THE

HONEY ANTS

OF THE GARDEN OF THE GODS,

AND THE

OCCIDENT ANTS

OF THE AMERICAN PLAINS.

A Monograph of the Architecture and Habits of the Honey-Bearing Ant, Myrmecocystus melliger, with Notes upon the Anatomy and Physiology of the Alimentary Canal; together with a Natural History of the Occident Harvesting Ants, or, Stone-Mound Builders of the American Plains.

By HENRY C. McCOOK, D. D.

Author of "The Agricultural Ant of Texas," "The Moundmaking Ants of the Alleghenies," etc.

ILLUSTRATED WITH THIRTEEN PLATES.

PHILADELPHIA:
J. B. LIPPINCOTT & CO.
London: 16 Southampton Street, Covent Garden.
1882.

TO

JOSEPH JEANES,

A MEMBER OF THE

ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA,

THIS VOLUME IS

DEDICATED,

AS A MARK OF ESTEEM, AND A TOKEN OF GRATITUDE FOR MANY KINDLY AND HELPFUL PROOFS OF HIS INTEREST IN THESE AND KINDRED STUDIES,

BY

THE AUTHOR.

PREFACE.

THAT portion of the studies herewith presented which relates to the Honey Ants, will appear as the original publication in the Proceedings of the Academy of Natural Sciences for the current year, A. D. 1881.

The wide interest which has been awakened during the last two years in the Honey Ant, and the expressed wish of many persons to possess the monograph thereon, have seemed to justify its publication in separate form.

In order to increase the value of the paper to students, an index has been added, and the explanations of the figures have been placed opposite the plates, where they can be used with the least inconvenience and the greatest advantage. The Key to References has also been arranged upon a double page in order to prevent turning back and forth in studying those plates (especially) which illustrate the Anatomy. Moreover, the matter has been divided into appropriate chapters, and a Table of Contents prefixed.

The press of professional duties has delayed this authorized publication of my observations, and in the meantime my verbal communications to the Academy of Sciences have been reported and reprinted in a number of scientific and other journals both here and in Europe. I do not know how far this fact may have gone to satisfy the interest of general readers in the curious creature whose history is here given; but I venture to think that the limited public of naturalists, whom I especially address, will

wish to have my own report. Incomplete as this report necessarily is, it yet gives much that is new, settles some interesting questions, and solves some difficulties which had caused no little perplexity to entomologists and biologists.

Whatever value my studies upon the Honey Ant may have, has been largely increased by the liberality of MR. JOSEPH JEANES, who contributed the funds required to illustrate that part of this work. I have so far transgressed ordinary custom as to dedicate the volume to him without asking his permission, or even informing him of my purpose; for which my apology must be the assurance that the modesty which veils so many generous acts, would have declined a public recognition which I deemed most fitting to be made.

THE SECOND PART of this work is devoted to one of the most interesting of our native Ant fauna, the Occident Ant of the American Plains, and the facts presented have not heretofore been published, even in abstract.

My studies of this insect were made during the visit to Colorado in which the Honey Ant was studied, and chiefly in the same general locality. Indeed, the purpose of my expedition was to observe the habits of both ants.

The chief interest and value in this Second Part lie in the facts that Occidentalis is so closely allied to her congener, the Agricultural Ant, and like her proved to be a harvester; so that my observations here will be of especial value to those who have been interested in my studies of that insect. The present work is, in fact, supplementary of my work upon "The Agricultural Ant of Texas," of which it may be considered a companion volume.

It is a striking natural phenomenon that is presented by the differences which appear in the habits of ants so closely resembling

each other that some of the worker forms can scarcely be distinguished even by the trained eye. These differences have been noted, and the new facts uncovered given in detail.

It is, perhaps, no less interesting to observe the resemblances which have survived; these, therefore, have been indicated; but as the points involved have been fully exhibited in "The Agricultural Ant," they have not been enlarged upon here.

The illustrations of the book have all been reproduced in India ink from my original sketches and drawings, and thence transferred to the plates by photo-lithography. The figures illustrating the history of the Occident Ant are wholly autographic.

I have noted with great satisfaction that my former studies have been found useful by writers of both current and permanent literature, at home and abroad, in discussions upon the nature of the so-called instinct, or mentalism, or intelligence of insects, and trust that these notes may contribute something further to so interesting a problem.

In spite of the expressed wishes of esteemed scientific friends that I should generalize upon this theme my studies of ant life, I have preferred, as before, to keep within the province of the naturalist, and present the facts. And this, not only because it seems better befitting a Natural History, but because it does not seem to me that the facts are yet all in that may warrant any confident generalization—any theory, or any *new* theory—upon the nature of animal instinct, the relations of insect mentalism to human reason. The philosophers, to whom the facts are given, have the liberty of the facts and their speculations thereon. For the former the author stands sponsor; but may be permitted to remind some of his theological friends, especially, that he accepts no responsibility for the latter.

The facts disclosed in the Divine revelations of material Nature are as veritable facts as any others. Those facts, rightly seen and

interpreted, can never mislead; nor can they falsify or belittle other and more important Facts. Nature is one, and of One; and whether human thought pursue the history of an ant or of an Archangel, so that it follow the truth truly, it must find harmony. The author has, therefore, here as elsewhere, been careful only to be true. The very least of his concerns has been the fear—which has somewhere found expression—that in recording the marvelous behavior of Ants, so human-like, he should write somewhat that might lower the intellectual grade of Man, or lessen the claim and hope to a holy Immortality wherein, after all, lies his chief distinctive characteristic as Man.

ACADEMY OF NATURAL SCIENCES,
PHILADELPHIA, A. D. 1881.

TABLE OF CONTENTS.

PART FIRST.

THE HONEY ANTS OF THE GARDEN OF THE GODS.

CHAPTER I.

GEOGRAPHICAL DISTRIBUTION.

CHAPTER II.

ANT-HONEY AND HOW IT IS GATHERED.

CHAPTER III.

INTERIOR ARCHITECTURE OF THE HONEY ANT'S NESTS.

CHAPTER IV.

Queen Life and Acts of Beneficence.

CHAPTER V.

Economy of the Honey-bearers.

CHAPTER VI.

Anatomy of the Alimentary Canal in the Honey Ant.

CHAPTER VII.

Parasites—Literature—Description.

PART SECOND.

THE OCCIDENT ANTS OF THE AMERICAN PLAINS.

CHAPTER VIII.

GEOGRAPHICAL DISTRIBUTION OF OCCIDENTALIS.

CHAPTER XI.

ARCHITECTURE OF NESTS.

CHAPTER X.

GATE ARCHITECTURE, OPENING AND CLOSING GATES, RISING, RETIRING AND NOONING HABITS.

CHAPTER XI.

Harvesting Habits—Interior Architecture.

CHAPTER XII.

Polemic Disposition, Incidents, and Armature.

FIRST PART.

THE HONEY ANTS

—OF THE—

GARDEN OF THE GODS.

CHAPTER I.

THE HOME OF THE HONEY ANT.

§ I.—Geographical Distribution.

The peculiarity in the Honey Ants (*Myrmecocystus melliger*) which has attracted the especial attention of naturalists is that one of the castes or worker forms has the abdomen distended to the size and form of a currant or small grape, and entirely filled with grape-sugar or "honey."

Very little of their habits has heretofore been known, and only the forms of the honey-bearer and worker-major. In order, if possible, to remove this reproach from Entomology, I started in the early part of July, A. D. 1879, for New Mexico, as the honey-ants have been found in the neighborhood of Santa Fe, and even as far north as Abiquiu, on the Big Chama River.[1]

During a brief visit at the cottage of Gen. Charles Adams,[2] of Manitou, Colorado, which is located in the mouth of the Garden of the gods, in the course of some observations made upon the ants of the vicinity, a nest was discovered whose external architecture was new to me. The sentinels were called out by the application of a straw, and their general appearance raised the suspicion that they might be Honey Ants, which, as I had never seen specimens, were known to me only by description. The nest was opened, and the delightful fact revealed that the objects of my search were before me. I thereupon made an exploration of the vicinity, and found that the nests were present in sufficient

[1] At the latter point Prof. Edward D. Cope informed me that he had seen them. Dr. Loew and Mr. Krummeck saw them near Santa Fe.

[2] Gen. Adams has recently been widely known by his intrepid venture among the hostile White River Ute Indians, and rescue of their unhappy prisoners, Mrs. Meeker and others, at the risk of his own life. As a recognition of this service he has been appointed Minister Plenipotentiary for the United States to the Republic of Bolivia.

numbers for purposes of study; whereupon I abandoned my New Mexico outfit, encamped in the Garden of the gods, and began the observations of which the following paper is the record.

Up to the time of my discovery, it had not been known that the Honey Ants were distributed as far north as Colorado. I found no formicaries at any other point in the State, although the opportunity to search for them was limited. There is little doubt, however, that they may be found in favorable locations in the entire southern portion of the state, and perhaps also north of the latitude of Pike's Peak.[1] Mexico, New Mexico and southern Colorado, may certainly be designated as the natural habitat of the Honey Ants. It is probable, however, that they may be found throughout the entire south-western portions of North America, especially the uplands. They will doubtless be found west of the Rocky Mountains, as I have recently found one female of this species among a collection of Hymenoptera sent to Mr. Cresson from southern California.

The following facts can be presented concerning the *vertical* distribution:—

Locality.	Elevation.	Observer.
City of Mexico, . . .	7482 feet,	Llave.
[2] Matamoras, Mex., Brownsville, U. S., . .	50 "	Langstroth.
Santa Fe, ...	7047 "	Loew, Kummeck.
Abiquiu, ...	5930 "	Cope.
Garden of the gods, . .	6181 "	McCook.

It will thus be seen that the points at which these insects have heretofore been found, lie for the most part upon uplands, ranging from 6000 to 7500 feet in height above sea level. Mr. Langstroth's find is recorded as "in the vicinity of Matamoras."[3] If this means the near vicinity, the fact prevents the generalization which

[1] The matter of their distribution is a point to which the attention of entomologists and other naturalists is called, and any information bearing thereupon will be of value.

[2] I could not lay hands upon the elevations of Matamoras, which cannot vary much from that of Brownsville, Texas, on the opposite side of the river.

[3] "Proceed. Acad. Nat. Sci. Phila.," vol. vi, 1852, p. 71.

one might otherwise have been tempted to form, limiting the ants to the upland, for Matamoras has but a slight elevation.

§ II.—Nest Sites and Exterior Architecture.

The Honey Ants are domiciled in large numbers throughout the section of country known as the Garden of the gods.

The conformation of the surface here appears to be an important element in determining the habitat of the insects, and deserves a brief notice. The Garden of the gods embraces a space of about two miles in length by one in width, the surface of which is broken into ridges crossing each other at various angles, and crowned or bordered at the top by the red sandstone and conglomerate rocks, whose peculiar shapes and likenesses to heathen deities have probably suggested the name given to this bit of landscape. A rude idea of the topography may be had by drawing a horse-shoe, the toe toward the north; within the mouth

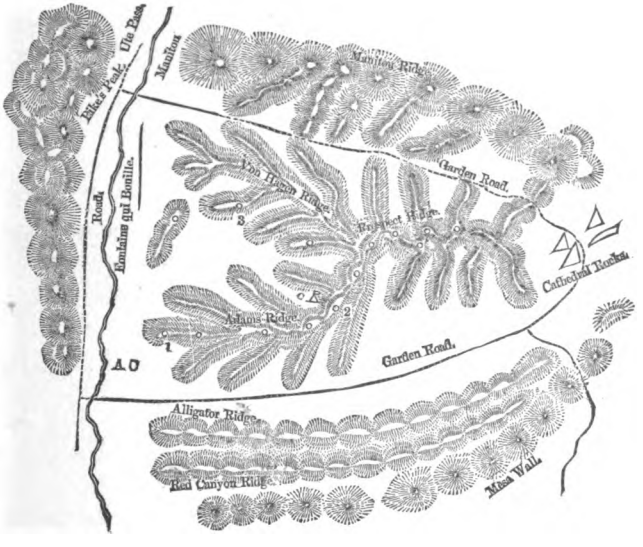


Fig. 1.—Sketch-map of the Garden of the gods.

of this let a second horse-shoe be described, occupying about one-half the space in width and one-third in length. Unite the toes of the two shoes by a zig-zag line, and draw lines east and west, on either side from the interior figure. The western line of the out-

side shoe will represent the Manitou ridge, which starts at the base of Pike's Peak. The eastern line will indicate the cretaceous wall of the table-land known as the Mèsa, and the two walls of the Red Canyon. The inner shoe has for its western line the Von Hagen ridge, for its eastern the Adams ridge; the east and west lines will represent the general course of the ridges which drop down from these two, from the broken central ridge, Prospect ridge, represented by the zig-zag line, and from the eastern face of Manitou ridge. These ridges are composed of red sandstone, which crops out freely, forming vast ledges and cliffs. The top soil, where the rock is not exposed, is a heavy gravel, upon which grow tufts of gramma grass, straggling bunches of grease wood, Spanish bayonet, low cedars and pine, and in the little vales or nooks wild sunflowers, wild roses, and numerous small thickets and clusters of a scrub oak (*Quercus undulata*). These localities are indicated diagramatically in the sketch-map at Fig. 1.

All along the tops of these ridges, and on the eastern and south-eastern slopes, the nests of the Honey Ants are located (Pl. I, fig. 2[1]). About ninety per cent. of those found were on the tops of the ridges, and every one on or near the summit or central line of the top. The choosing of such a site may, therefore, be inferred to be a fixed habit of the ant.

The advantage of this location is apparent, at least in the points of dryness and warmth. I made several observations of the effects of the heavy July and August rain storms upon the exterior architecture, which is a low, gravel-covered moundlet, penetrated at the centre by a tubular gallery or gate three-fourths of an inch in diameter (Pl. II, figs. 3, 4). The large gravel-covered mounds of the Occidental Ant (*Pogonomyrmex occidentalis*, Cresson), numbers of which were built in the valley of the Boiling Fountain Creek, and in the nooks between the ridges, were more or less damaged by the wash of the water. Some were seriously injured, one wholly swept away. The only damage wrought upon the Honey Ant nests was a little beating down of the pellets of gravel within the gate. There was no injury from the wash of the

[1] This is a sketch of my camp, from the point at which the Adams and Von Hagen ridges meet. One of the ant-nests is seen in the foreground; others are indicated by the white circles on the crests of the ridges.

water, and apparently no likelihood of any beyond that which the momentum of the rain-drops could inflict as they dashed upon the nest and within the gate. Throughout one storm, during the entire progress of which a nest was watched, several ants were stationed like sentinels within the gate around the upper margin (Pl. V, fig. 25). They were evidently on the look out for any damages to their home. The disarrangement of a few pellets moved two of these sentinels to bring up bits of gravel and attempt repairs. But there was little occasion for this, although the force of the rain was great enough to cause a good deal of discomfort to the observer. In half an hour the rain ceased, the sun came out over Pike's Peak, and a rainbow girdled the Mèsa. One worker-major crawled upon the crest of the nest, stretched herself, reared her head as though to snuff the fresh air, then hurried down the gravel side and started at a swinging pace along the trail to a neighboring oak copse. An hour afterward she had not returned, and not another ant had left the nest. Several, however, came out, but apparently were disturbed by a gale which followed the rain, and returned.

On another occasion, the slight disarrangement of the nest made by the rain was repaired immediately after the storm. It amounted to a closing up of the greater part of the entrance by some of the displaced gravel-stones along the crater.

The exterior architecture has been referred to as a small moundlet of gravel.[1] The largest seen was one on one of the ridges quite within the Garden; it measured around the base thirty-two inches, in height three and one-half inches, length of northern slope four and one-half inches (Pl. II, fig. 3). The average dimension of the nests is something less than this. The base diameter varies from ten to three and one-third inches, the greatest number of nests measuring six and seven inches.[2] The ordinary height is from two to three inches. The shape of the nests is a truncated cone. The section across the top is about

[1] Dr. Oscar Loew, "American Naturalist," 1874, says of Melligera collected near Santa Fe, that "they make no hills, like other ants." "A structure like a crater indicates where they live underground." Every formicary seen by me had a decided elevation.

[2] I succeeded in bringing one of these mounds home nearly entire, having fixed the gravel contents by liquid cement.

two inches in diameter. In the centre is a tubular opening or gate, from three-fourths to seven-eighths inch in diameter.[1]

§ III.—Position of Honey-Bearers in the Nest.

Leaving the details of the architecture to a later period, that habit which attaches the greatest interest to this insect, viz., the storing of honey, may be considered. The first nest that was opened, and called the "Bessie" nest,[2] for convenience of notation, is on the terminal slope of Adams ridge, looking due south, and quite near to the valley of the creek Fontaine qui Bouille. The gravel had not been penetrated to a depth of more than six inches before a honey-chamber was uncovered, and the presence of the honey-bearers indicated that a home of the true Honey Ant had been found (Pl. III, fig. 5). Within a dome-roofed vault, about three inches in width and three-quarters to one inch in height, hung the honey-bearers, clinging by their feet to the roof. Their yellow bodies stretched along the ceiling, but the rotund abdomens hung down, almost perfect globules of transparent tissue, through which the amber-colored honey showed. They looked like a cluster of small Delaware grapes or large currants. Most of the abdomens were quite round, but they were in various stages of fullness. Upon some the external membrane of the abdomen was gathered in folds. A few of the abdomens, and especially those but little distended, were of a white instead of amber color.

I have observed that the honey-bearers in my artificial nests show the honey, which has been gathered from white sugar, quite white and translucent. It is probable that the color becomes amber, and even a wine color, with age. When the abdomen is full it fairly shines, reflecting the light that falls upon it from the lamp. With most of the honey-bearers the abdomens hang downward without touching the ceiling, except at the rotundity near the base, and often not even at that point. With some, however, the whole lower part of the abdomen rests against the

[1] Dr. Loew says of the nests near Santa Fe, that the openings were the size of a quill. It seems strange that such a difference should exist within localities so near each other.

[2] A little girl, Bessie Root, a guest in Gen. Adams' cottage, whom I had enlisted in the search for ant-hills, first reported to me the nest in which I found the Melligers.

roof (Pl. IV, fig. 13). This appears to depend chiefly upon the contour of the perch, and not upon the relative degree of comfort to the ant in the two positions.

The roof of the honey-chamber is different in structure from the floor, the latter being comparatively smooth, while the former is rough, being the natural granulated surface left after the picking away of the sandy soil. This character, of course, enables the honey-bearer to cling more easily and securely to her perch. This position is not held by the mandibles clasping the rugose dome with their sharp teeth, but almost exclusively by the feet, whose claws, hairs and pulvuli all doubtless contribute to the effect.

Judging from observations upon artificial nests and from the utter unwieldiness and helplessness of the fully charged bearers, they are not much disposed to change their roost after once taking it, at least after they have reached a considerable degree of rotundity. But the statements generally made by writers, that they are wholly unable to move, and never change position, are inferences without the facts. They are not unable to move, and in point of fact do occasionally move their positions. Those whose abdomens are but half or even two-thirds the full globose, I have frequently seen coming out of their chambers, ascending the galleries and moving freely about the surface. Those with full globes can move about with no little agility when placed upon a table, or when exposed in their nests to some unusual danger or alarm. In the nests they slide along from point to point, moving their feet sidewise, and so make changes of position.

Fallen Honey-bearers Helpless.—If once they loosen their hold, however, and fall to the floor, they seem ordinarily helpless to recover. Numbers of my full honey-bearers dropping from various causes, or shaken down by thoughtless visitors, laid upon the floor helpless, resting upon the rotund abdomen, bodies up, antennæ and feet in motion, and seeming exceedingly uncomfortable. Those who so fell as to have some object upon which to lay their feet, as a clod or the surface of the jar, fared better. In very favorable positions a few recovered their roost. But as a rule they were helpless, remained stationary, and so passed their lives, which were evidently shortened by their position, although some of them lived thus several months (see Pl. VI, fig. 32).

CHAPTER II.

ANT-HONEY, AND HOW IT IS GATHERED.

§ IV.—Source of Honey-Supply.

The rotunds do not elaborate the honey, as has frequently been asserted. I was not for a moment misled by this fancy, being satisfied that, in the nature of things they were sedentary, and that their immense abdomens were charged by regurgitation from the workers who were the honey-gatherers. But whence do they obtain their supplies?

Not from Aphides, at this season of the year at least. I searched every bush and shrub in the vicinity, including large numbers of wild rose bushes, but failed to find any of these familiar and useful Emmet "herds." Certainly, at least, the honey ants were not there drawing supplies from them. It was not possible to trace the ants to these or other sources of food supply during the day, for I found very soon that they were nocturnal insects. Their nests were as silent, and to all appearance empty, as an abandoned habitation, during the daytime. I accordingly stationed myself beside a nest to await the nightfall. This nest was located upon the summit of a ridge which from a peculiar formation of a rock upon it I named Eagle-head ridge, and the nest Eagle-head nest. At 7.30 P. M., the sun was set, and darkness had begun to gather. A few ants appeared within the gate. They advanced to the top, followed by others; they pushed out upon the graveled sides of the mound, over which a goodly swarm of yellow insects was soon gathered. There were no rotunds or semi-rotunds 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, until within a brief time a vast column was seen trailed along the ridge, all moving in the same direction. The evening had now become so

far advanced that it was difficult to trace the column, but by stooping down close to the earth and using care not to alarm the ants, I was able to do so. The trail was somewhat winding, but on the whole seemed to be chosen with some regard to avoiding the inequalities of the ridge. I was not impressed, however, with the engineering skill of the insects in this matter.

At the distance of about fifty feet from the nest, the column turned down the slope and entered a copse of scrub oak (*Quercus undulata*, var.). I traced a number of ants to a bush several feet within the thicket, but failed to unravel the secret that night. The next night a similar experience awaited me. After a long, careful, but vain search, I retired to my tent baffled. The third night (July 29), the ants of Eagle-head next came out at 7.23 P. M. Those on Toad-stone ridge, to which I had assigned my assistant, Johnson, came out at 7.25 P. M., but did not begin to move until 7.44. Johnson followed them, but failed to find their feeding ground. They moved north and eastward, as did those of the Eagle-head. These latter began to move almost as soon as they came out. They followed the same trail as on the previous evening, the track having been marked by me. The movement was somewhat slower than before, perhaps because the trail had been washed by a heavy rain during the afternoon. There was no leader. A dwarf worker kept in advance over the greater part of the track, then a worker minor took the head of the column. The two were separated from each other, and the van of the column about eight to ten inches. There was, however, not the slightest evidence of any leadership at any time, in any part of the moving line, although I carefully looked for such.

The ants directed their movements to the same tree as on former forays, reaching it in seventeen minutes, at 7.40 P. M. They distributed themselves along the tree, hunting trunk, branches, leaves. I could trace their forms, but when it is remembered that I was wedged in among the thick, low branches of this dwarf oak, holding up a lantern with one hand, and using the other to clear space for it; that the necessity to avoid alarming the timid insects compelled me to retain very inconvenient positions for a long time, it will not seem strange that I could find nothing satisfactory until between nine and ten o'clock. At last, in course of the

slow investigations, I reached the extreme end of a branch on the south side of the tree, and found a number of ants engaged upon clusters of brownish-red galls. The ants were moving from gall to gall, not tarrying for any length of time upon any. They applied their mouth organs to the galls frequently. The dimness of the light, and the distance which I was compelled to keep, prevented me from seeing anything more than this. But it was plain that they were obtaining honey stores, for in the lantern light it could be seen that their abdomens were already much distended by the sweets which they had lapped.

The branch was carefully cut off without disturbing the ants, taken to my tent, and the movements of the insects observed during the remainder of the night, the branch having been so placed as to prevent the escape of the ants, who were yet easily under view. They, however, were so preoccupied with their honey gathering, that they made little effort to escape.

Directing attention to the galls, it was seen that some of them were gradually exuding minute globules of a white transparent liquid, which the ants greedily licked. I tasted the liquor, and found that it was very sweet and pleasant. The object of the nocturnal expedition of the ants, and the source of their honey supply, were thus revealed. These galls are of various sizes, from that of a currant downward. Most of them were of a Turk's-head shape, some flattened spheres. They are placed in groups of two and more along the stems of the branches; they are commonly of reddish-brown color, marked with black patches, but some of them are of a brighter tint, almost rose-color, some of a livid yellow marked with black, some almost green. By cutting off a few of the clusters and removing them from the ants, I saw that the sugary sap issued from several points upon the gall, which in some cases became beaded with six or more globules, several times larger than a pin-head. By removing these beads successively, I found that during the night one gall gave out at least three series. The continual flitting of the ants from branch to branch and gall to gall, was thus explained: the successive exudations invited their frequent return to the galls from which they had formerly fed. When the branch had first been brought to the tent, some of the gall-bearing twigs had been clipped off and placed within

the artificial nests, but received no attention from the ants. Some of the bleeding galls were now introduced, which were instantly covered by the ants, and soon cleaned of their beaded sweets. An examination of the first galls explained the reason for their neglect—they were sapless.

NECTAR-PRODUCING GALLS.—A number of galls of various sorts and sizes, was collected for dissection. They were readily divided into two classes (1), the livid and greenish galls which were soft and entire; (2) the darker colored ones which were hard, unyielding to the touch, and pierced at one side by a small, smooth, regular, cylindrical cavity. It soon appeared that the bleeding of honey-sap was confined to the first class. Upon cutting away the soft pulpy fruit (if it may be so termed), a hard whitish-green ovoid cell, not unlike a cherry seed, was found at the centre. It was about one-eighth inch in diameter. Lying outside of and against this, in a little cavity, I found in one gall a minute, living grub (Pl. III, fig. 12). The body was white, of eleven segments, the head tipped with a brownish hue. The inner cell when opened, showed a spherical cavity in which was a very minute gelatinous pyriform object, which adhered to the side of the cavity. I had no microscope with me, and in lieu of facts, can only conjecture that this may have been an embryonic form of an insect, which matures later in the season.

The hard galls were next dissected. They are all pierced on one side, invariably near the base (figs. 10, 11), by a circular opening made by the matured gall-insect in its escape. Fig. 11 represents one of these, a turban-shaped gall, magnified about three times the natural size. A section view of the gall (fig. 10) shows that the exit hole (*eh*) penetrates the interior cell-case, which must therefore serve as the cocoon in which the pupa transforms. Inside of some of these cells I found traces of a flôssy texture. The cells are commonly spherical, but (as in fig. 10) sometimes egg-shaped. They are separate from the rest of the gall, from which they quite differ in appearance, and are of a firmer substance. In fig. 10, the gall is three-sixteenths of an inch in length, of which the cell occupies two-thirds, that is, one-eighth of an inch. The largest gall observed had an outside measurement of three-eighths inch long and the same across the top. In

one of the galls opened, I found an imperfect insect (imago), which is identified by Mr. E. T. Cresson as of the genus Cynips, a true gall-fly. The specimen would not permit further identifitification.

At the meeting of the American Association for the Advancement of Science, held in 1880, at Boston, I had the pleasure of presenting the substance of this paper to the Entomological Section. My account of the extravasation of the galls, as above, caused much comment, the result of which was to confirm the accuracy of the observation which had been challenged. Prof. C. V. Riley, well known as an entomologist, declared upon his own observations, that many galls exude saccharine matter, citing among others, those of certain Phylloxeræ on Hickory, one of which he had named *caryæ-gummosa* on account of the abundance and stickiness of the exudation. Mr. H. F. Bassett, who has made extensive and careful studies of galls, said that he had found many species of galls visited by ants [1]

Specimens of the oak-gall visited by Melliger were sent to Mr. Riley, concerning which he says: The gall is one that is found quite commonly in the Rocky Mountain region on *Quercus undulata*, as determined by Dr. Engelmann, who sent me the same gall in 1874, though I had previously collected it myself. It is, undoubtedly, an undescribed gall, and a very similar one occurs on the *Quercus macrocarpa* in the Mississippi valley. It has the ordinary woody texture that belongs to so many Cynipidous oak-

[1] American Entomologist, Dec., 1880. The following additional remarks will be interesting in this connection: Mr. E. P. Austin remarked that the chemical composition of sugar and woody fibre are the same, and that sugar could be produced by conversion from woody fibre in the plant. Dr. J. L. Le Conte said that he understood tannin to be a conjugation of gallic acid and sugar. Mr. B. P. Mann suggested that some light might be thrown upon this food-supply of the ants, by the nature of much of the moisture which appears occasionally at night in great abundance on the leaves and other portions of plants, and which is usually mistaken for dew. This moisture, it is said, differs from dew in being produced under circumstances which would not account for the formation of dew, and in containing a perceptible quantity of sugar. It is the ordinary watery excretion from the surface of the plant, which, under favorable conditions of the atmosphere, collects in beads or in drops, instead of evaporating as rapidly as it is formed.

stem galls, and the architect develops in a paler cell that occupies a large part of the interior of the gall. When fresh, the gall is quite bright-colored, inclining to crimson or scarlet. It seldom attains a larger size than an ordinary pea, and differs from similar galls in my cabinet by having frequently a rather broad, flattened crown, though this character is by no means constant.[1]

Nocturnal Habits.—It has already been said that the ants collect the oak-gall nectar by night. Observations daily repeated upon a number of nests, determined that they leave their nests for the oak thickets at or near 7.30 o'clock P. M., and between that hour and 8 o'clock, which is about the time of sunset in July and August. Previous to the departure, the crater, gate and exterior of the mound become gradually covered with swarms of insects whose yellow bodies quite hide the red gravel surface of the nest. The marching of the honey-gatherers has already been described, but always there remained a very numerous force at home, who were seen at all hours of the night on guard within and around the gate. (Pl. V, fig. 25.) The return home began about or a little before midnight, and continued until between four and five, which was near daylight at that season. One or two extracts from my field notes will indicate the facts on this point. "11.30 P. M. Some ants returning home; the movement very slow and deliberate. . . . 12.30. Quite a number are now returning. Some are also still going outward. Numbers of workers patrol the mound and vicinity challenging nearly all incomers, who have to stand the test and give the required satisfaction. What is the antennal password? None of the returning repletes are tolled by the home sentries. . . . This morning at 4.10 A. M. the ants were seen coming in from the oak bushes, most of them well laden, but others not so full. There are evidently degrees of success in honey-gathering among them. Some of the dwarfs had very full abdomens. . . . 4.30 A. M. The ants are returning in numbers and rapidly moving from the brush to the nest. It is about daylight."

