NOTES ON THE LIFE HISTORY AND HABITS OF THE MOUND-BUILDING ANT, FORMICA ULKEI EMERY

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INTRODUCTION

In two sections of the Cook County forest preserve near Chicago, there occur two very large groups of colonies of the ant, Formica ulkei Emery. These colonies are located at Palatine and Palos Park, Illinois. The enormous mounds which these ants build attract the attention of anyone passing through these woods. Yet, curiously enough, very little has been known about the life history and habits of this species, and nothing at all about its hibernation, a life history phase of special interest to the writer. The enormous number of individuals in each nest, the availability throughout the year, the ease with which the ants could be maintained in the laboratory, made them very favorable material for study. Accordingly, observations were begun on their life history, concentrating especially on the hibernation phases. The notes on the life history and habits are herewith presented, while the hibernation studies will be included in another paper.

GENERAL METHODS OF STUDY

The study of these ants was begun in the fall of 1924. Throughout the fall, winter, and spring of 1924–25, the nests at Palatine were visited every ten days. The prime purpose of these regular field trips was to obtain information on the over-wintering phenomena. The nests were penetrated usually to soil water level. Specimens of ants and other inhabitants of the nests were collected for examination and identification, and for various physiological experiments; the character of the nests was noted and such life history and habit data collected as came to light. In addition to these trips, a number of trips were taken at irregular intervals in the summer of 1926 to both the Palatine and the Palos Park colonies in order to gather further life history data and to study their habits during the active season of the year.

Several artificial nests were established in the laboratory. These nests furnished most of the data on egg laying and rearing, and some of the observations on the habits of the ant. For maintaining ants in large numbers, a pan was constructed of galvanized tin about 12 inches square and about

1 This work was done at the University of Chicago. I am indebted to Dr. W. C. Allee for his aid and interest.

2 Identification by Dr. W. M. Wheeler. The description of the species may be found in Wheeler, 1913, pp. 481–484.
2½ inches deep. In the center was a water-tight, walled-in area, 6 inches square, in which soil and ants were placed. Around this was a water moat about 3 inches wide to prevent the escape of the ants. It was soon found advisable to hang strips of tin bent in appropriate fashion on the edge of the ant chamber or nest proper on all four sides. These strips provided convenient return paths for the ants which fell over the edge of the chamber in their excited activity when disturbed, and so prevented an appreciable loss by drowning. The ant chamber was covered by a loose, opaque cover so that evaporation from the soil might be reduced to the minimum. These nests were well suited for stock nests, but were poorly adapted for close observational work because of their depth and because the soil necessary in the nests interfered with the vision.

The nests devised by Miss Fielde (Wheeler, '26, pp. 551–554) were tried out for smaller groups of ants requiring more detailed observation. These nests are made of two glass plates supported by glass strips glued around the border of the bottom plate, so that the ants are at all times visible. Such nests are, however, inconvenient when one wishes to feed the ants, clean or otherwise enter the nest, since the much too lively ants often escape before the covering glass plate can be replaced. This type of nest was not used extensively.

The most convenient method for close observation of small groups of ants proved to be the finger bowl nest. This consisted of a finger bowl with moist blotting paper covering the bottom, and another folded piece of moist blotting paper under which the ants could crawl; a glass plate covering the finger bowl prevented the escape of the inhabitants. To feed the ants or to clean the nest, it was only necessary to set the finger bowl in a shallow basin of water before removing the glass plate.
All the laboratory ants were fed various types of food, but the ones that proved most attractive were apple, banana, honey and other insects. All the nests were kept at room temperature.

The description of the species given by Wheeler ('13) need not be repeated, but attention is called to the mandibles of the male which have been described as edentate, but in all those examined three teeth were present as shown in figure 1. Plate VI shows the relative size and proportions of the various castes occurring in this species.

**Ecology**

Formica ulkei has been reported from Wisconsin, South Dakota, Illinois, Nova Scotia and New Brunswick. "This species is evidently peculiar to the Canadian fauna and so rare in the transition zone that I have never had the good fortune to find one of its colonies," writes Wheeler ('13, p. 487). In Illinois, it has previously been reported only from the Chicago region. And here it occurs only in the two places already mentioned, Palatine and Palos Park. These two habitats are about forty miles apart, but are so similar that they can be described as one.

The forest in which the ants occur is of the oak-elm-hickory type, still in a natural state though not virgin forest, occurring on a series of low hills with low, ponded areas scattered through the woods. Some parts of the forest are rather dense with underbrush and high weeds; other parts are more open. The ant nests are in the more open places, some along the edges of the low areas, others on the higher ground. Plate VII, Fig. 1 shows a portion of the woods adjoining a low spot. Five mounds may be seen at the edge of the woods. There seems to be a careful avoidance of the deeper, shaded parts of the forest, so that all nests are exposed to the sun at least a part of the day. No nests occur in the fields and pastures adjoining the ant-inhabited sections of the woods. The confinement of the nest locations to the woods is very striking. A small section of the woods, less than an acre in extent, was found separated from the main body by a strip of low meadow only about thirty yards wide. Although there were a number of nests in the main body, only two colonies had established themselves in the small isolated woods. Even this small strip of open meadow acted as a partial barrier. Only one instance of a nest outside of the woods came to my attention. It was located across the road from the forest edge along the fence surrounding a meadow, but was completely surrounded by high weeds and a small amount of shrubbery. All these facts indicate that this species is limited to the open forest and the forest margin.

