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Proyecto de grado presentado como parte de los requisitos para optar al título de Ingeniero Forestal y al grado de Magister en Áreas Silvestres y Conservación de la Naturaleza.

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1. RESUMEN

Los hongos son capaces de crecer formando redes de hifas en los distintos sustratos que colonizan. Los políporos son un grupo de hongos importante entre los hongos habitantes de madera, se caracterizan por presentar poros en la superficie de dispersión de esporas. La UICN ha clasificado hasta la fecha 280 hongos a nivel global, un número muy pequeño tomando en cuenta la cantidad de animales categorizados (73.507). Este grupo de hongos ha sido ampliamente estudiado a nivel global. Sin embargo, en el cono sur (Chile y Argentina) la información es escasa y no hay documentos compilatorios que integren esa información. Por ello, se recopiló toda la información disponible en publicaciones que registraran políporos, considerando los datos nomenclaturales, espaciales y ecológicos relacionados con la propagación, sobrevivencia y crecimiento. Además, se digitalizaron las localidades de cada especie para determinar los patrones de distribución en conjunto con la revisión de los hospederos para analizar la relación hongo-hospedero. Chile tiene 95 especies divididas en seis órdenes y 13 familias, principalmente Polyporales e Hymenochaetales, distribuidos desde los 30° S en el Parque Nacional Fray Jorge hasta los 54° S en el Parque Natural Karukinka. La mayor diversidad reside en los Bosques Deciduos, Esclerófilos y en climas cálidos. Una gran porción de especies tiene una relación especialista con su hospedero. Polyporales e Hymenochaetales están ampliamente distribuidas, pero Polyporales crece predominantemente en los bosques con mayores rangos de precipitación en comparación con Hymenochaetales. En conservación, los criterios para categorizar especies utilizan información del tamaño poblacional y distribución, pero datos de estas variables en políporos son escasos. Aun así, la sobrevivencia y persistencia de este grupo no está limitada a estos tópicos. La disponibilidad de hospederos, flujo de dispersión y disponibilidad de compatibilidad somática son indicadores útiles del estado de la población. La disponibilidad de hospederos asegura la permanencia y el crecimiento de las especies. El flujo de dispersión ayuda en la zonificación de los planes de conservación. La disponibilidad de compatibilidad somática es un indicador claro de una deficiente dispersión o un declive poblacional. Información ecológica adicional, como es el tipo o estado del sistema (bosques antiguos, jóvenes con o sin manejo silvicultural) mejorará la toma de decisiones en planes de conservación.

1.1 Palabras clave

Relación hospedero-hongo, condiciones climáticas, comunidad fúngica, indicadores

2. SUMMARY

Fungi grow by creating a network of hyphae in different colonized substrata. Poroid wood inhabiting fungi is an important group between wood inhabiting fungal species, this group has pores in the surface of sporomata. Currently, IUCN red-list has classified 343 fungal species at global level. However, this is a very small amount compared with the species of the kingdom Animalia with 76,457 classified species. Diversity and distribution of poroid wood inhabiting fungi are relatively well studied at continental scale. However, the information in Southern South America (Argentina and Chile) is scarce. Therefore, a compilation of the available information in this group has been done, including nomenclatural, geospatial and ecological data related with dispersal, growth, and survival. Furthermore, the information of both spatial data and the host-fungi interaction were analyzed to determine the distributional pattern and the host-fungi relationship. Chile has 95 species in six orders and 13 families, mainly Polyporales and Hymenochaetales, distributed from 30° S in Fray Jorge National Park to 54° S in Karukinka Natural Park. The biggest diversity resides in Deciduous Forest, Sclerophyll Forest and warm climates. A great portion of species has a specialist relationship with their host. Polyporales and Hymenochaetales species are broadly distributed, but Polyporales grow predominantly in the forest with higher precipitation range in comparison with Hymenochaetales. In conservation, categorization criteria essentially use population size and distribution information to assign a category, but information of wood inhabiting fungi about these variables is scarce. However, the fungal species survival and persistence are not limited to these topics. Host availability, dispersion flux and mating type availability are useful indicators of the population status. Host availability ensure the persistence and growth of fungal species, dispersion flux aid the management of conservation programs, and mating type availability is a clear indicator of a deficient dispersion of the species or a population decline. Additional ecological information like forest age (old grow forest, young forest) or the silvicultural management (with or without it) will improve the decision making in conservations programs.

2.1 Keywords

Host-fungi relationship, climatic conditions, fungal community, indicators

3. INTRODUCCIÓN

Los hongos son entes vivos diferentes a plantas o animales, capaces de alimentarse mediante la degradación de la materia orgánica. Su principal estructura es somática (no reproductiva) compuesta de células que se elongan llamadas hifas. Éstas son capaces de producir estructuras de reproducción sexual llamadas cuerpos fructíferos o esporomas (Alexopoulos et al., 1996). Estas estructuras reproductivas tienen diversas formas (Deacon, 2006), las más frecuentes son las callampas o champiñones, otras adoptan formas delgadas y alargadas, discoides, terraza, coral, jalea e incluso adoptan formas de reproducción microscópicas, siendo incapaces de ser vistos sin un microscopio (Webster and Weber, 2007).

Los hongos utilizan un sustrato determinado en tiempo y espacio, además son muy dependientes del ambiente para su desarrollo y reproducción. Estas condiciones pueden variar según la especie y sustrato en el cual crece, algunos de estos son: hojas, estiércol, madera; en general cualquier tipo de materia orgánica de origen vegetal y en menor proporción de tejido animal (Webster and Weber, 2007). La relación entre el hongo y su hospedero genera una variación en la abundancia y ocurrencia de los esporomas, que a su vez dependen de la disponibilidad de los recursos (Klepzig and Six, 2004, Lindahl and Olsson, 2004). Esta variación produce cambios en la propagación de las especies y por ende en la adecuación biológica de ellas.

En la actualidad, los hongos en sentido estricto son clasificados en el reino Fungi, una gran cantidad de ellos son de tamaño microscópico (Carlile et al., 2001). En el reino existen dos grandes grupos monofiléticos que contienen todos los macrohongos descritos, Basidiomycota y Ascomycota (Hibbett et al., 2007). Ascomycota es un grupo monofilético que incluye a la mayoría de los hongos liquenizables, además de presentar una gran diversidad de especies sin evidencia de reproducción sexual (Taylor et al., 2006). Basidiomycota, en cambio, tiene parte de su diversidad con tamaños microscópicos (Aime et al., 2006, Begerow et al., 2006) y una gran parte macroscópica (Hibbett, 2006). Parte de este último grupo presenta relaciones simbióticas, otra parte tiene una relación parásita y una mayoría es descomponedor de materia orgánica (Alexopoulos, 1996).

En el grupo de Basidiomycota se encuentran los políporos, los cuales son uno de los grupos morfológicos de mayor relevancia entre los hongos degradadores de la madera, están ubicados específicamente dentro del clado *Agaricomycotina,* el cual está dentro de Basidiomycota (Hibbett et al., 2015). Estos hongos se identifican porque presentan himenóforo poroide, es decir, la zona del esporoma donde las esporas son producidas está constituida por tubos que se visualizan externamente como poros, gran parte de las especies crecen en árboles (Alexopoulos et al., 1996). Es un grupo parafilético disgregado dentro del clado *Agaricomycetes* (Hibbett et al., 2015). Los políporos necesitan humedad y alimento para su desarrollo, estas condiciones están dadas generalmente en árboles maduros (Siitonen et al., 2000). En ellos degradan la madera, debilitándola lo suficiente para que otros organismos puedan aprovechar esta condición para instalarse, como por ejemplo los pájaros carpinteros (Conner et al., 1976). Hay variabilidad en cuanto a las condiciones necesarias para el crecimiento de cada especie, muchas de ellas están condicionadas crecer recurrentemente en ciertos hospederos (Zhou and Hyde, 2001). Esto tiene fuertes implicancias en la conservación de estas especies (Runnel et al., 2013).

En las últimas décadas, el conocimiento sobre la sistemática, diversidad, distribución y ecología de hongos ha aumentado, permitiendo tener una mayor claridad sobre su clasificación y relaciones evolutivas (Junninen and Komonen, 2011, Justo et al., 2017, Robledo et al., 2006). No obstante, aún existen muchos grupos con información insuficiente, ausencia de ella o trabajos de investigación en desarrollo (Justo et al., 2017). Diversas instituciones gubernamentales e investigadores en el mundo se dedican a investigar y conservar hongos, revisando los estados de conservación, generando nueva información o evidenciando los problemas de conservación de cada país (Allen and Lendemer, 2015, Dahlberg et al., 2010, Moore et al., 2001, Senn-Irlet et al., 2007).

