

## Community structure of polypores (*Basidiomycota*) in Andean alder wood in Argentina: Functional groups among wood-decay fungi?

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**Abstract** The polypores (*Aphyllphorales* s.l., *Basidiomycota*) are very effective wood decayers. Different species differ in their capacity to decay wood; therefore, many functionally different species can be found decaying different substrate conditions (decay stages and log diameter). This study aimed to describe the structure of the wood-decay polypore communities that occur on different states of wood of the Andean alder (*Alnus acuminata*) within Argentina and to identify groups of polypore species that share the same substrate condition, and thus might have a similar functional role in the decay processes. We found 16 polypore species, among which *Trametes versicolor*, *Bjerkandera adusta* and *Trametes cubensis* were dominant species, showing the highest relative frequency in alder wood. Species richness was lower on trunks of living trees and higher on dead branches. Based on preferential occurrence on different wood conditions, a cluster analysis distinguished three groups, each of them containing one of the three dominant species. This corresponds to the situation of other groups of organisms, where each functional type consists of a dominant species that accounts for most of the 'function' and several subordinate species with similar functions. Albeit preliminary, our results provide a formal classification of wood-decay fungi into functional types.

**Key words:** *Aphyllphorales* s.l., dominance–diversity structure, functional-type approach, fungal ecology, neotropical mycology, substrate conditions, yungas.

### INTRODUCTION

Wood-inhabiting fungi release the carbon fixed during photosynthesis and stored in the form of cellulose, hemicellulose and lignin, and return other nutrients from the woody debris back to the soil (Alexopoulos *et al.* 1996). Within this group of fungi, the polypores (*Aphyllphorales* s.l., *Basidiomycota*) are the main wood decayers (Oberwinkler 1994). Different polypore species have distinct functional characteristics defined by their differential decay capacity in different wood substrate conditions (e.g. living stem, standing or fallen dead stem, dead log, branches of different diameters) with different physical and chemical properties (Rayner & Todd 1979). The polypore species that decay the wood of living trees are usually called parasites, and those species that decay the wood of dead trees or dead parts of living trees are called saprobes (Oberwinkler 1994). During the decay processes, the physical and chemical structure of the wood changes and therefore new species of polypores are likely to appear (Rayner & Todd 1979; Boddy 2001). At the level of the forest stand, changes in the diameter class and decay stage of the wood (substrate conditions) also

occur, not only during forest succession, but also under widespread forest exploitation or management (Siitonen *et al.* 2000; Shorohova & Shorohov 2001). Therefore, changes in the community structure of wood-decay fungi are expected (Siitonen *et al.* 2001; Snäll & Jonsson 2001). Because different species have distinct decay capabilities, these shifts in community composition can be associated with changes of certain functional traits (e.g. decay capabilities) that in turn can affect certain ecosystem processes (Chapin *et al.* 1997). Accordingly, alternative ways of classifying the living organisms, other than taxonomic classification, have been proposed – for example, by clustering groups of organisms with similar functions in relation to an ecosystem process (e.g. guilds among insects; Lavelle & Garnier 2001). Although polypore species have usually been considered as a unique functional entity (i.e. wood decayers), within them we can find many functionally different species that are found decaying different types and/or stages of the wood (Renvall 1995; Høiland & Bendiksen 1996). The functional-type approach has been used for organisms belonging to different trophic levels (Lavelle & Garnier 2001). Although wood-decay fungi have been divided traditionally according to the rot type (white and brown; Gilbertson 1980; Redhead & Ginns 1985), they have not been formally classified in terms of

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different capabilities to decay and to colonize different substrate conditions. The present study had two main objectives: (i) to describe the richness and abundance relationships of the wood-decay polypore communities that occur on different wood conditions of the Andean alder (*Alnus acuminata*, Betulaceae) in Argentina; and (ii) to identify groups of polypore species that share the same niche (substrate condition) and thus could have a similar functional role in decay processes.

## METHODS

### Substrate

The Andean alder is distributed from north-western Mexico to north-western Argentina (Furlow 1979). In Argentina, this species forms monospecific forests and is spread throughout the subtropical Mountain Forest called 'Yungas' (Amazonian Domain), in the Montane Forest district, between 1400 and 2100 m a.s.l. (Cabrera 1976). The southern distribution limit of this tree species is in the north of Catamarca province.

