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Research article

Oribatid mite predation by small ants of the genus *Pheidole*

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Summary. Using "cafeteria experiments" with forest soil and litter, I obtained evidence that at least some small Neotropical species of *Pheidole* prey on a wide array of slow-moving invertebrates, favoring those of approximately their own size. The most frequent prey were oribatid mites, a disproportion evidently due in part to the abundance of these organisms. The ants have no difficulty breaking through the calcified exoskeleton of the mites.

Key words: Mite predation, food chain, *Pheidole,* ants.

Introduction

Among the most abundant invertebrates of the soil and litter in the 0.1–1.0 mm body length range are the oribatid mites (order Acariformes, suborder Oribatida), comprising over 6000 species in about 1000 genera and 150 families worldwide (Norton, 1985). Very little is known concerning the predators of this important group, other than several families of small beetles (Pselaphidae, Ptiliidae, Scydmaenidae) and ants of the genus *Myrmecina* (Masuko, 1994). Oribatids move much more slowly than most other mites and the adults are shielded by the hardness of the cuticles, which are stiffened with calcium carbonate and calcium oxalate (Norton and Behan-Peletier, 1991).

In parallel manner, among the most diverse and abundant ants are members of the genus *Pheidole*. Especially abundant in the New World tropics, indeed among the dominant insects, are small to very small species in the *flavens, perpusilla,* and *punctatissima* groups, of which 190 have been described to date. During a systematic study of *Pheidole* (Wilson, 2003), I noticed that almost nothing was known about the food habits of these ants, and set out to determine whether they might be utilizing the rich resource offered by the oribatid mites that swarm around them.

Methods

I established laboratory colonies of several Neotropical *Pheidole* species in artificial nests, allowing them to settle for a period of at least two weeks, during which they were fed with Bhatkar-Whitcomb diet (Bhatkar and Whitcomb, 1970) and freshly killed *Nauphoeta* cockroaches. In the experiments the ants were then given access to 14 × 20 cm foraging arenas surrounded by 10-cm-high walls coated with unscalable Fluon©. Foraging minor workers were allowed to travel to the arenas through transparent plastic tubes.

Next I conducted "cafeteria experiments" to observe predation by the ants. Litter and shallow layers of soil beneath were collected from forest floors, on different occasions in temperate hardwood forests in Lincoln, Massachusetts, and lowland tropical rainforest at La Selva, near Puerto Viejo, Costa Rica. Each sample, 2 liters in volume, was then processed with a "dry" collecting bottle, that is, a bottle containing a quarter-liter of soil and ground litter resting on a moistened piece of paper towel, and into which invertebrates could fall without injury. The contents of the bottle were spread over the floor of the foraging arena and the ants released into it (the enrichment procedure was necessary because the rate of prey capture was too slow in unprocessed soil and litter and the consumption of prey too fast to make observation practicable).

A census was made of the invertebrates in the enriched sample before the ants were given access, and the *Pheidole* colony examined thereafter at two hour intervals for the presence of prey. The three species tested most thoroughly in this manner, with the provenance of the colonies and their three most common prey, are given in Table 1.

Results

The data summarized in Tables 1 and 2 show that the small *Pheidole* species tested collect oribatid mites readily, eat them, and feed them to the larvae. Moreover, as demonstrated by the frequency of invertebrate captures by the *P. flavens* colony, which was closely approximated by prey frequencies in *P. bilimeki* and *P. nebulosa* (not shown), oribatid mites are the leading prey. Colonies of two other small *Pheidole* species, *P. aripoensis (punctatissima* group) and *zeteki (perpusilla* group) also captured oribatids, although too few data were obtained to determine the true relative frequency of the prey.

The mites captured by *P. flavens,* the colony of which was studied most closely, were all slow-moving, armored members of the suborder Oribatida, spread across several taxo-

Table 1. *Pheidole* species tested for invertebrate predation and the prey recorded

Ant species	Ant species group	Origin of colony	Number of replicates, cafeteria experiment	Three most frequent prey, rank-ordered
P. flavens	*flavens*	Trinidad	10	Oribatid mites, non-oribatid mites, isotomid collembolans
P. bilimeki	*flavens*	Costa Rica	5	Oribatid mites, spiders, beetle larvae
P. nebulosa	*flavens*	Costa Rica	8	Oribatid mites, pseudoscorpions, ants

Table 2. Number of invertebrates identified in litter and soil offered *Pheidole flavens* colony, compared with number observed to be retrieved and placed with the *Pheidole* larvae. Summary of 10 trials.