The forest floor is covered with decaying leaves, grass and weeds. The soil is black, rich loam underlain with a layer of yellow clay several feet deep. The surface soil is acid. The soil water level fluctuates with the season, but is always near the surface, from a foot to five or six feet in depth, depending
on whether the nests are located on high or low ground. Because of this close proximity of the soil water to the surface, the nest is kept rather moist throughout the year, though in dry seasons the mound may become dry and hard.

THE NEST

*Formica ulkei*, like *F. exsectoides* of the eastern states, which it resembles in appearance and habits, builds a prominent mound out of the excavated soil and debris of the nest. (See Plate VII.). These mounds vary greatly in size. The youngest nests observed are about one foot in diameter, while the older, more heavily populated ones may have a mound several feet in diameter (the largest seen was nine feet long, seven feet wide and two feet high). Usually, the mounds are circular, but the largest are nearly always elongated. The apex may be pointed or rounded. The mound of the smaller, younger nests is usually covered with grass, but this is seldom the case with the larger, well-populated nests. Numerous holes occur on the surface of the mound, not in the form of craters, but mere openings in the surface.

A large number of nests have been entered and the inner architecture noted. The material composing the mound is largely excavated soil (mixed loam and clay). On the surface is a thin layer of mixed soil, grass, roots, small twigs, buds and other debris, about an inch thick, and frequently very dry, forming a crust (see Plate VII, Figs. 2 and 3). This crust is also much undermined, and the wide, low spaces underneath it parallel with the surface permit one to raise it up in thin chunks. Below the crust, the mound is much burrowed out with many connecting galleries running parallel to the surface, some vertically, and here and there small cavities for the storage of the young. The burrows penetrate deeply into the ground, extending down to soil water level in every nest opened, whether located on high or low ground. Since the ants spend most of their active life in the upper parts of the nest, it was found that the burrows were most numerous in this portion. They do not appear to extend beyond the border of the mound. However, the finding of a single specimen of *Cyclops*, and two of *Gammarus*, in the soil water of one of the nests about 25 feet from the pond indicate some sort of a connection between the nest and the pond. It would be difficult to conceive of these crustaceans gaining access to the water in the nest by simple seepage through the soil; they are too large for that. And there was no chance of accidental contamination. No galleries were found extending between the various nests, as is the case with some species, but I am not ready to state positively that none exist.

Nests located on high and low ground were opened for purposes of comparing their architecture. No essential difference was found, except that the burrows extended deeper into the ground before soil water was reached in the case of the high ground nests, whereas the burrows were necessarily limited in depth in those located along the border of the low areas.
Toward the close of the hibernation period (April), field trips were made to the ant colonies, and a large number of hibernating specimens collected for observation in the laboratory. These comprised several wingless females and a large number of workers, the only stages which hibernate. The ants were temporarily kept in artificial nests in cold storage until activity began in the nests in the field. Seven small colonies were then established in the laboratory (April 21, 1926) in the finger bowl nests already described, and two (No. 6 and 7) on May 10 in Fielde nests. Each colony contained a single female and five or ten workers to care for her. All nests were kept at room temperature. The colonies were observed continuously until all but one of the females were dead. Record was kept of each batch of eggs. A few life history notes were obtained from large stock nests, some of which were established in April, 1926, and others in the fall of 1924. These notes were from chance observations, but are introduced in support of other observations made in the laboratory. The laboratory notes have been checked up with those obtained in the field so far as possible.

A large number of eggs was obtained from the females; but a large mortality occurred in the young due to the cannibalistic tendencies of the workers. Eggs and larvae disappeared continually. Cannibalism is common among ants, and constitutes a difficulty in the rearing of the young in laboratory nests. Tanquary ('13) and Reichenbach ('02) also reported this difficulty in the rearing of Lasius niger. Some of the F. ulkei eggs failed to hatch for other reasons. As a result, only 9.7 per cent of the 903 eggs for which complete records are available produced larvae (see Table II). Of these larvae, only 1 attained the pupal stage.

A number of eggs was obtained from workers. No mature females of the usual type were present in the nests in which these eggs were found, since they were wanted for rearing experiments, and were carefully picked out from the rest of the ants, and placed in separate rearing nests. It is possible that the eggs may have been laid by worker-like females, but polymorphism has not been studied in this species. The laying of eggs by workers is commonly reported in the literature on ants.

An interesting point should be recorded here. Females appeared in the larger nests which had been stocked only with workers. That these females were not accidentally overlooked when the nests were established is attested by the finding of large, empty, pupal cases in the water moats of these nests. The old controversy as to the application of the Dzierzon theory of sex determination to ants will hardly be settled by the above observations, since the virginity of these workers is doubtful. Seminal receptacles have been found in some of the workers of other species, so it is possible that workers may be fertilized by males. Males have been seen to pursue workers with as much

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8 Work of Miss Holliday, reported by Fielde ('05).
energy as they do females (Fielde '05), though copulation of males with workers has never been observed (Wheeler '26). Fielde obtained only males from the eggs of virgin females and workers in four species of ants, and concluded that unfertilized eggs of ants produced only males. Further observations and more carefully controlled experiments would be needed to determine this point for F. ulkei.

