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INVESTIGATING THE ECOLOGY OF THE MOUND-BUILDING ANT, *ACANTHOMYOPS CLAVIGER* (HYMENOPTERA: FORMICIDAE), IN RE-CREATED PRAIRIE

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ABSTRACT

Acanthomyops claviger (Roger) (Hymenoptera: Formicidae) forms conspicuous mounds within clumps of big bluestem, *Andropogon gerardii*, and prairie dropseed, *Sporobolus heterolepsis*, within a re-created tallgrass prairie in northeastern Illinois. This study explored the ecology of the nesting ant in the re-created prairie regarding the persistence of colonies, soil characteristics, the growth of grass clumps, and the species richness of the surrounding flora. Persistence of nests over one year was positively correlated to the diameters of mounds created by the colonies. Differences in soil moisture at 10 cm depth were significant over a growing season between grass clumps having nests of *A. claviger* and those not. Soil temperature at 10 cm depth over a growing season, organic fraction of the soil, and above-ground oven-dried biomass of grasses did not significantly vary based on nest presence. Floral richness was significantly higher in the vicinity of *A. claviger* nests than where nests were absent. Benefits of the ant-grass relationship are unknown, although a commensalistic relationship is at least suggested by the location of nests in grass clumps. The presence of *A. claviger* nests appears to have a positive effect on the richness of the surrounding flora, possibly through soil tunneling and seed distribution.

Acanthomycops claviger (Roger) (Hymenoptera: Formicidae) is one of some 100 species of ants that have been recorded from tallgrass prairie (Trager 1998). The subterranean ant is thought to feed on excretions of aphids and dead invertebrates (Burrill and Smith 1919). Like other ants of the tallgrass prairie, *A. claviger* is not restricted to tallgrass prairie, but can be found in other habitats such as open field, pasture, and forest where they nest under stones, and in the soil and logs (Burrill and Smith 1919, Gregg 1944, Talbot 1934). Opportunistic in habitat, this species has also been observed nesting between soil and an upper layer of sod, discarded aluminum sheathing, or cinder block (Petersen et al. 1998).

Within our study site, a re-created tallgrass prairie in northeastern Illinois, *A. claviger* forms conspicuous nests in clumps of tall grasses that include big bluestem, *Andropogon gerardii* Vitman, and prairie dropseed, *Sporobolus heterolepis* Gray. The ant adds to the base of the grass clump, frequently elevating the soil surface 10 cm or more. Larger nests concentrate in the upper soil of the clump as evidenced by removing a few centimeters of soil. However, the extent of soil penetration by a colony in grass clumps is not known.

Ants that nest in soil, like *A. claviger*, are known to mix and change the soil by making it more friable, increasing soil fertility, and modifying the temperature and moisture content (Beattie and Culver 1977, Eldridge and Myers 1998, Eldridge and Pickard 1994, Wilson 1971). They influence the composition, abundance, and distribution of plant and animal species by dispersing seeds and consuming living tissue (Culver and Beattie 1983, Handel et al. 1981, Lei 2000, Lesica and Kannowski 1998, Rissing 1986, Soulé and Knapp 1996, Stiles and

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Jones 2001). Ant activity has also been related to changes in the biomass of soil microflora (Anderson and Sparling 1997).

A. claviger was not intentionally introduced to our study site and the significance of its presence on the establishing floral community is not known. In this study, we investigated the ecology of nesting *A. claviger* in the re-created prairie regarding persistence of colonies and relationships of nests to soil characteristics, the growth of grass clumps, and the distribution of surrounding flora.

STUDY SITE

The Russell R. Kirt Prairie, a 7.1 ha re-created tallgrass prairie established in 1984, is located on the campus of College of DuPage, Illinois (41°45'N, 88°00'W). Kirt (1996) provides a history of and selected chemical measurements taken in 1989 from the site. Re-creation efforts have included planting some 150 species of forbs and graminoids (Kirt 1996) that are characteristic of the mesic tallgrass prairie and wetlands that once covered the area (Swink and Wilhelm 1994). Common grasses in the plot include big bluestem and prairie dropseed. The re-created prairie has been burned annually since 1987.

