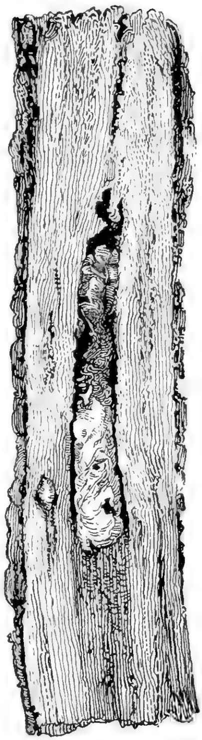
Her method in clipping out the leaf sections is quite like that of the cutting ant, whose legions I have seen in Texas and Cuba stripping bare the foliage of wild shrubs and such trees as the live-oak, and marching to their great cavern-communes with the bits of leaf held above their heads and waving as they go. No wonder folk have called them "parasol ants."

They must be dreadful pests? queries the reader. The ants? Yes. For they breed by the million and operate in armies. But not so the bees. They are few, and, being solitary, cannot plot and organize mischief. It is your "social" creatures who develop the vicious traits that waste our orchards, fields, and gardens, and vex our souls by their depredations. But one does not need to vent his wrath on our leaf-cutter bee, for the rose-bushes can well spare all that she will take, though she is no laggard, whether as cutter or draper. In laying her upholstery it would not do, of course, to allow edge simply to join to edge. The edges must overlap to make a compact compartment. And so we find it, whether by haphazard or by fair intent. The end or opening into this patchwork cradle must be closed, and it must need nice management and delicate touch to curve and tuck and fit until the closure is made.

And now the winged upholsterer has formed a cartridge longer and larger than herself, whose leafy shell of several layers is ready to be charged. Herein must go an egg, and food for the beeling that shall hatch therefrom. Away our bee mother flies, her body aquiver with maternal eagerness to fill the cradle that her hands have made. Her course is not to the rose-garden now. She is off to the fallow fields where the golden-rod bends with pollen, and asters blue and white, and many wild flowers besides, are holding up their nectar cups for their winged visitors to sip. What a chalice, and what a draught is hers! And as she flutters from flower to flower, and quaffs an elixir that only Flora can mix, she drinks not as the wine-bibber, for the selfish pleasure of the draught, but mingles therewith the spicery of motherhood's kind thoughts; for from this honey of the flowers, mixed and kneaded with pollen, she will make a rare confection known as "bee-bread." A tiny roll of this she will put within the cell, will drop thereinto a minute atom of life from her ovaries, then seal up her casket and hie away again to her harvest-field of rose-leaves, and begin to frame another cell. And so on, until death stays her beautiful career or her ovaries have spent their life-force.

How many of these cells she makes I do not know; but they are commonly found in tubes wherein as many as five or six are sometimes united. However, Professor Putnam, an admirable observer, records that he watched one worker for twenty days building and provisioning her cells underneath a board. There were thirty cells in all, in nine irregular rows, and he estimated that more than a thousand leaf-cuttings had been used by the little architect.

What an ingenious creature! And how admirable her work! And she and her numberless fellows, in forms and varieties innumerable, over all this landscape and throughout the universe, are at work upon tasks like these, marked with a like ingenuity. What an aggregate of wisdom, and how it mounts towards infinity! — is vital within this great bosom of animated nature from which these creatures draw their varied cunning and skill. One cannot but wonder, as he thinks of it, where—what—Who—back of mother Nature, must be the Original Fount of it all?



BROODING NEST OF LEAF-CUTTER BEE

From photograph of specimen in American Museum of Natural History

Meanwhile the insect-net has been busily sweeping the flowers as we slowly move across the open fields. We have fallen upon quite a colony of that interesting group known as mining or burrowing bees. We have several examples, in both sexes, of Colletes[1] and Andrena, Panurginus and Augochlora,[2] who drive narrow, tubular tunnels into the ground, wherein they put their cells, protected against the dampness by a thin, membranous lining which reminds one of oil-paper. One of these, *Andrena solidaginis*, gets its specific name from its fondness for the pollen of Solidago; and the naturalist who so named it made no mistake, for here we find the pretty little fellows fluttering among the blossoms of goldenrod. They visit other flowers, doubtless, but here

[1] *Colletes Americana* and *C. compacta.*

[2] *Panurginus compositarum.* I am indebted to Mr. H. L. Viereck for these and other determinations of species.

there is no temptation to inconstancy, for there is more than enough for all comers. Did Thomas Moore have some such case in mind, or did he simply draw upon imagination, when he wrote his familiar verse:

> "The bee through many a garden roves
>   And hums his lay of courtship o'er,
> But when he finds the flower he loves
>   He settles there, and roves no more"?

It is a pretty emblem of constancy, indeed; but one must needs revise the poet's facts. The bee never "settles" among the flowers. It is a rover always, except that now and then an errant male will lodge for a night in a convenient blossom; a dainty place for camping-out, one fancies—for a bee! Our golden-rod Andrena is an autumn wanderer; but her family, for the most part, are out early in the spring, and complete their flitting season in forty-eight days. Here at Brookcamp a large colony appeared (1906) in mid-April.

The burrowing bees are commonly ranked with solitary insects. Certainly they are not "social"—*i. e.*, living in organized communities, like honey bees. But one might venture to call them "neighborly insects," for they love to make their cavernous hermitages in well-peopled neighborhoods, like the monks of the ancient Thebaid. Their burrow-sites are preferably upon hard, dry spots, sandy or loamy, sparsely covered with grass, and with a bit of slope, maybe. Therein the mother will sink a tubular shaft eight or ten inches deep and about a quarter of an inch wide. On either side of this she will dig out small, ovate cells, five or six in all, which she duly lines, provisions, and supplies with an egg apiece.

A striking diversion from the general habit of the group has been noted by Professor Kellogg, of Leland Stanford University, in a California burrowing bee (*Anthropora Stanfordiana*) which makes its side galleries a series of branching cells, each like the typical nest of Andrena. Instead of sealing up and provisioning these cells, leaving the larvæ to feed themselves, she passes to and fro in the open burrow, bringing her offspring food, a curious appropriation of the habit of the social wasps.

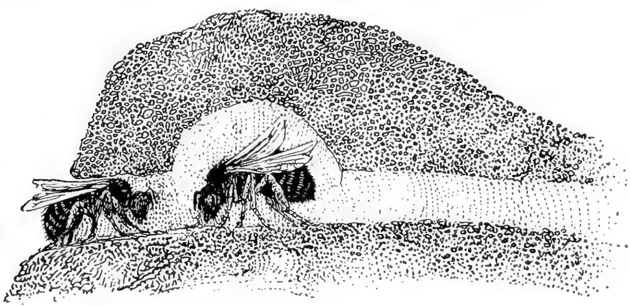
These "neighborhoods" of burrowing bees sometimes consist of hundreds of separate nests, in one recorded case of nearly two thousand. One easily sees that it is no light task to dig out and deport the quantity of soil required. There is at least one record of an ingenious miner who eased her toil by bringing moisture to soften the soil. But the records do not show that this rare development of genius has been transmitted.

It has often befallen the author in his study of insect and aranead life that the rarest finds were made on well-worked ground and at his very doors. He was not surprised, therefore, that one of the most interesting stories of these apian troglodytes should have been written lately of one that inhabits Wood's Holl, Massachusetts, a summer headquarters for naturalists.[1] *Halictus pruinosus* Robertson, is a brilliant greenish bee, a third of an inch long, that ranges from the Atlantic coast westward to the Rockies. In the early summer the workers begin to drill their burrows in sandy slopes by the roadside, and by September their neighborhoods are closely settled. The openings are several inches

[1] *Guests and Parasites of the Burrowing Bee Halictus.* By Axel L. Melander and Charles T. Brues.

apart, but the drifts sometimes cut closely to one another. One wonders what the effect might be should they chance to intersect, and whether their subterranean worldlet may not witness strange happenings "i' the imminent deadly breach."

The burrows are about the bigness of the occupant, and extend inward for a foot or so with sundry enlargements, after the fashion of their kind, wherein the young are bred. In the height of the season these bee neighborhoods are the scene of a busy life. The air resounds with the hum of wings as the insects fly to and fro on parental duties bent, plenishing their nurseries with pollen and honey-of-the-flowers. But just inside each burrow gate an interesting phase of insect life goes on. Beyond the gateway, which is about the length of the bee, there rises a vestibule, a tiny expansion of the



MALE OF *HALICTUS PRUINOSUS* ADMITTING THE FEMALE TO THE GUARDED BURROW

burrow, whose use soon appears. Just within the gateway, with face towards the opening, one of the housekeepers, now the male and now the female, but oftener the former, keeps constantly on guard. And great need there is for such sentry-duty, for insect rogues and thieves besiege the doors to plunder the contents of the nurseries or infect them with parasitic eggs.

Here, then, we see the male on sentry-duty, his body blocking up the gateway and his rounded head closing up the entrance. When his mate comes home with her bee-basket full, the guard backs into the vestibule, which is large enough to allow the passing of the female, and returns to his post. A loving welcome awaits the incomer, for the door-keeper, with open mandibles and waving antennæ, the apian style of embrace, greets his partner right joyously. Thus the good mistresses of our homes, and their maids at the back gate, are not the only order of housekeeping creatures that exchange kisses at one's doorways.

But other sorts of greeting are seen at these portals. The velvet ant (*Mutilla Canadensis* Blake), a beautiful but dangerous neighbor, besets the Halictus gates. If a female chance to be on guard, she rushes forth and pluckily grapples with her great and vicious intruder. A rough-and-tumble fight ensues, from which Halictus-madam often, though not always, escapes. But her home-coming now is not so heartily greeted as afore. Her tussle with Mutilla has left some hostile taint upon her person which, although she has tarried to preen herself, her nest-mate at the gate perceives, and holds her back until, after due inspection, her identity is made plain. Should the male chance to be too slow in coming to a decision, the overtired female will thrust the sting-clad abdomen into the door, as much as to say: "See! Do you not know the sight and scent of your partner's weapon?" The argument is always conclusive.

The male, whose discretion overtops his valor, has an odd way of meeting these intruders when he is on guard. He turns tail, and pushes the point of his abdomen into the opening, an effective though seem-

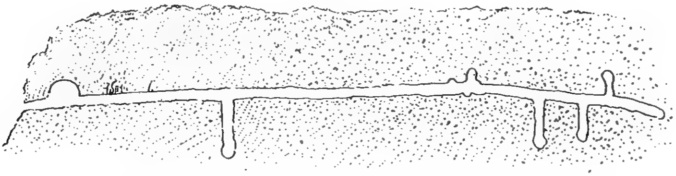
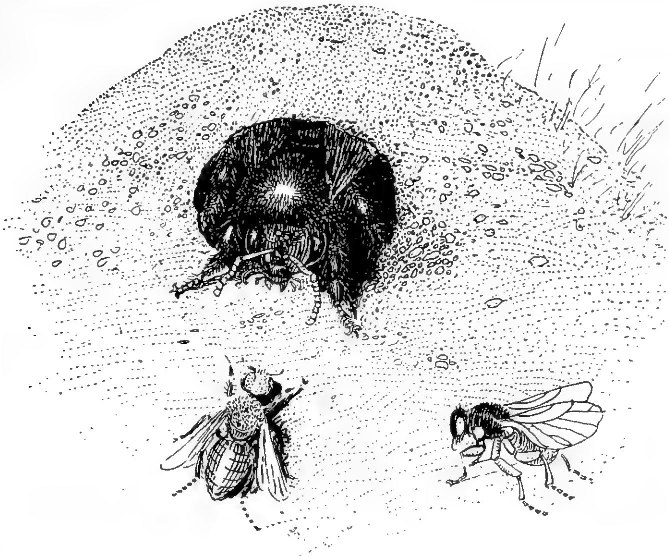


DIAGRAM OF THE NESTING BURROW OF *HALICTUS PRUINOSUS*, A SOLITARY BEE

ingly not a valiant mode of defence. But, indeed, Sir Halictus is not to be blamed, for nature has denied him the fighting weapons with which the female is endowed; for in this sphere of life of which we are writing real Amazons are the rule, not the exception.

One of the most dangerous and annoying of the Halictine foes is a small parasitic fly, *Phora cara*. This insect, on maternal duty bound, following the same instinct that sends the mother bee to the flowery fields, loiters at the Halictus gate. Now comes thither the burdened bee. She pauses a second at the door to pass the marital sentinel's challenge. It is enough! That pause is fatal. Swiftly the dipterous ovipositor thrusts a parasitic egg into the pollen mass, and the mother herself bears to her offspring's cradle the germ of death. So goes on to-day, and day by day forever, the old story of how the Trojans themselves brought into the walls of Troy the armed destroyers of their town!

To these alien parasites one must add sundry species of guest bees, who rear their offspring at the expense of the hard working Halictus and Andrena. They bear the popular name of "cuckoo bees," and fittingly, since they image on a smaller scale the habit of that rather disreputable bird to foist upon nobler birds its eggs, the offspring from which grow up to oust its mates from

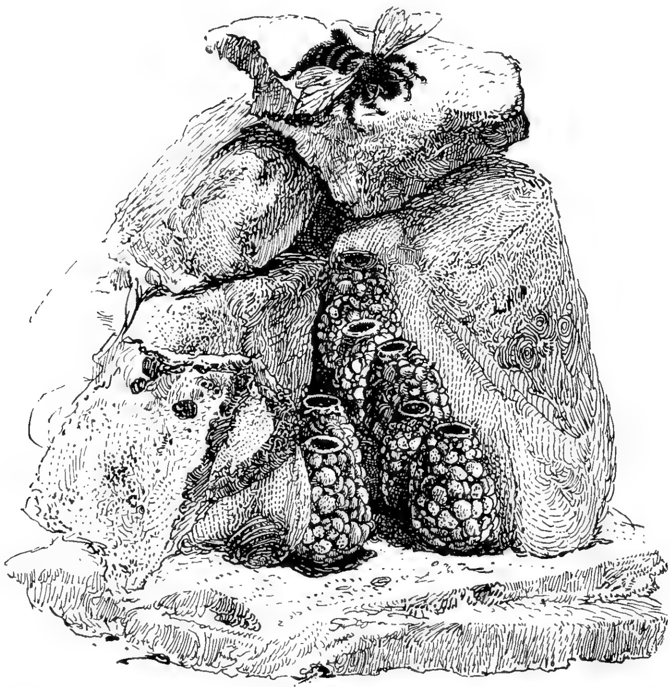


MALE HALICTUS BEE GUARDING HIS BURROW AGAINST *PHORA CARA*, A PARASITIC FLY

their own parents' nest. But, for that matter, one might get quite as apt a name from the annals of our own race, and not go far afield. Cuckoo habit, indeed, runs through the whole octave of living things.

The cuckoo bees, many of which belong to the genus Nomada, have the grace to live on good terms with their hosts, and may be seen in the adult stage, sipping nectar from the same flowers or droning their peaceful cadences around the same nests. But they are robbers, quite the same. They steal into their neighbors' homes and drop their eggs within the cells. When the larvæ appear they feed upon the pollen-mass prepared for the young Andrena or Halictus. It would seem that there is, for the most part, enough bee-bread for the families of both the host and the guest, which is no credit to the robbers, and that the young live peacefully together, which, perhaps, may be reckoned a virtue, as virtues go among cuckoo bees.

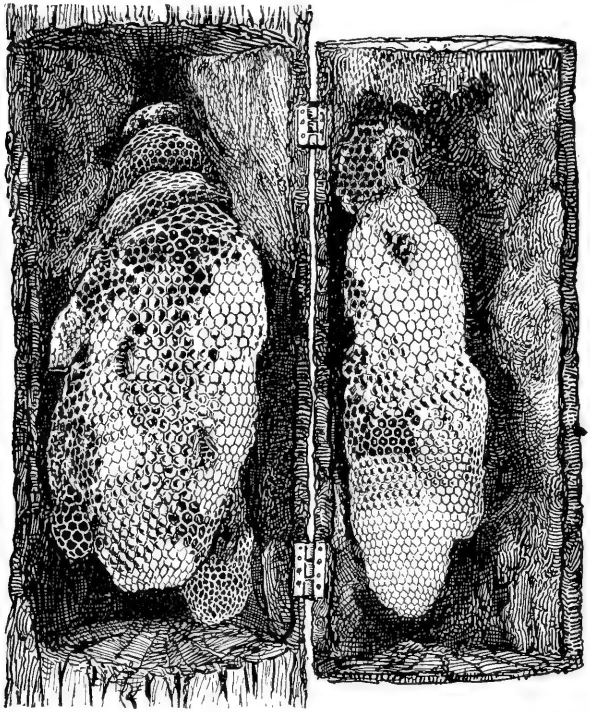
Another form of nest-architecture among these soli-



MUD-PELLET CELLS OF A MASON BEE (OSMIA) BUILT IN A STONE-HEAP tary workers is that of the mason bee, whose habits are well represented by members of the genus Osmia. She reminds one of the well-known mud-dauber wasp in her way of working. Her brick-kiln is a convenient bed of soil, and, if it be moist, so much the better. But if not, a bit of earth the bigness of a small pea is rolled between her jaws and moistened by saliva as it is rounded into shape. Thence the pellet is borne to the spot chosen for a building-site. That has a wide range of diversity — the under side of a stone, an abandoned insect burrow, a bit of decayed wood, the open space between bricks or stones in heaps, even a deserted snail-shell. Here the mason begins to set in a ring her well-kneaded mortar pellets. Fore feet and mandibles place and shape them, and they are kept plastic by saliva. Round after round of these mud-pats is placed, intermixed with wood scrapings and tiny pebbles, all firmly cemented together, until a jarlike cell is made. The outside is left as laid down, but the inside is smoothed, and then provisioned in the usual way.

"And here," remarked our bee-hunter, interrupting the flow of discourse, "is a honey bee—and another! Do you raise bees?"

No; nor any of my neighbors. The nearest beehives are in the village, a full mile away. But who knows? It is a far wanderer, this *Apis mellifica.* And when it was first brought to our shores and became thoroughly naturalized in America, it soon learned to look out for itself. Perhaps these are the descendants of some of the wild bees of which our fathers and grandsires used to tell us as inhabiting hollow trees on the verge of our native forests. In those days wild honey was one of the few luxuries that pioneers could indulge in, and to



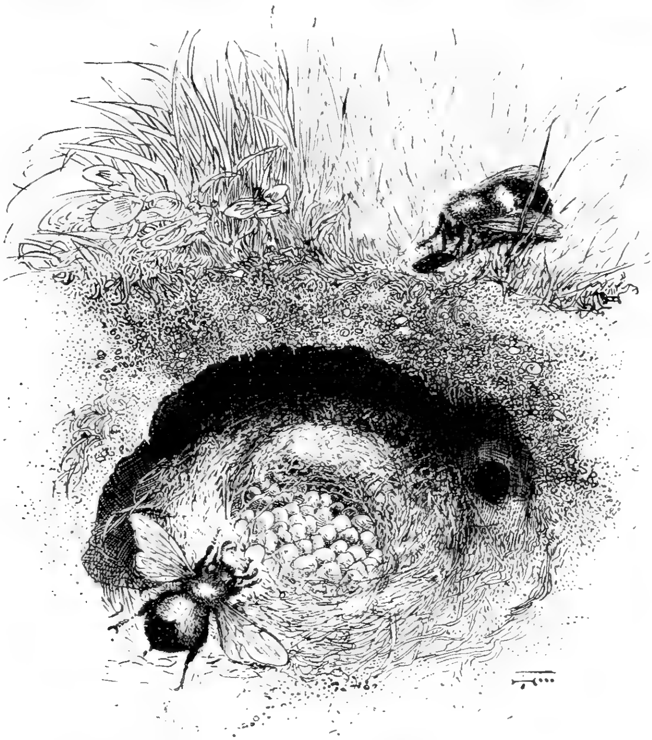
SECTION OF A WILD-BEE-TREE WITH HONEYCOMB CLINGING TO THE INTERIOR

From a specimen in American Museum of Natural History

them a "bee-tree" was a fair godsend. Like the bee, man has always been a searcher after sweets. Witness the Bible story of Jonathan, the princely friend of David, who was tempted to disobey orders by the wild-bee honey in the clefts of the rocks. Indeed, one might go further back to the wild bee's nest that Samson found in a lion's skeleton. The race of wild honey bees has by no means passed away, although bee-trees are rare finds now save in our most unsettled parts.

But that they still exist one may see for himself by visiting the American Museum of Natural History, one of the noblest possessions of New York City.

Hark! The call to the mid-day meal sounds across



CAVE NESTS AND CELLS OF THE BUMBLEBEE (*BOMBUS VIRGINICA*)

the fields of golden-rod. The dogs know it as well as we, and are prompt to lead the way homeward. They have enjoyed the excursion, at least the beginning of it, and they are good companions save that they are over-forward to push their noses into affairs and thus disturb conditions. Moreover, they snap at the bees and wasps as though they felt called upon to share in their master's hunting. But they have grown aweary of such tame sport, and have been lying in the tall grass watching us with apparent wonder and a disgusted air, as though puzzled at the methods of those superior creatures, their masters. Poor dogs! Our ways must indeed seem to them a bit peculiar, and our unreasonableness (from their stand-point) most vexing. Such a way of hunting, for example!

"And here is our last capture for the day," quoth Mr. Four, as he swept a bumblebee into his net. And rarely interesting fellows are these children of Bombus. We look upon them more complaisantly since Charles Darwin taught us that we owe them the heart's-ease and the red-top clover. Indeed, let men remember, when they make up their balance-sheets in account with nature and her wild children of the insect world, that without them the life and infinite variety and beauty of plants would not have been achieved.

So ends our field-day, with thirteen species of bees to our credit, and our wild-bee hunter's promise is more than made good.

CHAPTER XI

BURROWING AND CARPENTER BEES

A FIELD-DAY in search of wild bees gives one good proof that they live in great numbers in our rural parts. Here are thirteen separate species representing eight genera taken in a few hours' ramble in the fields of Devonside. It is not difficult to capture them with an insect-net; but to find their nests is often a matter of good-fortune, and to discover their habits is an enormous task. Yet it has been done; and well does it reward the patient entomologist, who, in turn, richly endows his readers with rare and interesting facts.

For popular guidance, our wild bees may be thus roughly grouped around their social characteristics. First are the *social* species, like the bumblebee and the bee-tree honey-maker, that live in communes; second, the *neighborly* species, like the burrowing Colletes and Halictus, that keep each to a separate domicile, but group their nests in neighborhoods; and, third, the *solitary* species, like the leaf-cutting Megachile and the mason Osmia and most of the wood-working or carpenter bees, who live a strictly hermit life.

These, again, we might broadly divide around their nest-making habits, first, into those that place their brooding-cells in burrows dug in the ground or bored in wood; second, those that fashion their brooding-cells from clay or woody composite, and fasten them upon various objects, as do the "potter" bees and the "cottoniers"; and, third, those that, like bumblebees, are opportunists, and avail themselves of some fitting natural site which they may adopt and in a measure adapt for a domicile. Even such a popular grouping as this will give one a general idea of the vast range of varied habits which entomologists have undertaken to explore and describe.

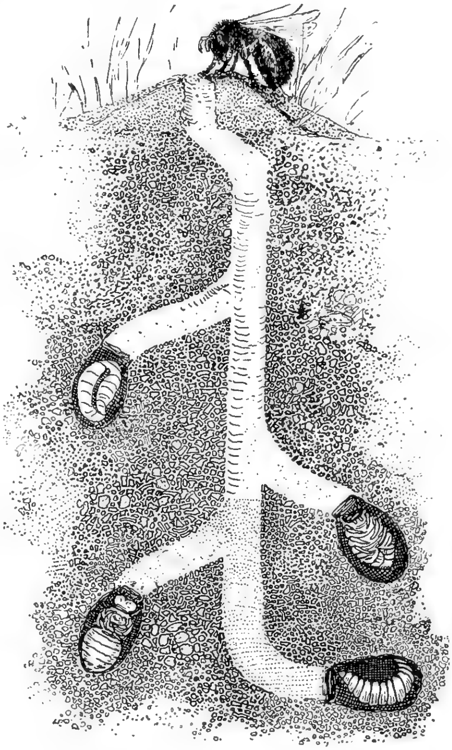
Some most valuable observations of burrowing bees have lately been made by Professor J. B. Smith [1] on three of our Brookcamp genera—Colletes, Andrena, and Augochlora—which he studied in the pine-lands of New Jersey. There he found the adults creeping from their winter-quarters and beginning their work as early as March 12th. Here, at this season (March 22, 1906), with the snow lying deep upon the fallow fields in which they gleaned last summer, the boldest bee pioneer would not venture an ascent. As the Jersey pines are also in the grip of Jack Frost, one may safely predict that there are now no bees abroad even there. But it was a favored year in which our naturalist made his studies, and the burrowers broke from the ground before the spring solstice. Such conditions supposed, their life-record thus runs:

At once the females begin to dig perpendicular burrows into the compact sand and clay. A moundlet of moist pellets gathers about every entrance, which, in that sandy soil, soon dries and is blown away. Down, down the burrower goes—a foot, eighteen inches, two feet, twenty-eight inches! Then she bends her shaft

[1] New York Entomological Society, *Journal*, 1901.

a little to one side, rounds out the end, and spreads upon it a mucous secretion that hardens into a pouch-like lining. This is her brood-cell.

She has pierced the soil at the rate of about five inches a day, subject somewhat to the fickle weather of the season. Meanwhile her toil is lightened by marital visits, as the male seeks his mate in the privacy of her subterranean quarters. And now the cell must be duly charged, so away the expectant mother flies in search of pollen and nectar. Where she finds these at that border season of the year has not been discovered. But the bee has a sharper eye and a keener scent than even a naturalist; and duly her brooding chalice is half filled with a pasty mixture of pollen and honey, and covered with a parchment-like seal.



BURROW AND BROODING-CELLS OF A BURROWING BEE (*COLLETES INEQUALIS*)
The bottom of the burrow is filled with sand

Thence Colletes ascends her shaft, and begins from its opposite side a lateral drift. This is pushed to a distance of from two to six inches, and, with its terminal pouch, becomes the nursery of another larva. The sand removed from this lateral (and so also with the next) is dumped into the shaft, quite filling it and covering over the brood-cell. This, of course, lays upon the resurgent beeling the burden of digging its way to the top through the overlying sand. But it has an important defensive office.

The sheltering bosom of mother earth is the refuge and nursery of multitudes of insects, chief among them the ubiquitous and inquisitive ants. And most of them, like the ants, have a sweet tooth. Fancy, then, what an attraction to this subterranean horde must be those sealed vases of apian honey-paste, with their tender and juicy larvæ, themselves a sort of vital confection? Here, indeed, is "treasure hid in a field"; and were it not for the maternal act by which, consciously or unconsciously, it is so carefully "cached," there would be scant likelihood that the race of Colletes and her kind would continue upon the earth.

July finds the larvæ full grown and ready to pupate; and even before that the adult bees have disappeared from the fields or become exceeding rare. After that —what? Their history lies, as yet, in mistland or in mythland. Do the young bees mature and bore their way out to the flowery fields until the frost warns them to their caves? or, which is far more likely, do they keep to their cells the winter through and ascend in the coming spring, true children of Proserpina? At least, our field-day with the wild-bee hunter proved that some Colletes, both male and female, linger among the astersand golden-rods in mid-September.

A naturalist, in his narrower field, continually falls upon experiences like that of Columbus, who, while searching for the Indies, found a new world. For a year the vicinage of Brookcamp had been vainly explored for a settlement of burrowing bees. One mid-April morning (1906), while passing, on another errand, a fallow field hard by our very gate, lo, the flutter of wings above the withered grass, and there lay the object of our long search!

