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A UNIQUE PREDATORY ASSOCIATION BETWEEN CARABID BEETLES OF THE GENUS *HELLUOMORPHOIDES* AND COLONIES OF THE ARMY ANT *NEIVAMYRMEX NIGRESCENS*.*

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This paper presents preliminary observations of a unique relationship between predatory beetles, *Helluomorphoides latitarsis* LeConte and *H. ferrugineus* Casey, belonging to the family Carabidae, and colonies of the army ant, *Neivamyrmex nigrescens* (Cresson).

Studies of interactions between these beetles and *N. nigrescens* are important because: (1) they have revealed unique predatory interactions between species of *Helluomorphoides* and colonies of *N. nigrescens*; and (2) they have increased our understanding of the role of the kinds of stimulation involved in group raiding and emigrations in army ants.

In southeastern Arizona, colonies of *N. nigrescens* are characterized by large populations, group predation, and cyclic behaviour consisting of alternating nomadic and statary phases (Schneirla, 1958). Colonies contain 150,000 to 250,000 workers and a brood population of approximately 30,000 individuals. In the study area, during the nomadic phase, raiding begins at dusk and is followed by emigrations to new nest sites. These predatory forays and emigrations are conducted on branching anastomosing chemical trails, laid down continously from the hindguts of the ants (Watkins, 1964). Worker ants maintain their positions in the columns by following these trails, and by close contact with adjacent individuals.

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In the course of nightly studies of colony emigrations and bivouac locations, during the summers of 1966 and 1968, as many as 15 individuals of *H. latitarsis* and *H. ferrugineus* were found feeding on the booty and on the broods of *N. nigrescens*. The beetles were observed running in army ant columns or standing off to the sides of the columns, behind rocks or beneath clusters of leaf litter. During their predatory activities, beetles ran along the trails in both directions, "plowing" through the continuous two-way ant traffic. When a beetle of either species contacted a worker ant bringing booty back to her bivouac, the ant usually dropped the booty. On some occasions, if the booty was a larval or pupal individual of another ant species, the beetle immediately ate it and continued on the trail. On other occasions the beetle picked up the dropped booty, left the raiding column, and proceeded to a nearby rock. There, the beetle quickly ate the larva or pupa, returned to the column, and resumed running along the trail.

On two occasions, I observed individuals of *H. latitarsis* "forcibly" taking booty from ants. In both instances a beetle encountered an adult worker returning to the bivouac with a larva of the ant *Pheidole* sp. protruding anteriorly from her mandibles. The beetle grasped the protruding portion of the larva with its mandibles, while the worker of *N. nigrescens* was still holding the larva. The beetle then flexed its head sharply upwards, lifting both ant worker and larva, and held them off the ground for almost two seconds; the ant then released the larva and dropped back onto the ground. On the first occasion, the beetle immediately ate the larva. The second time, the beetle scampered away from the column with the larva as soon as the ant had released it.

Both species of beetles fed most intensively on nights during the nomadic phase when colonies of *N. nigrescens* emigrated with their larval broods. Individuals of *H. latitarsis*, the larger of the two species of beetles, were often observed eating as many as 28 larvae. Whenever a beetle encountered a brood cache, consisting of several hundred larvae clustered beneath a leaf at a trail junction, it fed rapidly until satiated. As the beetles consumed the ant larvae, their abdominal sclerites separated, and their abdomens swelled until they protruded considerably beyond the posterior edges of their elytra (Fig. 1).

Once beetles became associated with a colony of ants, they either fed briefly on booty or brood and then wandered off, or they remained near the colony throughout the night. In the latter case, when army

Figure 1

An individual of *Helluomorphoides latitarsis* eating pupae of *Neivamyrmex nigrescens*. Note workers biting the beetle's antenna, head, and abdomen. Other workers are removing pupae. The reference line is equivalent to 5 mm.

ant activities ceased at dawn, the beetles often entered sheltered areas beneath rocks adjacent to the ants' bivouac. Three individuals of *H. latitarsis*, marked with red dye while foraging in a column of *N. nigrescens* at night, were recovered during the following day by turning rocks adjacent to the colony's bivouac. However, no beetles have ever been found in excavated army ant nests.[1]

Six individuals of *H. latitarsis* and four individuals of *H. ferrugineus* were removed from army ant raiding columns, and maintained in the laboratory in plastic petri dishes. To observe predatory interactions between beetles and army ants, a beetle was removed from its "home" chamber, and introduced into a petri dish containing 50 adult ants and 100-200 eggs, larvae or pupae. In this situation, individuals of both beetle species fed voraciously on all developmental stages of the army ants' brood (Fig. 1). The beetles exhibited bouts of running and feeding, which were followed by periods of complete inactivity, lasting up to 20 minutes. Since the only shaded areas in the plastic chambers were beneath the inactive beetles, workers of *N. nigrescens* often deposited their brood in clusters beneath them. When the beetles again became active, they readily fed on these brood clusters.

