Ant mounds influence soil composition, but not vegetation

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Introduction

Ecologists view anthills as natural disruptions that maintain heterogeneity in an ecosystem (Wagner et al. 1997). Considering that the longevity of ant mounds may range from 30-60 years, their effects on the surrounding soil and vegetation may be substantial and sustained (Kelly 1996). These factors make ant nests important factors of many ecosystems, including the closed savanna.

Studies have shown that the soil and vegetation of ant mounds differ from those of their surroundings in the pH of the soil, organic matter content, soil moisture, and composition of vegetation (Culver & Beattie 1983, Czerwinski et al. 1971, Kelly et al. 1996, McGinley 1994, Wagner et al. 1997, Whitford 1988). Scientists have found both that ant mound soil is more basic than the surrounding area (Czerwinski et al. 1971), and that mound soil is more acidic than the surrounding area (Wagner et al. 1997) . Additionally, researchers have found that control points have more biomass below ground (Kelly 1996), that control point soils had more moisture than mound soils (Culver & Beattie 1983, McGinley 1994, and Whitford 1988), and that the vegetation composition was different at the mounds than at control points (Whitford 1988). We decided to investigate how ant mounds relate to vegetation composition and some soil characteristics at CERA in order to better understand the role of ants in an Iowa closed savanna ecosystem. CERA, the Conard Environmental Research Area, is a preserved and reconstructed area containing prairie, savanna, forest, and wetland areas. It is situated on Tama silt loam in Jasper County, Iowa (DeLong 1998). Our field study of ant mounds took place in the closed savanna portion of CERA, where there are a large number of visible ant mounds. We hoped to learn more about the relationship between ants and their surrounding environment by researching pH levels, soil organic matter (SOM), moisture content, and the biomass of grasses and forbs. We expected to find differences in all of these factors between anthills, points 0.5 meters away from ant mounds (offset points), and the control points.

Methods

Location of Ant Mounds

We surveyed ant hills in the closed savanna at CERA. We used a Global Positioning System (GPS) to determine the coordinates of each mound. This rough survey did not locate every ant mound in the area, but it did provide a group of anthills from which to draw our random sample. We chose ten control points using random sampling, most of which were located at least ten meters away from any ant mounds. We then chose ten anthills. Because we were unable to find the exact anthills selected by our random sampling, we selected our ant mounds haphazardly.

Vegetation Composition

On October 28, November 2, and November 4, we clipped aboveground vegetation from directly next to our sample and control points. We were not able to clip vegetation from the ant mounds themselves, as there was no vegetation in the center of the ant mounds. We randomly selected which side of the ant mound to sample, and we then and clipped all vegetation that was rooted within a .25 square meter quadrat. We sorted out the grasses from the forbs, dried them for 48 hours at 65° C, and then weighed each sample.