On the low bank of the roadside rose a crowded "neighborhood" of yellow tumuli of fresh clay pellets, each pierced with a circular tube the bigness of a lead-pencil.

A SECTION OF A BEE-TOWN OF *COLLETES INEQUALIS*

Like a Western mining-village, our "bee-town" had sprung up literally in a night. The bees had evidently just emerged from the ground wherein the winter had been spent, and on the bright spring morning were sunning themselves at the mouths of their burrows, which rise in tiny mounds in the shape of truncated cones.

Two hundred and more of these moundlets were scattered along the marge of the field by the cross-roads. From many of them protruded the furry heads and shoulders of the gray bees (*Colletes inequalis*), about the size of our common honey bee. The mounds were quite uniformly about an inch high and one and one-half inch at the base, thence slightly tapering to the top. Here and there two burrows came so closely together that the mounds interblended.

The bee-town occupied a strip of seventy-one feet along the north side of Chester Road, thence along the west side of Fairfield for fifty-six feet, and stretching inward for from fifteen to twenty feet. Within a triangle whose sides were eleven feet and base ten feet long, ninety-six nests were counted. In another strip, ten feet long by three wide, there were seventy-six. These were the most thickly settled sections, and give one an idea of how many of these insects, for the most part unobserved by passers-by, escape the rigors of winter and the perils of lurking subterranean foes, and emerge from their catacombs into the sunlit upper world.

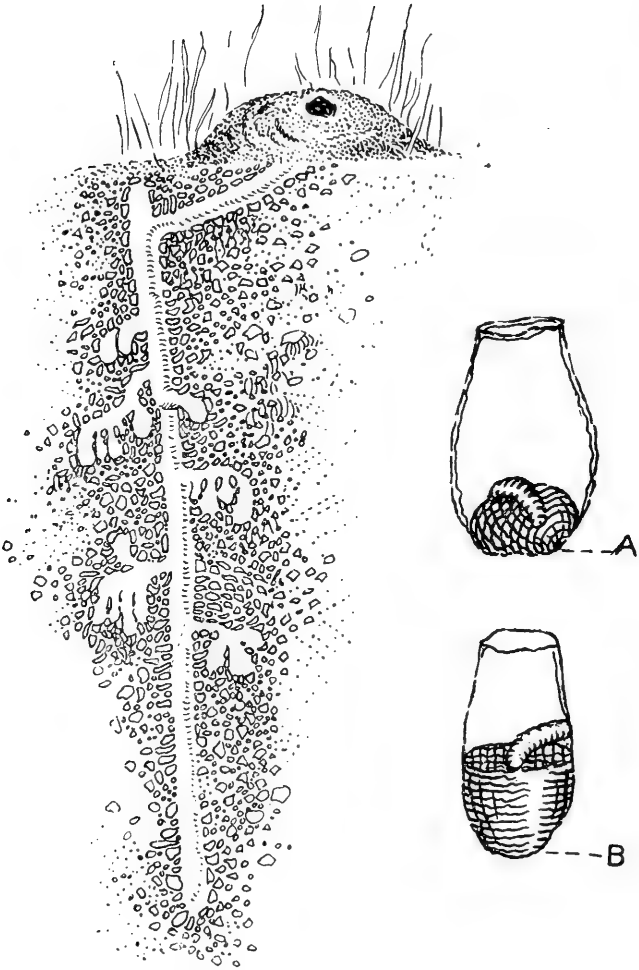
As the day advanced and gathered warmth, many bees were found fluttering over the blossoms of neighboring trees, foraging for pollen and nectar. At that season (April 16–20th) the trees seemed to be the chief sources of supply. A number of the burrows were preserved by plaster casting, and thus the work of Professor Smith was verified.

These facts concerning Colletes are even exceeded in interest by the habits of the blue digger bee (Augochlora), uncovered by Professor Smith and his efficient collaborator, Mr. J. T. Brakeley, who had the advantage of a summer residence upon the field. This bee is a brilliant metallic blue in color, and spends practically all its life under ground. The remarkable burrowing power of Colletes is doubled by Augochlora, for one tunnel was found over five feet deep!

Mr. Brakeley, intent upon comparing the relative working powers of a human athlete with those of this insect, put the matter thus: A blue bee weighing less than one grain will dig a hole double its own diameter sixty-four inches deep. How much ought a college athlete weighing (say) 185 pounds or thereabouts, with a diameter of two feet (more or less), be able to burrow without tools in order to equal the blue bee, weight for weight? His answer is, a tubular tunnel 1295 miles deep and four feet wide! And that is only half the just estimate, for when it was made it was not known that the bee really makes two similar burrows during its life; moreover, no account is taken of sidings for the cell clusters, which largely increase the labor.

The entrance to the blue bee's nest is always under some bit of natural protection, such as a tuft of grass or moss or lichen. Hence, by a short arm, the burrow runs obliquely to the main shaft. In carrying her diggings, the little miner squeezes the released pellets against her breast and abdomen, then carefully creeps upward to the entrance and dumps her load literally by a somersault. This leaves her with head to the gate, and, without the delay of turning around, she hurries down to her task. Meanwhile a low moundlet grows around the entrance.

Her cells are made in small clusters, of which the central one and sometimes others are converted into nurseries; but commonly these are surrounded by



THE BURROW OF AUGOCHLORA

A. Brood cell of *Augochlora* with egg upon the pollen leaf.
B. Brood cell of *Colletes* with egg upon the honey paste. From nature.

empty cells, as though to insure greater safety to the young. The nurseries are barrel-shaped, about three-fourths of an inch long, clay-lined, and smooth inside; the larval food is a round pollen loaf, dry and compact, and the bottom cells are not covered with dumpings from the upper laterals. There are marked differences from the single brood-cells of Colletes, with their membranous linings and pasty larval store, although in general structure they agree.

There is another point of difference. The blue digger bee has the odd habit—as it seems to us—of closing up its door while at home and leaving it open when afield. One would think the reverse conduct would be better, since the contents of the cell would appear to be safer from all sorts of depredators when the mother is at home, and therefore she would have less need to put up the portcullis. It looks as if the danger she guards against is rather to her person than to her progeny.

The mature Augochloras commence to break from their native burrows and at once begin to dig their hibernating burrows. Only a week or ten days of its career is given to sunlight and flowers, a revolutionary fact in one's idea of bee life.

The author knows by many fruitless and some successful experiments the patience, time, and immense labor required to study accurately the burrowing habits of insects and spiders. The chief difficulty lies in the constant crumbling of the soil and breaking-down of the structure. Mr. Brakeley overcame much of the difficulty and assured a larger success by the ingenious method of pouring liquid plaster into the holes. He used fine dental plaster, well mixed, ounce for fluid ounce, with water. This preparation found the bottom of the deepest burrows and searched out the sidings, with their brood-cells. The liquid hardened in a day or less, giving a nearly accurate cast of the bees' entire domicile. But even with this admirable contrivance there was enormous labor involved in digging the necessary trenches—in one case over five feet deep—and their approaches of several feet to the casts. As these were fragile by reason of their small size, there was not only much work, but great pains and patience, required in getting them out. But this is the price that every naturalist pays, and gladly, for every real success.

A curious variation in the habit to which the maternal impulse urges insects is seen in solitary bees of the genus Anthridium. Their brooding-cells are small detached cylinders of the general type, but are protected in a way that strikes one as more in harmony with our notions of proper bee behavior. We are apt to associate bees with flowers and plants; and, although that fancy has been shaken somewhat by the facts of their history, it still seems natural that they should go to plants and flowers for household furnishing. Thus we quite approve the industry of the mother Anthridium, who finds in the vegetable world an ample storehouse for her babies' needs.

The older entomologists knew how she gathered the down from woolly plants and blanketed there-with her brooding-cells. We can still share the pleasure with which White, of Selborne, as told in his delicious notes on natural life, watched the address with which Anthridium stripped off the down, running from the top to the bottom of the branch and shaving it bare with the dexterity of a hoop-shaver. We can catch up from afar the echo of the good man's joy as, with radiant face and mayhap unclerical haste and mien, he follows the deft upholsterer as she flies away with her bundle, almost as big as herself, "holding it secure between its chin and fore legs."

Our knowledge of Anthridium's manners leaves her substantially where her first observers found her. However, of the five or six hundred species in the world (according to Dr. Henry Friese), although two hundred and twenty have been described, the habits of twenty only are known. More than forty described species are North American, of which the habits of less than half a dozen are known. What a field is here before some enterprising young entomologist! What possibilities of new discoveries lie within this unknown realm! Bees (and other insects, for that matter) are such conservative bodies that one may look for little change in the two characteristic methods of nest-building which have fixed upon them the general names of "Cottoniers" and "Resiniers." But around these will doubtless run a great variety of differences.

The American species fairly represent the better-known habits of the European. The Cottoniers are opportunists in their nesting sites, choosing with apparent indifference an abandoned burrow of other insects, a hollow plant, a depression in the ground, or even a key-hole! In all these cases they protect their brooding-cells with a cottony composite rasped by their toothed jaws from the stems of downy plants. Cresson's *Anthridium illustre*, as reported by Mr. S. Arthur Johnson,[1] from a clay-bank at Denver, Colorado, con-

[1] *Entomological News*, October, 1904.

structs her cylindrical nest, four-fifths of an inch long, from the white down that covers a local gall or the brown, hairlike tufts on certain composite flowers. The cells are thus white or brown, varying with the bee's gleaning, and they are placed end to end in the abandoned burrows of mason bees with which the bank is honeycombed. Commonly there are two to four cells in a burrow.

Cresson's Texan Anthridium (*A. Texanum*), as described by Mr. Melander,[1] is one of our American "Resiniers" species that bind their nests together with the aid of the resin of various conifers. Texanum's nest was fastened to a branch of cedar about eight feet from the ground. It was a small, rounded conglomerate averaging about four-fifths of an inch in diameter, composed of minute limestone pebbles, cemented together with an amber-colored resin presumably taken from the cedars. In this mass were six cylindrical pupal cells, wrought of a tough, brownish, translucent membrane, showing the pupæ within. The first two bees emerged May 16th, and immediately crawled back into their cases head-first. The next transformed on the 19th, the fourth and fifth on the 25th, and the last, a male, on June 4th. Each imago followed its leader by crawling back head-first into its empty pupa-case. In getting out they appear to have eaten the flat end of their envelope.

The habit of wild bees to prepare cartridge-shaped cells in which to rear their young runs through many species. Vast numbers of solitary bees, as we have seen, burrow in the ground, and therein prepare and

[1] *Contributions from the Zoological Laboratory of the University of Texas*, No. 12.

provision their brood-cells. Others keep substantially the same general habit of disposing of their eggs, but transfer their industry from the earth to wood. These are known popularly as "carpenter bees." They number some small species (the Ceratinidæ) and some very large ones, indeed, the largest of our native bee fauna, the Xylocopidæ.

The Ceratinidæ include some small, smooth-bodied species with metallic green or blue coloring. They may be found abroad in mid-May. They seek their breeding-homes in pithy shrubs, as elder, syringa, blackberry and raspberry bushes, and field asters. Removing the pith from the stalks, the little mother makes therein a cell about half an inch long and a third of an inch in diameter, provisions it, drops her egg, and seals it with a silklike enclosure topped with a thin, mud composite. Other like cells follow until a connected series of three or four is formed.

It seems a wide step from these creaturelings and their tiny borings in slender stalks to the huge creatures of our tropical and semi-tropical regions that remind one of humming-birds as they fly abroad. Yet there is little difference in their general habit; and all contribute, though in different degrees, to at least one great purpose in nature. They hasten that process of decay by which the waste growth of field and forest is reduced to dust and goes to form and enrich an arable soil for man and for living things.

The best-known of this group of carpenter bees is *Xylocopa Virginica.* It is widely distributed throughout the United States, and by its size and persistent borings in the porches and out-houses of our rural homes is sure to attract attention. When summer days grow warm and animated nature is astir, one may see the mother carpenter bee hovering around old fences or the dead limbs of trees or projecting bits of buildings.

"There is a bumblebee!"

One often hears that exclamation as the carpenter flits by. There is some excuse for the mistake, for she is even larger than that famous cave-dwelling Bombus,

MALE AND FEMALE CARPENTER BEE (*XYLOCOPA VIRGINICA*) whom most country lads have pursued with wisps of hay over many a meadow in harvest-time. But her habits are quite different, as we shall see.

Let us follow this mother-bee, who is plainly upon a house-hunting excursion. There she goes towards the old barn. She flutters about the cornice, now in view, now out of sight. Will she settle there? It is a fine site. A nest was located there last summer. Perhaps she was reared therein. If so, it would be nice to get back to the old home quarters! No, she is off! The place is pre-empted. A more enterprising house-hunter has been before her, in the shape of a mud-dauber wasp, perhaps. It is hardly worth while to quarrel over the premises with such a vixenish squatter, especially when good building sites are going a-begging everywhere around.

Away, then, flies my lady Xylocopa to the orchard, which is surrounded by an old-fashioned rail-fence. Here is a thick rider astride two pairs of tall, crossed stakes, to which our explorer pays particular attention. She has found a vacant house, and is taking possession. She has disappeared within the vestibule that opens on the under surface of the rail. What a commotion she makes inside! As you approach your ear to listen, out she comes in a fluster, almost flying into your face.

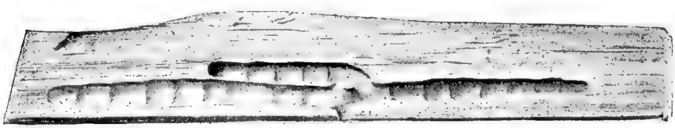
Following close in her wake is another bee whose angry buzzing and excited motions give to ear and eye that warning of apian wrath which the wise heed well and the ignorant pass by and are punished. Here, too, is an ancient bee-ranch which an earlier comer has occupied and is busily enlarging, as one may see by the woody pellets that dust the lower rails and lie in a little heap on the grass below.

Our house-hunting carpenter is not discouraged. Perhaps she knows that such disappointments are part of the natural life of dwellers in beedom, and are to be taken good-naturedly and as a matter of course.

At least she is off again as though nothing had happened, and this time heads for the farm-house. There is a railed balustrade around the porch, above which twines a honeysuckle-vine. Here at last our Xylocopa stays her flight, and, creeping underneath the gray, wooden hand-rail, begins the serious business of her life. Having given up the plan of planting her new colony in an old and abandoned settlement, she has started work upon a fresh site.

It will be an all-summer task, so we may as well sit down on this rustic bench and watch her. With her strong-toothed jaws she bites out a bit of the yellow pine, which she drops upon the floor. Another and many others follow in rapid succession, the bee revolving, as she works, upon her six feet, until she has gnawed a shallow circular concavity in the wood, while the pile of fragrant pellets beneath grows apace.

There we may leave her. It will be tedious to watch her further, for a day or more will pass ere she can open



DOUBLE BURROW OF CARPENTER BEE

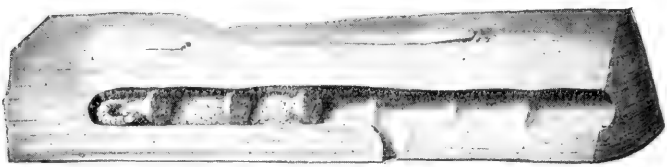
up the vertical tubular vestibule, about an inch long, that shall serve as the approach to her nest. This done, she will turn at a right angle thereto and strike the line along which, following the grain of the wood, she will rasp out a new tunnel in which to establish her household.

The tunnels of the carpenter bee are straight, cylindrical tubes, cut out quite smoothly, about one-half inch in diameter, or a little longer than the bee herself. Sometimes, in the case of re-used tunnels, the tube will be longer, having been widened, probably, to get material to form the cell portions. The longest tunnel I have measured, shown on page 176, was sixteen inches, and there was a branch five inches long. The main tube was three-fourths of an inch wide, and the vestibule a half-inch long. Judging by the ringed elevations that marked the locations of the cell partitions, nineteen cellfuls at least had been reared in this nest, which had doubtless seen several summers' use, and there were six cells in the branch.

The bee, of course, works with her head inward, and throws the gnawed pellets behind her, like a dog digging after moles or ground-hackees. When the tunnel is finished, she marks off a section about her own length and places therein an egg, and adds a piece of bee-bread, which fills up about half the space. Then she closes the section with a solid, circular partition, slightly concave on one side. This is made out of the sawdust gnawed from the tunnel, mixed with a glutinous secretion or saliva, which hardens and forms a sort of wood composite. The section thus sealed up is a breeding-cell. This done, the mother fits out another similar cell in the same manner, and adds cell to cell until her quota is filled, which will be half a dozen, more or less.

The eggs thus deposited become in due time small larvæ that feed upon the pollen bread with which the cell has been provisioned by the mother. They eat and grow until they have reached full size, when they change into full-formed insects.

After maturing, the young bees cut themselves out of their cells in the order of nearness to the vestibule and door, and begin their open-air life. A great change, indeed, it must be for the little fellows—from their dark, cramped quarters to the bright sunlight and the free, busy life of a winged insect coursing the summer air.



BURROW OF CARPENTER BEE, WITH PARTITIONS, BEE HEAD, AND ONE LARVA IN SITE

They enter at once upon the round of duties pursued by their mother and by their ancestors. Unlike human beings, who have to go through a long stage of schooling and training, they do not have to "learn the trade." They are born carpenters. Without teaching and without the hints one gets from seeing others at work, they turn to their task and carry it through successfully. What a convenience this must be! Our bee brothers certainly have some advantage over us.

The bee-carpenters always carry their "kit" with them. Nature has provided them with powerful jaws, or "mandibles," armed with sharp, tough teeth, and operated by muscles of great strength. These are their tools, at once axe and chisel and saw. They are palm-shaped, and hollow within, like one's hands; thus the bee can squeeze together the pellets of wood cut out by the jaws, as the boy presses a snowball, in order to form the hard, circular partitions between the cells.

Their legs are armed with stiff clumps of hairs that serve as brushes or whisks to clean out the sawdust from the tunnel. These hairs also form the well-known "bee basket," in which the pollen is gathered and carried to the cells to feed the hungry little larvæ or beelings when they are hatched from the egg. On the whole, Dame Nature has given Xylocopa a rather snug outfit for her work, and, moreover, has taught her how to use it well.

The home of the carpenter bee is, for the most part, in the country or in the rural sections. But sometimes an adventurer wanders into the city and sets up house-keeping in crowded streets. One day a carpenter—carpenter man, not bee!—rang the door-bell of my manse, and handed in a bit of pine-wood, which he said, his "boss had sent to the doctor, knowing that he was fond of 'bugs'!" It was a chipping from a church that the builder was repairing, in the midst of which was a neatly bored nest of a carpenter bee. It had been slit open by the workmen, just enough to show a row of bright, brand-new young carpenters wedged within their cells and separated by the wheel-shaped partitions. There were five of them, pretty fellows, just ready to get out of their cradles. Thus, whether city-bred or country-bred, these famous insect wood-workers have the same manner and skill.

Carpenter bees have many natural enemies. Boys kill them, which is poor business, since the insects do little harm. It would be better to observe what they do, and how they do things, and thus grow wise in the ways of nature. Dogs dislike them; the sharp buzzing of the bee's wings seems to irritate them.

Seated one summer day on a country cottage porch, I became interested in the movements of a Xylocopa that had begun to bore a nest in the wooden rail around the porch. Bobwhite, the collie who lay at my feet, seemed to be equally interested. He watched every motion of the bee with keen attention, and at last made a vicious snap at her as she flew by. He acted as though he had taken a hot coal into his mouth, snorting and shaking his head violently. But the experience did not abate the ardor of his zeal against carpenter bees. All summer he lay in wait for them, for there were several at work around the porch. One, at least, he succeeded in killing—poor thing! Nothing gave him quite as much pleasure as hunting bees. No reasoning and no remonstrance could dissuade him from his prejudice. "Bees annoyed him! He would be annoyed! What right had they to be buzzing and boring round the premises? To be sure, master and mistress didn't mind them; but he did! No, they didn't hurt him, but they annoyed him. He wouldn't stand it; and—snap!" So Bobwhite seemed to argue.

The male of Xylocopa deserves a brief notice, although he has nothing to do in the family economy. Like the Indian warrior—and, indeed, like all men in their savage state—he leaves to his female all the work of establishing the household, and of building the house as well. Beedom is a matriarchate, not a patriarchate; and so, indeed, is the whole insect world. Those qualities in insects that may be counted the analogues of virtues in men, as parental love and care, family and communal devotion, industry, patriotism, self-sacrifice, even to the offering of life, are confined to the females. However, Monsieur Xylocopa is more gayly clad than his mate, having a bright patch along his back and a creamy front which has given him the popular name of "white-face" among country-folk. He is harmless, too, and many a knowing boy has won a reputation as a hero among city lads and lasses by handling "white-face" without gloves. One wonders if some other reputations have not been as cheaply gained!

CHAPTER XII

AERONAUTIC SPIDERS

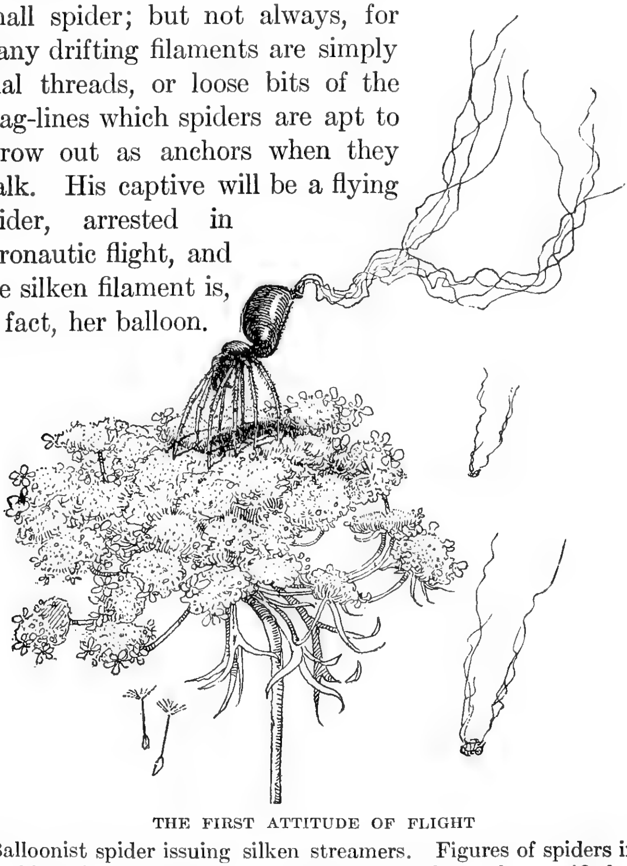
MAN is adapted by nature to move upon the earth's surface. Yet, in fancy, he has always been an aeronaut. Like the Psalmist, he has sighed, "Oh that I had wings like a dove! for then would I fly away." The author never gave a serious practical thought to aeronautics, but the one dream of sleep that persisted for many years is that he could fly! This is a common experience. Such visions of the night have typified the waking dreams of the race. Montgolfier, with his balloon, made the first practical step towards their fulfilment. Since his day men have puzzled over and planned a dirigible balloon or air-ship.

It is interesting and curious to find a lowly arthropod a close fellow with ourselves in the above experience. The spider, like man, is a terragrade. Like man, she can overstep nature's bounds and move over or through the water. Like man, she has invaded the air and essays to fly; though, also like man, she falls short of directing her mimic air-ship and, in chief at least, drifts before the wind. Moreover, like man, in rare divergence from the habit of lower animals, she does these things, as she gets her food, by the aid of a manufactured implement, and not by direct use of her natural locomotoria. These facts give zest to our study of "ballooning" or, as they are popularly called, "flying" spiders. That an animal which has none of the natural gifts of winged creatures for progress through the air should nevertheless be able to overcome gravity, mount aloft, and make long aerial journeys, is well suited to excite imagination, awaken curiosity, and stimulate research.

Spider ballooning is not limited to any period of the year; but the seasons when it most prevails are spring or early summer and the autumn after the young have been hatched. The fall is especially the time for flying spiders, and October the month most favored. But in early November the balloonists are abroad, notably during Indian summer. Nor is the habit confined to any one group. It is probable that the young of all spiders, and certain that many small species of all the great groups, are more or less given to aeronautics. The infant aranead, when aloof from its fellows and exposed to a puff of air, seems instinctively to throw out its spinnerets and send forth jets of silken filament, just as a human baby sets in motion its hands and feet. As the jets are soon of sufficient buoyancy to counterbalance the spider's weight, the creature becomes an aeronaut, *nolens volens*. One can see how from this involuntary act the habit of ballooning could have been formed, and fixed by heredity.

Let one walk in the fields on a warm October day when a soft breeze is blowing. If he will stoop low and glance along the meadow, his eyes will catch the sheen of myriads of fine, silken filaments. They float from every elevated spot. They fringe fence-posts and hedges. They stream like pennants from tall weeds. They interlace the foliage of bushes with delicate meshes or flutter like ribbons from their tops. These are the ropes and netting of ballooning spiders.

If, now, one will glance upward, he will be apt to see long, white, sinuous filaments drifting through the air, over tree-tops, across streams, far aloft, or perhaps low enough to be within reach. If he will grasp one of these threads he may find in his hand a small spider; but not always, for many drifting filaments are simply trial threads, or loose bits of the drag-lines which spiders are apt to throw out as anchors when they walk. His captive will be a flying spider, arrested in aeronautic flight, and the silken filament is, in fact, her balloon.



THE FIRST ATTITUDE OF FLIGHT

Balloonist spider issuing silken streamers. Figures of spiders in this and following illustrations are relatively much magnified

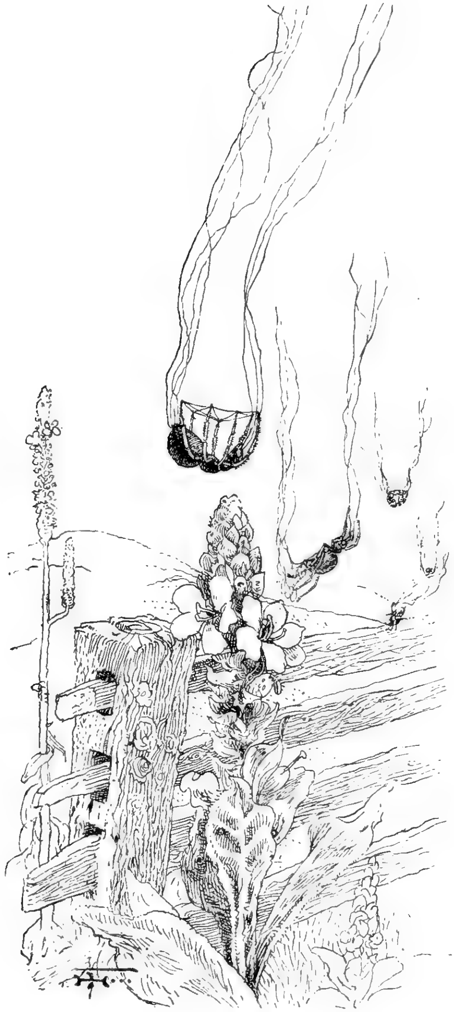
The story of a baby spider's life is most interesting, from its silken cocoon cradle to the final flitting and setting-up for one's self on an independent web. With all stages thereof the ballooning habit has much to do. But let us now suppose that baby life is over. The strong foster-hand of nature is on the young aranead, urging it by the instinct of migration to seek a home in the wide world of yonder meadow. It is a Lycosid—a ground-spider—we will say; yet here we find it on the top of this fence-post, where, with the aid of a pocket-lens, one can watch its movements. Fences are favorite ascension points, and upon them clusters of young Lycosids are gathered. But the bushy heads of tall weeds, the dainty, circular platform of the wild carrot's mosaic bloom, the feathered plumes of the golden-rod, the star-faced blossoms of the field-daisy and the wild aster are requisitioned for their flight by groups of balloonists. The purpose in choosing these elevated spots is plain, for the currents of air are stronger there and the course clearer than close to the surface, thus facilitating flight. A wise volition seems clear in the case of Lycosids, at least, which, being ground spiders, are not found habitually in higher places.

