

XLVIII.—*On the Architecture and Habits of the Cutting Ant of Texas* (*Atta fervens*). By the Rev. H. C. McCook*.

THE observations of which the following is an abstract were made during an encampment, for purposes of study, south of Austin, Texas.

1. *Exterior Architecture*.—Two forms were noted. The first, seen at a point distinguished as Camp Wright, was that of a mound, 21 feet long and about 4 feet high, which had been accumulated around the trunk of a double live-oak tree (*Quercus virens*) which stood on the side of a road. The second form was located at a point distinguished as Camp Jeanes. It was on a high, flat, upland prairie, and was a bed of denuded earth, in the midst of the grassy open, 8 feet 9 inches long, and 7 feet, more or less, across. Over this denuded surface were scattered between twenty and thirty circular, semicircular, and S-shaped elevations of fresh earth pellets. The circular moundlets had the appearance of an American spittoon, the resemblance being stronger by reason of a round open entrance or gallery-door in the centre. All had apparently been naturally formed by the gradual accumulation of the pellets of sandy soil, as they were brought out and dumped upon the circumference of the heap. The moundlets were massed at the base, and gradually sloped off towards the top. They were from 3 to 4 inches high. This "bed" (as the natives call it) was quite free from grass, as was also the mound at Camp Wright. Another nest of the same character was found at Camp Jeanes; this was situated in a grove, but was fully exposed to the sun. A fourth nest was found about a mile distant from this spot, of the same character. This is, therefore, probably the normal form of the external architecture of the formicary, the mound at Camp Wright being probably formed by accumulations around the tree, caused by the bordering road, which restricted the limits of the gates, and so threw the separate moundlets back upon each other.

2. *Gates or Doors*.—His first view of the mound at Camp Wright led Mr. McCook to fear that he had made a mistake, and pitched his camp near an abandoned nest. There was not a sign of life. The mound was covered over with earthen knobs or warts of various sizes; but the action of a recent shower upon the black soil gave the hill the appearance of an old one. Here and there were scattered over the surface small

* From the 'Proceedings of the Academy of Natural Sciences of Philadelphia,' Feb. 11, 1879.

irregular heaps of dry leaves, bits of leaves, and twigs. Otherwise the mound seemed lifeless, deserted. As the evening began to fall the scene was wholly changed. Hosts of ants of various sizes and in countless numbers were hurrying out of open gates into the neighbouring jungle; and two long double columns were stretched from the bottom to the top of the large overhanging live-oak. The ants in the descending columns all carried above their heads portions of green leaves, which waved to and fro and glanced in the lantern-light, giving to the moving column a weird look as it moved along. It seemed like a procession of Liliputian Sabbath-school children bearing aloft their banners. It is this habit which has given this insect in some quarters the popular name of the "Parasol Ant." It is also called in Texas the "Brazilian Ant," but is quite universally known as the "Cutting Ant," certainly a most appropriate name.

The opening and closing of the gates occurs before and after every exit from the nest. The process is a long, careful, and complicated one, and was studied fully. Towards evening the gates are gradually thrown open, and so remain until morning, when they are gradually closed, the process continuing in some cases until 10.30 A.M. The closing is done by carrying into the gallery bits of dry twigs of various lengths, some as long as $1\frac{1}{2}$ inch, dry leaves, and other refuse. A number of closed gates were opened to note the depth to which this refuse was placed. It varied from half an inch to an inch and a half from the surface. In some cases the gallery had been sealed up with sand pellets *below* the refuse. The galleries quite often slant inward from the gate, and at as great an angle as 45° . They also sometimes divide a short distance from the surface. These conformations allow more readily the process of closing. In carrying in the refuse the larger forms of the ant are engaged; as the hole gradually closes, only the very smallest appear. The last touches are carefully and delicately made by the minim, who in small squads fill in the remaining interstices with minute grains of sand; and finally the last labourer steals in behind some bit of leaf, and the gate is closed. It then presents to the casual observer the appearance above described of a little heap of dry chips accidentally accumulated upon the mound. The galleries at Camp Jeanes were closed in the same manner.

