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Impact of the Western Thatching Ant (*Formica obscuripes*) on invertebrate abundance and diversity

Kate Jenks[1,2] and Jennifer Reithel[2,3]

[1]Kalamazoo College, Dept. of Biology, Kalamazoo, MI 49006 (kjenks@wi.rr.com)
[2]Rocky Mountain Biological Laboratory, PO Box 519, Crested Butte, CO 81224
[3]University of California at Irvine, Dept. of Ecology and Evolutionary Biology, Irvine, CA 92697 (jreithel@stanford.edu)

Abstract– Manipulation of *Formica obscuripes* abundance and its effects on invertebrate abundance and diversity were studied in Colorado, from June 26 to August 18, 2000. Aluminum barriers at fifteen ant colonies were used to reduce, but not exclude, *F. obscuripes* from areas absent of ant colonies. Pitfall traps at each colony were used to sample invertebrate abundance at three locations: 1 meter from an active ant mound, 6 meters from an active ant mound, and 1 meter from the mound, but on the side of the barrier without a colony. The abundance of ants and leafhoppers did not differ significantly between the three locations. Wolf spiders were most abundant on the side of the barrier without the ant mound. Ant and spider abundance differed significantly between colonies. Ant and spider abundance were positively correlated, contradicting other published results. There was no significant difference in invertebrate diversity among treatments. This study suggests that ants may affect the abundance of wolf spiders. Thus, ants may play a role in structuring invertebrate communities.

Key words: Formica obscuripes*; ants; pitfall traps;* Cicadellidae*;* Lycosidae*; invertebrate communities*.

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Ants have great potential to structure invertebrate communities in their role as both predator and prey, and in competition with other invertebrates. They forage in large numbers throughout their ranges, collecting insects including hemipterans, beetles, sawfly larvae, caterpillars, and other herbivores (Hölldobler & Wilson 1990). In addition to ants' possible influence on the invertebrate community through predation, they are specifically known to influence community composition of insects on plants. In this scenario, benefits often accrue to plants foraged on by the ants. In some cases, mutualisms have evolved in which ants protect plants from predators, and in turn are housed or fed by the plants (Hölldobler & Wilson 1990). Previous accounts of such interactions include ants being attracted to plants secreting extrafloral nectar. Certain plants, such as the aspen sunflower, *Helianthella quinquenervis*, secrete extrafloral nectar rich in sucrose and amino acids. Ants collect the nectar for food, and simultaneously guard the plant from herbivores by patrolling the flower head (Inouye and Taylor 1979). Inouye (1984) compared differences in levels of seed damage on ant-tended and untended flower heads for *H. quinquenervis*. Plants were determined to sustain a greater percentage of seed damage when the ant species of the genus *Formic*a was experimentally excluded. This was primarily due to the fact that the presence of ants seeking nectar guarded the plants against larvae of tephritid flies that eat seeds.

If the genus *Formica* affects the abundance of invertebrate predators on plants, it might also impact overall invertebrate abundance and diversity in its foraging areas. It is not known if *Formica* simply influences invertebrate abundance directly on the plants by attacking intruders, or if an abundant ant population limits predator density throughout the foraging range of the colony. More specifically, competition or predation between ants and spiders could influence spider abundance. Heikkinen (1999) looked at the number of spiders (*Araneae*) on sagebrush (*Artemisia tridentata*) around active, abandoned, and exterminated ant mounds. He found that *Formica obscuripes* on sagebrush significantly depress spider abundances and attributed the results to interference competition between the species (Heikkinen 1999).

The aim of this study was to further investigate the impact of *Formica obscuripes* on overall invertebrate abundance. In addition, we repeated a component of Heikkinen's experiment and examined the effect of ants on spider abundance around active ant mounds. The following questions were addressed:

(1) Are barriers effective in manipulating ant abundance?
(2) Does a high abundance of *Formica obscuripes* affect invertebrate abundance?
(3) Does a high abundance of *Formica obscuripes* depress spider abundance?
(4) Is there an impact on invertebrate diversity in areas foraged by *Formica obscuripes*?



Fig. 1. Aluminum barrier at Almont Triangle, CO.

Methods

Ant mounds were manipulated in the Almont Triangle (approx. elevation 2300m), which is 30km southeast of Gothic (39°N, 107°W), in Gunnison County Colorado, USA. The predominant vegetation types are sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus viscidiflorus*), and mule's ear (*Wyethia arizonica*).