Soil Characteristics: pH, Percent Moisture, and Percent Organic Matter

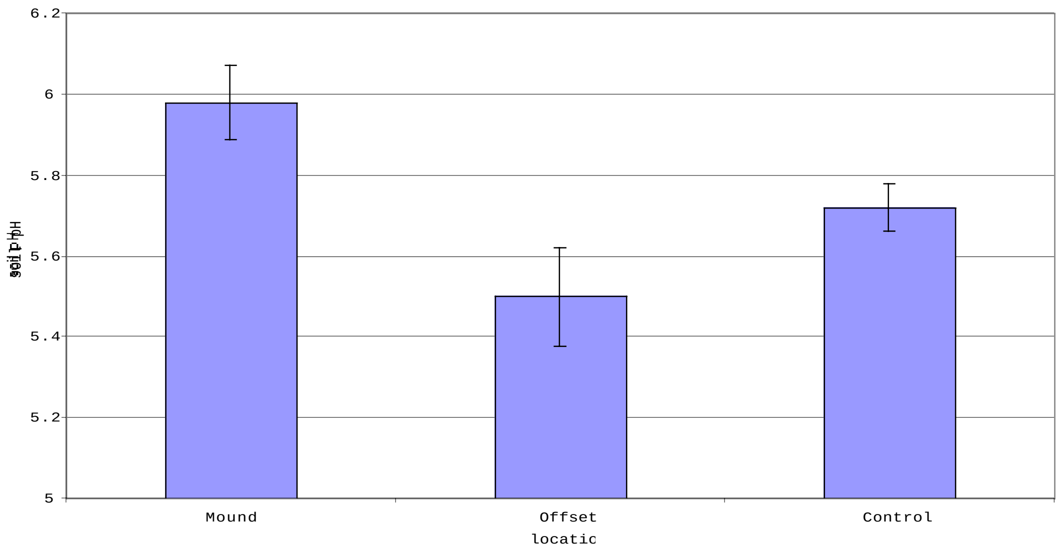
On November 11 and 16 we took ten soil samples each from the sample ant hills, points 0.5 meters away from our ant hills in a random direction (offset points), and from the control points, for a total of thirty samples. We needed to use different sampling tools for the ant hills than we did for the normal soil, as the sandy soil at the ant mounds did not stay in the narrower soil corer and the wider corer was not sharp enough to cut through the hard soil of the control points. To be sure that we had enough samples for all of our lab tests, we took two samples at the control and offset points. At the ant nests we used a 15 cm by 6 cm core scoop, and for the other samples used a 15 cm by 2 cm soil corer. We crushed the soil to a uniform consistency with a mortar and pestle and performed three tests on each soil sample: pH, percent moisture content, and soil organic matter (SOM).

To measure the pH of the soil, we mixed 20 mL of soil with 20 mL of distilled water. After standing an hour, we determined the pH of the slurry using a digital pH meter. We determined percent soil moisture by weighing the soil samples, putting them in a 65° C drier for at least 24 hours, and weighing them again. Percent soil moisture is the difference between the damp and dry weights divided by the dry weight. Finally we used this dried soil to calculate the SOM using a muffle furnace. We fired our samples for three hours at 500° C. The percent organic matter in the soil was the difference between the weights before and after firing in the muffle furnace divided by the pre-firing weight.

Statistical Analysis

To determine if the soil characteristics were statistically significant among the three soil areas, we performed ANOVAs and Tukey pairwise comparisons for each soil test. We compared mean biomass of grasses and forbs between the offset points and control points using a t-test.

Figure 1: Average soil pH by location



Ant Identification

While we were taking soil samples, we collected ant specimens. We later used these specimens to identify which genus of ants we are studying, using the *Identification Guide to the Ant Genera of the World* as guides in the identification process. We identified the ants as members of genus *Acropyga*, which is part of the subfamily *Formicinae*.

Results

We found that the pH difference between the ant mounds' soil and the soil 0.5 meter away from the mound was statistically significant ($p < .05$), using an ANOVA (P 0.003, df 27). The ant mounds tended to be less acidic than the soil from the offset points. The mean pHs of the soil mounds, offset points, and control points were 5.98, 5.50, and 5.72 respectively (Figure 2). In addition, the difference in SOM between the offset points and the control points was statistically significant (*P* 0.003, df 27), as was the difference between the mound and control points (*P* 0.053, df 27), with more organic matter in the control point samples than the other points (Figure 2). We also found a significant difference in the soil moisture between the ant mounds and the control points, with more moisture at the control points than the ant mounds or offset points (Figure 4, *P* 0.019, df 27). Lastly, we found no significant difference in biomasses of grasses and forbs between the offset points and the control points (Figure 4, *P*>.05).

Discussion

We discovered that there were significant differences in the soil characteristics of mound, control, and offset points. We did not find any significant differences between the grass and forb composition of the mound and control points. In order to explicate these findings, we will address the scientific research that relates to our data. We will also introduce possible explanations for our findings and suggest areas for further study.