When the gates are opened at dusk this process is reversed. The minim first appear, deporting from the heap particles of sand. Larger forms follow, carrying away bits of refuse, which they drop a couple of inches, more or less, from the gate. This is a slow process; and apparently little is accom-

plished for a long time; but evidently the whole mass of refuse is thus loosened. Then comes the final burst, with soldiers, majors, and minors in the lead, who rush out bearing up before them the rubbish, which flies here and there, and in a few moments is cleared away from the gallery, and spread around the margin of the gate. These chips are evidently gathered together for this purpose and are among the "treasures" of the ants, being kept near by for this use. The pieces were easily identified as being thus used several days in succession.

The above observation points out at least the use found for the extremely small forms peculiar to this species. At least ten distinct castes (forms or sizes) were exhibited to the Academy. They vary as follows, the measurements being in sixteenths of an inch, viz. ♀, 14; ♂, 11; soldier 7; worker major 6, minor 5; and the remaining castes in the proportion $3\frac{1}{2}$, 3, $2\frac{1}{2}$, 2, $1\frac{1}{2}$, 1. A more careful comparison may possibly reduce this series one or two; but the result as above will probably stand.

The gates first opened are the first closed, and those last opened are the last closed.

3. *Leaf-cutting Habit.*—The whole process of cutting and carrying leaves from trees and shrubs was observed at Camp Wright and at a vegetable-garden near Austin. In order better to see the mode of cutting, small tender branches of live-oak were thrust into the mound near the gates. These were soon covered with ants; and as the lantern could thus be used conveniently, the operations of the cutters were completely in view. The cutter grasps the leaf with outspread feet, and makes an incision at the edge by a scissor-like motion of her sickle-shaped toothed mandibles. She gradually revolves, steadily cutting as she does so, her mandibles thus describing a circle, or the greater portion thereof. The feet turn with the head. The cut is a clean one, quite though the leaf. The cutter will sometimes drop with the excision to the ground, sometimes retire when the section has dropped, sometimes (it is inferred) seize the section and carry it down the tree. A division of labour was apparent. At the foot of one tree was a pile of cut leaves, to which clippings were continually being added by droppings from above. Carriers on the ground took these up and bore them to the nest. The loading of the cuttings is thus: the piece is seized by the curved mandibles; the head is elevated; the piece is thrown back by a quick motion, seeming to be lodged on the head within the deep furrow that runs along the entire median line of the head (except the clypeus), and supported between pro-

minent spines on the edge of this furrow and on the prothorax. The furrow and spines thus appear to serve a very useful end. The cutting and carrying were not done (so far as noted) by the smaller castes. The soldiers rarely engaged in this work, but were seen to precede the excursion columns as they moved out and up the tree, and afterward to return, as though engaged as scouts or pioneers.

The principal leaves gathered at Camp Wright were those of the live-oak. The young saplings in the neighbourhood of the mound were in great part or entirely defoliated. The great tree above was in parts stripped to the very top; so also was some wild vine unknown to the author. In beginning work, the cutters seem to aim first at the topmost leaves. A nest on the grounds of an intelligent nurseryman and gardener near Austin was visited; and from the proprietor many facts were learned. Ants were here seen at work late in the afternoon. They had come up through the garden from the formicary, 300 feet distant. They prefer trees with a smooth leaf; are severe upon grapes, peaches, the China tree, radishes, take celery, beets, young corn and wheat, plum, pomegranate, honeysuckle, cape-jessamine, crape myrtle, althæa. They do not like lettuce, will not take the paper mulberry, nor figs and cedar, except the bud-ends in the scant days of winter. They love sugar, grain, and tobacco! This proprietor assured Mr. McCook that the ants made foraging excursions into his house, entered his desk-drawers, and carried away a portion of his chewing-tobacco before he discovered the robbery. He had to be very careful thereafter where he deposited the delectable weed. Mr. McCook saw at another plantation an immense column engaged in plundering a granary of wheat, which was being carried away to the nest.