MATERIALS AND METHODS

Sampling for this study was limited to 2002 except for locating nests of *A. claviger* during the previous spring. Ten stakes were placed in strategic locations during late spring of 2001 and the proximities of nests near each stake were recorded along with measurements of nest diameter. The diameter did not necessarily provide a measure of colony size, but a dimensional estimate of the physical size. The number of nests persisting into late spring of 2002 provided a measure of nest survival over one year. Nests found again during 2002, as well as newly discovered nests, were included in the sampling procedures that follow. Repeated measurements of nests were not assured due to the difficulty in relocating nests amidst vegetation that became increasingly dense through the summer season.

A grass clump was distinguished as a dense aggregate of tall grasses separated by at least 20 cm from another grass clump. Soil characteristics compared between clumps of tall grasses with nests of *A. claviger* and those without included moisture content, temperature, and fraction of organic content at a 10 cm depth of soil. *A. claviger* worker activity was high at the 10 cm depth which roughly coincided with the base of the emergent portion of the mound. All soil measurements were taken from clumps big bluestem and prairie dropseed having nests of *A. claviger*, and within 3 m of each of these, a randomly selected clump of like grass that lacked nests of any ant species.

We were able to locate and repeatedly measure soil moisture and temperature from 60 grass clumps (30 with *A. claviger* nests and 30 without nests) six times at roughly 3-wk intervals beginning in mid-May and ending in mid-September, using an Aquaterr Temp-200 meter (Aquaterr Instruments, Costa Mesa, CA). Measurements were always taken between 2 pm and 4 pm. Fraction of organic content was determined by taking 10-cm soil cores within grass clumps during September, oven-drying the soil to a constant weight at 60°C, and then burning the soil at 600°C for 6 hours within a muffle furnace.

Biotic parameters were selected to test if the presence of *A. claviger* nests is associated with differences in floral richness and above-ground growth over a growing season. During July, counts of plant species were recorded from 1-m^2 quadrats having clumps of big bluestem and prairie dropseed that contained nests of *A. claviger*, and also from 1-m^2 quadrats within 3-m distance that lacked ant nests but which were otherwise randomly selected. Above ground biomass was determined by harvesting stems from clumps of big bluestem and prairie dropseed having nests of *A. claviger*, and within 3-m distance of each of these, a randomly selected clump of like grass that lacked nests. Shoots were cut at 5 cm height during late September when the grasses senesced. The grass cuttings were oven-dried to a constant weight at 60°C.

Data analysis - *Statistica* (StatSoft 2001) was used in all statistical procedures. Spearman-rank correlation was used to test for a relationship between the five size categories of nest diameters (diameters were categorized according to intervals of 10 cm beginning with > 0 cm) and the persistence of nests in each. Repeated measures analysis of variance (ANOVA) was performed for soil moisture and again for soil temperature to test for differences in these measurements between clumps of grasses having *A. claviger* nests to those without. Arcsine $\sqrt{x_i}$ transformation of moisture content or $\log_{10}$ temperature (°C) was treated as the dependent factor per ANOVA, sample period served as the within-subject measure, while grass type and nest presence provided between group factors. Factorial ANOVAs were used to examine differences in the arcsine $\sqrt{x_i}$ transformation of fraction organic content of the soil at 10-cm depth and for $\log_{10}$ transformed above-ground biomass of grasses. As measurements of the dependent factors (organic content and above-ground biomass of grasses) were not necessarily taken from the same grass clumps, separate factorial ANOVAs were performed per factor. One-way between-group ANOVAs were performed to test for differences in floral richness between 1-m² quadrats having *A. claviger* nests in clumps of big bluestem or prairie dropseed to those lacking nests of *A. claviger*. Significance was determined where $P < 0.05$.

RESULTS

Categorized diameter of 61 *A. claviger* nests was positively correlated to persistence over one year ($r_s = 0.976$; df = 3; $P < 0.05$; Fig. 1). The effects of nest presence and sample period on soil moisture were significant (Table 1). Differences in soil moisture in clumps of both grass types during spring and early fall, in addition to that of July for prairie dropseed, were mainly responsible for this interaction (Fig. 2). Soil temperature did not significantly differ based on the presence of nests, but did differ according to grass type (Table 2, Fig. 3). Relationships of fraction organic content, above-ground biomass and floral richness between grass clumps having nests and those not are illustrated in Figure 4. Factorial ANOVA did not indicate a significant effect of ant presence on either organic content or above-ground biomass of grasses (Table 3). Floral richness was significantly higher when nests of *A. claviger* were present, although no differences were found according to grass type (Table 4). Of the 22 quadrats lacking nests of *A. claviger*, all contained either big bluestem (19 quadrats) and/or prairie dropseed (8 quadrats).