In the data given on the rearing experiments, only such as are free from these and other disturbances have been used.

The first active female was found among active workers close to the surface of the mound on April 11, 1925. On May 2, all the females were found in the upper burrows, none being found at the bottom of the nest in the aggregations of workers which were still hibernating.

The first batch of eggs was found in the laboratory on April 27, six days after the establishment of the nests. The other females of the laboratory nests began laying during the first few days of May. Most of the egg laying took place in the latter part of April and early May, but some females continued laying even up to the first days of June. No eggs were obtained thereafter (see Table I.). Eggs were first found in the field on May 2, 1925:

<table>
<thead>
<tr>
<th>Serial No. of female</th>
<th>Date of first laying</th>
<th>Date of last laying</th>
<th>Total eggs laid</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apr. 27</td>
<td>May 24</td>
<td>182</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Apr. 26</td>
<td>June 7</td>
<td>167</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>May 3</td>
<td>June 2</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>May 3</td>
<td>June 17</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>May 1</td>
<td>May 19</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>May 17</td>
<td>May 19</td>
<td>About 50</td>
<td>These eggs were not removed.</td>
</tr>
<tr>
<td>7</td>
<td>May 19</td>
<td>Only 1 mass laid</td>
<td>About 50</td>
<td>These eggs not removed.</td>
</tr>
<tr>
<td>8</td>
<td>May 3</td>
<td>May 10</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>May 3</td>
<td>June 17</td>
<td>128</td>
<td></td>
</tr>
</tbody>
</table>

Table I. Dates of egg laying for F. ulkei in the laboratory

this date coincides well with the appearance of eggs in the laboratory nests of 1926. These eggs were found both in the surface soil of the mound and in the wet clay at the bottom of the nest where the ants hibernate. The latter may either have been laid there, or carried there subsequent to laying in an apparently erratic manner by workers. With the exception of the two batches of eggs referred to as having been found at the bottom, all eggs were near the surface, and it seems safe to assume that this is where they are laid. Very young larvae were found on the field trip of June 18, 1925, but no eggs. On June 26, 1925, no eggs were found, and the larvae appeared to be much larger. It is evident that egg laying had ceased some time before the middle of June. It seems, therefore, that the normal egg laying period extends from the latter part of April to the early part of June. The date will vary somewhat from one season to the next. Nests kept in the laboratory at room
temperature all winter showed eggs and even larvae in January, 1925. This hastening of the egg laying period is a well known phenomenon due to the warm temperature at which the ants were kept.

Each batch of eggs was removed as soon as laid in seven of the finger bowl nests, and placed in a separate finger bowl together with 5–10 workers to care for the eggs; a record was made of the date of laying and of the subsequent history. Each of these seven females laid a large number of eggs, the maximum being 190 +, and the minimum 126 for each female (see Table I). The eggs were laid in batches of 1–51 eggs with an average of 13.8 per batch. The laying of a representative female (No. 1) is given below:

<table>
<thead>
<tr>
<th>Date</th>
<th>Eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 27</td>
<td>36</td>
</tr>
<tr>
<td>Apr. 29</td>
<td>13</td>
</tr>
<tr>
<td>Apr. 30</td>
<td>12</td>
</tr>
<tr>
<td>May 2</td>
<td>19</td>
</tr>
<tr>
<td>May 4</td>
<td>4</td>
</tr>
<tr>
<td>May 5</td>
<td>4</td>
</tr>
<tr>
<td>May 6</td>
<td>4</td>
</tr>
<tr>
<td>May 7</td>
<td>20</td>
</tr>
<tr>
<td>May 8</td>
<td>4</td>
</tr>
<tr>
<td>May 10</td>
<td>16</td>
</tr>
<tr>
<td>May 11</td>
<td>6</td>
</tr>
<tr>
<td>May 13</td>
<td>4</td>
</tr>
<tr>
<td>May 17</td>
<td>14</td>
</tr>
<tr>
<td>May 19</td>
<td>12</td>
</tr>
<tr>
<td>May 20</td>
<td>4</td>
</tr>
<tr>
<td>May 24</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>182</strong></td>
</tr>
</tbody>
</table>

In the above record and the record of other females, the egg laying proceeded in rhythms, the laying of a large batch of eggs alternating with the laying of a series of smaller batches, the high peaks in these rhythms occurring just a few days apart.

In the other two laboratory nests (No. 6 and 7), the eggs were not removed. These females had been collected at the same time as the other seven (April 12), but had been kept in cold storage until May 10 when they were placed in Fielde nests together with a few workers. Female No. 6 began laying on May 17, and by May 19 a mass of about 50 eggs had been laid. This female laid no more. Female No. 7 laid one large mass of about 50 eggs and none thereafter. The difference in treatment of these two females as compared with that of the other seven may account for this difference in egg laying.

The eggs hatch into the usual legless, white larvae, shaped very much like a summer squash (see Plate I). The time of hatching for *F. ulkei* appears to be somewhat variable (9–16 days), but the average is about 12 days (see Table II). This is shorter than that recorded for *Aphaenogaster fulva* (17–22 days, usually 19 days, Wheeler, '26, p. 81), of *Myrmica rubra* (23–24 days, Wheeler, '26, p. 81), or of *Camponotus herculeanus pennsylvanicus* (24 days, Pricer, '08).