A nivel mundial se encuentran clasificadas sólo 280 especies del reino *Fungi* en alguna categoría de conservación, número que al comparar con la cantidad de especies animales en alguna categoría de conservación (73.507) resulta sumamente minúsculo. A partir de estas 280 especies, 234 corresponden a *Basidiomycota* y 46 a *Ascomycota*, lo que implica que los hongos micorrícicos arbusculares y muchos otros clados se encuentran sin clasificar (IUCN, 2020). Todas las especies de *Basidiomycota* clasificadas son macrohongos, lo que deja a una gran cantidad de *taxa* de hongos sin clasificar, como carbones, royas y levaduras (Swann and Hibbett, 2007). Dentro de los hongos clasificados, siete son Políporos. Gran parte de las especies categorizadas están presentes en Europa o Norte América, en Europa existe una gran cantidad de países colaborando, de los cuales Suecia, Noruega, Finlandia y Austria son los principales. En cambio, Estados Unidos es el principal contribuidor para el caso de Norte América (IUCN, 2020).

Sudamérica presenta una variedad de ambientes y especies únicas en el mundo ((UNEP), 2016). Cada país del continente se dedica a la conservación de la naturaleza, priorizando los ecosistemas y especies singulares que estiman convenientes, como se puede observar en los proyectos actuales de *Global Wildlife Conservation* (GWC, 2018). También hay un aporte de información base de los libros rojos desde el 2000 (IUCN, 2018).

El Ministerio del Medio Ambiente es el encargado de revisar los procesos de categorización de especies amenazadas y generar el listado de especies en categoría de conservación en Chile ((MMA), 2020). Ellos registran 44 especies del reino *Fungi*, que se encuentran en alguna categoría de conservación, de estos sólo uno es políporo, categorizado en preocupación menor (MMA, 2020). En comparación con las especies de plantas ya categorizadas (594), se evidencia un bajo número de especies clasificadas en alguna categoría de conservación, lo cual está directamente relacionado con la falta de información y conocimiento de los hongos a nivel país.

En Chile se han realizado trabajos de historia natural que consideran hongos desde la época de los grandes historiadores naturales, Claudio Gay en su primer tomo del "Atlas de la historia física y política de Chile" (Gay, 1842) registra 42 hongos siendo 3 de estos polípor os. Existen registros de Spegazzini (1887) en la Isla de Tierra del Fuego, describiendo un total de 14 especies, mismo autor que posteriormente registró cuatro especies de polípor os chilenos (Spegazzini, 1910). Diez años más tarde, Espinosa (1917) contribuye con tres nuevas especies de Polípor os. En la década de los 80, Mujica y Vergara (1980) crean su última versión de un libro recopilatorio de hongos chilenos titulado "Flora Fungosa Chilena", en la que se registran 2.342 especies incluidas en 623 géneros, en los que se incluyen más de 87 especies de Polípor os, no obstante, una gran cantidad de estas especies son sinónimos, lo que no permite saber con precisión la cantidad de poliporos presentes en Chile.

En la actualidad, la información de la diversidad y estados de conservación de hongos chilenos es confusa e insuficiente. Por ejemplo, Furci (2013) registra cuatro polípor os con distribución en nuestro país, de los cuales tres estaban ya descritos por otros autores. Por su parte Sandoval-Leiva (2014) registra un nuevo polípor o. Lazo (2016) incorpora 3 especies al registro de este grupo en Chile. La mayoría de estos registros son puntuales y la distribución asociada a ellos resulta imprecisa, clasificando a la mayoría de las especies en "Chile Austral" o "Chile Central". Esto da cuenta de la falta de información y lo disgregada de la misma y no permite establecer con certeza un recuento global de la diversidad actual de hongos chilenos, lo que ha generado un déficit de información para la toma de decisiones y en realizar las acciones concretas de conservación de polípor os y hongos en general.

Este trabajo sistematiza la diversidad biológica, los patrones de distribución y propone indicadores que ayudan a la gestión de planes de conservación que incluyan a polípor os en Chile.

Por medio de una revisión exhaustiva de la información presente, listando las especies, evaluando los criterios para la categorización de éstas (IUCN, 2012) y analizando la información ecológica relevante que ayude a la conservación de estos organismos no considerada por estos criterios.

4. PUBLICACIONES ÍNTEGRAS

4.1 Diversity and distributional pattern of poroid wood inhabiting fungi: the case study of Chile

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4.1.1 Abstract

Diversity and distribution of Poroid Wood Inhabiting Fungi are relatively well studied at continental scale. However, the information in Southern South America (Argentina and Chile) is scarce and scattered, only Argentina has enough compiled data on these topics. This group has different kind of association with their plant host species, some fungal species depends on the host species and others are associated with multiple hosts, and at the same time its availability is related with the climatic conditions. Thus, information about the host-fungi relationship and climatic conditions of this group is relevant to understand their distributional pattern. Chile has 95 species in six orders and 13 families, mainly Polyporales and Hymenochaetales and distributed from 30° S in Fray Jorge National Park to 56° S in Cabo de Hornos. The biggest diversity resides in Deciduous Forest, Sclerophyll Forest and it is associated with warm climates. A great portion of species has a specialist relationship with their host. However, most of the species recorded in articles and books have a generalist relationship with it and are frequently associated with Angiosperm host rather than Gymnosperm hosts. Polyporales and Hymenochaetales species are broadly distributed, but Polyporales grow predominantly in forests with higher precipitation range in comparison with Hymenochaetales. The distributional pattern of this group of species is not only influenced by climatic variables but also by their host distribution as well.

4.1.2Keywords

Host-fungi relationship, climatic conditions, ecology, Southern South America

4.1.3 INTRODUCTION

Poroid wood inhabiting fungi (PWIF) is one of the most relevant morphological decay group of species among wood inhabiting fungi (Hibbett et al. 2014), with multiple uses in medicine (Gill and Rieder 2008; Muszyńska et al. 2018), gastronomy (Arnolds 1995) and biotechnology (Harper et al. 1988). They grow along the forest gradient of succession (Junninen et al. 2006) with higher diversity associated with larger log size (Bader et al. 1995). Forest systems and the vegetational formations are strongly influenced by climatic conditions (Biurrun et al. 2019). These conditions influence the forest dynamics and create a mosaic of situations within the landscape, with different combinations of even-aged, multi-aged, young or mature stands (Veblen et al. 1981). Likewise, PWIF distribution is strongly influenced by its climatic conditions worldwide (Ryvarden 1991). Furthermore, fungal community changes along the gradients of succession in forest and forest composition (Heilmann-Clausen et al. 2014; Junninen et al. 2006; Olou et al. 2019).

PWIF have different kind of association with other organisms, e.g. Red-cockaded Woodpecker (*Picoides borealis* Vieillot) selects pines rotted by *Fomes pini* (Brot.) P. Karst. when they nest (Conner et al. 1976). Furthermore, some species of insects colonize and eat fruit bodies of PWIF, e.g. *Dorcatoma* or *Cis* species (Jonsell et al. 1999). Host-fungi relationships has been categorized as a specialist relationship when their association is frequent or specific with the host plant (Gilbert et al. 2002; Iqbal et al. 2017; Zhou and Hyde 2001) and as a generalist relationship when their association is not specific with few hosts, but a broad variety of them (Edman et al. 2004; Nordén et al. 2013). These relationships limit fungal distribution in host specialist associations to the distribution of their host. Information about host-fungi relationship of PWIF species has been recorded in different ecosystems at community level, in which the inherent characteristics of the forest systems and vegetational formations (dead wood availability, abundance of logs or log size) change the diversity and composition of PWIF species (Bader et al. 1995; Berglund et al. 2011; Küffer and Senn-Irlet 2005; Lindblad 2001). Thus, not only the host-fungi relationship is relevant to understand the diversity of this group, but the composition and the structure of their hosts as well.

Recently, evolutive relationships between PWIF taxa (Amalfi et al. 2014; Drechsler-Santos et al. 2016; Gottlieb et al. 2002; Ji et al. 2017; Larsson et al. 2006; Parmasto 2014) and ecological relationships in different landscapes (Burcham et al. 2015; Gilbert et al. 2008; Iqbal et al. 2017; Krah et al. 2018; Nogueira-Melo et al. 2017; Purahong et al. 2017; Zhou and Hyde 2001) has been done. Diversity and distribution of PWIF at continental scale is relatively well known (Gilbertson and Ryvarden 1986; Gilbertson and Ryvarden 1987; Ryvarden 1991; Ryvarden 2000; Ryvarden 2004; Ryvarden and Guzmán 2001; Ryvarden and Iturriaga 2003; Ryvarden and Melo 2017). However, in Southern South America (Argentina and Chile) there is not a compiling document of diversity and distribution, only in Argentina there are publications on this group (Rajchenberg 2006; Rajchenberg and Robledo 2013). Chile has a broad variety of ecosystems (Martínez-Tilleria et al. 2017) with high biodiversity (Myers et al. 2000) but PWIF diversity information is scarce, with few documents and records of this group (Espinosa 1921; Furci 2018; Gay 1852; Lazo 2016; Mujica and Vergara 1980; Spegazzini 1887; Spegazzini 1910).

The objective of this study is to determine the distributional patterns of PWIF to understand the diversity in different ecosystems. we reviewed all published records of PWIF from Chile, checking the current nomenclatural state, then analyze the host-fungi relationship at order and family level and analyze the climatic and host effect on the diversity at landscape scale through vegetational formations.