Aluminum barriers (7.32m x 20.3cm, Fig. 1) were nailed into the ground next to 15 individual *Formica obscuripes* mounds. The positioning of the barriers relative to the side of a mound was randomized. Ant colonies included in the study were at least 6m apart. An attempt was made to reduce, but not exclude *F. obscuripes* on the sides of the barriers absent of colonies by coating top edges of the barriers with Tanglefoot (The Tanglefoot Company, Grand Rapids, MI). All of the colonies were active at the time of the study.

Invertebrate abundance at each of the 15 colonies was estimated with pitfall traps at three locations: 1 meter from the center of the mound, 6 meters from the center of the mound, and 1 meter from the center of the mound on the side of the barrier without the colony. Plastic cups (9oz.) were utilized for pitfall traps and buried in a vertical position in the soil so that the cup lip was flush with ground level. The bottom 2.54cm of each cup was

filled with water to trap invertebrates. Pitfall traps set at 1m from the mound provide data from a region of high ant density, whereas traps at 6m represented an area of lower ant density. Heikkinen (1999) identified a range from 6.0-8.6m from mounds at which spider numbers leveled off with distance from the mound. Based on this range, a distance of 6m was selected to position the farthest pitfall trap from each mound. On the opposite side of the barrier without the colony, pitfalls were placed 1m from the mound (Fig. 2) to sample an area with reduced ant density. We did not include a treatment 6m from the mound on the side of the barrier without the ant mound because our aim was to reduce ant densities in that area, therefore, the treatment at 1m was thought to be sufficient. In addition, a fourth treatment was not added due to the long amount of time it took to process samples. Relevant data (species, date, location) were taken on specimens collected. Sample specimens identified to morphospecies were preserved in 70% ethanol, and deposited in the insect collections at the Rocky Mt. Biological Laboratory, Gothic, CO.

Data were collected on 28 July 2000 from pitfall traps at all colonies after the cups had been left with water in them for four days. Four traps were at each location (3 treatments), making a total of twelve pitfalls traps at each colony. A total of 180 traps (12 traps X 15 colonies) were collected on 28 July 2000.



Fig. 2. Pitfall trap and barrier near ant mound.

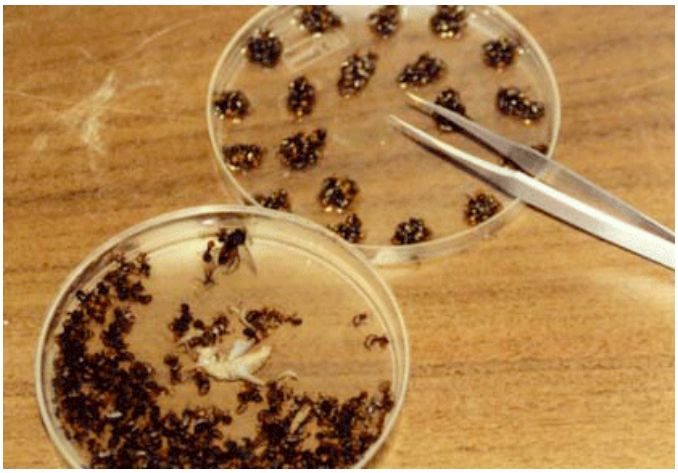


Fig. 3. Sorting pitfall trap samples.

ANOVA—factorial analysis was used to examine the effect of the barriers on *F. obscuripes*, leafhopper (*Cicadellidae*), and wolf spider (*Lycosidae*) abundance. The independent variables were treatment (1m from mound on side of barrier without ant colony, 1m from mound, 6m from mound) and colony. Interactions were not calculated because we did not use an experimental design that replicated colonies. It would only have been possible to determine interaction effects if treatments were independently replicated within colonies. In addition, we calculated correlation coefficients between ant abundance, leafhopper abundance, spider abundance, and diversity. The other morphospecies collected were not analyzed individually due to small sample sizes.

We calculated Shannon-Weiner values as a measure of diversity and ANOVA was used to determine whether overall invertebrate diversity between treatments and colonies differed. For all tests, values were averaged for the four cups at each treatment. Statistical analyses were conducted with SuperANOVA version 1.11 (1991) and StatView version 4.1 (1994).

Results

There was no significant treatment effect ($F_{(2,28)}$=0.218, P=0.806) on *Formica obscuripes* abundance (Fig. 4A). In contrast, there was significant variation ($F_{(14,28)}$=2.636, P=0.014) among colonies in number of ants captured in pitfall traps.