We return to our place of observation, one of the side-posts of the "bars" that form the gateway between two fields. These are let down to allow fair opportunity to follow the aeronaut, when it shall ascend, without the stress and delay of getting over the fence. With back to the sun and lens in hand you may see the mode of ascension. Several younglings are atop of the post and the upper rail near by. You fix your eye upon one. It leaps upward and is off! No; it is back again, like a boy's return-ball. The buoyancy of the thread exuded is insufficient to sustain the animal's weight, and it cannot rise aloft. Other feints, perhaps, will follow, which soon cover the posts and top rails with streaming trial threads.

In the mean time you have noted the spider's attitude preceding flight. It faces the direction of the wind. The abdomen is elevated about forty-five degrees, and at the same time the eight legs, four on either side, are straightened out, and the body thus raised above the surface. At the apex of the abdomen and beneath it are the spinnerets, covered with minute spinning-spools, through which jets of liquid silk are forced from a multitude of glands within the body. These harden at contact with the air, and are held apart or combined at the spider's will, by closing or outspreading the spinning mammals. Keep the lens directed upon the spinnerets of your little adventurer. A ray of several threads is issuing, which, caught by the breeze, are drawn out and upward six, ten, even twenty or more feet. Meanwhile, the legs incline towards the breeze and the joints stiffen. The foremost pair sink almost to the level of the post. All the legs and the whole attitude show the muscular strain of an animal resisting an uplifting force.

Suddenly and simultaneously the eight claws are unloosened, and the spider mounts with a sharp bound into the air, and floats above the meadow at a rate more or less rapid, according to the velocity of the wind. The threads have been drawn out so far that their buoyancy has overcome the specific gravity of the balloonist, and thus she is able to keep afloat.

What is her manner of flight? It may be a long time before the observer shall find examples that give satis-



BALLOONING SPIDERS IN THE ACT OF FLIGHT

The lowest figure shows attitude immediately after vaulting. The highest and largest figure shows manner of floating after adjusting the foot-basket factory answer. Some are caught up into the heavens with so sharp a rapture that they are out of sight at once. Others scud along under so swift a wind that they cannot be followed. But fortune favors patience. Here at last is one that is off before a light breeze, and is hugging the ground at about the height of a man's face. And there, too, goes the man, following her across the meadow at a brisk run, his head turned to one side, his eyes fixed on what seems vacancy to yonder ploughmen, who have stopped their teams to gaze in wonder and debate the question of his sanity! Nevertheless, he has seen something which sane people will be glad to learn.

As the spiderling vaults upward, by a swift motion the body is turned back downward, the ray of floating threads is separated from the spinnerets and grasped by the feet, which also by deft and rapid movements weave a tiny cradle or net of delicate lines, to which the claws cling. At the same moment a second silken filament is ejected and floats out behind, leaving the body of the little voyager balanced on its meshy basket between that and the first filament, which now streams up from the front. Thus our aeronaut's balloon is complete, and she sits or hangs in the middle of it, drifting whither the wind may carry her.

She is not wholly at the mercy of the breeze, however, for she has an ingenious mode of bringing herself to earth. When the human aeronaut wishes to descend, he contracts his balloon's surface and lessens its buoyancy by letting out its gas. The spider acts upon the same principle, by drawing in the filaments that buoy her up and give sailage surface to the wind. Working hand over hand, as one may say, she pulls down the long threads, which, as they are taken in, she rolls up into a flossy white ball above her jaws.

As the floatage shortens, the aerial vessel loses its buoyancy, and at last the spider sinks by her own weight to the field. Thereupon she throws out a silken rope, after the manner of aeronauts, which anchors to the foliage, and the young voyager abandons her "basket" and begins life in her new-found site. This voluntary descent seems to be a rather exceptional experience. For the most part the balloon is stopped by striking against some elevated object.

The above description covers the average manner of the araneal aeronaut. There are variations, of course, one of which may be noted. Some orbweavers, instead of vaulting into the air from a perch, spin against a filament streaming from some elevated object a tiny cone-shaped puff or pellet of silken floss, underneath which they hang until it is twisted off by the wind or cut loose by their sharp jaws. This, with streamers floating fore and aft, forms the little creature's balloon. On a soft October day one may see many such swinging and drifting away from shocks of corn, from clumps of thistles and golden-rod, and from russet patches of blackberry-vines.

Given a steady breeze and a free course, there is practically no limit to the distance which a ballooning spider may traverse. The author has taken orbweavers from their snuggeries under divers sheltering projections at the highest attainable point on the dome of St. Peter's in Rome, whither they had doubtless been carried by the wind when younglings. One may see flecks of gossamer afloat at far greater heights. Seafaring folk often note spider balloons speeding by them at sea or entangled upon various parts of the vessel. Darwin, in his famous voyage of the *Beagle,* when sixty miles from land saw great numbers of small spiders with their webs. When they first came in contact with the rig-

A SPIDER ISSUING TRIAL THREADS FROM A FOOT-BASKET

ging they were seated upon threads, and while hanging to these the slightest breath of air would bear them out of sight. Thus, though so far from land, the wee voyagers were still moving on over the main.

Captain George H. Dodge, of the American Line steamship *Pennsylvania,* told the writer, during a voyage in the winter of 1881–82, of a like observation made by him. While sailing along the eastern coast of South America during the month of March, his ship was covered with innumerable spider-webs. He was then more than two hundred miles from land, about four hundred miles south of the equator. The wind was blowing from the continent. "The spiders seemed like elongated balls," said the captain, "with a sort of umbrella canopy above them. They settled upon the sails and rigging, and finally disappeared as they came. You know," he added, "that it is not unusual for birds to be blown out to sea. How much easier for a spider, provided he has the means to keep himself suspended in the air!"

To the ballooning habit of spiders is due so-called "gossamer showers." On an early autumn morning when the dew upon floating spider filaments betrays their presence, one is surprised at the vast amount visible. Later in the day quantities of this spinning-work will be seen sailing through the air. A great excess of tufts of these filaments is known as a gossamer shower. At times it has assumed such proportions as to win record as a natural marvel. Pliny appears to have seen one when he noted that "in the consulate of I. Paulus and C. Marcellus it rained wool about the Castle Carissa." In later days in England, where gossamer showers seem rather prevalent, they received a stranger explanation than Pliny's, as voiced by some of the English bards. Thus Spenser wrote:

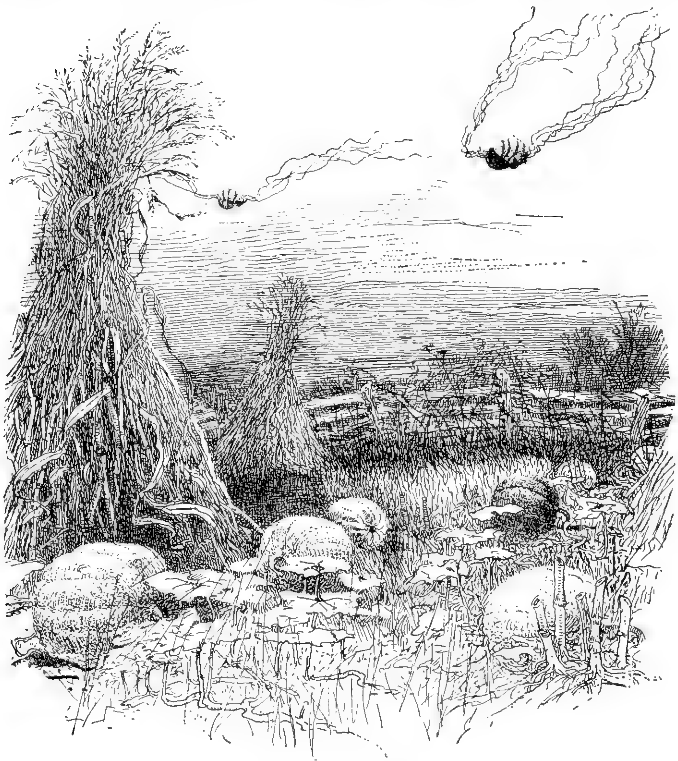
"More subtle web Arachne cannot spin:
Nor the fine nets, which oft we woven see,
Of scorched dew, do not in th' ayre more lightly flee."

Even as late as Thomson's day this curious fancy had utterance in the "Seasons":

"How still the breeze! save what the filmy threads
Of dew evaporate brushes from the plain."

Such records serve to mark our progress in the knowledge of natural phenomena. Our school-children now know better than to account for floating cobwebs by such impossible theories as a rain of wool or a descent of autumnal dews scorched by the sun.

The author has not seen in America such notable downfalls of gossamer as described by English writers. The Rev. Mr. Kirby, for example (Kirby and Spence,



THE ORBWEAVER'S BALLOON

A tiny cone-shaped puff or pellet of silken floss with streamers floating fore and aft

Introduction to Entomology), tells us of gossamers observed by him early in the morning, spread over stubbles and fallows so thickly that they seemed "covered with a gauzy carpet, or, rather, overflown by a sea of gauze, presenting, when studded with dewdrops, a most enchanting spectacle." The Rev. Gilbert White, whose *Natural History of Selborne* is still a delightful and inspiring book, describes a gossamer shower that occurred in England, September 21, 1714. At daybreak the stubble and clover grounds were matted with a thick coat of cobwebs, in the meshes of which a heavy dew hung so plentifully that the whole face of the country seemed covered with fishing sea-nets drawn one above the other. The dogs were so blinded by this deposit that they could not hunt, but lay down and scraped the webs from their faces. As the morning advanced, the sun grew warm and the day became cloudless and serene.

About nine o'clock an unusual appearance demanded attention. A shower of cobwebs fell from a great height and continued until evening. These webs were not single, filmy threads, but flakes or shreds, some of which were nearly an inch wide and six inches long. The velocity of their fall showed that they were much heavier than the atmosphere. On every side the observer noted a continuous succession of fresh flakes falling into sight from the upper air, and twinkling like stars as they turned their white sides towards the sun. This shower extended over at least eight miles of territory. One of Mr. White's neighbors met it while riding abroad, and rode to a near-by hill three hundred feet high in order to escape it. When he reached this lofty spot he was astonished to find the gossamers as far above him as before. The flakes, adds Mr. White, hung in the trees and hedges so thick that one might have gathered baskets full.

The origin of the gossamer thread has been explained already. It needs only to add an explanation of the shreds and flakes. In many, perhaps in most cases, a number of feints are made before ascent. A spider will take due position and spin out a thread; but it fails to mount aloft. Other unsuccessful attempts follow, each producing a filament. These, while waving to and fro in the eddying air, are often tangled together before they are whipped off. Others again are united in the air after release. If, now, we think of the myriads of young spiders abroad at this season, all moved by the impulse to flee their present site, and all spinning out gossamer threads, we may imagine the enormous quantity that would be set afloat within a brief time. These masses of gauzy material are carried up by the warm ascending currents of air; and, as the day grows cooler and the currents begin to descend, the flakes fall, often entangling in their fibrous meshes minute insects.

One suspects that there may be some physical condition peculiar to the British Isles that promotes the accumulation of the gossamer and its precipitation in that region, and which does not prevail in America. May it be that the gossamer material is generated on the main-land of Europe, and, being carried seaward by the winds, is deposited upon the English coasts?

Closely related to the ballooning habit of spiders is their ability to pass from point to point by means of bridge-lines of varying length. Thus, also, are formed the foundation-lines strung between various objects,

GATHERING IN THE BUOYING LINES
The way ballooning spiders regulate their descent

upon which the orbweaver spins her geometric snare, sometimes thereby bridging a brook or creek or country road with her dainty, lacelike web. In the same way, some individuals have been known to sail over the surface of water by setting loose several long filaments which, floating above the creature's back, act as a sail. The wind playing upon these streamers drives the voyager over the water as she stands erect with outspread legs upon the surface-film.

The recent bicentenary of the philosopher and theologian Dr. Jonathan Edwards suggests that the name of this great man is associated with the habits here reviewed. While a boy in his thirteenth year he was led, by his unaided observations, to anticipate in their main features some of the discoveries of our own time. He hit upon a rudely accurate division of the several groups of spiders. He noticed that the ballooning habit is associated with the bridge-lines stretched from tree to tree across roads, between fences and like positions. He appears to have seen that the spider, while engaged in casting out its threads, often swings free in a little basket of gossamer lines held between its bunched feet—an observation which the author long supposed original with himself. He even defined accurately the manner in which the spider's web is formed. He perceived that the balloonist-spider had no direction of its frail aerial vessel after it had once embarked, but went perforce at the will of the wind, and disembarked wherever its air-ship was entangled. And he correctly discerned and explained the theory of equilibrium by which the spider navigates the air.

In view of these facts, one may well echo the language of Professor Benjamin Silliman, one of the most eminent of America's men of science: "The observations recorded by him present a very curious and interesting proof of philosophic attention in a boy of twelve years. Had he devoted himself to physical science, he might have added another Newton to the extraordinary age in which he commenced his career; for his star was just rising as Newton's was going down."

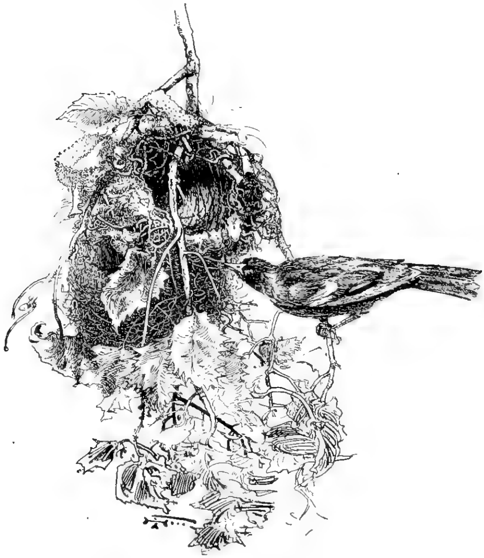
CHAPTER XIII

TAILORING ANIMALS

CARLYLE in his *Sartor Resartus* reduced the philosophy of human civilization to a question of clothes. One must admit that the art of putting together various fabrics to protect the person is a chief concern of life. Even architecture owes somewhat of its development to the tailoring habit, using the phrase in its larger sense. For primitive man sheltered himself and his household, as is still the wont with ruder peoples, in shacks of wattled limbs thatched with leaves or grass. In a higher stage of civilization he dwelled in tents, which are tailor-made houses. The nomadic man, the soldier, the pioneer, the man of science, the camp-meeting devotee still make large demands upon thread and needle for shelter.

This is a development of the instinctive gift which led the original man to clothe himself with aprons of fig-leaves. But this art is not the exclusive possession of man. At the outset of his career some of the lower orders shared it with him. Man has advanced; the animals remain stationary at the fig-leaf period. This difference is of immeasurable value, and marks an impassable gulf between the two. Yet a glance backward at "the rock whence we were hewn"—if it so be that we *were* hewn from the vast, primitive mass of life-stuff—should stir within us a kindlier interest in and sympathy with those lowly brothers who with us possess the earth.

If the dexterous use of natural threads of various sorts in the construction of homes be a test of tailoring,



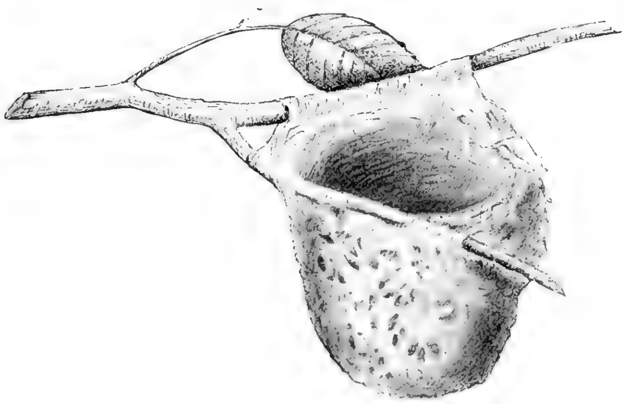
A BALTIMORE ORIOLE AND ITS NEST

many birds may be grouped with tailoring animals. The long, stocking-like nest of the Philippine weaver bird is a fine example of the use of dried grass by a process which closely resembles the familiar "darning" of domestic life.[1] The vireo gleans the silken tissue of the spider's web, and, drawing it out and twisting it into strings, weaves and felts it into her nest. Our Baltimore oriole has the same ingenious habit, and with its bill for a

[1] The original photographic studies of bird figures were made from specimens in the Academy of Natural Science of Philadelphia.

needle and grasses for threads will put together its pretty pensile nest. But it has learned the superiority of artificial fibres; for strings, wrapping-cord, and silk and cotton threads are freely appropriated and wrought into the bag wherein her household treasures are kept.

The most striking achievement of birds in the sartorial line is perhaps that of the tailor bird, a small Asiatic species. When tailor birds are house-hunting they choose a plant with large leaves, say the size of a man's hand, which they proceed to make into a bag wherein to establish their nursery. They are said to pluck the boll of the cotton-plant and actually to spin it into thread with their bills and feet, and therewith



A VIREO'S NEST, WOVEN AND BOUND WITH GATHERED SPIDER SILK

literally sew together the edges of the chosen leaf. This sack is filled with down and feathers, and therein the female lays her eggs and rears her young.

This bit of avian tailoring, with its helpless birdlings tucked therein, can hardly fail to suggest the needlework cradle that the Indian mother makes for her infant, which she is wont, like the bird, to hang upon a tree, perhaps for the same reason. For all practical

A TAILOR BIRD AND ITS NEST

uses, at least, the tailor bird and the tailor woman have wrought to the same end by similar methods.

The tents of many spiders are fair examples of the tailoring art. Like the tailor bird the children of Arachne find their material close at hand, ready made in the loom of nature. The manner in which they manipulate the leaves of bushes and trees, blades of grass, and stems of divers plants is highly creditable to their skill. One of our most expert aranead tent-makers is the handsome orbweaver known as the Trifoil spider (*Epeira trifolium*). Let us note the method of a worker of this species.

Here is a large oak-leaf swinging just above and to one side of the site chosen for a snare. Our Epeira has eight hands to work with; indeed, we may say ten, for the palps, one on each side of the face, are serviceable in grasping, turning, and holding. Thus she seems to have the advantage over a human seamstress, who has only four hands, although the upper pair have the incomparable endowment of ten fingers, and the lower pair, since the era of sewing-machines, are almost as effective as the upper. However, our spider's hands—or feet, in common parlance—are not without admirable adaptations for her work. She can deftly seize and hold her material as between thumb and finger. Beginning at the stem, where the stride is easy, she grasps with her claws an under edge of the leaf, and, reaching out her fore feet, draws the two selvages towards each other. Now from the spinnerets, one of nature's most wonderful and beautiful mechanical arrangements, is forced a liquid, silken jet. It adheres to the leaf, and hardens at once into a tiny white disk, which serves the use of the "knot" upon a lady's sewing-thread. Swinging the abdomen around, Epeira reverses her position, grasps the leaf's opposite side with her hind feet, and fastens her thread thereon. Thus the first "basting"-line is made, and the slightly curved form of the leaf is fixed. Back and forth, with alternate movements of hands and spinnerets towards the free end of the leaf, the industrious creature goes, crossing and recrossing,

LEAF-WOVEN TENT OF A SPIDER (*EPEIRA TRIFOLIUM*) shortening and drawing taut her threads, until the edges of the leaf are approximated and overlaid and a pretty, bell-shaped tent is formed. Into this the spider crawls, and by a process which our lady friends might call "satin-stitching" or "blind embroidery" spreads a soft, white, silken lining. Then, with face turned towards the front of her miniature wigwam, and fore legs outreached, she clasps the strong trap-line that unites her to the centre of her orbweb and gives her control of its delicate machinery, almost as responsive to touch as nerve-tissue.

Often the tent is to be made up of several leaves, or of a cluster of grass tips or a bunch of ferns. The manner of work is then more complex, but the essential method is the same. The several bits of material to be wrought into shape are gradually approximated by a series of successive trial threads until all are drawn together. This basting process is applied to the inner side of the leaves as well as to the outer. It is not all done at once. The tent is a development, being improved, enlarged, strengthened, as the creature grows or as circumstances require, quite after the fashion of human habitations. Always the aranead will adapt herself to the situation. Whether one leaf or two leaves or a tuft of wild flowers, grasses, or ferns be the chosen material from which to fashion her tent, she joins the parts together with her silken threads with a rude but effective skill.

If we may include, within that wider conception of tailoring which this meditation assumes, such combinations of fibre and fabric as netted-work, the spider has further claim to a place within the guild. The hunting-nets of ancient Egypt were of such fineness that one might pass through a finger-ring a net that would enclose a field. Arachne's silken toils, were they capable of like manipulation, would be found of even greater fineness. Certainly no lace-maker's art excels in beauty and delicacy some of the snares that our common field and garden spiders spin daily in summer fields and groves, and in such numbers that the face of nature, when moistened with mist or besprinkled with dew, seems draped with a dotted veil of white silk.

The spider mother makes a yet nearer approach to her human sister. Mother love and care are the threads that bind into one garment the various pieces of natural life. There is no sweeter thing within the compass of human actions than a

AN ORBWEAVING SPIDER'S NESTING-TENT OF FERN-LEAVES SEWED TOGETHER mother clothing her infants in the garments her own hands have made. The happiness, the hope, the eager fondness that play over her face and find expression in smiles and gentle cooings and kisses placed upon face and body and pink fingers and toes, and, like outbreaks of rapturous love, have no likeness and seemingly no analogue in the mechanical actions of the spider mother. Yet, in the deftness of her art, in the beauty of her work, in the patience of her spirit, in her self-abnegation even unto death, the aranead does not show to disadvantage.

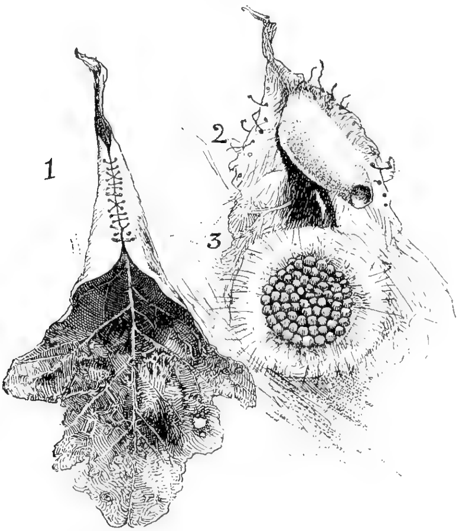
NESTING-TENT OF A SPIDER ON LAUREL-LEAVES

In the natural handicraftmanship of living things there is nothing of higher artistic merit than the silken baby-clothes which a spider mother provides for her offspring. Her eggs are swathed in softest silken floss, covered with silken sheets and blankets, and these again wrapped about with a weather-proof encasement. These are not only the cradle furnishings of the eggs, but flossy swaddling-bands for the young in the tender and callow period following their hatching. The spider mother even indulges in the bright colors with which maternal love in our race is wont to find expression. The vaselike cocoon of our splendid orange Argiope (*Argiope aurantium*) contains three hues of silk—white, brown, and yellow. Other species use silks of delicate green; but white and yellow are the prevailing colors.

Some of our native spider fauna combine with the maternal egg-nest or cocoon a home-tent in which the mother lives, and, later on, her young occupy it. This is a curved tent or tube, or a thick, hollow mass of flossy silk, which envelops the eggs. One sees good examples of these in the maternal industry of our saltigrade or jumping spiders.

Among foreign spiders an interesting example is that of a Venezuelan Theridioid described by M. Eugène Simon as *Anelosimus socialis.* Many hundreds of this species spin a common web, soft and transparent, but of a compact tissue like that of our familiar speckled tube-weaver (*Agalena noevia*), whose funnel-shaped snares are among the most common natural objects on American lawns, lanes, and roadsides. At first sight it appears more like the work of social caterpillars than of spiders. The interior is divided into regular lodges by silken partitions. The egg-cocoons are flocculent balls fixed to the common web by threads that form a soft net. This colonial tent attains immense dimensions, even enveloping an entire coffee-tree.

It seems a long step from the spider, with her silk-sewn tent and satin-stitched enswathements for her young, to the larvæ of moths and other insects. But the step is a natural one from the stand-points of both structure and habit. A spider is an insect larva in a lower stage of advancement, or one should say, perhaps, in a different stage of transformation. The aranead original has been transformed into the spider, dropping many characteristics, but carrying with it the spinning function among others retained. This has been highly developed and made permanent. It may be due to the latter quality that the thread-making and manipulating organs have been transferred from the head, as is common with insect larvæ, to the lower and terminal end of the abdomen. There is another distinction. With spiders the tailoring instinct is largely applied to preserve the young. It is altruistic as well as personal.



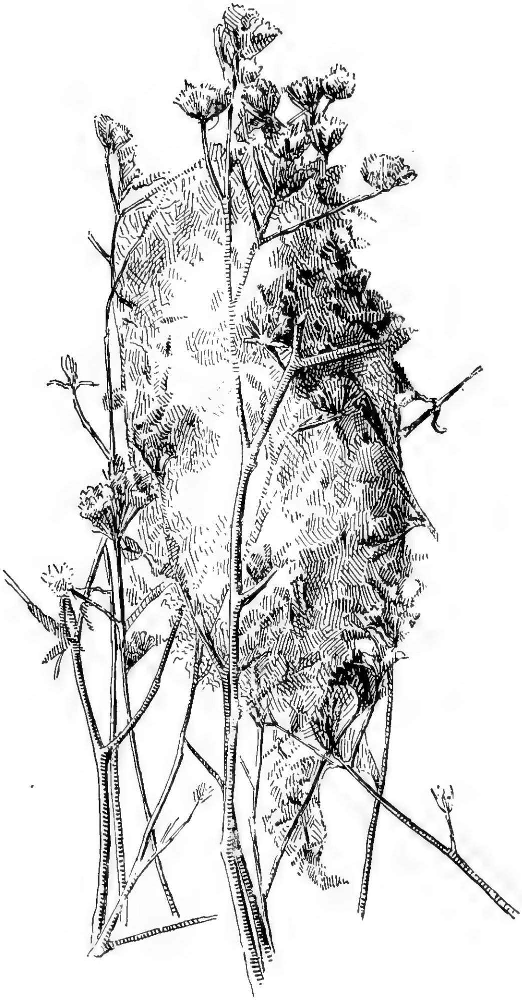
A BABY SPIDER'S SILKEN TENT AND CRADLE
1. Silk-sewn leaf-nest of spider.—2. Interior of same.—3. Cluster of eggs whose silken enswathement is thrown back

With the silkworm and its order it is used exclusively for self-protection.

One of the most ingenious of the tailoring insects is the bagworm. Even those whose foliage plants suffer from its depredations must allow that its endowments, if provoking, are interesting. Indeed, it seems to be a rule that nature's mischievous children have the most interesting habits; and thereto our own race is no exception, especially in the period of life that corresponds with the bagworm's in activity. The bagworm is the caterpillar of a small moth that bears the formidable name of *Thyridopteryx ephemeræformis!*

On the leafless branches of small trees, in winter or early spring, one will sometimes see curious conical pendants, no bigger than an almond, hanging from the tips like the ornaments of a Christmas-tree. They are lashed to twigs by silken loops, and are composed of tough silk. Attached to the outside are tags of leaves and stems, withered and brown, but, when first put on, green like the summer foliage. These are the bagworm's cocoons, with their odd ornaments like the dangles, loops, bows, pendants, rosettes, and other like devices with which ladies trim their gowns and military and diplomatic gentlemen decorate their dress-suits. The bagworm begins life as a small, soft-bodied, hairless larva, whose one manifest destiny is to eat its way to the top or tip of the bush on which it lodges. It is not confined to any one food-plant, but ranges miscellaneously among the trees. Thus nature has greatly eased the insect's struggle for life. The young worm's first act is to weave around itself a silken, caselike frock, which is gradually enlarged and widened at the middle as the creature grows.