### Study area

Three sampling sites were established to reflect the Andean alder distribution in Argentina. The first site was located in Calilegua National Park, Ledesma Department, Jujuy province (23°41'S, 64°53'W, 1700 m a.s.l.). The second site was in Quebrada del Portugués, Tañi del Valle Department, Tucumán province (27°00'S, 65°45'W, 1900 m a.s.l.). The third site was at the southern distribution limit of the Andean alder, at Sierra de Narvárez (27°36'S, 65°55'W, 1800 m a.s.l.), Ambato Department, Catamarca province.

### Sampling methods

Each study site was sampled three times (9–12 November 1999, 14–17 February 2000 and 3–6 April 2000) from the beginning to the end of one rainy season, in order to cover the main seasonal variability of fruit body occurrence. In each study site, two sampling plots of 50 m × 50 m were established and the entire area of each plot was surveyed. We recorded all the polypore fruit bodies found in the plots. In order to avoid recording the same fruit body more than once, different sampling plots were surveyed on each sampling date. The complete surface of each log was carefully examined and all fruit bodies of polypores

were recorded, together with the log diameter and substrate conditions: living trunk (LT); cut stump (CS); dead trunk (DT); and dead branch (DB). DT and DB involved both standing or fallen logs or branches.

In the present study, we assumed there was a gradient in the diameter of the logs and a gradient in the level of decay, ranging from standing living trunks (less decayed) to dead trunks (more decayed). As the branches were all dead and usually had a small diameter, they were considered to be at one end of the gradient. The cut stumps were considered to be at an intermediate stage between standing living trunks and dead trunks.

The preference of each polypore species for a substrate type and quality was determined through the presence of the fruit body on the substrate, indicating that the vegetative mycelium was decaying wood there.

A floristic study, including taxonomic discussions, of the polypores decaying Andean alder wood has been published elsewhere (Robledo *et al.* 2003).

### Data analysis

The relative frequency of each polypore species was calculated as

$$Fr_x = n_x / Rt \quad (1),$$

where  $Fr_x$  = species relative frequency,  $n_x$  = number of occurrences of each polypore species and  $Rt$  = total number of occurrences of polypore species (across all sampling plots and dates).

The relative frequency of each polypore species in each substrate condition (LT, CS, DT and DB) was calculated as

$$Fr_{xi} = n_{xi} / Rt_x \quad (2),$$

where  $Fr_{xi}$  = relative frequency of each polypore species in substrate condition  $i$ ,  $n_{xi}$  = number of occurrences of polypore species  $x$  in substrate condition  $i$  and  $Rt_x$  = number of total occurrences of polypore species  $x$ .

The richness of polypore species in each substrate condition was also calculated.

We performed a cluster analysis to classify polypore species into groups in which the internal similarity decreases until the complete set of species is combined (Goodall 1980). This method is based on distances between species and combines the species computed from their relative frequency on different substrate conditions and the average log diameter for those on which they occurred (Table 1). The mean Euclidean distance was used as a measure of similarity between species and clustering was based on the average linkage method using the Infostat statistical package (Di Rienzo *et al.* 2001).

## RESULTS

In the present study, 175 fruit bodies from 16 species of polypores were encountered. *Trametes versicolor* had the highest total relative frequency (Table 1), followed by *Bjerkandera adusta* and *Trametes cubensis*.

Species richness was lowest on living trunks and highest on dead branches (Table 1). Based on the relative frequency of each species in the different log conditions and the mean diameter of the log on which the fruit bodies were found, the cluster analysis produced three main groups of polypore species when the dendrogram stems were cut at a distance of 1.2 (Fig. 1). In the first group, *T. cubensis*, *Ganoderma aff. adpersum* and *Phellinus gilvus* were characterized by the capability to decay standing living trunks and by showing their highest fruit body frequency in dead trunks with large diameter (Table 1). In the second group, *B. adusta* and *Lenzites betulina* were characterized by having the highest frequency on dead logs (mainly on cut stumps and dead branches) of intermediate diameter. *B. adusta* was also found on trunks of living standing trees albeit in a very low frequency. Finally, *Gloeoporus dichrous*, *Funalia gallica*, *Schizopora radula*, *Datronia mollis*, *Hexagonia papyracea*, *Jung-huhnica carneola*, *Perenniporia* sp., *Polyporus tricholoma*, *Pycnoporus sanguineus*, *Trametes villosa* and *T. versicolor* formed a group that was always found on decayed wood, mainly on dead branches. Within this group,