The length of larval life in *F. ulkei* is uncertain. For the only pupa obtained in the rearing experiments in the laboratory the larval life was 21 days. In *Aphaenogaster fulva*, the larval period is reported as 24–27 days, that of *Myrmica rubra* 30–71 days, and of *Camponotus herculeanus pennsyl-
The larval period is very variable in most ants, depending upon the quantity of food which is given the larvae. Tanquary (13) reported that he maintained larvae of Lasius niger in a nest for over a year, and other observers have obtained similar results. Larvae were present in the field nests of *F. ulkei* until August 16 (1926), at which time only large ones were found. On September 1 (1924) no larvae were discovered.

### Table II. The number of larvae hatching, and hatching time, for eggs of *F. ulkei*

<table>
<thead>
<tr>
<th>Serial no. of female</th>
<th>Total no. eggs laid</th>
<th>No. larvae hatched</th>
<th>% of eggs hatched</th>
<th>Variation in hatching time</th>
<th>Av. time for hatching</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>182</td>
<td>21</td>
<td>11.5</td>
<td>11–14 days</td>
<td>12 days</td>
</tr>
<tr>
<td>2</td>
<td>163</td>
<td>11</td>
<td>6.7</td>
<td>12–14</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>131</td>
<td>11</td>
<td>8.4</td>
<td>9–15</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>158</td>
<td>20</td>
<td>12.6</td>
<td>11–14</td>
<td>12.5</td>
</tr>
<tr>
<td>5</td>
<td>126</td>
<td>1</td>
<td>0.8</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>26</td>
<td>18</td>
<td>69.2</td>
<td>11–16</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>117</td>
<td>6</td>
<td>5.1</td>
<td>10–16</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>903</td>
<td>88</td>
<td>9.7 av.</td>
<td></td>
<td>12.5 av.</td>
</tr>
</tbody>
</table>

No data were obtained on the pupal period in the laboratory. The first indication of worker pupae in the field was on June 18 (1925), when several pupae and larvae were found. These pupae continued in the nests in the field for a short time after the onset of hibernation.

Although eggs, larvae and worker pupae had appeared in the field nests by the end of the 1924–25 season’s collecting (June 26), no indication of the young of the larger, mature, sexual forms had been seen. On July 8, 1926, the first field trip that summer, a few very large pupae were taken from among the smaller worker pupae; these were reared and proved to be the pupae of mature males and females.

On the next field trip (July 14, 1926), large male and female pupae were numerous, and found near the surface of the mound. A number of recently-emerged, winged males and females and a number of active, winged males were also found, besides a larger number of worker pupae and a smaller number of larvae. No callows were seen on this date. This seems to be the approximate date of emergence of the mature sexual forms in the field. It seemed from the condition of affairs in the nest at this time that the nuptial flight, if one occurs, must be near. I was unable to remain with the ants continuously to see their mating activities.

On July 20, another trip was taken. At this time, I dug over the entire mound to a depth of one foot, and made a special but unsuccessful effort to find the large pupae; so all sexually mature forms must have emerged by this time. Several dead males were seen, and a few, live, active males, some of which dashed out of holes in the mound. The females were still winged, and crawled out very actively on the surface of the nest, on twigs and other nearby
objects. A large number of workers crawled up and down the trunk of a large tree bordering the mound. Such behavior I had not before seen in this species. The picture presented was such as one might expect to see at or just after the mating season—some dead males, males and females still winged and active outside of the nest. I was led to conclude that mating was just taking place, or had just occurred, though I did not actually see the mating activities.

Three days later at Palos Park, no male or female pupae were found, but mature, winged males and females were present. There was no apparent inclination for the males and females to crawl in the open on the surface as on the last field trip. Several sexually mature individuals were collected in separate vials to see if they could be mated in the laboratory, but without success.

While I was not so fortunate as to see the mating of *F. ulkei*, the facts seem to warrant the conclusion that this life history phase took place on or about July 20, 1926. I am also inclined to believe that the nuptial flight is very limited in extent judging by the limited distribution of the species.

Several attempts were made to observe the deflation of the females in the laboratory, but without success. However, two deflated females were found in a large stock nest in the greenhouse on August 4, 1926; these were young ones that had emerged during the summer.

Callows were seen in very small numbers in the field on July 23, 1926, when worker pupae were very numerous, and only larger larvae were found. This date seemed to represent the beginning of the period of emergence from the pupal cases. Larvae were diminishing in numbers until August 16, 1926, when only a few large ones were present. On September 1 (1924), only workers, worker pupae and callows were found, but no larval forms were taken on or after this date. The pupae were still in the upper six inches of the mound soil. On September 10 (1924), the pupae were in small groups of 2–3 at the bottom of the nest about six inches above the soil water level. They were still numerous, however. At this time, also, many of the workers were found in small, loose aggregations just above the soil water level, where they were entering hibernation. Others were still active on the surface of the mound. A few days later, the pupae were fewer and the aggregations of hibernating workers greatly augmented. By October 21 (1924), all the pupae had disappeared from the nests. And by November 1 (1924), the callows were indistinguishable from the older workers. This was also the last date on which surface activity was noted, and all the colonies were definitely in hibernation.