When the inmate wishes to feed, it loops its smock to a leafy twig and begins to eat the foliage. Its table postures are often odd enough, sometimes reminding one of a squirrel eating a nut, sometimes of a child with a napkin under its chin eating a stick of asparagus. It is perfect master of the situation. It can turn at will within its bag, stretch forth its head to take surrounding leaves, or, if need be, cut itself loose and march away a-foraging, with its bag and all its dangles on its back.



THE SILK-WOVEN HOME AND COCOON NEST OF A SALTIGRADE SPIDER

One sees how naturally the fragments of leaf and twigs are put on when once the method is observed. When the larva seizes its food it bastes it to the mouth of her bag by the liquid silk exuded. From time to time uneaten particles are rejected, and, being fastened to the rim of the case, simply drop along the side. As the larva eats and grows, the rim rises higher, and each succeeding increment gets its girdle of dangles. When the bagworm is full grown it loops itself to a branch, shuts up the mouth of its sack, passes into the pupa state, and in due time transforms.

In tailoring establishments the cutting department represents the highest trained skill. To plan a garment and then cut its various parts from the stuff is distinctly the work of a finer intelligence than to put the parts together. It may be forcing analogies too far, but at least it is a fancy that lies close to fact that the highest order of insects, the Hymenoptera, contains species that cut from the leaves of plants a covering for their young, which pieces they unite upon a fixed and traditional but apparently premeditated plan. The cutting or parasol ants may be grouped with these species, and the leaf-cutting bee has even a better claim to the first honors in the cutters' association of their guild. Her brooding-nest is a tapestried tube made in soft wood, in the pith of an elder-stalk, the hollow of a tree, an opening in an old wall, the shelter of a cornice, or a hole in the ground. Having chosen and arranged her quarters, she proceeds to get material to drape its walls. You may see her then, squat upon a rose-leaf, revolving upon her feet while she uses her jaws as scissors, thus clipping out a circular patch, which she carries to her quarters. The piece is thrust into the tube, with the serrated edge, it

A COMMUNITY OF SOCIAL SPIDERS IN THEIR SILK-BOUND NEST OF LEAVES

After M. Eugène Simon

is alleged, habitually placed upon the outside. The elasticity of the cutting causes it to cling to the walls, and when a dozen pieces, more or less, are laid in and overlapped a small, thimble-shaped cell is formed. Into this the mother drops an egg and puts a bit of bee-bread, and seals up the cell with a cutting or two. Like cells are added until they are lengthened out into a chamber two or three inches long. Other chambers follow, the mother placing half a dozen cells in every one, until her maternal zeal is satisfied, which, at times, is not until several separate rooms are tapestried. This feat, in the number of pieces cut and placed, rivals that of our grandam's patchwork quilts. For the bee may cut and carry and drape a thousand pieces ere her task is done.

These are some examples of work wrought in nature by what have been called—by courtesy, if the reader so please—the tailoring animals. All have methods that suggest, at least, the human tailor's cult. If sewing be defined as the art of joining together separate pieces of pliable material by means of threads, then the tailor bird and the spider may be said to "sew." If, again, we define tailoring as the art of clothing the body with various fabrics, the silkworm, the bagworm, and many other insect larvæ are natural tailors. It is true that the leaf-cutter bee produces her tapestry effects without the aid of threads; but so does the human garment-cutter, the ranking member of the tailor's guild.

CHAPTER XIV

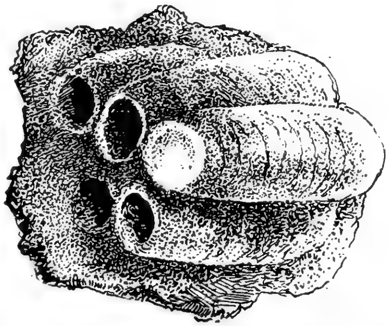
THE HUNTRESS WASPS

IT is not mere fancy that sees in insect commonwealths, in tailoring birds, in kidnapping ants, and ballooning spiders resemblances more or less distinct of well-known actions of men. The analogies clearly lie in the facts. Is not this what one should look for if, as the theory of evolution requires, all nature is bound together in a common origin from one Overmind and Overforce? One is therefore prepared to moderate his surprise at learning that the idea of preserving flesh foods in sealed vessels has its analogy in the method of the huntress wasps.

Many a village or country bred reader will recall his surprise at finding dead spiders within the clay cell of a mud-dauber wasp. Had he opened the nest at a favorable moment, he might have satisfied part of his wonder by finding a white larva devouring the creatures enclosed with it in the cell. At this point we may take up the story of nature and help the curious mind in its research.

When summer warmth has awakened the maternal instincts of the insect world, the mud-dauber wasp may be seen gathering mortar at the margin of stream, pool, or puddle. Filling her mandibles, which serve as both spade and hod, she bears the load of mud to some rough surface, rock or wall, or board or beam. She spreads and shapes her mortar, until, after many visits to the mud-bed, she has built a tubular cell about an inch long and three-eighths of an inch wide.

Then her huntress instinct awakes and her raids upon the spider realm begin; for within this cylinder the mother mason will put a single egg. In course of time this will hatch into a ravenous larva, whose natural food is living spiders; and these the mother proceeds to capture and entomb within her mud-daub nursery. On this errand she may be seen hawking over and near cobwebs of various sorts, venturing within the meshed and beaded snares that prove fatal to most incomers and sometimes even to herself. If the occupant, expectant of prey, sallies forth to seize the intruder, it finds itself a captive, not a captor. The wasp shakes the silken filament from wings and feet, turns upon the spider, seizes and stings it, bears it to her cell, and thrusts it therein.



EGG-CELLS OF BLUE MUD-DAUBER WASP (*CHALYBION CÆRULEUM*)

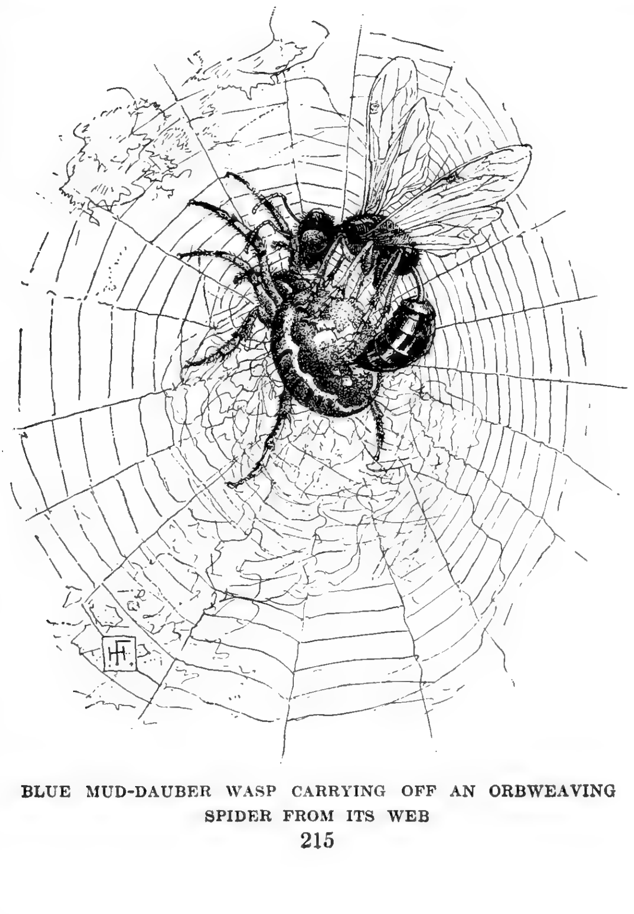
Goethe, in his autobiography, alludes to this habit in speaking of his father's aversion to inns. "Often," said the poet, "he would say that he always fancied he saw a great cobweb spun across the gate of an inn so ingeniously that insects could indeed fly in, but even the privileged wasp could not fly out again unplucked."

Our inns may have advanced beyond the standard of the Goethe-*père*, but our wasps are still so far "privileged" that they rarely fail to pluck the spider from its web.

The huntress wasp has other preserves than cobwebs. She flutters over flowers, burrows among fallen leaves, creeps with nervous, twitching tread along branches of trees and bushes, wherever spiders dwell or hunt, and snatches them away to add to the growing store within her egg-nest. When the cavity is filled, the opening is sealed up and the spiders are literally entombed alive within that clay sarcophagus.

If at this stage one should open the cell, he might challenge the statement that the spiders are alive. They seem to be dead; but in fact are simply paralyzed. The poison which the wasp's sting injects within her captive's tissues may kill at once, and often does so; but more commonly suspends activity without destroying life. So, when the larval waspkin first feels the pangs of hunger, it finds in reach abundant natural food. Thus, before the era of man, nature, in the person of a wasp, had attained the art of preserving animal flesh without impairing its value as food.

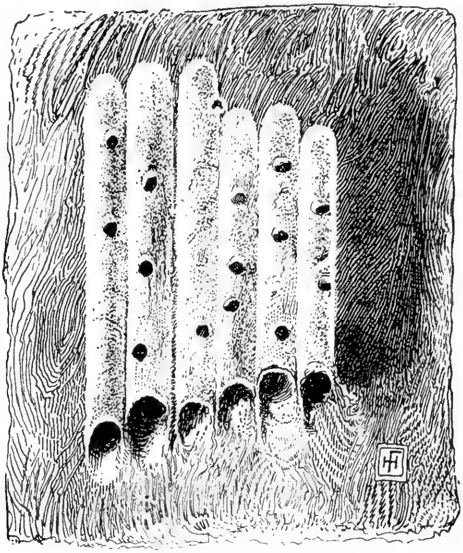
The author's observation of wasp-stung spiders taken from their captors indicates that the virus may retain its preservative effect for at least two weeks before death ensues. In the cells the period would probably be longer, but that amply covers the time taken for hatching and the larval stage of the waspkin. During this period the victims remained motionless, alive but apparently without sensation, and there was no recovery from the poison. Indeed, the extended experiments of Professor and Mrs. Peckham in their fascinating studies, *The Solitary Wasps*, show that such recovery is extremely rare. It is one of the unhappy possibilities in a spider's destiny that it may abide in a living death within a dark vault awaiting the awakening appetite of a voracious worm. But we may believe that nature has so far tempered this doom as to destroy all consciousness of its condition and consequent suffering therein. The proof is wellnigh conclusive that sensa-



BLUE MUD-DAUBER WASP CARRYING OFF AN ORBWEAVING SPIDER FROM ITS WEB tion is wholly suspended at the prick of the insect's sting.

When the enclosed larva has satisfied its appetite it follows the law of its kind, spins about itself a thin swathement, passes into the chrysalis state, and after transformation cuts its way out and begins the cycle of life pursued by endless generations of its forebears. The openings through which the mature wasps escape may often be seen. The blue mud-dauber, *Chalybion (Pelopœus) cœruleum,* is wont to place its cells one atop of another in small masses. Sometimes they are found, or the work of kindred species, arranged alongside of one another in extended tubes like "pipes of Pan." From one such series the author saw emerging a number of black digger wasps, *Trypoxylon politum.* That seemed proof that the nests had been made by that insect. By no means. This species is reputed by such good authority as Walsh, a guest wasp, not building a nest for itself, but laying its eggs in cells made and provisioned by another species. It is curious to trace this use and wont from the guest wasp and the cuckoo, up to the human species as represented by the imperial "annexers" of Europe and the Orient, and the "land-grabbers" of the Indian Territory, not to speak of others of the "guest" habit who may be found nearer home! However, whatever may be the truth as to *politum,* we know that some of her congeners are most insatiable captors of araneads.

Spiders are not the only victims of the huntress wasps. Few insects are exempt from their attacks. Some provision their nests with grasshoppers, some with cockroaches, some with snout beetles, some with aphides, ants, and bees. A great number prefer the two-winged flies (Diptera); the hornets, for example, invading our kitchens and rooms to prey upon the house fly. Still other species capture the larvæ of moths. The handsome digger wasp (*Sphecius speciosus*) provisions her



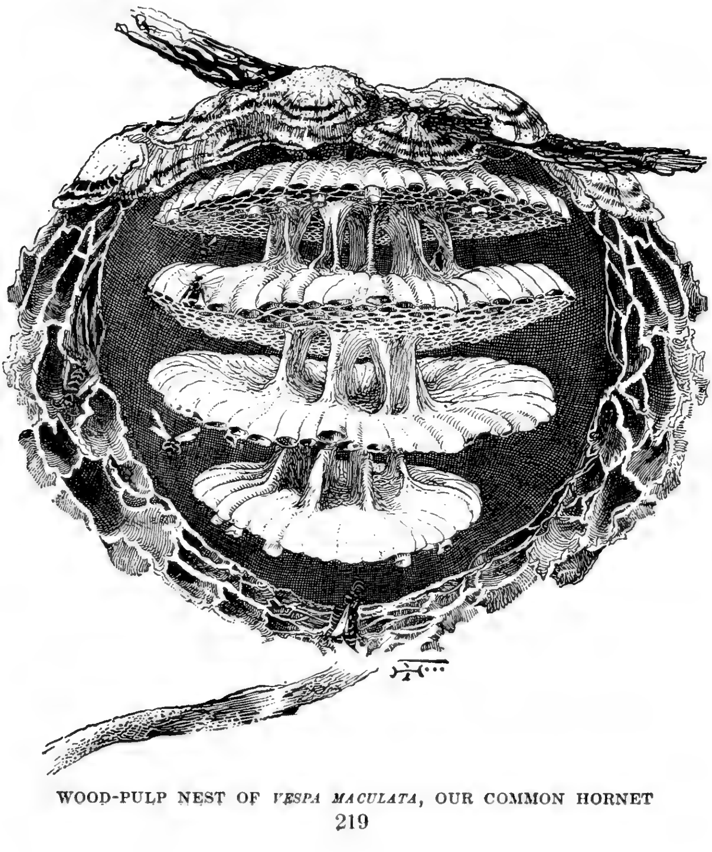
PIPES-OF-PAN CLAY CELLS OF MUD-DAUBER WASP OCCUPIED BY A GUEST WASP

tunnel with the cicada, or harvest-fly. But perhaps the spider-hunting wasps have the most interesting habits.

The general reader may be satisfied to know that, broadly speaking, wasps may be roughly divided on the basis of their habits into three great groups. The mud-daubers are solitary insects, and build clay cells, which they store with food, and therein leave their young to their fate. With these may be included the potter wasps, so-called because of the jug or pot shape of their globular clay cell. The digger wasps make tubular burrows in the ground, and care for their offspring after the fashion of the mud-daubers. The paper-making wasps are for the most part social insects, rear their progeny in the home nest, like ants and bees; and the insects which they capture are manducated and fed to the wasplings by mouth. Most of these, like our bald-faced hornet (*Vespa maculata*), lash their wood-pulp nests to trees and bushes. This is but a rude and approximate grouping, and any observer might cite exceptions. Our common yellow-jacket will at once occur, which, although a social insect, commonly burrows in the ground, and in the hollow shelters her wood-pulp cells, an odd combination of the habits of the paper-making and the burrowing wasps. Yet for popular ends it will be useful, and may easily lead to a more scientific classification.

Even the most formidable of the order *Araneæ* are not exempt from the wasp's incursions. The "tarantula" of our Southwestern States (*Eurypelma Hentzii*) is the giant of our spider fauna, but it cowers and falls before a large and beautiful wasp (*Pepsis formosa*) known as the "tarantula-killer." The author has seen this insect in Texas hunting for its gigantic victim, whose flurried and excited movements showed that it knew its peril and sought to avoid it.

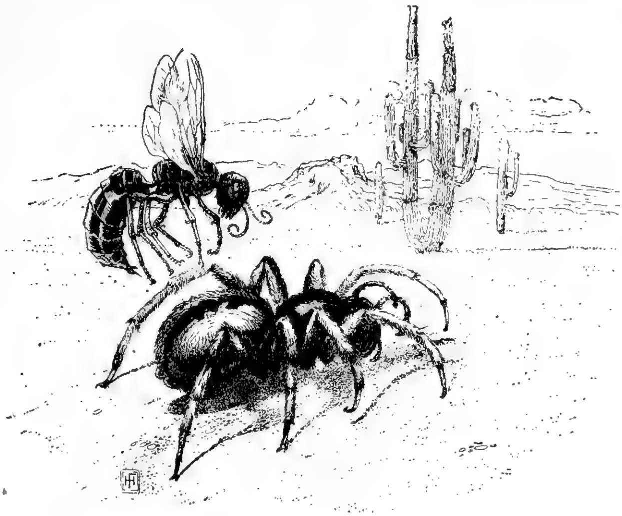
The tarantula-killer is a bustling, unquiet creature. When running on the ground its wings vibrate continuously. When it sights its prey it flies in circles around it. The tarantula trembles violently; now runs and hides; now, rising rampant, shows signs of fight. The watchful huntress finds a favorable moment, darts upon its victim with curved body, and thrusts in its sting, if possible into the soft abdomen. Often the spider is at once paralyzed, but a second and even a third wound is sometimes necessary. The victor seizes its motionless prey with its jaws and drags it to a hole previously dug. She thrusts it in, deposits an egg upon it, and covers it up. In this case the bulk of the tarantula insures sufficient food for the offspring, and one alone is provided, as seems to be the case with the cicada-storing wasps. But the mud-dauber and her ilk, which



WOOD-PULP NEST OF *VESPA MACULATA*, OUR COMMON HORNET select smaller prey, garner many spiders, rarely sealing a cell ere it is quite full.

The above facts fairly present the general habit of these insects and their motive in their hunting excursions. Whether they have developed a love for the chase simply as sport may be queried. Certainly they seem to enjoy it in every quivering fibre of their animated frames; and one who watches their various modes will be amused to trace resemblances, real or fancied, between them and the "mighty hunters," the Nimrods and Esaus, of the human species. But there is a field in which we may reach definite results that deserve notice. What reflex influence has this behavior of the huntress wasp wrought upon the subjects of her pursuit? Has it modified their habits, and in what direction and to what extent?

Here again we may reason from analogy; within the realm of facts, to be sure, but not disdaining a "scientific use of the imagination," without which the naturalist's studies would be often dull and aimless, even fruitless. The progress of modern warfare, or, more accurately, of implements of war, has been largely a contest between the efficiency of defensive armor against offensive weapons. As human ingenuity has devised destructive weapons of attack, opposing ingenuity and skill have prepared surer means of defence. Indeed, in the wider field of man's current life the same process may be noted. What, for example, is the growth of architecture, in the widest sense of the word, but a history of man's efforts to meet his needs through the assaults of nature, by counter-movements that have developed works of skill better suited to protect and defend life and health? It is natural that, within its limited compass, something like this should occur as we study the influence on other species of the wasp's offensive warfare. Wherein does this appear? We select a single field — the counter-defences of spiders against wasps and other enemies.



A TRAP-DOOR SPIDER (*CTENIZA CALIFORNICA*) PURSUED BY A TARANTULA-KILLER (*PEPSIS FORMOSA*)

Take first the orbweavers. As evening falls they are seen hanging from the roofs of porches, or from the branch-tips of shrubs and low trees, laying out the radii or spinning in the viscid spirals of their wheel-shaped webs. A little later they may be seen settled head downward against the central mat of the orb, with legs stretched across the circular space on which no beaded lines are spun. They are ready now for a meal of night-flying moths, and they can take the exposed place at the centre with comparative impunity, for their enemies, the wasps and birds, have settled to sleep. By morning they have disappeared. Where have they gone?

Once while on a summer fishing trip on the St. Lawrence River, the skipper of the yacht noticed me looking at the orbwebs that festooned many parts of the boat, and thought an apology therefor was due.

"I try to keep a tidy boat, sir," he said, "and I clean out those spider-webs religiously every day, and day after day. But next morning there they are, as many as ever. It's a marvel to me, sir, how they get there! They seem to drop from the sky."

I took the puzzled skipper a little journey around the yacht, and in the angles and corners and concavities of cornices and mouldings and beadings, and in other sheltered spots, showed him numbers of spiders snuggled away in tough silken tubes and tents, deftly hidden and safe from the beating of rains and the splashing of boatmen's hose and mop. Thereat the captain's wonder was turned into another channel. And when I assured him that these stowaways were harmless, and, indeed, helpful friends in that they waged war upon flies and mosquitoes, he vowed that thenceforth they should ride secure, especially as the cleaning away of the webs seemed to do "the critters" no harm!

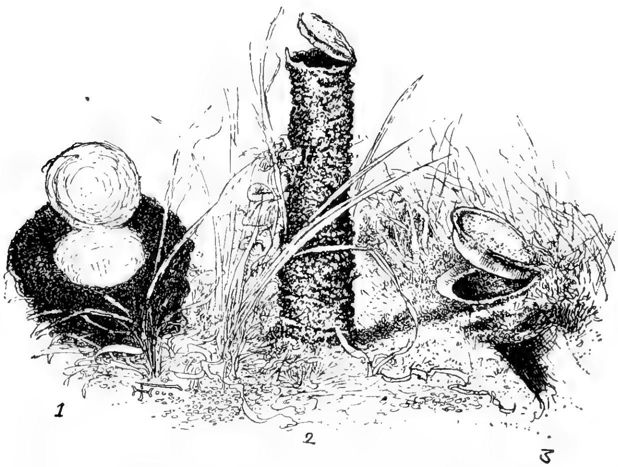
Yet even in such hiding-places their enemies will find them; for the conflict between defensive and offensive instincts tends to develop skill on both sides. But the secretive habit that has been nurtured by the sense of danger stands them in good stead.

Turning to the fields and other haunts of orbweavers, one will occasionally, sometimes often, find by day the araneads upon their snares, especially before and after the season of highest maternal activity among wasps.

But commonly the round webs will be seen vacant, strung between the stalks of wild flowers and grasses, or among the boughs of shrubs and trees. Be sure that the architect and owner is not far off. Note this separate, strong, taut thread attached to the centre. It is the trap-line. Follow it upward along its course, and you will trace it to the outreached front paws of a spider whose body is sheltered within a pretty, bell-shaped tent of leaves deftly bent and basted together and daintily lined with silk. This is the proprietor and builder of snare and tent. She has learned—or, let us say, she knows, and her race has learned—the need of such a sheltering domicile and fort. Therein she lies in ambuscade, waiting until the agitation of an entangled insect "thrills along the line," whereat she rushes forth, seizes and swathes her victim, and bears it to her den to feed upon at leisure. Some of these leafy tents are really pretty objects, and show no little architectural ingenuity and skill—anthropomorphic terms which we must use until philologists or dissenting philosophers shall supply our poverty of words when speaking of animal mentalism and its products.

We may turn to a widely separated group, the Territelariæ, or tunnel-weavers. In the trap-door spider protective industry has reached almost its highest results among lower animals. Its usual nest is a tubular tunnel in the ground, lined with thick, white silk tapestry, and closed at the top with a hinged and neatly bevelled semicircular door made of alternate layers of silk and soil. The outer layer is soil when the surrounding surface is bare of vegetation. Otherwise the growth of herbage upon the top of the door is sometimes encouraged if not caused.

When the author first learned that this animal (*Cteniza californica*) took its prey by night and kept its nest by day, he ventured to predict that its elaborate defence must be chiefly if not wholly against a diurnal enemy,



1 AND 3. CALIFORNIA TRAP-DOOR SPIDER'S NEST (*CTENIZA CALIFORNICA*).—2. TURRET TRAP-DOOR NEST (*DOLICHOSCAPTUS LATASTEI*). AFTER M. EUGÈNE SIMON

probably some species of wasp.[1] This inference has been verified; and observers upon the field have found that the tarantula-killer captures and provisions her egg-nest with the trap-door spider also. Its smooth, soft body and inferior size make it more vulnerable than the tarantula, and hence perhaps its more elaborate defence.

It is well known that ground spiders on the approach of winter, and preparatory to moulting, when their helpless condition peculiarly invites attack, and while co-

[1] *American Spiders and their Spinning-work*, vol. ii., p. 414.

cooning, when maternal instinct is sensitive to the welfare of offspring, invariably resort to special architectural protection. That such occasional acts might readily be developed into fixed habits is probable.

The studies of M. Eugène Simon, an eminent French aranealogist, give many examples from the spider fauna of Venezuela and elsewhere of the remarkable architecture of various trap-door-making genera. Some have nests on the outer bark of trees; some lift above the ground a composite open tower, even more perfect than that of our turret spider (*Lycosa arenicola*), and some have a silken tower that at a distance looks like a full-blown lily, a fine "strategy," indeed, to allure hapless flower-visiting insects. Others rear towers which they top with hinged lids. Most of them keep to the ground, but with structures of varying ingenuity, all apparently protective. Such facts strengthen the belief that these examples of aranean architecture have gradually arisen from the accumulating instincts of many generations, self-protection and motherly interest, the strongest feelings in nature, operating upon the animals' original endowments.

Mrs. Mary Treat [1] has given a most interesting illustration of a conflict between vespal offence and aranean defence. The tiger spider (*Lycosa tigrina*)—a fine, large Lycosid with striped legs—makes a curved burrow which is sometimes carefully closed with a dome of surface litter basted together, and having a rudely hinged door. Tigrina is sought by the four-spotted Elis (*Elis 4-notata*)—a large wasp with four orange spots on its abdomen. She hunts over the ground until she finds an open tunnel,

[1] *Harper's Magazine* (1880), p. 710.

into which she dives, and soon returns with the paralyzed occupant. This she drags away at a pace almost as fast as a man's walk, until she finds her own burrow, into which she thrusts her prey, fills up the hole, levels the top, and conceals it with litter from the adjacent surface.

For two or three weeks the mother wasps keep up their raids, from which only spiders with closed doors

THE FOUR-SPOTTED ELIS DRAGGING *LYCOSA TIGRINA* FROM ITS BURROW

escape. Others invariably perish. After August, when the maternal rage has expended itself, the survivors open their doors, even remove the thatching, and resume their own predatory raids with evident sense of security. Such well-attested facts seem to interpret for us the impelling motive to the entire series of aranean architecture of which Tigrina's dome, Arenicola's turret, and Cteniza's trap-door-covered tunnel are types.[1]

It sometimes happens that one huntress wasp attacks another individual of her species who is home-bound with the fruits of her hunting, and attempts to rob her. A fight ensues, fiercely waged and often with a fatal ending to one or both of the combatants. Quite an animal trait, indeed! — not excepting the lord-paramount, Man.

[1] See the author's *American Spiders and their Spinning-work*, vol. ii., p. 402 sqq.

CHAPTER XV

THE STRANGE CYCLE OF THE CICADA

THE true locust of our meadows and fields, which is closely related to the dread destroyer of Holy Scriptures and to the Rocky Mountain locust, is commonly called a "grasshopper," which it is not. The real grasshopper resembles the true locust in many respects, but is a different insect. Then, again, the proper name of the so-called "seventeen-year locust" is Cicada (*Cicada septendecim*), and it belongs to a genus known especially in Great Britain as "harvest-flies."

There is an annual cicada whose buzzing note is popularly held to predict hot weather, and which in form and habit resembles the seventeen-year species. Its high, sharp trill is well known to village lads whose self-made toy of a paper-covered cylinder whirled upon a horse-hair has amused many summer hours. Its scientific name, *Cicada tibicen*, well enough expresses one of its popular names, "the lyreman"; but it is better known as the dog-day harvest-fly, or cicada, or "locust."

