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Wood-decaying polypores in the mountains of central Argentina in relation to *Polylepis* forest structure and altitude

Gerardo Lucio ROBLEDO[a,*], *Daniel RENISON*[b]

[a]*Laboratorio de Micología, IMBIV, Instituto Multidisciplinario de Biología Vegetal, CONICET – Univ. Nac. Córdoba, CC 495, CP 5000 Córdoba, Argentina*
[b]*Cátedra de Ecología, FCEFyN, Univ. Nac. de Córdoba – CONICET, Av. Velez Sarsfield 299, CP 5000 Córdoba, Argentina*

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ABSTRACT

To determine how altitude and forest successional stage are related to richness and composition of wood-decaying polypore fungi in *Polylepis* mountain forests of central Argentina we sampled 48 forest plots of 900 m^2 which included a range of successional stages and altitudes. We recorded a total of 19 species and our main results show that overall richness increased with forest successional stage and altitude, while endemic species richness was positively related only to altitude. Polypore community structure as exemplified by DCA Axes 1 and 2 was also related only to altitude with no pattern with forest successional stage, meaning polypore species are added during succession with no loss of early successional species. We conclude these forests must be managed to promote more mature forests and emphasis must be placed on a range of altitudes, especially highland areas where slow decomposition allows for a more diverse polypore community.

Introduction

The long land use history of the high mountain forests of central Argentina, and other tropical and subtropical mountain forests of South America, has greatly reduced the surface area occupied by forests dominated by trees of the *Polylepis* genus (Fjeldså & Kessler 1996; Renison *et al.* 2006; Cingolani *et al.* 2008). The restoration of forest extension and connectivity has been highly recommended because *Polylepis* forests harbour a high richness of species many of which are endemics including birds (Fjeldså 2002; Herzog *et al.* 2002; Bellis *et al.* 2009), plants (Fernández *et al.* 2001; Fernández-Terrazas & Ståhl 2002) and rodents (Tarifa & Yensen 2001; Yensen & Tarifa 2002), and because *Polylepis* forests provide important ecological services to humans such as clean water and carbon sequestration (Fjeldså & Kessler 1996).

Polylepis forests, often called woodlands or shrublands, and mostly have a simple vertical structure. This structure was usually interpreted as a result of high altitude stressful environmental conditions (i.e. Enrico *et al.* 2004). However, a recent study pointed out that the long lasting human impact on *Polylepis* forests has greatly contributed to a reduction of vertical complexity, and that late successional forests with a complex vertical structure may still be found in remote areas (Renison *et al.* 2009). Several recent studies have shown that *Polylepis* forest with a complex vertical structure (mature

* *Corresponding author*. IMBIV, Instituto Multidisciplinario de Biología Vegetal, CONICET – Univ. Nac. Córdoba, CC 495, CP 5000, Córdoba, Argentina. Tel/fax: + 54 0351 4331056
E-mail addresses: glrobledo@yahoo.com (G.L. Robledo), darenison@yahoo.com.ar, danielrenison@ecosistemasarg.org.ar (D. Renison).
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forests) harbours several rare bird endemics (Cahill & Matthysen 2007; Lloyd & Marsden 2008). To the best of our knowledge, the effect of a simplified *Polylepis* forest structure has not been studied in other organisms. Because wood-decaying polypore species are often related to different forest successional stages, including many species which inhabit coarse woody debris only found in mature forests (Renvall 1995; Sippola *et al.* 2001; Junninen *et al.* 2006), they are potential candidate taxa which could highlight the importance of preserving mature *Polylepis* forests.

Studies in eastern US and boreal forests show that forest structure has a profound influence on wood-decay fungi and associated insect fauna (Komonen *et al.* 2000; Siitonen 2001). In boreal ecosystems wood decomposition is slow and hence wood accumulation high. As *Polylepis* forests are also situated in cold enviornments where wood decomposition may be slow, a similar situation may be suspected, and recent studies have described a diverse wood fungal community inhabiting these forests, with high levels of endemism and new species to science (Urcelay *et al.* 2000; Robledo *et al.* 2003, 2006; Rajchenberg & Robledo 2005).