4. *Interior Architecture.*—The use of this leaf material, in part at least, was unfolded when the work of excavation began. Two trenches were made, one 10 feet long, 5 feet deep, and a second at right angles to it and wide enough to allow free entrance and study. The number of insects that swarmed to the defence of their home is simply amazing. They were, however, not so difficult to manage as sometimes when disturbed at their night work, as the swift use of the spade by the assistants and the general convulsion of their emmet world quite dazed most of them. However, when the speaker himself entered the trench to work with trowel, knife, rule, &c. the ants rallied, and attacked so fiercely that the men were compelled to brush them off. The wound inflicted by them was sharp, but nothing to compare with the severe sting of the agricultural ant. The interior of the formicary

may be briefly described as an irregular arrangement of caverns communicating with the surface and with each other by tubular galleries. These caverns or pockets were of various sizes, 2 feet 10 inches long and less, and 12 inches deep and 8 inches high and less. Within these chambers were masses of a very light delicate leaf-paper wrought into what may properly be called "combs." Some of the masses were in a single hemisphere, filling the central part of the cave; others were arranged in columnar masses $2\frac{1}{2}$ inches high, in contact along the floor. Some of these columns hung, like a rude honeycomb or wasp-nest, from roots which interlaced the chamber. The material was in some cases of a grey tint, in others of a leaf-brown. It was all evidently composed of the fibre of leaves which had been reduced to this form within the nest, probably by the joint action of the mandibles and salivary glands. On examination the masses proved to be composed of cells of various sizes, irregular in shape, but maintaining pretty constantly the hexagon. Some of the cells were half an inch in diameter, many one fourth of an inch, most of them one eighth of an inch, and quite minute. Large circular openings ran into the heart of the mass. Some of the cells were one inch deep; they usually narrowed into a funnel-like cylinder. Ants in great number, chiefly of the small castes, were found within these cells. In the first large cave opened were also great numbers of larvæ. The material was so fragile that it crumbled under even delicate handling; but a few specimens of parts of the ant-comb, with entire cells, were preserved and exhibited. Reference was made to the late Mr. Belt's opinion that these leaf-paper masses were used as a sort of "mushroom garden," a minute fungus being purposely cultivated upon them, which the ants used for food. Mr. McCook's specimens, when submitted to the microscope, did indeed show the appearance of such growth, which, however, is only what might have been expected under such environment. The belief was expressed that the ants fed upon the juices of the leaves. But (if investigations in progress should succeed) it was hoped that the subject of the true food of the cutting ant would be hereafter solved.

5. *Tunnelled Tracks*.—The ability of these emmet masons to excavate vast halls and subterranean avenues is remarkable. Several holes in the vicinity of Austin were visited, out of which "beds" or nests of ants had been dug, by an old man who used to follow the business of ant-killing. These holes were nearly as large as the cellar for a small house. One such excavation, about three miles from Austin, was 12 feet in diameter and 15 feet deep. At the lowest

point had been formed the main cavity, quite as large as a flour-barrel, in which were found many winged insects, males and females, and quantities of larvæ. This nest was situated 669 feet from a tree that stood in the front yard of a house and which the ants had stripped. Mr. McCook took the range of the underground way traversed by the ants to reach this point, from which an accurate route was constructed and exhibited. The course varied very little from a direct line. Two branch tunnels were made to a peach-orchard 120 feet distant. Reference was made to a paper by Dr. Lincecum in the Proceedings of the Academy, which gave an account of the tunnelling of a stream by these ants. There is nothing improbable in this, as the tunnel above referred to went down in places as deep as 6 feet, the average, however, being about 18 inches. At the exit hole the tunnel was 2 feet from the surface. The digging operations were described, in which the small forms alone seemed to take part. The large forms would therefore appear to assist in opening the gates, make the excursions, and do the cutting; the small forms to do the digging, or, at least, the carrying out of excavated earth; while the minimis, or least forms, assist in opening and closing doors and keeping charge of the larvæ. The minimis are quite ferocious in attack, and gallantly support the large-headed soldiers.