In these night observations the light of the lantern seemed to

[1] He suggests for the gall the name *Cynips quercus-mellariæ*. Am. Ento., Dec. 1880.

cause the ants in column no little disturbance. They would go toward the lantern as it sat on the ground near the trail, appear to examine it, then move away. It really seemed to confuse their ideas of locality, and shake their confidence as to the site of the trail, although no one was finally thrown off the track thereby. The sentries at home were always more or less excited by the light, and delicate manipulation was everywhere required in order to preserve the natural conditions and get the natural behavior.

At no time were the ants seen during the day except when it rained, and then only a few sentinels appeared at the gate. Ordinarily the entrance, as far as the eye could see, was entirely abandoned. It is doubtful if Melliger can endure a great amount of sunlight and heat. While excavating a nest, a number of specimens were collected in a large empty glass bottle, which was set aside for further use. Not more than three minutes afterward when I took up the vessel to insert more specimens, those already collected were dead. The sun had killed them. I was surprised at this quick fatal issue, and tried to revive the insects; but no, they were quite dead. The sun was of the usual August temperature, but the bottle was large, and such a result in so brief a time argues extreme sensitiveness to the heat. I have observed that the agricultural ants[1] always avoided the noonday heats of Texas, which are certainly intense; and indeed all ants appear to me to shun, more or less, the midday fervor of the sun. But Melliger doubtless is more susceptible to solar influences than most of her fellows. It cannot therefore be wondered at that she seeks her food under the shelter of night.

§ V. Quality of the Ant-Honey.

A number of the honey-bearers were unavoidably injured and their abdomens broken during the excavations of the nests, and I observed from these the quality of the honey. It is very pleasant, with a peculiar aromatic flavor, suggestive of bee-honey, and quite agreeable to me. Dr. Loew describes it as having "an agreeable taste, slightly acid in summer from a trace of formic acid, but perfectly neutral in autumn and winter." It contains, according

[1] Op. cit., p. 18.

to this writer, a little more water than the honey of bees, and has therefore somewhat greater limpidity.

Fortunately, the composition of this ant-honey has been subjected to a thorough chemical analysis by a competent authority, Dr. Chas. M. Wetherill.[1] The experiments were made at the request of Dr. Leidy, from specimens of *M. melliger-mexicanus* collected by Mr. Langstroth at Matamoras, Mexico.[2] These ants showed the variations observed by me in the distension of the abdomen, and the amount and color of the honey. Six of the average-sized honey-bearers were weighed, and showed the average weight of the honey-bearer's body alone (without honey) to be 0·048 grammes, and the average of honey in a single ant 0·3942 grammes. The amount of honey was therefore 8·2 times greater in weight than the body without the honey. The density calculated for the ants filled with honey was 1·28, and for the bodies alone 1·05. Dr. Wetherill's calculations expressed in English Troy weight would allow about six grains for the weight of each honey-bearer. It would thus require about one thousand (960) honey-bearers to yield one pound of honey (Troy weight), or about twelve hundred (1166) to yield a market or avoirdupois pound.

The syrup extracted from the ants had an agreeable sweet taste, and an odor like that of the syrup of squills. When set aside as removed it showed no trace of crystallization to the naked eye or under the microscope. Under high powers fragments of organic tissue were seen. When evaporated by the heat of steam, it dried to a gummy mass, which did not exhibit traces of crystallization after standing for a couple of weeks.

This mass was very hydroscopic, becoming quickly soft from the absorption of water from the atmosphere. It dissolved without residue in ordinary alcohol, leaving a residue in nearly absolute alcohol. These solutions did not crystallize when set aside. They had exactly the smell of perfumed bay rum. After various tests, which are described, Dr. Wetherill analyzed by combustion with oxide of copper and chlorate of potassa a portion of the gum-like substance which resulted after the ant-honey had been left in

[1] Proc. Acad. Nat. Sci. Philad., Vol. VI, pp. 111, 112, 1852.

[2] I have some of these still in good condition after twenty-nine years preservation in alcohol.

vacuo for two weeks. As this was not perfectly hard, but of a sticky nature, it was necessary to introduce it into the combustion tube upon a piece of glass. 0·497 of honey gave 0·306 of water, and 0·684 of carbonic acid, corresponding to a percentage of C = 37·535, H = 6·841, O by loss = 55·634. This corresponds, as nearly as could be expected under the circumstances of the analysis, with the formula of crystallized grape sugar, C_{12} H_{14} O_{14}.

Dr. Wetherill, who in this analysis was especially seeking light upon the origin of the ant-honey, thus announces his conclusion: "It results, I think, from these experiments, that the honey contained in the Mexican ant is a nearly pure solution of the sugar, so called, of fruits, which is in a state of hydration, isomeric with grape-sugar, C_{12} H_{14} O_{14}, and differing from grape-sugar in not crystallizing." It is certainly an interesting confirmation of the value of this reasoning from analysis, that the ants have been proved by field observations to have collected their honey-dew as Dr. Wetherill concluded, from the nectar of plants. Thus the methods of cabinet and laboratory, and the objective studies of the field, confirm and complete each other.

With regard to the acidity of the ant-honey, which has been referred to, Dr. Wetherill found that it reacted slightly acid to blue litmus paper, but want of material prevented satisfactory experiments. He was in doubt as to whether it was formic acid, or acetic from the oxidation of the alcohol in which the ants were preserved. A portion of the alcohol (reacting acid like the honey) neutralized by caustic potassa, when distilled with sulphuric acid, gave an aqueous acid liquid, which, on addition of nitrate of silver, gave a whitish precipitate, becoming black on boiling, rendering the supposition of formic acid probable.

The uses to which the Mexicans and Indians put this ant-honey are various. That they eat it freely, and regard it as a delicate morsel is beyond doubt. Prof. Cope, when in New Mexico, had the ants offered to him upon a dish as a dainty relish. The Mexicans (Loew) press the insects, and use the gathered honey at their meals. They also are said to prepare from it by fermentation an alcoholic liquor. Again, they are said (Edwards) to apply the honey to bruised and swollen limbs, ascribing to it great healing properties. Dr. Loew's suggestion to bee-keepers to test

the commercial value of these ants as honey-producers is wholly impracticable. The difficulties of farming the colonies, gathering the supply, and the limited quantity of the product, would prevent a profitable industry. The greatest number of honey-bearers in a large colony, taking my observations as a standard, will not exceed six hundred, which, counting six grains of honey to the ant, would be little more than one-half pound avoirdupois. Besides, the sentiment against the use of honey thus taken from living insects, which is worthy of all respect, would not be overcome. The Mexicans and Indians will therefore probably not be disturbed in their monopoly of the honey-product of the nests of Melliger.

CHAPTER III.

INTERIOR ARCHITECTURE OF THE HONEY ANT'S NEST.

§ VI. Interior Architecture.

Gate Architecture.—In order to determine the gate architecture—a term by which I characterize the structure of the nest nearest to the entrance—several formicaries were carefully opened and studied. Four of these are here given as fair types of all. It will be seen from these that a general similarity of plan prevails. The gate itself is a single tubular opening in the centre of the mound, from three-fourths to seven-eighths of an inch in diameter. It is smooth within, and penetrates the mound and the earth perpendicularly to a depth varying from three and one-half to six inches. This gate is funnel-shaped at the top, and the funnel (Pl. IV, fig. 14, F) is gravel-lined, differing therein from the lower part or nozzle of the gate (fig. 18, N). The nozzle descends perpendicularly, or with a slight slope, for three inches, more or less, and then deflects at an angle more or less abrupt, forming an arm (A) usually shorter than the nozzle. This leads into a series of radiating galleries and rooms, and the point of deflection may be called the vestibule, V. These galleries and rooms appear to extend quite habitually beneath and chiefly in one direction from the gate. There are indeed galleries immediately surrounding the gate on every side; but these appear to be limited except in the one direction, within a radius of about eight to ten inches, and to the same distance in depth.

These general statements may be illustrated and expanded by the following details of particular nests.

1. Nest No. 7, fig. 19, was a small nest three and one-third inches in diameter. The gate had a perpendicular depth from the surface of three inches. Thence at nearly a right angle it bent south-east for two and one-half inches, forming the arm, A, and meeting at V a series of branching galleries, *a*, *b*, *c*, *d*. Gallery *a*, bore westward, terminating under the gate; *b*, bore southwest,

appearing to run upward toward the surface; *c*, extended downward and southward at a sharp inclination, entering a long room. E, was a small circular chamber, at one end of which was a beautiful gallery, *f*, running deep downward and inclining slightly west. It was entered near by and above by another gallery, *d*, running toward the surface.

2. Nest No. 6, fig. 18. The depth of the gate, G, was three inches; the length of the arm, A, two inches. The gallery into which A opened toward *b*, divided at one end with two branches separated at their mouths by a little column of two stones resting one upon the other. The gallery, *c*, could be traced at least six inches downward, and a gallery opened directly downward at *a*.

3. Nest on Eaglehead Ridge, Pl. V, fig. 20. This nest, from which many of my night studies were made, was finally opened, and the section view, fig. 20, taken. The vestibule, as in the above examples, also opened into a main gallery, *b*, which led to the northeast, and joined a circular gallery which passed around the vestibule and terminated in an oval room, A. At the other end it entered a circle, which widened upon one side into a bay-room, and sent off a couple of branches, one of which, *c*, was a chamber. Two galleries, *g g*, opened downward. Beyond this, southward, was a long waved gallery, D D, which ended at *e e*, and branched at *h*. Galleries, *g g*, in this series, also led downward.

No. 4. Fig. 23, Nest No. 4, on Adams Ridge. The diameter of this mound was three and one-half inches at the top and seven inches at the bottom. The vestibule sloped eastward from the summit, downward three inches to the main gallery, which had three branches, *x*, *y* and *z*; *x* was followed six inches northeast and upward; *y*, extended southwest and downward; *z*, southeast and downward. A gallery, 1, ran upward from *z*, and connected with *x*. Another, 2, opened on the southwest into a room, A, six inches long and three inches wide, at the west end of which were galleries dividing north and south. A third gallery separated from *z* at 3, and bent northward, apparently uniting with a room, A, five inches long. This room was entered again by a widened mouth, B*e*, about one-half inch above *z*. At the vestibule and upper part of *z* were a number of cocoons. The room, A, was five inches below the surface of the ground at G.

GALLERIES AND HONEY-ROOMS.—The last figure gives an idea of the relation of some of the honey-rooms to the gate and the upper series of galleries. These rooms lie at least as near to the surface as six and eight inches. They vary in size, but for the most part, are about five or six inches in length and three or four in width. They are irregular in their outlines, but have a general tendency toward the oval. One of the most irregular is figured at Pl. V, fig. 21, HR, a large chamber which lay nearly underneath the gate. The gallery, *g g*, into which the vestibule opened, debouched into this room, and a portion of the gallery roof unbroken is shown at *ug*. At B, appeared a bay-room, or enlargement of a gallery, which penetrated the earth horizontally at one end and at the other seemed to wind into the vestibule. The height of the rooms at the walls or sides is from one-half to three-fourths of an inch. The roof is vaulted, thus causing the height to increase gradually until at the centre it is one and one-half inches, which is the greatest distance that I measured.

FLOORS AND ROOF.—The floors and walls are well nigh invariably smooth, quite smooth some of them. The roof, on the contrary, is rough, presenting the natural condition after the sandy pellets of earth and the little pebbles had been picked out by the workers. This can hardly be otherwise than by purpose, precisely as with the smoothness of the floors. The roughness of the roof evidently greatly favors the use to which the honey-bearers put it as a perch. So the smoothness of the floor and walls much better adapts them for the use of gangways. The amount of travel to and fro must be enormous, it is true, in a large formicary; but I cannot think that the resulting friction will account for the smoothness, independently of the purposed masonry of the ants. In the galleries the entire surface, above and below, is smooth, a condition which might be anticipated on the ground of adaptation.

GALLERIES AND ROOMS.—The galleries are tubular openings, varying somewhat in size, from one-half to three-fourths of an inch, and even more, in diameter. A vertical section, however, uniformly shows a quite perfect circle. The underground formicary may be described in general terms as a system of galleries and rooms, arranged in several horizontal series, one above another,

approximating the order of "stories" in a house, and intercommunicating at many points by vertical galleries. The character of the interior architecture can, perhaps, be best shown further by giving somewhat in detail my studies of one nest.

The nest selected for exhaustive exploration was situated upon the summit of Adams Ridge, just above the nook within which my camp was located. Three entire days, besides other portions of time, were spent in this work by myself and assistant. The nest interior sloped eastward, and toward the base of the hill, and occupied a space (in round numbers) eight feet long, three feet high and one and one-half feet wide, the whole tunneled through the soft red sandstone rock of which the ridge consists. This rock is much of it quite friable, crumbling readily under the pressure of the hand, but packs tightly under the stroke of mallet and chisel, thus making difficult mining for men if not for ants. Most of our work was done with the chisel, and the galleries and rooms had to be worked out with knives.[1] These thirty-six cubic feet of rock were fairly honeycombed by the series of galleries and chambers above referred to.

The dimensions of the exterior nest are as follows (see Pl. IV, fig. 15): Height, north side, $2\frac{1}{2}$ inches; west side, $1\frac{5}{8}$ inches; east side, $1\frac{7}{8}$ inches; south side, $1\frac{7}{8}$ inches; distance across the top, $a\ c = 10$ inches; distance around the base, $a\ i\ e\ c = 29$ inches; distance around the crater, $m\ o\ n\ r = 8$ inches; eastern ridge of the crater, $v\ n = 1\frac{1}{8}$ inches; western ridge of crater, $m\ s = \frac{1}{2}$ inch; distance across the gate at $x\ z = 1$ inch, at $s\ v = \frac{7}{8}$ inch; depth of the gate before bending, 4 inches. The mouth, as appears from measurement, was ovate (Pl. IV, fig. 14), but the entrance beyond was a circular tube.

The mound was removed and the soil carefully scraped away. Close to the surface, at the distance of one-half to three-fourths of an inch, openings were found of various sizes, from one-fourth to one inch in diameter. These openings occurred at various distances from the gate, on all sides, four and one-half, five, five and

[1] While engaged upon this part of my work, I was pleasantly surprised by a brief visit of Prof. A. S. Packard. I am glad to be able thus to refer to his valuable testimony in confirmation of some of the statements of this paper.

one-half, eight, eight and one-half inches and upwards to ten inches on the northwest side, eighteen inches on the south side, and eighty-two inches on the southeast, in which direction the formicary extended. Toward the termination of the nest, however, they did not appear so near to the surface.

Section views were next had by cutting across the nest. On the north side I found no galleries at a greater depth than eight inches. On the south side, the first cutting was made east and west, and thereafter the rock cleared away outwardly, until the end of the nest, when the cutting was made inwardly from the starting point toward the gate. The character of the architecture is the same throughout the entire nest, so that the following views will suffice to typify all the interior. The figures Pl. VI, fig. 35, and Pl. V, figs. 16, 17, give views of vertical and horizontal sections made from the gate (southeast), the bottom of the section being twenty-one inches below the surface and the distance of the furthest point from the gate twenty-three and one-half inches. Fig. 35, Pl. VI, is a front view of galleries looking south, and exhibits a surface about seventeen inches in length by seven in height.[1] The main series of galleries within this area are accurately shown, but the connecting vertical galleries were broken away in the excavation, and are not figured.

Fig. 16 is a vertical section showing the southwest and southeast sides of the excavation at the same point as the preceding figure, part of which is included in this view.[2] There are here shown the general tendency of the galleries (*g*, *g*, *g*) toward stories, arranged one above another; the relative position of the honey-rooms (R, R), and the relation of the series to the large honey-rooms, C, D, E, shown fully at fig. 17.

The broken lines, *c l d*, and *e h k*, show a series of rooms,

[1] Detailed measurements.—*a* to G — 5½ inches; G to *d* — 11 inches; *e* to *f* — 10 inches; *h* to *i* = 11 inches; *k* to *l* = 11 inches; *m* to *n* = 3 inches; *b* to *e* = 2⅝ inches; *o* to *f* — 3½ inches; *p* to *q* = 1½ inches; *q* to *k* = 2⅛ inches; *i* to *l* — 2¼ inches; *o* to *r* = 3¼ inches; *l* to *s* = 6¼ inches.

[2] Fig. 16 measurements.—*a* to *b* = 4½ inches; *c* to *d* = 10 inches; *e* to *f* — 4 inches; *h* to *i* = 4⅛ inches; *i* to *k* — 4⅝ inches; *c* to *j* = 10 inches. The gallery, *j*, appeared to connect upward with the lowest series of rooms, *e f h k*.

some of which were occupied by larvæ and some by honey-bearers. The large rooms, C D E, Fig. 17, belong to the lowest series, and are figured and described as fairly typical of all the honey-rooms and other chambers. They were carefully uncovered by chisel and knife, and after being sketched, a plaster cast was taken of them, which is preserved in my collection.[1] These rooms were of an irregular oval shape; in length five, three and one-half, and six inches successively (C, D, E), and were of an average width of about four inches. They were not built upon a level, the origin of C, at *b*, being three and one-half inches above the middle point of D, and six inches above the termination of E. A side gallery, *g g*, skirted two of the rooms, and appeared to open upon a fourth chamber at F, which, however, was too much broken in the digging to be identified. Of course, only the floor and part of the side walls of the rooms are shown, but the roofs were vaulted and rough, as already described, and rose to the height of three-fourths to one and one-fourth inches. Within them, clinging to the roofs, were packed the rotunds. The number in each room averaged about thirty; and as there were at least ten chambers thus occupied, the number of rotunds in the nest was certainly not less than three hundred. Of far the greater proportion of these the abdomens were distended to a perfect sphere.

THE QUEEN ROOM.—I had the good fortune to capture the fertile queen of this colony. She was found quite near the extreme end of the formicary, in a nearly circular room four inches in diameter. The series of galleries and honey-rooms which composed the formicary terminated in a single gallery (fig. 22, *g g g*), about eighteen inches long, three-fourths inch wide and one-fourth inch deep. The gallery sloped sharply with the slope of the hill-side on which the nest was made. Near the

[1] I succeeded by vast painstaking and labor in securing a number of fine specimens of the architecture, which were carefully packed in boxes and committed to the Express Company at Colorado Springs. The company received a heavy bill for transportation, and delivered my beautiful and costly specimens at the Academy broken in pieces! It was an act of gross carelessness, which merits this notice, as some specimens brought home in my trunk survived even the "baggage smashers."

middle part thereof was the queen-room (C), being seventy-two inches from the central gate and twenty-eight and one-half inches below the surface of the hill. Besides the queen the room contained a large number of naked grubs, callows, honey-bearers and workers. It is not improbable that the queen habitually dwelt in or near this room; but it may be that during the successive attacks upon the nest, the workers bore their queen still further and further from the point of danger until the limit was reached.

Ten inches below the queen-room, the gallery, *g g g*, was continued until it finally terminated in a small circular chamber (E) or bay on the one side, and on the opposite side a narrow gallery (*t g*), which curved upward. This was the end of the formicary. It was eighty-two inches from the central gate, forty and one-half inches below the level of the main nest gate, and twenty-nine and one-half inches below the level of the hill-side. The entire length of the formicary from northwest to southeast was thus seven feet eight inches.[1]

[1] While preparing clay models of some of the above examples of ant architecture for my cabinet of Insect Architecture in the Academy of Natural Sciences, it was suggested that moulds be made, from which plaster casts could be taken, for the benefit of such other scientific collections and public museums as they might be wished for. This I had done, and the moulds are now in the hands of the Curator in charge of the Academy, by whom they will be furnished, upon proper order, at the cost of reproduction and packing, as nearly as may be. Five specimens are cast, viz., those figured at Pl. II, fig. 4, and Pl. V, figs. 16, 17, 22 and 23. They are cast natural size, except fig. 16, which is half size. The cost, painted natural color, will be $10 for the set, unpainted $6. Orders should be sent to Charles F. Parker, Curator in charge Academy of Natural Sciences, Philadelphia, Pa., U. S. A.

CHAPTER IV.

QUEEN LIFE AND ACTS OF BENEFICENCE.

§ VII. Queen Life.

The captured queen of the large excavated nest was transported to Philadelphia, placed in one of my artificial nests, a large glass globe, and afforded several interesting observations upon her habits.

Her Body-Guard.—After the usual custom of ants, she was continually surrounded by a guard of workers (Pl. VI, fig. 29) varying in number, but usually as many as twelve or twenty. These attendants quite enclosed her, and restricted her movements, apparently watching and guarding her with great carefulness. On one occasion when she escaped to the upper surface of the nest, she was followed and seized by a worker-major, who interlocked her mandibles with the queen's (Pl. VI, fig. 26) and dragged her down the gateway into the interior. The royal lady gave only a passive resistance, holding back somewhat heavily.

Depositing Eggs.—I quote from my notes the description of this process, the various stages of which I was also able to sketch. "The queen has been laying a small heap of eggs. She is now on a little elevation of earth, surrounded by a number of workers of all castes, some of whom lick her abdomen, especially beneath and at the apex. One, meanwhile, gives her food in the usual way, by regurgitation. I see the tongues of the two insects overlap in the act. The queen's abdomen is raised high, her head is stooped, she lifts the abdomen up and down. The workers have clustered under her body, giving her somewhat the appearance of a successful candidate undergoing 'a chairing.' She has changed her position; the workers follow, quite surrounding her. Two are beneath the abdomen, which is depressed now, the head being elevated. The attendants sit down patiently to watch. They

keep their antennæ moving continually, while they amuse themselves by cleansing their persons. The queen moves; a dwarf seizes a fore-foot and attempts to control her course. This and "nipping" with the mandibles, is the common mode by which the guard directs the queen's motions. The eggs laid are in an irregular mass about one-eighth of an inch thick. There are twenty to thirty minute yellowish, ovoid objects, which adhere to each other. The workers surround the mass, some appeared to lick it. The queen straggles over the eggs, places a foot upon the mass. A dwarf seizes the foot hastily and draws it back, while another worker catches up the egg-mass and draws it aside." The observation was made at 11.20 P. M.; at 1 A. M., when I retired, no change had occurred. This is as much of this interesting behavior as I was able to observe in this female. I have, however, seen the actual deposition of the eggs by a queen of *Camponotus pennsylvanicus*.[1]

§ VIII. Acts of Beneficence.

In the natural sites the workers showed great interest in the preservation and removal of the rotunds, dealing with them very much as with the larvæ. As the honey-rooms were opened and the rotunds disturbed from their roosts, the workers of all castes rushed eagerly to them, and dragged them into the unbroken interiors. Sometimes several ants would join in removing one rotund, pushing and pulling her along. One sketch (Pl. VI, fig. 27) made in my notes, represents a major pulling a rotund, whom she has seized with her mandibles by the outer abdominal wall, while a dwarf-worker is mounted upon the globe, standing upon her hind legs "a-tip-toe," as it were, pushing lustily. Another sketch (Pl. VI, fig. 36), caught on the spot, represents a worker-major dragging a rotund honey-bearer up the perpendicular face of a cutting made in the excavation of the nest. The mandibles of the two insects were interlocked, and the worker *backed* up the steep, successfully drawing her protégé.

This interest is maintained in the daily life of the formicary. The workers were continually seen hovering about the rotunds as they hung from the roof of my nests, or as they lay upon the floor

[1] See a note in "Proceed. Acad. Nat. Sci. of Phila.," 1879, p. 140.

cleansing their bodies. It is evident that these creatures are regarded as dependents, and, as with the queen, virgin females, males and larvæ, are fed and tended by the active members of the community. In all these cases the same communal instinct would of course control action, giving at least the semblance of beneficence.

Lack of Individual Beneficence.—But a great number of examples fell under notice which go to throw doubt upon the possession of any personal or individual sentiment as towards special cases of need, outside of the above limit. Some of these may deserve permanent record.

1. In making up my artificial nests, I placed in the natural soil, which was closely packed down, and then introduced the ants, knowing that they would work out their own habitations. The honey-bearers were thus mingled upon the surface with the workers, upon whom fell the entire task of digging galleries. In this work, and in the distribution of the excavated pellets, there was much room for the exhibition of individual carefulness and tenderness toward the honey-bearers. Not a single such instance was noted, although I watched closely and with some anxiety to discover such excellencies in my little friends. On the contrary, the exhibitions of an apparent cruel neglect and positive cruelty were many. The grains of sand and soil were heaped around the rotunds (Pl. VI, fig. 31) until the poor creatures were literally buried alive. It would have been easy for the busy masons to draw their fellows aside and thus carry on their work. But it either never occurred to them to do so, or the disposition was wanting.

2. Again, as the openings were made into the earth, most of the rotunds, not prevented as above, managed to roll down the galleries and secure a place in the honey-rooms. They were not observed to be aided in this by the workers, and I believe that they attained their perches unaided. Some of them, on the route, became fastened in the gang-way in most uncomfortable positions, heads downwards, bodies awry, etc. The workers passed by and over them continually, for many days, without the slightest apparent concern, and certainly without a single observed effort

to relieve their comrades, who could readily have been extricated and drawn into the chambers.

3. It frequently happened that the rotunds dropped or were shaken down from their perch against the roof to the floor. These creatures remained in the positions in which they fell, except when they chanced to so fall as to be able to clasp with their claws some clod of earth, or bit of gravel, or the rough surface of the projecting walls or roof. In such case, they either recovered their perch, or placed themselves in comparatively comfortable postures. The greater number, however, fell upon the round abdomen in such wise that the body stood up quite erect (Pl. VI, fig. 32), leaving the legs thrust out unsupported. These unfortunates were faithfully attended, often cleansed and caressed, but in no single instance did the workers attempt to right them and restore them to the roof. Yet they were abundantly able to do so, with little effort, and the fallen rotunds were in sore need of help. Some of these lived for two months and longer in this awkward position, but it was very evident that they were extremely uncomfortable.

When it was practicable to extend my help to those near the surface it was eagerly accepted, the offered stick or quill clasped by the mandibles, sometimes assisted by the feet, so firmly as to enable me to transfer the heavy creatures to any point, even to lift them out of the nest. Here again the idea or at least the act of helpfulness was lacking. If we are to suppose the power of communicating their distress and desires to have been possessed by the bearers, we must think the workers even yet more lacking in feeling and intelligence.

4. One honey-bearer was partly buried under her perch, that portion of the roof having fallen. Her abdomen was quite covered by the fine sandy particles at the margin of the little landslide. The task of rescuing her would have been easy to the workers, but it was never undertaken. A sketch (Pl. VI, fig. 28) was made, shortly after the occurrence, which shows one worker-minor standing before the rotund with head and body erect, antennæ atent, with every mark of curious interest in her deportment. She watched the struggles and mute appeals (as it seemed to me) of her unhappy comrade, who by great exertion had succeeded in heaving up the clod, and then "passed by on the other

side." Meanwhile a second worker was perched atop of the clod, coolly and cosily combing her back-hair and antennæ! This tableau is simply characteristic of the ordinary behavior of the workers.

An apparent exception was noted in the case of a semi-rotund who was overtaken in a gangway by water with which I was supplying the community, and stuck fast in a bed of mud. For a long time the workers, who were incited to masonry, as usual, by the water supply, dug and traveled around and over the imbedded ant without notice of any sort. Finally one stopped and licked the antennæ and head of the prisoner, who began to struggle, and so dropped down a little into the gangway. Meanwhile the first-comer had left. A second ant stopped, applied the tongue a moment, gave a little tug at the unfortunate, and was off. Still the stream of workers passed on. Finally, an additional pull from below was given by a concealed worker, but when I closed the observation the ant was still imbedded in the mud within the gangway. It was impossible to decide in this case whether the helpers noted were moved by personal kindness, or rather (as is most likely), by the same impulse which directs them in ordinary mason operations and toward supposed dead comrades.

Sir John Lubbock, who has made interesting experiments and observations with a view to testing the presence of benevolent feeling in ants,[1] does not have a very high opinion of emmet charity, but concludes that there are "individual differences," and that among ants, as with men, there are Priests and Levites, as well as Good Samaritans. I am much inclined to the view that anything like individual benevolence, as distinguished from tribal or communal benevolence, does not exist. The apparent special cases of beneficence, outside the instinctive actions which lie within the line of formicary routine, are so rare and so doubtful as to their cause, that (however loth), I must decide against anything like a personal benevolent character on the part of my honey-ants.

Such an example, indeed, as one of those cited by Lubbock,[2] viz., the neglect on the part of co-formicarians to remove the decapitated heads of enemies from the limbs to which they are

[1] Journal of the Linnæan Society, Zoology, Vol. XII, p. 497.