In the confined observation chambers, each period of feeding by the beetles aroused the ants to exhibit their "alarm" reaction, which consisted of ants standing on their hind legs, opening and closing their mandibles. The ants also "attacked" the beetles by biting and stinging their antennae and legs (Fig. 1). However, these activities rarely disturbed the beetles, and although they are capable of secreting a defensive, repellent chemical (Eisner *et al.*, 1968), there was no indication that they had sprayed the ants with it.[2]

Discussion

Although many species of carabid beetles are numerous in the field study area, and routinely forage actively at night, *H. ferrugineus* and *H. latitarsis* were the only beetles found with colonies of *N. nigrescens*. Whether they encounter colonies of army ants accidentally while foraging, or actively orient towards them, is not known. Lab-

[1]Professor Julian Watkins II has informed me that an individual of a related species, *H. texanus*, was uncovered in an excavated bivouac of *N. nigrescens*.

[2]Plsek *et al.* (1969) reported that an individual of *H. texanus*, confined in a plastic chamber with 100 workers of *N. nigrescens*, sprayed the ants that were attacking it. The repellent spray caused the ants to withdraw from the beetle.

oratory experiments by Plsek *et al.* (1969), showed that individuals of a related species, *H. texanus* (Le Conte) can follow chemical trails deposited by workers of *N. nigrescens*. In the field, army ant trails are reinforced by thousands of ants running to and from their bivouac during the course of each night's raiding. This results in the deposition of a very strong and relatively non-volatile chemical trail. If a beetle accidentally crossed a trail used by army ants during the previous night, it could run along the trail until it encountered a colony of *N. nigrescens*.

After locating a colony of *N. nigrescens*, beetles may forage in the ant columns by responding to combinations of visual, chemical, and tactual stimuli. Both species have large protruding compound eyes, which could enable them to orient visually at night. Our field observations indicate that tactual orientation is important in the beetles' foraging pattern, and is accomplished by their continuous responses to physical encounters as they "plow" through ants running to and from their bivouac.

Our field and laboratory observations of contacts between beetles and army ants, has also explicated the role of tactual stimulation in army ant group raiding and emigrations. When individuals of both species of beetles ran through raiding columns, foraging and booty-laden ants returning to their nest were repeatedly pushed aside, or knocked off their feet. Surprisingly, these ants were only momentarily interrupted by the activities of the beetles; they quickly resumed their positions on the trail, without appreciably disrupting other ants in the column.

In order to test the effect of mechanical stimulation on workers of *N. nigrescens* in the field, tactual interactions between beetles and ants were simulated by running the tip of a flexible wire probe through a column of raiding ants. Ants displaced by the moving probe were only momentarily aroused, and the column remained intact. These reactions to mechanical stimulation were then contrasted with the ants' behavior when subjected to stimuli not normally present in their nocturnal environment. Tests showed that even low intensity stimulation by light (from a headlamp) or by air currents (created by blowing) causes the running ants to disperse from the column.

The lack of significant arousal of *N. nigrescens* workers by beetles foraging in their columns, may be explained, in part, by considering the stimulus-environment characteristic of army ant colonies. Throughout their development and adult life, army ant workers live in an environment in which they are continuously stimulated by

chemical and tactual interactions among all individuals in the colony. Since individual ants contact each other continually in the bivouac and in raiding and emigration columns, their thresholds of arousal for tactual stimulation may be very high. Effectively then, this low level of reactivity on the part of the ants makes the beetles' typical pattern of foraging well adapted to the physiological state of the ants. Thus, although the beetles exhibited no specific adaptations for preventing the ants from becoming aroused, they were successful predators on the army ants' brood and booty, because their contact with the ants did not result in the dissociation of the ant columns.

Although our observations represent only a preliminary study, we feel that both *H. latitarsis* and *H. ferrugineus* must be added to the list of organisms important in the biotic environment of the army ant, *N. nigrescens*. During the present study, as many as 15 individuals of *H. latitarsis* and *H. ferrugineus* were found associated with each colony of army ants, and each beetle consumed approximately 10-30 army ant larvae during every emigration. Since the nomadic phase of *N. nigrescens* lasts about 18 days, during which time colonies may emigrate up to 15 times, several thousand larvae might be consumed by the beetles during the nomadic phase of each colony. This represents a substantial degree of predation.

The queen of *N. nigrescens* lays approximately 30,000 eggs every 30-35 days. This potential increase in the size of the adult population is offset mainly by mortality of workers during the predatory raids in other ant nests, and by myrmecophiles which feed on all stages of the colony's brood. These myrmecophiles are specialized insect "guests," adapted to live within the ants' bivouac and to emigrate with the colony each night during the nomadic phase. Most myrmecophiles associated with colonies of *N. nigrescens* are flies of the family Phoridae and beetles of the family Staphylinidae. Akre and Rettenmeyer (1968) have shown that several species of these staphylinid beetles closely mimic army ant workers, and can easily follow their chemical trails. The carabid beetles, *H. latitarsis* and *H. ferrugineus*, by contrast, are not specialized myrmecophiles. We have never found them in any of the 11 army ant bivouacs excavated during the past three years, and they apparently associate with the ant colonies only at night.

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