

BEETLES ASSOCIATED WITH THE MOUND-
BUILDING ANT, *FORMICA ULKEI* EMERY

BY ORLANDO PARK

Northwestern University

The mound-building ant, *Formica ulkei* Emery, has been reported as far west as South Dakota to Nova Scotia and New Brunswick (Wheeler, 1926; Holmquist, 1928). It is recorded from Wisconsin (Burrill and Smith, 1918) and Illinois, and is apparently abundant in northern Ohio¹ where its range merges with that of the eastern mound-builder, *Formica exsectoides*.

In Illinois *ulkei* is at present known only from the Chicago Area where it is well established in two localities (Palos Park and Palatine). In both places the numerous mounds, varying from young nests of less than a foot in diameter up to old hills more than four feet across, are found within the upland oak-ash-hickory forests, where they tend to follow the forest margins and clearings.

These ant mounds present an infinite array of problems which remained uninvestigated until 1926. Since then, a literature upon these Illinois mounds has steadily accumulated, including the life history and behavior of the host ant (Holmquist, 1928a), hibernation (Holmquist, 1928b; Dreyer, 1932), distribution of the nests (Dreyer and T. Park, 1933), and the species of arthropods associated with the host ant (Park, O., 1929; Park, T., 1929).

Among the numerous arthropods associated with ants the myrmecocolous beetles are numerous, both in species and individuals. Many of these beetles are nest scavengers,

¹I am indebted to Dr. C. H. Kennedy for personal communication upon the Ohio distribution of *Formica ulkei* and *exsectoides*. The latter species is reported from Iowa (Wickham, 1900) and Indiana (Blatchley, 1910) so that the actual distribution of these two closely allied ants can not be certainly known until a carefully planned survey can be made. Both *ulkei* and *exsectoides* are present in the Chicago Area, however; a small mound was investigated, and workers preserved, near Smith, Indiana on August 27, 1934. These ants I sent to Dr. M. R. Smith who determined them as *Formica exsectoides*.

but the majority probably strike at the vitality of the society by feeding upon the host brood. The ant brood appears to be especially stimulating and may be infrequently raided by species which may or may not live in the nest (Park, 1933a), attacked by tolerated nest predators (Park, 1932b), or assiduously licked or devoured by highly specialized commensals and temporary ectoparasites (Park, 1932a, 1933b).

In the following table the beetles associated with *Formica ulkei* are listed with their seasonal range as far as known for the nests, and authority for the data.

From the above table we find that ten families and fifteen species of beetles have been reported from nests of *F. ulkei*, fourteen of which have been recorded from the Illinois mounds. In passing, mention should be made of the activity of these beetles during the last three weeks of May. Individuals were especially numerous during this period; two species, *Atheta polita* and *Batrisodes globosus* made repeated short flights of several inches on the evenings of May 12 and 13, and the syrphid flies of the genus *Microdon*³ pupated on the mornings of May 17 and 18. This seasonal activity is in general agreement with the maximum appearance of species and individuals of Coleoptera in the Chicago area (Park, 1930), as well as that of isolated or specialized communities, e. g. beetle population of fungi (Park, 1931).

Formica ulkei and *F. exsectoides* are not only related taxonomically, but ecologically they are very similar and it is interesting to observe identity of some, and ecological equivalence of other, myrmecocoles from the mounds of these two species of hosts. The following table (Table II) lists those species said to occur in the *exsectoides* nests as far as I have been able to ascertain from the literature.

So far, no true guest (symphile) has been reported from either *Formica ulkei* or *exsectoides* nests. A comparison of tables I and II shows that three species, *Tachyura incurva*, *Megastilicus formicarius*, and *Heterius brunneipennis*, are common to both host ants, and the species of

³These flies are at present being determined, and the data concerning their behavior in the nest, and pupation data are to be given later.

