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BULLETIN

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Article I. — THE HABITS OF THE TENT-BUILDING ANT (CREMASTOGASTER LINEOLATA SAY).

By WILLIAM MORTON WHEELER.

PLATES I–VI.

The large cosmopolitan, but mainly tropical genus *Cremastogaster* is represented in the United States by some seven different species. These are confined to the Southern and Southwestern States, with the exception of the common *C. lineolata* which ranges over the whole country from the Atlantic and Pacific seaboards to an altitude of about 7000 feet in the Rocky Mountains. Like most of our widely distributed ants, it shows a remarkable tendency to vary. Emery [1] recognizes some ten different varieties and subspecies. He finds, moreover, that this number could be increased by recognizing some of the varieties which connect the subspecies. From the extraordinary variety of these ants that have been accumulating in my own collection, I should say that the number of subspecies and varieties hitherto recorded might readily be doubled. I must postpone, however, a detailed taxonomic study of these ants till some future time.

In such a protean form as *C. lineolata* we should expect to find marked variability in habits. While this is undoubtedly the case, this variability does not seem to be definitely correlated with particular color or form variations, but each single subspecies or variety exhibits a considerable range of adaptations, some of which may manifest themselves only in certain localities or at certain seasons. Thus, in its nesting habits, the beautiful yellow and black var. *clara* of Texas shows much the same range of adaptations as our common northern *lineolata* (typical) and its variety *cerasi*, for all of these forms may be found nesting either in the soil under stones, in

[1] Beiträge zur Kenntniss der nordamerikanischen Ameisenfauna. Zool. Jahrb. Abth. f. Syst. VIII, 1894 pp. 280–286.

dead wood, or under bark, boards, etc. The workers of all of our forms have the same habit of climbing trees and plants in straggling files and of attending aphides and coccids. The excrement of these animals, popularly known as "honey dew," certainly constitutes a large portion of their food. All of our forms have a rank, indescribable odor. When in large colonies, they are often very courageous and sting and bite with great fury. Small colonies, however, or small groups of foraging workers are very timid and when disturbed take refuge in crevices in the bark or depressions in the soil. Like the other members of the genus, *lineolata* workers are able while walking or running to throw up and turn forward the tip of the gaster, so that its flattened dorsal surface becomes ventral and its convex ventral surface becomes dorsal in position. (Figs. 1 and 2.) This peculiar position, however, is not so readily or frequently assumed as in some of the tropical American species, like *C. minuta* and *C. ashmeadi.*

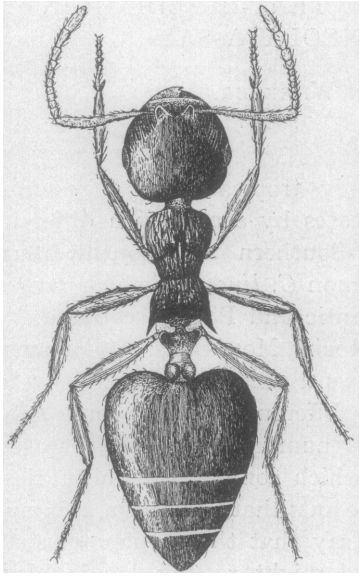


Fig. 1. Cremastogaster lineolata Say. Worker.

Among the habits of *C. lineolata* there is one that is as striking in its manifestation as it is obscure in its phylogenetic origin, — the habit of constructing, often at some distance from the ground or the nest, small enclosures, variously designated as 'tents,' 'pavilions' or 'cowsheds' over colonies of aphides or coccids. These structures, which consist of agglutinated earth or vegetable detritus, have been described by several observers, though they have neither been adequately figured nor satisfactorily explained. Such tents are erected by other ants, but those of *C. lineolata* seem to show greater perfection of workmanship and a higher degree of adaptation to special conditions.

One of the earliest accounts of these structures among our American ants was published by Baron Osten Sacken in 1862.[1] His

[1] Entomologische Notizen. VII. Stallfütternde Ameisen. Stett Entomol. Zeitg., 23 Jahrg. 1862, pp. 127, 128.

article, which was translated and republished in 'Psyche' twenty years later,[1] is here quoted in full:

"On a horizontal twig of a juniper (*J. virginiana*), about five feet from the ground, I observed a colony of a species of *Lachnus*. A small reddish ant with a brown abdomen was diligently working at a tube-shaped structure of soft, grayish brown, felt-like material, enclosing the twig in a kind of sheath. The material probably consisted of short fibers of liber closely packed together; it had a pitchy smell, burnt well, the smoke having the same smell, but stronger. The structure was about an inch long and one third of an inch in diameter.

"The second case observed by me was near the Berkeley Springs, in Virginia. A black ant had built a globular structure of a sandy material, of about an inch and a half in diameter, around the stem of an *Asclepias*, which was closely packed with aphides. Although the sand was sufficiently mixed with clay to have the necessary consistence, and although several leafstalks served as supports, the structure was so brittle that I did not succeed in bringing it home."

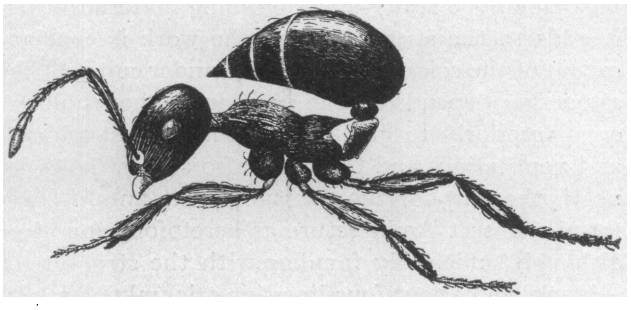


Fig. 2. Cremastogaster lineolata Say. Worker with the gaster turned up and directed anteriorly.

It is clear from Osten Sacken's description that the two aphis-tents which he observed were made of very different materials, one being of felted vegetable detritus, the other of sand and clay. As all the tents described by subsequent writers consist of one or the other of these two substances they may be distinguished as the carton and earthen types, respectively. In the original German paper Osten Sacken ascribes the felted or carton nest to a *Formica*, but it is very probable that both of the tents were constructed by forms of *C. lineolata*, for the term *Formica* need not be construed in the restricted modern sense; the fact that it was omitted in the translation may be taken to indicate that Osten Sacken may have employed it in a general sense as synonymous with the word 'ant.'

[1] Ants and Aphides. Psyche, Vol. III, No. 97, May 1882, p. 342.