Since this insect is known to appear from year to year, some persons have doubted the existence of a seventeen-year species on the ground of what they call their own observation. But Septendecim is truly periodical, and takes seventeen years to mature. That time is spent underneath the ground, in an undeveloped condition known as the pupa state. The "shells" are the cast-off pupa-cases, or final "moults," of the insects when they come up after their long sojourn within the earth.

THE SEVENTEEN-YEAR CICADA AND ITS PUPA-CASE

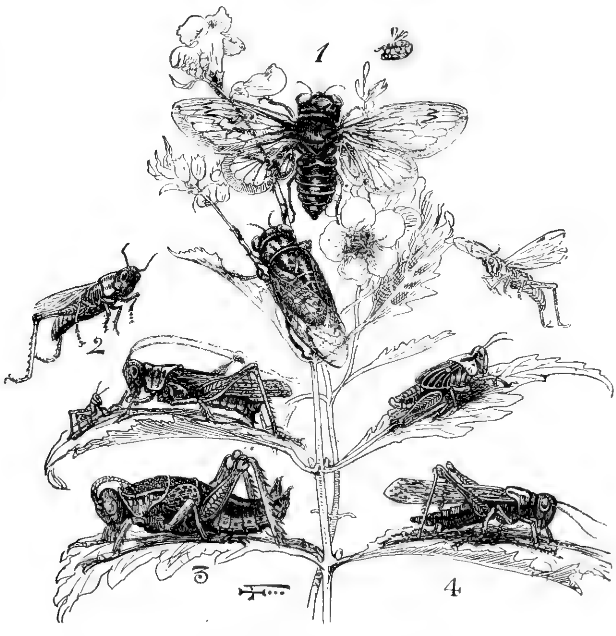
At several points in the United States seventeen-year cicadas appeared in the spring of 1902, while in other parts there were none. This uncovers one of the curious facts in the insect's natural history. Somewhere throughout the continent there appears, almost every year, a brood which is limited to a certain belt of country of greater or less extent. Entomologists, by keeping the track of these broods, have been able to predict their appearance within certain zones. For example, in the western suburbs of Philadelphia immense numbers of cicadas appeared in the summer of 1885. Their visit was predicted and announced by the author several months before it occurred. The only knowledge needed for this was that a brood had appeared in 1868; and the only ability, that of adding seventeen to these figures. In like manner, by adding seventeen again, a

1902 brood was predicted, and it arrived "on time." If readers will make note of the cicadas' coming in their own neighborhood, they may be sure that seventeen years thereafter another brood will appear. There is, however, a thirteen-year brood which must be allowed for, at times. But there is no need to consider here that exceptional incident.

We begin our history with the exode of the pupæ from the ground, and will limit it to observations of the brood of 1885 in Philadelphia. The first pupæ appeared about May 23, but were not out in great numbers until the second week in June. The exode began about six o'clock, evening, and continued during the night, but chiefly the first part thereof. The exit from the burrow was deliberate, as was also the insect's progress over the surfaces on which they travelled. They moved forward and upward without manifest directing purpose, but with a general tendency to get as far up as possible. They paused at various distances from the ground, and attached themselves to sundry parts of trees and other objects. More than a dozen pupa-cases were seen clinging to the leaves of a small twig eight inches long. Apparently, where the uncontrollable sense of their coming transformation arrested them, there they halted, obedient to that Overforce that brooks no denial from any creature.

On the evening of June 4th great numbers were ascending tree-trunks in a neighbor's spacious grounds. They had directed their course towards the trees from all parts of the lot, but an adjacent fence received a portion of the host. They issued in such numbers that trunks, branches, and leaves of trees were covered with them, in motion or at rest. The ground beneath was riddled with holes, and in a few days the fallen shells lay so thickly at the roots of trees that they hid the surface, and quantities adhered to bark and foliage. The movements of this host, creeping out of their open burrows and huts, crawling along the grassy surface, climbing up trees, and breaking forth from their shells, as seen in the light of a full moon, formed a weird and interesting spectacle.

Some idea of the vast issuing swarms may be had from the number of exit holes within certain surfaces. In a space six feet square, lying between two trees, there



A STUDY IN IDENTIFICATION

1. Cicada
2. Grasshopper and young
3. The lubber locust of the West
4. Locust, and pupa above

were 665 openings. Within a circle described by a radius of ten feet from the trunk of a large maple-tree, a careful count and estimate showed 9600 openings. The most extraordinary perforation was underneath a beech-tree which had a spread of thirty feet in diameter. Within this circle the earth was pierced with the enormous number of 31,500 burrow-holes. In one square foot of surface there were forty-one openings, and in another space they averaged sixty-eight to the square foot.

Almost invariably the burrows were more thickly placed around the bases of trees than elsewhere. This naturally followed, since the roots marked the sphere of subsistence during the subterranean life. With insects as with men, one cannot escape from his past, even when he seems to emerge therefrom.

Most of the pupæ after ascension passed directly to the tree or bush whereon transformation occurred. But there were exceptions. In many places were little elevations, somewhat resembling the heaps that earthworms make, but higher. These were the much-talked-of cicada huts, turrets, or towers. They were about the length and twice the thickness of a man's thumb, were built immediately above the open burrow, and were hollow inside. In fact, a turret is simply a continuation of a burrow above the ground. The builder literally carries up its hole with it! Entomologists have speculated as to the use of these turrets. The author's opinion is that they are built by pupæ who for some reason had miscalculated the time of their exode. They reached the top too soon, halted, and built themselves a temporary refuge, as men and cicadas who are "ahead of their time" must commonly do, or die. Of course, the turrets are simply the mud-ball borings from the tunnel as the pupæ dig their way upward, and which, as they near the surface, they carry before them instead of pushing behind them. Naturally and almost

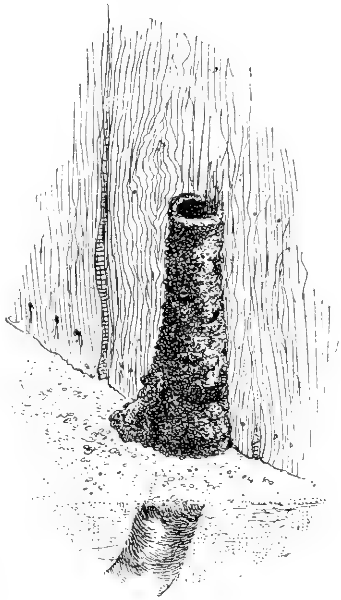
CICADA CITY OF MUD HUTS, OR TURRETS

inevitably the dumpings would assume a tubular form around the opening from the ground.

There are few things in nature more wonderful than the common impulse which seizes these millions of undeveloped insects living in dark tunnels underneath the ground and urges them to cut their way upward, that they may complete their appointed life in the upper air. Stirred by this strange unrest, the mighty host begins to move. What engineering skill directs their course aloft? What instinct guides their movements and enables them with unerring accuracy to burrow to the sunlight? If we suppose that a pupa reaches the surface before it is quite prepared to transform, or, when the surface is reached, that weather or other conditions retard the change to the winged form, we have the influences that require it to build a shelter. Its manner of proceeding is interesting and ingenious. It brings up from its burrow a little ball of mud, which it carries between its mouth and strong fore paws. The latter are admirably designed for digging. The pellets are placed atop of one another, as a mason would lay stones while building a circular tower. They are moistened by saliva, which serves as a sort of cement, and are pushed down upon each other by the head and feet, and thus adhere tenaciously. The inside is smoothed by continued motion of the jaws, as a plasterer spreads mortar upon a wall. It is not varnished, however, as some naturalists have asserted. The top is closed, and the builder awaits within nature's signal to emerge, whereat it breaks through the top, or occasionally the side wall. Like a frontier pioneer, it leaves its house and moves on, joining the mighty procession of its migrant fellows. The huts stand empty in the silent cicada city, like an abandoned mining-town whose "boom has burst," or like the winter-quarters of an army when the spring campaign calls afield.

Beneath the surface of the area occupied by our city brood, as shown by deep section cuttings, the earth was a net-work of crossing and interblending burrows. It would seem that the normal preference of the pupæ was each for its own ascension track. One fancies that this preference was fortified by a wholesome regard for safety, although no special signs of quarrelsomeness were seen. But they were wise enough to use a ready-made roadway when it fell convenient; for in many cases several individuals would issue from the same hole.

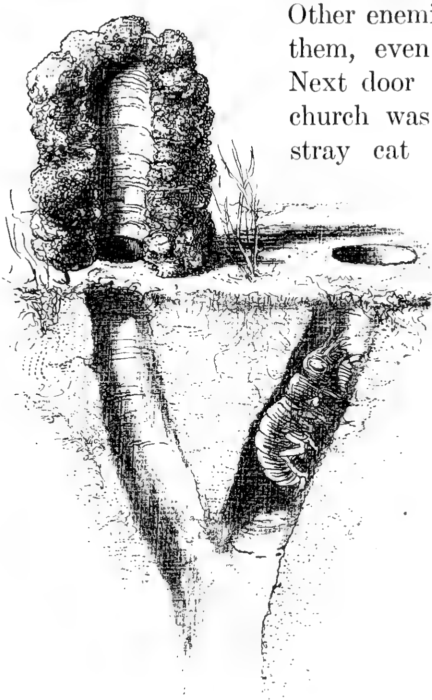
Shortly after leaving the burrow the cicada's transformation occurs, which is only partial, not complete as with moths and butterflies. This is the pupa's emergence from its shell, and is technically known as the ecdysis. Fastening itself by its sharp claws, the pupa remains perfectly still for a little while. Then the hard outer skin begins to crack along the middle of the back. As the insect thus appears it is plump, white, and soft. When the forepart of the body is pushed out, it presents a grotesque figure, looking like a snow-white pupa mounted pickaback upon a yellow one. Next it begins to pull out its legs, first the front ones and then the hind ones, until at last the body is free from the tough case, which all the while clings to the tree. This process, which resembles the moulting of a spider or snake, is not without danger, for one will



A CICADA TURRET
Built against a board fence, at the base of which the burrow opens

often find pupæ maimed or that had died during ecdysis.

These soft, white objects are delicate and tempting morsels for the birds, which destroy quantities of them. Other enemies await to destroy them, even the domestic cat! Next door to my house a large church was being erected.[1] A stray cat had taken up her abode underneath a wooden shanty built on one end of the lot as a tool-house; and she developed a taste for the emerging cicadas. She would watch until the insects had got out of their shells, and then snap up the white, soft morsels and eat them with greedy relish. It seems a hard fate; but what is nature to do with her superfluous children? Unless a vigorous check upon increase were provided, certain species would soon overrun the earth.



SECTIONAL VIEW OF CICADA HUT AND BURROW
Showing crossing and interblending burrow

After emergence the cicada fastens itself at a little

[1] The new sanctuary which my own congregation was building.

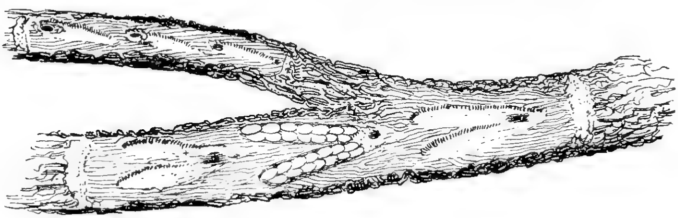
distance from its abandoned case, and then occurs a swift and striking change. The head becomes jet black; the body darkens into a dull yellow and rapidly takes upon itself a tough skin. On either side of the thorax, close up to the head, two little "buds" may be seen just after emergence. These are rudimentary wings. The juices of the white, plump body rapidly run into these winglets. They broaden and lengthen, pushing downward, until within the space of from eight to fifteen minutes they have expanded into the full proportions of the insect's wings, whose tips extend beyond the end of the body. It is a pretty sight, this rapid growth of the beautiful wings of a freshly emerged cicada. As the wings expand, the body diminishes, and soon assumes its normal size.

Now follows another period of rest; but the insect has completed its form. It has attained the perfect stature of what is known as the "imago." By-and-by it is able to stretch its new-found wings and fly into the tree-tops.

In a little while the air is filled with music. The cicada-lover is serenading his sweetheart, and he woos his mate to his side by sounding the little drums with which he is provided. These are slight cavities, placed underneath the forepart of the body and covered with a membrane something after the manner of a drumhead. The rapid tightening and contracting of this membrane is supposed to produce the male cicada's call. The females are without drums, and are therefore silent listeners to the male orchestra. An ancient Grecian poet has alluded to this in his ungallant lines:

"Happy the cicadas' lives,
Since they all have voiceless wives!"

The male cicadas spend a few weeks flitting from bough to bough and rolling their mimic drums to summon their lady-loves to their sides. Then their lives are ended. But the mother cicadas have serious work to do before their death. They must provide for another brood. Nature has endowed the female with an instrument known as a "piercer," which has the power and does the work both of an awl and of a double-edged saw, or rather of two keyhole saws cutting opposite to each other. With this instrument she cuts for an egg-

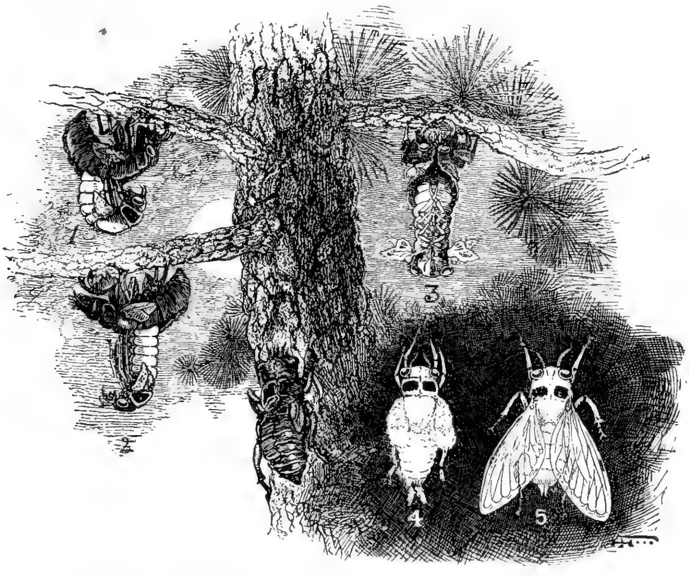


EGG-TRENCHES IN TWIGS, MADE BY FEMALE CICADA

trench a little V-shaped slit through the bark into the fibre of a twig or the tender tip of a larger branch. Within this she deposits a certain number of eggs. Then she moves farther along the branch, saws another slit, and again oviposits. Thus she continues until she has exhausted her store of four or five hundred eggs.

At length, weakened by her labors, she falters and falls and soon dies. Like a good mother, her last care is for her offspring, whom, however, she is never to see. A month or six weeks of sunlight and song, of happy courtship, of busy maternal duty—this is the sum of the cicada's mature life after its long subterranean career. And that is liable at any time to be cut short by a raiding wasp, who stings and paralyzes it, and thrusts it with an egg into her cave. Thus life may end as long as it had been spent, in an earthen burrow!

We now follow the life of the little ones. Twigs within which female cicadas have oviposited generally die. Forests thus infested present the appearance, along the tops and sides of trees, of having been blighted by frost. The leaves die, giving a ragged and sorry aspect to the trees which otherwise are uninjured. This is about all the harm that cicadas do after emergence. It is only when tender young trees are assaulted that plants can be destroyed. It is during pupa life, while living in their cavernous homes near the roots of trees, that cicadas are most likely to do mischief.



FORMS OF THE CICADA ISSUING FROM THE PUPA-CASE

1, 2, and 3. Positions of the issuing cicada.—4. Immediately after issuing from shell.—5. Twenty minutes later, before the roofing of the wings—pure white

In six weeks the young are hatched. They are about a sixteenth of an inch long, tiny miniatures of a pupa-shell. The first pair of their six legs are relatively large, shaped somewhat like lobsters' claws, and armed with strong spines beneath. They have shoulder-knots, the future wing-buds, and attached to the mouth and carried under the breast is a long beak. These wee creaturelings fling themselves from their cradles "on the tree top" and fall to the ground as lightly as thistle-down. At once they begin to burrow, their strong fore legs enabling them to dig rapidly. Down they go until they have reached a roost upon some branching rootlet. Clearing away a little cell around the root, they fasten their sharp beaks into the tender bark and pump out the sap, which becomes for them both meat and drink. There they stay and thus they live until their long pupilage of seventeen years is ended.

We may perhaps venture to guess that during this period they burrow back and forth amid the maze of roots, and drink long and deep from the streams of savory sap which they tap with their beaks. They thrive and grow. They take no end of sleep. Perhaps they greet one another, and pass who knows what communications, in the mysterious language of the mute children of the insect world.

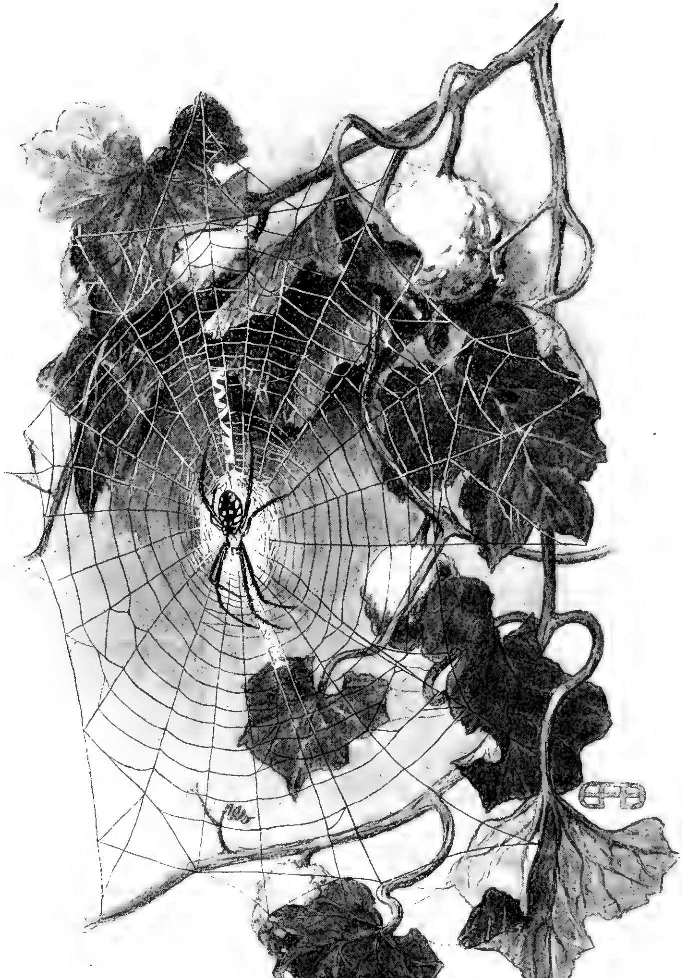
When Nature gives the signal, an irresistible impulse seizes the entire host. They leave their caverns and, guided by an unerring instinct, mount upward. When the spring winds blow softly, out they come. Soon the air is filled with the flutter of their wings, and the rolling of their drums is heard among the trees. In six weeks they are gone, an extinguished nation, and silence falls upon the groves.

CHAPTER XVI

ORANGE ARGIOPE

IF size and beauty and fair handicraftmanship might give a title to queenhood of Araneæ, the crown, without doubt, would go to Orange Argiope. And, pray, who is she? Good sooth, she is a spinster, a spinner, a spinder, a spider! Hold back your prejudice, good reader, and hear her story. Mayhap, then, your gorge will not rise, as is its wont, at her very name. Familiars of rural scènes often have seen her vast and shapely cobweb hung in divers sites, especially in low-lying places, which she chiefly affects, perhaps because they give the best foraging-grounds for her enormous appetite for insects. Professor Hentz, the father of American araneology, found her so often in such places that he gave her the specific name *riparia,* and so for long she was called—Bank Argiope. In like places one will oftenest find her in the Eastern and Atlantic States.

True, she does come at times into our gardens and shrubbery-dotted lawns; mainly in the corners where clumps of bushes grow. There you may see her great snare hung amid the honeysuckles or swung between the retinosporæ in the evergreen plantations. You will know it by the broad, white shield that often fills the centre, from which there reaches downward a fair zigzag of spinning-work that may well have been the



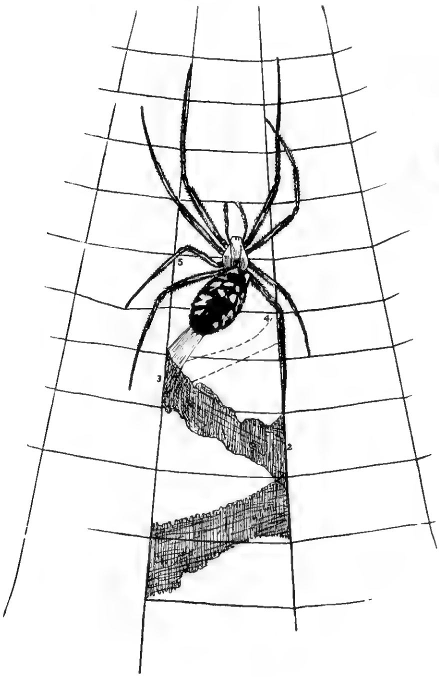
ORBWEB OF ORANGE ARGIOPE

model of that "winding stair" which in the verses of old-time reading-books led to "the dismal den" of that touching ballad, "The Spider and the Fly."

Argiope herself you will know by the orange-yellow pattern of circular and irregular spots upon her velvety-black abdomen, and her orange and black legs outstretched from her gray trunk. In fact, were she to receive an up-to-date name, instead of that of *Argiope aurentium,* her colors would well justify calling her *Argiope Princetoniensis;* and thus better even than the famous "tiger" she might symbolize the athletes of the "orange and black"!

But the garden is not her favorite haunt. She hears the call of the wild. Like a true pioneer, she thrives better outside the belt of highest culture. In yonder fallow fields that embosom our Brookcamp and Devon Runs and the upper waters of the Darby Creek you will find her in October or the closing days of September. She comes to her maturity in the maturing season of the year; but during the summer months you will find the snares of immature specimens hung, at times, cheek by jowl with the almost equally pretty webs of their congener, *Argiope argyraspis,* the Silvery Argiope. Here is one individual housed within a tuft of tall grasses whose feathery tops she has banded together with silken ligatures, and whereon by-and-by she will hang her egg-nest. Downward thence she has stretched her web where it is sure to ensnare frisking grasshoppers that thrive here undisturbed.

Hard by another orb is woven between the stalks of a cluster of wild chrysanthemums whose white flowers make a dainty bower above her. A third spinder has chosen the drooping heads of twin stems of golden-rod for the foundations of her snare. A fourth, nearer the stream, is encamped upon a copse of wild blackberries, whose leaves are already taking on that rich russet which heralds the coming autumn and the ripened year.



WEAVING THE ZIGZAG OR SPIRAL STAIR

Your approach, signalled from plant to plant by the rustling foliage, has disturbed our aranead, watching solitary, head downward, against her white silken shield. See! the web begins to move. Slowly it sways towards you—then away; forward and back, to and fro, faster and faster—until the whole orb seems in a whirl of motion, the centre of which is the silken shield. Curious! And how is it done? And why?

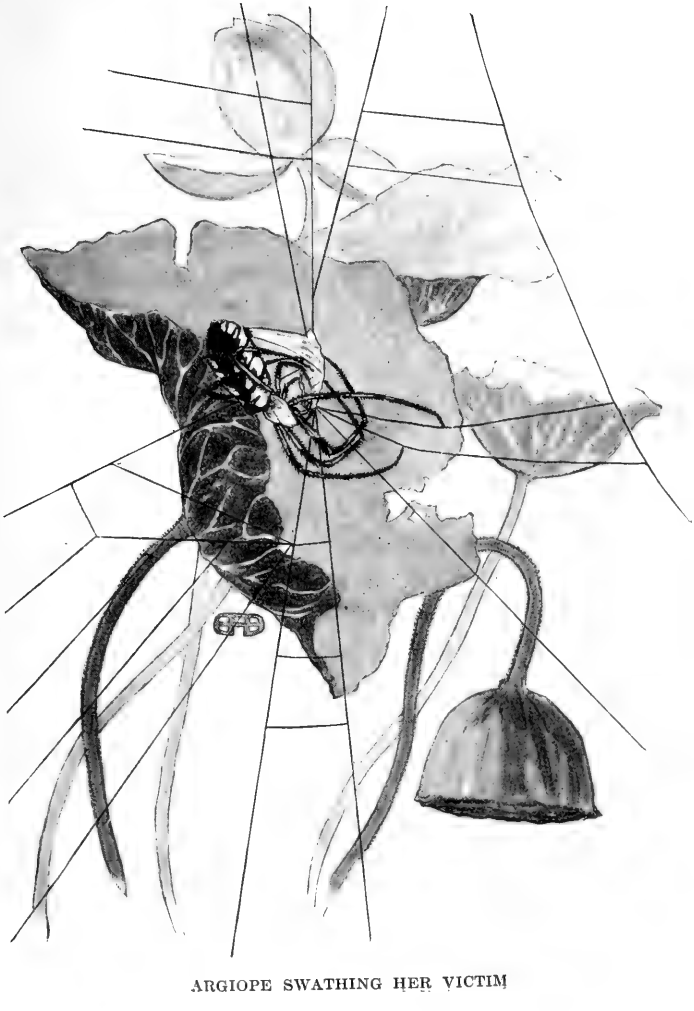
At first you can note the bending and straightening of the legs by which the web is drawn backward and forward. But soon your eyes cease to follow the movements, and you stand in amaze at these rare gyrations until the web gradually grows still. Perhaps the oscillating orb touches some thread of memory along which there runs from the *loci* of the brain cells a record of the past, a vision of a country home, or a rural picnic-ground, or a school-house in its grove by a spring. A cable swing is there, hung to a high branch of a wide-spreading oak. And you remember a brown-haired lass —whose laughing eyes and rosy cheeks you love to think upon—enthroned on the notched-board seat beneath, while you, with feet on either side of her and close against the rope, by alternately straightening and bending your legs and arms, "worked up" the swing. How high you go, and how fast!—till the maiden's fluttering skirts seem to sing in the rush of the swing as it rises and falls. Or mayhap you were yourself that laughing-eyed girl who had the nerve and the skill to "work up" the swing with some playfellow seated below?

Ah me! But what has all this to do with your Orange Argiope vibrating her big web among the golden-rods? Nothing, in truth, if you do not see it. Only there came a passing fancy that she "works up" her oscillating orb, hung by its silken cables to the yellow, drooping plants, somewhat as we were wont to do the big swing in those days upon which some of us already look through a far vista.

But why does the spider do this? We have often asked her that, in our silent naturalist way, and thus it seems to us the answer should run: The prime motive of animal life is food; and one comes to think that an insect, especially if it be a strong one, were it to strike that outspread net, would have less chance to break into freedom—scant as that might be—when involved more and more closely within the beaded meshes of the lassoing lines as they sway back and forth around it. We may therefore count this swaying of her web as one of Argiope's tricks to secure her prey.

Next to gaining its food the animal's instinct looks to its safety. Many perils beset Argiope and her ilk besides the collecting-bottle of a naturalist, or the club of a thoughtless boy, or of a foolish man who still has the ill manner of "killing those who are sent unto him." Her tribe are cannibals, one is loath to confess, and must be watched and fended against. And then the raiding wasps! Of all merciless enemies, these are the most death-dealing, especially at their time of maternal activity in provisioning their egg-nests. Now, if you will observe closely, you shall find that this rapid swaying and whirling of Argiope's orb must confuse the aim of a foraging foe and tend to shut it from her quarters, or even so entangle it as to verify in the raider's experience the adage, "Caught a Tartar." Here, confessedly, we are theorizing; and if the reader has an hypothesis that better pleases him, let him hold it stoutly.