DISCUSSION

The diameter of *A. claviger* nests appears important to colony persistence although the relationship between nest diameter and colony size is unknown. Larger colonies may penetrate deeper into the soil, allowing the colonies to escape the cold of the northern Illinois winter. Likewise, increased nest diameter may function to buffer colonies from the cold. Estimation of colony size through excavation would offer to test these hypotheses. Nevertheless, nests having small diameters showed a precarious persistence.

Soil moisture was the only physical factor in grass clumps that differed according to the presence of *A. claviger* nests. This may be explained by water runoff as influenced by mounds and increased soil porosity due to mound building and tunneling. Water infiltration rates can be affected by tunneling ants (Eldridge and Pickard 1994).

Nests failed to show significant relationships to temperature or fraction organic content of the top 10 cm of soil, two factors which could also influence

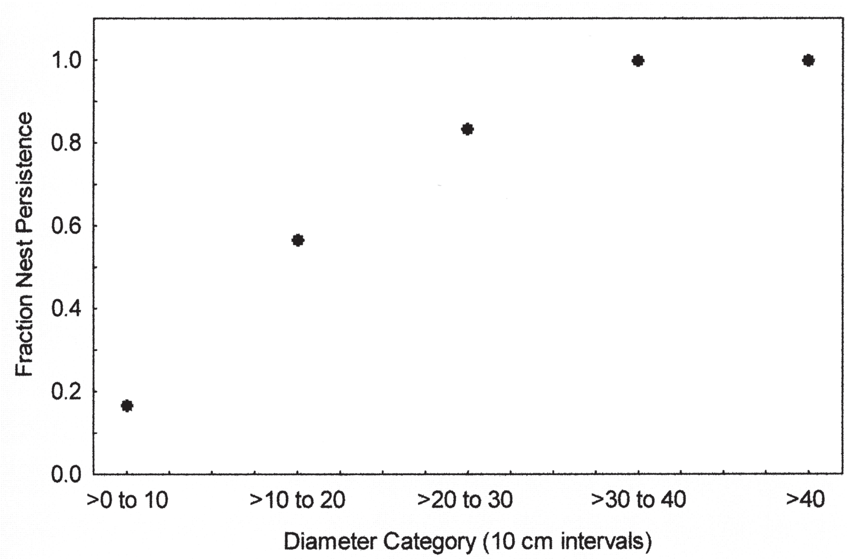


Figure 1. Nest persistence of *Acanthomyops claviger* over one winter season according to category of nest diameter. Sample size per nest category beginning with the smallest size and proceeding to > 40 cm were 6, 23, 18, 8 and 6 nests, respectively.

Table 1. Repeated-measures ANOVA on arcsin√fraction soil moisture where presence of *Acanthomyops claviger* nest and grass type are between groups factors and sample period is the within-subjects effect.

Effects	**df**	**F**	***P***
Between subjects			
Nest presence	1	15.03	0.0003
Grass type	1	0.01	0.9201
Nest presence × Grass type	1	0.03	0.8667
Error	56		
Within subjects			
Sample period	5	29.93	<0.0001
Sample period × Nest presence	5	7.29	<0.0001
Sample period × Grass type	5	5.53	<0.0001
Sample period × Nest presence × Grass type	5	0.72	0.6093
Error	280		