Figure 3: Average percent soil moisture b

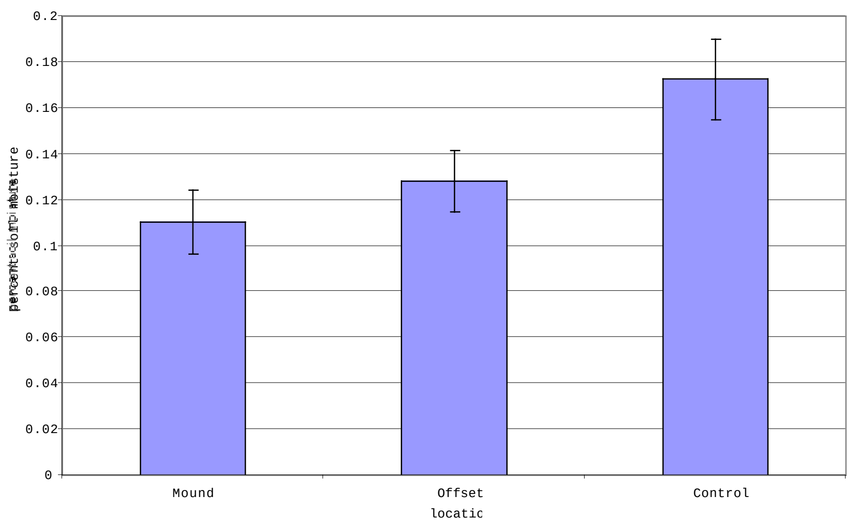


Figure 2: Percent organic matter in soil

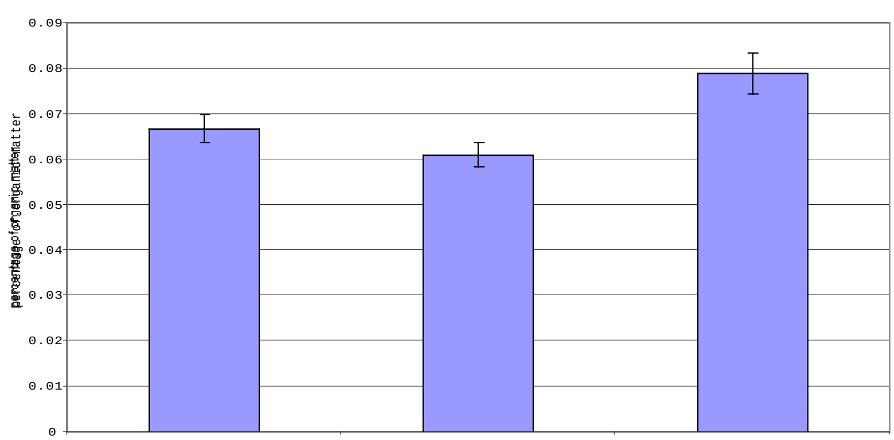
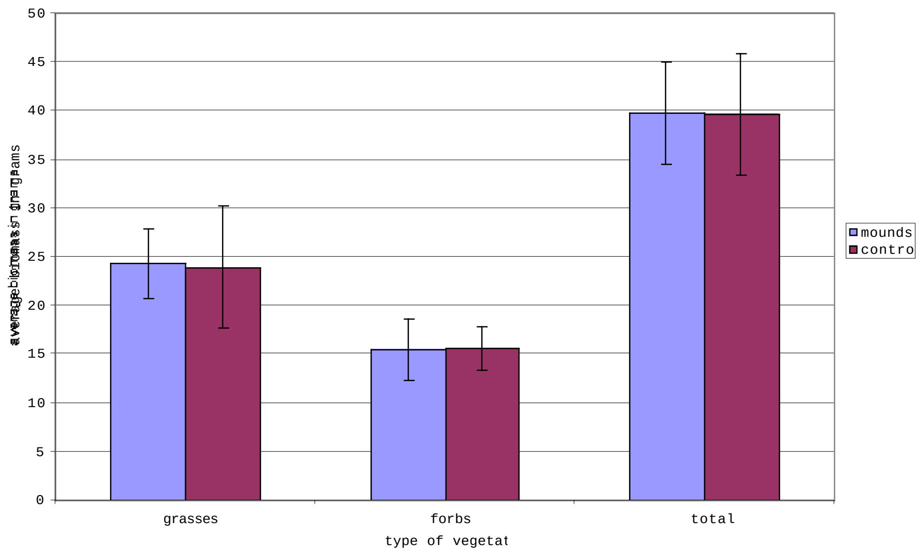


Figure 4: Average biomasses of grasses, forbs, and total veget



The only difference in pH that we found was between the ant nest and the offset, but we can find nothing in the literature that speaks to this finding. Many researchers have studied pH in ant mounds and control points (Czerwinski et al. 1971, Culver and Beattie 1983, Wagner 1997), but they do not compare the soil in ant nests with soil immediately outside the nest. We have been unable to find research that addresses this difference, indicating that more research is needed in this area.