The winter is spent in the deeper burrows of the nest just above the soil water level. The ants (workers and mature, deflated females) aggregate in very dense masses numbering thousands of individuals in the wet clay at this level. A few scattered individuals may be found in the upper frozen
soil often surrounded by frost crystals. These are no doubt the ones that were tardy in seeking winter quarters and were caught when the first cold weather chilled them. They are also the ones which first resume activity in spring when the frost leaves the ground. There is some evidence for thinking that they are responsible for the general awakening of the whole colony in the spring, when the surface earth becomes warmed. Activity begins again in the spring simultaneously on all the nests just as soon as the frost is out of the ground.

The ants maintain a very sluggish state of activity throughout the winter. They are able to crawl slowly to cover when disturbed, and quickly become active when warmed. In this respect, they are different from some Hymenoptera (e.g., Vespa, Camponotus, etc.) of this region, which can scarcely be roused from activity by ordinary warming methods. Further details on the hibernation phase of the life history of Formica ulkei will be given elsewhere.

**FOOD AND FEEDING HABITS**

The food of Formica ulkei is varied. Different foods were tried out in the laboratory nests. The ants are quickly attracted to sweet fluids which they lap up voraciously. Sugar solution, syrup, and honey proved successful; the ants seem to be especially attracted to honey, no doubt, because of its strong odor. Fruits were also introduced; apple and banana were greedily devoured. Here, too, the smell of these fruits seemed to attract them. Occasionally, fresh insect bodies were cut up into bits which the ants ate. On several occasions, insect bodies have been found in the nests in the field, so other insects normally constitute part of their diet. Attention has already been called to the fact that the ants feed on their own young in the laboratory nests. It is conceivable that this happens also in nature, especially at times of food shortage. A rather large number of tree buds were found in the nests in the field, and it is probable that the ants obtain sweet materials from the surface of these buds.

Like most ants, F. ulkei makes use of aphids to secure the sweet honey dew which they secrete. Small groups of wooly aphids were found in the galleries of the nest on several occasions during the winter; and on August 14 (1926), workers were observed in attendance upon some black aphids (species undetermined) on a small poplar.

Males and females have both been observed to feed directly upon the food put into the nests. Females are commonly seen being fed regurgitated food by the workers, but the males were never observed receiving any attention. Workers often definitely solicit food from their fellows by the usual method of stroking the head with their antennae.

There is a keen sense of smell that leads these ants directly to the food. As soon as honey is put into the finger bowls, invariably the nearby ants wave their antennae in various directions and then start crawling in an al-
most straight line for the food. This striking behavior was seen time and again.

The very active crawling of the workers makes it possible for them to cover a considerable range in their foraging expeditions which extend out into the surrounding grasses and weeds. These expeditions are not organized, but each worker shifts for herself. Several attempts were made to determine how far they strayed from the edge of the mound. An isolated nest near a recently cut meadow gave the best opportunity. There, just after noon on a day in mid-August, a worker was found 57 feet from the nest mound. None were located at a greater distance.

**Care of the Members of the Colony**

The eggs cohere in small masses which vary up to about 50 in number. These masses are carried about by the workers, and deposited in various parts of the nest. The larvae stick together in masses by means of the hairs on their bodies, and are fed with regurgitated food by the workers. They are sorted out according to size, so that scattered masses of larvae may be found in the nest, each mass containing larvae of the same approximate size. The pupae are kept separate from the larvae. Usually, the pupae are placed rather near the surface of the mound, exposed to warmer temperatures and drier conditions. The cocoons makes them resistant to drying, and enable them to profit by the higher temperatures at the surface level of the nest. The larvae are usually found in deeper parts of the mound than the pupae. At the beginning of hibernation, those pupae still remaining are carried to the bottom of the nest near the soil water level, and there the last callows emerge. The pupae at this time of the year profit by the more constant temperatures at this level as compared with the fluctuating temperatures of the surface.

Great solicitude is shown the females. Several workers may attend a single female at one time, keeping her body immaculate and shiny, and sometimes feeding her, as before described.

The stronger workers often carry the weaker or exhausted individuals bodily to or from the nest. This may occur in migrations from one nest to another, or on foraging trips when individuals venture too far and cannot return in their exhausted condition. This form of solicitude has been observed on several occasions in the field and in the laboratory. Once a large stock nest had become accidentally flooded over night. To save the ants, a bridge was constructed from a strip of tin appropriately bent, extending from the flooded nest over the water moat to a freshly prepared nest. In order to get the ants to move into the new nest, a few workers were placed upon the bridge. These crawled to the new nest, explored it, and some returned to the old nest, where they caught up the other ants one by one in their mandibles and carried them up on the bridge and into the new nest. The
transported ants always carefully folded up their legs against their body, thereby facilitating the transportation. They looked like dead ants, while they were being carried, but as soon as they were deposited in the new nest, they began to crawl around exploring the new abode. This carrying of workers has also been observed on the surface of the mounds, and always in the manner described.