TABLE I
Coleoptera associated with Formica ulkei

Family	Species	Seasonal record with host	Citation
Carabidæ.....	Tachyura incurva..... (Say)	All year.....	Holmquist, 1928 Park, O., 1929
.....	Clivina bipustulata.... (Fab.)	May 7.....	Present report
.....	Amara polita LeC.....	April 11, May 7.....	Holmquist, 1928 Present report
.....	Harpalus pleuriticus..... Kirby	February 24....	Holmquist, 1928
Leptinidæ.....	Leptinus testaceus..... Mueller	October 6.....	Park, O., 1929
Staphylinidæ...	Gastrolobium bicolor..... (Graves)	May 7 to August 20....	Present report Park, O., 1929
.....	Atheta polita.... Melsh.	March 1 to October 6....	Present report Holmquist, 1928
.....	Megastilicus formicarius.... Casey	March 1 to August 4....	Present report Holmquist, 1928
Pselaphidæ....	Batrisodes globosus..... (LeC.)	All year..... ²	Park, O., 1929 Present report
Histeridæ.....	Hetærius brunneipennis. Rand.	May 7.....	Present report
Cucujidæ.....	Cathartus advena..... (Walt.)	October 6.....	Park, O., 1929
Phalacridæ....	Stilbus probatus..... Casey	September 13 June 2.....	Present report
Elateridæ.....	Melanotus communis..... (Gyl.)	August 6.....	Park, O., 1929
Scarabæidæ....	Phyllophaga horni..... Smith	October 6.....	Park, O., 1929
Chrysomelidæ..	Coscinoptera dominicana.... (Fab.)	Wisconsin record.....	Burrill and Smith, 1919

²*Batrisodes globosus* (Lec.) is probably the only species of this genus so far reported from these nests of *Formica ulkei*. In 1929 I reported that *B. denticollis* Casey was also present, but subsequent study and collection has proven that the latter were all females of the former species. Holmquist (1928) in addition reported the presence of a third species, *B. spretus* Lec. and, although I have not examined this latter material it is possible that this record also refers to females of *globosus*. Extensive and intensive collecting in these mounds since 1929 has never yielded either *B. denticollis* or *B. spretus*, although *B. globosus* is almost always to be had in numbers.

TABLE II

Coleoptera reported from nests of Formica exsectoides

Family	Species	Citation
Carabidæ.....	Bembidion quadrimaculatum. (Linn.)	Schwarz, 1889
.....	Tachyura incurva (Say) ...	Schwarz, 1889, 1890 Ulke, 1890
Staphylinidæ.....	Edaphus nitidus LeC.	Schwarz, 1889
.....	Megastilicus formicarius Casey	Schwarz, 1889 Wickham, 1900 Blatchley, 1910 Wheeler, 1926
.....	Nematolinus longicollis (LeC.)	Schwarz, 1889
.....	Diochus schauimi Kr.	Schwarz, 1889
.....	Goniusa obtusa (LeC.) ...	Schwarz, 1889
Pselaphidæ.....	Batrisodes scabriceps (LeC.)	Leng, 1928
.....	Batrisodes fossicauda Casey	Wickham, 1900
.....	Cedius ziegleri LeC.	Schwarz, 1889 Leng, 1928
Histeridæ.....	Psiloscelis harrisi LeC.	Schwarz, 1889
.....	Hetærius brunneipennis ... Rand.	Schwarz, 1889 Liebeck, 1891 Wickham, 1900
Anthicidæ.....	Anthicus melancholicus ... Laf.	Dury, 1903 Wickham, 1900
Monotomidæ.....	Montoma fulvipes Melsh. ..	Wickham, 1900
Scarabæidæ.....	Euphoria inda (Linn.)	Wheeler, 1908
.....	Cremastocheilus canaliculatus Kirby	Wheeler, 1908
.....	Cremastocheilus castaneæ Kirby	Wheeler, 1908

Batrisodes are probably ecologically equivalent. Such identity and parallelism when investigated more fully should further our imperfect understanding of host-guest interrelations within the nest biocoenose.

In such a populous community as a *F. ulkei* nest it is expected that many species stray into the mound, or are taken in by the ants. The cases of *Harpalus pleuriticus*, *Amara polita* and *Cathartus advena* may indicate such accidental circumstance, penetration for purposes of hibernation, or passing the day within the nest in the case of a nocturnal form such as *polita*. Other species may pass a part of their life cycle in the mounds, either accidentally (*Melanotus communis*), or habitually (*Microdon* larvæ). The larvæ and pupæ of *Phyllophaga horni* and other species not yet determined are rather abundant in the nests. Their presence may or may not be significant, but since many other scarabæids are myrmecocolous, exclusive of the Cremastocheilini, (Riley, 1882; Smith, 1886; Schwarz, 1889; Wickham, 1892, 1896; Wheeler, 1908, 1926; Donisthorpe, 1927) more investigation is needed in the case of the May-beetles.