Similar to ants, there was no significant treatment effect ($F_{(2,28)}$=1.123, P=0.340) found for the abundance of leafhoppers among locations (Fig.

4B). Leafhopper abundance tended to differ among colonies ($F_{(14,28)}$=1.883, P=0.075).

A significantly greater (Fisher's post-hoc test; P=0.007) number of spiders were found on the side of the barrier without the mound as compared to 1m away from the ant mound (Fig. 4C). In addition, a significant number (Fisher's post-hoc test; P=0.021) of spiders were found on the side of the barrier without the mound as compared to 6m away from the ant mound (Fig. 4C). There was a significant treatment ($F_{(2,28)}$=4.899, P= 0.015) and colony effect ($F_{(14,28)}$=2.369, P=0.025) for spiders.

To further analyze the relationship between ant and invertebrate numbers we tested for correlations. Ant abundance and spider abundance were positively correlated (Table 1, Fig. 5), but leafhopper abundance and diversity were not correlated with ants, with each other, or with spider abundance (Table 1).

A Shannon-Weiner index of diversity was calculated for each individual pitfall trap. An ANOVA with factors of colony and treatment was done to compare differences in diversity. There was no significant difference ($F_{(2,28)}$=0.099, P=0.906) in invertebrate diversity among treatments. A significant colony effect ($F_{(14,28)}$=2.939, P=0.007) was found, indicating that invertebrate diversity differs among colonies.

Table 1. Correlation matrix for pitfall trap abundances of ants, leafhoppers, and spiders, and invertebrate diversity (Shannon-Weiner index).

	Ants	Leaf-hoppers	Spiders
Ants	1.000		
Leafhoppers	-0.116	1.000	
Spiders	0.300*	0.180	1.000
Invertebrate diversity	-0.279	0.084	0.098

* Significant at the 0.05 level

Fig. 4. Effect of the barriers on ant (A), leafhopper (B), and spider (C) abundance. Columns represent the average numbers collected per treatment. Error bars indicate one standard error. The asterisk indicates a significant difference from both of the other treatments.

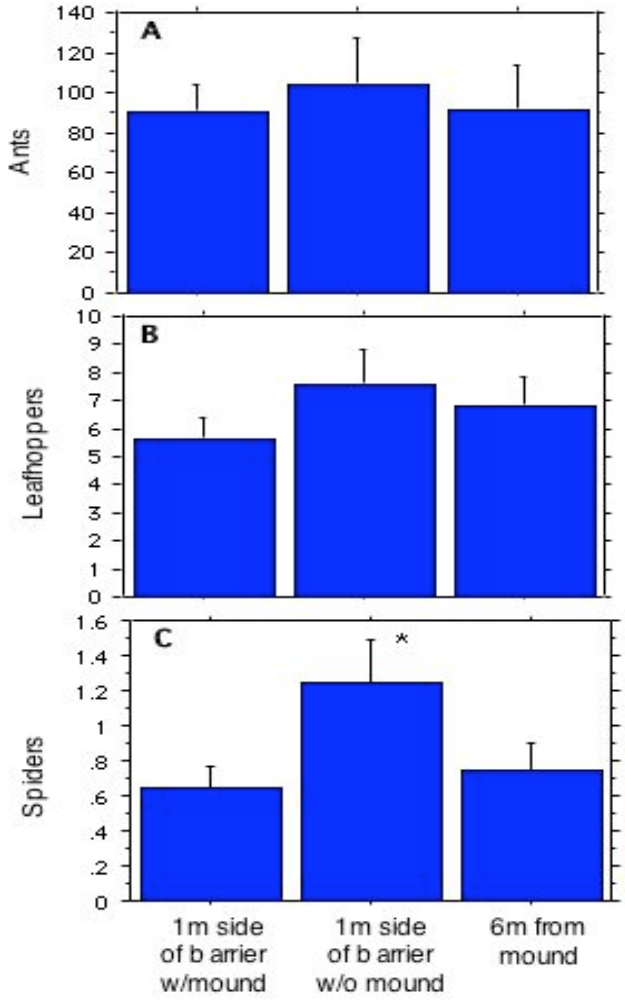
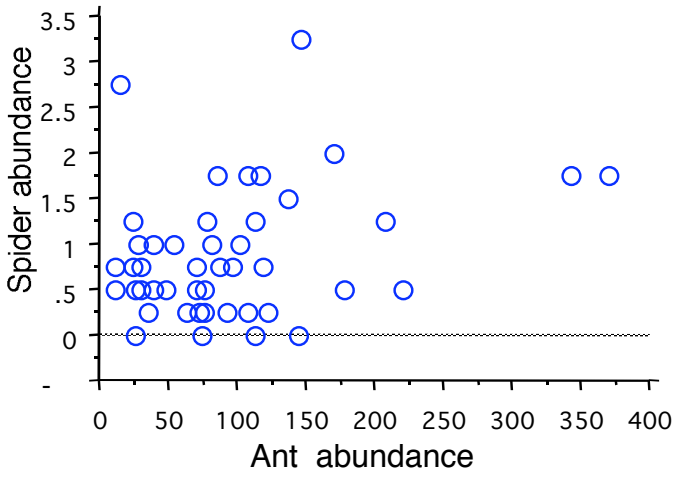