A year after the publication of Osten Sacken's paper, Couper described some tents of the carton type [1]:

"An ant occurs on the Homewood estate, near Toronto, U. Canada, that constructs a kind of *papier-mâché* tent over Aphides, parasitic on a species of alder. This structure is attached to the smaller branches of the tree, generally about two or three feet from the ground. The material used by the ants appears to be fine dust fallen from the interior of decayed hard-wood trees. They convert the dust into a sort of paste which is carried up in small particles. It is wonderful to notice the steadiness and rapidity of these little architects about their work. During the cooler portions of sunny days, the whole working force (neuters) of the nest are out at labor, running up and down on the main trunk of the shrub on which the Aphides are living. Each ant in its upward course, having a small particle of the ready-made building material in its mandibles, which it adds to the structure, and the work is continued daily until the extent of the colony of Aphides is under cover. The form of structure altogether depends on the position of the Aphides. It is sufficiently open interiorly to give the ants and plant-parasites plenty of room and ventilation, and there are also several holes leading from underneath the tent for the passage of the ants. I am led to mark this form of Insect Architecture as heretofore unnoticed in America, and although sufficiently familiar with the structure, the species, which is black, and about four lines long, is unknown to me."

A more detailed description of a carton tent of *Cremastogaster lineolata* than either of the preceding was published in 1882 by Professor William Trelease [2]:

"While collecting leaf-fungi on *Andromeda ligustrina*, in a sphagnum swamp at Woods Hole, Mass., in the early part of September, 1881, my attention was attracted by a small, rough mass, apparently of dried sphagnum, surrounding one of the twigs, at a distance of about a metre and a half above the ground. Curious to know how it had reached that unusual place, and what it really was, I went to it, and on closer examination found it to be a shelter erected by a colony of about a dozen worker ants and a numerous herd of small wingless brown aphides, which feed on the sap of this plant.

"The twig on which the nest was placed had a diameter of about 3 mm., branched once at the top, and again at about 8 mm. from the bottom of the nest; between these branchlets a single leaf was given

[1] Remarks on Tent-building Ants. Proc. Entomol. Soc. Phila., Feb. 1863, pp. 273, 274.
[2] Unusual Care ot Ants for Aphides. Psyche, Vol. III, No. 94, Feb. 1882, pp. 310, 311.

off. The nest was 3 cm. long, 1.3 cm. broad at the largest part, near the middle, tapering somewhat toward each end, where it was quite abruptly rounded off, running down the stem in a thin, solid layer for a very short distance. The walls, which had an average thickness of about 0.5 mm., also ran out in the same way, where the branchlets passed through. These decurrent portions formed the only support of the structure, which thus enclosed a capacious chamber surrounding the twig. On the inner surface, so far as seen, the wall was carefully smoothed off; the outer surface was quite irregular and rough. A small round opening existed at each end. That at the top was 3 mm. in diameter: the lower one was very minute, having a diameter of less than 1 mm. As I have said, the nest at first sight appeared to consist of dry bog-moss; a microscopic examination, however, showed the material to be chiefly small fragments of wood — evidently obtained from an old log lying at the foot of the shrub — with small quantities of the leaf-fragments of mosses and phænogams, the whole apparently glued together by the saliva of the ants. . . .

"The ants proved to be workers of *Cremastogaster lineolata* Say; not having winged individuals, I did not attempt to identify the aphides. Both, with the nest, have been placed in the biological collection of the Museum of Comparative Zoölogy at Cambridge, Mass."

In more recent years our entomologists seem to have paid little attention to the aphis-sheds of *C. lineolata.* Professor Comstock has found these structures repeatedly in the neighborhood of Ithaca, N. Y., and has kindly sent me a specimen of one of them together with a photograph of another. They are both of the earthen type and are reproduced in Figs. 1 and 2, Pl. IV. The specimen from which Fig. 1 was made is 3.5 cm. long, 2 cm. broad, and only 1.5 cm. thick. It is somewhat pyramidal in outline and has a circular opening 1.75 mm. in diameter, in its lower portion. Professor Comstock sends me the following field-notes concerning these tents: "The aphis-tents occurred upon dogwood growing on the banks of a stream. The dogwood was growing in a perfectly dry place, but only a few rods above a wet one. Although I collected these tents in several succeeding years, I never took the time to trace the ants back to their nest. The locality is a considerable distance from the University, and I visited it each year on an excursion with my class when there were many things to see, so that I had not much time to devote to these ants. These trips were made during the month of August of each year. I find one of my tents labelled Aug. 2d, '88, another

Aug. 25th, '96. On the 25th of July, '89, I found in another locality quite near the University some ant-tents built over *Kermes* on an oak sapling. This was growing in a dry place several rods from one of our streams."

Mr. E. Daecke has loaned me a fine carton tent of *C. lineolata* which he found October 23, 1903, near Hammonton, New Jersey. It is reproduced, nearly twice the natural size, in Fig. 2, Pl. III. Mr. Daecke writes me that "it was found about four feet from the ground on swamp huckleberry alongside of a wagon road. The spot, located in the typical pine-barrens, was rather moist on account of a small spring in the neighborhood."

Another tent of the carton type, but in a very dilapidated condition, was received from Mr. A. M. Ferguson, who found it near Columbia, Missouri, during the summer of 1903. This specimen, like the one mentioned by Professor Comstock, was built over some *Kermes* on an oak twig.

In the preceding paragraphs I have taken pains to bring together the scattered observations of previous authors for the reason that even in localities where *C. lineolata* abounds, it rarely constructs tents over the aphides and coccids. These structures are of local and sporadic occurrence, as if owing their origin to some unusual condition in the environment rather than to the normal instincts of the species. Though I have often sought for these structures, I have been able to find them in only one locality. August 20 and again September 5, 1905, while collecting insects in the sandy barrens about Lakehurst, New Jersey, I happened upon several fine carton tents built about the terminal twigs of some young pitch pines (*Pinus rigida*). The pines were scattered over an area of about an acre in a damp place that must have been a bog at some former time, as it was still partly overgrown with *Sphagnum* moss and studded with the stumps of larger pines destroyed by a forest fire. The *C. lineolata*, which belonged to the subspecies *pilosa* Pergande, were nesting in some of these stumps. The tents were widely scattered and probably represented the work of several colonies of ants, except in one spot where as many as fourteen were found on a single small pine only six feet high. At first sight they resembled the gray or whitish accumulations of a twig-boring tortricid caterpillar (*Retinia comstockiana* Fernald) which is destructive to the pitch pines. One of these accumulations with the hole from which the moth has escaped is shown in Fig. 1, Pl. I. Closer inspection, however, shows that the tents consist of a substance like coarse, pale gray blotting paper or

dried paper-pulp. Under the microscope this resolves itself into bleached particles of *Sphagnum* moss agglutinated by some secretion from the cephalic glands of the worker ants. Several of these tents are shown in Figs. 2, 3, and 4, Pl. I, Pl. II, and Fig. 1, Pl. III. They completely envelop the terminal twigs a few inches from the tips and, though fragile, are evidently well protected from the wind and rain by the needles projecting through and a considerable distance beyond their walls on all sides. Some of the differences in the sizes and shapes of these tents are shown in the figures. The smallest specimens are 2.5 cm. long and 1 cm. in diameter, the largest 4 cm. long and nearly 3 cm. in diameter. Their walls are rarely thicker than ordinary blotting paper and as they are perforated and supported by the needles at a little distance from the surface of the twig, each tent encloses a space obstructed only by the bases of the needles, which thus answer the same purpose as the poles in a veritable tent. As a rule there is but one entrance, a circular hole about 1.5 mm. in diameter usually on one side and near the lower end of the tent, that is, the end nearer the ground or first reached by the ascending files of workers.