*S. radula*, *D. mollis*, *H. papyracea*, *J. carneola*, *Perenniporia* sp. and *P. tricholoma* formed a subgroup of species that occurred on branches with the lowest diameter values and were also the most rarely found species in this study. These clusters did not change when the mean log diameter was omitted from the analysis (data not shown). This could be because of the probable correlation between the gradient involved in log categories (from trunks to branches) and log diameter. Each of the three most dominant species, *T. versicolor*, *B. adusta* and *T. cubensis*, belonged to a different group.

These patterns of dominance and substrate preference were similar among the three sites. Species richness was also similar, although it was higher in Catamarca, followed by Jujuy and Tucumán with 10, 9 and 7 species, respectively.

## DISCUSSION

### Polypore community structure

The presence and abundance of the fruit bodies of any fungal species do not necessarily directly correlate to the vegetative mycelium biomass and activity. Nevertheless, it is a suitable approach to determine the community structure of wood-decay polypores at the

**Table 1.** Total relative frequency and number of polypores species in the substrate conditions and mean diameter of the logs where they were found

Species	Total relative frequency	Living trunk	Relative frequency			Mean substrate diameter (cm)
			Cut stump	Dead trunk	Dead branch	
Group 1						
<i>Ganoderma aff. adpersum</i>	0.040	0.29	0.14	0.57	0.00	49.1
<i>Trametes cubensis</i>	0.183	0.09	0.19	0.53	0.19	30.7
<i>Phellinus gilvus</i>	0.029	0.20	0.00	0.80	0.00	29.3
Group 2						
<i>Bjerkandera adusta</i>	0.200	0.03	0.31	0.23	0.43	13.8
<i>Lenzites betulina</i>	0.034	0.00	0.33	0.00	0.66	11.1
Group 3						
<i>Gloeoporus dichrous</i>	0.010	0.00	0.00	0.50	0.50	27.0
<i>Funalia gallica</i>	0.029	0.00	0.00	0.40	0.60	18.3
<i>Pycnoporus sanguineus</i>	0.034	0.00	0.17	0.00	0.83	14.1
<i>Trametes villosa</i>	0.034	0.00	0.00	0.33	0.66	15.5
<i>Trametes versicolor</i>	0.331	0.00	0.04	0.14	0.83	11.3
<i>Hexagonia papyracea</i>	0.006	0.00	0.00	0.00	1.00	5.7
<i>Polyporus tricholoma</i>	0.034	0.00	0.00	0.00	1.00	4.8
<i>Schizopora radula</i>	0.017	0.00	0.00	0.00	1.00	4.7
<i>Junghuhnina carneola</i>	0.006	0.00	0.00	0.00	1.00	3.2
<i>Perenniporia</i> sp.	0.006	0.00	0.00	0.00	1.00	2.6
<i>Datronia mollis</i>	0.006	0.00	0.00	0.00	1.00	1.9
No. species in each substrate condition		4	6	8	14	

Groups are indicated based on cluster analysis based on relative frequency of the species in each substrate condition and the mean diameter of the logs where they were found.

