

Ant Presences Alter Plants:

The Impact *Formica obscuripes* presence on plants and soil micro- arthropod diversity

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Independent Research and Course

Summer 2011

Keywords: ecosystem, bioturbation, community, microhabitat, *Formica obscuripes*

Introduction

Ant presence can alter both plant and soil community composition. For example, Wardle et al. (2011) found that removing ants from an ecosystem can alter plant species composition and those shifts resulted in differences in the plant community which influenced belowground properties in the food web, decomposition of organic material, and stored carbon and nitrogen. Similarly, Wagner et al. (2004) found that the ant mounds of *P. barbatus* in North America has significantly higher concentrations of total nitrogen, mineral nitrogen, and orthophosphate compared to ant-free surrounding soils. These studies demonstrate that ants, especially ones that are conspicuous on the landscape, can have large and sustained influences on both plant and soil communities. However, these interactions are not always straight-forward. Reyes-Lopez et al. (2003) found that the impact of ants on plants could be positive or negative and that effect was contingent on how close the trees were clustered. Scattered trees at their site had a positive effect on ant community abundance; however when the trees became too dense and shade increased, the effects of the trees were negative on ant nest richness (Reyes-Lopez et al. 2003).

Clearly ants can have a diversity of impacts on soil and plant communities. *Formica obscuripes* is a thatch mound ant that dominates the semi-arid mountain meadows in Almont, Colorado. Wood ants often bring plant litter, honeydew from aphids, and prey into their mounds, which can form islands of nutrients on the landscape (Domisch et al. 2009) and can cause a distinct pattern of vegetation type surrounding the nests (Beattie et al. 1997). These results suggest that these ants are capable of altering their ecosystems on a broader scale, even if the direct effects are local.

In this experiment, we took advantage of a large-scale observational experiment that has tracked the activity of ant activities for two years to ask: (1) does ant presence alter aboveground plant communities? and (2) does ant presence affect belowground micro-arthropod communities? We predict these ants may alter this meadow ecosystem by influencing the vegetation type surrounding the mounds as well as the soil ecology. By altering soil chemistry and microclimate, the soil arthropod diversity in the vicinity of the ant mounds may be different from the surrounding soils.

Formica obscuripes build mounds that consist of a series of excavated tunnels and building these tunnels increases soil bioturbation (Brussaard et al 1997). Increased bioturbation can create microhabitats for other small organisms to live, increase soil nutrient turnover, and alter the soil microclimate. Because ants respire, ant mounds have a higher soil temperature than the surrounding soils; however, larger mounds may see less temperature fluctuations than the smaller mounds (Conway 1996). Another driver of microclimate in these mounds may be moisture content. Because the soil is more porous, drainage and evaporation of moisture may be increased in these nests

compared to the surrounding soil. This could also allow for a better habitat for other arthropods to live.

Methods

Study site description and experimental design

The study was conducted in a dry mountain meadow at the Almont Triangle Wilderness Area in Almont, Colorado at 11 mi N, 5 mi E of Gunnison, Gunnison County, Co. US. Latitude: 38.66 N Longitude: -106.84 W. The dry meadow consists of rocky soil substrate dominated by woody brushes like Sage-brush (*Artemesia tridentata*) and Rabbit-brush (*Chrysothamnus viscidiflorus*), herbs like Mariposa lily (*Calochortus gunnisonii*), Indian paintbrush (*Castilleja miniata*), Sunflowers (*Wyethia amplexicaulis*), Yarrow (*Achillea millefolium*), Snowball sandwort (*Arenaria congesta*), Lupines (*Lupinus argenteus*), Blue Flax (*Linum lewisii*), and Showy Fleabane (*Erigeron speciosus*), and grasses such as *Festuca thurberi* and Junegrass (*Koeleria macrantha*). The ant *Formica obscuripes* is dominant across this meadow and has no fewer than 200 mounds. Plants were surveyed in the meadow on ten mounds as well as ten ant free sites (n=10; sample size=20). All twenty sites were chosen at random.

Soil microclimate:

Volumetric soil moisture (0-20 cm) was measured and recorded at three different dates between the times of 1:00 and 3:00 p.m. The probe was placed in the mineral soil in middle of the mound as well as 1 m away from the mound to determine on colony and off colony moisture content. Temperature of the soil was taken once in the middle of the colony and 1 m away from the colony at 20 cm depth. Ten on colony sites were

recorded as well as ten off colony (paired) sites (n=10, total=20). Three moisture readings were recorded on different days.