[2] Op. cit. p. 492.

firmly clasped, does not seem to me as remarkable as it does to Sir John. I have often observed the same fact among various species, and, knowing by experience, the difficulty of unloosing those formidable jaws, clasped by their immense muscles in the rigor of death, would charge it to inability rather than indisposition, that these adhering death's-heads are not removed by kindly offices of comrades. But such examples as are here recorded, together with kindred ones given by Lubbock, may fairly be quoted against the existence of a personal benevolent character in ants. However, the question can by no means be regarded as settled.

Cleansing and Feeding Larvæ.—One or two miscellaneous observations may, perhaps, be allowed a place in this connection. The solicitude of the workers for the helpless larvæ was a matter for continual admiration. The offices of nurse do not seem to be confined to any one caste, but the burden of duty appeared to be assumed by the dwarfs, and next to them the minors.

When the grub is to be cleansed it is taken in the mouth, turned by the fore pair of legs, the antennæ meanwhile touching and apparently aiding, while the mandibles are applied over the grub, their teeth apparently working chiefly within the annular divisions of the several joints. Doubtless this motion is accompanied by a free use of the tongue, but this I did not observe.

When the grubs are to be fed, the workers pass from one to another, striding over them, and standing among them (Pl. VI, fig. 34) as they lie in little groups. The wee white things perk up their brownish yellow heads, which they stretch out and move around, evidently soliciting food. Their nurses move from one to another, apply the mouth for a moment, and pass on.

At the slightest alarm the grubs are seized and hurried into the recesses of the nest. Their position is frequently changed, from higher to lower, from outer to inner rooms, and the reverse, without any purpose which I could discover or imagine. When this sort of transfer was not going on, the nurses would often be engaged in shifting the position of their charges, flitting restlessly among them, picking them up, turning them around, putting them down again, with an aimless uneasiness that bore an amusing like-

ness to the dandling which human infants undergo at the hands of certain young mothers.

Toilet Habits.—It has been said that the honey-bearers are cleansed by the workers. This is the rule; but the rotunds are not wholly dependent for this upon their fellows. In one of my formicaries, the rotunds when placed within the light, began to cleanse themselves, without leaving their perch. They held on to the roof by the two hind legs and one of the middle pair, and used the other middle and the two fore legs in the usual manner of ants.[1] They were quite able thus to draw a leg through the spur-comb of one of the fore-feet; to brush the head, etc.

In one case I even saw a honey-bearer performing the offices of the toilet upon a worker. The latter held her mandibles apart, while the rotund licked the mouth parts; and from thence proceeded to the vertex of the head. Both insects were in a semi-rampant posture the meanwhile.

Fraternal Relations with Sister Colonies.—A few experiments upon several nests quite widely separated, showed that as in the case of some other ants,[2] the inmates (of the same species) fraternized completely, and engaged within the artificial nests, in the care of the larvæ, cocoons, honey-bearers, and in all other formicary duties.

[1] See Toilet Habits of Ants, in Agricultural Ants of Texas, Ch. VIII, p. 125.

[2] Mound-Making Ants of the Alleghenies, p. 281.

CHAPTER V.

ECONOMY OF THE HONEY-BEARERS.

What is the economy of the remarkable structure and habit presented in the honey-bearer? The naturalist is shut out from all observations in natural site that might give answer to this question. But from studies thus far made upon my artificial formicaries, from structure, and from reasonable analogy, I have little hesitation in saying that the economy is precisely that of the bee in storing honey within the comb. The difference lies in the fact that the bee puts her store within inorganic, the ant within organic matter; the bee within the waxen cell which her industry constructs, the ant within the living tissue of her sister formicarian, provided to her hands by the Creator. The honey is held in reserve within its globular store-room of animal tissue for times when the workers fail to gather food, or the supply fails in Nature. The queen, the virgin females, the males, the teeming nursery of white grubs, are all and always altogether dependent upon others for nurture. During the winter months and in seasons when the honey supply is scant or wholly fails, perhaps during the long rainy seasons, the entire family must have food. Precisely as the bee goes to the honey-comb in such emergencies, the honey-ant goes to the honey-bearer.

There is, to be sure, a corresponding difference in the mode of eliciting the stored sweets. The bee breaks the cell and laps the honey. The hungry ant places her mouth to that of the bearer, from whose mouth it is received as it is regurgitated from the honey crop. The muscles of the abdomen act upon that organ as does the pressure of a lady's hand upon the eau-de-cologne within the elastic bulb of a toilet jet or spraying bottle. It is forced up, gathers in a little globule, a honey-dewdrop, upon the filament-like maxillæ under the jaw, whence it is lapped off by the waiting pensioners. The admirable adaptation by which the ant's structure is fitted for this function, will be noted further

on. It may be well to state such facts as appeared in various efforts to arrive at the truth of the above opinion, viz., that the honey-bearers serve as store-houses of food for the inmates of the nest. If these facts fall short of a complete demonstration, they at least form a chain of evidence which creates a very strong probability.

1. Regurgitation of Honey.—On the occasion of the discovery that the ants collected nectar from the oak-galls, a branch upon which the foragers were at work was removed to my tent for study. First, however, it was taken to the home site, and a dwarf worker coaxed upon a leaf and laid on the nest. She seemed much confused, and evidently did not at first recognize the fact that she was at home. The workers around the gall, who were quite easily distinguished by the smaller size of their abdomens, also showed marks of surprise at this unexpected arrival. However, two dwarfs and a minor soon sufficiently recovered their equanimity to arrest their fellow and "take toll" from her mouth of the syrup with which her crop was well charged. (Pl. V, fig. 24.) The mode was that which is common among ants, and has been fully described.[1] A worker-major was next transferred from the bush to the nest, and showed the same confusion at this unexpected "railroading" home. She also was tolled by the ants clustering upon the mound. In both cases I saw the drop of liquid honey sparkling as it passed, a lantern having been placed on each side, thus throwing light fully upon the group. The major, after her first confused hesitation, seemed inclined to start again on the trail, but after being tolled entered the gate. It thus appeared at the outset, that the honey collected by the foraging parties is served out to the sentinels, working parties and others at the nest, precisely as has been fully shown in the case of the mound-making ants of the Alleghenies.[2]

2. The act of receiving supplies from the honey-bearer was observed by me soon after the transfer of the ants to an artificial nest. The rotund threw her head up, raised her thorax, and regurgitated a large drop of amber liquid, which hung upon the

[1] See Mound-Making Ants, p. 275.

[2] Op. cit., p. 277.

mouth and palps. At first two ants were feeding—a major, who was in a position similar to that of the rotund, and a dwarf who stood upon her hind legs and reached up from below. During the feeding another major was attracted to the banquet, and obtained her share by reaching over the back of the first worker, indeed, partly standing upon her, and thrusting her mouth into the common "dish." (Pl. V, fig. 24.) The mandibles and maxillæ of the pensioners serve as a sort of dish, upon which a particle of honey is taken and afterward is licked off more at leisure.

3. Workers fond of the stored Honey.—The fondness of the workers for the store within the rotunds was strikingly shown during the excavation of a nest. Necessarily, in breaking down the rooms, the distended abdomens of some of the honey-bearers were ruptured. The high state of excitement which pervaded the colony, the ordinary instinct to defend the nest and preserve the larvæ, cocoons and other dependents, were at once suspended in the presence of this delicious temptation, and amid the ruins of their home the workers paused, clustered in large groups around the unfortunate comrade, and greedily lapped the sweets from the honey-moistened spot. It was a pitiful sight to see, and was noted with a mild sort of indignation, and to the disparagement of the ants, until I remembered that history has often recorded, and, indeed, I myself have seen, the humiliating fact that human beings have exhibited a like greed and ignoble self-gratification amid the perils and threatened wreck of their country and homes.

Treatment of Dead Rotunds.—Over against this fact may be placed one seemingly more to the credit of our Melligera. From time to time the honey-bearers died. The bodies of those who perished upon their perch would hang to the roof for days before the death-grip finally relaxed and they fell. It happened more than once that the workers failed to perceive the change, and for some time, a day or more, after death, continued to cleanse and tend them with the accustomed solicitude. When the fact was at last perceived, and the dead removed, the round abdomen was first severed from the thorax by clipping the petiole, then the parts were separately removed to the "cemetery," that common dumping-ground for the dead, which these ants, like all others

whom I have observed, invariably maintained. In view of the fact last recorded, it seemed curious that the stored treasures of these "honey-pots" were not secured by cutting the sealing tissue. In point of fact, this was never seen to be done, and the amber globes were pulled up galleries, rolled along rooms, and bowled into the graveyard along with the juiceless legs, heads and other members. I verily believe that they were never once deliberately opened, in spite of their tempting contents. If this act were the result of an instinctive sentiment by which Nature guarantees protection to the living honey-bearer (and this, indeed, is likely), it must seem to us very beautiful and praiseworthy. But what if it were only the consequence of a mentalism so low and fixed within its instinctive ruts as to hinder even a suggestion of utilizing the wasting store by opening the abdomen?

4. Effects of Withholding Food.—In order to determine beyond doubt the relations of the honey-bearers to the other ants, I made a number of experiments, which, I regret to say, led to no decided conclusion.[1] One or two of them, however, gave results of some value. A number of rotunds and workers were placed in a nest, and denied all food. A little water was allowed them, but for more than four months their fast was not otherwise broken. It was my hope that this prolonged separation from external food supplies would compel the workers to resort to the honey-bearers for food, and thus afford the positive proof that the latter were the natural storehouses of the colony. Most provokingly, the perverse Melligers made the room of the honey-bearers within the very heart of the nest, and no strategy of mine could tempt more

[1] An unusual press of professional and domestic duties during the winter of '79-80 absorbed even my evenings and those leisure hours which I feel at liberty to devote to natural history. I was thus unable to give to my little friends that attention which might have assured a complete success. On one occasion, just as a long series of preparations promised satisfactory results, a family bereavement intervened, and when it was possible to resume observations, the hour of advantage had passed. Then followed the untimely destruction of my captives, as will be related hereafter, and the estopment of all study. Naturalists, at least, will know how to estimate the various ordinary as well as extraordinary interruptions and hindrances with which the observer has to contend, and which often prevent the most satisfactory results.

than one or two of the rotunds into a position under my eyes. I was therefore limited to such inferences as might be drawn from the general condition of the inmates during and at the close of the fast.

During the entire four months, the workers, whose movements were of course observable, were in perfect health and good condition. Indeed, it was very evident that they were in a more healthy state, more vigorous and active than the inmates of the other nests. When the nest was finally opened the remaining workers had well-filled abdomens, all of them looking more like foragers freshly returned from a banquet of nectar among the oak galls, than like the victims of a four-months' siege. The abdomens of the honey-bearers were undoubtedly diminished, but presented little appearance of having been largely drawn upon by hungry workers.

The complement of this experiment over a nest of workers who were wholly separated from honey-bearers, and denied food, came to an untimely end. The purpose had been to make such a comparison between the two sets of workers as would have shown what effect the presence of honey-bearers had upon the abdomens.

5. COVERING OBNOXIOUS MATTER.—Two other formicaries were established with the special purpose of determining whether the workers habitually transferred food to the sedentary insects upon the roof. One colony was fed syrup mixed with carmine, the expectation being that if the ants ate this and fed it to the honey-bearers, the color would show through their abdomens, or be discovered by dissection. The experiment failed, as to its main purpose, but was the occasion of uncovering an interesting trait. The carmine-syrup was obnoxious to the ants. Some tasted it, turned away, and rubbed their mouth parts upon the earth, with evident tokens of dislike. Others tested it with their antennæ, and although they had been prepared for a banquet by previous fasting, refused to eat. Moreover, they instantly, deliberately, and with one accord set to work to cover up the offensive material. The syrup had been placed upon large corks, hollowed out atop into little dishes, and set in the soil. One cork projected an inch above the surface, and up this the workers climbed, carrying pellets of earth and gravel, from the very bottom of the nest, four

inches below the surface. These pellets they dropped into the syrup, until the dish was filled and heaped up high. Some of the bits of gravel were quite large, of greater bulk, and several times heavier than the ants. As the nests were made of their native soil, I thus saw the ease with which the workers carry up the gravel stones, that cover their mounds (Pl. VI, fig. 30).

A broad trail of syrup was forced down one side of the cork, and it also was covered. This required more delicate management, as the ants were forced to support themselves upon the perpendicular surface of the cork, and, working side-wise, daub the dirt into the syrup, and fix it there! The whole trail was thus covered from top to bottom. The syrup was fed to another formicary with precisely the same results.

This was not the only occasion on which food given the ants was thus served. A crushed grape, and a juicy bit of a pear were covered in the same way in four of the nests. The fruit did not seem to be relished by the ants, yet I am not sure that the juice may not afterwards have been lapped from the soil which absorbed it. White sugar the ants took freely; bees' honey was not so much relished.

In the meanwhile, during the progress of these observations, I found that the semi-rotunds, at least were not wholly dependent for food upon the workers, as they partook freely of the sugar. But I never saw a honey-bearer, one of full rotundity, taking food or drink.[1] One might imagine that they are quite independent of outside supplies after they have once reached that state, and could spend the remainder of their lives, unless greatly prolonged, without eating. The question of chief interest here is: are they brought to that state by the deliberate action of workers in feeding them? I believe that after a certain point of distension this is the case. But the belief does not yet rest upon positive demonstration. We now proceed to the anatomy of the creature, which may afford some additional light upon this question.

[1] I substituted for carmine Prussian blue, which Dr. Forel had used for staining living ants (Fourmis de la Suisse, p. 110), but had no better success, although some of the ants fed upon the colored sweets.

CHAPTER VI.

ANATOMY OF THE ALIMENTARY CANAL IN THE HONEY ANT.

These questions, closely related, required answer:

I. Are the honey-bearers a distinct caste?

II. How is the peculiar dilated condition of the abdomen to be accounted for?

III. What is the condition of the digestive organs in the abdomen of the honey-bearer?

There are some field observations that have a bearing upon these questions:

1. The workers observed returning from foraging excursions had largely inflated abdomens. This is an ordinary experience with ants; the workers of *Formica exsectoides*, our mountain mound-builders, for example, returning from attendance upon the Aphides with their crops very much swollen. The workers of Melliger, however, seem to have an especial elasticity of the crop, which gave the abdomens of some of the returning repletes a nearly semi-rotundity.

2. These repletes and semi-rotunds in my artificial nests adopted in a measure the sedentary habits of the honey-bearers, and perched upon the roofs, where they hung quite persistently. They were often very sluggish, but more ready to move than the rotunds, and at times showed much activity, though not greatly disposed to work. (See Pl. III, fig. 6.)

3. In the formicaries opened in natural site, I observed, what Llave had seen from his specimens, that there were several degrees in the sizes of the honey-bearers in the honey-rooms.

4. There was an apparent growth in the abdomens of the sedentary workers in the artificial nests. As early as September 7th, 1879, I made this record in my note-book: "It begins to dawn upon me that the worker-majors become honey-bearers. Many of them hang in the nests to the honey-rooms. In 'B' nest the entire line along the upper margin of the large room is composed of

this rank." Honey-bearers with abdomens distended from one-half to two-thirds the full size were continually noted, and I could only infer that they were recruited from the number of the sedentary majors. In fact it became difficult to mark the individuals in whom the sedentary major ceased and the honey-bearer began.

5. A series of experiments was attempted to solve this point. Semi-rotunds or sedentary majors were separated, freely fed, and their growth noted. They never exceeded the condition of about two-thirds the usual spherical abdomen. What the result would have been had they lived the entire year, and how long it would have taken them to attain the rotund condition can only be guessed.[1]

6. Among the callows, or young ants, collected, I could find no evidence at all of a separate honey-bearer caste. Among the larvæ there were some large, broad grubs, that differed much from the others, which I supposed to be queen-grubs. I was not able to hatch these and the cocoons, and observe results, a process which would probably determine the whole inquiry. The cocoons collected were all of three sizes, corresponding in length to the workers, major, minor and dwarf or *minim* as this smallest caste might perhaps be called.

7. A comparison of the workers with the honey-bearer shows that there is absolutely no difference between them except in the distended condition of the abdomen. The measurements as to length and size of head, length of legs and thorax are precisely the same. This appears to be true also, of some of the smaller rotunds and the minors.

My conclusion from the above facts is that the worker majors, for the most part, and sometimes the minors, are transformed by the gradual distention of the crop, and expansion of the abdomen, into the honey-bearers, and that the latter do not compose a dis-

[1] Some observer upon the field might readily take up these and other experiments and carry them to a satisfactory conclusion. There are invalids at Colorado Springs and Manitou, who might follow the admirable example of the late Mr. Moggridge at Mentone, and find both enjoyment and prolonged life in some such studies.

tinct caste.[1] It is probable, however, that some of the majors have a special tendency to this change by reason of some peculiar structure or form of the intestine and abdominal walls.

8. Finally I undertook an anatomical comparison of the honey-bearers and workers. I made a large number of dissections, which were carefully studied and compared, and these observations strengthened, I might almost say entirely confirmed my opinion.[2] Some of the results thus obtained will have value to many students, and they are therefore briefly presented here. Without entering fully into anatomical and histological details, enough will be given to confirm and explain the facts related and opinions stated above.

THE ALIMENTARY OR INTESTINAL CANAL.—The whole course of the alimentary tract from the mouth to the anus was carefully worked out in many dissections. Less attention was given to the head; the pharynx and mouth parts were, however, worked out. Attention was, of course, chiefly directed to the abdomen and contents.

The intestinal canal is composed of the following parts:

I. Within the head there are:

§ 1. The mouth and the mouth-parts, viz.: the mandibles (Plate VII, figs. 37, 38) *mb.*,[3] which are armed with teeth of irregular size; the maxillæ, *mx*, and maxillary palps, *mx. p*; the labium, *lb.*, and lower lip, the labial palps, *lb. p.*, and the tongue, *to.*

§ 2. The buccal sac (fig. 51, *bc.s*), a spherical expansion at the anterior part of the pharynx, in the middle of the front part of

[1] I am glad to be confirmed in this opinion by Dr. Aug. Forel, to whom I early sent specimens and notes, and who has shown a gratifying interest in these studies, and has cordially aided them by valuable suggestions. See a communication to the Morphologico-Physiological Society of Munich, in *Aerztlichen Intelligenz-Blatte*, Jan'y, 1880.

[2] I mounted many of my preparations for more leisurely study under the microscope, and they have been submitted to the Academy of Natural Sciences of Philadelphia. I acknowledge here the assistance and advice of Prof. J. Gibbons Hunt, M. D., in these studies, whose unrivaled skill as a microscopist was cordially placed at my disposal.

[3] The reference-symbols are uniform in all the figures, and are for the most part such abbreviations of the names of the parts as may aid the memory in studying the plates. See the key to reference symbols.

the head. Its function is not determined.[1] It is frequently found filled or partly filled with various, amorphous particles, the debris of food, etc. Brants, who first discovered it in the wasps, supposes that it may serve those insects in the preparation of their paper-nests. Forel conjectures that it may serve the purpose of a special digestion for the anterior part of the body. Lubbock once found in it an entire worm. It would appear to be a sort of anatomical "Botany bay" for the temporary seclusion of such food material as may not be prepared to yield the juices which alone pass into the crop.

§ 3. The pharynx (fig. 51, *px.*) a strongly muscular wall situated within the head in front of the neck, *nk.*

II. Within the body there is the œsophagus (*œ.* fig. 52), a muscular tube[2] or canal which passes through the neck and petiole, and connects the head with the abdomen.

III. The parts within the abdomen, which most concern us are:

§ 1. Segmental Plates of Abdomen.—It is first necessary to understand the structure of the wall of the abdomen. This consists of ten strongly chitinous segmental plates, five dorsal and five ventral (Pl. VII, figs. 53, 54). These overlap one another, like scales, from the base toward the apex, and the dorsal plates overlap the ventral. The last plates which guard the cloacal cavity, are known as the pygidium (*py.*) and the hypopygium (*hy.*) The anus, in Melliger is surrounded by a circle of strong bristle-like hairs.

These plates, in the normal condition of the abdomen, are set upon (if I may so say) a strongly muscular inner wall, which is highly elastic in all ants, particularly of the Formicidæ. This elasticity appears to reach its extreme point in Melliger. In ordinary excessive feeding, the distension of the crop causes the expansion of the muscular coat between the plates which are thus forced apart, at various degrees of separation, according to the amount of food taken, until in the case of the honey-bearer of Melliger the three middle plates (Nos. 2, 3, 4) are wholly isolated,

[1] See Forel, Swiss Ants, p. 109; Lubbock, Microscop. Jour., London, 1877, p. 139; Agricultural Ants of Texas, p. 119.

[2] Forel, quoting Meinert, speaks of the muscularization as feeble; but in Melliger, at least, the muscles appear to be sufficiently strong.

appearing, as Forel has well said, like little islands on the tersely stretched, light colored abdominal membrane. (Plate VII, fig. 54, D2, 3, V2, 3), (Plate X, figs. 72, 73). Plates D1, V1, retain their normal position, and plates D4, V4, are not so widely separated from D5, V5, as from their next anterior plates.

We may now view the abdominal portion of the intestinal tract, in order to understand what happens in the growth of the honey-bearer.

§ 2. The Crop or Ingluvies.—The crop is the anterior and superior sub-division of the abdominal portion of the alimentary canal. It is simply an expansion of the œsophagus within the abdomen. The normal condition of the crop was determined by examination of the workers with undistended abdomens, and more readily from the study of a virgin queen (Pl. VIII, fig. 59).

The œsphagus *œ*, is there seen passing through and bent over the hard ring (*Jn*) which forms the junction of the petiole and abdomen. The œsophagus is seen as continued (*œ c*) within the abdomen, where it has precisely the same structure as within the thorax. The crop or ingluvies contains a moderate amount of food and is fairly distended. The exterior coat of the crop is a net-work of muscles which present the branched character sometimes found in insects (Pl. VII, fig. 45). Another section of the crop showing the character of this muscularization is given at Fig. 46. This enlarged view is taken from the object shown at Pl. VIII, fig. 55, and is made at the margin. The spherical crop is thus seen to be hung within the muscular netting, something like an inflated balloon within its net bag.

Forel thinks[1] that the muscles of the segmental walls of the abdomen alone are concerned in the act of regurgitation; but I see no ground for this opinion, except possibly with the honey-bearers, whose abdominal muscles alone might suffice to expel the contents of the crop. Such a remarkably efficient structure as is here demonstrated and illustrated, can hardly be without its proper function.

Before proceeding to demonstrate the main point in hand, it will be well to follow the alimentary canal to its termination.

[1] Swiss Ants, p. 111.

§ 3. THE GIZZARD OR PROVENTRICULUS.—The crop is continued posteriorly by the gizzard, *gz* (Pl. VIII, figs. 55, 56, 57, 59), a singular and complicated organ in ants which has given rise to conjectures the most diverse. Meinert regards it as serving to regulate the movement of the aliments. Forel thinks it certain that it serves above all to close, and for the most part hermetically, the digestive canal between the crop and the stomach.[1] The gizzard properly belongs to the anterior part of the intestinal canal its internal cuticle (*tunica intima*) being a direct continuation of the crop, œsophagus, pharynx and mouth. It consists in Myrmecocystus (and the entire sub-family Camponotidæ) of three parts.

1. The anterior part, or gizzard proper, a lily-shaped organ composed of a spherical bowl (*b.gz*) and four blades or sepals, *s.gz*. It is strongly chitinous, appears intact in all dissections, and is easily seen. The crop contracts at the posterior end within the four sepals of the gizzard, which thus appear to act as valves to regulate or moderate the flow of aliment from the crop to the stomach. What, if any, action it may have upon the food is not known; it can hardly have the usual function of trituration, as ants do not receive solid food into the crop.[2]

2. The middle part of the gizzard, or cylinder, *cy.gz*, is a straight cylinder, with a fine, transparent internal cuticle whose matrix is surrounded by a compact coat of transverse striated muscles. Exteriorly the cylinder appears to merge directly into the stomach. Only the muscular coat, however, is thus directly continued and expanded into the fine muscular bag-net of the stomach (Pl. VIII, fig. 57).

3. The internal cuticle of the gizzard traverses the walls of the stomach accompanied by its matrix, and projects within the cavity

[1] The gizzard varies largely among ants, and the variations form generic characters of great value, which Dr. Forel has shown, first in his "Fourmis de la Suisse," p. 112, seq., and afterward, more fully and clearly, in his "Études Myrmécologiques," *Bulletin de la Soc. Vaudois d. Sci. Nat.*, Vol. XV, 1878, pp. 337, 392. This last study of this organ is one of the most admirable contributions yet made to myrmecological histology.

[2] The various sections of the bowl appeared to me to have upon their interior edges certain tooth-like inequalities, which suggested at least the office of triturating or *agitating* the passing food. These may be, however nothing more than longitudinal flutings upon the external surface.

of the stomach, terminating in an elongated bulb, which is the button, *bn.gz.* (fig. 57), *bn.* (fig. 59), or posterior part of the gizzard. The anterior and posterior parts of the gizzard are always found in ants, the first varying greatly, the latter scarcely at all. The cylinder, on the contrary, is wholly wanting in many genera, and in others undergoes great variations of length. The entire organ is united to the crop externally by a strong muscular netting, so that the two might be compared to a balloon (crop) and the car (gizzard) and the enfolding muscles to the network swinging between the two.

§ 4. THE STOMACH.—The stomach, *stm* (Pl. VIII, figs. 55, 56), like the gizzard is always easily discernible, inasmuch as a quantity of solid amorphous matter within it, of a dark brown or blackish color, betrays its presence even through the segmental plates. It is commonly spherical or ovate in shape.

§ 5. MALPIGHIAN TUBES.—Around the posterior pole of the stomach are grouped the Malpighian vessels, *mpg* (figs. 56, 60), twelve in number.

§ 6. THE INTESTINE.—The location and appearance of the intestine, is seen in fig. 56, more clearly in fig. 60. The ileum (*il*) passes from the posterior pole of the abdomen, and appears to be united to the colon (*col*) by a fold which I have ventured to refer to as the ileo-secal valve (*il.v*). The rectal glands (*re.gl*) appear upon the colon, and the rectum (*re*), a strongly chitinous and muscular structure, terminates in the ciliated anus (*an*).

Finally, Pl. VIII, fig. 58 [1] will show the relative positions of all the organs opening into the cloaca. See Explanation of Plates, fig. 58.

We may now construct for further illustration the synthetic figure, Pl. IX, fig. 61, giving a side view of the entire intestinal canal *in situ*. This will indicate the normal position of the crop relative to the abdomen and the other alimentary organs. It will be seen that it occupies a position anterior and superior to these. The natural tendency of the pressure caused by the expansion of the crop, as it fills the abdominal cavity, would be to force the

[1] Adapted from Forel, "Der Giftapparat und die Analdrüsen der Amei sen," *Zeitschrift f. wiss. Zool., Bd. XXX.*

remainder of the tract backward and downward. In point of fact it is so found. A number of workers, with abdomens in various degrees of distension were examined, and the condition and site of the digestive organs noted. A few outlines of these abdomens are given:

The series begins with Fig. 63 (Pl. IX), where the crop is shown in nearly normal site, and well filled.

The same condition is indicated at Fig. 66, except that the crop shows marks of having once been quite distended and afterward emptied.

Fig. 64 shows a worker, whose crop about half fills the abdomen. The gizzard, *gz*, is forced downward (ventral) and has the anterior poles of the sepals turned upward (dorsad). The effect of subsequent pressure (should the crop have expanded), in forcing the stomach, etc., backward and downward into the cloacal cavity, can readily be predicted from the figure.

In Figs. 62 and 65, the abdomens of workers in the semi-rotund state, the distension has advanced a little further so as to push the stomach in one case (62) as far as, in the other (65) partly beyond, the fourth segmental plates, compressing the intestine proportionately.

That the same results follow in all the worker castes may be seen in Fig. 67, the abdomen of a minim or dwarf worker.

Turning to the honey-bearers, we find precisely the same condition of the abdomen, except that the distention of the crop has greatly increased, pushing its walls in all directions quite up against the inner walls of the abdomen, forcing the latter into rotundity, and compressing the other organs into the smaller space.

Fig. 69 is the abdomen of a honey-bearer, which appeared to be a little short of the full rotundity. The crop filled the entire cavity, but the gizzard, stomach and intestine, instead of being crowded together upon each other, were in their normal relations, and appeared to be in an entirely healthy state. The aspect of many of the bearers raised the query, whether the anus might not be sealed by the organs forced against it, thus stopping all excretion, and making the animal simply a vital honey-pot. The above individual, at least, had every appearance of normal condition and action of all the organs.

In the next example (fig. 70), the gizzard, stomach, Malpighian vessels and intestine are forced down quite within the compass of the fourth pairs of segmental plates, and directly over the cloacal vent. For the most part these organs are situated ventral, but here they are partly dorsal of this cleft. The most usual position of the stomach in the honey-bearers is between and quite close to the fifth and fourth ventral plates. The gizzard is a little anterior of this, the sepals, which mark the posterior pole, or entrance of the crop within the gizzard, being directed downward, upward, downward and backward, upward and backward, or forward, at hap-hazard.

Another illustration is given (fig. 68), in which the crop of a honey-bearer is seen in the act of contraction, after having been punctured through a slit (*s*) in the abdomen. When one holds a rotund up to the light, and looks into the semi-transparent abdomen, it is not possible to distinguish the crop from the abdominal membrane. But in the example here figured, as the honey flowed out from the pierced crop, the slowly contracting and thickening folds of the partly emptied organ were thus revealed. Nothing could demonstrate more clearly than this experiment and figure, that it is *the crop alone* which fills the distended abdomen.

