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Arbuscular mycorrhizal fungal composition in high montane forests with different disturbance histories in central Argentina

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ABSTRACT

The aim of this work was to describe and compare the arbuscular mycorrhizal fungal (AMF) morphospecies community and root colonization in three *Polylepis australis* forest disturbance types (degraded forest, young forest and mature forest). Rhizosphere soil samples were collected during wet and dry seasons in three sites located at the high mountains of central Argentina. A highly diverse AMF community was detected with 32 different morphospecies. AMF richness, density, Shannon diversity and evenness were neither influenced by forest disturbance type nor by season. Nevertheless, indicator species analyses showed two AMF taxa mostly associated with the degraded forest, one with the young forest and two linked preferentially to the mature forest. Moreover, the latter forest type showed the highest biovolume of *Gigaspora* spp., a genus representative of conserved ecosystems. *P. australis* root colonization was similar among forest disturbance types and seasons. However, higher abundance of vesicles was observed during the dry season than during the wet season. This study showed that AMF community composition was relatively similar among forests with distinct structural complexity. These results suggest that the AMF community may be resistant to the kind of disturbances that shaped the forests compared, or that natural successional processes may permit AMF to recover from these disturbances.

1. Introduction

Soil microorganisms represent a great part of global biodiversity and play a crucial role in ecosystem functioning (Fitter et al., 2005; Johnson et al., 2013). Arbuscular mycorrhizal fungi (AMF; Phylum Glomeromycota) (Schüßler et al., 2001) are one of the most relevant soil microorganisms due to their direct influence on essential processes between plants and soil (Fitter et al., 2005). AMF are obligate symbionts that associate with ~80% of the studied vascular plants (Brundrett, 2009; Wang and Qiu, 2006), improving soil exploration, mineral acquisition, water relations and root pathogen resistance in their hosts (Smith and Read, 2008). During the last years AMF spore community variation in response to the original plant community changes (e.g., through disturbances as fire, habitat fragmentation or agricultural practices) has been widely evidenced (Grilli et al., 2012; Longo et al., 2014; Stürmer and Siqueira, 2011).

Forest structural changes that are caused by anthropogenic perturbation might indirectly influence AMF morphospecies communities (i.e., spore density, morphospecies diversity and richness) and root mycorrhizal colonization through variation of the vegetation, micro-climatic conditions, soil physical–chemical characteristics, etc. For instance, plant cover reduces soil erosion while its removal exposes soil to increase radiation (Cingolani et al., 2003; FAO, 2005; Renison et al., 2004) affecting AMF composition (Carpenter et al., 2001; Dumbrell et al., 2010; Lopes Leal et al., 2013) and root colonization (Entry et al., 2002; Haugen and Smith, 1992).

There is contradictory evidence about the influence on AMF communities of disturbance history that results in structural changes to forests, some reporting AMF resilience (Johnson and Wedin, 1997; Picone, 2000) while others reporting changes in AMF communities compared to the original forest (Grilli et al., 2012; Longo et al., 2014; Stürmer and Siqueira, 2011; Zhang et al., 2004). In addition, AMF community seasonality has been demonstrated and some morphospecies may be dominant depending on the time of year (Becerra et al., 2009; Lee and Koske, 1994; Lugo and Cabello, 2002; Merryweather and Fitter, 1998; Soteras et al., 2012). Also, root colonization by AMF is usually higher during the growing season (Lugo et al., 2003).

High mountain forests of *Polylepis australis* Bitt. (Rosaceae), the southernmost species of *Polylepis* spp. (Simpson, 1979), are highly

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impacted by anthropogenic disturbance (Cingolani et al., 2008). Forest degradation has occurred mainly due to the influence of anthropogenic changes (livestock rearing and intentional fires) since the XVII century (Cingolani et al., 2003). Nowadays, structural complexity differences of the forest remnants of this species might be related to the extent of disturbance (Renison et al., 2011) together with topographic characteristics (e.g., altitude) (Marcora et al., 2008) and other particularities of the species (e.g., Pollice et al., 2013; Renison et al., 2004; Renison et al., 2011). The influence of *P. australis* forest structural changes on physical soil conditions has been evidenced (Renison et al., 2010). However, whether these forests changes affect belowground organisms and, especially AMF community, remains unknown.

The aims of this work were to describe and compare the AMF spore community composition and to determine the mycorrhizal root colonization of *P. australis* in three forest types varying in their structural complexity (degraded forest, young forest and mature forest) at three sites, during two seasons. Considering that the variation of the original plant community could be related to both AMF community composition and root colonization changes and that AMF usually shows seasonal variations, we hypothesized that forests disturbance types and seasonality affect AMF spore community and root colonization.