Fig. 5. Correlation of ant and spider abundances.



Discussion

The presence of the barriers was not effective in manipulating ant density. While we expected the number of ants to be greatly reduced on the side of the barrier without the mound, ant abundance did not significantly differ among locations (Fig. 4A). The primary explanation for the failure of the barriers to lower ant numbers is the fact that the ants were observed tunneling underneath the barriers. An increase in ant activity was also observed following disturbance in the surrounding area as a result of digging to set up pitfalls and barriers. In addition, attempts were made to deter ant tunneling by piling and compacting dirt over tunnel openings. However, this may have resulted in ants becoming trapped on the side of the barrier away from the ant mound.

While there was no treatment effect found for the abundance of leafhoppers or ants among locations, the abundance of both insects tended to differ among colonies. This result suggests that variation in spatial factors other than the abundance or activity level of ants are likely better at explaining leafhopper abundance. Additional studies could consider microhabitat factors that influence differences in insect communities among colonies.

The abundance of ants and spiders were positively correlated (Fig. 5). These results contradict those of Heikkinen who found that the presence of ants on sagebrush negatively affected spider abundance (Heikkinen 1999). He suggested the ants were attacking spiders to defend their honeydew (Heikkinen 1999). In this study the roles seem to be reversed, with the possibility of the spiders preying upon ants. We and other researches have observed predation by spiders on *F. obscuripes* at this study site (I. Billick pers. com.). Furthermore, wolf spiders are active foragers that search and capture prey (Borror, De Long, and Triplehorn 1981). Ants milling around in an attempt to get over the barrier and rejoin their colony may provide easy prey for spiders and other predators.

This study found no impact from ants on overall invertebrate diversity. It is known that *F. obscuripes* provides protection to plants by wandering around on them and warding off predators (Inouye 1984). The greatest impact of *F. obscuripes* may simply occur directly on plants and not extend to areas on the ground where they are foraging. Alternatively, we may not have sampled from a large enough range in ant abundance to see an effect on invertebrate diversity.

Pitfall traps are also biased towards invertebrates that are active on the ground. Therefore, even though numerous ants were caught in the traps, it is not an indication of overall ant activity. It is possible that isolated ants reduced time foraging or tending and instead allocated energy to tunnel under the barriers in an attempt to rejoin their colony. Additional studies could compare ant abundances directly on plants versus on the ground in the vicinity of the barrier.

Although barriers to manipulate ant density were ineffective, they are potentially useful in manipulating ant activity. For increased success in reducing ant numbers, the barriers could be dug deeper into the ground. Furthermore, ants from other colonies could influence abundance and result in high ant density even on the side of barriers without the mound. In this study some barriers may have been set up too close to other colonies to effectively reduce ant abundance. Caution should be taken when setting up barriers to be confident the site is free of mounds not directly included in the study. Sampling with pitfalls at 1m from the barrier instead of 1m from the ant mound might also yield different results. Highest ant activity was observed directly adjacent to the barriers, which may have biased collection if large numbers of ants running along the barrier fell into cups.

The positive correlation between ant and spider abundances suggests that ants may in fact influence spider abundance. One explanation for the relationship between ants and spiders is that predaceous wolf spiders may be attracted to locations where ants are abundant. No correlation was found between ants and leafhoppers or between ants and overall invertebrate diversity. These results suggest that ants may affect abundance of predaceous invertebrates, like spiders, but not insect herbivores. Future research could better test this idea by sampling not just ground invertebrates, but also flying insects and insects found primarily on plants.

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