The presence of the chrysomelid larvæ of *Coscinoptera dominicana* in the Wisconsin *ulkei* mounds (Riley, 1882?; Burrill and Smith, 1919) is interesting, and suggests further study since the genus in North America, and in England and Europe related genera, are known to be myrmecocolous in the larval and pupal stages (Riley, 1882; Schwarz, 1896; Wickham, 1898; Wheeler, 1926; Donisthorpe, 1902, 1927).

The single record for *Clivinia bipustulata* was probably accidental, and the beetle was undoubtedly stimulated by the darkness and moisture of the nest. It is a geocole by habit, burrowing in moist earth and mud margins of streams or marshes, and has been found to be nocturnal (Park and Keller, 1932). When taken, the beetle was a foot beneath the dome of the nest, in wet clay soil with a temperature of 16 C.° In a laboratory nest it buried during the day and was not found by the host ants. It was attacked and readily put to flight by such nest predators as *Megas-tilicus formicarius*.

Three of the small phalacrid beetle, *Stilbus probatus*,⁴ were taken on September 13, 1932, from one part of a deep *ulkei* gallery, and six more from another nest at a depth of four feet on June 2, 1934. Their presence with *ulkei* was the only datum obtained, however, the records are of interest.

The small *Atheta polita*, belonging to a tribe of staphylinids which includes many habitual myrmecocoles, is an all year resident of the *ulkei* nest. However, little is known concerning it. It is capable of making short evening flights, and in artificial nests easily evades the ants. Its food and ecological position within the nest society are unknown. Although it occurs elsewhere in some abundance, its continual presence with *ulkei* can hardly be accidental.

The exact status of another staphylinid, *Gastrolobium bicolor*, is also uncertain. It has been taken twice in the nests. A male and female were obtained on May 7, and a third beetle on August 20, 1932. These records are probably accidental since the species is widely distributed over the Chicago Area, where it inhabits moist forest floors and stream margins beneath logs and stones. In the laboratory the beetles avoided the host ants, running away with up-lifted abdomens. On the night of May 18 one of the beetles attacked and dismembered and devoured three *Batrisodes globosus*. Since the latter fills a constant niche in the *ulkei* society we see the possibilities for disturbing the equilibrium of the biocoenose arising from even accidental penetration by a non-myrmecocolous predator.

The role of *Leptinus testaceus*⁵ is poorly understood, chiefly due to its presence in such a variety of habitats. It is found within the nests of small forest mammals, bird nests, certain of the social wasps, bees and ants and in isolated log mold, not harboring mammals. Such a list provokes inquiry as to the natural niche of the species, especially in view of the probable ectoparasitism of related

⁴The first lot were collected by the writer, and the second group by Mr. Strohecker. Both lots were independently determined by the writer, and by Mr. Emil Liljebblad of the Field Museum.

⁵In 1929 the following data were unfortunately omitted. Donisthorpe (1909) records three collectings of *Leptinus testaceus* with *Lasius fuliginosus* but states that it is usually taken in nests of bees, birds, moles and small rodents.

leptinids, and has been discussed elsewhere (Park, 1929). These delicate animals, eyeless, extremely flattened, and of pale yellow color were apparently unmolested by the *ulkei* workers, but were attacked and devoured by nest predators mentioned later. The food of this species remains uncertain, but as far as its presence with *ulkei* is concerned, it appears to be a tolerated form, one of the loricate synoeketes.

