

Soil temperature and arthropod abundance are lower near ant mounds

LARA JANSON, LIZ MALLOTT, and LOUIS MCGINTY

Biology Department, Grinnell College, Grinnell, IA 50112, USA

Abstract

*Because so little of tallgrass prairie remains in North America, conservationists must monitor the general health of remaining prairie sites to ensure their survival. Disturbances are crucial to boosting overall diversity for prairies, since they create patches that allow less-dominant species to gain a foothold in the environment. In order to better understand the importance of disturbance in a savanna ecosystem, we studied the effects of a common disturbance, ant mounds, on soil conditions and on underground arthropod abundance and diversity in the savanna area of Conard Environmental Research Area (CERA), a reconstructed prairie in central Iowa. In fall 2002, we gathered soil and arthropod samples from 16 *Formica montanis* and *Formica exsectoides* ant mounds and 16 control sites, analyzed soil conditions, and identified soil arthropods. We predicted ant mounds would boost both arthropod abundance and diversity by creating soil conditions favorable to arthropods, including higher percentages of moisture and organic matter, higher temperatures, and lower levels of pH, as shown by earlier studies. However, we found that ant mounds did not significantly alter soil conditions, aside from creating lower temperatures, nor did they boost arthropod abundance or diversity. Future studies could isolate one soil factor to examine its effects on arthropods in more detail. Results from this type of study could help ecologists better understand how to successfully incorporate ant mounds into prairie ecosystems.*

Introduction

Existing studies about disturbances show that ant mounds create soil conditions that promote arthropod abundance and diversity. Several studies of ant mounds (Beattie and Culver 1977, Bode et al. 1999, and Gibson 1989) found that mounds, as natural disturbances, help maintain the configuration, composition, and heterogeneity of plant communities. Wali and Kanno (1975), who studied prairie ant mounds in North Dakota, and Trager (1998), who summarized the ecological roles of ants, suggest that they exert a large influence over the soil and living organisms of the ecosystems in which they reside. Kustritz and Melis (1999), who studied soil arthropods in the Conard Environmental Research Area (CERA) savanna, stated that all soil arthropods are critical to maintaining the heterogeneity of savannas and prairies because of their ability to decompose and distribute organic matter.

Wali and Kanno (1975) and Wagner et al. (1997), who investigated grassland harvester ants in New Mexico, found that ants were as effective as earthworms in creating soil conditions that stimulated high abundances of microarthropods through processes such as the accumulation of organic matter and the aeration of soil. Wagner et al. (1997) write that the detritus and stockpiled food ants bring to

mounds change soil characteristics such that ant nests sustain 30-fold higher abundances of microarthropods than nearby control soils. Furthermore, a study on Montana peatland ant nests performed by Lesica and Kanno (1998) showed that the circulation of nutrients through aeration by ants also alters these soil conditions

Many studies have linked ant mounds to the following soil conditions: high temperatures, carbon and moisture contents, and acidity. Mounds increase temperature, which creates a favorable environment for soil fungi and bacteria (Lesica and Kanno 1998, Lussenhop 1976). In his 1976 study of the effect of burning on soil arthropods, Lussenhop asserted that higher soil carbon content directly raises soil decomposition rates and energy abundance for certain arthropods. This increased organic debris at mounds was broken down by fungi and bacteria to create other soil conditions that attracted a wide variety of arthropods, according to Wagner (1997), who examined the effects of ant nests in Arizona. Wagner (1997) links the bacteria and fungi found at many types of ant mounds with increased soil moisture. Furthermore, studies by Wali and Kanno (1975) and Wagner et al. (1997) showed that ant mounds increase soil acidity.

By understanding the benefits and drawbacks of natural disturbances such as ant

mounds, ecologists can better monitor the success of prairie restoration efforts. Investigating the effects of ant mounds on soil arthropods could help ecologists answer these questions: do disturbances, such as ant mounds, help maintain healthy ecosystems, and if so, what conditions must exist for these disturbances to flourish?