4.1.4 METHODOLOGY

4.1.4.1 Reviewed data

The species records were extracted from books of fungi of Chile (Fontaine 2017; Furci 2018; Lazo 2016; Mujica and Vergara 1980) and a full review in journals associated with biology, taxonomy or ecology of fungal organisms (e.g. Mycological Progress, Revista Chilena de Historia Natural, Mycotaxon, Gayana Botanica, Forest Pathology and others). We compiled taxonomic, host and locality information, such as order, family, genus, species, host species, locality or coordinates where the PWIF species was found.

Scientific names were reviewed and updated from Mycobank and IndexFungorum databases (https://www.mycobank.org and http://www.indexfungorum.org respectively). To ensure a correct update of the scientific name, both databases needed to coincide. When names differed in both databases, the original description was reviewed and compared with the species recorded in Chile. The Host names were recorded and corroborated with the Catalogue of the vascular plants of Chile (Rodriguez et al. 2018) and the Catalogue of the vascular plants of the Southern Cone of South America (Zuloaga et al. 2019) for native hosts, and Tropicos (http://www.tropicos.org) were used for alien hosts. Localities without coordinates were georeferenced with GeoNames Chilean locality information (GeoNames 2019).

4.1.4.2 Spatial analysis

Every georeferenced record was digitalized using R Project software (R-CoreTeam 2020). Raster package (Hijmans 2019) and sp package (Pebesma and Bivand 2005) were used in the spatial analysis and QGiS program (QGIS-DevelopmentTeam 2019) for map edition and digitalization.

Chilean vegetational formations data (Luebert and Pliscoff 2018) was used to analyze the host species effect and Köppen-Geiger climatic classification (Beck et al. 2018) for climatic effect on PWIF species. Both effects were analyzed at landscape scale because a great portion of the data was compiled at different localities with a possible high distance error and just a minority of it was collected through coordinates, this error impede the analysis at community scale.

A point layer of the PWIF species with taxonomic information included was constructed based on the localities and coordinates. These points were intersected with the vegetational formations and the climatic spatial data. The final layer contains the taxonomic information of the PWIF species with hosts clades, vegetational formations and Köppen-Geiger climatic classification. This information was used to analyze the climatic and host effect on the diversity at landscape scale.

The maps were constructed with the reclassification of the final point layer with family information of each species over the surface of Chile. The distribution of the whole group was constructed to show the general geographic pattern. Then, a map of the families with a wide geographical distribution and a map with the rest of the families were created to analyze specific geographic patterns separately.

4.1.4.3 Generalist and specialist relationships

All species with host records were classified as specialist or generalist. Additionally, Gymnosperms and Angiosperms hosts were counted separately. Generalist or specialist relationship depends on the number of hosts, but the threshold between them is not clear. PWIF species with only one host record indicates a specialist relationship (Lindblad 2000). However, some species have specific associations even when three host are recorded (Gilbert et al. 2008). Therefore, a specialist relationship was considered when the number of hosts is less or equal to three, and four or more was considered as a generalist relationship.

Specialists PWIF relationships could result from subsampling with insufficient records, leading to type I errors. To avoid it, a hypothesis contrast was performed between the number of hosts recorded and the number of citations. Additionally, the host relationship (generalist or specialist) and the number of citations per fungal species were analyzed to verify if they were related (Fig. 2). Emmeans package (Lenth 2019) was used for hypothesis contrast and ggplot2 package (Wickham 2016) for the graph elaboration.

4.1.5 RESULTS

A total of 95 species were found in six orders and 13 families. Polyporales and Hymenochaetales have 92% of the species diversity, distributed in 66 (69%) and 22 (23%) species respectively. The other seven species (8%) are found in Gloeophyllales, Russulales, Agaricales y Trechisporales (**Appendice 1**). However, only 83 species have coordinates or locality information (**Tabla 1**).

The vegetational formations with the highest proportion of PWIF species are Deciduous Forest (DF), Sclerophyll Forest (SF), Evergreen Forest (EF), and Laurifolio Forest (LF). The families with the highest number of species across vegetational formations are Polyporaceae, Fomitopsidaceae, Ganodermataceae, and Hymenochaetaceae. Rickenellaceae (Hymenochaetales) do not have records of vegetational formations, because the localities associated with this family are found in Juan Fernández Archipelago and this place is not classified with any vegetational formation, and Hydnodontaceae (Trechisporales) do not have localities recorded other than “founded in Chile”, thus this family is not classified with any vegetational formation or climate. The climatic categories with the highest number of species are “Temperate, dry summer, warm summer” (Csb) and “Temperate, no dry season, warm summer” (Cfb). Both categories have species from almost every family with a big proportion of Polyporaceae and Hymenochaetaceae species.

Chilean PWIF distribution ranges from 30° S in Fray Jorge National Park to 56° S in Cabo de Hornos, Juan Fernández Archipelago and Alejandro Selkirk island included (**Fig 1 a**). The greatest diversity is located between 32° S and 34° S in Región de Valparaíso with 32 species. Central Chile has 57.5% of the records between 36.4° S in Región del Biobío to 43.6° S in Región de Los Lagos. Polyporales and Hymenochaetales have a wide distribution in Chile (**Fig 1 b**), contrary to Agaricales, Gloeophyllales and Russulales, which have a narrow distribution from 36.4° S to 43.6° S (**Fig 1 c).** Most of the species are found in forests while the minority in cities.

Table 1. The effect of climate and vegetational formation on diversity of PWIF. Species column counts the number of PWIF species with coordinates or locality. Next columns have the number of species per vegetational formation (Luebert and Pliscoff 2018) and Köppen-Geiger climate classification (Beck et al. 2018). DF = Deciduous Forest, SF= Sclerophyll Forest, SpF= Spiny Forest, LF= Laurifolio Forest, RF= Resinous Forest, EF= Evergreen Forest, SG= Steppes and Grassland, DS= Deciduous Scrub, DeS= Desert Scrub, P= Peat. Cfb=Temperate, no dry season, warm summer; Cfc=Temperate, no dry season, cold summer; Csa=Temperate, dry summer, hot summer; Csb=Temperate, dry summer, warm summer; ET=Polar, tundra; Dsc=Cold, dry summer, cold summer; BSk=Arid, steppe, cold; BWk=Arid, desert, cold.

Order	Family	Species	Vegetational Formations										Köppen-Geiger classification							
			DF	RF	SpF	SF	DS	LF	EF	P	SG	DeS	Cfb	Cfc	Csa	Csb	ET	Dsc	BSk	BWk
Polyporales	Polyporaceae	24	10	1	5	5	0	8	7	1	1	1	10	0	4	15	8	0	1	1
	Fomitopsidaceae	11	5	0	1	1	0	3	4	2	2	0	5	2	0	5	3	0	2	0
	Ganodermataceae	8	2	3	2	5	1	3	7	0	1	2	8	3	2	4	1	0	1	2
	Meripilaceae	2	1	0	0	0	0	1	0	0	0	0	1	0	0	2	0	0	0	0
	Meruliaceae	10	3	2	1	2	0	2	2	0	1	0	6	0	1	5	0	0	1	0
	Phanerochaetaceae	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Hymenochaetales	Hymenochaetaceae	17	6	2	5	12	0	4	6	0	0	2	5	3	4	15	2	0	1	1
	Rickenellaceae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Schizoporaceae	3	0	0	0	3	0	0	0	0	1	0	0	0	0	3	0	0	1	0
Gloeophyllales	Gloeophyllaceae	2	1	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Russulales	Bondarzewiaceae	1	1	1	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0
Agaricales	Fistulinaceae	2	2	1	0	1	0	0	1	1	1	0	2	0	0	2	1	1	1	0
Total		83	30	10	14	31	1	22	28	4	7	5	38	8	11	58	15	1	8	4