Kind of invertebrates	Number of individuals identified in the litter and soil samples	Number gathered as prey
Oribatid mites	58	47
Non-oribatid mites	55	4
Entomobryomorph collembolans	44	1
Symphypleonan collembolans	6	0
Isotomid collembolans	18	2
Spiders	7	0
Pseudoscorpions	2	1
Pauropods	2	0
Millipedes	4	0
Beetle adults	4	1
Beetle larvae	4	2
Ants (*Leptothorax, Myrmica*)	4	0
Fly larva	0	1

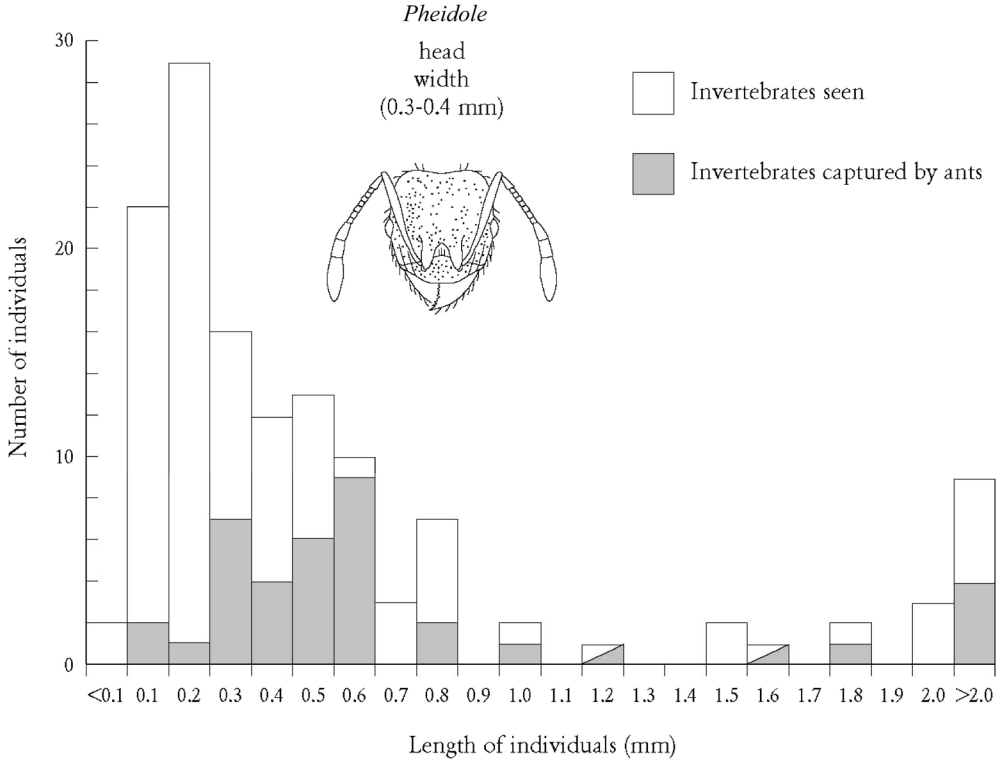

Figure 1. The maximum body length of invertebrate offered in enriched litter to *Pheidole flavens* colonies and of invertebrates taken as prey. The approximate range in head width of the minor *P. flavens,* the foraging caste, is also depicted. The head shown is of a *P. flavens* minor worker. The two columns divided obliquely into clear and shaded are those with identical values for "invertebrates seen" and "invertebrates captured by ants"

nomic families. They included *Galumna* sp. near *lanceata,* and *Pergalumna nervosa* (Galumnidae); *Nothrus* sp. (Nothridae); *Damaeus verticillipes* (Damaeidae); *Xylobates lophotrichus* (Haplozetidae); *Tectocepheus* sp. (Tectocepheidae); and *Scheloribates* (Scheloribatidae). The small number of non-oribatids (4 of 51 mite prey recorded) were not identified. Non-prey mite species identified in the soil-litter sampler were all fast-moving, predatory species of the suborders Mesostigmata and Prostigmata. These included 2 species of *Pergamasus* (Parasitidae), *Podocinum pacificum* (Podocinidae), and a member of the Stigmaeidae not placed to genus.

As the lists for *Pheidole flavens* in Table 2 show (paralleled closely by those for *P. bilimeki* and *P. nebulosa),* foraging minor workers capture a wide variety of small invertebrates. By and large, however, the ants caught only those that are relatively slow-moving. They also favored prey whose maximum lengths were about 1–2 × the minor worker head width, in other words neither very small nor too large to be easily picked up and carried (Fig. 1). This propensity, combined with the great abundance of Oribatida, resulted in the bias by the ants toward mites of this group.