All of the tents contained herds of plump Coccidæ, 2–3 mm. in length, which sometimes completely covered the enclosed bark of the twig. There were also a number of *pilosa* workers busily imbibing the ejecta of their protégées or resting quietly in or among them as if loath to leave the pleasure pavilions. In Figs. 3 and 4, Pl. I, two of the tents are reproduced with a large portion of the wall removed to show the extent of the enclosed cavity, the way in which the walls are supported by the pine-needles, and the Coccidæ clustered on the bark of the twig.

The striking character of the tents described in the preceding paragraphs leads naturally to the question of their function and the study of the instincts of which they are an expression. There are several possible answers to such a question. We may suppose that *C. lineolata* builds these structures

1. for the purpose of preventing the escape of the aphides and coccids to other plants or to other parts of the same plant;

2. for the purpose of protecting these insects from their natural enemies or from other ants;

3. for the purpose of protecting them from the cold;

4. for the purpose of protecting themselves from exposure.

For some or all of these purposes the tents would seem to be most admirable contrivances. It is probable that the aphides and coccids

make the same appeal to the ants' sense of ownership as their own larvæ and pupæ. This is certainly true of some other ants, like our species of *Lasius*, which are very fond of cultivating white root aphides and coccids in their subterranean galleries. Whenever the stones covering their nests are overturned, the workers seize their snowy charges in their mandibles and hurry away with them to a place of safety. It is natural, therefore, that ants should try to prevent the escape of their charges from a simple sense of proprietorship such as all ants display towards their own brood.

It is probable, moreover, that the protection of the aphides and coccids from other insects is an instinctive precaution not so much against the natural enemies of their charges, as against the larger and more powerful ants, which are quite as fond of honey dew as *C. lineolata.* This ant, being a weak and rather defenceless species, at least while foraging at some distance from its nest, must often be forced into competition with other aphidicolous and coccidicolous ants like our larger species of *Camponotus* and *Formica.* The fact that a herd of aphides or coccids is never attended by more than one species of ant at a time [1] shows that the different species of ants are quite as intolerant of one another on their feeding grounds as in their nests. It is not improbable, therefore, that *C. lineolata* in constructing tents over its charges merely emphasizes its sense of proprietorship in the presence of the larger and more powerful ants with which it has to compete in the struggle for existence; and it may well be that the tents are constructed only in localities where such competition is unusually severe.

That the tents may also serve to protect their occupants from the cold seems not to have been suggested by previous authors. Brandes [2] has shown that aphides — and the same is probably true of the coccids — are relatively inactive before dawn and do not begin to imbibe the juices of the plants till the diurnal temperature has risen sufficiently. The tents, by protecting their occupants from the cold night air, may thus prolong their feeding hours and increase the excretion of honey dew. This would, of course, be a decided advantage to the ants. In support of this supposition we may note the singular fact that the majority of authors above cited found the *lineolata* tents late in the season (August and September) and in damp localities. The cold, due to the greater evaporation in such places, coupled with the lateness of the season, would probably tend to inhibit the feeding

[1] Except in the case of *Formica sanguinea* and its slaves, *F. fusca,* and then only when the two species belong to the same mixed colony.

[2] Die Blattläuse und der Honigthau. Zeitschr. f. Naturwiss., 66 Bd. 1893, pp. 98–103.

activities of the aphides and coccids at least during the night hours. Under such circumstances a paper or earthen tent would be of great service not only to the aphides or coccids, but also to the ants themselves, since the latter feel bound to spend so much of their time in the company of their charges. This time, of course, is not misspent, since it is obviously of advantage to the ants to be on hand to prevent any waste of the honey dew.

The tents of *C. lineolata* may seem to some to be admirable examples of foresight and reason on the part of their little builders. But although I have just shown how useful these structures may be, I am unable to maintain or even to believe that the ants are aware of these purposes. Like all ant structures, the tents undoubtedly exhibit a considerable degree of variability both in form and texture, but it is clear, nevertheless, that they are built on a common plan even in widely separated regions, so that instead of explaining them as the results of rational activity in the face of new conditions, there may be considerable justification in regarding them as due to an hereditary instinctive disposition, present in all the colonies of the species, but manifesting itself only under conditions formerly prevalent or universal but now of rare and sporadic occurrence. In order to obtain light on this matter, it will be necessary to inquire into the related instincts not only of other species of *Cremastogaster* but also of other genera of ants. In such inquiries the comparative method is of very great value. No instinct is known to be restricted to a single species, and in no two species is an instinct ever manifested in exactly the same way. Hence careful comparison of similar instincts in different species is apt to throw light on the phylogeny of animal behavior and often points the way to profitable observation and experimentation. Let us adopt this method in our study of the tent-building instincts of *C. lineolata*.

The tent-building instincts are not peculiar to the ant under discussion. In his incomparable work [1] published nearly a century ago, Pierre Huber gives the following account of the tents constructed by the "brown ant" (*Lasius niger*):

"One day I happened on a spurge plant that bore in the middle of its stem a little sphere of which the stem was the axis. This was a habitation that the ants had built of earth. They left it through a tiny opening made in its base, descended along the stem and passed into a neighboring formicary. I demolished a portion of this pavilion, built almost in the air, for the purpose of studying its interior.

[1] Recherches sur les Moeurs des Fourmis Indigènes. Paris, 1810, pp. 198–201.

It was a little chamber with vaulted, smooth, and continuous walls. The ants had taken advantage of the form of the plant, suspending their edifice so that the stem passed through its center while the leaves formed its only scaffolding. This retreat enclosed a numerous family of plant-lice to which the brown ants were peacefully resorting for the purpose of feeding on their ejecta in a shelter from the rain, sun, and alien ants. No insect could molest them, and the plant-lice were protected from their numerous enemies. . . .

"Several spurge stems laden with plant-lice rose from the very midst of a formicary of brown ants. These, profiting by the peculiar arrangement of the leaves of this plant, had built around each branch as many elongated chambers, to which they repaired in search of food. When I destroyed one of these domiciles, the ants straightway carried their precious animals into their nest. A few days later the structure was repaired by the insects under my very eyes and the herds were brought back to their pasture.

"These tents are not always so near the earth. I have seen one five feet above the ground, and this one merited a description. It consisted of a blackish, rather short tube surrounding a small poplar branch where it left the trunk. The ants entered it from the hollow interior of the tree in such a way that, without exposing themselves, they could reach their plant-lice by means of an opening at the very base of the branch. The tube consisted of rotten wood from the tree itself, and I saw the ants repeatedly bringing particles in their jaws in order to repair the breaches I made in their pavilion. This particular act is not very common and is not one that can be attributed to the routine of habit.