We investigated the relationship between ant mounds and surrounding soil arthropods at CERA by studying soil conditions and the abundance and diversity of arthropods at the base of mounds, 0.5 meter from mounds, and at control sites uncorrelated to mound locations. We expected to find that ant mounds boost both arthropod abundance and diversity by creating soil conditions favorable to arthropods, including higher percentages of moisture and organic matter, higher temperatures, and lower levels of pH, as shown by earlier studies. We predicted that diversity would be highest in samples taken 0.5 meters away from mounds, where arthropods could benefit from the effects of ants without competing with them for resources, as would happen at the base of mounds. However, we found that ant mounds did not significantly alter soil conditions, aside from creating lower temperatures, nor did they boost arthropod abundance or diversity.

Methods

We conducted our research from mid-October to mid-November 2002 in the savanna area of CERA, located in central Iowa. The soil we studied at CERA is silty clay loam (DeLong 1998). Soil samples were taken from two areas of the south slope savanna that differed in vegetation and elevation; one sample area was near the bottom of a hillside in the heart of the savanna prairie and contained thorny shrubs and trees, while the other area bordered a grassland area towards the top of the hillside and consisted predominately of grasses. A total of sixteen *Formica montanis* and *Formica exsectoides* mounds were haphazardly chosen for analysis, using two criteria: first, that they were clearly active, meaning they had no vegetation on the crown of the mound, there was a distinct base, and, in most cases, ants were present; and second, that they were located at least one meter away from walkways (to minimize human impact). We collected soil at the base of the ant mounds, 0.5 meters away from mounds, and at a randomly chosen control location. The control sites were located along three transects at

different locations on the hillside: A, B, and C (Figure 1). For samples at 0.5 meters, a random point was located along the circumference of a 0.5 meter diameter circle around each mound.

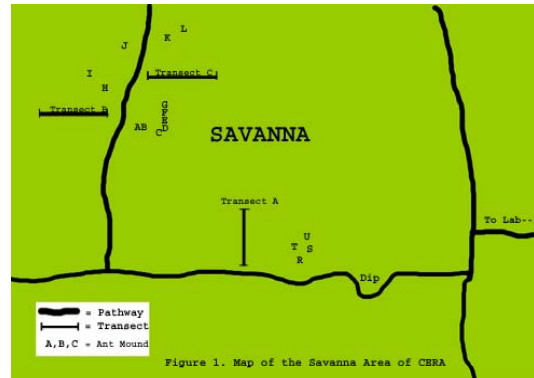


Figure 1. Map of the Savanna Area of CERA.

On four afternoons in October and November, samples were taken for soil and for arthropod analysis. We used a soil corer with a diameter of two centimeters and a depth of 5.5 centimeters to collect three cores (51.836 cm³ of soil) for each soil analysis sample and five cores (86.394 cm³ of soil) for each arthropod analysis sample. At the same time cores were taken, soil temperature was determined at a depth of two centimeters at each sampling point.

We tested the soil samples for percentage moisture content, acidity (pH), percentage organic matter and arthropod content. Acidity was assessed with a digital pH meter placed in a solution of soil and distilled water mixed in a ratio of 1:1. We recorded the wet mass of each sample, placed them in a 60° C drying oven for at least 48 hours and recorded the dry mass. To find percentage organic matter, we weighed powdered soil before and after burning it in a 400° C oven. To separate arthropods from the soil core samples taken at CERA, we used Berlese funnels. Dissecting microscopes were used to identify and count the arthropods using a key to common small soil animals (K. Christiansen, unpublished).

We used ANOVA and T-tests to determine if day or mound proximity affected our results for mean temperature, pH, percent soil organic matter, and percent soil moisture. ANOVA, a statistical test that analyzes the variance between both samples within a particular treatment and between different treatments, was used to analyze data with more than two variables (e.g., proximity and day). We used T-tests to evaluate the significance of other data. Arthropod data was examined using arthropod abundance, taxon

richness, and a variation of Simpson's Index that measures the likelihood of two individual arthropods in a random sample being from the same taxon. This probability ranges from 0 to 1, with lower numbers indicating the highest diversity.