I venture to add a final illustration to this series. I was enabled to separate a crop *entire* from the abdomen, and mount it for microscopic examination. In this delicate work, which could not otherwise have been done, I was aided by some morbid condition of the abdomen. I occasionally noticed, both in the natural and artificial nests, honey-bearers whose abdomens had the appearance of cones (Pl. VI, fig. 33) and the outer membrane hung in folds.[1] They seemed to have suffered some injury, which apparently had affected the crop. It was from one of these that the crop (Pl. VIII, fig. 55) was taken.

These studies point to the following conclusions :

I. *First*, and absolutely, that it is the *crop alone* which contains

[1] I do not credit the statement (Loew) that many of the rotunds burst by force of the pressure upon the crop. Probably this never occurs in nature. The spots of moistened clay seen by observers rather mark the wreck of ants crushed by pressure upon the chambers and galleries during excavation, or ruptured by falling from the roosts.

the nectar received at the mouth, which, immensely distended thereby, fills the rounded abdomen of the honey-bearer.

II. *Second*, and absolutely, the organs of the abdominal portion of the alimentary canal in the honey-bearers are ordinarily in a natural state, except in so far as their position has been changed by the downward and backward pressure of the expanding crop. This condition of the abdomen is frequent, in a greater or less degree, among ants.

There has been much error and loose statement on this point among authors. So eminent an anatomist as Dr. Joseph Leidy supposed that the honey was contained within the stomach; that all the other viscera of the stomach were obliterated, and that even the tracheal vessels had entirely disappeared.[1] Dr. Oscar Loew[2] makes some correct notices of the honey-ant, as seen at Santa Fé, New Mexico, but permits himself to recognize "the intestine . . as a narrow canal winding through the rounded and puffed up abdomen." This could only, in any sense, be affirmed of a small part of the abdomen, the posterior portion into which, as we have seen, the intestine is crowded. It is possible that the dorsal vessel may have been mistaken for the intestine, as this may be seen in some specimens very plainly.

Dr. James Blake[3] has published a brief report in which he falls upon an error quite the reverse of Dr Loew.[4] "The intestine of the insect," he says, "is not continued beyond the thorax, so that there is no way in which the remains of the food can be expelled from the body, except by the mouth." It follows, of course, that with this view, he should further err in supposing the honey-bag to be formed simply by the expansion of the abdominal segments.

[1] Proceedings Academy Natural Science, Vol. VI, 1852, p. 72. This, however, was twenty-nine years ago.

[2] Chemist and mineralogist to Lieut. Wheeler's Exploring Expedition, *American Naturalist*, Vol. VIII, 1874, p. 365-6.

[3] Proceedings California Academy Science, 1873, part II, page 98.

[4] Dr. Forel, in the communication to the Morphologico physiological Society of Munich, already alluded to, appears to me to have misunderstood Dr. Loew's *published* statement. Dr. L. erred in seeing *too much* intestine, instead of none at all.

The illustrations above figured, on the contrary, show that the intestinal canal has neither been ruptured, nor resorbed, nor otherwise disposed of than is quite natural.[1]

III. *Third*, it is seen that the process by which the rotundity of the honey-bearers has probably been produced, has its exact counterpart in the ordinary distension of the crop in over-fed ants; that, at least, the condition of the alimentary canal, in all the castes is the same, differing only in degree, and therefore, the probability is very great that *the honey-bearer is simply a worker with an overgrown abdomen.*

If this last conclusion has not been fully demonstrated, it has at least been shown that there is no anatomical or physiological obstacle thereto, but very much confirmatory thereof.

THE AUSTRALIAN HONEY-ANT.—An exceedingly interesting discovery of a new species of honey-ant, adds to the probability of this last conclusion. Sir John Lubbock has described this species as *Camponotus inflatus*,[2] from specimens collected at Adelaide, Australia. I received examples through the courtesy of Mr. Gerald Waller, last summer, which enabled me even in advance of Lubbock's admirable description, to note that a condition supposed to be peculiar to our American Melliger, obtained in an Australian species belonging to a genus quite removed from *Myrmecocystus*. Mr. Waller could tell me nothing of the habits or habitat of *C. inflatus*, and Lubbock has no account of any. But the congeners of the Australian insect are "Carpenter ants," quite generally making their formicaries in the roots and trunks of trees, and thus in economy as well as structure differ from *M. hortus-deorum*. This widening of the range within which this hitherto phenomenonal condition of the abdomen is found, not only raises the suggestion which Sir John makes of an independent origin of the modification in the two species, but also adds to the probability that the modification may have originated in the natural mode which I have described.

[1] It is not worth while to more than mention here the opinion which has been largely circulated, that the workers *bite and wound* the ends of the abdomens, producing thereby an inflammation which seals up the anus, stops all excretion, and so causes the repletion of the abdomen.

[2] Journal Linn. Soc. Zoology, 1880, Vol. XV, p. 185, seq.

It is to be regretted that Lubbock did not make an examination of the alimentary canal of his species, which, with the material and resources at his command, would doubtless have been highly satisfactory. However, I undertook from my limited material, to make at least so much of a study of the digestive organs as would permit some comparison with results obtained from Hortus-deorum. I had but one perfect specimen, which is figured Plate X, fig. 74. The abdomen of this example was removed and carefully mounted without rupturing the abdominal walls. The result is shown at Plate IX, fig. 71, and as will at once be seen, corresponds with those obtained fully from Hortus-deorum, and as far as pursued, from Mexicanus also. The crop (fig. 71) fills the cavity of the abdomen, and the rest of the digestive organs are seen crowded into the anal region. The gizzard has the general features of that of Hortus-deorum, but has marked characteristics, quite identical with those of the genus *Camponotus* as pointed out by Forel.[1] The sepals are not deflected at the anterior pole, as in the lily-shaped sepals of Hortus-deorum, but are clavate and straight.

This fact certainly strengthens the conclusion arrived at concerning the American species of honey-bearer, viz., that the rotund has been developed by natural habit from the ordinary worker, and that the possibilities of such a condition exist in the structure and functions of all nectar-feeding ants. Why the extraordinarily distended crop seen in the honey-ant should be limited to two species (so far as known), and why so limited a number of workers in the formicaries of these two species should develop the round abdomen, are questions that provoke sufficient wonder, but yield scant satisfaction.

§ XI. Possible Organs of Stridulation in Ants.

The segmental plates of the abdomen are composed of numerous hexagonal epithelial scales, Pl. VII, fig. 48, which present a very beautiful appearance, as of delicate mosaics, when viewed through a microscope. When a profile view of one of these plates is exposed to the lens, as at fig. 49, the scales are seen to be

[1] Etudes Myrmecologiques, Bull. Soc. Vaud. de Sci. Nat. 1878. Pl. XXIII, fig. 1.

imbricated, that is, to overlap each other like tiles on a house roof, and show the serrate edge figured in the cuts, figs. 49 and 50. The former (49) is drawn from a section of *Camponotus inflatus*, and the latter (50) from *Hortus-deorum*. This serrate edge not only shows upon the external part of the plate *e. ab. pl.*, but upon the imbricated portion, *i. ab. pl.* By referring to the manner in which the one part overlaps the other shown at figs. 53, 54, it may be seen that a backward and forward motion of the plates upon each other might produce a faint rasping sound. That this motion is entirely possible can hardly be doubted. The abdominal plates are continually, though gradually, sliding out and in, like the parts of a telescope, under the expansion and contraction of the crop, as the ant feeds or regurgitates the contained nectar. All that is required to have the complete conditions for stridulation seems, therefore, to be the muscular ability to perform this action rapidly; which, it appears to me, ants certainly possess.

I have often noticed the peculiar *hiss-z-z-z!* which arises from an excited colony or column of ants, a sound which grows in intensity according to the degree of excitement. I have also met an opinion prevalent among ordinary observers, that the ants produce this sound by some organ analogous to some one of those by which other insects produce musical notes or noises—in short (to use the popular phrase), that "ants sing." But I have heretofore been disposed to consider the noise referred to simply as the result of friction of a great multitude of insects moving rapidly over the surface of the earth, the litter of leaves, twigs, etc., and against the hard, shell-like bodies of their fellows, or possibly (also) by the gratings of the hard tooth-like mandibles upon each other. I am not yet prepared to abandon this opinion, nor to affirm that ants do produce audible sounds by proper stridulating organs; but simply record the structural possibility of such behavior.

Since making the above note, Mr. Swinton's work on "Insect Variety"[1] has reached me. The author records an example of what seemed to be an act of stridulation by a small yellow ant, *Myrmica ruginodis*.

[1] "Insect Variety, its Propagation and Distribution," by A. H. Swinton, member of the Entomological Society of London, p. 106, and Pl. VI, fig. 7.

This insect was observed stationed near the edge of an inverted wine glass, underneath which it had been confined, its head downward, rapidly vibrating its abdomen vertically from the pedicle, and simultaneously giving out a continuous singing sound, in color and intensity resembling the sharp whining of the little dipteron, *Syrilla pipens*.

Concluding that the rhythmical motion accompanying the music indicated this ant as a stridulator, the author undertook a microscopic study of its anatomy, from which the following facts appear:[1] The ant belongs to the family MYRMICIDÆ, which are distinguished from the FORMICIDÆ, to which our honey ant belongs, by having two knots or nodes to the petiole. The second or posterior knot is commonly the larger, and is placed quite near to the anterior pole of the abdomen. Upon the insertion of the abdomen into this node, were observed twelve minute yet regular annular striæ. (Pl. X, fig. 81.) This striation was produced, but less distinctly, upon the articulation of this (the second) node with the first (anterior) node. It was conjectured that the rapid movement of these joints of the petiole, back and forward upon each other and upon the abdomen (like the jointed tubes of a telescope), produced the sound above described. As the nodes are to be regarded as abbreviated segments of the abdomen, and as the abdominal segments have already been shown to be capable of movement one upon another, Mr. Swinton's interesting observation gives new value to the suggestion above made concerning the structural possibility of stridulation in the honey ant and others of like organism.

[1] The writer's account is somewhat confused by false punctuation, and he falls into the error of conjecturing that the small worker may have been a male. I have given my understanding of the structure as derived chiefly from the figure, which I reproduce with some alteration.

CHAPTER VII.

PARASITES, LITERATURE, DESCRIPTION.

§ XII. Destruction of the Ants by Mites.

The untimely end of my artificial colonies is worthy of a passing note. The ants were brought from Colorado in large jars, domiciled in their native soil. Every precaution which circumstances would allow was taken to preserve their health, but after a confinement of over seven months, during which many of the observations noted above were made, they became infested with mites. These parasites, or their germs, were probably brought from Colorado with the insects, although I did not observe them until late in their imprisonment. However, I have seen the same or similar parasites upon other ants while in their home-nest, and more than once have suffered the loss of colonized formicaries from their inroads.

In the case of the honey ants I was powerless to give relief of any kind, and witnessed with real grief the helpless little sufferers in their struggles to free themselves from their destroyers. I have figured the head of an ant thus infested, at Pl. VII, fig. 39, where the mites may be seen clinging to the cheek, mandibles and antennæ. I have spared the feelings of my readers so far as to figure but a few of the pests. In point of fact they literally covered the mouth parts, where they were chiefly congregated, although they were attached to other parts of the body. The poor "host," although so admirably provided with implements for cleansing her person—such as the mandibles, mouth and tarsal comb—found all efforts to rid herself of her "guests" futile. Even that friendly aid in toilet service which one emmet is wont to extend to another, was vain. Gradually the poor victim yielded life to the parasitic swarm that sucked at her vital juices. The charnel-house—the little cemetery centre at one side of the formicary—gained many inmates daily; the galleries and chambers thinned of their busy populace and grew lonely; at last, as

in some plague-stricken human commonwealth, the dead were suffered to lie where they fell, for the living were themselves sealed to death, and unable to give their comrades sepulture. So my nests faded away, until, unwilling longer to witness their sufferings, I gave them all a painless death.

My studies were seriously interfered with by this calamity, as many of my well-nigh ripened experiments thus came to nought. But one cannot complain, for Nature and Destiny pursue ants also, and that this particular form of insect doom is unhappily not rare has long ago been voiced in the familiar couplet:—

> "Great fleas have little fleas, they smaller fleas to bite 'em;
> Smaller fleas have lesser fleas, and so *ad infinitum*."

One might pass to the opposite pole of the zoological series—Man—and add the reflection of Quintus Serenus upon the death of the Dictator Sylla:—

> "Great Sylla, too, the fatal scourge hath known,
> Slain by a host far mightier than his own."

It might be supposed, at least I had so thought, that the presence of these parasites would greatly irritate the ants, and produce an excited behavior, and animated struggles to be rid of their guests. On the contrary, they endured the affliction with wonderful patience. It seemed to me, although one must allow in such cases for the anthropomorphic color upon his observations, that the unfortunate creatures were quite conscious of their doom, of the hopelessness of contending against it, and had yielded themselves in a philosophic resignation.

The mites are, in color, white, almost transparent, and are about one millimetre in length. I am not certain as to the species, but present correct drawings of the animals, from which they may be determined by a competent authority. (See Pl. VII, figs. 40, 41). Greatly magnified views, in several degrees of expansion, of the sucking organs, by which the mites cling to their host, are shown at figs. 42, 43, 44.

§ XIII. Previous Accounts of the Honey Ant.

The first account of the Honey Ant was given to the world by Dr. Pablo de Llave, in the year A. D. 1832, in a Mexican journal.[1] A translation into French of the substance of this paper was given by Monsieur H. Lucas in the French Review and Magazine of Zoology, June, 1860.[2] Meanwhile (1838), M. Wesmael had published a description of the ant, with figures, without knowledge of the above paper of Llave, establishing for it the Genus Myrmecocystus. Wesmael's generic name remains, but his specific name (*Mexicanus*) has of course yielded to that of Llave, modified, however, from *Melligera* to *Melliger*. The Colorado insects, upon which the studies of this paper are based, I have ventured to regard as a new variety, and have named *Myrmecocystus hortusdeorum*, and thus have retained Wesmael's name as a variety name.

It will be well to state briefly the facts in the economy of these insects indicated in the foregoing and other papers, in order to mark precisely the new facts which have now been communicated here.

Llave's information was all at second hand, he having made no personal observations of the habits of Melliger. From a person living at Dolores, a village in the vicinity of the city of Mexico, he learned:

1. That the ants were popularly known under the name of *Busileras;*

2. That they do not erect heaps of earth at the entrance to their nests;

3. That on opening the nest, a species of gallery is reached, to the roof of which certain ants are suspended, packed one against the other;

4. That these ants cover the roof as well as the wall of the gallery.

5. The women and children of the valley know these nests perfectly well, and frequently open them for the sake of the honey-bearers, or rotunds. The honey is sucked from the abdomen of the

[1] Registro trimestre o collecion de Memorias de Historia literatura ciencias y Artes, 1832.

[2] Revue et Magazin de Zoologie, Tome XII, 1860, p. 271.

rotunds, with great relish, at the nests; or, if it is wished to preserve them, they are lifted by the head and thorax and placed upon plates, in which they grace the village feasts, and are eaten as delicacies.

6. The rotunds when thus placed together, stir around, lay hold of and tear one another, and finally end life by bursting.

7. The skin of the abdomen, which binds the segments together, is so thin, and the upper coat so distended, on account of the quantity of honey which it encloses, that the least pressure suffices to cause the ants to disgorge.

8. When they do not so disgorge, that is, by elevating the head and thorax, the honey diminishes, and the ants eat it.

9. Dr. Llave observed, moreover, from specimens of the ants sent to him, that there were different castes of workers and degrees of distension in the abdomens, and

10. That the honey in the rotunds varied in color from a crystal whiteness to a wine-color.

Several of the above statements, as has been seen, are without foundation, but the majority of them are confirmed in whole or part by my observations.

Wesmael,[1] who made his study from specimens sent him from Mexico by the Belgian Envoy, Baron Normann, records his credence of the theory announced by that gentleman, viz., that the honey-bearer elaborates the honey and deposits it in certain reservoirs, analogous to the cells of bees, for the nurture of the formicary. Baron Normann was unable to obtain examples of these reservoirs to send to Europe, or rather failed to do so under the conviction that they would be destroyed during shipment. In point of fact, such reservoirs exist only in imagination.

One of the most perplexing accounts of the honey ant is that of Mr. Henry Edwards.[2] The statements recorded are made at second hand from the verbal narrative of a Capt. W. B. Fleeson, whose observations were made at or near Santa Fè. They are so extraordinary and contradictory of my own experiences,

[1] Bulletin de l' Acad. Roy. des Sci. et Belles lettre de Bruxelles, Tome V, p. 770. Pl. XIX, figs. 1-4.

[2] Proceed. California Acad. of Sciences, Vol. V. 1873, p. 72; "Notes on the Honey-making Ants of Texas and New Mexico."

that I am compelled to withhold credence, until some experienced observer shall have corroborated them, a result of which I have little expectation. According to this account, no exterior moundlet surmounts the formicary, but simply two openings into the earth. Within the nest, at a depth of about three feet, "a small excavation is reached, across which is spread, in the form of a spider's web, a network of squares spread by the insects, the squares being about one-quarter inch across, and the ends of the web[1] fastened firmly to the earth at the sides of the hollowed space which forms the bottom of the excavation. In each one of the squares, supported by the web, sits one of the honey-making workers, apparently in the condition of a prisoner, as it does not appear that these creatures ever quit the nest."

But the marvels of this strange story are not exhausted. "The inmates of the formicary are composed of two distinct species, apparently even of different genera, of ants. There are the ordinary yellow workers and honey-bearers of Melliger, and besides, black workers, who act as guards and purveyors. One column of the blacks surrounds the openings on three sides, attacking, driving off or destroying all intruding insects. Another column bears, through the unguarded side of the hollow square, fragments of flowers, aromatic leaves and pollen, which (adds our author), by a process analogous to that of the bee, the honey-makers convert into honey."

One can hardly refrain from the thought that Capt. Fleeson was testing the credulity of the writer by one of those jokes of which naturalists are occasionally the victims. But, if the narrative is to be taken in good faith, I can only explain the facts by supposing, first, that the observer happened upon a nest of cutting-ants (*Atta fervens*), within whose boundaries a nest of Melliger had chanced to be established, and had confounded the habits of the two as those of one formicary; or, second, that the cutting-ant, or some other species of similar economy, has really acquired the habit of kidnapping and domesticating the honey-ant for the

[1] Of course, this is pure fiction, as no ant makes a web, or anything that could well suggest one. The cutting ant does make out of fragments of leaves a "comb" of more or less regular cells, resembling the nests of the paper-making wasps.

sake of its treasured sweets, precisely as many ants domesticate aphides; or, as the slave-making ants, *Formica sanguinea* and *Polyergus lucidus*, domesticate *Formica fusca* and *F. Schauffussi*.[1]

One of the latest accounts of the honey-ant, and so far as it goes, one of the best, is that of Mr. Saunders, the editor of the *Canadian Entomologist*,[2] who communicates to his journal some observations made by Mr. Kummeck, at Santa Fè.[3] According to this observer, considerable numbers of these insects are found in the mountains of that vicinity. He sat by a nest six or seven hours and noticed the workers carry home leaves of different plants to feed, as he supposed, "the others that produce the honey." This would seem to confirm the leaf-bearing habit quoted by Mr. Edwards from Capt. Fleeson. The inference as to the use of these leaves is, however, quite unwarranted, as the portage of leaves, etc., into nests is not an uncommon habit among ants of divers species. Without stopping to discuss the question whether such material may contribute to the food supply of the formicary, it may be remarked that its most probable and ordinary use is for purposes of architecture or nest-building.

Mr. Kummeck also makes the remark, which I had not seen at the time my own conclusions had been reached, that "in early life none of these insects present any unusual distension of the body, but when arrived at a certain period of maturity some individuals begin to show a distended abdomen."

The ant-honey has no commercial value among the New Mexicans. It has a place, however, as a remedy in the domestic therapeutics of the native Indians, who compound a drink by mixing

[1] One may not be over rash in refusing belief even to facts that go counter to all past experiences, for the marvels of Nature are ever widening within our view. While, therefore, I am inclined to reject the whole story, I await the observation of some trained naturalist, giving the account the benefit of the above possible explanations.

[2] Can. Entom., 1875, Vol. VII, pp. 12-13.

[3] I may be permitted to explain why I did not go to New Mexico, to attempt on the spot a solution of some of the questions raised by these accounts. I had made every arrangement to do so, after my studies in the Garden of the gods were completed, but on the morning that I was to break camp, was taken with a sudden and violent illness which compelled me to abandon my journey.

three to four drachms of the honey with six ounces of water. The drink is used in cases of fever. The honey is also applied as an unguent in eye diseases, especially cataract.

To the above may properly be added two accounts of my own studies published in the London *Journal of Science*.[1] These are reports made by Mr. Morris, of the verbal communications in which my observations were originally announced to the Academy of Natural Sciences of Philadelphia. They were made and printed without any oversight or responsibility on my part, but are admirably, and in the main, accurately done. They have been reproduced with various degrees of fulness in other journals.

Such other notices of this ant as I have been able to find, and have had occasion to use, will be found properly referred to in the text of this paper, where those who are interested in the literature can readily find them.

[1] Jour. Sci., February, 1880, "Living Honey Comb; a novel phase of Ant Life." By Mr. C. Morris. Ibid. July, 1880, "Habits and Anatomy of the Honey-bearing Ant." By Charles Morris.

§ XIV. Description of Species.

FORMICARIÆ.

Family FORMICIDÆ.

Subfamily CAMPONOTIDÆ (Forel).

Genus **MYRMECOCYSTUS**, Wesmael.

Cataglyphis, Fœrster, Verh. d. Nat. Ver. d. Rheinl., 1850; Mayr, Europ. Formic., 1861; Norton, Wheeler's Report, Vol. V, Zool., p. 734.

Monocumbus, Mayr, Verh. d. Zool.-bot. Ver. in Wien, 1855.

Myrmecocystus, Forel, Etudes Myrmecologiques, Bull. Soc. Vaud. de Sci. Nat.

M. melliger, Llave.

1. Var. *mexicanus*, Wesm.
2. Var. *hortus-deorum*, McCook.

Workers.—Three castes, major, minor and minim or dwarf. Color, a uniform light yellow; the body is covered quite thickly, the legs more thickly, with short yellow hairs. The maxillary palps are very long, six-jointed, third joint longest; they are covered, especially beneath, with long hairs, curved backward. Labial palps four joints; mandibles with nine teeth. The head is quadrate, in the worker-major more rounded at the sides than with the minor and dwarf; wider than the thorax. Clypeus smooth, rounded, slightly flattened in front of the frontal area. Frontal area smooth, shining, triangular, somewhat truncated posteriorly. Ocelli sufficiently prominent; a tuft of hairs on the face beneath, directed forward. The body is of good length, narrow and compressed beneath at the mesothorax; metanotum as high as, or slightly higher than the pronotum. The node cordate, cleft at the tip, thickened at the base, set perpendicularly upon the petiole. Anus strongly ciliated. Length, worker-major, $8\frac{1}{2}$ mm.; worker-minor, 7 mm.; worker-minim, $5\frac{1}{2}$ mm.

Honey-bearers.—A sedentary class or caste distinguished by abdomens distended into spherical form by expansion of the crop

filled with grape-sugar. The length (including abdomen) is 13 mm. (one-half inch); the proportions and description of the head and body are those of the worker-major, of which it may be a developed form.

Female.—Virgin queen, total length, 13 mm., as follows: Mandibles, 1 m.; head, 2 mm.; body, 5 mm.; abdomen, 5 mm. Width of abdomen, 3 mm.; of prothorax, 2 mm. Color, livid yellow. Fore-wing, 14 mm. long; venation as in Pl. X, fig. 77.

Male.—Length, 5 mm.; length of fore-wing, 5½ mm. Color, livid yellow; the head, upper part of thorax and dorsum of abdomen blackish. The mandible has one feeble tooth at the tip, and two others shorter and feebler.

Habitat.—Southern Colorado, occupying subterranean formicaries with small gravel-covered exterior moundlet, pierced by one central gallery.

PLATES

AND

EXPLANATION OF PLATES.

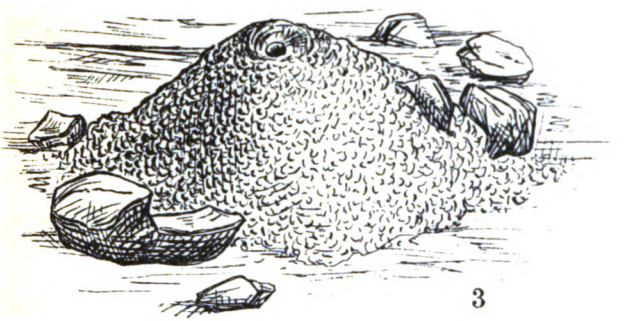
Plate I.

Fig. 2. View of my camp in the Garden of the gods, showing the site of some of the nests of the honey ants studied. The view is taken from the rocks at the junction of Adams and Von Hagen ridges (see Fig. 1, p. 19), and looks towards the south, and the eastern face of Pike's Peak. One of the nests is shown in the foreground, and the sites of others are indicated by the white circles on the tops of the ridges. My tent and booth are seen near the centre of the sketch, and just opposite, on the right, is the oak copse in which the ants were discovered feeding on the exudations of galls. Page 19.

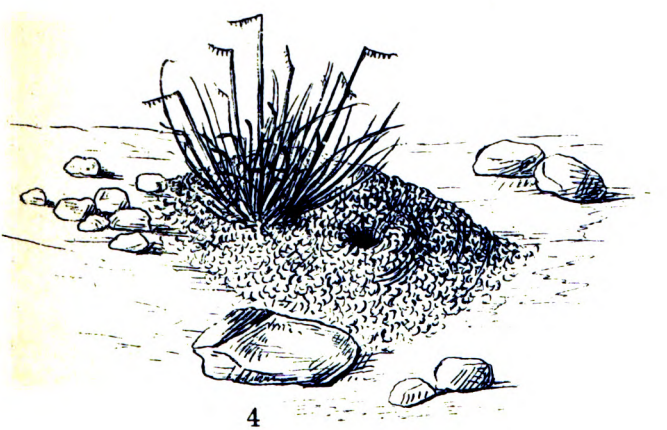
Plate II.

Fig. 3. Elevated gravel cone of a honey-ant nest; the gravel is of red sandstone, and the rocks around are bits of quartz of several colors, giving a pretty effect. This nest is the largest seen, and measures three and one-half inches high and thirty-two inches around the base. Page 21.

Fig. 4. A nest built partly around a tuft of gramma grass, and less conical in shape than the above.



3

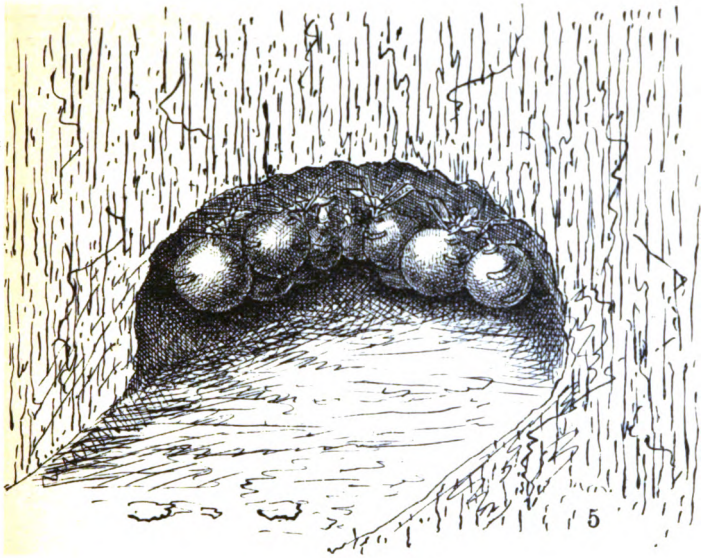


4

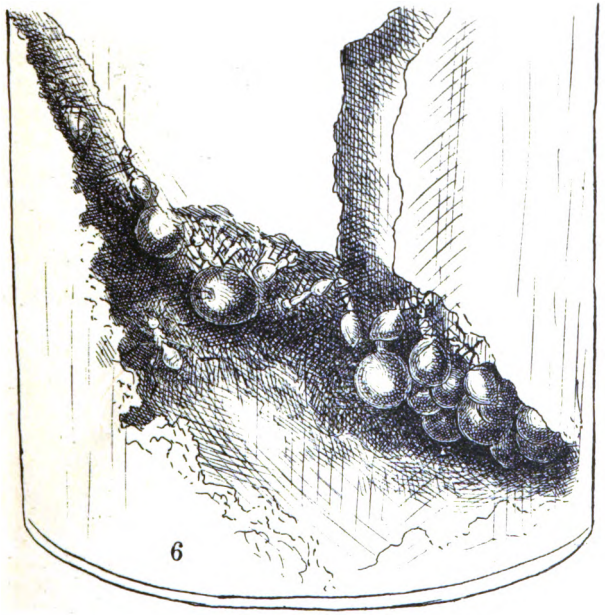
Plate III.

Fig. 5. View of honey-bearers as seen in natural site, clinging to the roof of a honey-room. About natural size. Page 22.

Fig. 6. View of honey-bearers in same position, drawn from one of my artificial nests. Mingled with them are seen ordinary workers, and semi-rotunds, or workers apparently in process of transformation into honey-bearers. About natural size.



5



6

Plate IV.

Fig. 7. Sprig of dwarf oak, *Quercus undulata*, with galls of *Cynips quercus-mellaria*, showing the beads of sweet sap. Page 26.

Fig. 8. The same galls enlarged.

Fig. 9. Another cluster of the same galls.