But while we stand theorizing, a grasshopper comes our way. How gracefully he swings on yonder grass stalk! How gayly he skips! What an athlete he in jumping! Alas! he has made one jump too many, for his last leap—literally his last—lands him upon the fatal snare of Orange Argiope. Saw you ever a swifter transformation than this which befalls? Our spider, hanging there so placidly and seeming so lethargic, has instantly become a type of frenzied energy. She leaps upon the partly entangled insect. She seizes it with her sharp claws and strong spiked legs. From her spinnerets pours forth a stream of silk ribbon which, dexterously drawn out by the hind feet, encompasses the



ARGIOPE SWATHING HER VICTIM

struggling insect, which is meanwhile revolved by the captor's fore legs and palps. The motions are so rapid that one hardly follows them; and ere he has well grasped the situation the captive is swathed in a white silken bag, and hangs there in the gap in the broken web made by its struggles, like a canvas-covered ham hung to a cellar rafter.

Poor grasshopper!—or, let us say rather, poor locust! For since the creature must die and be eaten, let it perish under its own name. And now, see how deftly Argiope swings her prey in its silken wrapping from point to point until she has reached her central shield! Thereto she lashes it and settles quietly to her feast. But scarcely has she well begun ere there is another ring at her door-bell. In other words, a large fly has struck another part of the orb, and the news "thrills along the line" to the central shield. In a trice Argiope is upon it. It is enswathed, and hangs there by a short cord in a small silken sack—a trussed-up fly.

Admirably done! No cow-boy ever flung lasso more effectively or more thoroughly tied up and disabled his victim's limbs. And the creature manufactures her ropes as she goes! Thus done, Argiope returns leisurely to her feast, leaving the fly in reserve as a sort of dessert. One feels a touch of pity for these unfortunate insects. But consider, in a utilitarian spirit, what a vast service our Orange Argiope and her kind are conferring upon man by thus acting as nature's checks upon an increase of insect life that would soon make human life miserable if not impossible. For without such natural helps man could ill contend with the innumerable progeny of pygmy insects who hold the utmost antipodes of "race suicide."

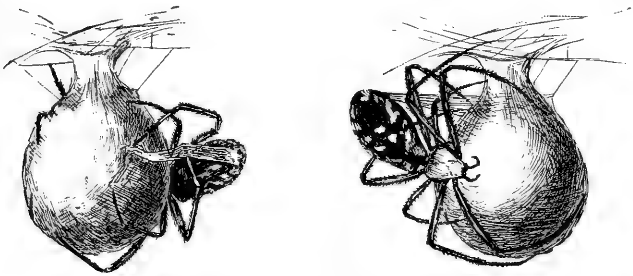
Standing thus at gaze upon the masterly way in which our aranead gets her food, one admires not only the tremendous energy of the animal, but the rare efficiency of the instruments with which she works. To begin with, there is her wide-spread net, with its radiating lines and spiral infilling. It covers at least

A SECTION OF A DEW-LADEN ORBWEB

four square feet of surface, and any insect vaulting or in flight that shall strike it must surely be halted. In the momentary pause and shock of its arrest, even if not entangled, it gives the skilful operator the opportunity to seize it.

But that is not all. Look more carefully at these spirals that wind their way over the radii to the central shield. Scoop out a section thereof with a glass cup and examine it with your hand-lens as it is out-stretched across the mouth of the vessel. Every spiral thread is covered with minute beads. Touch your pencil to this spot. See! Your pearly beads have disappeared; and as you withdraw your pencil you perceive that they have melted into a viscid liquid that has caused the silken threads to stick tightly to the pencil. You cannot release it without breaking a gap into the web. It is this armature of viscid beads that makes Argiope's web effective in so entangling insects within the lines that they are usually at her mercy, and escape only by uncommon vigor or a rare chance. The dews of summer gather upon these viscid beads and their connecting threads, forming strings of minute translucent spheres that in the changing lights of morning glisten like diamonds. It is not inapt to compare such a dew-bespangled orbweb to a jewelled necklace, for truly fair lady never hung about her neck one more lovely in form or more artistic in construction. Thus seen, there are few objects in nature more striking and beautiful than Argiope's snares; but they are terrible engines of destruction to the unfortunates who fall into their embrace.

Another feature of this remarkable structure, which we are studying here in the tall growth of the brookside, now catches our eye. The spider's silken shield, or mattress, is placed, as a rule, above the centre of her orb. On either side of it are thrown out strong interlacing cords which form an open canopy that serves as fender or protective wings. Insects striking against these are suddenly arrested and are apt to flutter down into the orbweb, and so into the claws of the sentinel ogress. Or, should the insect be a raiding wasp, it may be fended off; or, at least, by the sharp contact it signals the alarm and puts Argiope upon her guard



ARGIOPE WEAVING THE COCOON

for defence or warns her to escape. The latter she often does by slipping dexterously behind her orb, thus putting her thick shield between herself and her foe.

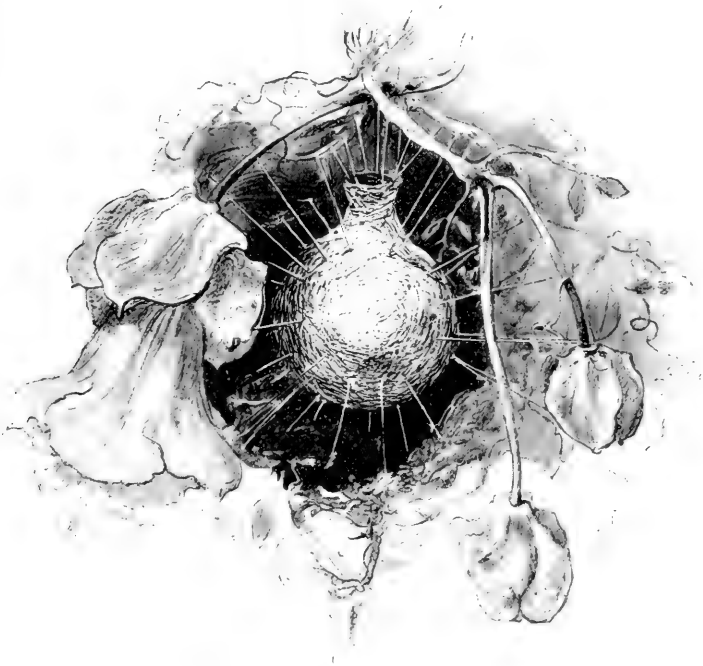
A few days later you are back in the aranead settlement, and miss Orange Argiope from her seat and snare. Mousing a bit through the bushes, you find her diligently swathing a silken ball the bigness of a walnut, swung to a small sheeted canopy well lashed to the surrounding stems and leaves of a high stalk of wild field flowers. This is her egg-cocoon. She strides around and around it, changing her course at every round, drawing out, the meanwhile, ribbons of white spinning-stuff. These she eases up into half or quarter inch loops by slacking her abdomen, and beats them down or spreads them out with her spinnerets upon the surface. Thus she manages to enwrap her pretty casket evenly; and when it is done she leaves it hung amid a maze of crossed lines, and so balanced and stayed that it is like to outlive the winter with its snows and winds.[1]

Had you come a little earlier, you would have seen the spider mother thrusting up against the wee silk canopy a round bunch of yellow eggs. There are a thousand of them, or thereabouts—good promise, one would think, for a full household in due time. But, like the orchard blooms of spring, there will be many a life-bud lost in Argiope's garden ere October comes again. Next, the mother, still working upward, had overlaid the egg-mass with a crinkled silken yarn of a brownish hue, which, as the eggs shall hatch, shall be cradle and commons for the spiderlings until the call of spring bids to their exode. Next to this was placed a bright-yellow floss, loosely spun between the eggs and the inner surface of the outer case at which the mother was spinning when you came upon her.

This she will closely wrap and pack, and, as it seems, finish it with a sort of varnish that makes it water-tight. At least, if you will visit it in midwinter you shall find that it crackles beneath your touch like oil-skin. Indeed, the good spider matron has made canny provision for her children's future in this silk-spun, pear-shaped cradle home. How got the cunning and skill into her brain cells? And did the first mother Argiope have the same? And if not, why not? And how did her houseful of baby spiderlings manage in those early days to get on without it? But—"Silence in the ranks!" Hath it not been said that a certain order of intellect can ask more questions in a minute than a sage can answer in a day?

[1] This whole process is described and illustrated in the author's *American Spiders and their Spinning-work*, vol. ii., pp. 159–164.

One cannot know all this rare handiwork without wondering by what delicate machinery has it been done. Delicate indeed; and ingenious, and beautifully wrought beyond one's best powers to describe. There are few things in nature so well fitted to awaken admiration as the vital mechanism by which a spider's spinning work is made. To dissect its various parts from an aranead corpus and mount them for study and exhibition is not difficult for one who has some skill with the microscope. The limitations of this book will not allow more than a general description here.



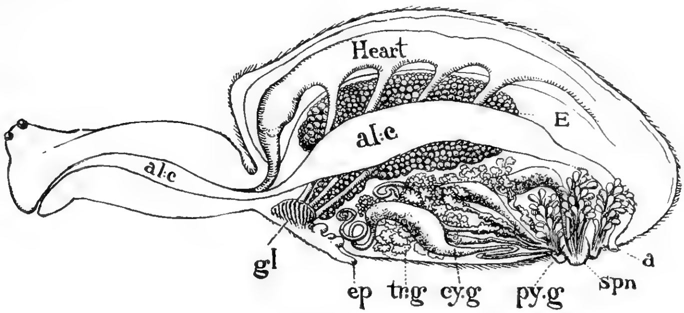
EGG-COCOON OF ORANGE ARGIOPE

To begin with the manufacture of the raw material, one must go to the silk glands. These lie in an orderly mass in the lower part of the apex of the abdomen, and consist of a large number of glands of several shapes and sizes. Many are pear-shaped (pyriform), some are "tree-formed," some are cylindrical or vermiform. Within these are secreted several kinds of liquid silk and the substance that forms the viscid beaded armature of the spiral lines of the orbweb.

Argiope is able to secrete at least three colors of silk stuff — the white, which forms the web, and the enswathement of captives and the egg-cocoon; the brown mass that fills the cocoon interior; and the flossy yellow between that and the inside of the sac. The glands end in minute ducts which empty into spinning-spools regularly arranged along the sides upon the tips of the six spinnerets, or "spinning-mammals," or "spinning-fingers," which are placed just beneath the apex of the abdomen. The spinnerets are movable and can be flung wide apart or pushed closely together, and the spinning-spools can be managed in the same way.

The silk glands are enfolded in muscular tissue, pressure upon which, at the will of the spider, forces the liquid silk through the duct into the spool, whence it issues as a minute filament, since it hardens upon contact with the air. One thread, as seen in a web, may be made up of a number of filaments, and is formed by putting the tips of the spools together as the liquid jets are forced out of the ducts. When the spinnerets are joined and a number of the spools are emptied, at once their contents merge, and the sheets or ribbons are formed which one sees in the enswathement of a captive or the making of Argiope's central shield. This delicate and complicated machinery the owner operates with utmost skill, bringing into play now one part, and now another, and again the whole with unfailing deftness and a mastery complete.

Once more let us visit our favorite hunting-grounds in these open, fallow fields. September is mellowing into October. That indescribable softness which marks



DIAGRAMATIC VIEW OF THE LOCATION OF THE SPINNING ORGANS IN (*ARGIOPE AURANTIUM*) ORANGE ARGIOPE

Spn, spinnerets; py.g, pyriform glands; cy.g, cylindrical glands; tr. g, tree-form glands; ep, epigynum through which the eggs are deposited; gl, gills; E, eggs; al:c, alimentary canal; a, anus. The figure is a composite one.

these halcyon days overhangs the meadows, the woods, and yonder distant hills. We pass along the brook. We pause by the familiar sites where a few weeks ago our Orange Argiopes had encamped in the full swing of their activity. They are gone! The splendid creatures whose restless vigor in spinning-work and in capturing prey you had noted and admired have disappeared. Whither? Ah, here is one, suspended in listless mood upon a tattered web. Here is another, a shrunken remnant of her former self, sluggishly striding around the margins of her orb, weaving in her spirals as though spreading a table for the last banquet of fast-ebbing life.

Still further, as one moves on, he sees fragments of the once beautiful snares stretched out at various points between the stalks of tall grass and low-lying shrubbery. The strands flutter in the breeze. The central patch of white silk flaunts like a tattered banner after a battle. The radii are snapped asunder. The spirals have been disarmed of their viscid beads, or keep only enough to capture helpless insects of the smaller sorts that expire without even the poor satisfaction of helping to rejuvenate exhausted nature by rendering their lives an offering to the vigor of another creature. The race of Argiope is gone for the current year.

If further you seek these noble araneads that lately brightened and enlivened the landscape, you will find some of them hanging lifeless and limp to strands of their broken webs. The legs are relaxed, out-stretched or crumpled up, and hanging by death-clinched claws to pendent threads. The abdomen is shrunken, drooping, and sways dully in the light autumn breeze. "It is the old, old fashion—death!"

Other dead forms will be found in various nooks, beneath embowering leaves or in other cosey retreats whither they have crept to weave their egg-cocoons. The last force of life had been spent in this act of fidelity to the future of her race; and hard by the shrivelled corpse you may see the pretty casket on which Nature has laid her sign of life. Soon the rains of autumn and the winds shall have eased the body to the earth to mingle with the leaf-mould and the soil. But when spring has revived the world, another generation shall

COCOON AND DEATH FASHION OF ARGIOPE

issue from the cocoons, and go forth to follow the life-round of the race that has passed away.

It is thus that Orange Argiope fulfils the course of her days. Would you call this a natural death? Be it so; yet it is not the common fashion. The most natural death of spiders is, perhaps, a violent one. To feed the hungry maw of a stronger, more skilful, or more fortunate fellow-aranead; to be rapt from her home and hunting-field; to be paralyzed and entombed within a clay sarcophagus by a mother wasp, and to serve as food for a growing waspling worm; to be snapped up as a delicate tidbit by birds, toads, and other creatures that feed upon her—these are some of the modes by which in the appointments of nature Orange Argiope and her congeners meet that doom which must befall all the living. And a painless death no doubt it is, even thus.

CHAPTER XVII

WATER-STRIDERS

THE first week of March found the banks of Brookcamp Run free from the snow and ice that had fringed the stream the winter long. Still the flanks of the South-valley Hills northward of Devon were streaked with snow, and the drifts in some sheltered nooks were unmelted. But we knew the winter had gone; for, walking by the brook that winds through our grove, we saw the water-striders skating over the surface. The robins, meadow larks, and bluebirds had already given notice of spring. But when these little fellows, among the first of the insect horde to appear, had come out upon their summer campaign, we were sure that we had said good-bye to winter, albeit Jack Frost might pay us a few visits more.

And what are these prophets of the spring, the water-striders? One might answer (and truly), "They are bugs!" But that, perhaps, would not be quite definite to many Americans, who have the odd habit of calling all insects "bugs," and insect-lovers by the inelegant title of "bug-hunters." Moreover, the name might handicap our brothers of the brook at the outset of our story, for to many minds it has an ill savor. Let us say, then, that they belong to the family Hydrometridæ of the great order of Hemiptera (or true bugs), insects which, with divers variations in form, character, and habit, agree in having the mouth parts formed for piercing and sucking instead of for biting.

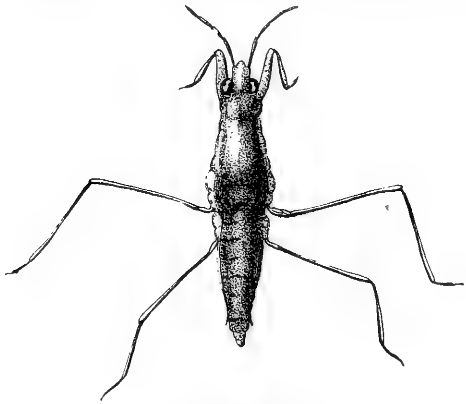
On the whole, it is a disreputable group, which we fancy we could easily spare from the world; although, perhaps, if we better knew "the balance of the powers" in nature, we might reverse our opinion. It embraces among its many families twenty thousand known species, and probably a yet greater host of species unknown. Some of these are most interesting creatures. There, for example, are the cicadas, or seventeen-year "locusts," as our countrymen will insist upon miscalling them. And there are the tree-hoppers, those odd little chaps, the brownies of the insect world, whose queer shapes suggest that there must be a streak of mirthfulness in the broad bosom of Mother Nature.

And here are our Hydrometrids, or water-striders, whom we are glad to put on the credit side of the long and heavy account against the Hemiptera; for they do no harm, but really help us somewhat by aiding to scavenger our ponds and running streams, besides giving no end of pleasure to boys and girls and idle fellows, like the author, who love to wander in the open fields and groves and watch the busy life of our little brothers and sisters of the land and water. And surely there is no lad or lass who ever loitered along a brook who has not seen a bevy of water-striders skimming over the surface like a bunch of skaters upon ice! Perhaps it may be well to suggest to such observers that the name "water-*spiders*," which one often hears, is a popular perversion.

Here, in a bit of quiet water between two ripples, is a group of a dozen or so; for, although they do not belong to what entomologists call the "social insects," such as ants, bees, wasps, and termites, they are sociable chaps and like to keep in companies. They are resting quietly on the surface-film, their six legs outstretched so that a line drawn through the tips would form an irregular oval. The front legs are short and stout, and are often carried bent almost at a right angle. The second and third pairs are long and slender, and not thickly clothed with hair. The body of the species (*Hygrotrechus remigis*) most common in our parts (eastern Pennsylvania) is in color a yellowish brown above, with a blackish rectangular mark upon the thorax and a double row of small white spots along the abdomen that look like little buttons. On the sides and beneath, the abdomen is covered with short, silvery pubescence which gives the insect a bright appearance, and, as some authors assert, helps to support the body upon the water. This, however, is contrary to my own observation, for I have never seen a water-strider touching its body to the water, its sole support being the legs.

This is difficult to note in natural site. But we can easily create an artificial pond and study the point at leisure. The cook—if she be good-natured—will supply a big bread-pan, and this, partly filled with fresh water, with a chunk of grassy sod from the brook-side placed in the middle, will give the natural conditions required. Armed with a wire net, or, in lieu thereof, with a small-meshed hand-strainer from the kitchen, several water-striders may be captured and transferred to your home-made pond.

Now, if you have keen eyes, or, if not, with a hand magnifier, note the position of the legs. The last two joints—there are six joints in all—rest lightly upon the water, making a dimple therein which is circular at the front feet and oval at the others. When the sun shines full upon a water-strider thus confined, or resting in a shallow place of the brook, the dimples in the surface-film cast black shadows precisely as do the body and limbs; and around the edges thereof is a bright aureola



A WATER-STRIDER

that reminds one of that which engirdles the sun when in full eclipse. They are dainty footsteps indeed that these creatures lay upon the water; and one wonders at the fairy-light tread that never seems to push through the delicate film which rides the stream, and gives to the water-strider a footing as secure as the floor of ice which the frost lays for merry skaters in the winter months.

Away the insect goes! Gently and slowly, or with a rush and swiftly, it glides along, a picture of graceful motion. How does it propel itself? So rapid is the movement of the legs that one is puzzled for a time, for the eyes can hardly follow them. But by-and-by, fixing the attention first upon one pair alone, then upon another and another in order, it appears that the middle pair of legs (not the last pair, as has been asserted) are used as oars. They are plied just as a boatman plies his oars, whether to move straight forward, or to swerve to this side or that, or to turn about. The hind legs are held steady, seeming to serve as a rudder, while the fore legs are lifted up, bent at the "knees"—as one may say—and are thus ready to seize any chance edible that may drift by. Thus it appears that our little vital craft may be said to be "manned" by a rower, a steersman, and a harpooner who stands at the bow to transfix the game!

And what is the game? On what do water-striders feed? Chiefly on insects that flutter over and drift upon the surface. As they flit to and fro over the water, darting here and there in the sunshine, they seem to be in a merry play. In truth, however, it is serious duty that engages them, for they are hunting their daily bread. In the early April days, in which these notes are written, that is not an easy task, for insects are scarce. Yet even now there are some small flies abroad.

Leaning upon the rail of the rustic bridge that spans the brook, you may see them, by the soft light of the setting sun that slants straight upon the stream, rising and falling and circling through the air near the water. Now and then one touches the surface. Then you will see a rush of wingless striders, and—alas for the luckless fly! Though oftener, indeed, quite unconscious of the unseen danger it had barely escaped, it flutters away and resumes its seesawing flight.

Will water-striders feed on the juices of such animals as men eat? They must be hungry now. Let us try an experiment. We tax once more the cook's good-nature; and fortunately a mess of finely ground boiled beef is just ready to mix into those inviting conical croquettes that so many folks relish, and a portion of this is secured. But how shall we feed it to our striders? It will not float long enough to give them approach thereto. So much the better for the small fishes below, whose appetites do not seem to be tempted by the insects walking the water above them, for I have never seen a strider taken by a fish. Then we must float our meat rations to them.

Dry leaves and bits of paper are mounted upon twigs or upon wooden toothpicks thrust in crosswise and lengthwise, and morsels of the meat are spread upon the edges. The tiny rafts are pushed into the stream. They float past one group, and then by another. Some are wrecked in the riffles where the brook runs over stones in its bed. Some are stranded in the long grass and bunches of water-cress by the water's edge. But at last one craft is challenged by a curious strider who throws one leg upon it as it floats by. Then follows its head; then it swings its body round, and, resting on the forepart of the leaf, thrusts down its beak into the savory mess and falls into that repose which gives token to the observer that it has found a feast and is enjoying it. Presently it is joined by a companion, who also "falls to" with apparent gusto.

Farther down-stream is one of our supply-ships that has safely passed a miniature water-fall and floated into a placid basin frequented by a large group of our Hydrometrids. In a moment half a dozen have scented the meaty cargo, have surrounded it, and, clinging to the edges or standing atop the craft, are making a hearty meal. Meanwhile the raft has drifted within the sweep of the next riffle. The first wavelets are entered. The boat rocks—and in a moment is overswept by the current; the bow is sucked under, and all the banqueting passengers are thrown into the stream.

Oars all, now! It is hard pulling; but our wee watermen are sturdy oarsmen, and at last all have rowed up the rapid into quiet water, while their bark lies bottom up upon a rock. Thus these tiny creatures, too, have their "moving accidents by flood." It was a pretty study and enjoyable, since no lives nor limbs were endangered. And we know now that human folk and water-striders both like meat croquettes!

At night, in the cool days of early spring, at least, our insects seek the edges of their native stream or pond, and, sheltered within clumps of grass or water-plants, clinging to the stalks thereof, they rest until morning. In such positions, or even while standing amid-stream, they often may be seen brushing themselves, as is the habit of insects. The short first legs seem to be used most frequently for this function. In May the female glues her eggs to the stems of bordering grasses, and seventeen days thereafter they are hatched, and the young insects enter upon their career along with their partly grown and adult congeners.

When winter sets in the survivors of the season burrow into the mud, or under bunches of dead leaves and withered grass-stalks or stones or other rubbish, and there lie dormant or semi-dormant until spring again calls them to active life. On the whole, that life seems to be a pleasant one as life goes among insects. At least so it appears to the human onlooker, who can only guess at the delights and the tribulations of these lowly fellow-creatures who share with him the joys and sorrows of the world of material nature.

As one walks along the brook-side he notes that the water-striders have a fancy to keep in groups, as though fond of society, and perhaps each group having its favorite haunts. One wonders if they have developed the sense and love of locality, a sort of home feeling for one spot rather than for another. They come upon the scene in groups, and there are several broods during the year.

They appear suddenly. One morning this or that bit of surface will be dotted with a new fleet, dimpling the surface-film as they scoot here and there. It is a freshly hatched brood. Born amid the grasses on the edge of the run, here they will spend their seemingly merry days. Most insects, like Father Adam, come or seem to come at a bound into the adult state. After transformation they do not grow. Flies, butterflies, moths, ants, wasps, beetles, dragon flies have an immense and mysterious interval between their youth as larvæ, pupæ, chrysalids, and their winged imagohood. But not so with our Hydrometrids. They belong to the insect orders that undergo incomplete transformation. They have a distinct childhood as water-striders, and grow therefrom as do higher animals. Thus we can watch our new-come flotilla of youngsters as day by day they increase in size without any decided change in form. Here in the shady nooks, the smooth bays, the jungles of grass, forget-me-nots, and water-cress, the tossing riffles and the quiet harbors of Brookcamp

Run, they spend and end their days. Their youth, their courtship and mating, their daily excursions for food, with their varied excitements and battles, and their exit from life are all wrought out here.

The broods gradually decrease, but what are their special enemies I have not yet made out; and they do not seem to be quarrelsome among themselves. However, there is one factor in their lives that is likely to shift for them the scene of action—the summer rains that change our brook in an hour or two from a laughing stream to a roaring torrent. It fills the bed, lips up against the rustic bridge, and has even overflowed the road. What has become of our water-striders? We will don our rain-coats and go see.

Here, just above the rustic bridge, is a group of forty or fifty. They hug the bank on either side where the waters go more quietly, and hold close to the grasses that fringe the edge above whose tops the flood is slowly rising. Now and then a venturesome body will push out towards the centre where the current is rough and strong. The rush of the water strikes it full sweep and drives it like an arrow down-stream. One would think it quite impossible that so slight a creature could withstand the force of such a torrent, on whose crest a heavy four-inch plank has been tossed like a feather. But with comparative ease our strider "backs water" against the current, and with only a short drift downward gets into the calmer eddies of the shore.

Let me quote the rest of the story from my field notes: "Below the bridge, the mass of rocks that forms a dam across the run is a young Niagara, with its 'whirlpool rapids' beyond. Here a few striders have gathered. What are they doing? Really, one might fancy they were playing 'dare' like a lot of venturesome boys! Secunda[1] ventures to the very verge of the fall. Surely, she cannot resist the suction of the riffles? Yes, by hard rowing and a final long leap above the surface she has reached port behind a bunch of grasses. . . . Now Tertia tries. She gradually glides along from her anchorage on the edge of the central current, which here runs strong but smooth. She seems unconscious of danger, holding herself steady and still, as one who shoots a rapid in a canoe, until she has touched the crest of the cataract. Then begins a struggle to return. Too late! Over she goes, and is lost to view in the whirlpool beyond. I do not see her emerge; but she may be one of the bunch of striders rocking in the harbor just against the bank in the lee of a big bowlder, along with several whirligig beetles, riding there at anchor like miniature torpedo-boats. . . . Quarta glides to the verge of the fall; and I thought she was over; but by hardest pulling she gets back. Again she ventures, and slides down fully one-third the water slope, and reascends it, to my great surprise and admiration. She takes a third dare—gets even farther down—then turns and by tremendous exertion climbs up the face of the fall and gets back to her harbor! Wonderful vigor! And now our plucky Quarta takes a fourth risk—she is caught in the rapids, leaps up from the lashing wavelets several inches, but alights just inside the rush and is swept down and under the boiling waters. Four feet below, the whirlpool casts her up; she struggles to the bank, clasps a bunch of grasses

[1] In my field notes, successive individuals were, for clarity of reference, often designated *Prima, Secunda, Tertia,* etc.

bobbing at the foot of the fall, and holding thereto sways back and forth, under and out of the water for a time, when I lose sight of her. . . . The storm is now nearly over. It rumbles down the Chester Valley and growls among the Valley Forge hills. The heavy rain has dwindled to scattering drops. The sun looks out from a bank of glowing clouds in the horizon. The bells of Berwyn ring the Angelus. There is a sunburst; the trees are gleaming as though studded with diamonds, and there is a rainbow in the east." So end the field notes for that day.