"There are also some ants that obtain their food from the plant-lice on the common plantain. These insects are usually stationed under the flower spike, but when this has faded and the stem begins to wither — and this occurs towards the end of August — the aphides retire beneath the root-leaves of the plant. Thither they are followed by the ants, which cloister themselves with their protégées by walling up with damp earth all the openings between the edges of the leaves and the ground. Then they excavate the earth underneath, in order to gain access to the aphides and be able to pass from them to their nest through covered galleries."

Huber's observations have been confirmed by Forel,[1] who has shown that in Europe tents are constructed by various species of *Lasius* (*niger*, *alienus*, *brunneus*, and *emarginatus*) and *Myrmica*

[1] Les Fourmis de la Suisse. Zürich, 1874, pp. 204, 205.

(*lævinodis*, *scabrinodis*, etc.). *L. brunneus* is especially devoted to attending "enormous bark aphides, which it covers with vaulted galleries made of detritus." The forms of *Myrmica* above cited "make earthen cells on plants for the purpose of covering their aphides. Some of these communicate with the nest by means of vaulted passages running along the stem, others are built freely in the air without a covered communication with the soil. It is especially the latter which with Huber we may call pavilions. The aphides, and particularly the coccids, are literally immured by the ants, although their prison is rather roomy, and the ants can enter and leave it through a little opening. I have seen a pavilion of *M. scabrinodis* situated a few centimeters above the soil on an oak branch. It was 1.5 cm. long and shaped like a cocoon. It enclosed some *Chermes* which the ants were carefully attending. When these pavilions communicate with the formicaries, the ants often carry their larvæ into them so that they become a simple dependence to the nest. I have seen a pavilion thus built about a plant stem by *Lasius emarginatus*. This pavilion also enclosed *Chermes*." Forel[1] has also observed *Brachymyrmex heeri* constructing vaulted passage-ways of vegetable débris between its nests and the coccids which it attends.

Our common American form of *Lasius niger* (*L. niger* var. *americanus*), which is very closely related to the European *alienus*, occasionally builds detritus tents around the stems of plants. One of these which I found during the past summer at Colebrook, Connecticut, is represented in Fig. 3. A small colony of *americanus*, nesting under a flat stone, was keeping aphides on a prostrate stem along which a broad and very irregular gallery had been excavated. Around the stem at the point where it emerged from under the stone, the ants had woven a cylindrical tube of fine vegetable detritus about 1½ inches in length and closed at the outer end, as if to prevent the aphides from escaping from the nest.

Both Huber and Forel have described the much larger detritus tents constructed around the stems of plants at a level with the ground by *Formica rufa*. Very similar structures are built by our fine large *F. integra*, a subspecies of *rufa*. In one locality near Colebrook I found several of these tents about the roots of some sapling paper birches (*Betula populifolia*). Two of these tents are shown in Figs. 1 and 2, Pl. VI. One of them had been built around an abandoned bird's nest which happened to occupy the center of a cluster of young trunks. Within these tents, which were about fifty feet

[1] Études Myrmécologiques en 1875. Bull. Soc. Vaud. Sc. Nat., XIV, 1875, pp. 39, 40.

from their formicary, the ants were guarding a few large black membracids (*Vanduzea arcuata* Say). Late in the summer, in a very different locality, near Lakehurst, New Jersey, I found a number of *integra* workers attending a herd of large lead-colored aphides on the leaves of some small oaks (*Quercus obtusiloba*) around the roots of which they had constructed tents exactly like those seen at Colebrook. The ants had evidently been keeping aphides or membracids in these tents earlier in the season.

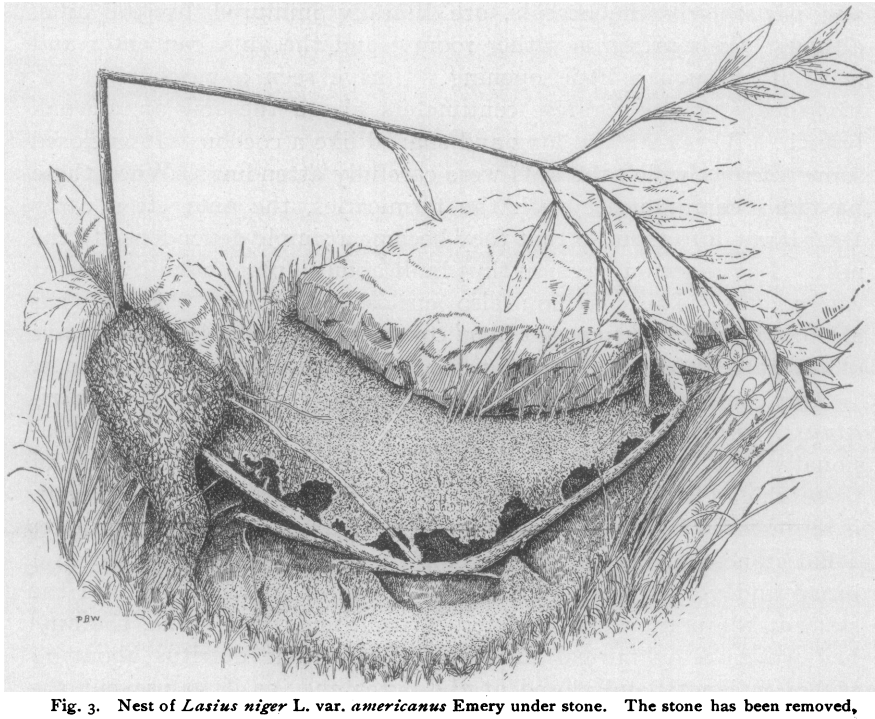


Fig. 3. Nest of *Lasius niger* L. var. *americanus* Emery under stone. The stone has been removed, showing a prostrate plant-stem along which the ants have constructed an irregular gallery. An aphis tent of vegetable detritus is shown on the left-hand side of the figure where the plant-stem rose from under the stone.

F. rufa and its subspecies *integra* may be regarded as typical of a large number of species and genera of ants and show very clearly the intimate connection between the construction of tents and that of the nest proper. The tents are, in fact, merely detached portions of the nest set aside for a particular purpose. Ants are apt to be regarded as mere excavators in soil or wood and their mounds as mere accumulations of the excavated materials. While such a view truthfully represents the conditions in certain species, it is, nevertheless,

a very partial view of the nesting instincts of ants in general. For in addition to the excavation of galleries and chambers, the workers of many species, like *F. rufa*, range far afield in search of vegetable débris such as twigs, bits of dead grass, leaves, pine-needles, pellets of earth, etc., and with these construct large mounds, in which the young can be more rapidly incubated than in the cold soil. These building instincts, which may be called positive and centripetal as distinguished from the negative and centrifugal excavating instincts, are so widely distributed among ants as to suggest very forcibly that the primitive ancestral forms of the family must have been architects like the wasps and bees, working the soil or vegetable débris up into rude nests and attaching them to plants and the sides of stones. From such a condition a great number of species have lapsed into mere excavators of the soil, a change the more easily accomplished because the under surfaces of stones and logs furnish such excellent roofs for their galleries and chambers as to render the constructive instincts superfluous. Whether this has been the universal tendency in the Formicidæ can be decided only after further investigation. That it has been the tendency in the genus *Cremastogaster* appears to be satisfactorily shown by the following observations.