CARE OF THE NEST

Surface activity begins as soon as the frost is out of the ground, and increases in intensity gradually until all the ants are out of hibernation. They desert the lower galleries near the level of the soil water and spend all their time during the active season on or near the surface (upper 6 inches). Here, they busy themselves with the care of the young, foraging, and the almost constant repair of the nest. Workers are seen on the surface carrying the tiny sticks, blades of dead grass, small particles of soil, empty pupal cases, etc. After rains, the collapsed surface crust must be repaired, and new exits made. These are all very common sights on any ant mound.

Sunlight does not seem to hinder the ants in their surface activity. It is interesting to note that on a very warm day, however, they confine their attention to the shaded parts of the mound and along the grassy edge of the nest. This statement is based on the following observations: On July 20 (1926), the air temperature in the shade was 33.5°C at 1:20 P.M., and the temperature of the surface soil of the mound exposed to the sun was 41.6°C. Not one of the 18–20 nests examined showed any activity on that part of the mound which was exposed to the sun, but, on the contrary, all surface activity was confined to the shaded portions of the nest. This was a reaction to the intense heat rather than to the light, for on other sunny days, surface activity was normal in the sunny as well as in the shaded portions of the mound.

Activity continues thus at or near the surface until the early days of fall when the ants gradually retire to the deeper parts of the nest and begin hibernation. Surface activity gradually diminishes; but not until the ground freezes do the ants cease their work entirely.

RELATION TO OTHER ANIMALS

*Formica ulkei* defends its nest against invaders or disturbers of the nest with great vigor. Any disturbance causes the workers to swarm in large numbers to the point of attack, and to dash about wildly in mad confusion. They rush at the invader with mandibles wide open ready to fasten on the attacker. When once the mandibles are fastened on an object, it is very difficult to dislodge the ant. The abdomen then bends ventrally so that the posterior tip is directed anteriorly and emits therefrom a fine jet of formic acid which enters the wound inflicted by the mandibles and may kill the
enemy. This formic acid is very powerful. Each worker may secrete a drop of it about half the size of the head of an insect pin. If the ant is confined in a closed space, such as a stoppered vial or a weighing bottle, it is quickly killed by the fumes of its own acid. It is well nigh impossible to handle the ants without stimulating them to secrete this acid. This proved to be a real difficulty in experimental work.

On one occasion, the last stages of a real battle was witnessed between *F. ulkei* and a species of small household ant (*Monomorium pharaonis?). A large number of *F. ulkei* workers had been placed in a dish-pan covered with a fine-meshed wire screen to prevent their escape. One day, it was discovered that a large number of the tiny household ants were running up and down over well-beaten paths to and from the laboratory nest. Upon looking into the nest, I beheld a desolate scene,—my laboratory ants scattered over the surface of the nest, still alive, but with mere stumps of legs remaining, and with several of the tiny ants still clinging savagely to the remaining stumps. *F. ulkei* had been completely routed by the superior numbers of its tiny enemies.

When the first survey of the colonies of *F. ulkei* was made, it was found that there were scarcely any nests of other species of ants in the vicinity. Only two nests of *Proformica neogagates* were found. Later a nest of *Lasius (Acanthomyops) interjectus* Mayr. was found. These three nests were only 3-5 feet apart and 12-15 feet from the *F. ulkei* nests. Yet they flourished and were unmolested in the midst of the large number of *F. ulkei* colonies. This would indicate that *F. ulkei* is not an aggressive species.

Throughout the extensive excavations of the nests, collections of other species of animals have been made and a record has been kept of these collections. A list of the species taken and the dates of collection are given in Table III.

Nests have been found on all occasions to be practically free from other species of ants. A single specimen of *Myrmica scabrinodis* Nyl. was taken from a nest on April 11; and on July 26, a female of the same species was discovered in a laboratory nest, but had been entirely overlooked in the field. Presumably, it must have been obtained from the *F. ulkei* nests when the workers were collected for experimental use. On October 11, a single specimen of *Crema
togaster lineolata* Say was collected from the surface of one of the weaker colonies. On June 18, a single specimen of *Lasius (Acanthomyops) interjectus* Mayr. was collected from the deeper parts of another nest. These are the only instances of the occurrence of other species of ants in or on the *F. ulkei* nests that have come under my observation. *F. ulkei* is not a slave-maker, and defends its nest with such energy that very few individuals of other species can gain access.

Since the above observations were made, this species has been found in considerable numbers by Dr. Allee and his students, who have observed that it occupies very tiny burrows in the *F. ulkei* nests. Its relation to *F. ulkei* is not clear.
However, a considerable array of species other than ants have been obtained from the ant nests. Attention has already been called to the finding of wooly aphids during the winter and to the attendance of workers on aphids