Fig. 10. Section of gall showing the inside cell, *c*, and the exit hole of the gall-fly, *eh*. Page 27.

Fig. 11. Turk's-head gall, showing exit-hole, *eh*.

Fig. 12. View of inside of a gall, showing a globular cell, and a small grub domiciled against it. Page 27.

Fig. 13. A honey-bearer clinging by her feet to the wall of a honey-room. Page 22.

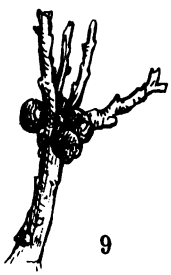
Fig. 14. The crater of a gate to an ant's nest, showing the graveled funnel, F, and the smooth nozzle, N. Page 34.

Fig. 15. Outline of the elevation of a formicary. Page 37.

7

8

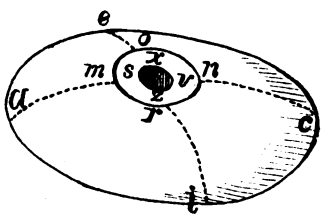
10



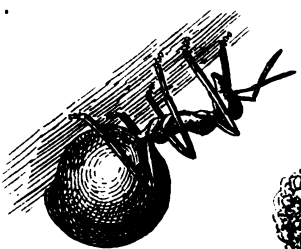
9

11

12



15



13

14

Plate V.

Fig. 16. Double section view of the interior of a nest, drawn from a point in the excavation twenty-one inches below the surface. Nest made in soft, red sandstone. *g*, *g*, *g*, galleries arranged in stories. R, R, R, vertical sections through honey-rooms and chambers for nursery purposes. C, D, E, the floors of a suite of honey-rooms, showing their connection with the general system. Page 38.

Fig. 17. The three honey-rooms, C, D, E, above referred to, and the indication of a fourth, F. Length of C from *a* to *b* = 5 inches; D, from *c* to *d* = 3½ inches; E, from *e* to *h* = 4 inches. Elevation of *b* above *x* = 3½ inches; of *b* above *e* = 6 inches. A little stairway united D with C and F; *g*, *g*, a gallery. Page 39.

Fig. 18. Section through middle of nest, showing the gate architecture. G, gate; N, nozzle; A, arm of the gate gallery terminating in the vestibule V. *a*, *b*, *c*, branching galleries. Page 35.

Fig. 19. A similar section of another nest. Letters as above; E, a small room, with gallery *f*, leading downward.

Fig. 20. Similar section of another nest. The main gallery branches to the right, and passes behind the gate, *b*, *b*, *b*, into room A. E, C, small bays or rooms; D, D, *ee*, curved and branched gallery on the same plane, with openings downward *g*, *g*, *g*. Page 35.

Fig. 21. A honey-room, HR; *g;* gallery leading into the gate gallery, G; *ug*, unbroken part of same; B, small bay-room. Page 36.

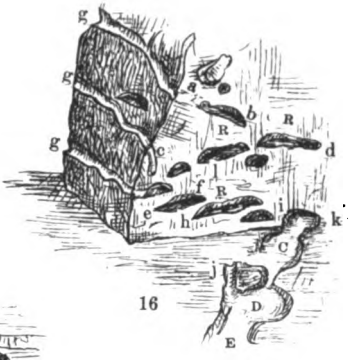
Fig. 22. Termination of excavated nest, 6 feet 10 inches from gate, 2 feet 5 inches below surface. *g g*, gallery entrance; C, Queen-room, 4 inches diameter. E, small bay-room, apparently beginning of a chamber; *t g*, terminal gallery, running upwards, as though the ants were in process of excavating a room resembling C. Page 39.

Fig. 23. Sloping section through middle of nest, showing relation of gate to the upper series of galleries and rooms. A, B, honey-rooms; *x*, *y*, *z*, main galleries; 1, 2, 3, side openings. Page 35.

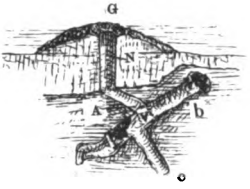
Fig. 24. A honey-bearer regurgitating honey from her crop at the solicitation of hungry workers. Page 49.

Fig. 25. Sentinels on guard at the gate. Page 21.

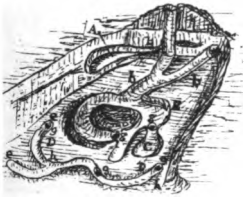
17



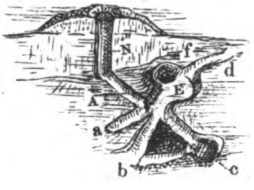
16



18

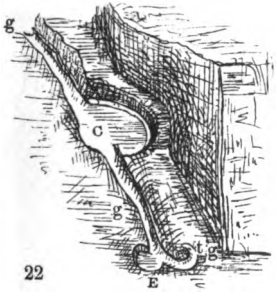


20

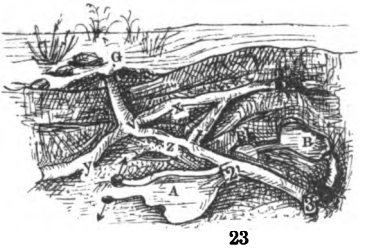


19

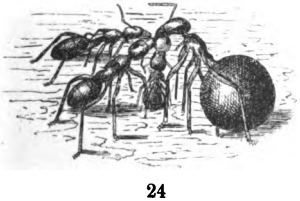
21



22



23



24

25

Plate VI.

Fig. 26. A queen dragged home by a worker. Page 41.

Fig. 27. A honey-bearer dragged and pushed by a worker-major and dwarf from a broken room into a gallery. Page 42.

Fig. 28. A honey-bearer under a "landslide," one worker looking on, curious but inactive, another on the clod at her toilet. Page 44.

Fig. 29. Queen surrounded by her "court" or body-guard of attendant workers. Page 41.

Fig. 30. Workers carrying a pebble up the mound.

Fig. 31. Honey-bearer partly buried alive under pellets brought up by mining workers. Page 43.

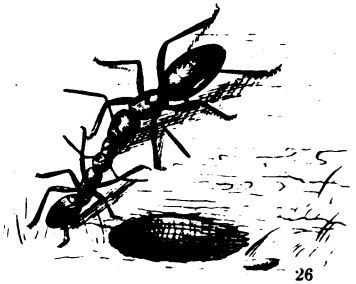
Fig. 32. Honey-bearer fallen from her perch, being cleansed by a worker, who reaches down from the wall. Page 44.

Fig. 33. Honey-bearer with (apparently) morbid abdomen. Page 62.

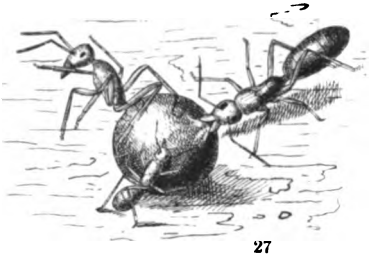
Fig. 34. Worker nurses feeding and cleansing larvæ. Page 46.

Fig. 35. View of vertical section of a nest, showing galleries arranged in stories. See Pl. V, fig. 16. G, location of gate; *a*—*t*, *e*—*i*, *k*—*l*, galleries; R, R, sections of honey-rooms. Page 38, and foot-note.

Fig. 36. A worker dragging a honey-bearer up a perpendicular surface into a gallery. Page 42.

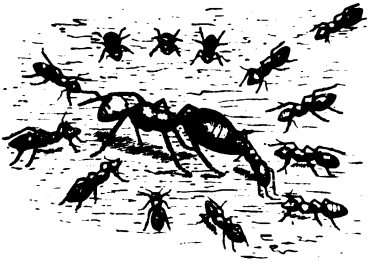


26



27

28



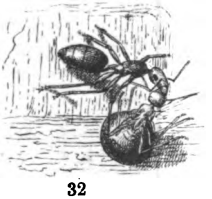
29

30

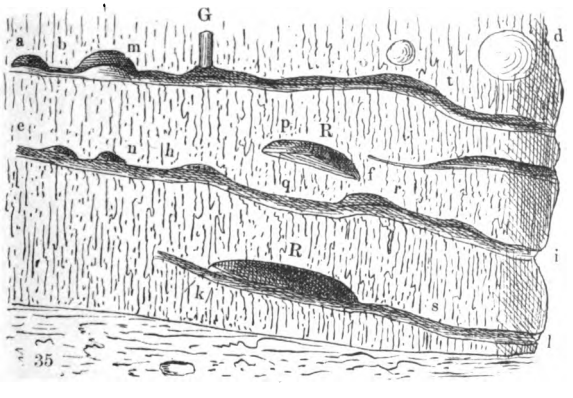
31

34

33



32



36

Plate VII.

Fig. 37. View of the under side of the head of *Myrmecocystus hortus-deorum*, showing the mouth organs. × 20, Page 56.

The letter-references in this and subsequent anatomical figures are uniform throughout. The Key to References, therefore (p. 79), will apply to all figures.

Fig. 38. Face sculpture of same. × 20, Page 56.

Fig. 39. Side view of head of worker to show parasitic mites clinging thereto. The mites are about natural size. Page 69.

Fig. 40 Dorsal view of mites greatly enlarged.

Fig. 41. Ventral view of same.

Fig. 42. One of the suckers, *su*, contracted.

Figs. 43 and 44, the same further drawn out.

Fig. 45. Muscles of the honey crop, showing their netted and branched character. × 30, Page 58.

Fig. 46. The same, from margin of the crop. *C. ms*, crop muscles; *b. ms*, branched muscles.

Fig. 47. Third leg of *M. hortus-deorum*, worker-minor. × 10.

Fig. 48. Section of segmental plate of abdomen of honey ant, showing hexagonal cells of epithelium, and a bristle-like hair, or seta, arising therefrom.

Fig. 49. Profile view of segmental plates of *Camponotus inflatus*, showing the overlapping of the same, and the imbricated epithelial cells, forming a rachet-like structure which suggests the possibility of a sound-producing organism. *e. ab. pl*, exterior abdominal plate; *i. ab. pl*, interior ditto. Page 61.

Fig. 50. Profile view of abdominal plate of *M. hortus-deorum*, to show the same.

Fig. 51. After Lubbock. Section through the head of *Lasius niger*, to show site of buccal sac, *bc. s*, the pharynx, *px*, and its muscles, *p. ms*. × 36, Page 56.

Fig. 52. View of the œsophagus of a worker of *M. hortus-deorum*. One side of the thorax and petiole are cut away in order to show the œsophagus in site. × 18, Page 57.

Fig. 53. Abdomem of honey ant, showing the segmental plates both dorsal (D) and ventral (V) in normal condition of the crop. × 16, Page 57.

Fig. 54. Same, when separated by partly expanded crop. Page 57.

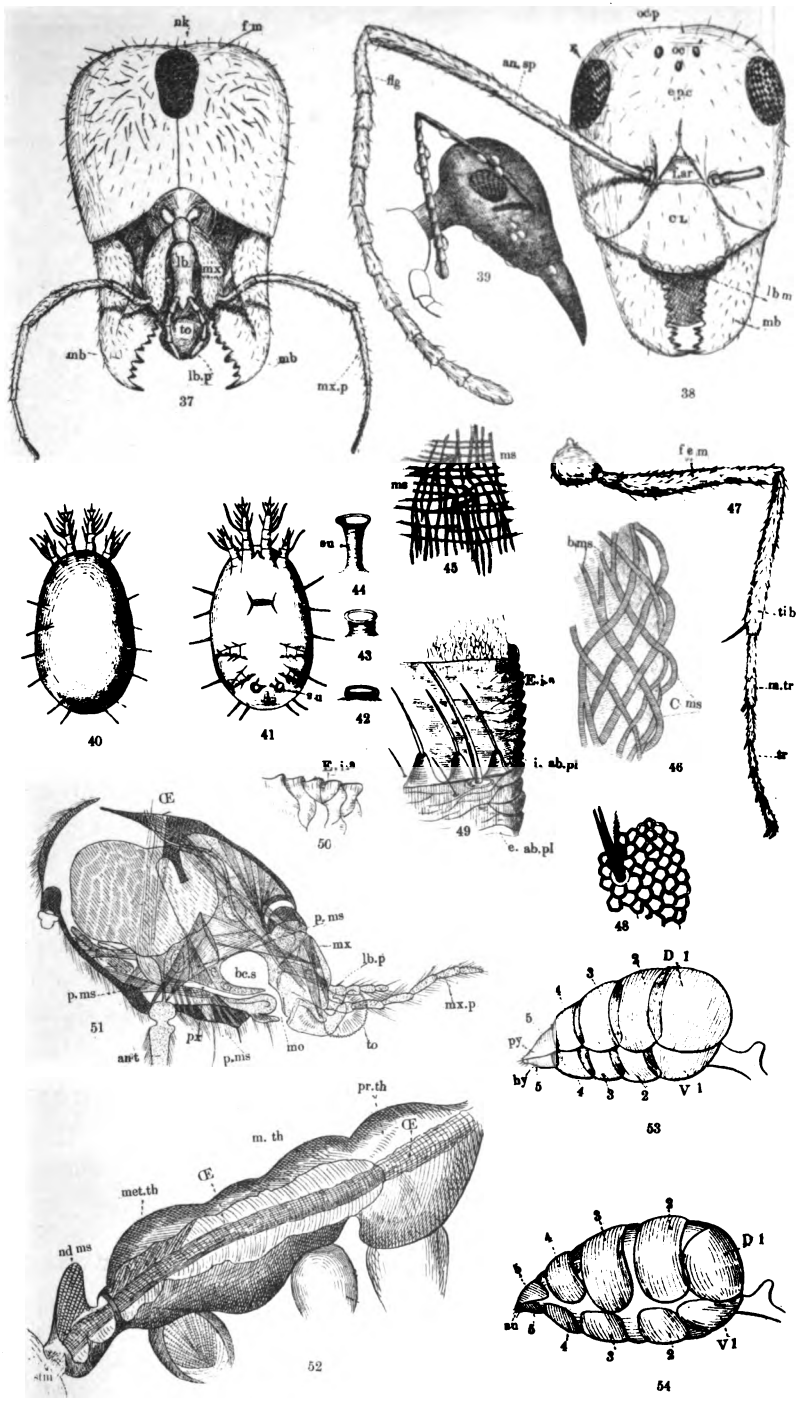


Plate VIII.

Fig. 55. Entire crop with gizzard and stomach. Dissected from a honey-bearer with morbid abdomen. × 14, Page 62.

Fig. 56. Crop, gizzard, stomach, malpighian tubes and intestine. From honey-bearer. × 14, Page 60.

Fig. 57. Enlarged view of gizzard. × 50, Page 59.

Fig. 58. After Forel. Topographic, somewhat diagrammatic representation of the organs opening into the cloaca of *Bothriomyrmex meridionalis* ♀, enlarged 18 times.

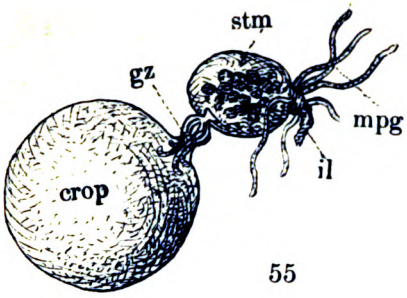
4, 5 and 6, optical section of the tergal chitinous pieces of what are really the 4th, 5th and 6th abdominal segments (nodes of the petiolus reckoned as one segment). Opposite and beneath there are shown the sterna of the corresponding segments. *do*, dorsal vessel; *an. v*, right anal vesicle; *an. gl*, right anal gland; *Can*, intestinal canal (intestine and rectum); *po. v*, poison vesicle with gland; *ac. gl*, accessory gland of the poison apparatus; *Ov*, rudimentary ovaries with vagina; *ab. g*, the last three abdominal ganglia of the ventral cord with their commissures.

Between 6 and the corresponding sternal plate (6′), lies a cleft (shown wide open in the figure) which leads into the cavity of the cloaca. In this cavity one finds, reckoning downwards from 6 to 6′:

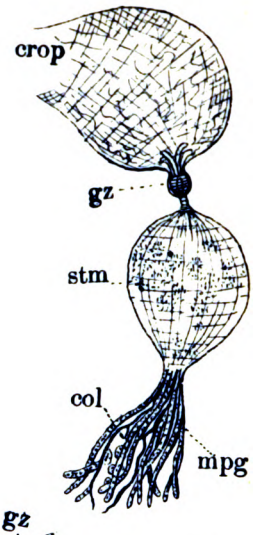
1. *O*, the common opening of the anal vesicles. 2. *an*, anus (opening of rectum). 3. *r. st*, rudimentary sting, into which the poison vesicle opens, and then lower down, the accessory gland of the poison apparatus. 4. *o. sa*, opening of the rudimentary female sexual apparatus.

Fig. 59. Crop in normal condition, from a virgin queen. The junction, *jn*, of the abdomen with the petiole is bent over, showing a part of the œsophagus as drawn from the petiole. The continuation of the same, *œ. c*, within the abdomen is shown; also the relation of gizzard to both crop and stomach. × 14, Page 59.

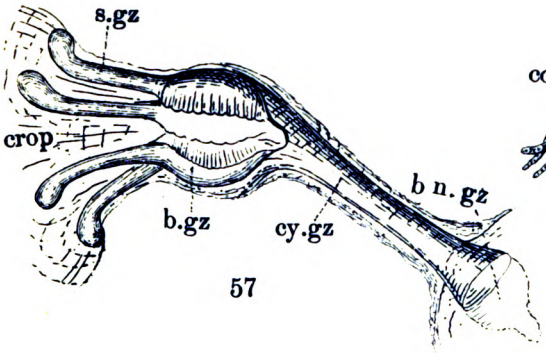
Fig. 60. View of the intestine from the posterior pole of the abdomen to the anus. × 35, Page 60.



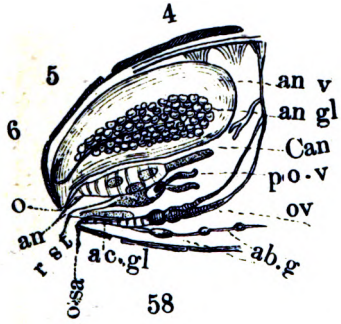
55



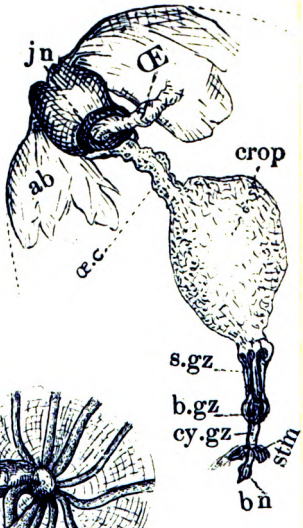
56



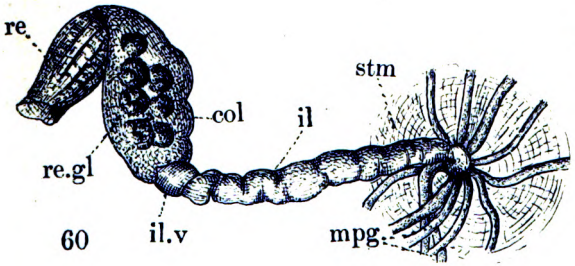
57



58



59



60

Plate IX.

Fig. 61. Synthetic figure exhibiting the entire course of the alimentary canal, from mouth to anus. Page 60.

Figs. 62–70 compose a series illustrating the progressive distension of the crop from the normal condition to that of the honey-bearer. Page 61.

The series begins with Figs. 63 and 66, where the crop is normal; in fig. 66 the crop has shrunken after distension.

Fig. 64. Worker crop, half filling abdomen.

Figs. 62, 65. Workers-major, or semi-rotunds, with distension of crop still further advanced.

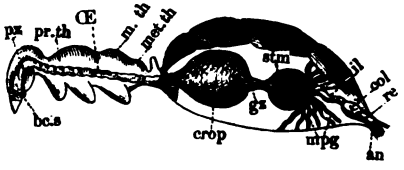
Fig. 67. Abdomen of a worker-minor, showing same process of distension.

Fig. 68. Abdomen of a honey-bearer, opened at the slit, *s*, to puncture the crop and exhibit by its shrinking away the fact that the crop fills the cavity of the abdomen. Page 62.

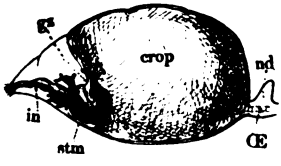
Fig. 69. Full crop of honey-bearer, with the lower part of the alimentary canal shown through the abdominal wall against which it is pressed, and evidently in healthy condition. Page 61.

Fig. 70. Abdomen of honey-bearer, the full crop pressing the gizzard, stomach, etc., into the cloacal cavity. Page 62.

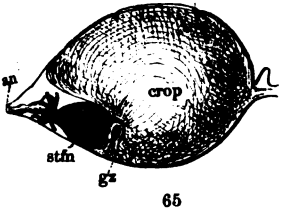
Fig. 71. Abdomen of the Australian carpenter-ant, *Camponotus inflatus*, exhibiting the characteristic distension of *M. hortus-deorum*. Drawn from an alcoholic specimen. The figure is somewhat flattened by pressure; other abdomens in my possession are quite spherical. The gizzard, stomach (ruptured and stretched) and intestine are shown in the same relative position as in the honey ant. Page 65.



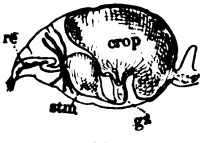
61



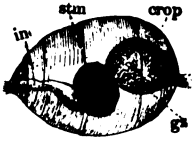
62



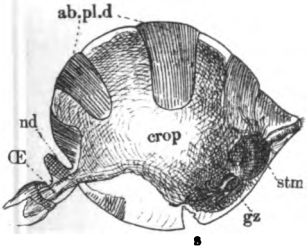
65



64



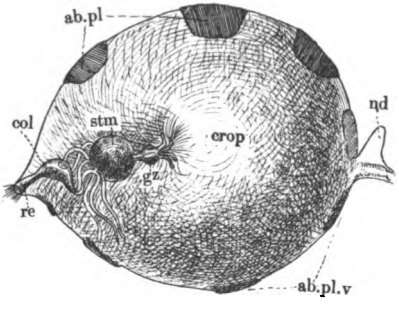
63



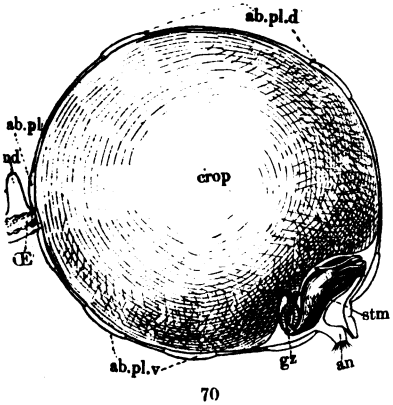
68

66

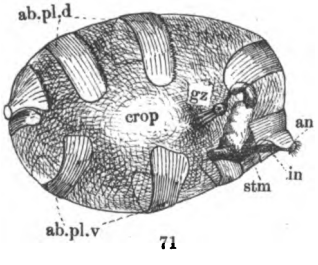
67



69



70



71

Plate X.

Fig. 72. Side view of honey-bearer, *M. hortus-deorum.* × 3.

Fig. 73. Dorsal view of same. × 3, Page 75.

Fig. 74. Honey-bearer of *Camponotus inflatus*, dorsal view. × 3, Page 64.

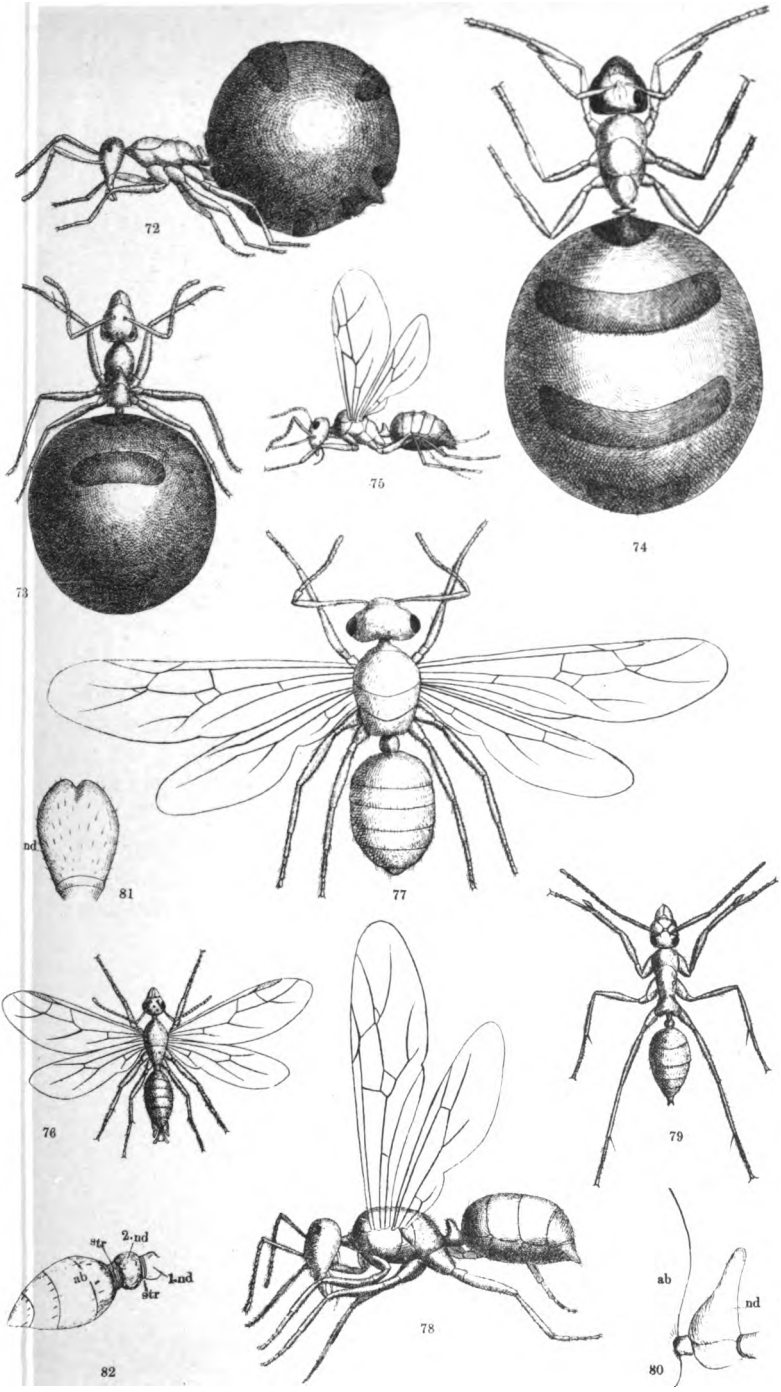
Figs. 75, 76. Male of *M. hortus-deorum.* × 5.

Figs. 77, 78. Winged female, or virgin queen of the same. × 3.

Fig. 79. Worker-minor of *M. hortus-deorum.* × 5. The workers-major and minor or dwarf are exactly similar in form, only longer in the proportions given in the description. Page 75.

Figs. 80, 81. Node or scale of the petiole queen of honey ant, side and front views. × 10.

Fig. 82. In part, after Swinton; to show the striæ, *str*, supposed stidulating organs, upon the junction of the abdomen and second node, 2. *nd*, and also on junction of second node with the first (1. *nd*,) of *Myrmica ruginodis.*



SECOND PART.

THE OCCIDENT ANTS

—OF THE—

AMERICAN PLAINS.

CHAPTER VIII.

GEOGRAPHICAL DISTRIBUTION.

The two objects most likely to arrest the traveler's eye as he fairly enters upon the great American Plains, are the villages of the Prairie Dog and the gravel-covered cones of the Occident Ant. They skirt the railroad on either side, and are prominent alike by their great numbers and the elevations which break the monotony of the level surface. The following chapters are devoted to a history of the remarkable insect whose industry has dotted the Western Plains with the last named of these natural domiciles. Strangely enough, considering the prominence with which the little creature has asserted her presence, the story has never yet been told. With the exception of a brief note by Professor Leidy, hereafter quoted, no chronicle has heretofore been written of these most conspicuous and numerous of the animal aborigines of our Far West.

My first observation of the gravel-covered mound of the Occident Ant (*Pogonomyrmex occidentalis*, Cresson), was at a point west of Sidney, Nebraska. This was at 6.30 A. M., and, therefore, the farthest eastward limit may have been passed during the night. Thereafter the nests were continually seen westward to Cheyenne, Wyoming Territory, and southward to Colorado Springs. I found the ants in the streets of Denver, running along the sidewalks, even in front of the crowded hotel. In this persistent clinging to home in the face of obstacles established by human occupancy, they resemble their congeners, the Agricultural Ant of Texas, whom I found domiciled under a stone-paved court in an Austin (Texas) hotel. The elasticity of their habits in adapting themselves to such abnormal environments, is thus illustrated.

By frequent and varied inquiries, I ascertained that the mounds are distributed throughout the State of Colorado, a considerable

part of New Mexico, Wyoming, Utah and Arizona. They abound in Kansas, where they are traceable along east and west lines parallel with the line of observation in Nebraska and Wyoming. Prof. Packard found them as far east as Brookville.[1] Dr. Horace G. Griffith, of Marengo, Iowa, kindly undertook a series of inquiries for me among friends east of the Missouri River. He reports, as the result of his letters, that the ant is not found in Iowa at all, the only mound-building species being "a small reddish ant, that throws up small mounds from one to two inches in height, found in fields and along roadsides." It is not found in Missouri, from Kansas City northward; nor in Minnesota, from St. Paul south and west. The only points west of the Mississippi from which Dr. Griffith secured a report, are Lincoln, in the southeast part of Nebraska, a small town in Clay County, and one in Adams County. The correspondents all made thorough search, but did not find any specimens. Such is the prominence of the mounds of Occident in the level landscape, that they must have been seen by these persons had the ant been distributed in the sections reported. Dr. Griffith's inquiries are not indeed exhaustive and conclusive, but indicate quite satisfactorily that the ant is not domiciled eastward of the Mississippi, and has not yet been, or is not now, distributed along the eastern belt of the Trans-Mississippi region.[2]

The Geographical and Vertical Distribution, so far as I have been able to trace them, are exhibited in the following Table[3]:—

[1] American Naturalist, 1878, p. 515.