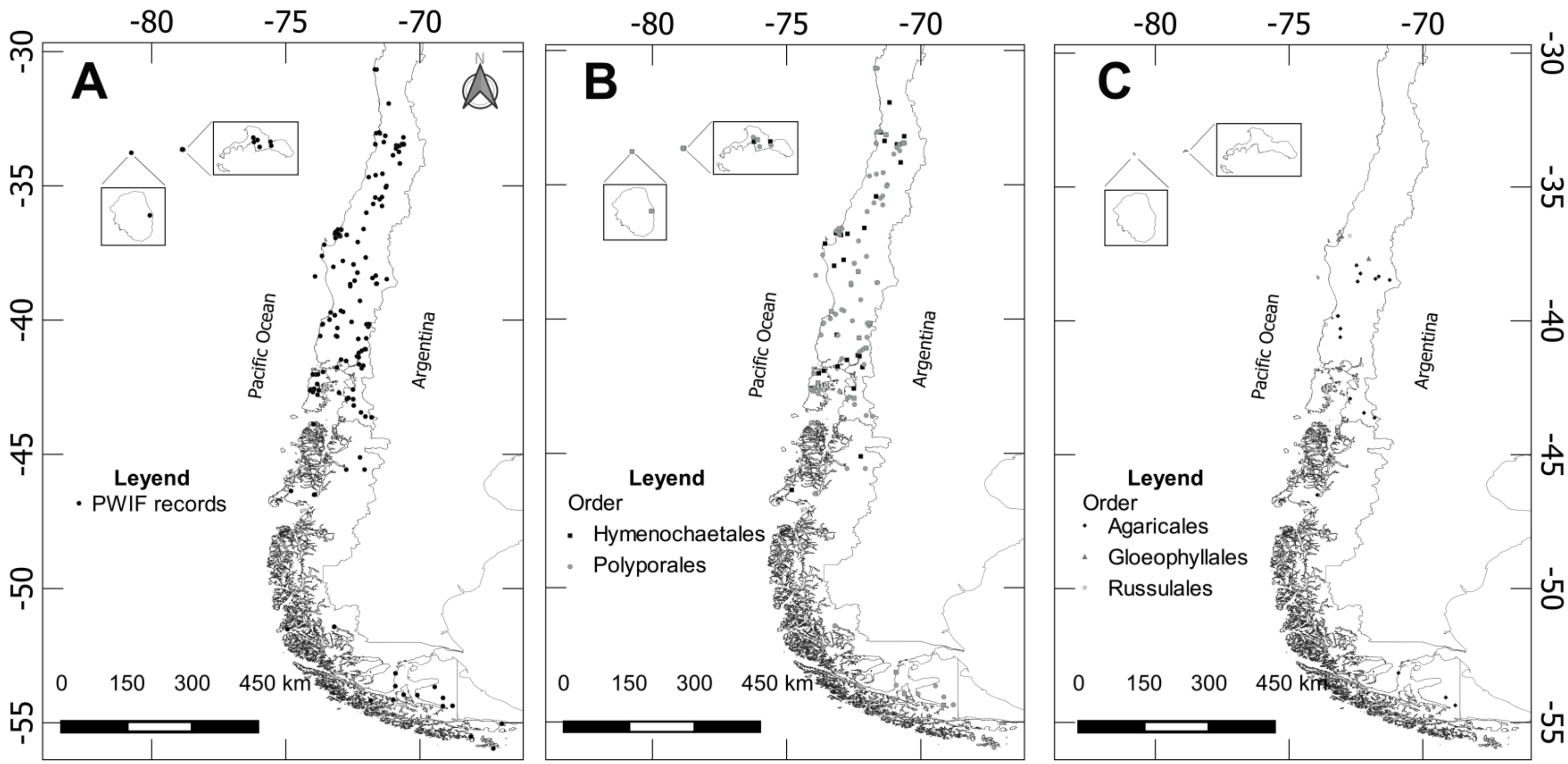

Figure 1. Chilean poroid wood inhabiting fungi distribution. (a) PWIF distribution along Chile, (b) Distribution poroid Polyporales and Hymenochaetales in Chile. (c) Distribution of poroid Agaricales, Gloeophyllales and Russulales in Chile.

Only 54 of the 95 PWIF species have host records (**Tabla 2**). Polyporales tend to have more generalist species, unlike Hymenochaetales that proportionally have more specialist species. Ganodermataceae is a generalist family. However, Polyporaceae, Fomitopsidaceae, Meruliaceae, and Hymenochaetaceae have a limited number of generalist species, but most of them are specialist proportionally. Other families only have few host records, because of the lack of information. Chilean PWIF species with more host species are *Ganoderma lipsiense* (Batsch) G.F. Atk (11), *Trametes versicolor* (L.) Lloyd (9), *Bjerkandera adusta* (Willd.) P. Karst. (9), *Ganoderma austral* (Fr.) Pat. (8), *Fomitiporella Americana* Y.C. Dai, X.H. Ji & Vlasák (9), *Ganoderma applanatum* (Pers.) Pat. (8), *Fistulina hepatica* (Schaeff.) With. (7) and *Fuscoporia senex* (Nees & Mont.) Ghobad-Nejhad (5) (**Appendices 2**,**3**)

The contrast analysis between numbers of host species recorded and the number of citations per species have significative differences (p-value <0.0001), therefore, specialist species described above might be classified as generalist if further research is done (**Fig 2**).

Table 2. Number of generalist and specialist species by order and family.

Order	Family	Generalist	Specialist
Polyporales	Polyporaceae	1	12
	Fomitopsidaceae	1	6
	Ganodermataceae	3	1
	Meripilaceae	0	3
	Meruliaceae	1	2
Hymenochaetales	Hymenochaetaceae	2	14
	Schizoporaceae	0	2
Gloeophyllales	Gloeophyllaceae	0	3
Russulales	Bondarzewiaceae	0	1
Agaricales	Fistulinaceae	2	0
Total		10	44

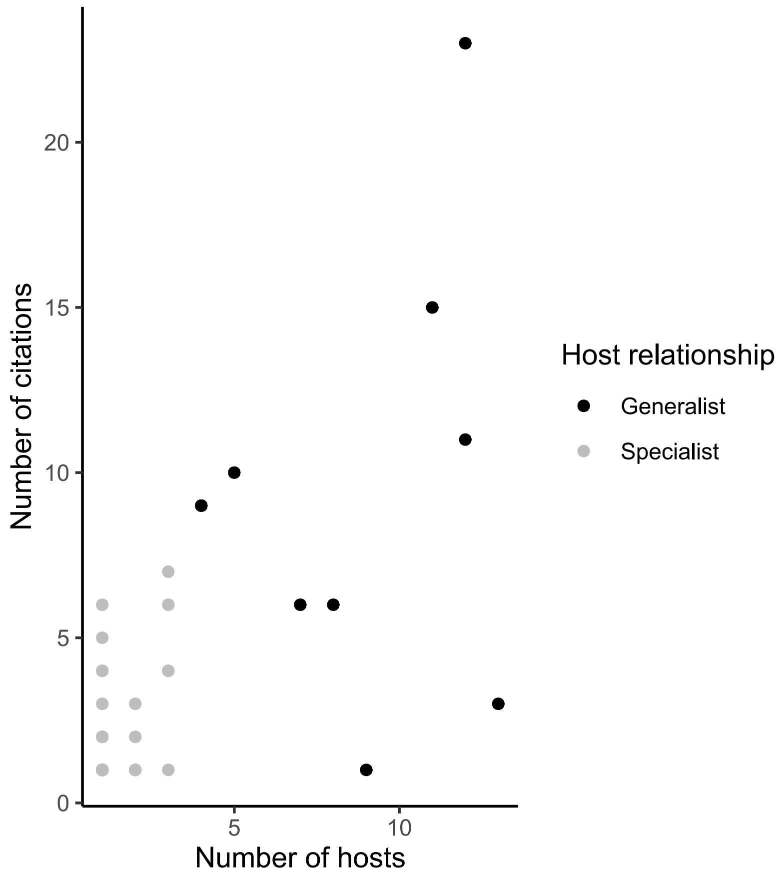

Figure 2. Number of citations per host. Black points are generalist species and grey points are specialists. Host relationships and number of citations have significant differences (p-value <0.0001).

4.1.6 DISCUSSION

Globally, PWIF species have a wide distribution (Ryvarden 1991). Regarding Chile, their distribution is wide as well because Hymenochaetales and Polyporales ranges along the distribution of the whole group. However, Hymenochaetales species grow predominantly in sclerophyllous ecosystems (SF) with reduced precipitation range (Armesto et al. 2007), and Polyporales species grow predominantly in deciduous (DF) and temperate forests (LF & EF) with higher precipitation amount than sclerophyll forest (SF) (Veblen 2007). According to the only two published records, Gloeophyllales has a narrow distribution, but this pattern might be wider under further research. *Fistulina* (Agaricales) and *Bondarzewia guaitecasensis* (Henn.) J.E. Wright (Rusulales) are narrowly distributed as well, the thin wall of these species (Rajchenberg 2006) may lead them to environmental sensitivity and are not able to endure a high range of climatic factors. However, the number of occurrences is insufficient to guarantee a clear distributional pattern.

The host-fungi relationship of Polyporales has more generalist species than other orders. Although, most of the families of this order have specialists and generalist species. A great portion of Chilean PWIF are specialist. However, most of the species recorded in articles and books belong to the generalist group, because generalist species are more frequent founded than the specialist group, and species with a specialist relationship are climate sensitive (Kassen 2002; Nordén et al. 2013), therefore less frequently founded. PWIF species are more frequently associated with Angiosperm than Gymnosperm hosts because Angiosperms host are widely distributed and has more species proportionally (Rodriguez et al. 2018). The number of PWIF species are scarce, thus protection of communities with Gymnosperm species should have priority.

Species with a higher number of hosts also have a higher amount of citations, therefore species classified as generalist cannot have type I error. But specialist group has a reduced number of citations that is significant different, then this relationship may be poorly sampled.

The climatic pattern shows that high diversity exists in warmer conditions, then PWIF species are temperature dependent. Temperature varies latitudinally and altitudinally (Hunter et al. 1993), therefore, the expected accumulation of species should be in the lower and northern zones of the distribution. However, the accumulation of species ranges from the northern to the central zones of it, where the different forest systems are located. The distributional pattern of PWIF is not only influenced by climatic variables but also by their host distribution as well.