Here, we study the wood-decaying polypore community of *Polylepis australis* forests from central Argentina. Our objectives were to: (1) describe *P. australis* wood-decaying polypore community in terms of species richness, diversity and composition; (2) determine the association between forest structure, altitude and polypore community; and (3) discuss management implications. Our hypotheses were that: (1) different successional stages harbour unique wood-decaying polypore communities; (2) species inhabiting rare late successional forests could be rare and endangered; and (3) polypore communities could be more diverse at higher altitudes where average temperatures and wood decomposition is slower. To the best of our knowledge, this is the fist study in South America that relates changes in wood-decay fungal diversity with forest successional stage or altitude.

Materials and methods

Study area

The Córdoba Mountains (central Argentina, North-South direction, rising up to 2884 m asl, 31° 34′ S, 64° 50′ W) have an annual precipitation of 840 mm and mean monthly temperatures at 2100 m asl of 5.0 and 11.4 °C in the coldest and warmest months, respectively (Cabido 1985). The landscape is a mosaic of different types of tall tussock grasslands, grazing lawns, natural granitic outcrops, exposed rock surfaces produced by anthropogenic soil erosion, and forest canopies dominated almost exclusively by *P. australis* (Cingolani *et al.* 2004, 2008). For a location map of the study area and *Polylepis* distribution see Robledo *et al.* (2006). *P. australis* is an endemic treeline species of the mountains of central and Northwest Argentina with a maximum height of 16 m and basal circumference of 3.65 m (Simpson 1979; Suarez *et al.* 2008). In central Argentina trees of this species may be found even on the highest peaks at 2900 m asl, but tree performance appears to be best at around 1850 m asl (Marcora *et al.* 2008).

Plot establishment

We established 48 plots of 30 × 30 m, distributed in four river basins, that differed in human impact and successional stage (as in Renison *et al.* 2006, 2009). Plot location was initially selected using a vegetation map (Cingolani *et al.* 2004). We randomly chose areas within vegetation units that were supposed to contain forest or open shrublands (*P. australis* cover generally >5 %). In the field we located plots using Global Positioning System and selected them for the study when: (1) there was at least a total of 20 *Polylepis* living stems, snags or logs (hereafter sampling units), and (2) all sampling units were accessible for measuring (i.e. plots on steep cliffs or in gorges were not selected). We attempted to establish a species richness/area curve (and also a species richness/number of sampling units curve) to determine the plot area or number of sampling units at which species richness was well captured. However, due to extensive forest fragmentation and the low relative frequency of all polypore species except one (see Results), the curve did not reach a plateau in degraded areas with small forest patches even when all the patch was sampled. Rather than continue to accumulate species by changing forest patch (thus unintentionally incorporating Beta diversity), or using differing study plot size for small and large forest patches, we opted for a fixed area of 900 m^2 and more than 20 sample units as a measure of relative density of individuals and species. In the final data set, neither relative species richness nor density per plot were correlated with the number of sampling units per plot (Spearman rank correlation: $r = 0.21$, $P = 0.15$; $r = 0.22$, $P = 0.15$, respectively) showing that sampling effort as measured in wood sampling units was not the main driving force determining relative species richness and abundance per plot, and hence of the patterns found in this study.

Data collection

We sampled plots from May 2003 to Jun. 2005 taking care to evenly distribute sampling periods between river basins (and hence plot successional stage). We recorded all wood broader than 4.5 cm diameter and classified them as (1) living stems, (2) snags (dead standing stems and natural stumps), (3) logs (dead fallen stems) or (4) fallen branches (dead fallen branches and tops) (Table 1), as in Urcelay & Robledo (2004) and Heilmann-Clausen & Boddy (2008). Each stem of multi-stemmed *Polylepis* individuals was considered a separate sampling unit because the colonization strategies and development of the heart rot species in the present study are more associated with stems than individuals (Schwarze *et al.* 2000; GR pers. obs.). We registered the perimeter of all sampling units and the polypore species through the presence of fructifications (a group of one or several fruit bodies in the same sampling unit was considered a single species occurrence).

Specimen identification

Wood-decaying polypore fructifications were identified to species level in the field or collected and studied in the laboratory. Morphological features of basidiocarps were observed