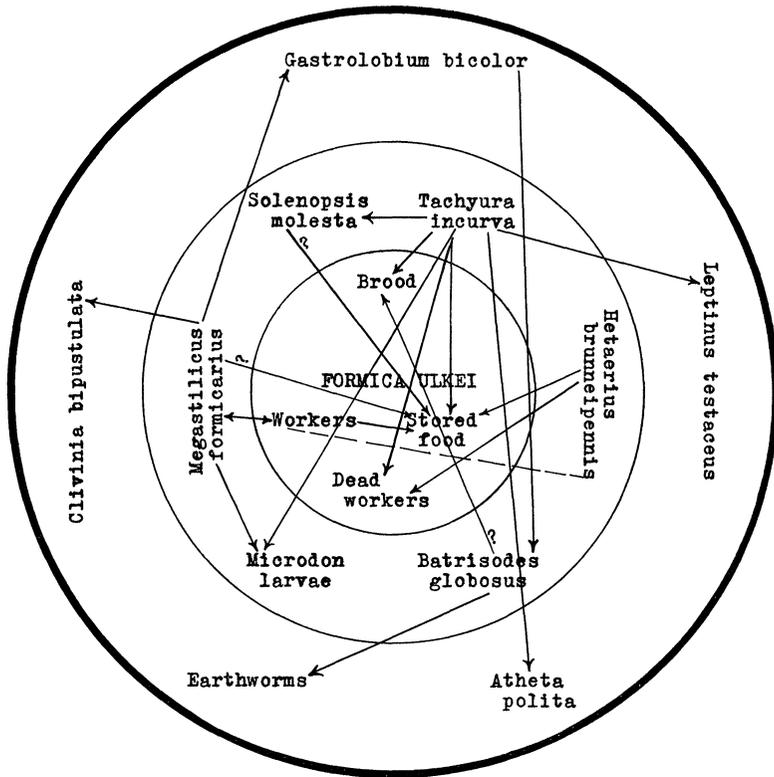


FIG. 1. Diagram of some of the food interrelations among the myrmecocoles of *Formica ulkei* Emery. The inner circle encloses the host species and its food supply; the intermediate circle contains those species where a definite association is known to exist with the host; the outer circle is reserved for either accidentals or those forms where the relationship is still obscure.

The arrows point to the food and away from the feeder. The broken line indicates regurgitation of food by the host workers.

The small predaceous carabid, *Tachyura incurva*, on the other hand, is a year round occupant of the *ulkei* mounds, and is the most consistently abundant myrmecocole in the nest and trophoporic field. Schwarz (1889) thought the species an accidental visitor of ant nests, but later, with accumulation of data, reversed his opinion (1890).

In the laboratory nests the food of *incurva* is highly diversified. The beetles feed upon dead or disabled individuals of their own species, dead and disabled host ants, the host brood, and dead insects brought into the nest by the worker ants. In addition, the ulkeicoles are also attacked where the species offers little resistance (*Leptinus testaceus*, *Atheta polita*), or are eaten when injured (*Microdon* larvæ, queens of the lestopibiotic guest ant, *Solenopsis molesta*). Finally, *incurva* fed upon the sugar water and honey placed in the artificial nests.

The nest conditions are apparently very favorable for the species and its general behavior has been discussed elsewhere (Park, 1929). It appears to be a tolerated form, or at least very successful in avoiding persecution by the host ants. Its catholic feeding habits fit it for the general role of nest scavenger, although it may be strictly predaceous upon occasion.

We now turn to an habitual myrmecocole, the actively persecuted staphylinid, *Megastilicus formicarius*. It is common in the nests of *F. exsectoides* (Schwarz, 1889; Blatchley, 1910; Wickham, 1900), and Wheeler (1926) discusses the relation of this latter host to the beetle upon (1) the red and black coloration and ant-like appearance of the species, (2) its defensive mechanism, which is similar to that of the related staphylinid *Myrmedonia*, consisting of emitting a volatile whitish fluid from the raised tip of the flexible abdomen, and (3) that the ants kill the beetle within a few hours when in laboratory nests, but are eluded easily by the beetles in nature. He found *formicarius* too feeble to kill living *exsectoides* workers.

Formicarius has been taken repeatedly from the *ulkei* nests and studied in the laboratory. The above summary of its relations with *exsectoides* has been found to hold in general for *ulkei*. However, in the artificial nests of *ulkei*, *formicarius* is an agile and wary species. The ants attack

the beetles whenever the opportunity is presented, but with very indifferent success. When attacked the beetles usually wheel to present the posterior end to the ant and raise the apex of the abdomen. At times the beetle merely crouches, with the head lowered and antennæ pressed back and in to the body, while the abdomen is raised and its apex directed forwards over the sloping elytra. Both maneuvers serve the same purpose, the ant recoiling and behaving as though temporarily stunned. Meanwhile, the beetle escapes.

Infrequently, upon meeting an ant the *formicarius* would not raise the abdomen but would dodge away and attempt flight, either by running or by crouching and then crawling away between the ant's legs as the ant attempted to bite the beetle. If this retreat was blocked then the abdominal defense was successfully employed.