2. Materials and methods

2.1. Study area

Three *P. australis* forest types with different disturbance history, described and georeferenced by Renison et al. (2011), hereafter called "degraded forest", "young forest" and "mature forest", were chosen at each of three sites ("Los Gigantes" (1800–1900 m asl, 31°23′S, 64°48′W);"Los Molles" (1800–2000 m asl, 31°58′S, 64°56′W) and "Santa Clara" (2000 to 2200 m asl, 31°44′S, 64°47′W)) (Fig. 1). According to the conservation degree the three sites could be ordered from the least to the most preserved as (1) Los Gigantes, (2) Los Molles, and (3) Santa Clara (Renison et al., 2006).

Mean temperature for the coldest and warmest months are 5 °C and 11.4 °C, respectively, with no frost-free period (Cabido, 1985). Mean annual precipitation is 840 mm, being concentrated in the warmest months (October to April) (Cabido et al., 1987). Soils characteristics of the three forest structural types were previously determined by Renison et al. (2010) (Table S1 Table S1).

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The landscape includes distinctive units differing in their slope, relief and percentage of rocky outcrops, including hilly uplands, plateaus, ravines and valley bottoms (Cabido et al., 1987). Vegetation consists of a mosaic of tussock grasslands and grazing lawns mostly represented by *Deyeuxia hieronymi* (Hack.) Türpe, *Festuca tucumanica* Alexeev, *Poa stuckertii* (Hack.) Parodi, *Alchemilla pinnata* Ruiz & Pav. and *Carex fuscula* Urv. intermingled with granite outcrops and eroded areas with exposed rocky surfaces. Interspersed among the grasslands are *P. australis* shrublands and woodlands, together with isolated *Maytenus boaria* Molina trees, *Berberis hieronymi* Scheid shrubs and fern communities (Cabido, 1985; Cingolani, 2004). Since the beginning of the XVII century the main economic activity has been livestock rearing, cattle and sheep, that have completely replaced the native herbivores (i.e., *Lama guanicoe* Müller) (Cabido et al., 1987; Díaz et al., 1994). Livestock and intentional fire management to promote grass regrowth have created different forest disturbance types varying in their structural complexity (Renison et al., 2011). Therefore, the most conserved mature forest type is now represented as small remnants restricted to rocky outcrops with steep slopes, where the impact of both livestock and fires is less frequent (Cingolani et al., 2008; Renison et al., 2006). This forest type has a mean canopy cover of 72%; shows some isolated individuals of more than 800 cm in height and mean age of the largest living tree is 67 years. The young forest stand shows evidence of previous disturbances but is regenerating naturally, with a mean canopy cover of 54%. Young trees are from 116 to 200 cm in height and mean age of the largest living tree is 37 years. The degraded forest type is characterized by sparse trees with mean cover of 8%; shows low regeneration rates, evidence of previous fire events and soil erosion; and the mean age of the largest living tree is 43 years (Renison et al., 2011).

2.2. Experimental design

During the wet (spring – October 2010) and dry (autumn – May 2011) seasons, soil samples (20 cm depth) were collected with a trowel from the rhizosphere of six randomly selected *P. australis* trees, in each forest type (6 replicates per forest type) at the three

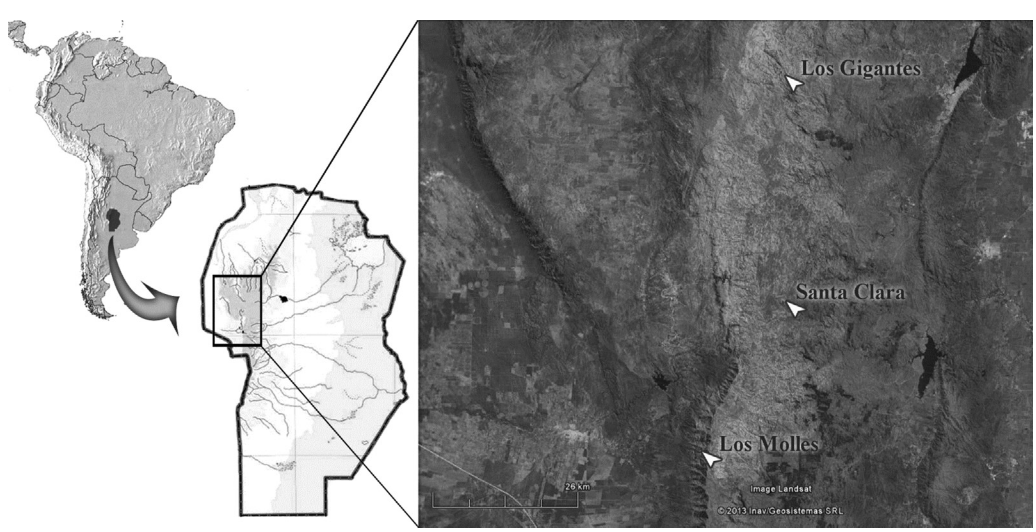

Fig. 1. Sites (arrowheads) located at the high mountains of central Argentina: Los Gigantes, Los Molles and Santa Clara from the degraded to the most preserved. In each site, three *P. australis* forest types (degraded forest, young forest and mature forest) were sampled, during wet and dry seasons.