The most elaborate and perhaps the most primitive form of architecture among ants is found among the species that use carton in the construction of their nests. These species are members of the genera *Camponotus*, *Polyrhachis*, *Lasius*, *Azteca*, *Liometopum*, *Dolichoderus*, and *Cremastogaster*, and represent three of the five subfamilies of ants. The carton-building species of *Cremastogaster*, with which alone we are here concerned, are nearly all confined to the tropics. As they are distributed over both hemispheres, however, we may infer that the instinct to agglutinate vegetable detritus, dried cow-dung, etc., and build it up into the form of spherical or subspherical nests, is fundamental and of long standing in the genus. Among the Indian species, these carton nests, which are suspended to the branches of trees like the nests of certain hornets in more northern latitudes, were long ago described and figured by Sykes [1] for *C. kirbyi*. Kirby has reproduced Sykes's figures in the Seventh Bridgewater Treatise.[2] Later Mayr, Wroughton, and Rothney called attention to similar habits in two other Indian species (*C. rogenhoferi* and *ebeninus*).[3]

[1] Descriptions of New Species of Indian Ants. Trans. Ent. Soc. London, I, 1836, pp. 99–103, pl. xiii, fig. 1.

[2] On the Power, Wisdom, and Goodness of God as Manifested in the Creation of Animals and in their History, Habits, and Instincts. Second Am. Edit., Phila., 1837, pl. xi.

[3] *Mayr*, Beiträge zur Ameisenfauna Asiens. Verhandl. k. k. Zool. bot. Gesell. Wien, 1878, pp. 39, 40; *Wroughton*, Our Ants. Journ. Bombay Nat. Hist. Soc., 1892, p. 23; *Rothney*, Notes on Indian Ants. Trans. Ent. Soc. London, 1895, Pt. II, p. 205.

Another species (*C. artifex*), according to Mayr,[1] builds paper nests in Siam and Singapore. In Madagascar *C. ranavalonæ* Forel builds spherical carton nests 3 dcm. (1 foot) in diameter and *C. tricolor* of the same island has a very similar habit.[2] In Africa no less than three species (*C. inconspicua*, *margaritæ* and *stadelmanni* var. *intermedia*) have been shown by Mayr and Aurivillius to construct large paper nests.[3] These authors describe an *intermedia* nest that was 68 cm. long, 37 cm. broad, and 80 cm. in circumference.

In tropical America there are several carton builders among the species of *Cremastogaster*. F. Smith long ago figured the paper nests of the Mexican *C. montezumia*[4] and Forel has more recently shown that similar structures are made by *C. sulcata*, its variety *ramulinida* and *C. stolli* in Central America and Colombia.[5] *C. stolli* also makes long vaulted galleries which wind about on the tree trunks and along the small branches in the thickets. The ants move about in these galleries and rarely expose themselves to the open air. This species is of particular interest in connection with the tent-building habits of *C. lineolata*.

Turning from these strictly arboreal species of *Cremastogaster*, we are led to inquire whether there are any indications of the carton-building instinct in the terrestrial species like *C. lineolata*. McCook several years ago briefly described the nesting habits of this ant as follows[6]: "The favorite nesting place is under stones or underneath and within the decayed matter of old logs and stumps. This material is sometimes prepared by the ant as a paper-like pulp, and arranged into cells and chambers, which are attached to the surfaces of logs." Similar carton constructions are often built under stones. Fig. 4, Pl. IV, shows the surface chambers of a large *C. lineolata* nest found under a stone in a pasture near Colebrook, Connecticut. In the center of the figure, to the left of the main opening leading into the subterranean galleries, there is a large chamber containing pebbles and traversed by a branching rootlet which is covered with irregular masses of black carton. In other nests somewhat greater accumulations of this substance are occasionally found.

In a variety of *lineolata* not uncommon in the mountains of Colo-

[1] Loco citato, pp. 40, 41.

[2] *Crandidier.* Histoire Physique, Naturelle et Politique de Madagascar. XX Hymenoptères, 2. Partie. Les Formicides par A. Forel, 1891, pl. vii.

[3] *Mayr, G.* Beiträge zur Kenntniss der Insektenfauna von Kamerun. Formiciden. Entomol. Tidskr., Arg. 17, H. 3, 1896, pp. 253–255. Taf. 4, 5.

[4] Catalog. Hymenopt. Insects, in Coll. Brit. Mus., Pt. VI, Formicidæ, 1858, pl. i.

[5] Biol. Centrali-Amer., Hymenoptera, Vol. III, Formicidæ, 1899–1900, pp. 83, 84, pl. ii, figs. 1 and 2. The nest of *C. sulcata* is also described by Emery in his Studii sulle Formiche della Fauna Neotropica. I, Bull. Soc. Ent. Ital., XXII, 1890, p. 53.

[6] Formicariæ in Comstock's Report upon Cotton Insects. Washington, 1879, p. 188.

rado at an altitude of 6000 to 7000 feet, where the scrub oaks grow among the red volcanic rocks, I have found a much greater tendency to construct masses of carton in the nests under stone. One of these masses of about $\frac{3}{4}$ the natural size is shown in Pl. V. A stone had rolled down on to a lot of dead oak leaves and the spaces between these had been built into a series of inosculating and slightly concentric chambers by means of black carton partitions carried up to the lower surface of the stone. In other nests the pebbles or twigs on which the stone happened to lie were similarly covered with irregular masses of carton. A fragment of this material from such a nest is shown in Fig. 3, Pl. IV. In all these cases the surface of the carton was covered with a delicate blue mould which probably derived its nutriment from the glandular secretion used by the ants as a mortar in agglutinating the fine particles. A similar mould has been observed by Lagerheim [1] covering the carton plates in the nests of the European *Lasius fuliginosus*, and is said to be eaten by the ant-larvæ. In the case of the Colorado *lineolata*, the layer of mould would be an entirely inadequate food supply for the thousands of larvæ found in one of these nests, and there is nothing to indicate that it is of the slightest use to the ants. The blackness of the carton in these nests is due to the large amount of soil used in its construction.