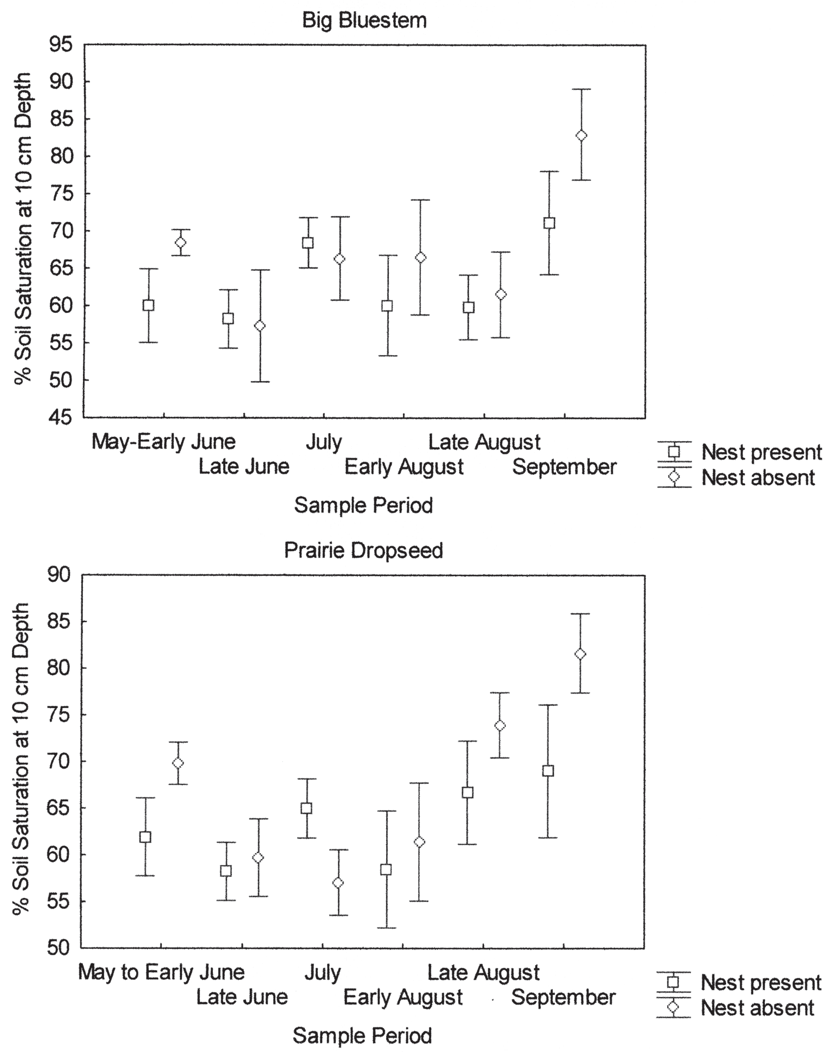


Figure 2. Percent soil moisture (sample mean ± 95% confidence interval) according to the presence of *Acanthomyops claviger* nests in grass clumps and type of grass per grass clump. Data have not been transformed. With all error df = 56, post-hoc testing for big bluestem showed significant differences in mean arcsin √soil moisture according to presence of *A. claviger* nests during May - early June (F = 11.35) and September (F = 8.36), while like testing for prairie dropseed indicated significant differences during May-early June (F = 13.17), July (F = 10.68), late August (F = 5.59), and September (F = 10.64).

Table 2. Repeated-measures ANOVA on $\log_{10}$ soil temperature at 10 cm depth where presence of *Acanthomyops claviger* nest and grass type are between groups factors and sample period is the within-subjects effect.

Effects	**df**	**F**	***P***
Between subjects			
Nest presence	1	0.30	0.5639
Grass type	1	5.50	0.0223
Nest presence × Grass type	1	0.00	0.9114
Error	56		
Within subjects			
Sample period	5	90.10	<0.0001
Sample period × Nest presence	5	0.00	0.9997
Sample period × Grass type	5	9.30	<0.0001
Sample period × Nest presence × Grass type	5	0.00	0.9999
Error	280		

moisture. Although soil temperature has been linked to causing changes in ant activity (Porter and Tschinkel 1987), our findings fail to indicate that *A. claviger* can, conversely, modify the thermal environment of their nests. Insufficient time for soil development since initial prairie re-creation may have precluded finding *A. claviger*-associated effects with regards to organic content. Contrarily, continuous burrowing and soil excavation by *A. claviger* and other soil-dwelling ants and arthropods of the re-created site may function to thoroughly mix the soil and prevent the development of soil horizons. Hughes (1991) provides evidence that continual and progressive tunneling by ants functions to prevent nutrient accumulations. A lack of heterogeneity in nutrient accumulations can explain the absence of a difference in above-ground biomass of grasses where nests were present. The question then becomes whether nests of *A. claviger* facilitate the growth of grasses or if grass clumps provide suitable areas for nest locations. An absence of organic enrichment would support the latter. Regardless, we failed to find evidence that the presence of ant nests harmed the grasses by reducing organic nutrient availability or above ground biomass, indicating an ant-grass relationship that is at least commensalistic.