I have said that the water-striders are among the earliest heralds of the spring, appearing in March, if the season is not too severe. I have an earlier record. The close of January, 1906, brought some extraordinary weather throughout much of the United States. January 20th to 23d were June days in temperature, the thermometer rising to nearly 72° Fahrenheit at Brookcamp. Many water-striders and a few whirligig beetles appeared on our brook. The striders were all adults, and they were rowing and leaping, and sporting, courting, and mating as though summer were in full sway. They had not disappeared from the waters until December 6th preceding.

There soon came, of course, the inevitable retrogression to the natural-season temperature. But even when the thermometer stood at or near the freezing-point our boatmen kept afloat, showing unexpected power to endure cold weather. But by-and-by the chilly air proved too much for them, or, at least, for their insect food supplies, and they retired to the shelter of the banks. But occasionally, with the advent of milder days, they would issue from the shelter of the fringing clumps of water-cress and forget-me-nots for a bit of exercise upon the brook. And ere long an early spring found them in full possession of their favorite water-haunts. Thenceforth their life ran on its even tenor.

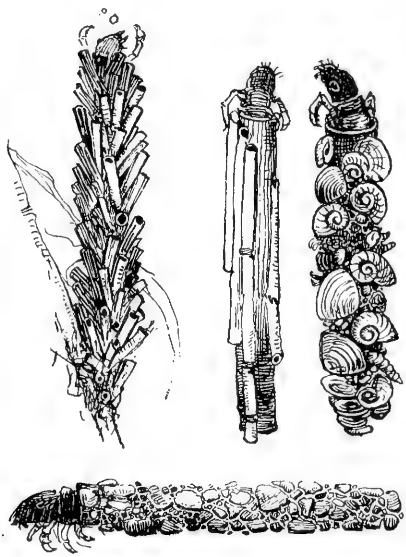
CHAPTER XVIII

THE NET-MAKING CADDIS WORM

ACCURATE accounts of insect architecture, especially if written with vivacity, are and always have been interesting. Not only students of entomology, but the general public, have taken rare pleasure in noting the structures reared by the more gifted and better-known representatives of the insect world. Doubtless this interest and this pleasure result largely from the contrast between the insignificant size and limited powers of these creatures and their comparatively vast and ingenious creations.

The architecture of such social insects as ants, bees, and wasps is wrought by the adult, or imago. The immature individuals are helpless charges upon the community, and upon them centre its chief concern, labor, and skill. In this respect they resemble human infants; and it may be that to this fact is due the development of those striking suggestions of human communal methods which many observers note in their behavior. Not until they have passed their pupal state and gained maturity do they enter upon an active career and begin to contribute to the general achievements of their race. The architectural instinct awakens with that sense of communal responsibility which comes with the adult stage.

There are, however, many families of insects with whom this quality is reversed. The architectural instinct is inborn with the larvæ and is wanting or quiescent in adults. While the former give some rare examples of skill in sheltering and caring for themselves, the latter live uninteresting lives, except in the maternal act of perpetuating their species, which for a brief period excites the female to interesting activity ere the spark of life expires. As the larvæ of these insects are solitary, and nature thrusts upon them responsibility for their own nurture and preservation, the possession of an adequate instinct is essential. It is the purpose of this chapter to give a record, with illustrations, of that instinct as shown in the life of a single example of one of these species—the net-making caddis worm.



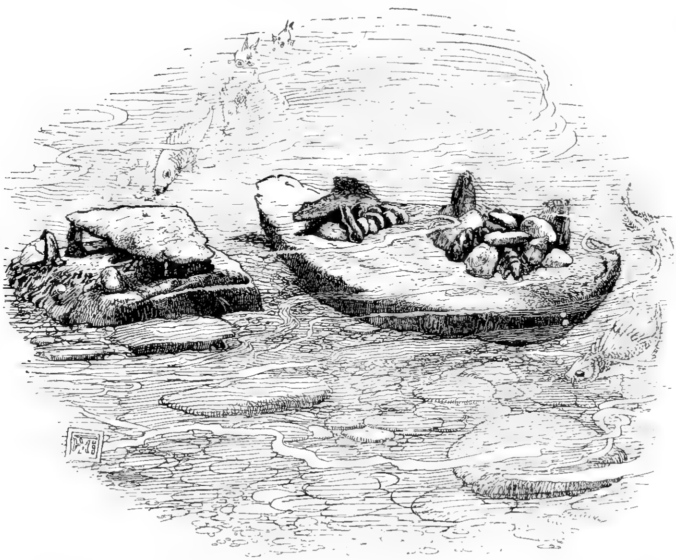
CASE-MAKING CADDIS WORMS

There are few familiars of American and English fresh-water streams who do not know something of the case-making caddis worm. It has the curious habit of covering the silken case in which it encloses its soft body with minute pebbles, or grains of sand and tiny shells, or bits of grass and leaves. Thus clad, it walks about on the bottom of running brooks and creeks, until ready to pass from the larval stage. Then it fixes its case to a convenient rock or pebble and shuts itself in to pupate. A score or more of such cases may be found upon a stone as big as one's fist. To the oddity of its appearance is due its wide popularity; and certainly it is a curious object as it slowly plods along beneath its mosaic-work armor of tiny stones, ever and anon thrusting its head and the upper part of its body out of its artificial shell.

But one rarely hears of the net-weaving caddis. The author confesses that until recently he knew it only from the books. While collecting a few specimens of the familiar armor-plated species from Brookcamp Run, a stream that passes through an open wood on his country-place, he drew from the water many of the peculiar domiciles of a net-making species, probably *Macronema rebratum* Hagen. His interest in them grew, and led to prolonged studies, some of which he hopes the reader will be glad to share with him.

Let us remove from this short stretch of riffle some of the stones that line the bottom. Our tray contains specimens on the edges and under-sides of which are fastened not only the compact, pellet-covered, tubular cases of the familiar caddis fly just mentioned, but many others of a quite different structure. They are little piles of pebbles held loosely together by silken threads; yet they adhere to one another and to their stone "host" firmly enough to resist the action of the current and the strain of removal. A number of specimens gathered three months ago show the little cairns unbroken.

They are made up of pebbles from the bigness of a

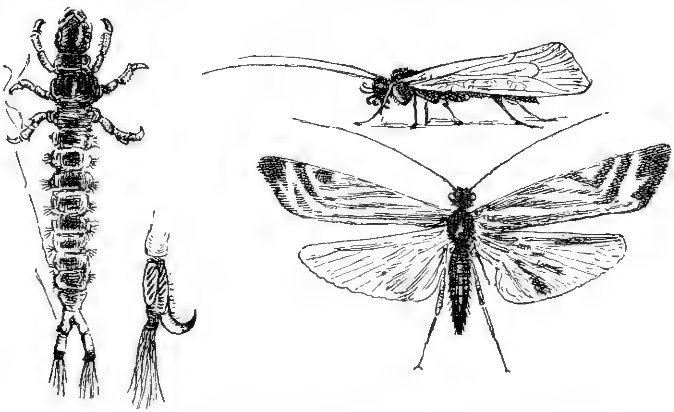


LARVAL CAIRNS OR DOMICILES OF NET-MAKING CADDIS WORM

pea to that of a pea-nut. Some lie upon the bottom in separate masses; most are attached to small stones of various sizes. Some of the pebbles are flat, and cover the others like a roof; indeed, one or more pieces of goodly size, leaned up one against the other, may usually be found in every group. All are so arranged as to form a rude sort of den or hut. In fact, they are the larval homes of the net-making caddis worm—an insect which belongs to the same order as the case-making caddis (Trichoptera), but to a different family (Hydropsychidæ).

Let us pull apart one of these stone domiciles. Here within the den, and commonly within a small tube, or a cavity, sometimes sparsely, sometimes thickly silk-lined, is the inhabitant. It is an active larva about three-fourths of an inch long, and one finds others of various shorter lengths, but few longer. The old name of "worm" clings to it, for in the early usage of the English tongue the scientific difference between a true worm and an insect larva was not regarded, and the habit persists. The larva is not stout or "chunky," but is rather elongated and narrow, and not uncomely in appearance, at least to the nature-lover's eye. Some specimens (collected in April) are tawny yellow, the head and two succeeding joints being dark brown. Others and younger specimens (taken July 27th) have the middle and terminal joints pale green. The head is flat and snakelike in appearance, the eyes small but prominent.

To the end of the body are attached two anal appendages, which terminate in bunches of flaring bristles.



NET-MAKING CADDIS FLY, IMAGO, LARVA, AND HOOK

Just beneath each appendage is a tiny hook, by which the larva anchors itself to some point within its nest, or to any other object, and can thus swing free beyond its tube and cairn without being carried away by the current. When from any cause it is set adrift, or ventures out of its bounds, these anchor-hooks must be of great use in aiding it to control its course and destination. When it wishes to stop, it has simply to "cast anchor" and hold on with its grapnels. When it wants to move on, it "hoists anchor" and drifts away. When forced out of its domicile, it can move about with much freedom; but in its native waters it probably keeps close to its own castle.

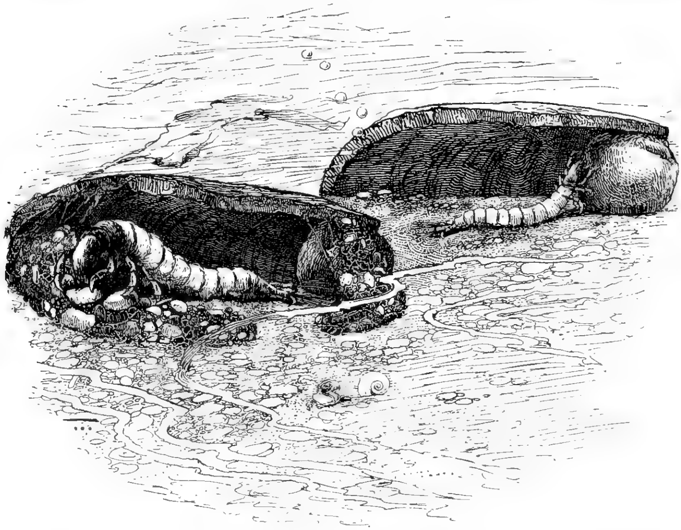
Net-making caddis worms are numerous in Brookcamp Run, as they doubtless are in most American streams. Nearly every stone within the riffles, or parts where the brook runs rapidly—which are the favorite sites for caddis settlements—has one or more caddis cairns upon it. As one looks down into the water he sees that many of the rocks, pebbles, sunken twigs, and other objects are covered with threadlike streamers, one end of which is free and floats downward with the current. Most of these are hydropsychid threads, and are covered with fine sediment. When taken from the water they collapse into a mass of slime. Other objects, as the trailing leaves of water-grasses, are similarly covered.

It is interesting to think how this habit of the caddis to fasten its threads upon rocks, and the habit of the threads to pick up sediment, may have contributed to affect the course of nature. Surfaces thus clogged by this and by other means gradually accumulate refuse of soil, of leaves, of chippage, and decaying matter. Germs of water-plants lodge therein; a rock-garden is formed; more and bulkier matter is assembled. The bed of the stream, the foot of the bank, and even the channel are affected. Little islets appear, and these slowly increase. Thus the changes go on, those minute and ceaseless changes by which, in the slow movement of ages, the face of nature is varied and renewed. One always must count upon the value of seemingly trifling forces and phenomena in the processes of world-building.

As one looks at these rude dens, he naturally asks, how were the pebbles that compose them assembled? Does the little cairn-builder collect, select, and arrange them? Are they chance accumulations? It may be that many of the pieces drift before the current when detached from the bed of the brook by the action of the stream, or by the movements of the multitude of water denizens, such as small fish, frogs, water snakes, crabs, and sundry insect larvæ, and become entangled in the sticky threads which caddises fasten to their lodging-rock. Thus their great variety of form may be partly due to the chance action of the riffle.

But the builders certainly have control over the position of the several pieces. This appears from the general design of the structures, which, with all their irregularity, are plainly intended for dwelling-places, and admirably serve their end. The pebbles are so adjusted that the silken tubes, above referred to as occupying the cavities formed within the heaps, have sufficient room, with free points of entrance and exit.

However, one likes to bring personal observation to determine such a point. To lie or crouch for hours upon the sloping bank of a brook and watch the movements of water larvæ is not just now possible to the author, although he has spent many pleasant hours in such studies in earlier years. Let us see what can be done by creating for our net-making caddis an artificial environment that may tempt it to show its methods. A long, shallow pan filled with water was transformed for the nonce into a miniature brook, and in it were placed several stones with hydropsychid cairns built upon them. The collection was taken to the house and put under observation. Soon the larvæ, who easily



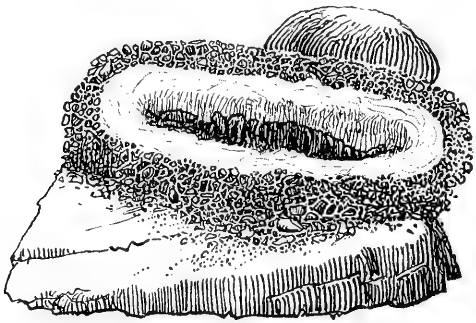
NET-MAKING CADDIS WORM BUILDING ITS UNDER-WATER CAIRN
The upper figure shows an earlier stage, the lower the pebble wall further advanced

knew that something out of the way had befallen them, crawled from their dens. Then the stones were removed, and over the bottom of the pan, which had been covered with sand, were strewn pebbles like those of which the cairns are composed, and the long watch for building operations began.

Let us follow the behavior of one nearly full-grown larva, as typical of all others. It had found refuge, after much wandering, against one side of a water-logged bit of wood, one end of which rested against a pebble as big as a filbert. The chip was so shaped that it sloped upward from the bottom, forming a projection like the eaves of a roof. A number of sand pellets as large as rice grains, and some as big as a pea, lay beside it.

The larva began work by clearing away the sand in the angle formed by the chip where it rested against the pebble and made a snug corner that promised to be the nucleus of a den. It bored into the underlying sand until a small cavity was formed, almost large enough to contain its body. Then it turned to the pellets in front. It moved its jaws—the under part of its head—many times over them, smearing them with a viscid secretion from its silk glands. The pieces were thus glued together in a loose bunch, and, ere one could make out exactly the process, were lifted and "butted" up against the pebble buttress. There they dangled, in the fashion of a bead necklace, and formed the beginning of a wall that was planned to enclose the angle made by the upward slant of the chip. When the wall was formed (by the same method) a circular space was cleared away near its union with the pebble, apparently the beginning of a tubular case of which this would be the door. The chief instruments in these acts were the head and fore paws; but undulatory movements of the body, kept up with almost rhythmic regularity, seemed to be effective in shaping the interior space and the general line of the wall.

While thus engaged, the little architect would now and then be lost to sight. But the agitation of the sand and the palpitation of the chip showed that it was at work underneath. At times it would reappear, to add to or strengthen its outer wall. Often it would thrust out the fore part of the body alone, and move it



PUPAL CASE OF A NET-MAKING CADDIS WORM, OPENED TO SHOW DEAD PUPA WITHIN

about, weaving threads to tie or cement together the sand grains with which it was building. Meanwhile it seemed to be anchored by its anal hooks to some point within.

Having thus been permitted to uncover the secrets of its craft, I was loath to disturb the little craftsman and destroy its work. But hardening my heart "in the interest of science," I lifted up the brown, water-logged chip which had been the background of the larva's operations. Down fell the wee protecting wall of threaded sand pellets. The builder wriggled its protest and fled; and, as expected, there appeared a tubular space which had been cleared away by pushing and packing the sand to either side. This was meant to be the refuge and home den, and in due time would have been hung and carpeted with silken tapestry, and so have become the tubular pupal case of a net-making caddis fly. Later in the season the mode of building here described was confirmed by observations fortunately made upon a half-grown larva working in natural site within the run itself.

Curiosity having been satisfied, the ingenious builder was replaced in favorable conditions, and left to restore its fallen house or erect a new one. The pan was covered with netting in the hope that the larva would pupate, and by-and-by emerge as an imago or perfect hydropsychid fly, and thus be captured and identified. This hope was disappointed; but within the pan was found, beneath a small cairn, a tough, silken, tubular case which held the dead body of a pupa. This marked the failure of some larva to attain its perfect life. It was the remains of our little builder, or mayhap of one of its fellows.

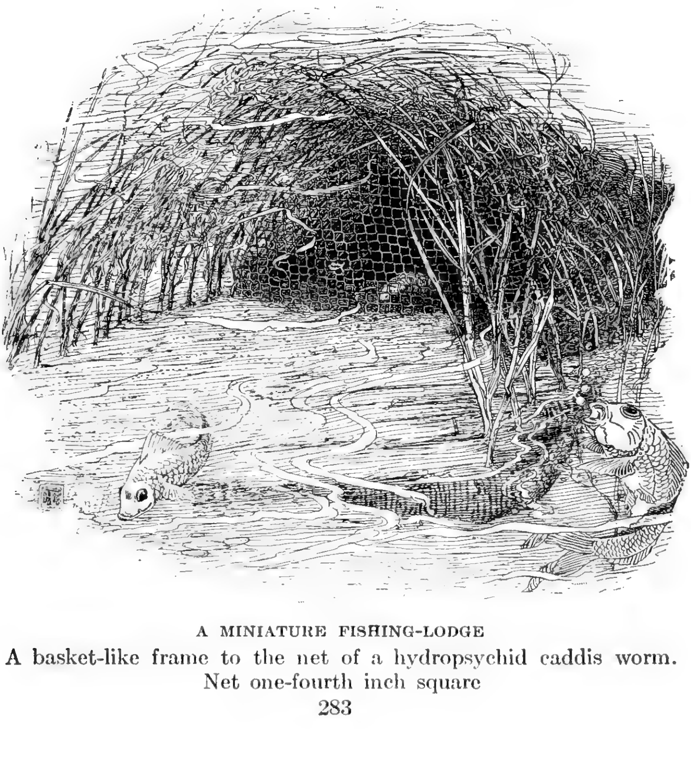
Another characteristic of hydropsychid cairns, and the most striking of all, is now to be told: they are fishing-lodges! This cairn-making caddis is a fisher worm, and earns its title of "net-making" or "net-building" by taking its prey in a woven net which is spread against some part of its cairn, or annex thereto, usually near the circular door of the tube. As the cairns are placed on the edge or facing the course of the current, such small-fry larvæ as it feeds upon drift into and are stopped by or entangled within the net, and thus are captured.

While noting the structure and arrangement of several of these nets grouped upon a plate, my thoughts, by that strange power of association which puzzles philosophers, were carried back through half a century, to boyhood fishing-days in eastern Ohio. I seemed to see a dam of loosely placed bowlders, built across a clear, running stream at the point where the riffle is most marked. A square wooden frame, wedged tightly into an open space in the dam, holds the wide mouth of a funnel-shaped fishing-net which is stretched backward against the current, and is fastened to a stake at the tapering point. Midway, the net narrows to a small circular opening that leads into the meshed pouch at the net's end which forms the trap. The fish, swimming up against the stream, as is their wont, enter the large square frame, and pass through the small inner circular door, and so are bagged. The farmer lads, who mostly practised this sort of fishing in those days, called the contrivance a "set-net."

How like the method of our hydropsychid larva!—only, it reverses the position of the net, and traps its prey as they move with the current, not against it. Is it strange that these structures should have suggested the set-net fishing of boyhood experience? Here is one before me, placed at the end of a conical, basket-like frame whose bowed ribs are tiny sprays of grass bent and lashed together by silken ropelets. It is rarely human in its style!—as though it might have been the work of veritable fairies.

The nets are irregular in shape, the average of several measured being one-fourth to three-eighths of an inch long and wide. The minute meshes are as regularly shaped as those of our own hand-knitted fishing-nets, and are of the same form. One net numbered about eight hundred within the above space. Perhaps one may appreciate the delicacy of touch and the machine-like accuracy shown in weaving this dainty, lacelike work if he will mark off a block a quarter of an inch square and draw within it twenty-six vertical lines crossed by thirty parallel ones, keeping the interspaces of equal size. He will thus have wellnigh copied the caddis worm's product.

It is interesting to note that the same peculiarity marks the meshes of the inner section of an orbweaving spider's snare, and doubtless is produced in the same way. When a thread is spun across the series of radiating lines, the cross-line adheres to the radius; and when it is passed to the next radius the pull upon the one just left draws it a little out of line. This gives the meshes the form of rectangles some of whose corners have been



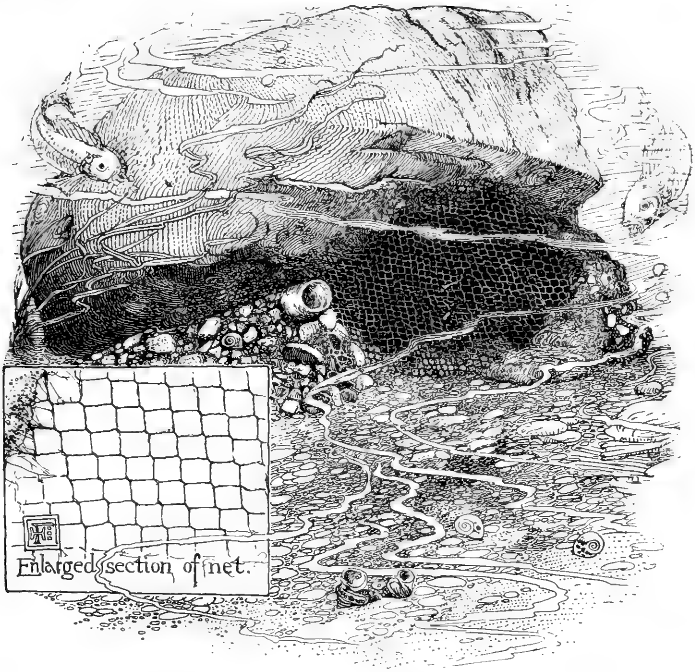
A MINIATURE FISHING-LODGE
A basket-like frame to the net of a hydropsychid caddis worm. Net one-fourth inch square

slightly trimmed off. The whole effect is that of a highly artificial and man-made implement.

It is suggestive of the unity of thought pervading nature that a contrivance of Man the Manufacturer and head of animate creation to capture water-food, and an implement wrought for the same purpose by a caddis larva which holds so low a grade in the scale of being, should be wrought upon the same general plan and in nearly the same form. And, further, that a spider, another animal of low grade, should use to capture its insect food a tool of much the same style; as man also uses his nets for snaring birds and small land beasts.

The hydropsychid larva not only holds its cairn as a domicile, fishing-lodge, and fortress, but makes it the scene of its pupation and transformation. It seals itself within its silken case and awaits the great change, while the brook ripples above it. Sometimes its case proves to be its sarcophagus; but if it survive the ordeal, in due time it awakens, and with the nature-given consciousness that a new life in a new element awaits it, cuts its way through the self-woven swathements, mounts to the surface of the water, and, finding rest upon some water-plant or projecting rock, casts its pupal skin.

The succeeding history has not yet been written but is of reasonable inference. Perhaps it may break from the pupal skin at the surface itself—a delicate and instantaneous act which one would think needs the deftest doing. For the water runs briskly, and the least untoward movement might lead to the wrecking of the dainty craft, or the wetting of the expanding wings, which would hinder escape from the turbulent element it is forsaking. This instantaneous expansion of the



CAIRN OF NET-MAKING CADDIS WORM, SHOWING ITS NET AND SILKEN TUBE

wings and up-springing in flight from the fragile boatlet tossing upon the riffle is a scene that may well give play to poet's fancy and romancer's imagination. One readily sees how men and women who have lived close to nature have caught from such scenes the inspiration which has peopled meadow and brook-side and grove with fairy folk, and woven about them the spell of fairy lore.

Once launched upon the air, the brief imago life begins. The perfect flies are often seen about the margins of streams. They love shady places. They are night-flying insects, and may be assembled by a bright light. Still forming our natural history from analogy of her near kindred, we may see the female hydropsychid ovipositing upon the foliage of some plant growing within or upon the margin of the stream. She may even crawl down a stem into the water to place her eggs. From these in due time come the larvæ whose form and industrial manner this study aims to tell; and thence the cycle of life recommences and runs endlessly on.

CHAPTER XIX

INSECTS AND CIVILIZATION

OF the great groups of animals, insects stand first in number and variety of forms. The genera and species discovered and described by entomologists have multiplied so rapidly that one wearies with the endeavor to keep count thereof. Less than a century ago an entomologist was one who had some knowledge of all known insects. To-day he is one who has a good knowledge of one order, or of a family within an order. No mind could compass the whole realm of insect life with scientific accuracy. Indeed, it has become impracticable for any specialist thoroughly to cover the field in the study of a single order, such as the Colceptera, confined to the beetles; or the Lepidoptera, which embraces moths and butterflies; or the Hymenoptera, which includes bees, ants, and wasps.

In the last-named order there are (in round numbers) thirty thousand known species; and a conservative estimate of the total number of species, known and unknown, is three hundred thousand. We may infer from this estimate of one order the vast aggregate of all the insect species on our globe. One who even dimly apprehends the direct influence of living creatures upon one another, and their indirect influence through the relations of animals to the waters, to the atmosphere, to the soil, and especially to plants, is prepared to believe that these innumerable hordes must have wrought in all time, and still must be exerting an enormous influence upon the mundane home of man, and upon man himself.

Long before man's apparition upon the geological horizon, insects were here. They must have had a foremost place in that mighty procession of zoological life that has moved through terrestrial history. Their fragile forms are not well adapted to survive the lapse of ages and the convulsions of world-building. But the mysterious Recorder, whose hand has graven upon the rocks the history of Creation, has not omitted them. Embalmed in the resins of sunken forests, and entombed in the mud-beds of ancient lakes, the fossils of the amber and of the shales have shown that insects early existed, in number, in forms, and in habits, not greatly unlike their congeners and successors of the present. Had such witnesses been wanting, the remains of insect-eating animals—birds, arachnids, reptiles, and quadrupeds—would have supplied the record. Thus insects have had a place in the development of the globe as we know it. Have they also had a part as forerunners of man in preparing the earth for Nature's masterpiece? And do we know, or can we conjecture what that part has been? Let us see.

The inter-relationship of created things, the adjustments and balances, the action and reaction of forces and objects upon one another and upon the whole, are too delicate and complex, and too obscurely set within their own secluded spheres, and our knowledge is as yet too limited, to permit us to specify or to speak with assurance. But enough is known to justify the inference that throughout the geologic periods insects were an important economic factor in forming habitable places for man, and in making the crust of the globe a suitable sphere for his development into the civilized being who now dominates it.

Take an example, or perhaps one should say a suggestion, of what may have been the function of insects in this great plan persistent throughout the ages. The action of insects in fertilizing plants is not only important but in many cases vital. Has it not always been so? One may easily infer that the primeval forests, and the exuberant vegetation of the plains, swamps, river-banks, and lake shores of ancient epochs, may have been indebted to insects for their fertilization, and so for their growth and perpetuation. Out of this vegetation—the flora of the Carboniferous era especially—have been formed our coal measures. Thus reasoning, one must score largely to the credit of insects as contributing to civilization all those elements that are dependent upon coal and the products of coal as fuel and as a generator of force. It may seem a far cry from the great human industries which characterize modern civilization—from transit and traffic on land and on sea; from human homes and their comfort and luxuries—to the insect orders of the paleontologist. But one may catch dim echoes of the voice, if he will put his ear close enough to nature.