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4.2 **Conservation management of wood inhabiting fungi: insights and indicators**

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4.2.1 Abstract

The Kingdom of fungi is one of the least studied area for conservation management, with 2.2 million estimated species, but only 280 of them classified in the Union for Conservation of Nature Red List of Threatened species. In conservation, categorization criteria essentially use population size and distribution information to assign a category, but information of wood inhabiting fungi about these variables is scarce. However, the fungal species survival and persistence are not limited to these variables. Host availability, dispersion flux and mating type availability are useful indicators of the population state. Host availability ensures the persistence and growth of fungal species, dispersion flux helps in conservation management plans, and mating type availability is a clear indicator of a deficient dispersion of the population or its decline. Additional information on the state of the habitat like old grow forest, young forest with or without silvicultural management will improve the decision making in conservation programs.

4.2.2 Keywords

Fungal community, fungal-host relationship, categorized fungal species, wood fungi dispersal dynamics, wood decaying fungi

4.2.3 Introduction

Fungal organisms are species reproduced by spores that thrive in different substrata (Alexopoulos et al. 1996). They discharge enzymes into the environment, digesting molecules from large to small that can be absorbed and used to grow their mycelia (McConnaughey 2014). These organisms have different association with plants, such as mycorrhizal symbiosis, endophytic symbiosis, saprophytic and parasitic relationship (Lewis 1973; Lee et al. 1995). The fungal organism needs organic matter to grow, this limits the fungal life cycle to a short time growth and reproduction (Webster 1970). Ecosystems with abundant organic matter contain a rich diversity of fungal species (Lindahl & Olsson 2004). Therefore, variation in the amount of organic matter would affect the diversity, reproduction, and growth of fungal species. The global diversity of the kingdom of fungi is believed to be between 2.2 to 3.8 million species, but only about 100,000 species are described (Hawksworth & Lucking 2017).

Poroid Wood Inhabiting Fungi (PWIF) is an important ecological group of species from agaricomycetes (Hibbett et al. 2014). Some sporomata of this group are used as medicine, food or to extract biosynthetic compounds (Harper et al. 1988; Arnolds 1995; Gill & Rieder 2008; Muszyńska et al. 2018). WIF grows rotting the wood of their hosts (Tanesaka et al. 1993) and releases nutrients to the environment (Lonsdale et al. 2008). They can interact with organisms of different taxa as hosts (Jonsell et al. 1999) or facilitators (Conner et al. 1976).

Globally, different institutions and researchers work in the life conservation field, reviewing the conservation status of endangered species and ecosystems, solving conservation problems or increasing and improving the existent data (Moore et al. 2001; Senn-Irlet et al. 2007; Dahlberg et al. 2010; Allen & Lendemer 2015). The International Union for Conservation of Nature (IUCN) through the IUCN Global Species Programme and IUCN Species Survival Commission, has evaluated the conservation status of many species in the last 50 years (IUCN 2018).

Currently, 280 species of the kingdom Fungi in six continents are mostly threatened, 234 species belong to Basidiomycota and 46 to Ascomycota. Europe and North America have most of the species classified with 138 and 113 species respectively, Asia has 85 species. Australia, South America, and Africa have 65,15 and 9 species respectively (**Table 3**). However, this is a very small amount compared to the species of the kingdom Animalia with 73,507 classified species or even kingdom Plantae with 38,630 species (IUCN 2020). This lack of information on the vulnerability status of fungal species may cause wrong decision making in conservation programs.

Table 3. Categorized fungal and wood inhabiting fungal species by continent (IUCN 2020).

Continent	Fungal species	Wood Inhabiting fungi species
Asia	85	26
Europe	138	27
North America	113	18
Australia	66	20
South America	15	1
Africa	9	1

4.2.4 Categorization criteria

Each species evaluated with the IUCN Red List criterion fulfills one or more conditions to ensure a correct categorization with the existent information. Mostly population or geographical variables are needed to categorize each species, such as population size, extent of occurrence or area of occupancy, population size of mature individuals or quantitative analysis showing the probability of extinction (IUCN 2012). Geographical and population variables are widely used in plants and animal species (Franklin & DeBell 1988; Miotto et al. 2007; Sérgio et al. 2007; Pedrono et al. 2009; Jiménez-Alfaro et al. 2012). Population size of fungal species is often used as a theoretical variable in genetical population patterns (Clayton & Hudelson 1991; Carbone & Kohn 2004), but practical examples of this variable are rare and often used with others covariables, e.g. density of genets of *Suillus bovinus* (L.) Roussel with forest age as a covariate (Dahlberg & Stenlid 1994). Thus, species categorized with 'population size' criterion or 'population size of mature individuals' criterion are usually estimated from the relationship between fungal species, their ecosystem and the current status of the ecosystem itself. However, geographical information of fungal species recorded in different institutions (e.g. GBIF, https://www.gbif.org), herbariums around the world (Thiers 2016), and articles is not enough to analyze these variables.

Fungal species have different ecological relationships, some fungi have close association with their host, such as endophytic or mycorrhizal fungi (Curtis 1939; Bever 2002; Otero et al. 2002; Hart et al. 2003; Rasmussen & Rasmussen 2007; Fang 2013). Therefore, an indirect estimation of the fungal species distribution is possible with this kind of relationship, through analysis of the distributional pattern of their host plant. The association of saprophytic and parasitic fungi is different from a mutualistic relationship. These species live in soil organic matter or organic matter from hosts plants (Leonowicz et al. 1999; Banerjee et al. 2016) and they are not necessarily dependent of one host or substrate (Nordén et al. 2013).

The WIF group has a wide range of relationships with their host, for example, Trametes versicolor (L.) Lloyd or Ganoderma australe (Fr.) Pat. are widely spread in different countries and host (Kaliyaperumal & Kalaichelvan 2008; Moncalvo & Buchanan 2008; Zmitrovich et al. 2012), but others species like Phellinus ralunensis are narrowly distributed with fewer hosts (Adaskaveg et al. 1991). Additionally, the population size of mature individuals is relatively easy to measure when we focus on species with persistent sporomata, because this kind of fruiting body is visible along the year and the limited extension of the hyphal system inside the wood. This condition ensures that different sporomata from different host are not the same individual (Stokland & Ylisirniö 2004), this fact might be seen obvious, but there are fungal species where one individual can grow in large areas with different hosts individuals, such as *Armillaria* species (Legrand et al. 1996). Better population size estimations are made with repetition of the surveys over time (Abrego et al. 2016).

Every variable previously mentioned is related to geospatial locations or population size. Thus, a generalized situation across different species can be deduced. But for the same reason, these variables do not reveal the inherent survival necessities of every group of species. WIF life cycle is the same as other saprophytic or parasitic fungal species: The spore germinates and grows on a host plant after their deposition, creating a hyphal net or mycelia inside a living plant when the species is parasitic or dead log when saprophytic. Then this net grows looking for another hyphal net of the same species and opposing mating type, both mycelia combine through plasmogamy, later, a sporome will develop for spore dispersal (Alexopoulos et al. 1996). However, sometimes different species develop an anamorphic sporome, a fruit body with half of the genes needed for the common dikaryotic fruit body. This anamorphic structure will spread asexual spores with the same genetic material of the parent mycelium (Ruisi et al. 2007).

4.2.5 Host availability

Complex ecosystems are composed by many highly interconnected dynamical units (Boccaletti et al. 2006). These units need to be studied as a whole, because the relevance of every species will depend on their level of connection (Estrada 2007). High species diversity and complex ecosystems have a high number of interactions and are sustained by a complex net with a high number of connections (Jordano et al. 2006). In this complexity, seed dispersers interact with pollinators, rotting agents and other species (Bascompte et al. 2006; Ovaskainen et al. 2016).

When a conservation management plan is focused on species and not in ecosystems (Arnolds 1995), knowledge about intrinsic ecological properties of the species is necessary, e.g. interaction of specialist/generalist WIF species with a fragmented forest (Nordén et al. 2013). How fungal-host associations assemble is relevant whenever conservation programs aim at the protection of fungal species of different successional states (Junninen et al. 2006), since certain plant-fungi associations are linked to old-growth forests (Ódor et al. 2006).

Host availability is a direct way to consider the dependence of WIF with species from the complex ecosystem. This dependence varies depending on the species (Zhou & Hyde 2001). However, from a conservation management perspective, a complex system with high diversity is more relevant.

4.2.6 Dispersion flux

Spores travels through the wind on most of the fungal species (Alexopoulos & Mims 1979). In this way WIF species can colonize new environments (Jönsson et al. 2008), but the distance traveled with effective colonization could reach a few hundreds of meters at the most (Nordén et al. 2008; Norros et al. 2012; Rieux et al. 2014), affecting rare or red-listed species with reduced viability in fragmented ecosystems (Stenlid & Gustafsson 2001). The species composition of WIF and plants will be highly related in the ecosystem, because most of the fungal species that depends on their host will colonize and disperse with it (Révay & Gönczöl 1990). In ecosystems with high diversity this pattern may change to different group of species, e.g. Fomitopsis rosea (Alb. & Schwein.) P. Karst., a red-listed species that is only recorded in highly diverse environments (Edman et al. 2004). Even after a forest fire, the species can re-colonize that habitat in a short period, but its composition can vary depending on the intrinsic nutritional strategies of the fungal species (Olsson 2008).