The worker *ulkei* almost always attacked these beetles at the slender neck or peduncle between the head and pronotum. Once such a hold was obtained the outcome was more doubtful. I have witnessed such combats where the ant had seized a beetle by the neck and the two struggled back and forth. One of these encounters lasted twenty-five minutes continuously, with the beetle thrusting the apex of its abdomen at the ant's head. At the end of this time the ant still held the beetle's neck between her mandibles, but appeared inert otherwise. The ant's jaws were pried apart and the *formicarius* ran off, unharmed, but the ant proved to be dead. The same beetle was then examined but the integuments were not even scratched. Of course, the ant may have been an enfeebled individual but we think that it was killed by the beetle's abdominal secretion. The protection of *formicarius* from *ulkei*, then, lies in (1) a hard exoskeleton, (2) agility, and (3) a defensive abdominal secretion which, under certain conditions at least, may be lethal.

At times a *formicarius* would be killed, when placed in a small watch glass with five or six workers. This usually happened during the night, and although the beetle would be dismembered, it was not eaten.

So far *Megastilicus formicarius* has not been observed to feed on dead host ants, although this is to be expected.

It does feed upon injured *Microdon* larvæ, chewing the flesh of wounds and licking the exuding body fluids. It has also been observed to attack and put to flight the larger staphylinid, *Gastrolobium bicolor*. *Formicarius* drinks from small pools of water in the artificial nests. In drinking, the head is lowered and the fore-legs spread apart; the water is pushed into the mouth by the maxillæ and labium, while the mandibles are held widely agape and partly immersed in the liquid.

After feeding, *formicarius* cleans itself elaborately. The vertex is rubbed by the prothoracic tarsi, usually both legs scraping together. The antennæ are cleaned by pushing them between the slightly gaping mandibles from above. The antennæ are then pulled back and forth, usually one at a time, in part by their own activity, but also by the fore-legs which push them upwards. After the antennæ are cleaned they are withdrawn and the prothoracic tarsi and tibiæ are thrust between the jaws, one leg at a time, and drawn back and forth rapidly. The front legs may also be rubbed together, after the manner of so many flies. The left elytron is scraped by the left middle leg and the right elytron by the right middle leg. The dorsal surface and sides of the abdomen are scraped by the metathoracic legs. Finally the wings are unfolded and held so that they parallel the abdomen, and moved from time to time. When the wings are retracted again, this action is aided chiefly by the raised apex of the abdomen.

Another characteristic myrmecocole is the small pselaphid, *Batrisodes globosus*. It lives all the year round with *Formica ulkei* as one of its most abundant guests. This beetle, however, is reported with many kinds of ants. Blatchley (1910) records the species "in the large cone-shaped nests of ants," which may refer either to *ulkei* or *exsectoides*. Schwarz (1889-1890) reported this pselaphid from nests of *Camponotus pennsylvanicus*, *Lasius americanus*, and *Cremastogaster lineolata*; Wickham (1898-1900) found it with *Camponotus herculeanus*, *Lasius americanus*, and *Lasius aphidicola*. Park (1932b) observed it with *Lasius americanus*, and I can now add the following hosts:⁶

⁶I am indebted to Dr. Thomas Park and Dr. M. R. Smith for determination of these host ants.

Springfield, Illinois (April 25) with *Lasius americanus*; Cambridge, Wisconsin (May 26) with *Camponotus noveboracensis*; Madison, Wisconsin (May 26) with *Lasius americanus*. The species, then, is known to have a number of hosts, but is not habitually taken with ants, since it is common in moist, decaying log mold in rich forests throughout the year.

The *ulkei* workers tolerate this pselaphid in their nests, seldom giving more than a wave of the antennæ when passing a beetle. On their part, the beetles usually walk on when passing a worker, and seldom crouch to the soil. Only once was an ant observed to attack *globosus*. On this occasion the ant picked up the beetle by surrounding it with her legs, and then attempted to bite it. The beetle however easily escaped, and walked off without the ant giving chase. Although rare, such an incident shows that the host will attack this normally tolerated form.