Our findings concerning soil organic matter (SOM) concur with the existing literature. We found significantly less soil organic matter at offset than control (Figure 2). This data fits in with Kelly et al. (1996), who found that western harvester ants (*Pogonomyrmex occidentalis* Cresson) reduce the amount of organic matter in the soil immediately next to ant nests. The Kelly data indicate that SOM would be higher at control points than offsets, since ants reduce the SOM near their nests. Our data also show that the ant mounds have more SOM than the offsets, although this difference is only marginally significant (Figure 2). This finding agrees with Czerwinski et al. (1971), who found that anthills experience increases in amount of organic carbon.

We found that the mounds had significantly less soil moisture than the control points (Figure 3), whereas McGinley (1994, cited in Wagner et al. 1997) and Whitford (1988) found the opposite, and Wagner et al. (1997) found no significant difference in soil moisture between ant nests and surrounding soil. Wagner et al. (1997) points out that soil moisture can vary with meteorological factors such as temperature and rainfall, and therefore soil moisture should be measured over time. This difference in soil moisture could be due to the elevation of the ant mounds, which facilitates more rapid water evaporation (Culver and Beattie, 1983). Also, the tunnels within the ant mounds provide large channels through which the water can flow rapidly from the mound to the soil below (Whitford

1988). A final possibility, not discussed in the literature, is that the ant tunnels may provide an opportunity for air circulation to dry out the soil.

We expected to find significant differences in the biomass of forbs and grasses between anthills and control points. Our visual observations and much of the literature indicated that plant populations were different near ant nests than in other areas. Whitford (1988) found that ant nests did not have the same composition of vegetation as areas away from the mounds, possibly resulting from differential seed selection and higher levels of soil nutrients in the surrounding soil. Culver and Beattie (1983) found plants around the ant mounds to be more homogeneous than control points. Perhaps the difference between our results and the literature is a result of our methodology. Whereas Whitford (1988) focused on annuals near ant nests and Culver and Beattie (1983) examined specific plant species, we compared biomasses of vegetation collected in the autumn, after many leaves had fallen. Sampling before leaves had fallen, or comparing ground cover of grasses versus forbs may yield different results. Also, a more detailed analysis of vegetation that identifies specific species of plants would provide a more refined description of how plant populations around ant nests vary from control points.

Our research points to several other opportunities for research. First of all, more research needs to be done on ants and pH. Although our research supports previous findings, we know very little about how ants affect pH in their nests. We recommend that future research looks at how specific ant process, such as bringing in food, excreting, and dying, affect soil pH.

Additionally, we recommend more research into how ants affect the below ground biomass of their surroundings. We hypothesize that when ants clip vegetation and gather fallen biomass, they prevent the accumulation of carbon in the soil. To test these hypotheses, researchers must first examine the ants to see if they engage in these behaviors, and then conduct tests to see if these behaviors affect biomass. To test if plant clipping affects biomass, they could clip vegetation and compare this to control plots that are not clipped, and they could compare the effect of gathering by raking plots free of litter and comparing these plots to unraked plots. However, since carbon accumulation is a slow process, and ant nests affect their surroundings for many years, these studies would need to be long term examinations of soil nutrients.

Finally, we recommend more research into the vegetation surrounding ant mounds. Specifically, we encourage researchers to examine vegetation distribution through a variety of means, including biomass, percent cover, and active tiller count. We also suggest more detailed study of vegetation that compares the distribution of individual species, rather than looking only at the larger categories of grasses and forbs.

Although our research does not explain fully how ants and the surrounding environment interact, it does show that the relationship is important. Our data fit with the larger body of literature, all of which indicate that ants do affect their environment. The research is clear -- ants are an important factor in the closed savanna ecosystem. They have been shown to affect soil moisture, soil organic matter, soil pH, and in some cases, plant composition. While more research still needs to be done, our data advance the understanding of ants in the closed savanna ecosystem.

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