In conservation, dispersion flux aids the creation of different protected zones in an integrated program, this indicator could easily be combined with a fragmentation analysis for other species. However, it is necessary to be concerned about rare or red-listed species with ecological restrictions (Stenlid & Gustafsson 2001).

4.2.7 Mating type availability

Although is rare, sometimes WIF species cannot find their opposing mating type to carry out plasmogamy, producing an anamorphic sporomata, e.g. *Inonotus rickii* (Pat.) D.A. Reid (Barnard 1993). This kind of sporome appears when harsh environmental conditions are met (Ruisi et al. 2007) and will spread spores with the same genetic information over the landscape. When the mycelium inside the plant species is going through environmental stress and cannot find another mycelium of the opposite mating type to combine both mycelia through the plasmogamy process, the organism invests its energy in an anamorphic sporome to disperse its spores and hopefully reach better conditions. The WIF species with anamorphic sporomata are indicators of two important things in conservation, a reduced population size and a possible reduction in future genetic diversity (McDonald et al. 1993; Schnieder et al. 2001).

4.2.8 Habitat loss

The fragmentation and the loss of the habitat reduce the biodiversity of different systems (Brooks et al. 2002; Krauss et al. 2010). The availability of habitat affects the abundance and diversity of WIF as well (Kouki et al. 2001). Better conditions for WIF are found in less patchy forest ecosystems with less edge effect (Snäll & Jonsson 2001). However, the diversity of WIF increases when the forest has gaps with medium and large log diameter, in addition with enough coarse woody debris (Brazee et al. 2014). These conditions are frequent in old-growth forest, from a successional perspective, when a given forest increases the density of trees with large dimensions, the number of gaps and coarse woody debris increase as well (Siitonen et al. 2000). But old growth forest is not the only relevant successional stage for WIF, different communities of this group of species grows along the gradient of succession (Junninen et al. 2006). Lindblad (1998) and Edman et al. (2004) denote that red-listed species appear when old-growth forest conditions exist, although old-growth forests are disappearing around the world (Lindenmayer et al. 2012, 2018). This suggests the hypothesis that red-listed WIF species are threatened because they grow in the forest with late-successional stage (Bader et al. 1995).

The forest is continuously losing its cover by 5 million hectares globally each year (Curtis et al. 2018). The boreal and tropical forest are the main zones of cover loss (Hansen et al. 2009) and the reduction continues nowadays (Rossi 2019; Seymour & Harris 2019; Svensson et al. 2019).

This disappearance in habitat represent a latent danger for complex ecosystems, thus conservation management must consider the current and future land use and its risks.

4.2.9 Wood inhabiting fungi management

Generally, a great portion of the work in conservation management of WIF focuses on the species diversity (Berglund et al. 2005; Heilmann-Clausen & Christensen 2005; Ódor et al. 2006; Bässler et al. 2012; Hattori et al. 2012) and red-listed species (Heilmann-Clausen & Christensen 2005; Bässler et al. 2012; Magnusson et al. 2014). Furthermore, the forest where WIF species grow is clearly identified. However, this information alone is not enough to make effective conservation planning on landscapes (Dahlberg et al. 2010), then a management with interactions between species and their environment is required, e.g. analysis at community level (Halme et al. 2013; Abrego et al. 2015), interaction between fungal species and its substrata (Abrego & Salcedo 2013; Juutilainen et al. 2014; Runnel & Lõhmus 2017) and successional dynamics related to a specific community (Müller et al. 2007; Josefsson et al. 2010).

WIF species grows on a variety of hosts, some of them have specific relationships with a limited number of hosts as specialist or a broad variety as generalist (Zhou & Hyde 2001). These fungal-host relationships are essential whenever a conservation plan is created, because communities with a high proportion of specialist relationship will need a long-term host availability. Furthermore, conservation management plans should include the environmental condition of the fungal community, e.g. old grow forest, young forest with or without silvicultural management (Müller et al. 2007; Josefsson et al. 2010). Future conservations plans should consider these environmental conditions and fungal-host relationship to ensure their survival and persistence.

The management of WIF at community level in each system is complex. It requires specific knowledge about the ecological conditions of different species (Juutilainen et al. 2014). Therefore, the WIF conservation management program must consider the structure of complex ecosystems (Tylianakis et al. 2010), where fungal species with animals, plants and other organisms interact (Conner et al. 1976; Jonsell et al. 1999; Kirker et al. 2012). The incorporation of ecological indicators such as host availability, dispersion flux, and mating type availability (**Tabla 4**) are necessary to reach a better and integrated conservation management.

Tabla 4. Wood inhabiting fungi conservation management indicators

Indicator	Justification	Criteria

Host availability	Host availability ensure the persistence and growth of the group of fungal species in the community over time.	Presence of the host plant and their regeneration.
Dispersion flux	This indicator is relevant whenever a conservation plan requires a coverture reduction on the habitat without isolated patches.	Presence of sporomata from the same lineage between different patches.
Mating type availability	Mating type availability indicates the current isolated condition of a population. Is useful in the diagnosis of the system whenever a species with anamorphic sporomata is included.	Strong presence or predominance of anamorphic sporomata.

In conclusion, population size, the extent of occurrence or area of occupancy are useful variables for a general idea of the conditions of WIF species, if specific information is added, such as host availability, colonization patterns, and species assemblage, the decision making will be more accurate. Complex ecosystems need a complete conservation program, not focused on single species programs only. To ensure an effective WIF conservation, the incorporation of biological and ecological criteria in the decision making is needed

4.2.10 References

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5. DISCUSIÓN

Los políporos se concentran a lo largo de Chile central, llegando hasta el inicio de Chile austral o el sur de Chile en la Región de Los Lagos. Sin embargo, la cantidad de Áreas Protegidas disminuyen hacia el norte de su distribución, especialmente en la Región Metropolitana (Rovira et al., 2008). Esto refuerza la urgencia de generar zonas de conservación en la zona central (Pliscoff y Fuentes, 2008). Esta insuficiencia de áreas protegidas se debe a su costo y al cambio de los usos de suelo históricos que han llevado a la transformación del paisaje natural (Aguayo et al., 2009).

Los sitios con prioridad de ser conservados y que al mismo tiempo cuentan con una mayor diversidad de políporos son el bosque esclerófilo y el bosque deciduo. Además, si en estos bosques, las condiciones ambientales son de clima templado, con verano seco y cálido, entonces este bosque presenta la mayor prioridad a la hora de crear un área protegida que incluya estos hongos. Ya sea la creación de un área protegida que incluya este grupo o un programa que intente zonificar los políporos en un área ya establecida, resultaría conveniente utilizar los indicadores de: disponibilidad de hospedero, flujo de dispersión y disponibilidad de compatibilidad somática (mating type en inglés). Esta planificación debe ir acompañada del conocimiento previo de que especies de políporos y de plantas se encuentran en el lugar. Ya que gran parte de este grupo de hongos forma relaciones especialistas con sus hospederos.

En los casos donde la planificación del sitio de conservación tenga recursos limitados y no pueda hacer un censo de hongos o políporos en toda el área, será recomendable priorizar zonas de bosques antiguos con una alta cantidad de restos de madera gruesa (Juutilainen et al., 2014; Siitonen et al., 2000). No obstante, conservar y mantener zonas con la mayor cantidad de etapas sucesionales también es importante, ya que hay especies que predominan en las diferentes fases (Junninen et al., 2006). El análisis de los indicadores de flujo de dispersión y disponibilidad de compatibilidad somática en escenarios de recursos limitados es un poco diferente. Las distancias estándares de dispersión de políporos con establecimiento y futura reproducción rondan los 100 metros sin problemas (Edman, Kruys y Jonsson, 2004; Nordén y Larsson, 2000; Norros et al., 2012), llegando a alcanzar unos pocos cientos de metros. Esta distancia adicional varía dependiendo de la especie, y por lo tanto, resulta recomendable mantener la menor distancia y/o conexión posible entre parches. La disponibilidad de compatibilidad somática requiere de una medición directa utilizando el esporoma del hongo, los métodos indirectos útiles en este caso requieren de hacer trampas de esporas en el ambiente para su posterior análisis y revisión

(Banchi et al., 2018). Este método indirecto resulta entonces igual o más costoso que la medición directa, porque necesita de equipo especializado. Tomando esto en consideración, la medición de esta variable es bastante demandante de recursos y plantea desafíos metodológicos. No obstante, la cantidad de especies que pueden producir esporomas anamórficos es reducida, por lo que es necesario cerciorarse de que las especies presentes en el sistema puedan reproducirse de esta manera antes de medir esta variable.

6. CONCLUSIONES

La diversidad de los políporos chilenos se concentra en la zona central y en el inicio de la zona austral, siendo más diversos en bosques esclerófilos y deciduos con clima templado, verano seco y cálido. Es prioritario incluir a este grupo de hongos en los planes de conservación de las áreas protegidas, considerando los indicadores de disponibilidad de hospedero, flujo de dispersión y disponibilidad del signo sexual. Las áreas protegidas que cuenten con recursos limitados y no puedan financiar un censo de hongos, se les recomienda priorizar bosques antiguos con alta cantidad de restos de madera gruesa, no obstante, todas las etapas sucesionales son importantes para este grupo. Esto se debe a que la mayor parte de los políporos se relacionan con una baja cantidad de hospederos. El flujo de dispersión se puede medir de manera indirecta, considerando una distancia entre parches optima de hasta 100 metros, alcanzando unos pocos cientos de metros. No es recomendable medir la disponibilidad del signo sexual en condiciones de recursos limitados, ya que la manera indirecta es igual o más costosa que la manera directa.