It is difficult to understand why the ants build masses of carton in these nests under stones unless they are exhibiting a merely vestigial instinct which may be called into activity whenever they find leaves or twigs — the very objects about which their arboreal ancestors built carton nests — in the way while they are excavating. The covering of the rootlets with carton in the Colebrook nest above described may also be taken to indicate that contact with vegetable surfaces acts as a stimulus to which the ants respond with an ancient and abortive instinct. This response may, however, assume extraordinary proportions in *lineolata* colonies that are compelled to return to a strictly arboreal life like their tropical ancestors, as shown in the following observation published several years ago by Atkinson [2]:

"The nest was built several feet from the ground on a bush, in the marshes bordering Broad Creek, Hyde County, N. C. . . .

"This nest is about eighteen inches long by twelve inches in circumference at its greatest diameter. I made a longitudinal section of it, and had a photograph taken, so as to represent both the

[1] Ueber Lasius fuliginosus (Latr.) und seine Pilzzucht. Entomol. Tidskr., Årg. 21, pp. 17–29, 4 figs.

[2] Singular Adaptation in Nest-Making by an Ant, *Cremastogaster lineolata* Say. Am. Naturalist, Vol. XXI, 1887, pp. 770, 771, pl. xxvi.

external form and internal structure. The ants were alive in the nest when I received it. They were chloroformed before sectioning the nest. I took from the nest about one-fourth pint of adults, pupæ and larvæ. They were collected in a mass through the chambers within a space four inches in length of the nest. This space is about two-thirds the distance from the lower end. The material composing the cells in this space is lighter in color than the other internal parts. . . .

"The material used in making the nest seems to be the same as that used by the ant in making its nest under stones, etc. Beside the woody pulp, a microscopic examination seems to reveal also some portions of dried grass. The nest is supported by the branches of the bush; a vine and some stalks of marsh-grass are fastened in it. Upon the outside the material is of a light gray color, much like that of the nest of the white-faced hornet. In the interior it is darker, in some places almost black. Probably the high tides, causing the creek to overflow, forced the ants to build their nest above the high-water mark instead of under stones and within logs."

In this exceptional instance, as shown by the figure accompanying Professor Atkinson's article, the ants had constructed a large carton nest of the same kind as the tropical species above mentioned. We may regard this occurrence as an interesting case of atavism and as demonstrating that instincts like structures may become latent and manifest themselves with almost pristine intensity after an apparent disappearance during many generations. Such conditions, which are apt to prove embarrassing when the potential aspects of instinct are ignored and only its manifestation as "instinct action" is taken into consideration, lead inevitably to the assumption of "dispositions" in the sense in which this term is used by some modern human psychologists.[1]

An explanation of the tents of *C. lineolata* is to some extent implied in the preceding consideration of the carton-building instinct of this species. They may obviously be regarded as small but detached portions of the nest, constructed in a specific environment which at one time, in the possibly not very remote phylogenetic history of the species, led to the building of carton nests. The worker ants, finding themselves detained by their strong appetite for honey dew in exposed situations on the stems of plants, build these small succursal

[1] These cases of the revival of instincts are particularly suggestive in connection with Hering's view recently elaborated by Semon in his interesting volume "Die Mneme als erhaltendes Prinzip im Wechsel des organischen Geschehens." Leipzig, Wilhelm Engelmann, 1904.

nests, primarily, perhaps, for their own comfort and protection, but at the same time admirably suited to a number of other purposes, as I have shown on p. 7. The presence of the aphides and coccids must also act as a stimulus akin to that which is exercised by the presence of larvæ and pupæ, in calling forth as a response the protective and philoprogenitive, and hence also the nest-building instincts of the species. Originally the tents may have been connected with the main nest by covered galleries such as are still built by *C. stolli*, *Brachymyrmex heeri*, some of the species of *Formica* of the *rufa* group, and many termites, as a means of avoiding exposure to light and enemies. Sometime it may be possible to test the truth of these conclusions experimentally by isolating and exposing colonies of *C. lineolata* on the stems of plants within depriving them of an abundant supply of food and the materials from which carton can be made.

EXPLANATION OF PLATES I–VI.

PLATE I.

FIG. 1. — Accumulation of resin on twig of pitch-pine (*Pinus rigida*) produced by the boring caterpillar of a Tortricid moth (*Retinia comstockiana* Fernald). x 1¾.

FIG. 2. — Carton coccid-tent built by *Cremastogaster lineolata pilosa* Pergande around a twig of pitch-pine, exposed by cutting away part of the needles and showing the opening through which the ants enter and leave the tent. x 1½.

FIGS. 3 and 4. — Similar tents cut open to show the coccids on the twigs and the way in which the carton walls are supported by the pine needles. x 1½.

PLATE II.

A carton coccid-tent built by *Cremastogaster lineolata pilosa* around a twig of pitch-pine. x 1½.

PLATE III.

FIG. 1. — Unusually large coccid-tent built by *Cremastogaster lineolata pilosa* around a twig of pitch-pine, showing the entrance near the base of the lower branch on the right side. x 1½.

FIG. 2. — Carton aphis-tent built by *Cremastogaster lineolata* on twig of swamp huckleberry. x 1¾. From a specimen in the collection of Mr. Erich Daecke.

PLATE IV.

FIG. 1. — Earthen aphis-tent built by *Cremastogaster lineolata* on dogwood. x 1½. From a specimen collected by Professor J. H. Comstock near Ithaca, N. Y.

FIG. 2. — Similar tent, natural size From a photograph made by Professor Comstock.

FIG. 3. — Piece of black carton built over twigs under a stone by a Colorado variety of *Cremastogaster lineolata*. $\frac{3}{4}$ natural size.

FIG. 4. — Surface chambers of nest of *Cremastogaster lineolata* under a large stone, showing black carton covering rootlets. $\frac{1}{6}$ natural size.