Results

The soil samples showed that mound proximity had varying effects on soil conditions. ANOVA tests indicated significant effects of the day samples were taken ($F=434.48, p<.001$) and nearness of samples to the mound ($F=5.75, p=.037$) on temperature, with average temperatures higher at the control sites than at either the mound or at 0.5 meter and temperature higher on particular sample days (Figure 2). Soil moisture and pH, however, were not significantly affected by day or mound proximity (Table 1). The day a sample was taken was significant for soil organic matter content ($F=3.48, p=0.024$), but not for proximity to mounds (Table 1).

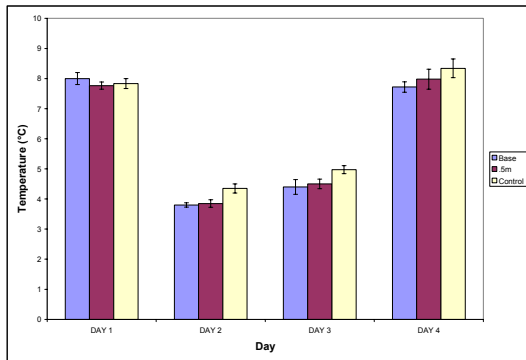


Figure 2. Mean temperature per day for 16 samples (± 1 S.E.).

	Mound	.5 m	Control	F=	p=
Mean pH	4.988 (± 0.191)	4.844 (± 0.156)	4.719 (± 0.125)	0.24	0.797
Mean % Soil Moisture Content	14.393 (± 1.385)	15.447 (± 0.946)	17.244 (± 1.298)	1.5	0.235
Mean % Soil Organic Matter	5.524 (± 0.207)	5.568 (± 0.242)	5.659 (± 0.164)	0.13	0.88
Mean Taxon Richness	5.063 (± 0.370)	4.563 (± 0.341)	5.5 (± 0.398)	1.72	0.192
Mean Simpson's Index	0.377 (± 0.038)	0.374 (± 0.028)	0.362 (± 0.034)	0.06	0.942

Table 1. Mean Results (ANOVA).

ANOVA analysis of soil arthropods showed that the three types of sample sites varied significantly ($F=5.51, p=0.008$); the average number of individuals was higher in the control samples than at the mound or 0.5 meter away (Figure 3). When examining the number of

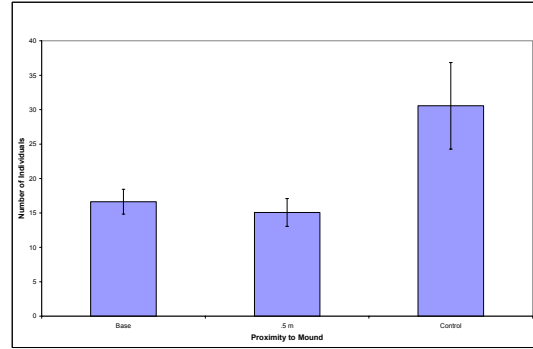


Figure 3. Mean number of individuals for 16 samples (± 1 S.E.).

individuals, specific taxa in each of the three treatments showed significant differences for arthropods such as *oribatid* mites ($F=6.06, p=0.005$), miscellaneous mites ($F=3.52, p=0.038$), and *coleoptera larvae* ($F=4.12, p=0.023$). For each of these taxon, we found higher average numbers at control sites than at or near mounds (Figures 4, 5).

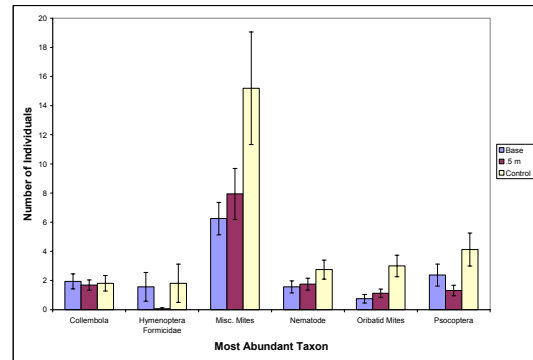


Figure 4. Mean number of individuals for most abundant taxa (± 1 S.E.).