### Table III. List of the co-inhabitants of *F. ulkei* nests

<table>
<thead>
<tr>
<th>Species</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANNELIDA</strong></td>
<td></td>
</tr>
<tr>
<td><em>Helodrilus caliginosus trapezoides</em></td>
<td>Jan. 13, Apr. 22.</td>
</tr>
<tr>
<td><em>Octolasium lacteum</em></td>
<td>Dec. 13, Jan. 13, Jan. 24, Mar. 20, Apr. 11, Apr. 22.</td>
</tr>
<tr>
<td><strong>CRUSTACEA</strong></td>
<td></td>
</tr>
<tr>
<td><em>Eucrangonyx gracilis</em> Smith</td>
<td>Feb. 15. From soil water at bottom of nest.</td>
</tr>
<tr>
<td><em>Cyclops bicuspidatus</em> Claus</td>
<td>Feb. 15. From soil water at bottom of nest.</td>
</tr>
<tr>
<td><strong>ARACHNIDA</strong></td>
<td></td>
</tr>
<tr>
<td><em>Agelea naevia</em> Walck.</td>
<td>Feb. 3.</td>
</tr>
<tr>
<td><em>Cicurina brevis</em> Emerton</td>
<td>Mar. 7.</td>
</tr>
<tr>
<td>Spider eggs</td>
<td>Feb. 7, July 23.</td>
</tr>
<tr>
<td><strong>MYRIAPODA</strong></td>
<td></td>
</tr>
<tr>
<td><em>Scutigerella immaculata</em> Newport</td>
<td>Jan. 3.</td>
</tr>
<tr>
<td><em>Arenophilus</em> sp.</td>
<td>Jan. 3.</td>
</tr>
<tr>
<td><em>Brachygeophilus embius</em> Chamberlin</td>
<td>Feb. 15.</td>
</tr>
<tr>
<td><em>Scytonotus granulatus</em> Say</td>
<td>Feb. 24.</td>
</tr>
<tr>
<td><em>Parajulus venustus</em> Wood</td>
<td>Feb. 7, Mar. 7.</td>
</tr>
<tr>
<td><strong>COLEMBOLA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>HOMOPTERA</strong></td>
<td></td>
</tr>
<tr>
<td>Wooly aphids (undetermined)</td>
<td>Oct. 11, Nov. 1, Jan. 24, Feb. 3.</td>
</tr>
<tr>
<td>Cicada nymphs</td>
<td>Dec. 13, Apr. 11.</td>
</tr>
<tr>
<td>Neuroptera pupa (Chauliodes?)</td>
<td>June 18</td>
</tr>
<tr>
<td><strong>ORTHOPTERA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>COLEOPTERA</strong></td>
<td></td>
</tr>
<tr>
<td><em>Amara polita</em> Lec.</td>
<td>Apr. 11.</td>
</tr>
<tr>
<td><em>Lachnosterna</em> sp. (larvae)</td>
<td>Dec. 13, Feb. 7, Apr. 11.</td>
</tr>
<tr>
<td><em>Batrisodes globosus</em> Lec.</td>
<td>Feb. 15. Other specimens of pselaphids taken on Dec. 2 and 13, Jan. 13 and 24, and Feb. 3.</td>
</tr>
</tbody>
</table>
Batrisodes spretus Lec. .................. Mar. 20.
Megastilicus formicarius Casey ........... Feb. 3. Other specimens of staphylinids
taken on Nov. 1, Jan. 24, and Feb. 15.
Undetermined coleopterous larvae .........Dec. 13, Apr. 2.

Diptera
Microdon sp. (larvae) .................. Nov. 22, July 14.

Hymenoptera
Amblyteles seminiger Cress ............... Jan. 3.
Myrmica scabrinodis Nyl. ............... Apr. 11, July 24. Among lab. ants, but
origin uncertain. Probably collected
with F. ulkei workers from nests in
the field.

Crematogaster lineolata Say ............. Oct. 11. Found on surface of mound.
Lasius (Acanthomyops) interjectus Mayr.. June 18.

in the summer. F. ulkei is an aphidicolous species like so many others of the
same genus. In addition to the above, pselaphid beetles (Batrisodes globosus,
and B. spretus) were collected; other undetermined individuals were found
throughout the winter. The same is true of the staphylinid beetle, Megas-
tilicus formicarius. Two specimens of the larvae of Microdon sp. were
taken from the nests, one on November 22, and the other on July 14. These
species represent various relations of dependence upon the ants from friendly
to persecuted. Of doubtful relationship to the ants is the carabid beetle,
Tachys incurvus, which was found on several occasions in the nest and also
crawling on the surface of the mound. This beetle is known to occur in ant
nests, but lives in other environments as well.

All the rest of the species listed in Table III probably represent individuals
attracted to the burrows in fall for over-wintering purposes. The majority
of the species in Table III come under this category. They are able to gain
access to the nests because of the early retirement of the ants into hiberna-
tion and the consequent reduction of activity in the nest. Very few of these
species have been taken in the summer; they are undoubtedly driven out of
the nests in the spring when the ants resume activity.

A large, deserted F. ulkei nest was opened on February 7. This nest was
partially overgrown with turf, but the ant burrows were still intact. A large
number of species of animals, ranging from annelids to Hymenoptera, had
taken possession of this nest for hibernation. The general similarity of these
animals to those listed in Table III further substantiates the fact that most
of the species listed in Table III are mere hibernants that are attracted to the
ant nests by the availability of hibernation quarters in the nests.

Attention has already been called to the wholly unexpected discovery of
the two species of aquatic crustaceans (Eucrangonyx gracilis and Cyclops
bicuspidatus) in the soil water of the nests. Two individuals of the former
and one of the latter were found February 15. Of course, these species do
not come in contact in any way with the ants, but are merely given in Table
III as having been taken in the ant nest, or more correctly stated, below the ant nest.

**Summary**

A number of experiments and observations on the behavior, habits and life history of the mound-building ant, *Formica ulkei* Emery, are here reported. These have come to light incidental to a more detailed study of the over-wintering phases of the life history, which will be reported in a later publication. The following points are brought out in this paper:

1. A correction is offered in the description of the male: The mandibles are 3-toothed instead of edentate as described by others.