[2] I expended much time and labor in private and public correspondence, in the endeavor to arrive at more satisfactory results. It is my misfortune to have failed in this case to sufficiently interest any one upon the field in my research, to secure attention to my questions. I acknowledge my obligations to the gentlemen mentioned here, who, though not residents upon the immediate field, yet have contributed much valuable aid from personal observations and inquiries.

[3] The *first* column in the Table gives the points at which the ant has been collected; the *second*, the elevation; the *third*, the longitude, reckoned from Washington; the *fourth*, the latitude; the *fifth*, the name of the person upon whose authority the distribution at that point is noted. The latitude and longitude are stated approximately.

TABLE I.

Geographical and Vertical Distribution of P. occidentalis.

PLACE.	Elevation.	Long.	Latitude.	Authority.
Brookville, Kansas.....	1346 ft.	22° W.	39° N.	Prof. Packard.
Sapa Creek, N. W. Kansas.	2400 ft.	23	38	Russell Hill.
Sidney, Nebraska.....	4109 ft.	26	41	McCook.
Cheyenne, Wyoming.....	6080 ft	27½° W.	47° N.	McCook.
Salt Lake City, Utah.....	4336 ft.	35 W.	41 N.	Prof Packard.
Farmington, Utah.....	.....	.....	.....	Prof. Packard.
Lake Point, Utah.....	.....	.....	42 ?	Prof Packard.
Ft. Bridger, Wyoming....	6753 ft.	33	41	Dr. Jos. Leidy
Reno, Nevada.....	4525 ft.	43 W.	39-40	Prof. Packard.
Montana Territory.....	Montana City. 4353 ft.	35 ?	45-6 ?	Prof. Packard.
Denver, Colorado.....	5196 ft.	28	40	McCook.
Colorado Springs, Colorado	5985 ft.	28	38	McCook.
Colorado City, Colorado...	6343 ft.	28	38	McCook.
San Luis Valley, Colorado.	S. L. de Culebra? 7596 ft.	29	36	Mayer.
Fort Yuma, Arizona.....	.....	38	33½	Dr. Griffith.
Los Vegas, New Mexico...	6460 ft.	39	36	Prof. Packard.

It will thus be seen that Brookville, Kansas, is the farthest eastern point of observation; while Reno, at the base of the Sierra Nevada, 1622 miles west of the Mississippi River, is the western limit of distribution. This is a range east and west of 21° of longitude. The insect is probably not found on the Pacific slope. No report of it in that geographical province has fallen under my notice, and I have never seen it in any collection of hymenoptera from the Pacific Coast. It would seem probable, however, if the reported location at Fort Yuma, in southwestern Arizona be wholly trustworthy, that the insect may have pushed westward into southern California.

The range north and south I conjecture to be at least 13° of latitude, say from 45° N. to 32° N. The mounds which I observed in the Indian Territory, but could not examine, may have been nests of this species. In the Gulf Coast and in Texas, their place is taken by the Agricultural Ant (*Pogonomyrmex barbatus*), whom they so closely resemble in structure and habit.

From an intelligent young officer in the United States Army, who has served in Dakotah, I learn that nests which correspond exactly to those of Occidentalis are distributed throughout the "Bad lands," in the southern part of that territory. I have,

therefore, included that region within the probable northern range.

On a journey to the Divide, fifteen miles northeast from Colorado Springs, I traced nests all along the road, but they were more sparsely distributed as the summit was approached. In the neighborhood of Pennington's ranche, but one was seen. Charles Pennington informed me that the sheep—which are herded in immense flocks throughout this section—greatly disturbed the Occidents, and had driven them off. He had followed columns of them fully a half mile in length, engaged in emigration or some general movement.

The Vertical Distribution of Occidentalis is probably not much above the altitude of 6300 feet, which is the height above sea-level of the Garden of the gods, the locality in which I studied its habits most closely. After I left the base of Pike's Peak and began to ascend the Ute Pass, I do not remember to have seen a single nest. They do not appear to occur in any of the parks or upland plains, Florissant, Hayden, or the Great South Park—at least, they were not observed by me. South Park is about 9000 feet above sea-level. It would appear, in other respects than elevation, to be quite as well adapted to the ants as the lower plains of Wyoming, Nebraska, Kansas and Colorado. The difference in height, therefore, probably constitutes a barrier to their distribution. Facts bearing upon this point are very desirable, and it is within the power of any careful observer to note and report upon them.

The Nest Site, as observed, was invariably upon the level plain, flats, or easily sloping hills as in the neighborhood of Denver, and on the slopes of Cheyenne Mountain. In the Garden of the gods the ridges were avoided, and the nest built in small level nooks and flats lying between the bases of the ridges of red sandstone, which form the peculiar feature of that spot. Not a single mound was seen upon the summits of the ridges, a fact which appeared in striking contrast with the sites of the Honey Ants, which were never in the flats, and were all upon the tops of the ridges.

CHAPTER IX.

ARCHITECTURE OF NESTS.

THE FORM of the nest is that of an elliptical cone, whose shorter face is about one-half the length of the longer. The cones are of various heights, regulated apparently by the age and size of the colony, rarely exceeding ten inches, although some large mounds which I observed in passing, without measurement, were fully one foot high, with occasional individuals even higher. Dr. Joseph Leidy, who published a brief note describing these formicaries, in the Proceedings of the Academy of Natural Sciences of Philadelphia,[1] found them "from ten to eighteen inches high" in the neighborhood of Ft. Bridger, Wyoming Territory. The mounds which I measured in Nebraska (Ft. Sidney) were from four to six inches high; the prevailing height of those in the Garden of the gods was six to seven inches.

These measurements are so small that one is continually surprised in making them. The casual observer quite generally reckons the mounds much higher than they are. This illusion is due in part to the flatness of the landscape, but principally to the great base expansion of the cone, and especially to the fact that the nest is made very prominent by the clear space which nearly always surrounds it. This clearing or "pavement" is circular or elliptical in form. The total diameter of the nest-space (including clearing, see fig. 83) is about twice (but sometimes only equal to) the diameter of the mound. I did not measure any clearings that exceeded ten feet in diameter, but Dr. Leidy speaks of some eighteen feet. The size of the clearing is ordinarily proportionate to that of the formicary; but this is not an invariable rule, as I found some large nests with comparatively small clearings around them.

[1] Page 304, Proceedings, 1877. This appears to be the first recorded description of the nests, and though quite short, is marked by the usual accuracy of the distinguished observer.

The mound is situated in or near the centre of the nest-space, and the width of the clear belt at any point is about equal to the diameter of the mound. These are only approximate proportions, as I could determine no fixed ones; but the tendency to the above relations is tolerably steadfast. Fig. 83, Plate XI, fairly represents the general outline of the cones and clearings. The nest-space covers a surface of (say) twenty-one square feet. The diameters measure seven feet three inches, and six feet. The mound is nine feet seven inches in circumference around the base, having a diameter of about three feet. The width of the clearing on all sides is thus about that of the mound, although the width is somewhat greater on one side than the other.

The following tabulated measurements will present some details which further contributed to a correct idea of the general dimensions and proportions of the exterior parts of the formicaries.

TABLE NO. II.

Measurements of Exterior Architecture.

	I. Height.[1]	II. Long Slope.	III. Short Slope.	IV. Diameter at Base.	V. Circumference at Base.	VI. Diameter of Nest-space.
No. 1	4	.....	.....	12	.....	.....
No. 2	6	.....	.....	24	.....	46
No. 3	.....	29	12-13	.....	.....	.....
No. 4	.....	21	12	.....	.....	.....
No. 5	.....	26½	16½-18	.....	.....	.....
No. 6	.....	25	.....	.....	115	87 x 72
No. 7	6-7	23	15-20	.....	101	.....
No. 8	.....	.....	.....	77 x 66	.....	.....

The clearings are without vegetation of any kind, with the exception here and there of a straggling tuft or blade. They appear in the midst of the gramma grass (*Bouteloua oligastachya*), which covers the Plains, and which was intermingled in the Garden of the gods, with various other plants. As observed by Dr. Leidy in Wyoming, the outside of the clearings are closely and often densely skirted with vegetation, especially by sage

[1] The measurements are in *inches* throughout.

bushes (*Artemesia tridentata*), grease wood (*Sarcobatus vermiculatus*), etc. The clearing is usually tolerably smooth, and naturally is level, but follows more or less any inequality of the surface. Near the margin of the cone little masses and winrows of gravel are seen washed down by the rains, as in fig. 83, which was drawn just after one of the heavy daily showers prevalent in July and August.

I was not so fortunate as to observe any ants engaged in the actual work of cutting away grass. But there is no reason to doubt that a clearing is accomplished by the deliberate action of the workers, and that the mode of operation resembles that of the Agricultural Ants, which I have quite fully described.[1] That the Occidents are at least abundantly able to get through with such formidable achievements in forestry, will appear further on in the description of their harvesting behavior.

The maintenance of the clearing is in accordance with the very common dislike among most mound-making species of ants to the presence of vegetation in the immediate vicinity of their nests. This may be accounted for by the hindrance to free ingress and egress wrought by the plants, and possibly by the harborage which they afford to enemies and intruders. Another consideration may lie in the fact that overhanging vegetation would endanger the health of the larvæ and pupæ, fostering dampness by the retention of morning dews and the moisture of rain. Moreover, the roots of plants which grow upon or on the edge of the formicaries might penetrate the underground galleries and rooms, and seriously damage them.

On the other hand, it is within the bounds of reasonable conjecture that the clearings are simply accidents, the result of injuries done the plants by the formic acid secreted freely by ants, and the decay which would naturally follow the mining operations around and upon the roots of the plants, in excavating the subterranean apartments. But, whether the fruit of emmet volition (as I think), or of a happy chance, the utility of the pavement is manifest. In all the daily industries and movements of peace the advantage and convenience of the clearing appeared to me as decidedly as from the yards, courts, pavements and streets of

[1] Agricultural Ants of Texas, p. 21 and fig. 86.

human habitations. In hostile actions, too, the broad open space between the home-fortress and the first approach of the assailant or intruder, seemed to have advantages quite similar to those arising from analogous conditions in the military operations of men.

The exterior form of the ordinary nest of Barbatus (the Agricultural Ant), is quite in contrast with that of Occidentalis. The former is a plain, circular disk, with a central opening into the underground formicary. There is, however, an intermediate type, consisting of a small central mound, which is a truncated cone, with a crater-like top, penetrated by one or two gates or openings. I even found a few mounds in Texas which had the barest trace of a clearing. In rocky soil the mounds were roofed with gravel, but were composed of soil alone on the alluvial fields and prairies. The nest of the Florida harvester (*Pogonomyrmex crudelis*) as described by Mrs. Treat, is simply the truncated cone of Barbatus *without* the clearing.

The domicile of Occidentalis presents (so far as my observation goes) no such variety of exterior as that of Barbatus, but is quite rigidly confined to the single form here described. That is evidently closely related to the plain-disk (fig. 85) and the cone-disk (fig. 84) exteriors of Barbatus, the latter of which (fig. 84) is intermediate between the former (fig. 85) and the exterior of the Occident Ant (fig. 83), just as it (fig. 84) is itself intermediate between the plain-disk (fig. 85) and the simple cone of Crudelis. The homologies have already been pointed out. Differences appear in the location of the gates and the presence of roads which will hereafter be described.

Moreover, in the nest of Occidentalis the cone is specialized and fixed, while in Barbatus the clearing is more specialized. I think I am not mistaken in the impressions—not to say conclusions—drawn from many little points in the structure of the nests and the behavior of the insects which cannot well be detailed, that with Barbatus the clearing is decidedly a matter of greater consequence in the life of the formicary than with Occidentalis. If for the moment we could allow imagination play with the evolution hypothesis, and suppose the Florida harvester and the Agricultural and Occidental Ants to have been derived from a common

emmet ancestry, we might fancy the cone-disk (fig. 84) of Barbatus to have approached more nearly the primitive typical nest of the Floridian species; that on the one side the rudimentary clearing was developed into the present characteristic and highly specialized clearing of the Agricultural Ant; while on the other, the rudimentary cone was developed with its builder, into the present conical exterior of the Occident Ant, of which the cone is specialized and the clearing has plainly become subordinate. At all events, one sees here an illustration of that wonderful unity in diversity which everywhere meets the students of nature, and points backward to the origin of all things, by whatever mode, in the One Infinite Mind.

A supposed special use of the clearing by the Agricultural Ants has been a matter of much speculation, and is still an open question. Lincecum believed that the disk was used by them as a harvest field upon which were sowed and raised crops of the needle-grass, *Aristida stricta*. That such crops are at least permitted to grow upon the clearing, and that the seeds of the plant are actually harvested, is the utmost that I could accurately establish.[1] No question of this kind, however, has been raised concerning the Occident Ant. So far as present observations go, there are no facts which could suggest such a question. The clearings are all and always absolutely void of vegetation, except an occasional straggling plant. When, however, the habits of Occidentalis have been the subject of as long and careful notice as those of Barbatus, facts may be uncovered which shall justify the query therein also.

THE PEBBLE ROOFING.—Every mound of the immense number seen by me was covered with pebbles of the nature of the gravelly soil in which it stood. In the vicinity of the Garden of the gods these pebbles were red sandstone. The mounds in Wyoming described by Dr. Leidy (who brought me his collection), were composed of a white stone. Mr. R. Hill saw them on the Sapa Creek, northwestern Kansas, composed of pellets of the limestone rock in which the great fossils are found, and in one or two cases even of portions of fossils. Thus, the conditions of the famous

[1] Agricultural Ants, p. 39.

riddle of the Judean Hercules are repeated in this far Occident, and the hymenopterous allies of the bees who made their nest in the skeleton of Samson's lion, burrow and build a home among the bones of extinct creatures of the geologic ages. In New Mexico, very pretty and valuable minerals are said to be picked up on the gravel-covered mounds of Occidentalis. On the Platte River, particles of gold-dust have been seen shining among the gravel roof-stones. One gentleman, a reputable and prominent citizen of Denver, assured me in all seriousness, that at Coalville, on the Colorado Central, where the coal-bed lies one hundred and sixty feet from the surface, bits of coal had been found mixed with the gravel on the ant-hills. His inference was that the ants had shafted the coal from that distance! My inference was—allowing the accuracy of the facts—that slight traces of coal are discoverable quite near the surface. The point to be noted is that the invariable habit of the ant is to bring up the pebbles excavated from her underground rooms and galleries, and deposit them, in the form described, upon the surface. The Honey Ant has the same habit, and the Agricultural Ant when building in very gravelly soil, will dispose of the little stones in a somewhat similar way.

Carrying the Gravel.—These pebbles are, of course, excavations from the underground rooms and galleries. They have first to be cut away from the soil in which they are imbedded, and then carried up to the top of the cone along which they are distributed. They are not (or but sparely) intermingled with the soil of which the interior and bulk of the cone is composed, but form a stone covering or roof, about one-half an inch thick, more or less. The pebbles are handled with the greatest ease by the worker-ants, who nip them with their outstretched mandibles, turn them around until the rugosities upon the surface are conveniently fitted to the teeth of the mandibles (Pl. XII, figs. 91, 92), and then move off, rarely stopping in route to adjust the burden or to rest. The body is lifted up, the head is elevated, and the pebble held well to the front, as in fig. 91, or slung more under the body as at fig. 92. There was ample opportunity to observe the portage behavior, not only in ordinary excavations, but during the opening and closing of gates, and in repairing breaks

caused by rains or purposely made by me in the surface. In the last-named work the ants would descend to the clearing at the margin of the cone, and carry the stones up the slope with as little apparent effort as when moving downward. This, however, must be an easier task than transporting the pebbles from their interior beds up the galleries to the surface. The space traversed by the ants in this underground portage (as will be seen hereafter), is sometimes equal to a perpendicular distance of nine feet, which has little mechanical relief from inclination or roughness of the gangways. Some of the pebbles have from six to ten times the weight of their little carriers. I never saw any copartnerships in these portages; no ant ever came to aid a struggling worker, and indeed, none seemed to need assistance.

I have often admired the vigor and skill shown by baggage porters in shouldering, and bearing up several flights of stairs, the immense trunks which American ladies take with them upon their travels. But here—if we may be indulged in the comparison—is an insect three-eighths of an inch long (the worker-minors are shorter), who can carry up sharp inclines and perpendicular surfaces, over a distance three hundred times its length, a burden six times its weight. If we estimate the average man at five and a-half feet in length, and one hundred and fifty pounds in weight, our baggage porter would needs carry a half-ton weight up one-third of a mile of stairway, to meet on equal footing the emmet athletes of the Occident ant-hills!

CHAPTER X.

GATE ARCHITECTURE. OPENING AND CLOSING GATES, RISING, RESTING AND MOONING HABITS.

The location of the gate, or external opening into the formicary, marks another striking difference between the nests of Barbatus and Occidentalis. In the former the gate is placed at the centre, and upon the cone-disks is in the middle of the shallow crater at the top. (See fig. 84). In the latter the gate is placed near the base of the cone. It may be here noted that a comparison of all our mound-building species of ants shows characteristic differences in location and number of gates. The Mound-making Ants of the Alleghenies (*Formica Exsectoides*), who rear a cone most nearly resembling that of the Occident Ant in size and appearance, place their regular openings—a large number—at the very base of the cone, and occasional gates for temporary use irregularly over the surface.[1] The Honey Ant makes a single large central gate, perpendicular and tubular. Such facts point in the direction of some uniform correlation between structural characteristics and gate architecture.

Table No. III presents a detailed view of the number, polarity and position of the gates in the nests of Occidentalis.

TABLE NO. III.

Number, Polarity and Position of the Gates.

Number.	Direction.	Distance from Base.
No. 1.—Two.....	S. E. Side.	Near Base.
No. 2. One.....	E. "	" "
No. 3.—One.....	N. E. "	About one-third.
No. 4.—One	S. "	" " "
No. 5.—Two	S. & S. E.	" " "
No. 6.—One.....	N. E.	" " "
No. 7.—One.....	S.	4½ in. (one-sixth).
No. 8.—One.....	S. E.	6 in. (one-fourth).
No. 9.—One.....	E. (little S.)	4½ in. (one sixth).
No. 10.—One.....	S. E.	5 in. (one-fifth).
No. 11.—One.....	.....	About one-half.

[1] See my Mound-making Ants of the Alleghenies, plates and text *in loc.*

The above eleven cones taken at random fairly exhibit the three points tabulated. It will be seen that the general tendency is to a single opening, eighty-two per cent. of the nests having one gate only. The facts concerning the polarity of the gates are not so decided, but there is a strong tendency to an outlook toward the Southeast and South, about sixty-four per cent. of the gates opening in those directions. The position of the gates is quite uniformly near the base of the mound, generally about one-third to one-fourth the distance from the summit to the surface of the ground, with an occasional erratic gate opening midway of those points.

In form the gates are simply funnel-shaped openings through the gravel roof into the interior soil, at an inclination downward of about 45°. They vary in width at the mouth; the single gates, (Pl. XI, fig. 87), or those which terminate in one gallery, being three-fourths of an inch, more or less, and the double gates (fig. 88), those which terminate in two gallery openings, vary in width from one and a-half to three inches. The gates are quite shallow, generally less than an inch in depth. The floor and roof of the inner part or vestibule, are quite smooth. Around these gates gathers the daily out-door life of the insects. Back and forth through them citizens of the emmet commonwealth are continually moving during the working hours of the day, and it soon appeared that they have their regulated hours for work—for out-door work at least. An exceedingly interesting series of observations, which will now be recorded, leads up to this statement. The details, which are entered in great number upon my note book, need not be written here, but enough will be given to show the manner in which the investigation was conducted.

First, as to the time of rising and retiring, or more accurately speaking, of opening and closing the formicary. It soon caught my notice that there was a fixed behavior in these points, the general tendency of which was readily seen to be to shut the gates about sunset and to open them late in the morning. I now established two regular "circuits" of nests, one in the immediate vicinity of camp, the other half-a-quarter of a mile distant. The nests were marked A, B, C, D, etc., and were visited daily, morning and evening. The visits began at or before eight o'clock in the

morning, and six in the evening, the time near which the opening and closing might be expected, and were repeated at short intervals, for an hour or more, as might be required. The condition of the nests was noted and entered at every visit on every round. A few extracts from some of these entries will be of interest:

July 19, 8.15 A. M.—Nest A, one ant out. . . . B, several ants out. . . . C, several out. . . . D, large number out. The nest has been overflowed by the last rain, and badly damaged, and the workers are busily repairing the breaks. . . . E, few out. . . . F, nest sealed up, silent.

July 28, 8.20 A. M.—Nest A, gate just open. . . . B, few ants out. . . . C, few ants out. . . . 8.40 A. M.—A, no ants on the hill; four (sentinels), rush out of the gate as though alarmed by my approach. . . . C, not many out; one carries into the nest the head of a gramma grass; another the abdomen of some hymenopterous insect. . . . D (the overflowed nest), numbers are out working on the nest and crowding along the sandy track of the walk. . . . 8.52 A. M.—Nest A, ants are now coming out in full numbers, and are scattering through the grass; some are already returning, two workers bring in bits of grass-straw two inches long, one carries in a head of gramma grass, one a yellow and red larva, some go down to the clearing and bring up pebbles to repair a break in the cone.

July 21.—The sum of the morning notes is, that at all the nests in all the rounds up to 8.45 o'clock, all the gates were closed, and at 9 o'clock most of the gates were open or opening, and but one was closed.

The conclusion reached by the observations of which the above are examples, is that the gates are ordinarily opened near or shortly after. 8 o'clock, morning, but the full activity of the colony does not begin until towards 9 o'clock. There are variations in the opening hour, however, which justify the general statement that the gates are opened between 8 and 9 o'clock. Thus it might not be unmeet that those persons whose love of sleep during late morning hours has been disturbed by the familiar Scripture proverb, "Go to the ant, thou sluggard, consider her

ways and be wise!"—should return upon their mentors with the above-recorded facts and cite this ant, who is indeed no sluggard, as being nevertheless fond of a morning nap! However, it must be remembered that it by no means follows that work has ceased because field work has not begun. The interior work of a formicary is very great, and this may well be in full operation while the gates are shut. Moreover, it will be observed (as in the case of nest D, above) that when a special exigency, as the partial injury to a mound by floods, or invading animals, or wanton breakage—calls for special activity, the ants readily modify their habit, and are found very early busily repairing the damage.

The manner of opening the gate cannot be fully described because the work is chiefly done within and behind the outer door of gravel which is shown at figs. 89, 90, Plate XII. The mode would doubtless be correctly indicated by reversing the process of closing gates, presently described. What I saw was, first, the appearance of the quivering pair of antennæ above one of the pebbles, followed quickly by the brown head and feet projected through the interstices or joints of the contingent gravel-stones. Then forth issues a single worker who peeps to this side and that, and after compassing a little circuit round about the gate, or perhaps without further ceremony, seizes a pebble, bears it off, deposits it a few inches from the gate, and returns to repeat the task. She is followed, sometimes cautiously and at intervals of ten, twenty, even thirty minutes, by a few other ants, who aid in clearing away the barricade, after which the general exit occurs. Again there is a rush of workers almost immediately after the first break, who usually spread over the hill, bustling around the gate, gradually widening the circles, and finally push out into the surrounding herbage. At first the exit hole is the size of a pea, perfectly round, and plainly shows that sand and soil have been used under the gravel to seal up the gate. The whole appeared to have been cemented, probably by the moisture of the night-dew.

The process of closing gates is even more interesting to the observer than the opening, as the various steps are more under his notice. It will best appear by transferring from my notes, with little alteration, the record of two days: About 6.30 o'clock,

this evening (July 19), the ants began to close the doors of their nests. At nest A, the closing was chiefly from within. The workers pushed the sand from the inside outward with their heads. A grass straw about an inch long was brought from the interior, and pushed out until it lay across the gate as a stay for the filling material. Soil was here principally used for closing, a few pebbles being added. The gate was not filled up quite flush with the surface of the mound; a little ridge was left, as in figs. 89, 90, which marked the outer edge of the vestibule roof. At nest B, which had a double gate (fig. 88), two workers-minor were the last and chief operators. They brought gravel from the surrounding cone, and filled in the two openings flush with the surface. I retired before finding out how they finally entered the nest themselves.

At nest C, with a single gate (fig. 87), a worker-major was operating in the same manner as at nest B. A number of ants had been engaged in the work at first, filling and gradually closing the inside, but all had retired within except the one major. When the gate was nearly sealed, a straggling minor came out of the commons and essayed entrance, wherein she failed. Several trials and failures succeeded, whereupon she commenced dragging the dirt from the opening. While thus engaged, the major approached with a huge bit of gravel which she deposited upon her comrade with as much nonchalance as though she were one of the adjoining pebbles. At last the minor dug out a tiny hole through which she squeezed into the nest, and the major, who was deliberately approaching close behind her, carrying another pebble, immediately sealed up the opening. During this amusing episode, the straggler made no effort to aid in the closing, being wholly intent on entering, and the gate-closer paid no attention to her whatever beyond the first sudden and satisfactory antennal challenge. Each moved forward to her own duty with the undisturbed placidity of a machine. In this case also I failed to see how the last gate-closer herself got in. I had better fortune in another example noted.

Nest E.—At 6.30 P. M. most of the formicary have found refuge inside the cone. Of the few outside, two were carrying little burdens that prove to be chopped-up bits of grass. These

were placed upon a distant part of the mound along with many similar particles and some husks of seeds. At 6.45 P. M. the gate is being closed; and at 6.55 only two ants are outside, slowly working at the gate which is now about half shut. An ant comes out with a bit of straw, carries it to the refuse heap, and returns. At 6.58 two ants come out with chopped leaves, and at 7 P. M. yet another; none of these make any effort to help the gate-closers who are slowly and steadily filling up the entrance.

Now occurs the usual side-play with late comers. At 7.07 a straggler comes along and tries to get in. As the gate is nearly closed, she deliberately proceeds to break it open. A pebble is taken from the gate-covering and carried three inches up the hill. Another is tugged still farther up, and yet another. Then in steps the gate-closer, plugs up the little break made with a very large pebble, and slips within at a by-cranny which had escaped the straggler. Now a second straggler appears while the closers are adjusting the material from within. The first straggler meanwhile has grappled with the big pellet, which at last she succeeds in dragging aside, of which straggler number two takes advantage, and slips into the nest. Thereupon one of the closers reappears from the inside, restores the piece to its place, and returns. Straightway the first straggler renews her effort, and has just set the pebble aside when a small black beetle comes up. This the straggler seizes, puts down, turns, reseizes and tries to push into the gate therewith. The beetle however escapes, and the foraging instinct which had led straggler to forego for the nonce her attempt at house-breaking, is not strong enough to divert her now from her entrance upon home. So beetle goes her way and straggler at last disappears inside.

At 7.20 a gate-closer comes out and adjusts several of the pebbles. I do not discern the advantage gained, but doubtless the ant quite understands it. The other closer is distinctly seen reaching up and adjusting pellets from within. At 7.21 the outside closer goes in at the small opening between the top of the gate and the inlying gravel. At 7.27 I still see by the motion of the pellets of soil the agitation of pebbles and an occasional glimpse of the tips of antennæ and mandibles, that the final sealing-up of the gallery is being accomplished within. In a moment all is quiet

and the gate of the emmet city is shut for the night. Externally it presents the appearance of a simple depression in the gravel covering, usually semicircular but sometimes triangular, as at fig. 90.

The same process is observed when a heavy rain storm threatens —particularly in the middle of the afternoon. There is, perhaps, more activity in the movements of the gate-closers, and a larger force at work, but the method and issue are the same. This habit of shutting up the doors at the approach of storms appears to be quite common, but is subject to many and perplexing exceptions. I was diverted from my earlier studies of this point, and in the end prevented from making more extended notes; a failure which some future observer would do well to remedy; but the results will probably not be widely different from the above.

The habit of opening and closing gates presents another point of difference between the Occident harvester and the Agricultural Ant. The latter was never seen by me to undertake such a task, and Dr. Lincecum has no hint of such behavior. My own observations upon Barbatus[1] show that night work is rather exceptional. Dr. Lincecum found the ants working early in the morning, but thought that when daylight hours were favorable late night work was not common. There is certainly here a contrast with the habit of Occidentalis, who does no outdoor work—except in unusual emergency—between sunset and eight o'clock, morning. It seems strange to note so radical a difference in habit between insects so much alike, especially as there is nothing in the respective environments to suggest the variance. Possibly, during the severer seasons of the year Barbatus might also be found addicted to shutting her gates at night? Possibly, some nocturnal enemy of Occidentalis peculiar to Colorado may have forced upon her that precaution?

It is worth noting here that the Cutting Ant of Texas (*Atta fervens*) has in a remarkable degree the gate-closing habit of Occidentalis.[2]

[1] See Agricultural Ant., p. 19.

[2] See my Notes on the Cutting Ant in the Proceedings Acad. Nat. Sci., Philada., 1879, p. 31.