Tunneling activities by *A. claviger* may function to break up soil, thereby encouraging seed germination and explaining higher plant diversity around nests. *A. claviger* is not known to be granivorous. Hence, the ant would not seem to have a role in seed distribution. Burrill and Smith (1919) is an original source commonly referenced concerning *A. claviger* food sources that do not include seeds or portions of seeds, but they do not provide evidence of how they reached their conclusions. More study on the feeding habits of *A. claviger* is warranted to eliminate the possibility that the species distributes seeds. Perhaps alteration of moisture content of soil contributes to increases in floral richness, or rather the presence of colonies has no effect on floral richness but instead floral richness attracts nesting *A. claviger* queens.

The re-created prairie has been found to be a suitable habitat by *A. claviger* as indicated by nests, and their presence appears to be associated with contrasts in the soil moisture of grass clumps and flora richness. More needs to be known about the basic biology of *A. claviger* including nest size, soil penetration by colonies and food sources. Common limiting nutrients such as nitrogen, phosphorus and potassium, could add to the understanding of the impact of *A. claviger* on soil composition and the establishment of the prairie flora.

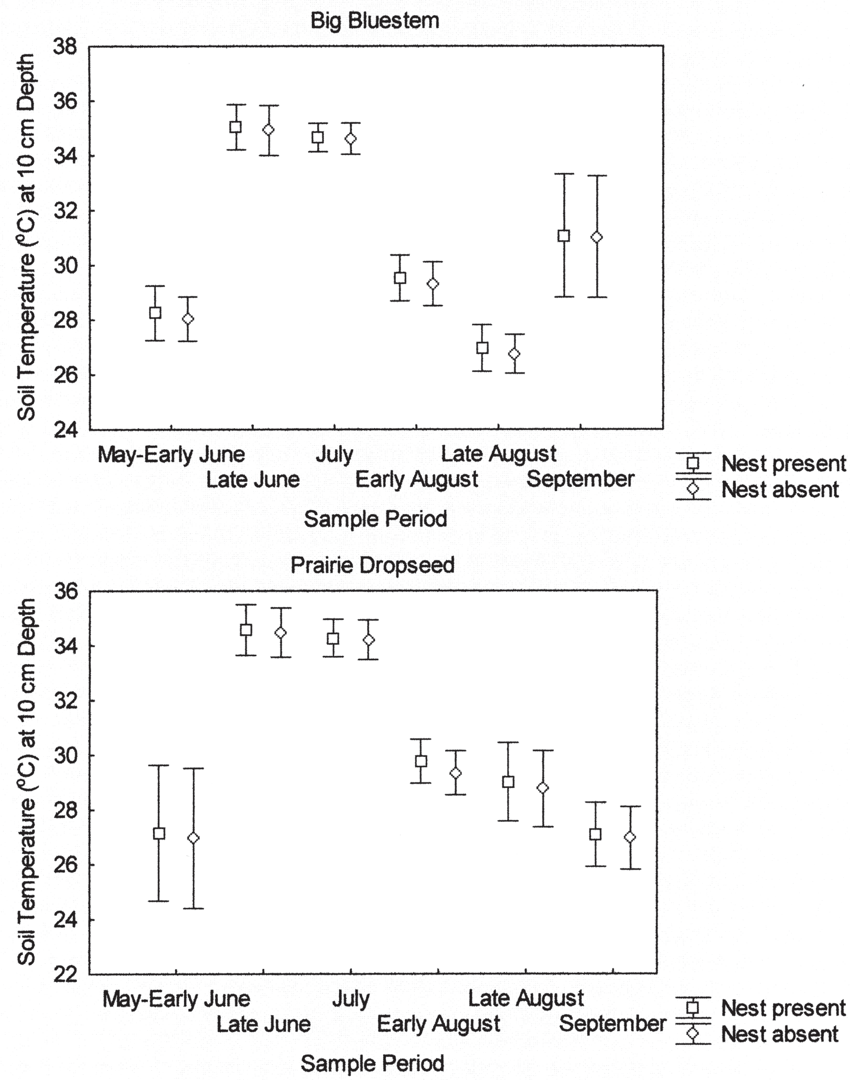
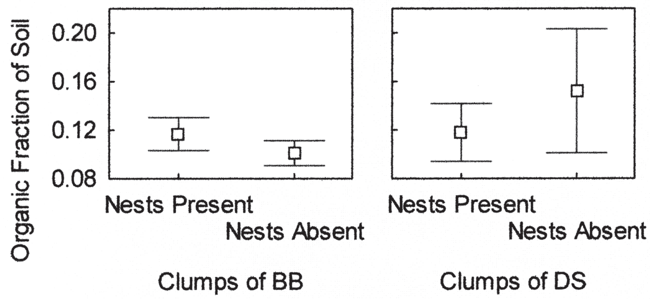
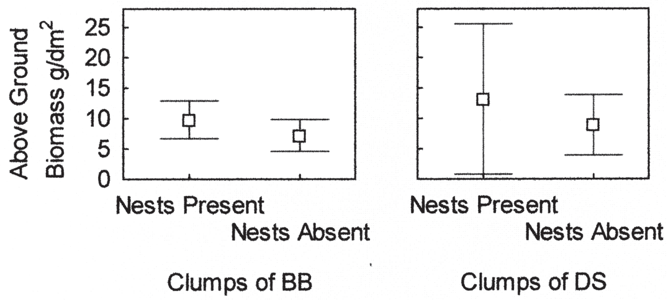