2. The species is largely confined to the Canadian zone. It has been reported from only a few scattered regions in the Transition zone. In the Chicago region it occurs only at Palatine and at Palos Park, Illinois. It is found in open, oak-elm-hickory woods situated on low hills with low areas scattered throughout the woods.

3. The species nests in the soil, and builds rounded or conical mounds that often attain considerable size (the largest was nine feet in length and almost as wide). The mound is much burrowed out, composed of excavated earth (mostly clay), and covered with a thin crust of a mixture of earth, roots, small twigs, dead blades of grass, etc. The burrows extend down to soil water level (1-5 feet below the surrounding level). No essential differences were noted in the architecture of the nests located on high and low ground except that the burrows extended deeper into the ground in the former than in the latter.

4. Activity begins in the spring as soon as frost is out of the ground. The wingless females and the workers are the only stages which hibernate.

5. Egg laying begins toward the close of April and ends the latter part of May or early June. In the observations here reported, they were laid in groups of 1-51 eggs. The egg laying proceeded in rhythms of activity; a large batch alternating with smaller ones. Each female laid 126-190 + eggs during the egg laying season in nests in which the eggs were removed as soon as laid. In two other nests in which the eggs were not removed in this way, only about 50 eggs were laid by each female.

6. The time of hatching is 9-16 days with an average time of 12.5 days. Only 1 larva succeeded in pupating in observation nests; in this instance, the length of larval life was 21 days. However, larvae were found in the nests until the latter part of August. No data were obtained on the length of the pupal life. Worker pupae were first found in the nests in the field on June 18, and callows were first taken in small numbers on July 23. Worker pupae continued in the nests until October 21. The large male and female pupae were first found on July 8, and on July 14 the first winged males and females were obtained in the field.

7. The nuptial flight was not seen. But indirect evidence seems to indi-
cate that mating took place very close to July 20. If a nuptial flight takes place at all, it is in all probability very limited in extent.

8. Some of the ants had begun hibernation by September 10, but surface activity did not cease until the early part of November. The winter is spent in the deepest part of the nest just above soil water level. Here the ants are aggregated into very densely packed masses. They are very sluggish during this time, but maintain enough activity to be able to crawl to cover slowly when disturbed.

9. Considerable difficulty was encountered in the rearing experiments because of the cannibalistic habits of the ants. Largely as a result of this, only a small percentage of the eggs hatched and only one larva pupated.

10. A large number of eggs were laid by workers. Even mature females appeared in the nests stocked only with workers originally. The virginity of these workers cannot be vouched for.

11. The ants get along very well in the laboratory on a diet of fruit, honey and other sweets, and other insect bodies. Regurgitated food is fed the young and also the adults. All castes have been observed to feed directly upon the food offered in the laboratory nests. Foraging activities carry the workers into the surrounding regions for an observed distance of 57 feet.

12. The well known solicitude for the various members of the colony is shown by the workers. The young are carried about in accordance with the changing conditions of the nest. They are fed and otherwise cared for. They are sorted according to age. The pupae seem to be kept closer to the surface than the larvae. Much time and energy are expended on keeping the females immaculate. The transport of workers by other stronger workers has been observed on several occasions.

13. In its relations with other species of animals, _F. ulkei_ is not an aggressive or slave-making species, but it defends its nests with great vigor. The workers possess a powerful means of defense in the ability to secrete formic acid, the fumes of which are toxic enough to kill the ants themselves when confined in a narrow space. In consequence of this energetic defense of the colony, very few specimens of other species of ants were found in the nests. A number of aphids, pselaphid and staphylinid beetles and Microdon larvae were found in the nests. Besides these myrmecophiles, a large number of other species of invertebrates, ranging from annelids to Hymenoptera, were observed inhabiting the ant nests in winter for the purpose of hibernation.

**Literature Cited**


Fig. 1. Females (a), workers (b) and eggs (c), enlarged about four times. The picture was taken May 23, 1925. Some of the bodies are covered with droplets of water due to the necessity of cooling the ants on ice to keep them quiet long enough to get a picture.

Fig. 2. Various life history stages, natural size. The picture was taken July 26, 1926. (a) Winged female; (b) winged male; (c) and (d) wingless females; (e) group of five workers; (f) three cocoons of males or females; (g) twelve worker cocoons; (h) ten larvae in various stages of development.
Fig. 1. Showing the distribution of colonies along the border of a low spot in the woods at Palos Park, Illinois. The picture was taken Feb. 12, 1925, the day after a light fall of snow. By noon, all the snow had melted except on the shaded side of each mound; thus the remaining snow sets off the mounds from the rest of the surroundings. Five colonies are indicated by the white spots.

Fig. 2. Large mound at Palatine, Illinois. Picture taken Oct. 11, 1924. The surface is seen to be strewn with debris of various kinds, and is without grassy covering.

Fig. 3. Large mound seen in cross-section and showing architecture of mound. Picture taken Aug. 14, 1926 at Palatine, Illinois. The mound was cut in two with a spade down to surface level. The surface crust, composed of mixed debris and soil, may be seen; also the galleried interior of the mound.