Plant sampling:

Percent coverage of plants was measured using a 2x2 meter quadrat surrounding the mound. Each plant in the quadrat was identified and percent coverage was determined. Ten colonies as well as ten randomly selected off colony sites were surveyed for plant cover (n=10, total=20).

Soil Community sampling

Soil samples (0-10 cm) were taken using a hammer core 2 inches diameter. Four of the previously selected colonies were randomly sampled. Cores were taken at the edge of each colony to avoid disturbing the colony, but to still sample soil impacted by the ants. A soil control, off colony, soil core was collected in a similar way, 1 meter away from each colony (n=4; total=8). Soil cores were retrieved and placed in freezer bags with labels, and kept in coolers with ice packs. This allowed for the activity of arthropods to slow down and the effects of disturbance on the arthropods to decrease.

Berlese funnels were constructed from 16.9 oz Gatorade bottles. Each bottle was cut in half and the top was inverted into the bottom to catch micro-arthropods. The bottom was filled with diluted (75%) ethyl alcohol to kill and preserve the specimens. Soil samples were placed into the funnel and placed under lamps with 60 watt light bulbs for 36 hours

Data analysis:

A one-way ANOVA test was performed to compare the evenness of plant distribution, total percent cover of plants, percent moisture content and temperature, and micro-arthropod diversity in the soil between ant mounds and the surrounding community. Shannon's diversity index was used to determine plant species richness and evenness. Data collected was analyzed using JMP and Excel.

Results

Soil microclimate:

The percent moisture content varied significantly on colonies and off colonies ($P < 0.0001$; $f = 79.7138$, Figure 1). The average percent moisture on colonies was approximately 1% and off colonies was approximately 5%.

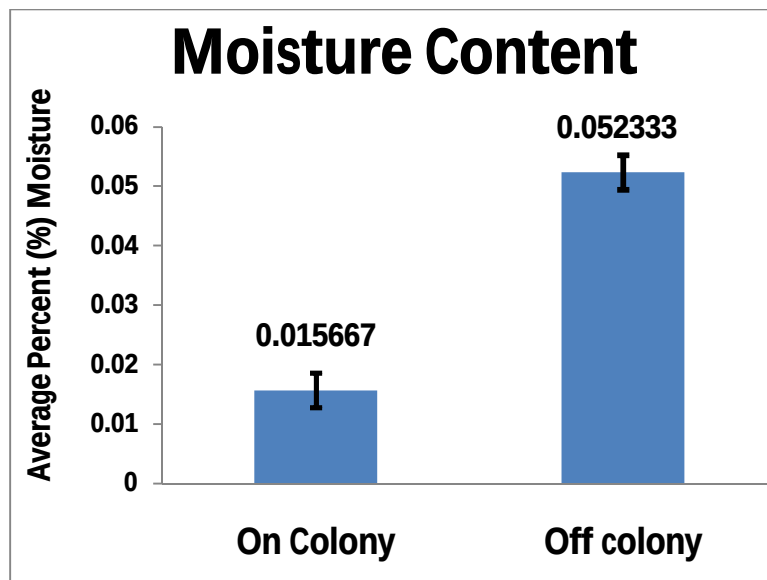
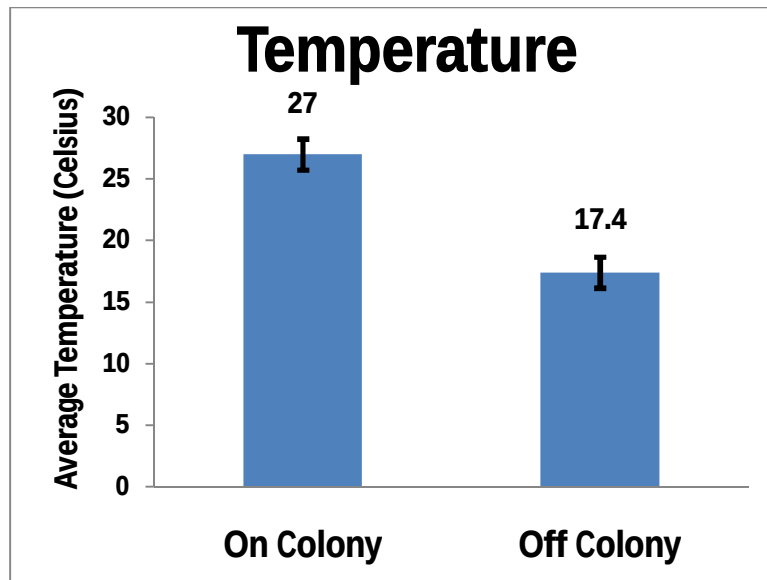


Figure 1

Temperature on and off colonies also varied significantly ($F = 29.3711$; $P < 0.0001$). The average temperature on colonies was 27 °C. The average temperature off colonies was approximately 17 °C (Figure 2).