In 1929 the writer was unable to discover what *globosus* fed upon in the *ulkei* nest. Since then further investigation has produced a great deal of information. When *globosus* is isolated in artificial nests with earthworms, the beetles feed avidly on the latter, biting the worm's integument and eating the slime secreted. Such feeding, when examined under magnification, showed that the pselaphids bit and gnawed the worm's cuticula in the manner of predaceous carabids and staphylinids. They planted their fore-tarsi upon the worm, bit savagely and then pulled upwards, bracing their legs against the writhing worm. When entangled in the slime, the beetles struggled and eventually freed themselves, extricating one tarsus after another. Wounds made in the worm's body wall were readily attacked, as were also amputated segments placed in the nests. The twisting worms did not deter their feeding, and as many as three pselaphids per square centimeter of earthworm surface have been seen feeding, under laboratory conditions. When one pselaphid approaches another feeding beetle too closely, the latter pauses long enough to bite at the intruder, and usually drives it away.

The pselaphids may feed for thirty minutes. When through eating they clean their antennæ and fore-legs as noted previously for *Megastilicus*. After cleaning them-

selves they may or may not resume feeding. Holmquist (1928a) listed two species of earthworms in the *ulkei* nests, and since these oligochaetes are abundant in the wet soil of the nest rich in organic debris, they may form a part of the normal diet of *globosus*.

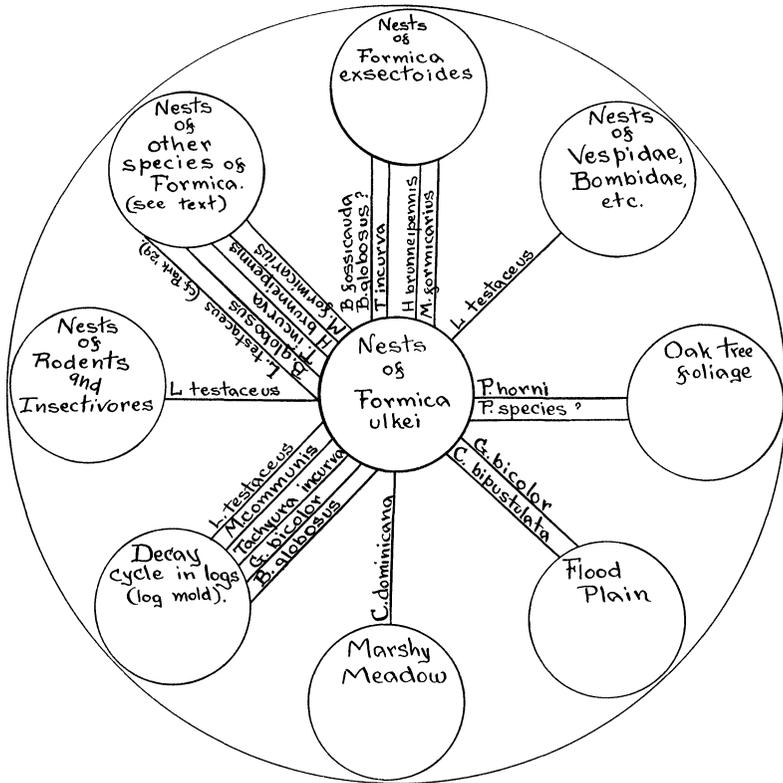


FIG. 2. Diagram of some of the habitat interrelations among the myrmecocoles of *Formica ulkei* Emery.

When a number of these pselaphids are isolated without food in an artificial nest the first individuals to die are summarily attacked by their cannibalistic companions who bite and lick at the integuments and especially at the articular membranes. From these data it is clear that *Batrissodes globosus* is a predator, attacking other ulkeicoles, and

may also act as a nest scavenger. Since this same species has been shown to eat the brood of *Lasius americanus* (Park, 1932b), it may well attack the young of *Formica ulkei*.

The last beetle to be discussed is the histerid, *Hetærius brunneipennis*. The genus *Hetærius* numbers some twenty-two species, all habitually found with ants. The ecology of most of the species remains unknown but *brunneipennis* has been well studied (Hamilton, 1888; Schwarz, 1890; Liebeck, 1891; Wickham, 1896, 1900; Wheeler, 1908, 1926). Wheeler assigns the genus to the symphiloid synoeketes (1926) and has given us our only comprehensive study of this species (1908). The following observations were made upon the *brunneipennis* found with *Formica ulkei*, and bear out the general conclusions of others concerning this beetle with different host ants.