La conservación de políporos y de hongos en general es un gran desafío, ya que requiere no solo de más dinero, sino que de especialistas en hongos capacitados para tomar decisiones de conservación concretas y realistas. En tiempos donde ambos son escasos y las transformaciones del paisaje como el cambio de uso de suelo y cambio climático siguen avanzando, resulta urgente mejorar los criterios para la toma de estas decisiones. Asimismo, incrementar investigación en esta área que permita tomar decisiones resulta ser de gran importancia.

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8. APÉNDICES

Apéndice 1 Listado de Políporos Chile

Orden	Familia	Nombre científico
Polyporales	Polyporaceae	*Aurantiporus albidus*
Polyporales	Polyporaceae	*Bresadolia uda*
Polyporales	Polyporaceae	*Cerioporus squamosus*
Polyporales	Polyporaceae	*Cerioporus varius*
Polyporales	Polyporaceae	*Fomes fasciatus*
Polyporales	Polyporaceae	*Fomes fomentarius*
Polyporales	Polyporaceae	*Perenniporia medulla-panis*
Polyporales	Polyporaceae	*Polyporus albus*
Polyporales	Polyporaceae	*Polyporus arenarius*
Polyporales	Polyporaceae	*Polyporus cycliscus*
Polyporales	Polyporaceae	*Polyporus dictyopus*
Polyporales	Polyporaceae	*Polyporus enteroleucus*
Polyporales	Polyporaceae	*Polyporus fuegianus*
Polyporales	Polyporaceae	*Polyporus gayanus*
Polyporales	Polyporaceae	*Polyporus limbatus*
Polyporales	Polyporaceae	*Polyporus picipes*
Polyporales	Polyporaceae	*Pycnoporus cinnabarinus*
Polyporales	Polyporaceae	*Pycnoporus sanguineus*
Polyporales	Polyporaceae	*Ryvardenia cretacea*
Polyporales	Polyporaceae	*Spongipellis chubutensis*
Polyporales	Polyporaceae	*Trametes albidorosea*
Polyporales	Polyporaceae	*Trametes hirsuta*
Polyporales	Polyporaceae	*Trametes leptaula*
Polyporales	Polyporaceae	*Trametes ochracea*
Polyporales	Polyporaceae	*Trametes polyzona*
Polyporales	Polyporaceae	*Trametes pubescens*
Polyporales	Polyporaceae	*Trametes versicolor*
Polyporales	Polyporaceae	*Trametopsis cervina*
Polyporales	Polyporaceae	*Trichaptum sector*
Polyporales	Fomitopsidaceae	*Amyloporia sinuosa*
Polyporales	Fomitopsidaceae	*Antrodia xantha*
Polyporales	Fomitopsidaceae	*Fomitopsis betulina*
Polyporales	Fomitopsidaceae	*Fomitopsis officinalis*
Polyporales	Fomitopsidaceae	*Grifola sordulenta*
Polyporales	Fomitopsidaceae	*Ischnoderma benzoinum*

Apéndice 1. Continuación

Orden	**Familia**	**Nombre científico**
Polyporales	Fomitopsidaceae	*Laetiporus sulphureus*
Polyporales	Fomitopsidaceae	*Oligoporus dissectus*
Polyporales	Fomitopsidaceae	*Oligoporus pelliculosus*
Polyporales	Fomitopsidaceae	*Postia caesia*
Polyporales	Fomitopsidaceae	*Postia punctata*
Polyporales	Fomitopsidaceae	*Ranadivia modesta*
Polyporales	Fomitopsidaceae	*Rhodonia placenta*
Polyporales	Fomitopsidaceae	*Rubellofomes minutisporus*
Polyporales	Fomitopsidaceae	*Spongiporus floriformis*
Polyporales	Ganodermataceae	*Ganoderma adspersum*
Polyporales	Ganodermataceae	*Ganoderma applanatum*
Polyporales	Ganodermataceae	*Ganoderma australe*
Polyporales	Ganodermataceae	*Ganoderma brownii*
Polyporales	Ganodermataceae	*Ganoderma chilense*
Polyporales	Ganodermataceae	*Ganoderma lipsiense*
Polyporales	Ganodermataceae	*Ganoderma lobatum*
Polyporales	Ganodermataceae	*Ganoderma tornatum*
Polyporales	Meripilaceae	*Meripilus giganteus*
Polyporales	Meripilaceae	*Rigidoporus microporus*
Polyporales	Meruliaceae	*Abortiporus biennis*
Polyporales	Meruliaceae	*Bjerkandera adusta*
Polyporales	Meruliaceae	*Bjerkandera fumosa*
Polyporales	Meruliaceae	*Ceriporia purpurea*
Polyporales	Meruliaceae	*Ceriporia violacea*
Polyporales	Meruliaceae	*Ceriporiopsis subvermispora*
Polyporales	Meruliaceae	*Flaviporus brownii*
Polyporales	Meruliaceae	*Irpex lacteus*
Polyporales	Meruliaceae	*Obba valdiviana*
Polyporales	Meruliaceae	*Steccherinum meridionale*
Polyporales	Meruliaceae	*Vitreoporus dichrous*
Polyporales	Phanerochaetaceae	*Chaetoporus tabacinus*
Polyporales	Phanerochaetaceae	*Junghuhnia nitida*
Hymenochaetales	Hymenochaetaceae	*Arambarria cognata*
Hymenochaetales	Hymenochaetaceae	*Coltricia perennis*
Hymenochaetales	Hymenochaetaceae	*Fomitiporella americana*
Hymenochaetales	Hymenochaetaceae	*Fomitiporia chilensis*
Hymenochaetales	Hymenochaetaceae	*Fulvifomes inermis*
Hymenochaetales	Hymenochaetaceae	*Fulvifomes merrillii*

Apendice 1. Continuación

Orden	Familia	Nombre científico
Hymenochaetales	Hymenochaetaceae	*Fuscoporia senex*
Hymenochaetales	Hymenochaetaceae	*Inonotus patouillardii*
Hymenochaetales	Hymenochaetaceae	*Inonotus tabacinus*
Hymenochaetales	Hymenochaetaceae	*Nothophellinus andinopatagonicus*
Hymenochaetales	Hymenochaetaceae	*Phellinus adamantinus*
Hymenochaetales	Hymenochaetaceae	*Phellinus ferruginosa*
Hymenochaetales	Hymenochaetaceae	*Phellinus igniarius*
Hymenochaetales	Hymenochaetaceae	*Phellinus ralunensis*
Hymenochaetales	Hymenochaetaceae	*Phellinus rimosus*
Hymenochaetales	Hymenochaetaceae	*Phylloporia boldo*
Hymenochaetales	Hymenochaetaceae	*Pseudoinonotus crustosus*
Hymenochaetales	Rickenellaceae	*Sidera vulgaris*
Hymenochaetales	Schizoporaceae	*Echinoporia aculeifera*
Hymenochaetales	Schizoporaceae	*Oxyporus latemarginatus*
Hymenochaetales	Schizoporaceae	*Schizopora paradoxa*
Gloeophyllales	Gloeophyllaceae	*Gloeophyllum abietinum*
Gloeophyllales	Gloeophyllaceae	*Gloeophyllum protractum*
Gloeophyllales	Gloeophyllaceae	*Gloeophyllum trabeum*
Agaricales	Fistulinaceae	*Fistulina antarctica*
Agaricales	Fistulinaceae	*Fistulina hepatica*
Russulales	Bondarzewiaceae	*Bondarzewia guaitecasensis*
Trechisporales	Hydnodontaceae	*Trechispora mollusca*