Figure

Plant communities:

Plant evenness (retrieved from Shannon's diversity index) did not vary significantly between on and off colony sites ($F=0.2575$; $P=0.6180$). In figure 3, the means are given on colony and off colony. The average evenness on colonies was 26% greater than off colonies (Figure 4). Total percent cover did vary significantly between on colony and off colonies ($F=10.9453$; $P< 0.0039$). On colonies, the average total percent cover was approximately 80%. Off colonies, the average total percent cover was approximately 50%. These differences suggest that the ants are drivers in the plant communities. The most abundant plant present on colonies was the rabbit brush (*Chrysothamnus viscidiflorus*). This brush varied significantly between on colonies and off colonies ($F=8.3976$; $P=0.0096$). This brush was not abundant off colonies, suggesting that ants play a key role in the population density of Rabbit Brush (See Figure 5).

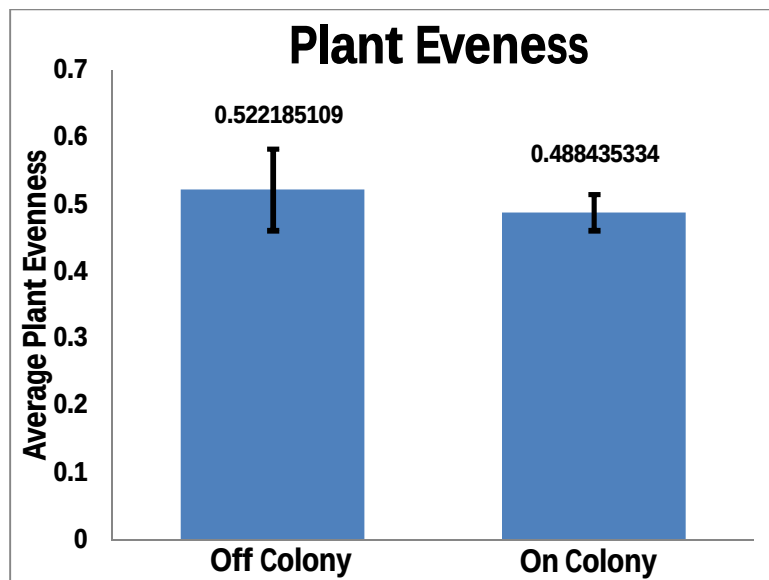


Figure 3

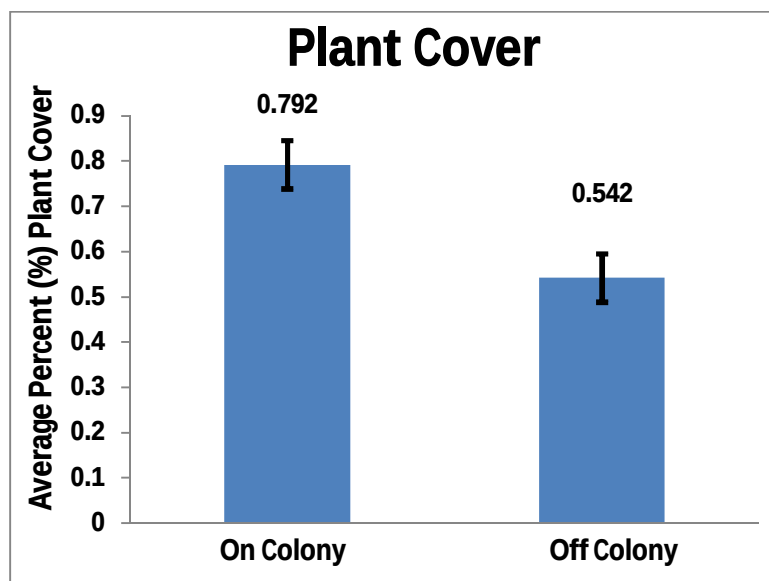


Figure 4

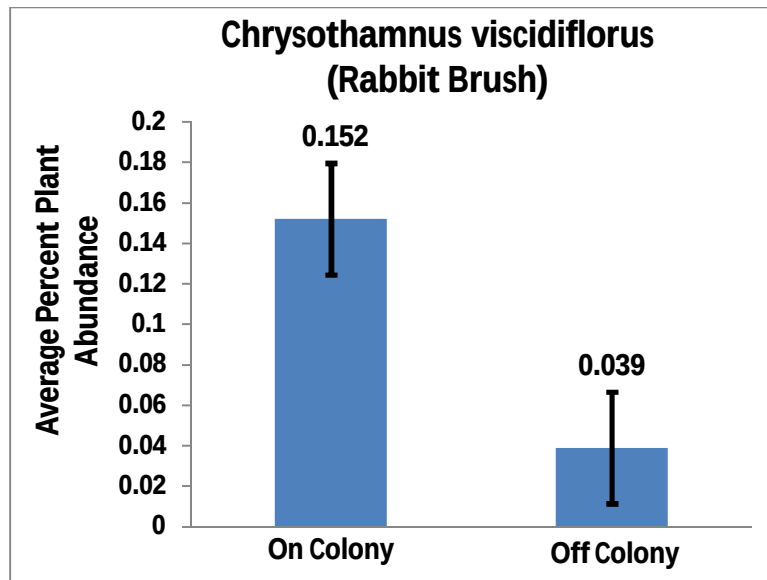


Figure 5

Soil communities:

Micro-arthropods in the soil between on colony and off colony sites did not vary significantly ($F=1.0897$; $P=0.3368$). The average abundance of micro arthropods was approximately 1 per colony and 3 per off-colony sites. Most of the findings consisted of larvae, however one beetle was found.

Discussion

It is clear that ants can be key drivers in ecosystem processes. There is a relationship between ants and the plant communities. There is a relationship between ants and the soil composition, such as micro climate and nutrients. Differences alone in the soil micro-climate could have an impact on the biodiversity of plants and soil arthropods. These organisms often require specific habitat conditions, and if these conditions are altered, the organisms living in that habitat may shift.

The ant-plant relationship and abundance of rabbit brush may have to do with the mutualism between ants and the aphids that they tend (Domisch et al 2009). If these ants tend aphids for their honey dew (in turn providing protection for the aphids), and the aphids are abundant on a particular plant such as rabbit brush, then it is possible that the ant-aphid mutualism is extending to the plant as well. The plant may benefit from this mutual relationship in a number of ways. First, if the aphids are abundant on the brush, then the ants may automatically favor that site to build a mound at. In turn, the changes that the ants cause by building their mounds at that site may be more favorable for the brush, allowing for better survival and reproduction.