May 11: a worker ant and one histerid placed in a petri nest at 2:00 P.M. The histerid letisimulated for five minutes and then began walking slowly ahead on the last two pair of legs, rubbing the anterior legs together at the same time. It walked in this manner for thirty minutes, covering twelve centimeters. During this time frequent halts were made to clean the legs and body. The front legs were drawn over the pronotum and head and then pushed slowly through the gaping mandibles. At intervals in its slow progress it would stop and rear up on the extended front legs. At 4:15 P.M. a dead ant was added. The histerid promptly mounted the latter but did not molest it. The living worker ran over to the beetle and licked the glandular area on the right posterior pronotal angle. While the host attended the beetle the latter remained motionless, not even withdrawing its antennæ. At 4:25 the histerid was given a thorough licking by the ant. The latter first licked the beetle's head and mouth parts and while doing so regurgitated a drop of liquid on to the beetle's mandibles. After this prolonged ministration the ant rolled the beetle over and bit twice at the right posterior pronotal angle again. The ant then licked the dorsal and ventral surfaces of the prothorax. This licking, fondling and feeding of the beetle continued for twenty minutes. During this period

the histerid remained passive with legs and antennæ outstretched.

On the following day the histerid was discovered in the morning gnawing spasmodically on the dead ant's left posterior leg at the femorotibial joint. Through the day this gnawing continued, and by 4:00 P.M. it had chewed free a small strand of the articular membrane and was persistently enlarging the perforation.

This isolated account is typical of the beetle's activities within the laboratory nests, and we conclude that the histerid is thoroughly adjusted to the *ulkei* biocoenose, where it is attended, cleaned, fed upon regurgitated foods by the worker ants and also eats dead insects in the nest. The workers in return for these many attentions bestowed upon the histerids, seem greatly stimulated by the glandular pronotal areas. This species is the most perfectly adjusted to *ulkei* of any of the guests so far reported.

Observation of these fifteen species of beetles associated with *Formica ulkei* show us that the several species eat many things and are in different categories with respect to food competition and adjustment to the host. The complexity of food interrelations for this very imperfectly understood biocoenose is suggested by the diagram in the accompanying figure (Fig. 1).

Another problem involved is the ecological role played by each form in the nest. The position of a species is usually a definite one with respect to its relation with other nest inhabitants, although this status is frequently different in its several life history stages. Our grasp of many of the larger community problems may depend to an unknown degree upon the amount of accurate information we have on the smaller, microhabitats, and therefore a great deal of autecological data must be had before we can really understand a large unit. The following table (Table III) is a tentative arrangement to indicate the role of these fifteen forms in the *ulkei* nest, the technical terms following the system employed by Wasmann and later modified by Wheeler (1926).

Since many of these species have a facultative role, and consequently occupy both the *ulkei* nest and other habitat niches, the complexity is greatly increased. These possible habitat interrelations are shown for some of the forms in Fig. 2.

TABLE III

Ecological Status of Ulkeicoles

Species	Status
1. Harpalus pleuriticus	Chance occurrence.
2. Amara polita	Chance occurrence.
3. Clivinia bipustulata	Chance occurrence.
4. Gastrolobium bicolor	Chance occurrence.
5. Cathartus advena	Chance occurrence.
6. Melanotus communis	Pupa. Chance occurrence.
7. Stilbus probatus	Status problematical.
8. Phyllophaga horni	Facultative larval stage?
9. Coscinoptera dominicana	Facultative or Habitual larval stage?
10. Megastilicus formicarius	Habitual Synecthran.
11. Atheta polita	Facultative Synecthran or Synoekete?
12. Tachyura incurva	Facultative Synoekete.
13. Leptinus testaceus	Status problematical: Facultative Loricata Synoekete.
14. Batrisodes globosus	Facultative Mimetic Synoekete.
15. Hetaerius brunneipennis	Habitual Symphiloid Synoekete.