The *P. flavens* foragers, upon finding a mite, immediately picked it up by its mandibles and carried it back to the nest. Occasionally the ants paused for several seconds to bring their abdomens forward as though to adjust the position of the mite, in the manner of a person carrying a heavy burden in his arms. Since *Pheidole* workers do not possess a functional sting, these actions could not and did not serve to disable the prey. Inside their nests the ants abraded the mite exoskeletons with their lower mouthparts to expose the tissue beneath. They did not appear to cut the mites open with their mandibles. Mites were also placed whole or in fragments directly on the heads of the larvae, which then consumed them.

Discussion

If these laboratory responses accurately reflect predation in nature, oribatid mites constitute an important part of the diet of at least some small species of *Pheidole*. It follows that due to their abundance and wide geographic range, these ants must also be among the most important predators of oribatid mites. Unidentified mites have been found to be taken as a secondary prey by *Strumigenys* and other small dacetines, which are otherwise specialized as trap-jawed predators of fast-moving collembolans (Wilson, 1953; Masuko, 1984). They also form at least part of the diet of the *Pheidole*-like *Oligomyrmex urichi* (Wilson, 1962). Masuko (1994) has determined also that two Japanese species of *Myrmecina (flava* and *nipponica)* feed on a variety of invertebrates, but predominantly on oribatids. He also presents evidence from worker behavior and larval anatomy that the *Myrmecina* are specialized predators on oribatids. Ito and Takaku (1994) and Ito and Aoki (2003) report that unidentified Oriental *Myrmecina* species they studied at least occasionally feed on oribatids.

Overall, the great relatively abundance of both oribatid mites and small *Pheidole* species points to the predation as a key link in the food webs of New World tropical and warm temperate habitats. Larger *Pheidole* species may not be implicated. A populous laboratory colony of *P. biconstricta* (minor Head Width about 0.8 mm) I tested took a variety of invertebrates but no oribatids. Another species, *P. titanis* (minor Head Width 0.9 mm) has been determined to be a specialized predator on termites (Feener, 1988).

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References

Bhatkar, A.P. and W.H. Whitcomb, 1970. Artificial diet for rearing various species of ants. *Florida Ent. 53*: 229–232.

Feener, D.H., 1988. Effects of parasites on foraging and defense behavior of a temitophagous ant, *Pheidole titanis* Wheeler. *Behav. Ecol. Sociobiol. 12*: 421–427.

Ito, F. and G. Takaku, 1994. Obligate myrmecophily in an oribatid mite. Novel symbiont of ants in the Oriental tropics. *Naturwissenschaften 81*: 180–182.

Ito, F. and J. Aoki, 2003. Bionomics of the myrmecophilous oribatid mite *Protoribates myrmeophilus* (Acari: Oribatida) in the Oriental tropics. *J. Nat. Hist. 37*: 2383–2391.

Masuko, K., 1984. Studies on the predatory biology of Oriental dacetine ants (Hymenoptera: Formicidae), I: Some Japanese species of *Strumigenys, Pentastruma,* and *Epitritus,* and a Malaysian *Lapidogenys,* with special reference to hunting tactics in short-mandibulate forms. *Insect. Soc. 31*: 429–451.

Masuko, K., 1994. Specialized predation on oribatid mites by two species of the ant genus *Myrmecina* (Hymenoptera: Formicidae). *Psyche* (Cambridge, MA) *101*: 159–173.

Norton, R.A., 1985. Aspects of the biology and systematics of soil arachnids, particularly saprophagous and mycophagous mites. *Quaest. Entom. 21*: 523–541.

Norton, R.A. and V.M. Behan-Peletier, 1991. Calcium carbonate and calcium oxalate as cuticular hardening agents in oribatid mites (Acari: Oribatida). *Can. J. Zool. 69*: 1504–1511.

Wilson, E.O., 1953. The ecology of some North American dacetine ants. *An. Entomol. Soc. Amer. 46*: 479–495.

Wilson, E.O., 1962. The Trinidad cave ant *Erebomyrma* (=*Spelaeomyrmex*) *urichi,* with a comment on cavernicolous ants in general. *Psyche* (Cambridge, MA) *69*: 62–72.

Wilson, E.O., 2003. Pheidole *in the New World: A Dominant, Hyperdiverse Ant Genus.* Harvard University Press, Cambridge, MA, 794 pp.