Figure 3. Soil temperature at 10 cm depth (sample mean ± 95% confidence interval) according to the presence of *Acanthomyops claviger* nests in grass clumps and type of grass per grass clump. Data have not been transformed.



(b)



(c)

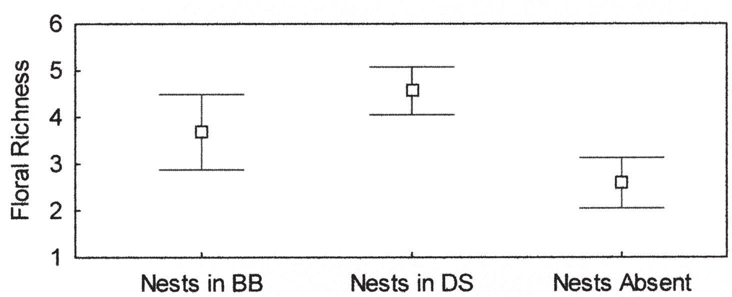


Figure 4. (a) Organic fraction of soil, (b) above ground biomass, and (c) floral richness (number of species per m^2) according to the presence of *Acanthomyops claviger* nests. Sample means ± 95% confidence intervals are provided. Data have not been transformed. BB = big bluestem and DS = prairie dropseed.

Table 3. Factorial ANOVAs testing the effect of *Acanthomyops claviger* nest presence on (a) organic content, and (b) above-ground biomass of grasses.

Effects	**df**	**F**	***P***
(a) Arcsin√fraction organic content			
Between subjects			
Nest presence	1	0.30	0.5639
Grass type	1	5.50	0.0223
Nest presence × Grass type	1	0.00	0.9114
Error	56		
(b) Log_{10} gram above-ground biomass of grasses/dm^2 in the clump			
Between subjects			
Nest presence	1	0.54	0.4648
Grass type	1	0.01	0.9047
Nest presence × Grass type	1	0.47	0.4942
Error	66		

Table 4. One-way ANOVAs testing for differences in species richness according to presence of nesting *Acanthomyops claviger* or grass type.

Effects	**df**	**F**	***P***
(a) Quadrats having nests in clumps of big bluestem compared to those lacking nests.			
Nest presence	1	5.49	0.0239
Error	42		
(b) Quadrats having nests in clumps of prairie dropseed compared to those lacking nests.			
Nest presence	1	28.64	<0.0001
Error	36		
(c) Quadrats having nests in clumps big bluestem compared to those having nests in clumps of prairie dropseed.			
Grass type	1	3.13	0.0855
Error	36		

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