It is unclear what the relationship between ants and soil micro-arthropods is, however, with further study, this relationship could be understood. The low abundance of arthropods could be attributed to not enough samples taken, or it could be due to the soil environment. The meadow in Almont is very rocky and dry, and may not be able to sustain a high abundance of diversity in the soil. The density of ant mounds in the meadow may play a role as well. In one meadow alone there are well over 200 ant mounds, most of which are close to each other. Ants as predators may influence what can and cannot live there, as well as competition for space. However, the low abundance of micro-arthropods has raised more questions than the data answered.

Ants are ecosystem engineers and can have a variety of effects on other biotic and abiotic factors, which is why ants are an important organism to study in a field such as ecology.

Literature Cited

- Beattie, Andrew J. and David C. Culver. "Effects of the Mound Nests of the Ant, *Formica obscuripes*, on the Surrounding Vegetation." American Midland Naturalist. 97.2 (1997): 390-399. 21 June 2011. <<http://www.jstor.org/stable/2425103>
- Brussaard et al. "Biodiversity in Soils." Royal Swedish Academy of Sciences. Ambio 26.8 (1997).
- Conway, John R. "A Field Study of the Nesting Ecology of the Thatching Ant, *Formica obscuripes* Forel, High Altitude in Colorado." Great Basin Naturalist. 56.4 (1996):326-332.
- Domisch, Timo. Leena Finer. Seppo Neuvonen. Pekka Niemela. Anita C. Risch. Jouni Kilpelainen. Mizue Ohashi. Martin F. Jurgensen. "Foraging Activity and Dietary Spectrum of Wood Ants (*Formica rufa* Group) and their Role in Nutrient Fluxes in Boreal Forests." Ecological Entomology. 34 (2009): 369-377.
- Reyes-Lopez, J., N. Ruiz, J. Fernandez-Haeger. "Community Structure of Ground-Ants: The Role of Single Trees in a Mediterranean Pastureland." Acta Oecologica. 24 (2003): 195-202.
- Wagner, Diane., Jeremy B. Jones. Deborah M. Gordon. "Development of Harvester Ant Colonies Alters Soil Chemistry." Soil Biology & Biochemistry 36 (2004): 797-804.
- Wardle, David A., Fujio Hyodo, Richard D. Bardgett, Gregor W. Yeates, and Marie-Charlotte Nilsson. "Long-term Aboveground and Belowground Consequences of Red Wood Ant Exclusion in Boreal Forest." Ecology. 92.3 (2011): 645-656.