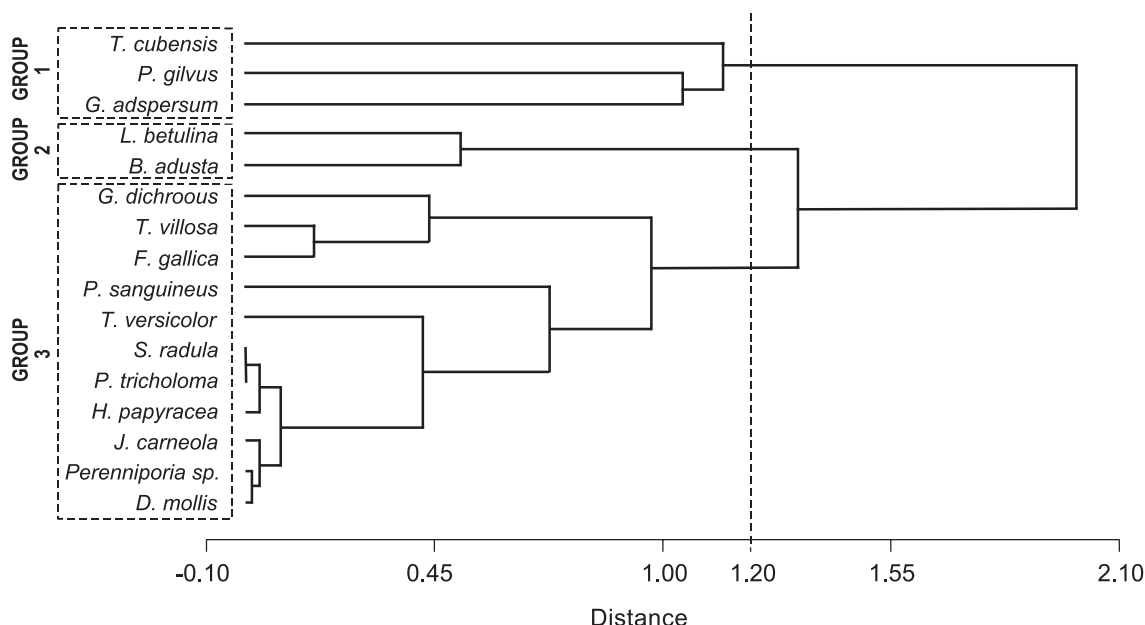
scale of this study (see Boddy 2001 for a discussion) and it is considered a reliable method when trying to assess polypore species abundance in natural communities (Renvall *et al.* 1991; Niemelä *et al.* 1995; Renvall 1995; Lindbland 1998).

The published information on the structure and dynamics of polypore communities in South America is very scarce. Our results offer a preliminary picture of a situation that cannot be generalized beyond the study region and host tree, but that involves many species that are widely distributed and have been found on different host species (Ryvarden 1978; Gilbertson & Ryvarden 1987). It is interesting that the distribution patterns detected in the polypore communities on the Andean alder are similar to those of other communities of organisms, in particular terrestrial plants. A dominance–diversity structure, in which most of the biomass of the community comes from a small number of very abundant species (dominants), whereas a large number of much less abundant species (subordinate and rare species) make up most of the species richness of the community, is typical of most terrestrial vegetation types (Whittaker 1965; Grime 1998). Moreover, it is widely accepted that dominant species, and in particular their functional traits, are most important in determining current magnitude, rate and direction of ecosystem processes, whereas subordinate and rare species play a minor role in present ecosystem dynamics (Grime 1998; Walker *et al.* 1999; Díaz & Cabido 2001). In our case, *T. versicolor* followed by *B. adusta* and *T. cubensis* were the dominant species, comprising 71% of the fruit bodies encountered. They probably account for most of the decay activity in the

woodlands under study. These data are consistent with other studies in Betulaceae woods, where *T. versicolor* and *B. adusta* are very abundant (Strid 1975). Furthermore, these two species are known to have a high decay capacity (Rayner & Todd 1979; Jones & Worrall 1995). Although there are no other available data regarding the abundance in natural communities and decay capacity of *T. cubensis*, our observations in the field and data from other species of the genus *Trametes* suggest this species might have a high importance in decay processes (Rayner & Todd 1979; Tanesaka *et al.* 1993; Jones & Worrall 1995). Whereas the relative frequency of *T. cubensis* and *B. adusta* fruit bodies peaked in dead trunks and cut stumps, respectively, *T. versicolor* showed the highest frequency on dead branches. The changes in relative composition and the positive relationship between species richness and decay stage of the logs have been reported previously for other communities in the northern hemisphere (Strid 1975; Niemelä *et al.* 1995; Renvall 1995).