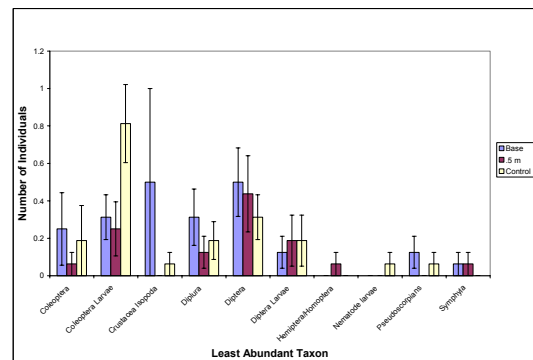


Figure 5. Mean number of individual for least abundant taxa (± 1 S.E.).

Variations in average taxon richness and average Simpson's Index, both indicators of diversity, were not significantly affected by

proximity to mounds (Table 1). The levels of diversity, as measured by these two indices, were nearly equal, at approximately 0.37, among the three treatments (Table 1).

We used ANOVA to test if the sample location on the hillside affected our results for acidity, soil moisture, number of individuals, taxon richness, and Simpson's Index, but did not find any significant correlation. We did not assess the affect of hillside location on organic matter or temperature results, since these soil conditions were affected by the different conditions between sampling days.

Discussion

The Effect of Mounds on Soil Conditions

Contrary to our hypothesis, the presence of ant mounds only affected temperature, which it significantly lowered. Lower temperatures were probably caused indirectly by soil aeration by ants at and around mounds. Wali and Kanno (1975) found that ant mounds retain heat in the summer and lose warmth during winter than nearby soil; because our study was performed in autumn, aeration caused by ants presumably allowed cooler air into the soil. That the presence of ant mounds did not otherwise affect surrounding soil contradicts previous research suggesting that mounds increase acidity, moisture and organic content, and temperature (see Introduction).

The Effect of Mounds on Arthropods

We were unable to prove that ant mounds created conditions that favored greater densities of arthropods. In direct opposition to previous studies, we found that arthropod abundance is higher *away* from ant mounds, rather than close to them. The lower temperatures at and near mounds contradicts our hypothesis but can be explained by Lussenhop's (1976) findings that higher temperatures support higher abundances of arthropods; temperature was significantly higher at control sites, where we found more individuals. A possible justification for the difference in arthropod abundance is that, away from mounds, soil arthropods presumably do not compete with as many ants for resources.

The lower abundances of miscellaneous mites, *oribatid* mites, and *Coleoptera* larvae at mounds and points 0.5 meters away can probably be explained by the difference in average temperature between control sites and mounds sites; arthropods such as these prefer the nutrient-rich soil created by fungi and bacteria

that favor warmer temperatures (Lesica and Kanno 1998, Lussenhop 1976).

One might think the difference in abundance results is because ants dominate areas close to their mounds, discouraging other taxon from populating the area. But diversity held steady between treatments. The similarity of arthropod diversity between sample locations could be influenced to the fact that the mounds we studied did not significantly change soil conditions, aside from temperature. A different explanation of the lack of a consistent difference in arthropod abundance is that amounts of activity varied between mounds; newly created mounds and mounds that ants recently abandoned do not alter soil conditions and arthropods as much as does a fully active mound. Since ant mounds can last up to 60 years (e.g., in shortgrass steppe; Kelly *et al.* 1996), not all of the mounds we studied have necessarily reached maturity.

Aside from mounds affecting soil temperature, our data contradicted previous studies showing that ants significantly affect a variety of soil conditions. Because a variety of factors such as day and season influenced our study, future studies in which one soil indicator is manipulated might clearly determine the effect of soil conditions on arthropods. Isolating and examining the effects of soil indicators in an experiment could clarify the reactions of arthropods to specific factors such as soil pH, which affects arthropod taxon in a variety of ways. Once ecologists comprehend the specific ways in which soil conditions influence arthropods, they will be better able to understand how disturbances, such as ant mounds, affect arthropods. They will also be better equipped to combat the negative effects of invasive species, such as fire ants. With these tools, ecologists can better introduce and monitor ant mounds and other disturbances that help maintain heterogeneity in prairie ecosystems.

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