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SHORT NOTE

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A survey of arbuscular mycorrhizal fungal root inoculum associated with harvester ant nests *(Pogonomyrmex occidentalis)* across the western United States

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Abstract Soil organisms are known to affect the population dynamics of mycorrhizal fungi in many ecosystems. The western harvester ant, *Pogonomyrmex occidentalis,* is widespread in its distribution and creates patch disturbances that affect both plant and soil microbial communities. Harvester ant-plant-fungus interactions can result in the formation of dense root mats in nest soils and abundant viable mycorrhizal root inoculum. We surveyed mycorrhizal root inoculum in nests of *P. occidentalis* across its distributional range to address whether root mats and fungal enrichment were a common consequence of ant activity. We concluded that mycorrhizal root mats were unique to particular plant communities (sagebrush steppe) and were not a common feature of *P. occidentalis*' nests across its distributional range.

Keywords Arbuscular mycorrhizal root colonization · Soil disturbance · Root proliferation · *Pogonomyrmex occidentalis*

Introduction

The western harvester ant, *Pogonomyrmex occidentalis,* is considered a significant disturbance agent to plant and soil communities in arid and semiarid ecosystems of North America (Hölldobler and Wilson 1990). *P. occidentalis* is particularly widespread in its distribution, including shortgrass steppe, intermountain shrub steppe, and Great Basin ecosystems. Ant colony densities can exceed 30 nests ha^{-1} (Crist 1990) resulting in the rapid turnover of soil (Whitford et al. 1986) and the denudation of significant areas of the land surface (Soulé and Knapp 1996). Although *P. occidentalis* clips vegetation from nest sites, arbuscular mycorrhizal (AM) fungal inoculum has been reported orders of magnitude higher in mounds than in surrounding soils (Friese and Allen 1993). Mats of densely packed root material (12–15 cm cm^{-3}) from shrubs of big sagebrush (*Artemisia tridentata*) provided favorable microsite conditions for AM fungus in *P. occidentalis* nests in Wyoming sagebrush steppe (Friese and Allen 1993). Roots which proliferated into nests, were subsequently clipped by nest workers, and supported significantly higher densities of viable AM fungus spores than undisturbed vegetation. Friese and Allen (1993) concluded that the availability of mycorrhizal fungi would affect plant community composition and succession on abandoned nests by favoring the establishment of mycotrophic native plants over non-mycotrophic invasive species found at their study site.

Because patch disturbances created by *P. occidentalis* are common in many ecosystems, we were interested in testing whether the pattern of root mat and nest mycorrhizal fungal enrichment previously reported was unique to Wyoming sagebrush steppe or a common nest architectural feature of this ant species in many habitats. In this study we examined total root length and root length colonized by AM fungi in *P. occidentalis* mounds and off-mound areas across its distributional range from Nevada to Nebraska. Five study sites with distinct plant community composition were selected across an existing precipitation gradient from Nevada to Nebraska (Fig. 1).

Materials and methods

Harvester ant nest sampling

Five mounds and five areas undisturbed by ant activity (3 m away from nests) were sampled at each study site during the summer of 1995. Three soil cores (2.5 cm diameter×30 cm deep) were collected and bulked from each mound and off-mound location, respectively. Fine roots were collected from soil and stained for the presence of AM structures using trypan blue. Mycorrhizal root colonization was assayed using the gridline intersection method (Brundrett et al. 1994). Total root length and root length colonized

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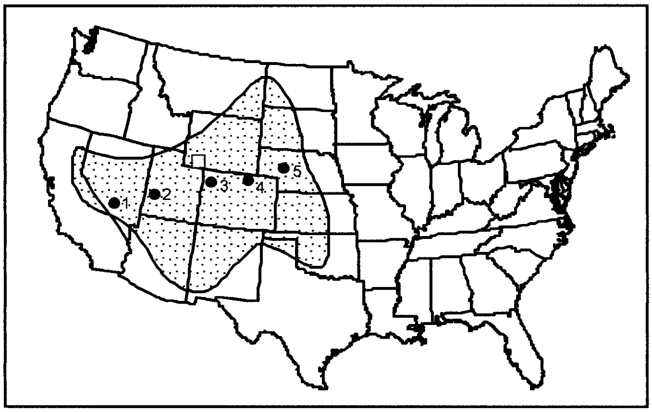

Fig. 1 Distribution of *Pogonomyrmex occidentalis* across the study sites. The Nevada test site (*1*) is a Great Basin-Mojave Desert transition. The Desert Experimental Range (*2*) is Great Basin Desert. The Piceance Basin (*3*) is sagebrush steppe. The Central Plains Experimental Range (*4*) is shortgrass steppe. The Cedar Point Biological Station (*5*) is mixed grass prairie. The *open box* represents the original field site studied by Friese and Allen (1993)

by AM fungi were compared between mound and off-mound samples using a two-way ANOVA, including site as an independent factor. Data was natural log-transformed prior to analysis.