6. *Origin of Castes by Evolution.*—This wide differentiation of form among the insects of one species and nest is one of the most serious special difficulties which the English evolution hypothesis has encountered. Mr. Darwin, with that candour which always wins him the respect and confidence of all sincere-minded opponents, fully admits this, and endeavours at some length to meet it. The knot of the difficulty lies in the fact that the worker castes are sterile, and are produced from eggs laid at different periods by the female. Supposing, therefore, that profitable or other modifications had occurred in the workers, how, on the principle of natural selection and hereditary transmission, could these operate upon such workers? All modifications of structure must be wrought and transmitted through the female alone, affecting thus the worker-life enwrapped in the egg. But it appears quite impossible to comprehend how any structural modifications could act from the worker upon the queen in order to thus react upon a succeeding generation of workers. The illustrations which Mr. Darwin cites*, the variation of domestic cattle by interbreeding, and M. Verlot's experiments

* 'Origin of Species,' p. 227.

with certain double annual flowers, if admitted to throw some light upon the inquiry, yet require an efficient superintending human intelligence, which cannot be supposed to have its analogue in the perpetuation and development of ant forms, unless, indeed, we may believe that the evolution hypothesis implies and requires the interposition of a Personal Intelligence infinitely superior to that of both ant and man.

The precise sense in which the workers may be called "sterile" admits of some question. Sir John Lubbock has recently shown that parthenogenetic eggs are sometimes produced by worker-ants in artificial formicaries, from which males alone are hatched. This is according to the analogy of other Hymenoptera, as, for example, bees and wasps. Here, then, there may be possible escape from Mr. Darwin's difficulty more satisfactory than that which he himself suggests; for it is conceivable that an opportunity might thus be opened for the transmission of a profitable variation which might arise in a worker. Still the difficulty appears impassable. One must suppose the growth and maturity of one such parthenogenetic male, produced from a worker with such useful modification, to have been contemporaneous with the maturity of the females of a "swarm;" this male, together with the males hatched directly from eggs laid by the queen, shall have gone forth, as is the habit of ants, in the regular marriage flight, or "swarming;" and therein shall have met a virgin queen. As the modification thus supposed to be transmitted must, on the hypothesis, be very minute, it could have been saved from obliteration only by supposing it fortified by the recurrence of other contingencies of like character in succeeding generations. Mr. McCook therefore concluded that the development by natural selection, according to Mr. Darwin's hypothesis, of so many and widely varied forms as exist in the cutting ant, requires a series of contingencies so multiplied and remote as to forbid a reasonable hope of its probable occurrence, even with the additional favouring circumstance of occasional males parthenogenetically produced.

He added that some of the points which Mr. Darwin had raised as to the structure of the driver ant of Africa were being carefully examined by him in the case of *Atta fervens*, with the best microscopic helps at his command. Thus far, however, after a quite careful examination, nothing that can suggest the idea of an interblending of the castes by rudimentary forms had been discovered. The lowest castes of minims, in all specimens examined with special reference to

the mouth-organs and eyes, showed the same structure, in equal definiteness and perfection, as the larger castes. Allusion was also made to the ravages of these destructive insects; and some of the modes for exterminating them were explained.

XLIX.—*On the Geological Distribution of the Rhabdophora.*
By CHARLES LAPWORTH, F.G.S.

Part I. HISTORICAL.

[Continued from p. 257.]

(d) *Recent Research.*

GEOLOGICAL.—It has been already shown that those geologists whose leanings were mainly palæontological accepted without question the reference of all prolific Graptolite-bearing strata to the general horizon of the Llandeilo formation, and endeavoured to escape from the numerous difficulties in which they consequently found themselves involved by appeals to the recognized rule of the restriction of certain fossil groups to special sediments, by references to the phenomenon of migration, by the adoption of the theory of "Colonies," and the like. But there were, in addition, a few influential geologists who looked upon geology almost wholly from the physical side, and who naturally relied only upon such palæontological testimony as distinctly coincided with the inferences they drew from the stratigraphical evidences. These viewed all attempts to correlate strata of disconnected areas by means of the Rhabdophora with the gravest suspicion, passing over with a careless indifference the clearest indications of a natural succession afforded by those entered upon their fossil lists. When, as occasionally happened, the palæontological testimony afforded by these fossils conflicted with that drawn from the apparent physical evidences, no matter how scanty or ambiguous, they at once set it aside with undisguised contempt.

However mortifying it may be to the graptolithologist to admit the fact, it cannot be denied that this course was at all events quite as reasonable as the habit of the over-credulous majority. The cautious field-geologist, on consulting the works of those who had made these fossils the subjects of special study, learnt at once that, according to the best authorities, many of the most characteristic Llandeilo Graptolites of Britain occurred in America in the very highest beds of the



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