#### Polypore functional types?

On the basis of the cluster analysis, we were able to identify three main groups of polypore species, according to their substrate preference. One group, *T. cubensis*, *P. gilvus* and *G. aff. adspersum*, are facultative parasites that can decay the wood of standing living trunks but reach their highest fruit body frequency on dead trunks. The second group, *B. adusta* and *L. betulina*, is characterized by having the highest frequency values in cut stumps and dead logs. The



**Fig. 1.** Cluster analysis of different polypores species decaying *Alnus acuminata* wood based on relative frequency of the species in each substrate condition and the mean diameter of the logs where they were found.

third group involves those species whose fruit bodies are always found on dead logs and especially on branches of intermediate to small diameter. Ferris *et al.* (2000) recognized three general groups among macro-fungi in a temperate woodland: saprobes in leaf litter; wood decomposers; and mycorrhizal fungi. Although we did not measure the functional traits of each of the wood-decay polypores studied, the preferential occurrence of those groups of species on different substrate conditions suggests different roles in Andean alder forest decay processes and perhaps also different responses to microenvironmental conditions. This can be used as a basis for distinguishing three polypore functional types (Gitay & Noble 1997). Interestingly, each of these groups contains one of the most abundant species in the community. Therefore, each group is characterized by a dominant species, with high decay capacity, that may be the main species responsible in the degradative processes in the substrate condition where it is found. This is in accordance with the ideas of Walker *et al.* (1999), who reported that, in the case of herbaceous plants, each functional group consists of a dominant species, which accounts for most of the 'function' at any given time, and several subordinate species with similar functions. Although the role of subordinate polypore species might be minor at present, they might be important for long-term resilience of wood-decay processes in the face of environmental variability, providing 'insurance' against changes that could negatively affect the dominant species (Grime 1998; Walker *et al.* 1999; Díaz & Cabido 2001).

The provision of ecosystem services is likely to be related to the distributions of species among guilds or functional groups that occupy different niches (Walker *et al.* 1999; e.g. wood of different parts of the trees, diameters and decay stages). Our data suggest that the polypore community composition and structure depend on the different substrate conditions present in the forest. Any changes in the availability of substrate conditions, as observed in current and widespread forest exploitation, could promote changes in the community structure and hence in the functional attributes linked to the species composition, which might in turn alter the ecosystem processes in which polypores are involved.

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## REFERENCES

- Alexopoulos C. J., Mims C. W., Blackwell M. (1996) *Introductory Mycology*. John Wiley & Sons, New York.
- Boddy L. (2001) Fungal community ecology and wood decomposition processes in angiosperms: from standing tree to complete decay of coarse woody debris. *Ecol. Bull.* **49**, 43–56.
- Cabrera A. L. (1976) Regiones fitogeográficas Argentinas. In: *Enciclopedia Argentina de Agricultura y Jardinería*, 2nd edn. Vol. 2 (1) (ed E.F. Ferreira Sobral) pp. 1–85. ACME, Buenos Aires.
- Chapin F. S. III, Schulze E.-D., Mooney H. A. (1997) Biodiversity and ecosystem processes. *Trends Ecol. Evol.* **7**, 107–8.
- Di Rienzo J. C., Robledo W., Casanoves F. *et al.* (2001) *Infostat*, Versión Beta. Estadística y Biometría, Facultad de Ciencias Agropecuarias, Universidad Nacional de Córdoba, Córdoba.
- Díaz S. & Cabido M. (2001) Vive la différence: plant functional diversity matters to ecosystem processes. *Trends Ecol. Evol.* **16**, 646–55.
- Ferris R., Peace A. J., Newton A. C. (2000) Macrofungal communities of lowland Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karsten) plantations in England: relationships with site factors and stand structure. *For. Ecol. Manage.* **131**, 255–67.
- Furrow J. J. (1979) The systematics of the american species of *Alnus*, Betulaceae. Part I. *Rhodora* **81**, 1–121.
- Gilbertson R. L. (1980) Wood-rotting fungi of North America. *Mycologia* **72**, 1–49.
- Gilbertson R. L. & Ryvarden L. (1987) *North American Polypores*, Vol. 1–2. Fungiflora, Oslo.
- Gitay H. & Noble I. R. (1997) What are plant functional types and how should we seek them? In: *Plant Functional Types* (eds T. M. Smith, H. H. Shugart & F. I. Woodward) pp. 3–19. Cambridge University Press, Cambridge.
- Goodall D. W. (1980) Numerical classification. In: *Classification of Plant Communities* (ed. R. H. Whittaker) pp. 247–86. Kluwer Academic Publishers Group, The Hague.
- Grime J. P. (1998) Benefits of plant diversity to ecosystems: immediate, filter and founder effects. *J. Ecol.* **86**, 902–10.
- Høiland K. & Bendiksen E. (1996) Biodiversity of wood-inhabiting fungi in boreal coniferous forest in Sor-Trondelag County, Central Norway. *Nord. J. Bot.* **16**, 643–59.
- Jones H. L. & Worrall J. J. (1995) Fungal biomass in decayed wood. *Mycologia* **87**, 459–66.
- Lavorel S. & Garnier E. (2001) Aardvarck to Zyzyxia – functional groups across kingdoms. *New Phytol.* **149**, 360–64.
- Lindblad I. (1998) Wood-inhabiting fungi on fallen logs of Norway spruce: relations to forest management and substrate quality. *Nord. J. Bot.* **18**, 243–55.
- Niemelä T., Renvall P., Penttillä R. (1995) Interactions of fungi at late stages of wood decomposition. *Ann. Bot. Fennici* **32**, 141–52.
- Oberwinkler F. (1994) Evolution of functional groups in Basidiomycetes (Fungi). In: *Biodiversity and Ecosystem Function* (eds E.-D. Schulze & H. A. Mooney) pp. 143–63. Springer-Verlag, Berlin.
- Rayner A. D. M. & Todd N. K. (1979) Population and community structure and dynamics of fungi in decaying wood. *Adv. Bot. Res.* **7**, 333–420.