BIBLIOGRAPHY

- Blatchely, W. S. (1910). Coleoptera known to occur in Indiana. Indianapolis: Nature Pub. Co., 1386 pp.
- Burrill, A. C. and M. R. Smith (1918). A preliminary list of ants of Wisconsin. Ohio Jour. Sci., 18: 229-32.
- (1919). A key to the species of Wisconsin ants, with notes on their habits. Ibid, 19: 279-92.
- Donisthorpe, H. St. J. K. (1902). The life history of *Clythra quadripunctata* L. Trans. Ent. Soc. London, 11-23.
- (1909). On the origin and ancestral form of myrmecophilous Coleoptera. Ibid, 397-411.
- (1927). The guests of British Ants. London: G. Routledge and Sons, 244 pp.
- Dreyer, W. A. (1932). The effect of hibernation and seasonal variation of temperature on the respiratory exchange of *Formica ulkei* Emery. Physiol. Zoöl., 5: 301-31.
- Dreyer, W. A. and Thomas Park (1933). Local distribution of *Formica ulkei* mound-nests with reference to certain ecological factors. Psyche, 39: 127-33.
- Dury, Charles (1903). A revised list of the Coleoptera observed near Cincinnati, Ohio. Jour. Cincin. Soc. Nat. Hist., 20: 107-96.
- Hamilton, John (1888). Catalogue of the myrmecophilous Coleoptera with bibliography and notes. Can. Ent., 20: 161-6.

- Holmquist, A. M. (1928a). Notes on the life-history and habits of the mound-building ant, *Formica ulkei* Emery. *Ecology*, 9: 70-87.
- (1928b). Studies in arthropod hibernation. II. The hibernation of the ant, *Formica ulkei* Emery. *Physiol. Zoöl.*, 1: 325-57.
- Leng, C. W. (1928). A list of the insects of New York. Mem. 101, Cornell Univ. Agr. Exp. Sta.
- Liebeck, Charles (1891). (Note). *Ent. News*, 2: 120.
- Park, Orlando (1929). Ecological observations upon the myrmecocoles of *Formica ulkei*, especially *Leptinus testaceus* Mueller. *Psyche*, 36: 195-215.
- (1930). Studies in the ecology of forest Coleoptera. Seral and seasonal succession of Coleoptera in the Chicago Area, with observations on certain phases of hibernation and aggregation. *Ann. Ent. Soc. Am.*, 23: 57-80.
- (1931). Studies, etc. II. The relation of certain Coleoptera to plants for food and shelter, especially those species associated with fungi in the Chicago Area. *Ecology*, 12: 188-207.
- (1932a). The myrmecocoles of *Lasius aphidicola* Walsh. *Ann. Ent. Soc. Am.*, 25: 77-88.
- (1932b). The food of *Batrissodes globosus* (Lec.). *Jour. N. Y. Ent. Soc.* 40: 377-78.
- (1933a). The food and behavior of *Tmesiphorus costalis* Lec. *Ent. News*, 44: 149-151.
- (1933b). Ecological observations upon the Ptiliid myrmecocole, *Limulodes paradoxus* Matthews. *Ann. Ent. Soc. Am.*, 26: 255-61.
- Park, Orlando and J. G. Keller, 1932. Studies in Nocturnal Ecology, II. Preliminary analysis of activity rhythm in nocturnal forest insects. *Ecology*, 13: 335-46; Errata, Vol. 14.
- Park, Thomas (1929). Notes on the relationship between *Formica ulkei* Emery and *Solenopsis molesta* Say. *Ent. News*, 40: 325-26.
- Riley, C. V. (1882). Habits of *Coscinoptera dominicana*. *Am. Nat.*, 16: 598.
- Schwarz, E. A. (1889). Myrmecophilous Coleoptera found in Temperate North America. *Proc. Ent. Soc. Wash.*, 1: 237-247.
- (1890). (Note). *Ibid*, 2: 88.
- (1896). (Note on *Coscinoptera dominicana*.) *Ibid*, 3: 73-77.
- Smith, J. B. (1886). Ants'-nests and their inhabitants. *Am. Nat.*, 20: 679-87.
- Ulke, H. (1890). (Note). *Proc. Ent. Soc. Wash.*, 2: 87.
- Wheeler, W. M. (1908). Studies on Myrmecophiles. II. *Hetærius*. *Jour. N. Y. Ent. Soc.*, 16: 135-43.
- (1926). Ants, their structure, development and behavior. New York: Columbia Univ. Press, 663 pp.
- Wickham, H. F. (1892). Notes on some myrmecophilous Coleoptera. *Psyche*, 6: 321-23.
- (1896). On Coleoptera found with ants. *Ibid*, 7: 370-72.
- (1898). On Coleoptera found with ants. *Ibid*, 8: 219-21.
- (1900). On Coleoptera found with ants. *Ibid*, 9: 3-5.



Hindawi

Submit your manuscripts at
<http://www.hindawi.com>