The large and numerous tubular openings from her immense caverns are closed with remarkable precision and ingenuity, the materials used being bits of dry twigs, leaves and pellets of sand. There is, however, an exact reversal of the hours of opening and closing, the latter occurring in the morning, and the former in the evening. Thus the forays of the Cutting Ant are made during the night, while Occidentalis confines her labor to daylight hours. The Honey Ant, like the Cutting Ant, is nocturnal in her foraging habits, but unlike her does not seal up the formicary gate in day-time, which, instead, is continually guarded by cordons of sentinels.

Nooning.—While there exists the above difference as to night habits between Barbatus and Occidentalis, they precisely agree in their dislike for the mid-day heat. A little before 12 M. the Occidents were seen hastening from all quarters toward the nest, and by noon, only an occasional straggler would appear. Not until after the mid-day fervor of the sun had passed was work resumed. The striking exceptions were those nests already noted as marked by prolonged hours of labor, where special exigency demanded special activity.

CHAPTER XI.

HARVESTING HABITS—INTERIOR ARCHITECTURE.

When the first specimens of the Florida harvester (*Pogonomyrmex crudelis*) had been sent to me for identification by Mrs. Mary Treat, I ventured the prediction, based upon similarity in structure to the Texas Agricultural, and correspondence in latitude of habitat, that the species would prove to be a harvester. This was verified by Mrs. Treat's careful and interesting studies.[1]

A like prediction was risked concerning the Occident Ant; and in view of the closer structural resemblance, and correspondence in geographical distribution, my confidence that it would prove to have harvesting habits was even greater than in the case of Crudelis. The only question was whether the farther northern latitude of the Great Western Plains and the influence of the Rocky Mountains might not seriously modify or suppress a natural habit. Accordingly, the earliest opportunity presented by the stopping of the railway train after the ant-hills were sighted near Fort Sidney, Nebraska, was used to examine this point. My eyes fell at first glance upon the familiar kitchen-midden—or refuse heap of husks, hulls and damaged seeds deposited at one side of the clearing—that marked the nests of the Texas Agriculturals. I was quite satisfied that again my forecast had been verified.

When fairly settled in camp, and systematic study had begun, attention was immediately directed to this point, and the first conclusion was wholly justified. Indeed the observations upon Barbatus in Texas were substantially repeated. It will not therefore be necessary to record in full the details of my studies, and, I will give only such as may outline the general facts, and those that supplement or show variation from the habits of Barbatus.

[1] See Mrs. Treat's "Chapter on Ants," Harper & Brothers; and Lippincott's Magazine, Philadelphia, 1878, p. 556.

We may begin our investigations by exploring the interior of the nest in search of store-rooms and granaries with their hoarded treasure of seeds.

After penetrating the gravel roofing of the cone, the trowel strikes the natural soil of the surface, of which the mound is chiefly composed. This, like the gravel, has been brought up from the subterranean excavations. The cone is penetrated by galleries having their outlet at the gates. Dr. Leidy found the earth forming the walls of these galleries mingled with root fibres, which raised the suggestion—and with great probability—of being retained to give greater coherence to the friable soil. I detected nothing of this sort in the nests opened, but saw the ants taking in and also bringing out filaments of grass and bits of leaves for which I can conjecture no use except the strengthening of the masonry.

The gallery into which the gate opens enters the cone at an inclination of about 45°, and extending downward, communicates with a subterranean system of galleries, granaries, nurseries and living rooms. This is situated for the most part, beneath the level of the surface of the ground. The cones do not appear to be used extensively as a true nest, the smaller ones especially, rarely have store-rooms, and that but sparely. One large cone opened showed granaries above the ground surface; but these were quite habitually massed beneath the surface. The contrast here with the cones of *Formica exsectöides*, the mound-makers of the Alleghenies, is very marked; these are always true nests, and present when opened the appearance of a honey-comb, being penetrated by beautiful galleries from summit to base.

The granaries when uncovered closely resembled those of the Agricultural Ant. Indeed my studies of the interior architecture of the formicaries of many species of ants point to the conclusion that there is among all a general and, in point of fact, quite close resemblance between the form and arrangement of the galleries and rooms. The former are cylindrical tubes; the latter are simply lateral expansions of the galleries into bays and bulbs whose walls follow curved lines more or less regularly. Were the data for the demonstration attainable, it might possibly be found that these are the lines of greatest advantage along which the

natural mechanical action of the muscles of the body urge the worker ants, precisely as the winding cattle-track and Indian trail mark the easiest and shortest paths along which the muscles unconsciously urge both beasts and men.

A horizontal section—more accurately, an inclined section—of the nest of Occidentalis shows a series of rooms (Pl. XIII, fig. 101) whose individuals are like those of Barbatus in form, and about half the size. The grouping appears to differ from that of Barbatus in that the rooms are more closely blended—their individuality not quite so marked. This is the case at least with the suite shown in fig. 101. These were arranged one above another, in terraces or stairs. The width rarely exceeds three and a-half inches, the greatest length is five or six inches. The example drawn (Pl. XIII, fig. 100) had a width (across the figure) of two and a-half inches, the depth of the bay was one and one-eighth inches, the height of the room three-eighths of an inch. The granary drawn (Pl. XII, fig. 98), which shows the roof and walls entire is in width two inches, depth two and five-eighths, height three-eighths. The highest room measured was a little less than an inch from floor to centre of roof.

If now we make a vertical section (Plate XIII, figs. 104, 105), we find these rooms arranged one above another, at distances greatly varying. They are limited to the space directly underneath the clearing, and indeed chiefly to that underlying the cone itself. They are connected by galleries of various lengths, from one-fourth to one-half inch in diameter (Pl. XIII, fig. 105). The depth to which the rooms descend was a matter of question, and in order to determine it I resolved to excavate two formicaries to the utmost. The task proposed was quite formidable, considering the size of the nests, and that they were made in compact red clay. I was favored by a "wash" of considerable depth, near to which several formicaries were located, which allowed easier approaches than otherwise would have been possible. The first stores of seeds were found at nine inches below the surface, and thereafter granaries were continually struck, filled with small black and green seeds, a single room containing as many as two full tablespoonfuls. These have been identified through the kindness of Mr. Thomas Meehan and Dr. Thomas Porter as *Amaran-*

thus albus and *Chenopodium hybridum*. Other rooms contained larvæ and callows in great numbers; rarely seeds and larvæ were found intermingled, and through all the openings the worker ants swarmed.

I carried this excavation to a total depth of eight feet, and found granaries and seed stores throughout the entire depth for six feet six inches. At that point was a granary (*x*, fig. 104, Pl. XIII) containing many seeds of both the above-named species, and numerous ants whose presence, of course, completely identified their connection with the seeds. This granary was situated almost directly beneath the central point of the cone, in or near which line most of the lower storerooms were placed. Three inches below this point (six feet nine inches from the surface) was a room two inches wide, and upwards of five inches deep, which contained no seeds. I continued the excavation fourteen inches lower, but finding no further openings, abandoned the search. The next excavation was pushed to a greater depth, but as this one was made entirely by myself, and the digging of the nest space—the portion of earth beneath the mound and clearing—was done very carefully with a large hunting-knife and a garden-trowel (two excellent tools for ant-work), I have reproduced the chart of this excavation in the accompanying illustrations (Pl. XIII, fig. 104).

In opening the nests every vertical section taken was charted, that is, the exposed openings were all located in proper relative position upon my notes; and such sections and charts were made every few inches after the border of the nest space was reached. The chart which I present in the plates shows the section lying just under the centre of the cone. The vertical distribution of the store-rooms and nurseries at that point is here quite accurately shown; although it must be understood that even with the most careful handling the more friable parts of the nest would crumble and prevent the exact location of rooms, a result which was also somewhat favored by the defensive activity of legions of ants armed with a sting as sharp as a hornet's. The galleries I found it impossible to chart, but have given a smaller vertical section which shows their ordinary arrangement and relation to the rooms, in Pl. XIII, fig. 105.

The second excavation was made at a larger nest, in much harder soil, but my own labors were lightened by the vigorous manipulation of pick and shovel in the hands of a veteran gold-miner. An opening six feet wide was made gradually converging to four feet as it approached the outer boundary of the cone. At this point the more tedious and careful work of knife and trowel began, and the sections were carried down and charted as before. The result was a substantial reproduction of the first excavation, with an exception, noted hereafter. The cone, in this case, was used as a true nest, for the first opening uncovered (in order), one and one-half inches from the summit, was a nursery-room containing larvæ. Lower down were other rooms and many larvæ. At four inches was the first store-room, a large granary, with many black and yellow seeds. Thereafter the rooms appeared to a depth of *eight feet and six inches!* At eight feet were granaries containing two kinds of grain, and six inches lower down was a room containing black seeds and callow ants. We carried the excavation to the depth of ten feet without finding further openings. We had cut away only one-half of this formicary—a little more indeed—but as two nests had now been opened, with like results, I was satisfied that the grouping of the rooms is similar on all sides, in all nests, and that in the construction of these subterranean chambers, the Occident Ant penetrates the earth to the distance of from seven to nine feet.

The discovery of these deposits of seeds, made in all nests, in large quantities, throughout the nest boundaries and to such remarkable depth, seems sufficient evidence to establish the fact that Occidentalis is a Harvesting Ant. To this I am permitted to add the actual observation of the process of harvesting the seeds of various plants. The worker ants were seen bearing these into the nests, and again carrying out shells or husks of the same and dumping them upon the kitchen-middens. I could not follow them to and from their harvest field as easily as the Agricultural Ants, owing to the absence of the well established and ordered roads which characterize the communities of the Texas harvesters, as shown in Pl. XI, figs. 84 and 85. I quite naturally looked for these roads around the nests of the Colorado congener, and was surprised at their absence until I had considered more carefully

the nature of the surrounding vegetation. In Texas the disks of Barbatus are established upon soil which bears a compact vegetation. The grass spreads uniformly over the surface in the manner familiar to most residents in civilized lands. There is, therefore, a manifest advantage, if not necessity, in the cutting of smooth thoroughfares from the formicary bounds to the harvest grounds. But in Colorado, and generally upon the American Plains, where Occidentalis domiciles, the gramma-grass is the prevailing vegetation; and this, as seen in Pl. XI, fig. 83, stands in bunches or tufts of spears. These are quite widely separated from each other, that is to say, by several inches—and the intervening open spaces present only the smooth surface of the peculiar soil of the plains. In point of fact these spaces afford clear roadways from the nests into all the surrounding space. Under the circumstances it would perhaps have reflected upon the natural sagacity of the insect had special roads been made where obviously they are not needed. A harvester could penetrate the surrounding vegetation for a long distance by the free ground between the clumps of grass, and vary little from a right line.

Along these inter-spaces and the smooth rain-tracks I was able to follow the ants to and from their harvesting grounds, and observe them at work culling seeds. Pl. XII, fig. 93, is a sketch of a worker engaged in cutting out a wild sun-flower seed. Several heads of the flower had been plucked out by one of our party, broken and thrown down. These pieces had attracted the foraging ants of a neighboring hill, who were busy for several days in removing and harvesting the seeds. I had the pleasure of seeing the entire process. The seed-stalk was first separated from the broken disk by the action of mandibles and feet, bent over and held down by the legs, as in the figure, while the mandibles were vigorously plied at the base, their action being facilitated by the taut condition of the fibres. When the seed was fairly disengaged it was "shouldered," in the same way as a pebble (fig. 91), and the ant started off with it at a smart trot toward the nest. The distance, upwards of thirty feet, was accomplished in two minutes. This might fairly be considered a celerity in work satisfactory to the most exacting taskmaster, inasmuch as the little harvester, at that rate, would have covered a distance (in round

numbers) twenty-one thousand times its own length (one-fourth of an inch) in an hour. A proportionate rate for the human harvester would be about twenty-one miles an hour.

Many seeds were reaped and garnered in this way from the same field; but the number of workers engaged thereon was small. To test on a larger scale the harvesting disposition of the ants, I laid a broken head of a sun-flower upon the clearing or pavement of the nest. A host of insects immediately attacked it; some cut out and carried away the yellow flower-leaves, others disengaged the seeds and bore them into the formicary; all except one erratic individual, who insisted upon dumping her garnered grains upon the outer margin of the clearing.

Thus the same chain of evidence by which Barbatus has been shown to be a harvester, exists in the case of Occidentalis. Seeds of various kinds were seen to be gathered upon the field and garnered within the nests;—the husks of these or like seeds were seen to be exported from the gates and deposited with heaps of similar husks;—the seeds were found in large quantities bestowed within subterranean graneries or store-rooms, and in a good state of preservation. This demonstration establishes the three known American congeners of the genus Pogonomyrmex—*P. Crudelis*, the Florida Harvester, *P. Barbatus*, the Agricultural Ant of Texas, and *P. Occidentalis*, the Occident Ant of the American Plains, as among the most extensive harvesters in the Emmet family. These represent upon our Western Continent that industry which commanded the attention of men of oriental nations from the earliest ages, and which has been celebrated in proverb and song by the writers of sacred and classical literature.[1]

These are not, indeed, the only harvesting ants found in America. At least two species of the genus Pheidole, *P. megacephala*, and *P. pennsylvanica*, are distributed quite widely. They have been studied to some extent in New Jersey by Rev. Mr. Morris of Vineland, and Mrs Mary Treat. I have observed the methods and studied the architecture of the Pennsylvanian Pheidole in the neighborhood of Philadelphia, and present here for the advantage of comparison, several figures. Pl. XI, fig. 86, is a sketch of the external appearance of a nest made in a pathway

[1] For a history of this literature see Agl. Ants of Texas, chap. iv.

and wagon track on a farm. A gallery opening straight downward, gave entrance and exit to the miners who dumped their pellets of soil near by until it formed a lunette three or four inches in diameter and three-fourths of an inch or less high. This was heaped about sprigs of weeds and short grass, and was a temporary structure, swept off by every rain and renewed by continuous excavations.

Other workers were busy among the surrounding weeds, harvesting the seeds of *Euphorbia maculata* as identified by Dr. Thos. Porter,[1] gathering them, so far as I could see, from the ground only. The nest was opened, and found to contain store-rooms in which many seeds were deposited. The two narrow oval-shaped rooms, Pl. XIII, fig. 103, were placed north of the gate, three-fourths of an inch below the surface of the ground. The rooms were an inch and a-half long and from one-fourth to three-sixteenths wide.

At the depth of one and three-eighths inches below the surface, was a double room (fig. 102), two and one-fourth inches long and one inch wide. Its relation to the gate *g*, is shown, and also various communicating galleries. Both these suites of rooms contained seeds as represented by the figures. It will thus be seen that the curious may observe the habits and homes of harvesting ants without the inconvenience of a journey to Texas, Florida, or the Rocky Mountains, although, to be sure, on a far less extensive scale.

There remains one very interesting observation upon the interior architecture. At various points in the underground formicary space, I found rooms, identical in form and size with the ordinary chambers (Pl. XIII, figs. 105–6), which were packed full of gravel. They were distributed at quite frequent intervals, and raised at once the suggestion that they were dumping rooms into which the workers temporarily stowed the pebbles excavated and carried up from lower rooms. The habit of working "by divisions" is

[1] Mr. Meehan, in forwarding identifications of the seeds submitted to him, calls attention to the fact that the croton and some other seeds harvested by the Agricultural Ant, are also Euphorbiaceous, showing in this respect a similarity of taste between the Philadelphian and the Texan species.

very common among ants. I have often seen the large, black Pennsylvania Carpenter Ant (*Camponotus Pennsylvanicus*) operating in this way upon standing trees, one gang dumping the cuttings from the trunk, another carrying them away and dumping them beyond the neighborhood of the trunk. I have even seen three divisions thus at work. I have noticed the Cutting Ant stripping leaves from a Texas live-oak in the same manner. It was, therefore, an easy conclusion that our Occident Ants had availed themselves of a like division of labor in the immense task of mining their deep chambers—one gang cutting out the pebbles and carrying them into the upper dumping rooms, whence a second gang transported them aloft and distributed them upon the cone.

Some of these rooms, however, had evidently been packed with their gravel contents for some length of time; they were browned, soiled and compacted in such wise as to forbid the idea that they had been recently deposited. They were not, therefore, simple dumping rooms to prevent the stagnation of work, and secure division of labor, but rather veritable lumber-rooms, emmetonian garrets, apparently sealed up in the very midst of the nest. A few rooms were found similarly stowed with husks, hulls and decayed or moulded seeds. They were filled up to the roof-top and also seemed to be sealed or shut off from the rest of the formicary.

I did not, of course, have the opportunity of demonstrating on the field that the seeds harvested by Occidentalis are intended as food. That fact may be considered as fairly established by my experiments with the Agricultural Ant, which it seemed needless to reproduce. The three seeds collected within the granaries are the wild sunflower, *Helianthus tenticularis*, *Amaranthus albus*, and *Chenopodium hybridum*. Concerning the last two named Mr. Meehan writes: "I am inclined to believe—and so is Dr. Porter—that the Amaranthus and Chenopodium have been introduced into Colorado of late years, though everywhere common now. If the Occident Ant is an aborigine in Colorado, it has probably changed its tastes in late years." In addition to this observation looking toward the flexibility of Occident's appetite, he calls attention to the fact that the Chenopodium and Amaranthus seeds

are very much alike in form and general characteristics, so that it may well have occurred that the harvesting of one kind may have led to that of the other. To the above-named seeds may probably be added the grain of the gramma grass, which I saw carried into the nests, although it was not identified among seeds sent to the botanists.

Like most other ants Occidentalis allows herself a good deal of latitude in the choice of food. She fulfills the general scavenger functions of her family by gathering up dead insects, preys upon larvæ, and not improbably feeds upon the sweet secretions of plants, and "honey-dew" excretions of Aphides. A casual observation of Professor Leidy's makes it probable that she even fosters insects for their saccharine productions. Noticing several ants carrying what he supposed to be large stones into their nests, on closer examination these proved to be a large species of *Coccus*. A specimen of this insect was about the one-fourth of an inch long and the one-fifth of an inch broad, of a pale pinkish hue. The source of the coccus was sought in the vicinity of the formicary but not found. *Opuntia* grew abundantly in the neighborhood, but no cocci were upon it.

In the same line is the traditional fact—of which I have often heard, but have fortunately never been in condition to experiment upon—that the Indians of the plains were in the habit of availing themselves of this insectivorous taste, to rid themselves of the vermin bred by their peculiar life in their blankets and furs. These articles when thus infested, were spread upon or near the ant-hills. Whereupon the emmets swarmed forth, invaded the haunts of the little pests, and thoroughly cleansed them out.

I have been told by pioneers who had crossed the plains before the modern tide of emigration had swept across the continent, that they had resorted to this very original mode of purification, on the strength of the Indian custom, and found it quite effective. The ova and larvæ of the vermin, the young as well as mature individuals were removed by the ants, who in the search explored every part of the garments exposed to them.

CHAPTER XII.

POLEMIC DISPOSITION, INCIDENTS AND ARMATURE.

Occidentalis is not a warlike, at least not a belligerent, insect. Although she is armed with a terrible sting, is the superior or equal in size of most species, and exists in vast and populous commonwealths, she is nevertheless fairly entitled to be called a peaceful and, on the whole, a good-natured insect. The proofs of this are abundant.

The nests of six species of true ants, and of our northern species of white ant (*Termes flavipes*) were found parasitic upon the nests of the Occident Ant. On three separate pavements I found colonies of the Sanguine Slave-maker, *Formica sanguinea*. Each colony was located upon the clearing not far from the mound, and was marked by openings into the earth quite surrounding the bases of one or two tall weeds, or wild flowers—one of them a sunflower. The openings were large, three-fourths of an inch wide, and served as the gates into the interior of the formicary. The sunflower nest had an opening around the plant one and one-eighth inch in diameter, and a surrounding moundlet of five inches diameter. The branches of the plant were covered with Aphides who were attended by numbers of the slave species, *Formica Schauffussi*, intermingled with whom were many of the slave-makers. Another slave species, a small black Formica, new to science (apparently), occupied one of the colonies in lieu of *F. Schauffussi*. The number of ants in these compound nests was quite large, judging from those in sight, and the territory occupied by them, as determined by an outside example explored, embraced a goodly portion of the interior nest space. Yet there was nowhere, upon any of the three formicaries, at any time discerned the slightest trace of antagonism to these guests on the part of their Occident hosts. The species were not greatly unequal in size, but the disparity in numbers was such that the Occidents could

soon have exterminated the Sanguines and their kidnapped retainers. That they did not do so seems to indicate a peaceful and tolerant nature. Again, in the larger nest of Occidentalis explored by me (Excavated Nest No. 2) there were found three nests of a small red species, one of a small black ant, and one of a large blue-black Formica—all within the compass of the underground nest space, all showing full organization, with queens, males, cocoons and larvæ, and all having their galleries and chambers perfectly formed and wholly undisturbed. Besides these, three colonies of the Erratic Ant were established upon the clearing. The nests of the small red ants were found within the cone itself, and one of them extended for eight inches directly across it. The small black ants were also nested within the cone, and had a domicile which was almost a miniature reproduction of the interior of an Occident nest.

The most curious and interesting of these parasitic formicaries was that of the large blue-black Formica. I first struck the galleries of this ant four feet beneath the surface, but thereafter traced them within four inches of the surface and downward for a distance which I do not find noted. The entrance I did not find, although it was diligently sought after the discovery of the colony. It was probably beyond the limits of the pavement, and had been cut away by the pick in the first approaches. The Formicas occupied the central and eastern part of the excavation, as shown in the section view—which is only a partial exhibit—drawn at Pl. XIII, fig. 106. The architecture was less regular than that of Occidentalis—which may well have been the result of necessity rather than natural habit—but showed, nevertheless, distinct arrangement in series or stories of rooms. These were carried thirty inches across the cutting at one point, apparently by one general gallery, of which we obtained an unbroken exposure of eighteen inches (fig. 106, F^1) besides contiguous chambers. The galleries were larger by one-half than those of Occidentalis, and the rooms higher and deeper; one was seven inches deep, the measurement, of course, being that of the exposed portion alone. The rooms communicated with each other, and were crowded with workers, callow ants and grubs. A glance at the figure will show the remarkable manner in which these chambers and galleries

(marked F) were placed *side by side, and in the very midst* of those of the Occident Ant (marked P). One of these (F^2), located in the heart of the nest, and full of larvæ, was just above and flanked on each side by granaries (P, *s*) of Occidentalis, packed with seeds. Another opening higher up (F^3) was literally surrounded by rooms of Occidentalis. I have rarely seen so curious a study as that presented by these interblended interiors.

My miner assistant might well raise the question, "Which of these fellows 'jumped the other's claim?'"—the Colorado vernacular for who was the intruder, and who the original possessor? The ants seemed to be of such equal vigor, and the architectural achievements of both so considerable, that the problem was a difficult one. My own inference is that Occident was first upon the field; that later Formica established a colony in the near vicinity; that the two communities grew, and, mutually expanding their bounds, approached each other, and thenceforward held the ground together. The whole arrangement and relative position of the rooms and galleries show that there must have been such a contemporaneous growth. But, then, the interesting queries arise: By what peculiar gift were the two species enabled to so guide their lines of engineering that they never conflicted? Or, did they conflict? I could find no traces of the intercrossing of openings or the impinging of chamber walls; closely as these approached, they seemed to be entirely distinct. What legal issues, what local battles and bloodshed have resulted from trespasses on boundaries made in the gold and silver mines of the human neighbors and fellow-miners of these insects, Coloradoans know too well. Were the emmets more peaceable and tolerant of each other than the men? or, would the secrets of their subterranean abodes, if given to Natural History, uncover scenes of dreadful conflict and death?

Certainly, there was nothing to indicate a state of warfare. As pick, trowel or knife uncovered the rooms one after another, both species were surprised in the midst of their ordinary duties, and showed by all those indications which the experienced eye learns to read, that the fury of war was not upon them, and that they were wholly engrossed in the peaceful labors of domestic life. It was only when by some more careless stroke of the pick rooms or

galleries of the two species were forced together, and when the crumbling earth precipitated the insects into the trench, that the polemic possibilities appeared. Then Blacks and Reds grappled in hot strife and fought with utmost fury. The powerful sting of the Occidents was brought into service, as the combatants rolled, struggling, in the soil, and the sharp mandibles did well the work of the French guillotine, as witnessed by the decapitated trunks of Formicas quivering in the trench, leaving the severed head (at times) still clinging to the Occident foe by jaws clasped in the rigor of death.

These battles clearly established the fact—which was indeed shown by the independent architecture—that no such relation existed here as in the compound nests of slave-making species, but that the ants preserved toward each other the normal attitude, and that one nest was parasitic upon the other. Moreover, it appeared to me, beyond any question, that had Occidentalis been so disposed, she had the superior power to drive Formica from her territories—a power which might have been exerted from the outset, but would have sufficed even when the colony of Formica had developed the proportions at which I found it. That this was not done is another indication of the general good nature of our Occidents.

Another testimony is of such a nature that while collecting it I was sometimes tempted to lose patience with the unreasonable forbearance of my Occident friends. There was scarcely a formicary which came under observation, from first to last, that had not upon the clearing one or more colonies of the Erratic Ant, *Dorymyrmex insanus*, Buckley, or of a new species or variety, *D. flavus*, Macook.[1] Usually there were two or three nests, sometimes four, located upon different parts of the pavement. These are small moundlets of fine soil, surrounding a central opening, which leads into an irregular series of galleries and chambers. The same insects are parasitic upon the disks of the Agricultural Ant in Texas, and exhibit there characteristics similar to those in the Garden of the gods. They are small, very active, irritable, intensely pugnacious and courageous to the last degree. They

[1] See Professor Comstock's Report upon the Cotton Worm, U S. Agricultural Reports, 1880.—ANTS.

are the *terriers* of the emmet tribes. The manner in which these little fellows bullied and badgered their Occident hosts was amusing, and indeed, amazing. An incident or two will illustrate this behavior.

One large hill of Occidentalis which had been badly damaged by the wash of heavy rains was the scene of active rebuilding operations. Four nests of Dorymyrmex were established on the pavement, one of them quite near a centre of operations in one of the main avenues or tracks by which the ordinary workers had ingress and egress. At the time my notice was first fixed upon them an incessant warfare was being waged by them upon their big neighbors. Every Occident that essayed the passage, to or from the ground, was attacked. Squads of the little Erratics surrounded their single little gate, and at the advent of one of the Occidents the nearest warrior flung herself with unhesitating promptness upon the unconscious intruder. That she was alone, that there was such disparity in size between her and her adversary were facts that evidently had no part in her calculations. It was curious to note the effect upon Occidentalis. She stopped instantly, drew her feet closer together, stiffened the legs, thus raising her body well above the earth (Pl. XII, fig. 99), bowed her back, elevated her head, stretched out the sensitive antennæ as though to guard them especially from harm, opened the mandibles, and, in fact, presented an amusing likeness to the attitude of a cat at the first onset of a dog. The fore-leg, upon which the Erratic had seized and which had instantly been raised, was then violently shaken, and the little assailant rolled upon the ground. Thereupon Occident unbent herself, and resumed her way, but had scarcely started ere her tormentor was again upon her, followed by another and another, until her body was dotted with them (Pl. XII, fig. 96). They grasped her feet, fastened upon the under parts of her abdomen, mounted her back, seized her antennæ. They could not be shaken off. She snapped at them with her strong jaws, struck at them with her claws, doubled under her abdomen and thrust at them her barbed sting. Some were crushed, some thrown off, but others came to the assault, and anon the warring mass rolled upon the ground a whirling ball of black and red, of quivering antennæ and legs. At last the

Erratics were thrown off, or released their hold, and Occident retired to a safe distance, combed out her ruffled hair, and finally passed by on the other side. Such is a fair record of one of the constantly occurring incidents of this strange warfare.

Some of the Occidents as soon as they approached the Erratic bounds, paused as though discerning the state of affairs, and stood quite still, evidently reconnoitering the hostile quarters. The pause was fatal, for they were at once attacked by the vigilant Erratics, who sallied forth to a goodly distance upon the avenue. Others, again, seemed to recognize the adage that discretion is the better part of valor, and made a wide detour of the skirmish-line of the little vixenish raiders. It was very evident that the Occidents thoroughly know the qualities and temper of their tiny guests, and regard them with great fear. The result of the species of guerrilla warfare above described was most remarkable. The next morning upon visiting the ground, I found that the Occidents had entirely abandoned their old avenue, had cut down and around the Erratic colony, and made an opening on the edge of a slight ridge several inches beyond the disputed territory, but still in the line of the avenue which they had been using in their work! A tithe of the pains required for this task would have literally cut out and carried away the whole nest space of the Erratics, whose scant numbers of diminutive warriors could have been overwhelmed in a moment by the legions of their huge hosts. That this would have been the policy, under like circumstances, of most ants of my acquaintance, I have no doubt. Subsequently, it appeared that the Occidents made a curious sort of retaliation upon their wee tormentors, for I found the nest of the Erratics literally buried under the dirt excavated from the new gangway; a fitting punishment for the little churls, who, however, would soon cut their way out.

This represents the invariable relations between these two species, when for any reason Dorymyrmex was pleased to be belligerent. There was a literal repetition of the above behavior at the opening of Excavated Nest No. 2. The Occident workers, hurrying away from the ruins of their nest, carrying larvæ, or bustling forth to seek and repel the unknown enemy who was agitating their home, with that rage upon them which is excited

in ants by such an invasion—even then would allow themselves to be checked in their path, and driven away from the vicinity of the Erratics by those pugnacious creatures. It would be hard to conceive a more striking exhibition of forbearance—one cannot truly say cowardice—than this.

