Local Arbuscular Mycorrhizal Fungal Diversity is Strongly Coupled to Regional Diversity in an Urban Ecosystem

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INTRODUCTION

Understanding of the community structure of arbuscular mycorrhizal (AM) fungi is of crucial importance for elucidating the relationship between soil and plant communities and the effective use of AM fungi in environmental conservation and restoration. One of the unanswered questions in the study of diversity of AM fungi is how diversity is maintained in local communities. Both niche-assembly and dispersal assembly perspective have been proposed to explain maintenance of high diversity in local communities. Bever et al. (2002) summarize evidence that niche assembly rules are important in the maintenance of a diverse AM fungal community with biotic and abiotic resources such as plant hosts, seasonality and edaphic conditions creating multiple niches in a habitat. Although increasing interest in the study of ecological processes across greater spatial and temporal scales has sparked renewed interest in the effects of geographical and historical factors on local communities, few studies of AM fungi have placed local communities within a regional context. In this study, we compare the AM fungal diversity in a small local site of relatively uniform habitat with information on AM fungal diversity collected as part of a regional survey. Both local and regional diversity were assessed in an urban arid ecosystem in the southwestern USA..

METHODS

Sampling for Local Diversity

Samples were collected from two 9.2 × 9.2 m replicated plots that were part of an experimental landscaped area located at the Desert Botanical Garden in Phoenix. In 1999, the native creosotebush vegetation was removed, and the plots planted with landscape plants typically used in the area (*Leucophyllum frutescens*. *Nerium oleander*, *Quercus virginiana*, *Eucalyptus microtheca*, *Rosmarinus officinalis* and *Opuntia violacea* var. *santa-rita)*. In the winter of 2001-2002, each plot was divided into 25 equally-sized quadrats and soil was collected at a sampling point in the center of each quadrat for a total of 50 samples.

Sampling for Regional Diversity

Samples were collected from 34 sites in the Phoenix metropolitan area in Spring of 1999 or 2000 as part of the Central Arizona Phoenix (CAP) LTER Survey 200. Sampling sites where located using a dual density tessellation-stratified design with the entire CAP-LTER ~6400 km^2 area divided into 4 x 4 square kilometer grids and one GPS-located site centered on a randomly selected point in each of these grid squares in the urban core. The 206 sampling sites were categorized by land use and 34 sites classified as urban were chosen for this study. At each site, soil samples were collected from three trees nearest the plot-center.

Spore Extraction and Identification

Spores were extracted from a 100 cm^3 sample from soil and from trap cultures established from field soil by wet sieving and sucrose density gradient centrifugation. Spores were examined using a stereomicroscope, and spores of each distinct morphotype were mounted in polyvinyl alcohol-lactic acid-glycerin (PVLG) and PVLG mixed 1:1 (v/v) with Melzer's reagent for identification.

Table 1.

	Total number species detected	Mean number species/site	Mean number species/sample
Local	12	9.0	3.0
Regional	19	5.9	3.4

Fig. 1. Species-sampling effort curves for local (A) and regional (B) communities. Generated using Colwell's *EstimateS* software (viceroy.eeb.uconn.edu/estimates).

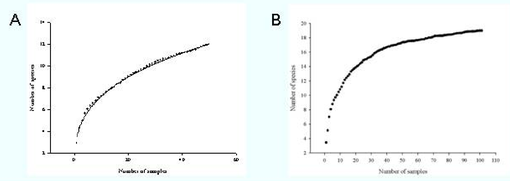


Fig. 2. Relative frequency of AM fungal special in local site and regional survey.

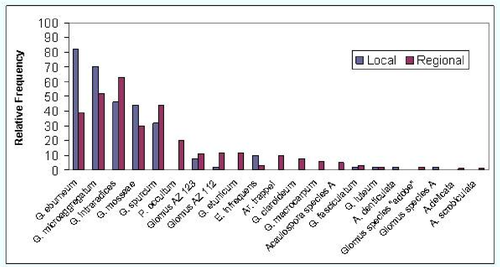
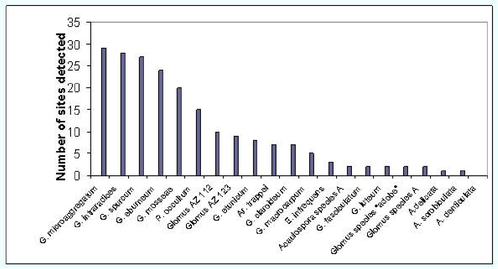


Fig 3. Number of sites in the regional survey at which each AM fungal species was detected (N=34).



RESULTS AND DISCUSSION

The number of species detected at the local site was almost as high as the 19 species detected the Phoenix regional survey (Table 1).
There was a strong overlap in species composition between the local and regional community with 10 of the 12 species detected in the local community also detected in samples from the regional survey.

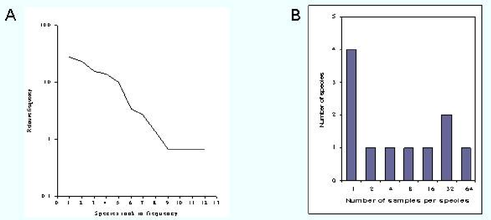
Additional species were most likely present at both the local and regional level (Fig. 1).
Species-sampling effort curves indicate that several additional species could be detected by increasing sample size. Because of the large number of samples necessary to detect 90% of species present, the difference in the mean number of species detected/site between the local and regional studies (Table 1) is probably due to the low number of samples per site (N=3) in the regional survey. The use of different sampling/trapping methodologies (i.e., different trap host plants, season of sampling, greenhouse conditions) could also reveal additional fungal species (Bever et. al 2002).

The most frequently detected species in the regional survey are also the most common at the local site. Species rarely encountered in the Phoenix area were also rare at this site (Fig. 2).
These results indicate that the local community is strongly coupled to the regional metacommunity. Hubbell (2001) argues that when relative abundance in the local community is similar to the regional community, the local community is strongly influenced by high immigration from the metacommunity.

Species with more extensive distribution tended to be more abundant locally than species with more restricted distribution (Fig. 3).
Hanski et al. (1993) describe possible explanation for this positive relationship including sampling artifacts, ecological specialization and metapopulation dynamics, but they also conclude it is difficult to discriminate among them.

The rank-frequency plot of species in the local community indicates a log-normal distribution (Fig. 4A) with no single dominant species and several rare species. A Preston-type plot reveals that singleton species are the most commonly occurring class at this site (Fig. 4B).
Hubbell (2001) postulates that this type of distribution, in which singleton species are the most frequent abundance class, indicates high dispersal between the local community and the surrounding metacommunity. Because wind serves as an effective dispersal agent for AM fungal propagules in arid areas (Allen, et. al. 1989), in-migration of species from the metacommunity is likely.

Fig. 4. Rank frequency plot (A) and Preston-type plot of relative species frequency (B) of local AM fungal community.



CONCLUSION

Our results indicate that dispersal assembly rules may impact local AM fungal communities. However, these results do not necessarily preclude the influence of niche assembly factors proposed by Bever et al. (2002). It is likely that both regional processes and local biotic interactions play a role in structuring local AM fungal communities.

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