Study site descriptions

Great Basin-Mojave transition

The Nevada test site in southern Nevada is managed by the US Department of Energy. The area is a transitional zone between the Mojave and Great Basin Desert. Dominant vegetation includes *A. tridentata* and black sagebrush (*Artemisia nova*). Mean annual precipitation is 117 mm.

Great Basin

The Desert Experimental Range in western Utah is managed by the USDA Forest Service. Vegetation is dominated by perennial shrubs such as winterfat (*Ceratoides lanata*), *A. nova*, and shadscale (*Atriplex confertifolia*). Mean annual precipitation is 160 mm.

Shrub steppe

Located in northwestern Colorado, the Piceance Basin is managed by the Bureau of Land Management. *A. tridentata*, rabbitbrush (*Chrysothamnus viscidiflorus*) and perennial bunchgrasses (*Oryzopsis hymenoides*, *Agropyron smithii*) dominate at this site. Mean annual precipitation is 280 mm.

Shortgrass steppe

The Central Plains Experimental Range is located in northeastern Colorado and is managed by the USDA-Agricultural Research Service. Vegetation is dominated by perennial grasses such as blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), and three-awn (*Aristida purpurea*). Mean annual precipitation is 311 mm.

Western Nebraska

The Cedar Point Biological station is located in western Nebraska and is managed by the University of Nebraska, Lincoln. This site is located on the south shore of Lake Ogallala and is dominated by shortgrass and mixed-grass prairie species. Common grasses include *B. gracilis*, little bluestem (*Schizachyrium scoparium*), western wheatgrass (*Agropyron smithii*), and needle and thread grass (*Stipa comata*). Mean annual precipitation is 460 mm.

Results and discussion

The amount of fine root material collected from mounds was similar to that from off-mound areas at all study sites (Table 1), suggesting that root mats were not present to the extent that Friese and Allen (1993) reported in Wyoming sagebrush steppe. The development of root mats appears to be a unique characteristic of the Wyoming site where mature big sagebrush grows in close proximity to large, well-developed harvester ant nests. Notably, the mounds we sampled were clear of vegetation so that root material collected from mound soil must have come from lateral root growth of shrubs and rhizomatous grasses along the nest edge. Because nests of *P. occidentalis* are typically enriched in available nutrients (MacMahon et al. 2000), root proliferation into ant clearings would explain why root material was present in mounds and why surrounding plants often show increased biomass production over non-mound areas (Wight and Nichols 1966; Rogers and Lavigne 1974).

The nesting activities of *P. occidentalis* did not influence levels of AM root colonization (Table 1). Mound and off-mound soils were similar in mycorrhizal root

Table 1 The effect of *Pogonomyrmex occidentalis* activity on total root length (cm ±SE, *n*=5), root length colonized by AM fungi (cm ±SE, *n*=5), and % colonization (% ±SE, *n*=5) in mound and off-mound soils across the distributional range of the harvester ant

Site	Total root length (cm)[a]		Root length colonized (cm)[b]		% Root colonization (cm)	
	Mound	Off mound	Mound	Off mound	Mound	Off mound
1	49±17	52±16	15±5	12±3	34±3	25±3
2	23±6	118±37	4±2	15±7	20±4	11±1
3	127±54	160±27	33±12	23±5	27±5	18±6
4	150±45	180±31	21±5	23±5	16±2	12±1
5	255±77	355±86	53±14	53±16	21±2	15±2

[a]ANOVA *P*-values: mound vs off mound (0.02); site (<0.01); interaction (0.20)
[b]ANOVA *P*-values: mound vs off mound (0.58); site (<0.01); interaction (0.35)

length and percent colonization at all study sites. It is important to note, however, that harvester ant nests maintained a source of mycorrhizal root fragment propagules even though there was no plant growth directly on mounds. The viability of AM fungus propagules following a disturbance event as frequent as ant colony activity has implications for plant establishment in arid and semiarid ecosystems because most plants, except for a small suite of annual weeds, form AM associations (Trappe 1981). An ant-plant-fungus interaction such as the one studied here may therefore affect plant community diversity and productivity by facilitating the re-establishment of mycotrophic plants on nest sites after colony abandonment.

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