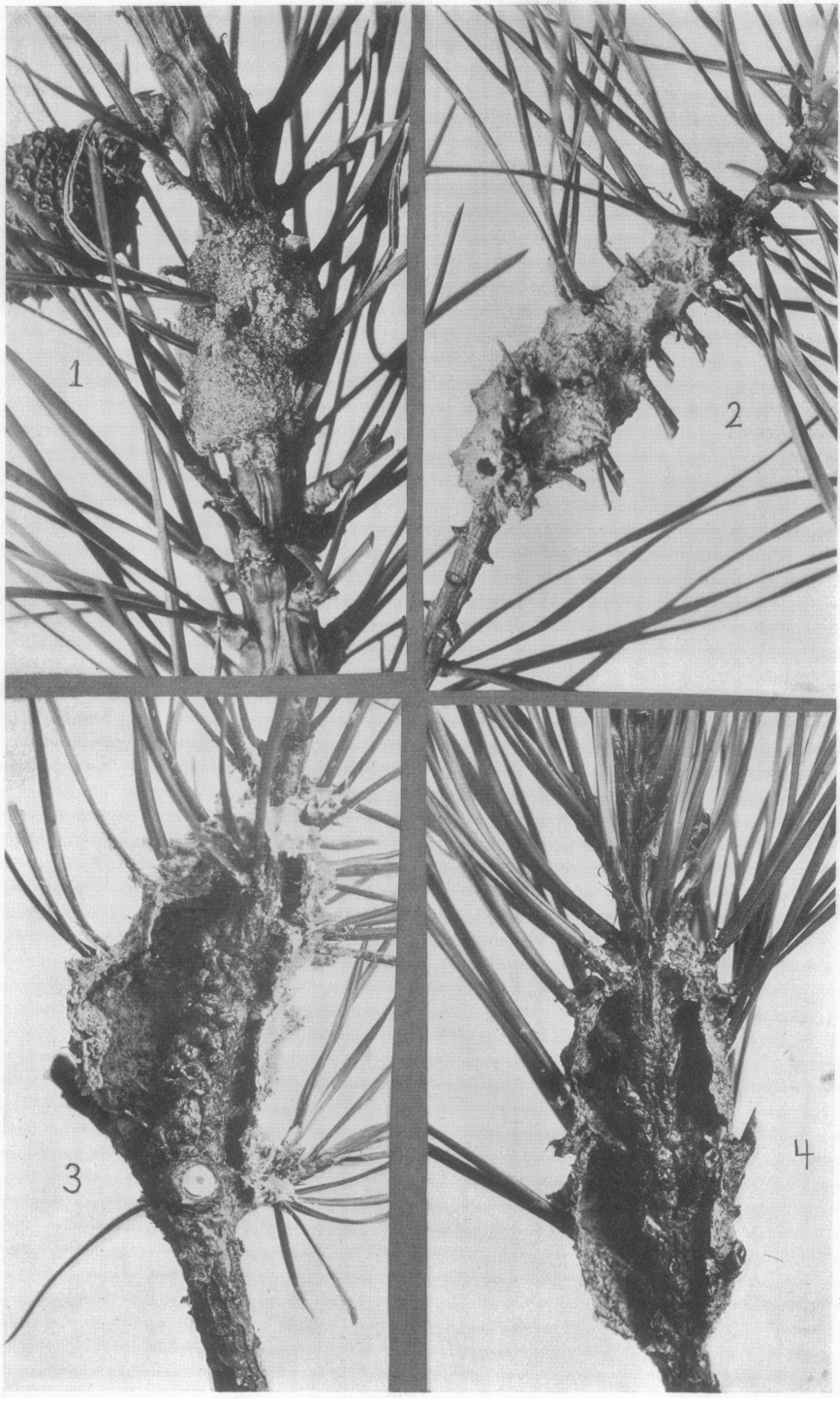
PLATE V.

Nest of a Colorado variety of *Cremastogaster lineolata* built of dead oak-leaves and black carton under a stone. $\frac{2}{3}$ natural size.

PLATE VI.

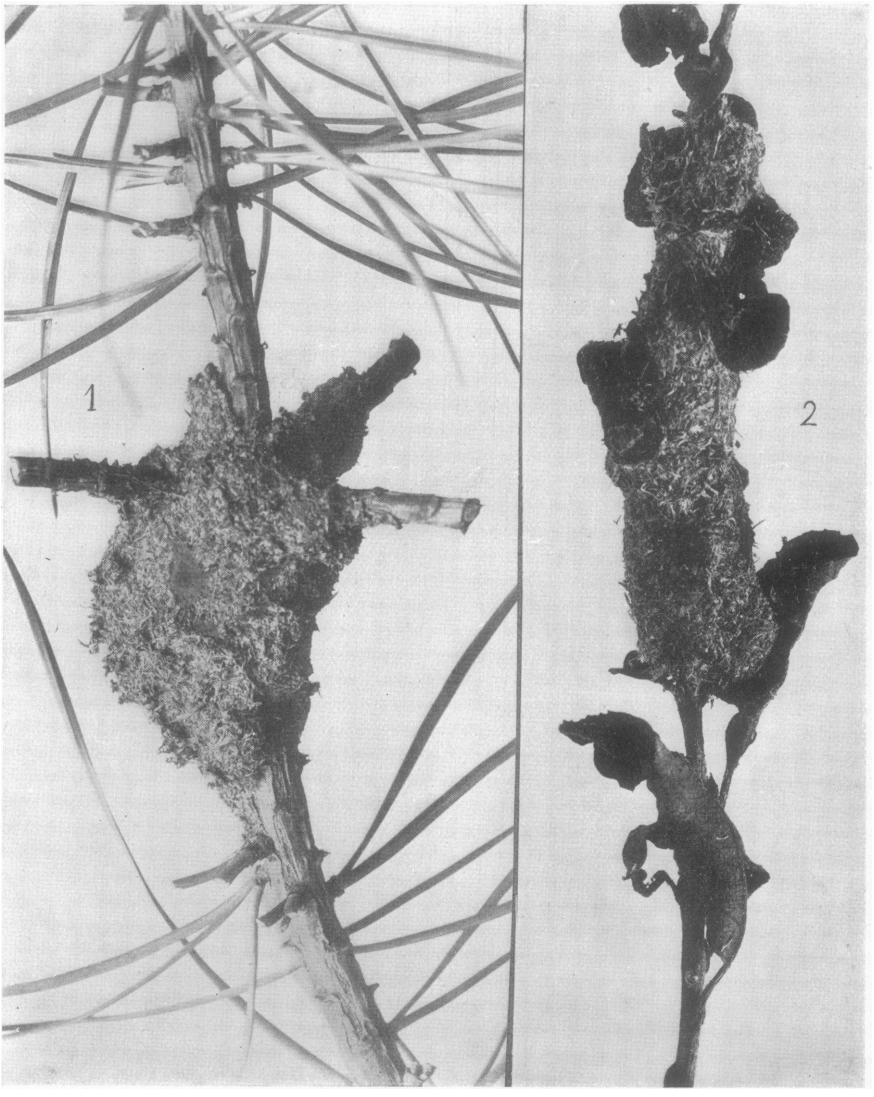
FIG. 1. — Membracid-tent of *Formica rufa integra* Nyl. built about the roots of a young birch (*Betula populifolia*). $\frac{1}{2}$ natural size.

FIG. 2. — Similar tent built around a bird's nest. $\frac{1}{6}$ natural size.