Not to go so far back, and with methods of plant fertilization still in view, we may think of the world's indebtedness to insects for a large part of its present flora. Even upon the basis of what is surely known and what justly may be inferred, the commercial woods, the fruits of orchards and vineyards, the vegetable foods, the vegetable medicines, the perfumes, the wholesomeness and delightsomeness of flowers, are more or less the indirect gift of insects to civilization. This line of suggestion will not be exhausted easily, and the curious may follow it independently.

In another direction insects are and always must have been benefactors. While one vast group carries the fertilizing pollen from flower to flower and from plant to plant, another group is destined to deal with and utilize the products of decay. One is a minister of life to the living; the other, although also in the end a minister of life, fulfils its ministry in the realms of death. For a forest is not a nursery alone; it is a cemetery also. And therein nature's agents, destined to preside over the birth of life, jostle those that undertake for the dead. The refuse of woodlands and fields must be disposed of, and in such wise that nature's vital functions shall not be hindered but helped. To that end she has enrolled insects among her scavengers; she has set them in her burial detail. Foremost in this duty are the beetles; but other orders, in hosts of species and innumerable individuals, unite in the grim service. They seize upon the fallen plant. They gnaw its fibre. They reduce it to powder. They feed upon it. They shape it into domiciles and shelters for themselves and their offspring. Thus they clear the forests and fields of litter.

They create the wood-mould. They are true yoke-fellows with frost and snow, with rains and stormy wind, and with the vital forces that grasp and assimilate the products of death to feed the living. If one would know somewhat of the extent and method of this service, let him study thoroughly the contents of an old fallen tree in a native forest. Or let him note the manner in which those original paper-makers, the wasps and hornets, convert a bit of timber into wood-pulp and therefrom build their papery nests.

Of course, human beings, who radically interfere with and divert or eliminate natural processes, conspire to make nugatory these crude methods of their fellow-tenants in the House Cosmos. With his hand-made tools and his Promethean torch, and his divine gift of reasoning intelligence, man invades the domain of the insect scavengers. He hews down forests. He splits up and removes and converts their woods into alien forms, and burns up waste and underbrush and the débris of ages. This usurpation advances with civilization. Such high directing intelligence in the creature and such swift execution are an abnormal force in nature, whose vast, gross, and patient processes are conceived upon a scale of ages. Impatient civilized man operates upon a scale of centuries, or even years. Nevertheless, with all his overturnings, and burnings and diggings and convertings, his usurpations, and remorseless destructions of his less, and his less powerful brothers of the animal kingdom, he cannot wholly dispossess them. Vast reaches of the globe are still their natural domain, and the past at least is largely theirs. How they strike back at the lord-paramount and civilizer will presently appear.

Another field in which insects have helped to lay foundations for civilization pertains to agriculture. Man is unique among animals as a tiller and planter of the ground. But he has received his arable soil from nature; and in its preparation the inferior orders have had no little part. Charles Darwin's last book sent us to the earth worm to learn our indebtedness to a creature universally loathed; preachers often have proclaimed man to be "a brother to the worm." This reminder of his comparative insignificance, and of inevitable fellowships in his last sleep, has not always been graciously received. But Dr. Darwin compelled us to see that in real fraternal helpfulness the earth worm is one of our greatest benefactors, and that we need not be ashamed to call it "brother." It is now classic ground to the naturalist, that English field wherein the great man of science demonstrated, by long and patient observation and calculation, that earth worms, in the course of a few years, brought up an amount of soil that raised the entire surface of the meadow a large fraction of an inch.

Every one has observed the "casts" reared by these humble toilers into small, rugose, conical heaps in yard and field. Conceive that process, as wrought over the whole face of the globe, from the time that these annelids were introduced until the present. Even at a far less rate of progress than that established by Darwin—and it was much greater rather than less—you will see how much the earth worms may have done to earn from us the title of "brother." Here, at least, Darwin and the divines agree.

What is true herein of earth worms is true of many insects. Innumerable and usually invisible hosts of beetles and their fellows chew up vegetation and help convert it into wood-mould. That, in part, is the crude material for tillable soil. When the woodman's axe has deforested the hills, and when rains have absorbed and floods have transported the rich substance to lower levels intermingled with pulverized rocks, a sphere has been prepared for agricultural man.

But in a manner more closely resembling the earth worm's, insects have contributed, and still contribute, to form the arable surface of the earth. Before Dr. Darwin's book on earth worms had been printed, the author had made and printed in the *Proceedings* of the Academy of Natural Sciences of Philadelphia[1] some observations upon the action of ants in forming and shifting the top-soil, and in keeping the surface open for aeration and the absorption of moisture. The observations were made upon two species, the pavement ant (*Tetramorium cæspitum*) and a little brown Lasius that, in some quarters at least, is popularly known as the meadow ant. The pavement ant abounds in the open spaces of cities and towns, and especially affects the warm layers of soil underneath the brick and flag pavements of sidewalks. It is a pugnacious creatureling, and its battles with neighboring communities of congeners are as frequent, as fatal, and apparently as foolish as are most human wars. Several formicaries of this ant were put under observation in the early part of the year when the workers are most busy enlarging their nests for the prospective increase of their communities. The quantity of earth brought up through the chinks of a brick walk, and from various parts of the lawn, was collected at frequent intervals. It was carefully weighed and measured, and a calculation made of the amount added to the top-soil by an average formicary within a specified time. The calculation was applied to a number of ants' nests, with results not greatly differing, but upon a much narrower field, from those reached by Darwin from the labors of earth worms. This may seem to be a small matter, and perhaps it is, under present conditions, which so greatly limit emmet operations by man's cultivation of the soil.

[1] *Proceedings* (1879), pp. 159–161.

But when we consider the myriads of ants at work, and the vast period of time in which they have wrought in unrestricted spheres in all parts of the world, the results are by no means insignificant.

An interesting chapter in the relations of insects to men traverses the history of human superstitions. Religion, love, and marriage, disease, death, war, travel, success in pleasure and business, have all been held to be under the spell of one or another insect. This is but a fragment of that impulse which led even the most civilized nations of antiquity into animal worship. The mystery of life and its development into strange and varied forms, comely and grotesque, helpful and harmful, was far greater to the ancients than to moderns. The familiar truths which natural science has disclosed were to them insoluble secrets within the bosom of an unresponsive Sphinx.

Yet they were more directly dependent upon animals, and lived far closer to them than we. So it befell that living creatures became emblems and representatives of the good and the evil in their lives. The forces that guarded and blessed them in their flocks and herds, in war and in the chase, were symbolized in the cow, the bull, the ram, the dog, the elephant. Creatures that held their lives in terror seemed to them exponents of dreadful superior powers which they must propitiate. Thus arose a worship of gratitude and a worship of fear, directed by the few, it may be, to deities or dæmons that the animals symbolized, but by the multitude to the animals themselves.

In this category insects have a place. Folk-lore presents curious illustrations of the impression made by insects upon the simpler periods and ruder races of mankind. Many and strange notions have prevailed concerning the occult influence these little creatures exert upon the life of man. Imagination personified the winged denizens of the air in field and forest. Therefrom may have been evolved the notions of fairies, brownies, goblins, and divers other tiny personifications of the weird and the supernatural. It does not seem strange to one who knows the wise ways and works of insects, and who has noted the close resemblances between the social habits of man and the communal methods and architecture of such insects as ants, bees, and wasps, that the untrained fancy of ruder tribes should have seen in them a miniature of man himself. That these tiny, manlike creatures evolved from the insect world should have been developed in course of time into beings with occult power upon human destinies will not appear improbable to the student of folklore at least.

This effect was increased by the hurtfulness of many insects. The destructiveness of certain flies in their larval form; the mournful waste wrought by locusts and grasshoppers; the annoyances of irritating insects like the gnat, flea, and mosquito, are well calculated to exhibit the fearful forces latent within the insect world. One of the best known of the ethnic deities of early Scripture times was Beelzebub, the god and lord of flies—a name which by natural transliteration is applied to the devil, and for the most part by people ignorant of its origin. The divine honors paid Beelzebub show how early men sought to propitiate the supernatural powers believed to lie behind destructive hordes of insects.

These conceptions were not limited to possibilities of evil. The sacred scarabæus of Egypt, in its typical form at least, was the homely beetle known to us as the tumble bug. With its wings out-stretched above the little ball of compost in which was hidden the atom of life from which its progeny should spring, the scarab seemed to Egyptians a symbol of that infinite care which spreads protecting wings above our globe, and nurtures with maternal love, as well as with paternal power, the life of all things. The butterfly, sacred to Psyche, has been associated from remote time with ideas of immortality. The cicada, or harvest fly, erroneously known among Americans as the "locust," was the chosen emblem of the ancient Greek autochthones, the original inhabitants of the soil; and those cultivated sons of the aborigines were wont to wear a golden cicada in their hair as a badge of their high descent. It is not greatly to the credit of the Grecian ear for melody that cicadas should have been held as sacred to the Muses. From Homer and Hesiod to Anacreon and Theocritus the Greek bards hymned their tuneful powers. Nevertheless, in their larval form they were a food delicacy; and one can sympathize with Ælian's indignation that an animal sacred to the Muses should be strung on threads like onions, to be sold and greedily devoured.

The Mantidæ are among the most noteworthy of the sacred insects. Their name, *mantis*—a diviner, a soothsayer — shows their traditional standing. They are known among us as rear horses and praying insects, and in some quarters as god horses. The gift of fortune-telling was ascribed to them by the ancient Greeks, who believed that they could foretell death and famine. Perhaps the popular superstition concerning them is due to their peculiar use of the fore feet, which are held up as men do hands in the attitude of prayer. This, it is said, led Moslems to regard them as fellow-worshippers of God who showed their pious intentions by their devout manner. In southern Africa the Mantidæ receive homage. Throughout the continent of Europe the belief prevailed that when consulted as an oracle they would give, by their responsive position, unerring judgment as to the best policy in matters questioned. The peasantry of France are said still to believe, as did the ancient Greeks, that the mantis will point out the right way to the perplexed traveller.

Leaving the insects of sacred repute, let us turn to folk-lore to note a few survivals of the belief that certain insects are interlinked with and can influence destinies. Among these is a little beetle known as the lady bird, a name doubtless due to the belief that it was sacred to the Virgin Mary. Who does not recall the sense of mystery and expectation with which in childhood those pretty, spotted creatures were picked from the bushes and cast into the air followed by a chanted couplet:

> "Lady bird, lady bird, fly away home!
> Your house is on fire, your children alone."

Or perhaps with the variant ending:

> "Your children all burn."

Is this custom a survival of a pagan enchantment out of which the ancient spirit has long since fled? Doubtless it is associated with the impression that the insect's life and liberty must be held sacred. A prosaic and practical explanation refers to the usefulness of the lady bird. Its larvæ are insectivorous. They feed upon aphides, or plant lice—the "ant cows" of the myrmecologist—which injure various plants. They are thus benefactors of men and not to be destroyed. Now, in those rude days when economic entomology was unknown, fire was the accredited instrument to destroy aphides, and when the torch was to be applied the useful lady bird must be set free from the fire-peril.

In England and Scotland the lady bird was reputed wise in divining one's lover and future mate, a dignity which it shared with the gypsy queen. A Norfolk tradition knows this beetle as "Bishop Barnabee," and the girls thereabout would hold it in their palms watching the direction of its flight while they crooned the ditty:

> "Bishop, Bishop Barnabee,
> Tell me when my wedding be:
> If it be to-morrow day
> Take your wings and fly away!
> Fly to the east, fly to the west,
> Fly to him that I love best!"

The Scotch gave this beetle the same prophetic insight, but varied the song of enchantment and the name.

> "Lady, Lady Lanners; Lady, Lady Lanners,
> Tak' up your clowk aboot your head
> An' flee awa' to Flan'ers.
> Flee ower firth, an' flee ower fell,
> Flee ower pule, an' rinnan well,
> Flee ye east and flee ye west,
> Flee til him that lo'es me best!"

These illustrations, which could be greatly extended, should include at least a reference to the cricket's power to mould human destiny. Dickens, in his charming story *The Cricket on the Hearth,* has embodied a superstition almost universal among Anglo-Saxons. America holds a multitude of stanch believers in the heroine's theory when she heard a cricket shrilling in the new home: "It's sure to bring us good-fortune, John! It always has been so. To have a cricket on the hearth is the luckiest thing in the world." Nevertheless, the creaking chirrup of the harmless creature has been deemed a harbinger of death. Is it not the *Spectator* who somewhere avers that the voice of the cricket has struck more terror than the roaring of a lion?

CHAPTER XX

BENEFICIAL AND INJURIOUS INSECTS

IT remains to note the more direct influence of beneficial and injurious insects on mankind. The history of ancient literature shows that honey bees were domesticated at an early period. They were favorites of the Muses and presaged the gifts of eloquence and poesy. Hence the story that Pindar was first moved to write verses by bees settling on his lips when sleeping on the road-side during a journey to Thespia. Bees also foretold the future eloquence of Plato. While Ariosto his father was sacrificing to the Muses on Mount Hymettus, the mother laid the child in a thicket of myrtle. Bees clustered above him, droning their augury of future eloquence, and—for so a myth is sure to grow—wrought a honeycomb within his mouth.

Roman soothsayers, on the contrary, believed bees, at least in swarms, to be of evil augury, foretelling the approach of hostile armies. Thus ran the tradition in other nations also, with many and curious variations. But underneath all lay the fact of their eminent service to men by producing honey. And this filled a larger place in satisfying human longing for sweets, in those remote days, than in this era when science and extended industry have so greatly enlarged and varied the production of confections. For, like ants and bees and insects generally, man has ever had a sweet tooth. In the course of time, apriculture grew into a vast industry whose chief product was widely used as a food delicacy and in the preparation of elixirs, and the by-product, wax, in many highly serviceable ways. To the men of this age it was left to know the far greater service of bees and other insects in the fertilization of plants.

In manifest value to man and influence upon his life, the first rank among insects belongs to the silk-worm moth. No labor of civilized men has a history that, with high antiquity, is so varied, so interesting, and so important as the silk industry. The search for the "Golden Fleece" has been thought to be the legend of Europe's long and eager search for the mystery of silk culture. The product appears to have reached Greece from India by way of Persia. India received it from that swarming hive of ingenious industry, China. As far back as eight centuries before Christ we have credible notice of the culture of the mulberry-tree and the manufacture of silk cloth among that people.

But Chinese tradition carries the art eighteen centuries further back. It attributes the rearing of silk worms and utilizing their cocoons to the Empress Siling Shi, and the art of making clothing therefrom to her husband, the Emperor Hwangti. The invention raised the empress to the rank of a divinity, an honor better deserved and more wisely bestowed than in most cases of human deification.

The subject opens tempting vistas. But we must turn therefrom, only stopping to reflect how largely the Chinese discovery must have influenced the character and life of the Chinese and of civilization at large. Consider the multitudes engaged in cultivating the mulberry, the food-plant of the silk bombyx (*Bombyx mori*); in rearing the larvæ, gathering and caring for the cocoons, and reeling therefrom the raw silk. Think of the hosts engaged in dyeing and weaving the silk, and in devising and making the machinery employed therein. Then follow, in imagination, the ramification of commerce for the distribution and sale of the product. Go into shops and homes where silken garments are being made. Picture the part silk has played in the social life of men and women. What high functions of ancient and modern times, in state and church and society, have not owed the chief accessory in their brilliancy and beauty to the silk worm's humble industry as developed by man?

Even a single branch of the great industry—as the manufacture and use of sewing-silk—presents striking pictures of typical incidents and stages in civilized life. There is the poor needle-woman sewing "with double thread" in ill-requited toil. There is the New England factory-girl fulfilling her daily round of duty with all the possibilities of bright American womanhood potent within her. There is the fair maid who bends over embroidery frame and hoops, and stitches in a flower or a winged insect, laying in every shade with a thought or prayer of love, while her cheeks rival in color the brightest thread she sews. There is the designer of patterns, racking the brain and gleaning in all fields of nature and technical art for suggestions, ideas, and forms available for stamping. There are the visions of home and of mother, or of wife, and the humble art that love glorifies as her deft hands bind into memory a hundred homely services with needle and sewing-silk. But the series may as well stop here, unless one would follow the silken thread into the whole labyrinth of woman's life. Now visit a "school of art-needlework," or a "Woman's Exchange," or some like organ or organization for the sale of fine sewing and embroidery. Take from the books a number. It may be "No. 9" or "No. 999." Only a number—that is all! But how much it represents! There is a story, a romance, it may be, inwoven therewith, which will slowly unfold as the thread within your hand unwinds. Yes, indeed; the silk worm's dainty skein has enmeshed many human lives.

All this—and there is much of like useful service—is on the credit side of the insect account. But there is, unhappily, a heavy *per contra*. Civilization is influenced by disaster as well as by prosperity. Misfortune often paralyzes effort and retards development. But sometimes it awakens, stimulates, helps. On this line of influence insects have been potent, for they have been agents of inconceivable disasters. So terrific were the inroads of insect swarms in olden times, that they were compared to the desolations of invading armies with their aftermath of famine, pestilence, misery, and loss. They seemed to afflicted peoples to be judgments of avenging deities. Our own sacred books thus refer to them; and Bible readers will recall the terrible picture drawn by the prophet Joel of insect depredations in Palestine wrought by palmer worm and locust, canker worm and caterpillar; and also some of the "plagues" of Egypt.

In recent years insect ravages have been equally extensive, but the recuperative power of humanity is so much greater that the consequences have not seemed so appalling. It is worth while to sum up the losses inflicted by some well-known insects, and the enormous total will surprise those who have not considered the matter. The author is indebted to Dr. L. O. Howard, the accomplished entomologist of the United States Department of Agriculture, for the following statistics, which were kindly furnished in compliance with a request addressed to Mr. Secretary Wilson. Dr. Howard is not an alarmist, but a careful and conservative man of science, at the head of the most important organization of economic entomology in the world. We learn through him that the chinch bug caused a loss of $30,000,000 in 1871, upward of $100,000,000 in 1874, and, in 1887, $60,000,000. The Rocky Mountain locust, or Western grasshopper, in 1874 destroyed $100,000,000 in the crops of Kansas, Missouri, Nebraska, and Iowa, and the indirect loss was probably as much more. For many years the cotton caterpillar caused an average annual loss in the Southern States of $15,000,000, while in 1868 and 1873 the loss reached $30,000,000. The fly weevil, our most destructive enemy to stored grains, particularly throughout the South, inflicts an annual loss in the whole country of $40,000,000. The codling moth, the chief ravager of the apple and pear crops, destroys every year fruit valued at $30,000,000 to $40,000,000. The damage to live-stock inflicted by the ox bot or ox warble amounts annually to $36,000,000.

In 1904 the loss to the corn crop by various insects was $80,000,000, of which $20,000,000 was caused by the chinch bug. In the same year (1904) the Hessian fly caused a shortage of fifty million bushels of wheat, a loss of $40,000,000. These are fair samples of the enormous money losses produced in one country by a few of the pygmy captains of pernicious industry whose hosts operate in the granaries, orchards, gardens, and fields, and in the stock farms and yards of our country. What is the grand total? Mr. B. D. Walsh was one of the best entomologists of his day. He had the rare faculty of clothing his careful observations with the charm of vivid description; and his genial but caustic pen impaled many popular entomological follies. Nearly forty years ago (1867) he estimated the total yearly loss in the United States from insects to be from $300,000,000 to $400,000,000. Twenty-three years later (1890), Riley, who began his remarkable career as a co-worker with Walsh, and was long the chief of the Bureau of Entomology, estimated the loss at $300,000,000. Dr. James Fletcher, in 1891, footed up the loss at about one-tenth of our total agricultural products, or $330,000,000. In 1899, E. Dwight Sanderson, after careful consideration of the whole field, put the annual loss at $309,000,000. With the increase of agricultural products, and the facilities for estimating gains and losses, Mr. C. L. Marlatt, Assistant Entomologist of the Department of Agriculture, estimated for 1904 the following direct losses:

To cereals	$200,000,000
To stored crops	100,000,000
To sugars	5,000,000
To hay and grass	53,000,000
To cotton	60,000,000
To tobacco	5,300,000
To truck crops	53,000,000
To fruits	27,000,000
To miscellaneous crops	5,800,000
To animal products	175,000,000
To forests and lumber	150,000,000
Total	$834,100,000

Over eight hundred million dollars a year! "'Tis a good round sum!" Of course, there are compensations. As crops go down, prices go up. It is perhaps needful that some extraneous elements should hold in check the excess of production, and thus cause an equalization of results and a distribution of labors. What man in his greed and overgrasping unwisdom would not do for himself, the inferior orders and physical forces are set to accomplish. Perhaps, from this view-point, the injurious insects may have a function of good that our philosophy has not yet fathomed. But, then, one must consider the maxim of his boyhood, "There's such a thing as having too much of a good thing!" And, decidedly, we have too much of these insect regulators of the balance of agricultural production. Eight hundred millions a year is far too much for even a fatalist to bear with equanimity; and the bulk thereof must be set down as an unmitigated misfortune.

Is it possible to prevent this enormous loss? Absolute prevention is not possible; but it is certainly practicable to reduce the damage within tolerable limits. This is the function of the Bureau of Entomology. Its leaders and chief workers proceed upon the assumption that a complete knowledge of the life habit and relations of an insect must be known before it can be attacked successfully. Its manner of propagation and growth, its food, its enemies—all must be studied. Does this seem waste of time?—mere curious quest of the secrets of nature, pleasant as natural history, but economically profitless? There can be no campaign without a plan of campaign, and that includes *first of all* a complete knowledge of the strength, quality, the supplies, the assailable points, the offensive and defensive armor, the natural allies and antagonists of your enemy. Everything must be covered, for no one can know the precise point at which attack may prove most efficient. The enemy and its manner of life having thus been uncovered, it is possible to devise and wisely employ means of destruction and control.

How far the organized entomologists have been successful in their war upon the injurious insects it is well to let them say for themselves.[1] "Enormous as is the annual loss which may now be fairly charged to insects," says Mr. Marlatt, "it would undoubtedly be vastly greater if such pests were left absolutely unchecked and no efforts were made to limit their operations. Were it not for the methods of controlling insect pests, resulting from the studies of the Bureau of Entomology and of the official entomologists of the various States, and the practise of these measures by progressive farmers and fruit-growers, the losses from insects would be greatly increased. Familiar illustrations of savings from insect losses will occur to any one familiar with the work in economic or applied entomology in this country. The cotton worm, before it was studied and the method of controlling it by the use of arsenicals was made common knowledge, levied in bad years a tax of $30,000,000 on the cotton crop. The prevention of loss from the Hessian fly, due to the knowledge of proper seasons for planting wheat, and other direct and cultural methods, results in the saving of wheat to the farm value of from $100,000,000 to $200,000,000 annually. Careful statistics show that the damage from the codling moth to the apple is limited two-thirds by the adoption of the arseni-

[1] See Mr. Marlatt's report for A. D. 1904.

cal sprays, banding, and other methods of control, representing a saving of from $15,000,000 to $20,000,000 in the value of this fruit product alone. The existence and progress of the citrus industry in California were made possible by the introduction from Australia of a natural enemy of the white scale, an insect pest which was rapidly destroying the orange and lemon orchards, this introduction representing a saving to the people of that State of many million dollars every year. The rotation of corn with oats or other crops saves the corn crop from the attacks of the root worm to the extent of perhaps $100,000,000 annually in the chief corn-producing regions of the Mississippi Valley. The cultural system of controlling the boll-weevil is already saving the farmers of Texas many millions of dollars, and, in fact, making the continuance of cotton-growing possible; and scores of similar illustrations could be cited."

The history of the origin and operation of that beneficent organ of our government, the Bureau of Entomology, is worthy of full consideration. Its importance to the country is still little understood. A few years ago the average citizen knew little about it, and in his crass ignorance turned off the subject with a jest about "bugologists," and "hayseeds"; and deemed the whole affair a sort of cranky side-show of the politicians, got up to please the farmers! In truth, it is one of the worthiest features of our civilization, one that we may justly boast of, and which we should zealously support. It is a reflex of civilization under the stimulus of an assault of hordes of creatures whose ravages were a real peril to the nation, and had wrung a cry of distress from a multitude of disappointed and ruined laborers struggling in an unequal contest with enemies too numerous, too powerful, too subtile and insatiable in methods of destruction, to be overcome single-handed.

State and governmental aid and organized effort were and are necessary. Some of the States of the Union have established separate entomological departments, and maintain them with more or less efficiency. The general government is represented in the war against insect invaders by the Entomological Bureau, and spends in connection with the State agricultural stations one hundred thousand dollars a year. Considering the interests at stake the sum is inadequate, even paltry. A hundred thousand dollars spent to save the nation a loss of over eight hundred millions! The mere statement shows the insufficiency of the endeavor. Yet even this appropriation is grudgingly given by many legislators, who unfortunately are not acquainted with the magnitude of the interests at issue. There is some advantage, but also much disadvantage, in the influx of new members brought by every biennial congressional election. The fresh element is unfamiliar with the details of such a work as our economic entomologists have in hand. The subject is foreign to their tastes and knowledge. The field lies outside the current of their ordinary experiences. Few farmers and fruit-growers are sent to Congress. The new-comers must be educated, and the "missionary work" must be renewed continually. It is, therefore, an act of real public beneficence when the editors of current literature and great publishing houses undertake to present the facts to large constituencies in popular form.

In quite another field, upon which we are not to enter now, the need for and the success of government action have been shown most notably. No page in the history of modern civilization carries more honorable deeds, or more victorious, than that which records the recent adventure of American science upon the mosquito host of the yellow-fever germ. No battle-fields in Cuba and upon her waters give witness to greater courage, skill, and devotion to human welfare, in the highest sense of those words, than that which marked the attack upon the fever terror of Havana and other ports of the island. The success achieved by the pioneers of the army of sanitation, both entomological and medical, and by the medical department of the United States army, is a fine answer to those who challenge the practical value of governmental war upon noxious and destructive insects.

It is now well understood by those practically interested in raising fruits, berries, flowers, hops, and the standard cereals, that unceasing vigilance and intelligent war upon hostile insects are required to assure successful crops. The profitable agriculture, horticulture, and arboriculture of the future will be more and more allied with economic entomology. A penny-wise and pound-foolish policy on the part of the government and the people will prolong the struggle and the losses and aggravate the situation. We spend millions to defend our coasts and our maritime interests from possible spoliation by hypothetical enemies. Very well. But here is an actual annual loss of over eight hundred million dollars inflicted by foes perennially present and active. Shall we palter with such a danger, and dole out grudgingly the pittance that heretofore has been allowed? That were, indeed, to be penny wise and pound foolish; or, to quote another homely proverb, that would be "saving at the spigot and letting out at the bung."

Our Agricultural Department, through its Bureau of Entomology, has accomplished wonders with its small appropriation. In a double sense it has earned the title of "economic." It is beyond doubt instrumental in saving the country a large sum, mounting into the millions every year. It has stimulated the energy and revived the spirits of men who had wellnigh despaired under their misfortunes. It has summoned civilization to practical and hopeful endeavor to stay and avert the ravages of insect hordes that seemed to be irresistible. Already it has proved that human intelligence, industry, and patience can overcome the persistent legions before which the ancients and even our fathers helplessly bowed. It has called into being a large and growing industry devoted to the manufacture and preparation of machinery, appliances, preventives, destructives—the artillery and ordnance of the great entomological conflict with the insect enemies and invaders of our fields, vineyards, and forests. It has shown that its beneficent work is one in which all classes are interested, and almost equally with the farmer. The masters of transportation on land and sea, merchants great and small, the people at large, are deeply concerned that American civilization shall not tamely submit to a remediable evil. Undisciplined nature is strong, but intelligence is supreme. The flying, creeping things innumerable are mighty foes. But man has been given dominion over all the earth, and modern civilization, which represents the highest type of man, will surely not surrender to the Insecta.

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