Only one other illustration will be cited. The nest from which was drawn the series of rooms at Pl. XIII, fig. 101, was opened by horizontal sections. The cone was cut away little by little to obtain horizontal exposures of the storerooms. None being found in this cone, the sections were continued beneath the ground surface. In taking plaster casts of the rooms figured in the plate, the openings had to be oiled. The next day the Occidents had already begun the work of reconstruction; but meanwhile the grease with which the soil was saturated, and of which ants are usually very fond, had attracted swarms of another species, a black ant of medium size, which is probably a new species, and which I have described in my notes as *Fœtidus*—the Fœtid Ant—on account of a strong, and very disagreeable odor which it emits. These Fœtids are curious creatures in many respects, and were nested in immense numbers in the Garden of the gods. Hundreds of them were clustered over the greasy floors of the uncovered rooms, and a double column, leading to and from them, stretched away across the ridges for many feet. For the most part they were permitted to banquet in peace. The Occidents pushed on their repairs without disturbing the ill-smelling harpies who had swarmed upon the ruins of their home. Here and there, however, an intruder had overstepped the bounds of even Occidental patience, and was being vigorously handled for the same. These conflicts, however, awakened no martial zeal among the Occidents; the fighting was confined to the two original combatants, and in one case I caught a sketch (Pl. XII, fig. 97) of such a duel, waged at the very door of a gallery, from which workers were continually carrying pellets of earth, and entering again with entire unconcern. The figure shows one of these workers peeping out of the gallery and regarding the duel with unruffled composure. Perhaps she had become so humanized as to be saying within herself: "Well, this is no affair of mine; it's the business of the police!" Certainly, at least it is not the usual behavior of ants, so far as I have observed.

These facts are all the more noteworthy because the Occident Ant has been endowed by nature with one of the most formidable offensive and defensive weapons known in insect anatomy. Her genital armature may be said to be an exact reproduction of that of the Agricultural Ant.[1] It consists of two barbed chitinous rods or needles, which are alternately operated back and forth, within a hollow case, by means of a series of compound levers. The stinging implements are lubricated on the one hand by an oil-gland, or accessory organ, and on the other by a poison-gland or sac; both of these glands communicate by a duct with the sting-case. Thus the barbed sting, when thrust into animal tissues carries with it the poisonous secretion, whatever it may be, which makes the wound inflicted so poisonous and painful.

I tested the stinging powers of Occidentalis upon my own person. Some of the ants collected in Nebraska were taken living into the railroad car, and the leisure of travel improved by experimenting upon the effects of the sting. The results were not different from those obtained from similar experiments with Barbatus. An ant was placed upon my wrist near the base of the thumb. She was sufficiently irritated by her kidnapping to be quite in condition for the experiment, and immediately grasped the skin with her mandibles and feet, bowed her back, bent under the abdomen, and thrust the sting into the tissues at an angle of about 45°. The action was rather deliberate than hasty and passionate. A sharp pain followed the wound, which was succeeded at brief intervals by like sensations. The skin gathered into a circular elevation, half an inch wide and quite colorless, immediately surrounding the puncture. The region immediately surrounding was very numb, and the feeling extended as far as the elbow. These pains were accompanied by a peculiar action of the heart which I do not know how to describe, except as a painful fluttering or quivering. In fifteen minutes the whiteness of the parts adjacent to the wound was succeeded by a redness which extended in small blotches along the thumb and around the wrist for a space of two and a-half inches long by two inches wide. There was a burning sensation in the parts, accompanied by a

[1] Agl. Ant, ch. xi, p. 163, and Plates. The reader will find there the anatomy fully given.

severe heavy pain; the flesh was very sore to the touch. An hour after the infliction of the sting the pains were intense; they were rhythmic, that is, they were not continuous but came in short paroxysms. What I have noted as "cooling sensations" characterized the wound at this stage.

I had abundant opportunity afterward, when excavating nests, to verify these sensations, as I was severely punished on several occasions. The sting of Occidentalis is fully as severe as that of the wasp, I hardly think that it is quite as serious as that of the Agricultural Ant.

Finally, if forbearance be a virtue, which is all the more eminent when exercised by those of superior powers toward their inferiors, surely the subject of this history may be accounted the possessor, in an eminent degree, of a quality which, in the mentalism of the emmet world, must lie hard by the analogue of virtue.

Description of Species.

Genus **POGONOMYRMEX**, Mayr.

(Formicidæ Novæ Americanæ, Annuar. d. Societ. dei Naturalisti. Anno III, Modena, 1868.)

P. occidentalis.

1865. *Myrmica occidentalis*, Cresson, ♀ ☿, Proceed. American Entomol. Soc. Phila., p. 426–7.

1865. *Myrmica seminigra*, Cresson, ♂,[1] Proc. American Ento. Soc. Phila., p. 427–8.

1870. *P. opaciceps*, Mayr, ☿, Neue Formiciden, Verhand. d. k. k. zool.-botan. Gessel. Wien, p. 971.

1875. *P. opaciceps*, Norton, Wheeler's Report Explor. and Surv. U. S., vol. v, Zool., p. 735.

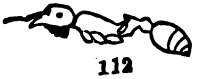
The technical descriptions are well given by Cresson and Mayr in the works above cited, and reference may also be had to my description of *P. barbatus*, p. 208, Agricultural Ants. I give, however, a brief description for the general reader, and mark the differences between this species (*Occidentalis*) and *Barbatus*.

The formicaries are composed of two castes or forms of worker ants, the worker-major (☿+) and worker-minor (☿—); the fertile queen (unwinged), numerous winged, virgin queens (♀), and males (♂) who are also winged and apparently more numerous than the virgins. Besides these are large numbers of larvæ and pupæ, who are naked, *i. e.*, never enclosed in cocoons, as with many species of ants; and callows or young antlings in various stages of induration of skin, from pure white, through divers shades of yellow to a light yellowish brown. They do not ordinarily seem to get the normal claret-brown color of the mature workers until they are exposed to the sun. I occasionally found yellow and yellowish workers outside the nest, who were evidently callows on their earliest journeys from home. Exposure to the sun doubtless hastens the "tanning" of the skin, but I have reason to believe that the normal color will by and by come to the antlings even if confined in the shade.

The worker-major is 8 mm. (five-sixteenths of an inch) long, the worker-minor 6·5 mm. (four-sixteenths of an inch). There is a

[1] Mr. Cresson described the male as a new species, but added the correct conjecture: "This may be the male of *M. occidentalis*."

111



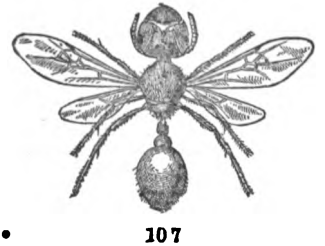
112

Fig. 111.—Worker-major, *P. occidentalis*, dorsal view. Fig. 112.—Same, side outline.

corresponding difference in body proportions, except that the head of the major is larger proportionately than that of the minor. In both castes the head is nearly three times the width of the pro-thorax. (Figs. 111, 112, are nearly three times the natural size.)

As compared with the workers of Barbatus, there is no perceivable difference, excepting size; the major of Occidentalis corresponds almost exactly with the minor of Barbatus.

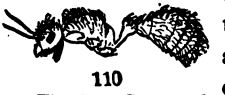
The female of Occidentalis closely corresponds in appearance with that of Barbatus, although the latter is much larger, being a full half-inch long (15 mm.), and proportionately large, while Occidentalis ♀ is thirteen thirty-seconds of an inch long (11 mm.), or four millimeters shorter, and smaller proportionately.



107

109

108



110

Fig. 107.—Virgin queen of *P. occidentalis*. Fig. 108.—Same, side outline. Fig. 109.—Male of same. Fig. 110.—Male, side view. Figures nearly twice natural size.

The spines of Occidentalis are somewhat the sharper of the two; but the most characteristic difference is in the venation: Occidentalis has 3 costal, *3 subcostal*, 3 median, 3 submedian and 1 internal cells; this corresponds with Barbatus, except in the subcostal cells, which are *only 2 in number*.

The male of Occidentalis is nine thirty-seconds of an inch (8 mm.) long, while Barbatus ♂ is thirteen thirty-seconds (11 mm.), the length of the Occident queen. Occident ♂ has the head and thorax quite black or blackish (hence Cresson's name *Seminigra*), while Barbatus ♂ is of a uniform reddish brown, corresponding with the workers and ♀ of both species. Occident ♂ is covered thickly with long, soft hairs, as is also the ♂ of Barbatus.

PLATES

AND

EXPLANATION OF PLATES.

Plate XI.

Fig. 83. Gravel-covered cone nest of the Occident Ant, showing the location of the gate and the clearing or pavement made in the midst of the gramma grass of the Plains. The openings between the clumps of this grass serve as roads for the workers. Diameter of nest space, 7 feet 3 inches. Some clearings measure 18 feet. Page 128.

Fig. 84. Cone-disk nest of the Agricultural Ant of Texas, showing the roads. Distance across disk, 8 feet. Page 134.

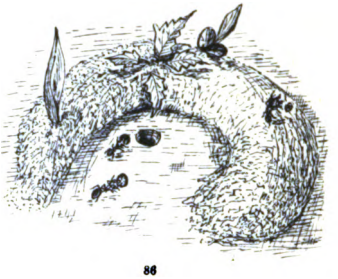
Fig. 85. Plane-disk nest of Agricultural Ant, with roads into the harvest grounds. Diameter of disk, 11 feet. Page 130.

Fig. 86. Surface nest and gate of *Pheidole pennsylvanica*, the Pennsylvania harvester. Diameter, 3 to 4 inches. Page 148.

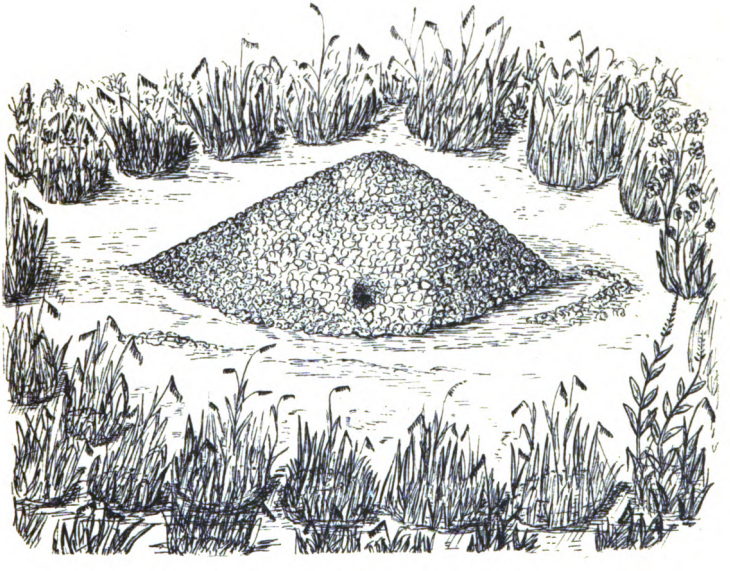
Fig. 87. Single gate of Occidentalis. Page 135.

Fig. 88. Double gate of Occidentalis. Page 135.

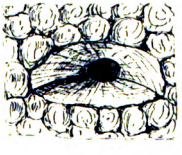
85



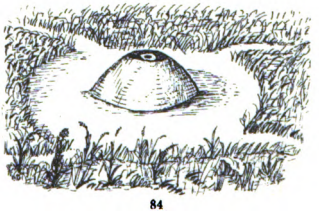
86



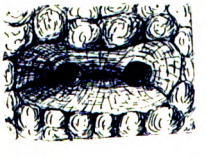
83



87



84



88

Plate XII.

Fig. 89. View of a gateway on nest of Occidentalis after being closed for the night. Pages 137, 140.

Fig. 90. Another view of the same. Page 140.

Fig. 91. Worker carrying a pebble held in front of the body. Page 132.

Fig. 92. Worker carrying pebble slung under the body. Page 132.

Fig. 93. Worker engaged in harvesting seeds from the head of a wild sunflower. Page 147.

Fig. 94. Gate-closer making her final disappearance before shutting up for the night. Page 138.

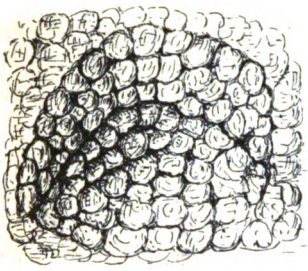
Fig. 95. Another view of the same. Page 138.

Fig. 96. Worker assaulted by Erratic Ants. Page 156. (The latter are shown somewhat too small; they are from one-fourth to one-fifth the length of the Occidents.)

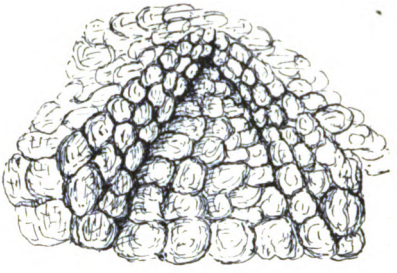
Fig. 97. A mining worker complacently watching a duel between a comrade and a Fœtid Ant. Page 158.

Fig. 98. View of a part of a granary, one-half natural size. Page 144.

Fig. 99. Worker when first attacked by the Erratics. Page 156.



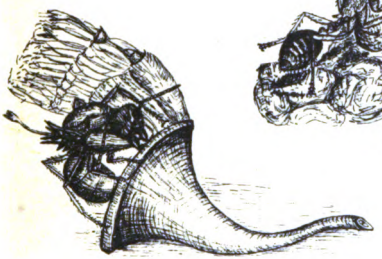
89



90

92

91



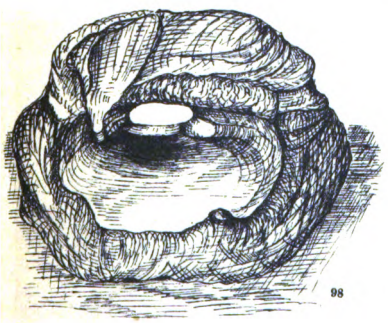
93

94

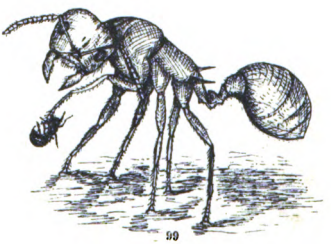
97

96

95



98



99

Plate XIII.

Fig. 100. View of granary, Occident Ant, showing seeds, and a connecting gallery. Page 144.

Fig. 101. Horizontal or sloping section of a nest, showing suites of rooms, AA, BB, CC, DD, arranged one above another, in irregular terraces. Galleries are shown here and there. This represents the floors of a connected series of storerooms and chambers. Page 144.

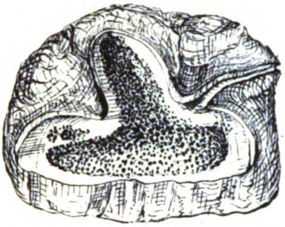
Fig. 102. A storeroom of *Pheidole pennsylvanica* from the nest, Fig. 86. *g*, indicates the location of the gate-gallery. Rooms 2¼ inches long. Page 149.

Fig. 103. Another view from same nest, showing connecting storerooms and galleries. Rooms 1½ inches long. Page 149.

Fig. 104. A vertical section view of an excavated nest of Occidentalis, showing the arrangement of rooms in stories and the depth to which the rooms extend. The figure represents a vertical surface 8 feet deep. The last room found containing seeds is marked at *x*. Page 145.

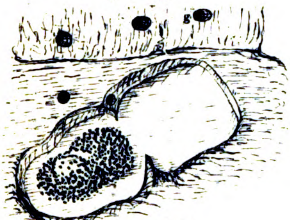
Fig. 105. A vertical section of same on a larger scale, to show connection of galleries, *g*, with rooms. *a*, Storeroom with seeds. *b*, A dumping-room (p. 149) filled with gravel. Page 144.

Fig. 106. Co-operative housekeeping. Section view of a nest of Occidentalis whose rooms intermingled with those of a large species of Formica. P, rooms of Occidentalis. F, F^1, F^2, F^3, rooms of the Formica. Page 153.



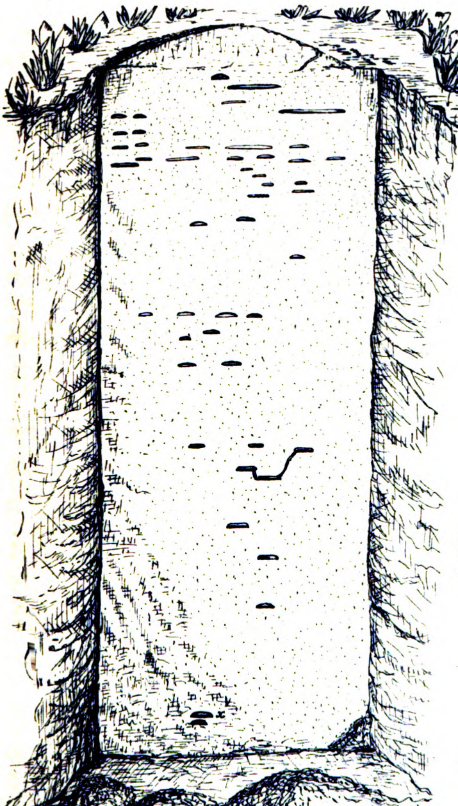
100

101

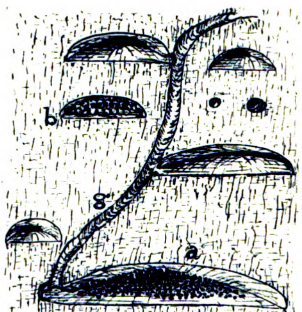


102

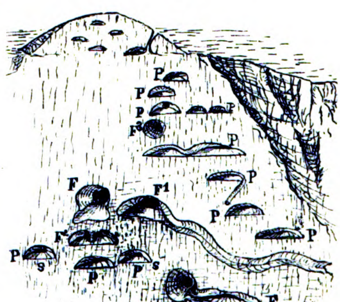
103



104



105



106

APPENDIX.

NOTE A.

ADDITIONAL OBSERVATIONS ON THE OCCIDENT ANT.

I requested Mr. Russell Hill, of Philadelphia, who was about to visit Kansas and Nebraska on a scientific expedition, to note such facts in the distribution and economy of the Occident Ants as might occur. A brief placed in my hands by him, was mislaid and only recovered in time to give it place in an Appendix. He first observed ant-hills at Cawker City, on the river bottom lands. They were not very large and were built of sand, pebbles and pieces of sticks and weeds, about one inch in length. About three miles west of the same place he saw one hill three feet long, one foot in diameter, and one foot high. These hills were probably the nests of *Formica aterrima* Cresson (*F. obscuripes* Mayr), the American form of or close ally to the European *F. rufa*.

Near Kirwin, a nest of Occidentalis, as attested by specimens collected, was found on the surface of a "slide" of cretaceous formation. The gravel-roof was formed of pieces of blue shale of which the formation consists at that point. On the way up the Sappa Creek several large ant-hills were noted, the circle of clear ground surrounding one of which measured *fourteen feet in diameter.*

Six miles west of Cedar Bluffs, in Decatur County, Kansas (lat. 40° N., long. 100° W.), specimens were collected from a hill *composed of soil alone.* This was a notable exception to the otherwise uniform observations of gravel-covered cones. It simply shows that a colony has been founded upon soil wherein was no gravel, or that the galleries had not yet penetrated to the pebbles (see p. 130 above). A portion of this hill was accidentally broken, and an hour afterwards it had been partially *repaired with small pieces of dried grass* about one and one-half inches long. This confirms the opinion recorded p. 143 above that the ants

bind their masonry with straw, as did the ancient Egyptians. The analogue in the behavior of modern men is the mixing of hair in mortar.

Mr. Hill further noted the presence of ant-hills on Blue Creek, Lincoln County, Nebraska (lat. 41° N., long. 101° W.); and on the top of a divide in Hitchcock County, Nebraska (lat. 40° N., long. 101° W.). The last named point was that (page 131) at which the roof of the nest was composed of fragments of fossil bones and shells.

NOTE B.

ON THE ECONOMY OF THE HONEY-BEARER CASTE OF THE HONEY ANTS.

The importance of the experiment recorded pp. 51–2 above, justifies the insertion here of one or two details which were overlooked. The ants were last fed October 4, 1879, and the nest was opened February 7, 1880. Thereupon one worker-major, with abdomen of healthy proportions, was placed in another nest. She stationed herself, as though perfectly at home, upon a clod covered with sugar. Instead, however, of immediately feeding she deliberately assumed a sort of squatting position, back bowed, abdomen touching the ground, head drooped, legs drawn up, and seemed to sleep. She permitted me to freely stroke her with a feather. A second worker had her abdomen distended to about one-half, and another about two-thirds the proportions of the full rotund. Both went down below without attempting to eat. Their four months' seclusion from food and friends had issued neither in hunger nor alienation.

NOTE C.

ON REGULATING THE CONICAL FORM OF THE NEST.

The suggestion is raised on page 144, that the interior arrangement of the formicary of Occidentalis may result from the unconscious action of the muscles working, according to the laws of animal mechanics in the lines of greatest advantage. The question has been asked, May not the conical form of nests in like manner have been formed unconsciously? It is indeed possible that in dumping the gravel brought up from below, gravitation

has naturally influenced the position of the pebbles and the form of the cone. But all my observations (I cannot recall any exception) are to the effect that the miners carry the pebble to and deposit it upon the spot where it finally rests. I have frequently seen the stones carried up the cone, across, around it, in all directions. Indeed it is obvious from the position of the gate near the base, that the bulk of the gravel roofing must have been carried in this way, contrary to gravitation. This is doubtless true even allowing for gates of convenience (or "man-holes") during active work. Thus the volition of the worker would appear to be the chief element in shaping the conical form of the nest.

NOTE D.

LIST OF THE AUTHOR'S PAPERS AND NOTES ON ANTS.[1]

I. *In Proceedings of the Academy of Natural Sciences of Philadelphia.*

No. 1.—1876. P. 199. Note on the Habits of *Formica rufu* (*F. Exsectöides*). Abstract of observations in No. 17 below.

No. 2.—1877. P. 134. On the Vital Power of Ants, pp. 4. Examples of survival under exposure to severe cold, of *Camponotus pennsylvanicus* and *Formica exsectöides;* endurance of extreme heat, by *C. pennsylvanicus* and *Pogonomyrmex barbatus;* survival after submergence in water, of *Formica sanguinea*, a species of Myrmicidæ, and *P. barbatus.*

No. 3.—1877. P. 299. Agricultural Ants of Texas, pp. 6. First announcement and abstract of observations of this ant, subsequently published in the book of that title.

No. 4.—1878. P. 15. The Mode of Recognition among Ants, pp. 5. Results of Experiments with *Tetramorium cæspitum* and *Camponotus pennsylvanicus;* is recognition of friends and foes by sense of smell?—effects of a strong alien odor (as cologne) to neutralize combativeness.

No. 5.—1878. P. 119. Toilet Habits of Ants, pp. 4. First announcement and abstract of observations contained in Chap. viii of "The Agricultural Ants of Texas."

[1] The publication of these titles was suggested by various inquiries for such a list, which are thus answered "in bulk."

No. 6.—1879. P. 33. Cutting or Parasol Ant, *Atta fervens*, pp. 8. Observations on the Cutting Ants of Texas. Exterior architecture of nests; gates or doors, modes of opening and closing; leaf-cutting habit; division of labor; plants collected by them. Interior architecture, leaf-paper combs or cells; tunneled tracks and caves; difficulties of origin of castes by evolution.

No. 7.—1879. P. 137. Note on the Adoption of an Ant Queen, p. 1. A queen of *Crematogaster lineolata* adopted by a separate colony of same species.

No. 8.—1879. P. 140. Mode of Depositing Ant-Eggs. Brief note on queen of *Camponotus pennsylvanicus.*

No. 9.—1879. P. 140. Note on the Marriage-flights of *Lasius flavus* and *Myrmica lobricornis*, pp. 4. Also reference to swarming of *Polyergus lucidus* and *Camponotus esuriens.*

No. 10.—1879. P. 154. Note on Mound-making Ants, pp. 3. Some new observations on the habits of *Formica exsectöides*, workers gnawing off the bark of yellow pine; sense of direction, a worker brings an insect home through the grass in a direct line 126 feet; preying on White Ants, *Termes flavipes;* abandoned nests; closing gates at night.

No. 11.—1879. P. 156. Combats and Nidification of the Pavement Ant, *Tetramorium cæspitum*, pp. 6. Warfare described; funeral habits; character of nests; economy in nature of ants, contributions to fertilizing the earth; drainage of nests.

No. 12.—1879. P. 197. On Myrmecocystus mexicanus, p. 1. Brief note announcing observations given fully in No. 15.

No. 13.—1880. P. 359. Note on a new Northern Cutting Ant, *Atta septentrionalis*, pp. 5. Observations upon nest architecture, with figure; compared with Texas Cutting Ant; Rev. Geo. K. Morris' observations on garnering pine leaves; description of species.

No. 14.—1880. P. 376. The Shining Slavemaker. Notes on the Architecture and Habits of the American Slave-making Ant, *Polyergus lucidus*, pp. 9, one plate. Nest described; slave

species, *Formica Schauffussi;* migration, slaves deporting masters; mode of carrying a queen; muscular power; marriage flight; masters' helplessness in all but war; toilet habits; war with *Formica sanguinea;* raids; difficulty in accounting for above facts by natural selection; distribution, Colorado specimens, compared with European *P. rufescens*, Huber's Amazon Ant.

No. 15.—1881. P. 170. The Honey Ant of the Garden of the gods, pp. 60, with ten plates. Original paper published in book form. See No. 22.

II. *In Transactions of the American Entomological Soc. Phila.*

No. 16.—Vol. V. 1874–76. P. 277. Notes on the Architecture and habits of *Formica pennsylvanica*, the Pennsylvania Carpenter Ant, pp. 13, three plates. A quite full description of the economy of *Camponotus pennsylvanicus.*

No. 17.—Vol. VI. 1877. P. 253. Mound-making Ants of the Alleghanies, their Architecture and Habits, pp. 45, five plates and five cuts. Also a small number of copies for sale under the above title, by John A. Black, No. 1334 Chestnut Street, Philadelphia. Price $1.00, delivered by post.

No. 18.—Vol. VII. 1878–9. Monthly Proceedings, p. xxii. Note on exhibition of formicaries of living Honey Ants, and Announcement that *Pogonomyrmex occidentalis* is a harvesting ant.

III. *Miscellaneous.*

No. 19.—1878. American Naturalist, Philadelphia, p. 431. Mound-making Ants of the Alleghanies, pp. 15. Abstract of Paper No. 17.

No. 20.—1880. On Certain Ants associated with the Cotton Worm, pp. 8, thirteen figures. Report on Cotton Insects, by T. Henry Comstock, Entomologist U. S. Department Agriculture, p. 182. Notes on Economy, with descriptions of *Dorymyrmex insanus* (*pyramicus*), *D. flavus*, *Iridomyrmex McCooki*, *Crematogaster lineolata*, *C. clara*, *Solenopsis xyloni* n. sp. (?) *Monomorium carbonarium.*

IV. *Published Volumes.*

No. 21.—1879. The Natural History of the Agricultural Ant of Texas. A Monograph of the Habits, Architecture and Structure of Pogonomyrmex barbatus. Author's edition. Academy of Natural Sciences, Anno Domini 1879. (This edition is exhausted.) Pp. 311, xxiv full page plates.

The same title and work as above. J. B. Lippincott & Co., Philadelphia, Publishers. Price $4.00.

No. 22.—1882. The Honey Ants of the Garden of the gods, and the Occident Ants of the American Plains. Pp. 188, xiii plates. Philadelphia, J. B. Lippincott & Co., Publishers. Price $2.50.

INDEX TO FIRST PART.

H.

I.

K.

L.

M.

INDEX TO SECOND PART.

H.

I.

K.

L.

M.

N.

PROSPECTUS.

AMERICAN SPIDERS

AND

THEIR SPINNING-WORK.

A NATURAL HISTORY OF THE INSTINCTS AND INDUSTRY OF THE SPIDER FAUNA OF THE UNITED STATES; TOGETHER WITH AN EXPLANATION OF THE SYSTEM OF CLASSIFICATION, AND DESCRIPTIONS OF COMMON SPECIES.

BY HENRY CHRISTOPHER McCOOK.

The author is now ready to begin the publication of the above work, which will embrace studies of Spider Life, extending over a period of ten years.

The book will be printed in full quarto form, with the best and most suitable paper, typography and binding, and will be illustrated by *several hundred cuts*, besides lithographic plates of the species described, colored as in Nature. It will be issued in three parts, each part *complete in itself*, containing from one hundred and fifty to two hundred pages, more or less.

The "Author's Edition" will number one hundred and fifty copies, and will be furnished to *subscribers only* at *five dollars per part* delivered by mail in America and Europe. Should the demand for the book exceed this edition, additional copies will be furnished for *twenty dollars* for the complete set with colored plates, or fifteen dollars plain.

Numbers will be furnished, to those who prefer, well bound in plain cloth, paper label, uncut edges, at a cost of sixty cents additional on each part. Payment will be made on each part as delivered.

☞ The work of publication will begin when *one hundred copies* are subscribed for. Part I will embrace studies upon the Orbitelariæ—Orbweavers.

☞ The author hopes for a *prompt response* from Societies, Libraries and individuals who may purpose to subscribe for the above work.

Address, naming style of binding desired, and giving name in full and post-office address distinctly,

HENRY C. McCOOK,
ACADEMY OF NATURAL SCIENCES,
Philadelphia, Pennsylvania, U. S. A.