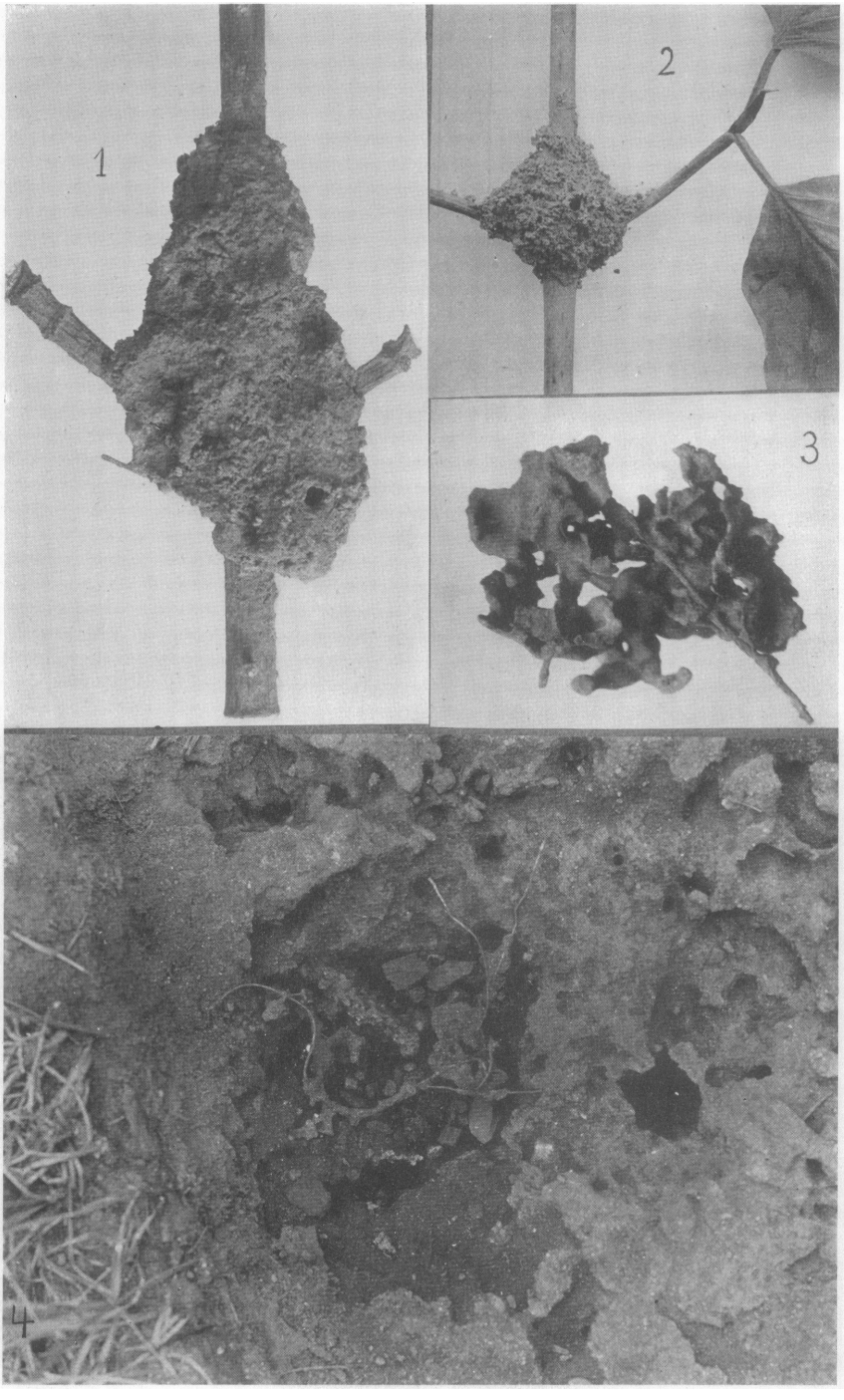


CARTON COCCID-TENTS OF CREMASTOGASTER LINEOLATA PILOSA PERGANDE.

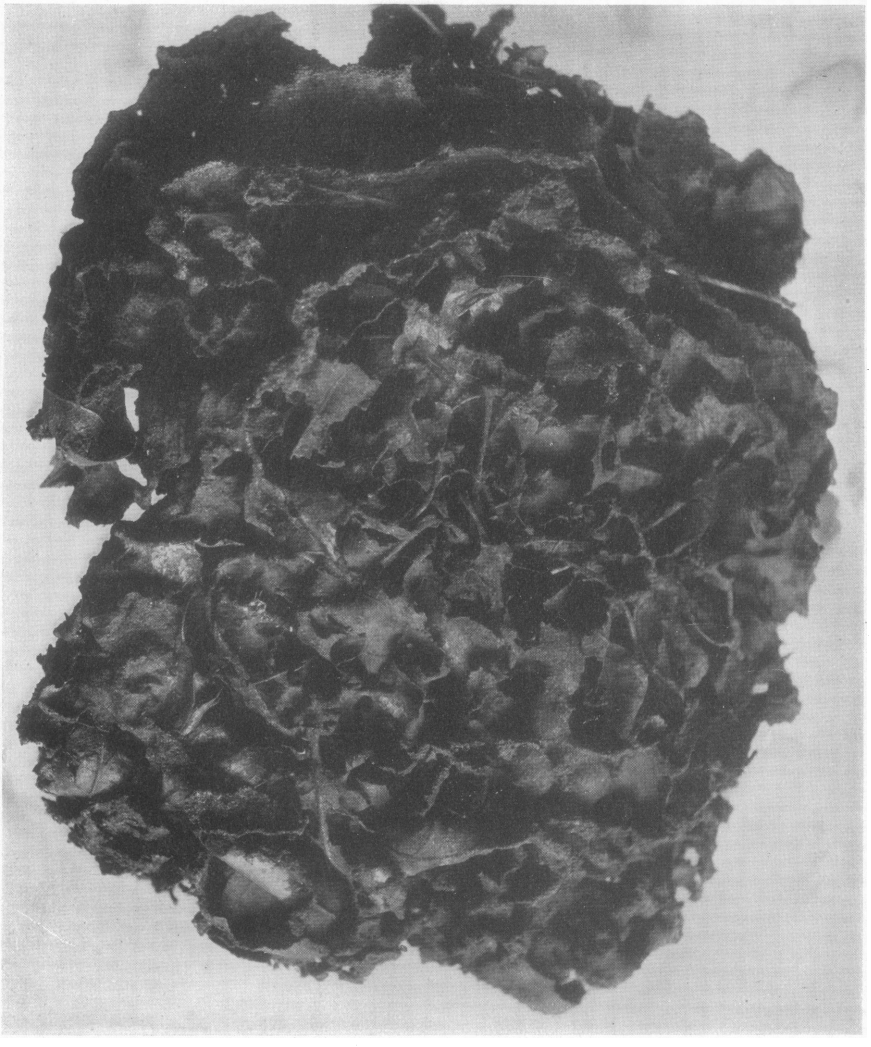
CARTON COCCID-TENT OF CREMASTOGASTER LINEOLATA PILOSA PERGANDE.



CARTON COCCID- AND APHIS-TENTS OF CREMASTOGASTER LINEOLATA SAY.



EARTHEN APHIS-TENTS AND CARTON CONSTRUCTIONS OF CREMASTOGASTER LINEOLATA SAY.



CARTON NEST OF CREMASTOGASTER LINEOLATA SAY, VAR.

MEMBRACID-TENTS OF FORMICA RUFA INTEGRA NYL.