- Redhead S. A. & Ginns J. H. (1985) A reappraisal of agaric associated with brown rots of wood. *Trans. Mycol. Soc. Japan* **26**, 349–81.
- Renvall P. (1995) Community structure and dynamics of wood-rooting *Basidiomycetes* on decomposing conifer trunks in northern Finland. *Karstenia* **35**, 1–51.
- Renvall P., Renvall T., Niemelä T. (1991) Basidiomycetes at the timberline in Lapland 2. An annotated checklist of the polypores of northeastern Finland. *Karstenia* **31**, 13–28.
- Robledo G., Urcelay C., Rajchenberg M., Dominguez L. (2003) Políporos (Aphylllophorales, Basidiomycota) parásitos y saprófitos de *Alnus acuminata* en el noroeste Argentino. *Bol. Soc. Argent. Bot.* **38**, 207–24.
- Ryvarden L. (1978) *Polyporaceae of North Europe*, Vol. 1–2. Fungiflora, Oslo.
- Shorohova E. V. & Shorohov A. A. (2001) Coarse woody debris dynamics and stores in a boreal virgin spruce forest. *Ecol. Bull.* **49**, 129–35.
- Siitonen J., Martikainen P., Punttila P., Rauh J. (2000) Coarse woody debris and stand characteristics in mature managed and old-growth boreal mesic forest in Southern Finland. *For. Ecol. Manage.* **128**, 211–25.
- Siitonen J., Penttilä R., Kotiranta H. (2001) Coarse woody debris polyporous fungi and saproxylic insects in an old-growth spruce forest in Vodlozero National Park, Russian Karelia. *Ecol. Bull.* **49**, 231–42.
- Snäll T. & Jonsson B. G. (2001) Edge effects on six polyporous fungi used as old-growth indicators in Swedish boreal forest. *Ecol. Bull.* **49**, 255–62.
- Strid Å. (1975) Wood-inhabiting fungi of alder forests in North-Central Scandinavia 1. *Aphylllophorales (Basidiomycetes)*. Taxonomy, ecology and distribution. *Wahlenbergia* **1**, 1–237.
- Tanesaka E., Masuda H., Kinugawa K. (1993) Wood degrading ability of Basidiomycetes that are wood decomposers, litter decomposers, or mycorrhizal symbionts. *Mycologia* **85**, 347–54.
- Walker B., Kinzig A., Langridge J. (1999) Plant attribute diversity, resilience, and ecosystem function: the nature and significance of dominant and minor species. *Ecosystems* **2**, 95–113.
- Whittaker R. H. (1965) Dominance and diversity in land plant communities. *Science* **147**, 250–60.