Apéndice 2. Número de hospederos por especie

Orden	Familia	Especies	TH	AH	GH	Asociación
Polyporales	Polyporaceae	*Trametes versicolor (L.) Lloyd,*	12	9	3	Generalista
		Fomes fomentarius (L.) Fr.	3	3	0	Especialista
		Polyporus gayanus Lév.	3	3	0	Especialista
		Polyporus P. Micheli ex Adans.	3	3	0	Especialista
		Spongipellis chubutensis J.E. Wright & J.R. Deschamps	2	1	1	Especialista
		Trametes leptaula Speg.	1	1	0	Especialista
		Polyporus dictyopus Mont.	1	1	0	Especialista
		Fomes fasciatus (Sw.) Cooke	1	1	0	Especialista
		Polyporus albus (Huds.) Fr.	1	1	0	Especialista
		Trametes albidorosea E. Bommer & M. Rousseau	1	1	0	Especialista
		Pycnoporus cinnabarinus (Jacq.) P. Karst.	1	1	0	Especialista
		Bresadolia uda (Jungh.) Audet	1	1	0	Especialista
		Perenniporia medulla-panis (Jacq.) Donk	1	1	0	Especialista
	Fomitopsidaceae	*Amyloporia sinuosa (Fr.) Rajchenb.*	4	4	0	Generalista
		Oligoporus pelliculosus (Berk.) Ryvarden	2	2	0	Especialista
		Rubellofomes minutisporus (Rajchenb.) B.K. Cui	2	2	0	Especialista
		Laetiporus sulphureus (Bull.) Murrill	1	1	0	Especialista
		Fomitopsis betulina (Bull.) B.K. Cui	1	1	0	Especialista
		Postia punctata Rajchenb. & P.K. Buchanan	1	1	0	Especialista
		Antrodia xantha (Fr.) Ryvarden	1	0	1	Especialista
	Ganodermataceae	*Ganoderma lipsiense (Batsch) G.F. Atk.*	13	13	0	Generalista
		Ganoderma australe (Fr.) Pat.	11	11	0	Generalista
		Ganoderma applanatum (Pers.) Pat.	8	8	0	Generalista
		Ganoderma lobatum (Schwein.) G.F. Atk.	1	1	0	Especialista
	Meripilaceae	*Rigidoporus microporus (Sw.) Overeem*	3	3	0	Especialista
	Meruliaceae	*Bjerkandera adusta (Willd.) P. Karst.*	12	11	1	Generalista
		Ceriporiopsis subvermispora (Pilát) Gilb. & Ryvarden	1	1	0	Especialista
		Irpex lacteus (Fr.) Fr.	1	1	0	Especialista

Apendice 2. Continuación

Orden	Familia	Especies	TH	AH	GH	Asociación
Hymenochaetales	Hymenochaetaceae	*Fomitiporella americana Y.C. Dai, X.H. Ji & Vlasák*	9	8	1	Generalista
		Fuscoporia senex (Nees & Mont.) Ghobad-Nejhad	5	4	1	Generalista
		Fomitiporia chilensis Rajchenb. & Pildain	3	3	0	Especialista
		Fulvifomes inermis (Ellis & Everh.) Y.C. Dai	2	2	0	Especialista
		Arambarria cognata (Bres.) Rajchenb. & Pildain	2	2	0	Especialista
		Phellinus rhabarbarinus (Berk.) G. Cunn.	1	1	0	Especialista
		Phellinus ferruginosus (Schrad.) Pat.	1	1	0	Especialista
		Phellinus ralunensis Adask., Gilb. & Blanchette	1	1	0	Especialista
		Phellinus adamantinus (Berk.) Ryvarden	1	1	0	Especialista
		Pseudoinonotus crustosus (Speg.) Rajchenb. & Pildain	1	1	0	Especialista
		Inonotus tabacinus (Mont.) G. Cunn.	1	1	0	Especialista
		Phellinus Quél.	1	1	0	Especialista
		Phylloporia boldo Rajchenb. & Pildain	1	1	0	Especialista
		Phellinus igniarius (L.) Quél.	1	1	0	Especialista
		Inonotus patouillardii (Rick) Imazeki	1	1	0	Especialista
		Fomitiporella Murrill	1	1	0	Especialista
	Schizoporaceae	*Echinoporia aculeifera (Berk. & M.A. Curtis) Ryvarden*	1	1	0	Especialista
		Schizopora paradoxa (Schrad.) Donk	1	1	0	Especialista
Gloeophyllales	Gloeophyllaceae	*Gloeophyllum abietinum (Bull.) P. Karst.*	1	0	1	Especialista
		Gloeophyllum protractum (Fr.) Imazeki	1	0	1	Especialista
		Gloeophyllum P. Karst.	1	1	0	Especialista
Russulales	Bondarzewiaceae	*Bondarzewia guaitecasensis (Henn.) J.E. Wright*	1	1	0	Especialista
Agaricales	Fistulinaceae	*Fistulina hepatica (Schaeff.) With.*	7	6	1	Generalista
		Fistulina antarctica Speg.	4	4	0	Generalista

Apéndice 3. Listado de hospederos por Políporo

Nombre científico	Hospederos	Nombre científico	Hospederos
Ganoderma lipsiense	*Laureliopsis philippiana*	*Bjerkandera adusta*	*Eucryphia cordifolia*
Ganoderma lipsiense	*Persea lingue*	*Bjerkandera adusta*	*Nothofagus dombeyi*
Ganoderma lipsiense	*Cornus mas*	*Bjerkandera adusta*	*Eucaliptus nitens*
Ganoderma lipsiense	*Populus nigra L. var. italica*	*Bjerkandera adusta*	*Liquidambar styraciflua*
Ganoderma lipsiense	*Nothofagus nitida*	*Bjerkandera adusta*	*Fraxinus excelsior*
Ganoderma lipsiense	*Acer negundo*	*Bjerkandera adusta*	*Beilschmiedia miersii*
Ganoderma lipsiense	*Prunus persica*	*Bjerkandera adusta*	*Nothofagus obliqua*
Ganoderma lipsiense	*Salix babylonica*	*Bjerkandera adusta*	*Laurelia serpenvirens*
Ganoderma lipsiense	*Robinia pseudoacacia*	*Bjerkandera adusta*	*Gevuina avelana*
Ganoderma lipsiense	*Eucryphia cordifolia*	*Bjerkandera adusta*	*Fitzroya cupressoides*
Ganoderma lipsiense	*Quercus*	*Bjerkandera adusta*	*Persea lingue*
Ganoderma lipsiense	*Pyrus communis*	*Bjerkandera adusta*	*Nothofagus obliqua*
Ganoderma lipsiense	*Laurelia sempervirens*	*Ganoderma australe*	*Eucryphia cordifolia*
Trametes versicolor	*Nothofagus dombeyi*	*Ganoderma australe*	*Eucaliptus nitens*
Trametes versicolor	*Araucaria araucana*	*Ganoderma australe*	*Prunus armeniaca*
Trametes versicolor	*Persea lingue*	*Ganoderma australe*	*Robinia pseudoacacia*
Trametes versicolor	*Beilschmiedia miersii*	*Ganoderma australe*	*Nothofagus obliqua*
Trametes versicolor	*Aextoxicon punctatum*	*Ganoderma australe*	*Cryptocarya alba*
Trametes versicolor	*Fitzroya cupressoides*	*Ganoderma australe*	*Persea lingue*
Trametes versicolor	*Pinus radiata*	*Ganoderma australe*	*Aextoxicon punctatum*
Trametes versicolor	*Saxegothaea conspicua*	*Ganoderma australe*	*Aristotelia chilensis*
Trametes versicolor	*Nothofagus*	*Ganoderma australe*	*Myrceugenia fernandeziana*
Trametes versicolor	*Eucaliptus nitens*	*Ganoderma australe*	*Nothofagus*
Trametes versicolor	*Aristotelia chilensis*	*Fomitiporella americana*	*Cryptocarya alba*
Trametes versicolor	*Nothofagus antarctica*	*Fomitiporella americana*	*Aextoxicon punctatum*

Apendice 3. Continuación

Nombre científico	Hospederos	Nombre científico	Hospederos
Fomitiporella americana	*Salix*	*Fuscoporia senex*	*Nothofagus dombeyi*
Fomitiporella americana	*Peumus boldus*	*Fuscoporia senex*	*Myrceugenia fernandeziana*
Fomitiporella americana	*Luma apiculata*	*Amyloporia sinuosa*	*Persea lingue*
Fomitiporella americana	*Nothofagus nitida*	*Amyloporia sinuosa*	*Fuchsia magellanica*
Fomitiporella americana	*Austrocedrus chilensis*	*Amyloporia sinuosa*	*Berberis ilicifolia*
Fomitiporella americana	*Eucryphia cordifolia*	*Amyloporia sinuosa*	*Nothofagus*
Fomitiporella americana	*Tepualia stipularis*	*Fistulina antarctica*	*Nothofagus pumilio*
Ganoderma applanatum	*Eucryphia cordifolia*	*Fistulina antarctica*	*Nothofagus antarctica*
Ganoderma applanatum	*Nothofagus dombeyi*	*Fistulina antarctica*	*Nothofagus*
Ganoderma applanatum	*Nothofagus obliqua*	*Fistulina antarctica*	*Nothofagus betuloides*
Ganoderma applanatum	*Laurelia sempervirens*	*Fomes fomentarius*	*Nothofagus antarctica*
Ganoderma applanatum	*Laureliopsis philippiana*	*Fomes fomentarius*	*Nothofagus betuloides*
Ganoderma applanatum	*Drimys winteri*	*Fomes fomentarius*	*Malus domestica*
Ganoderma applanatum	*Myrceugenia planipes*	*Polyporus gayanus*	*Nothofagus obliqua*
Ganoderma applanatum	*Nothofagus*	*Polyporus gayanus*	*Nothofagus pumilio*
Fistulina hepatica	*Podocarpus nubigenus*	*Polyporus gayanus*	*Nothofagus dombeyi*
Fistulina hepatica	*Nothofagus obliqua*	*Polyporus*	*Nothofagus dombeyi*
Fistulina hepatica	*Nothofagus dombeyi*	*Polyporus*	*Mespilus germanica*
Fistulina hepatica	*Nothofagus alpina*	*Polyporus*	*Salix babylonica*
Fistulina hepatica	*Nothofagus pumilio*	*Rigidoporus microporus*	*Rhaphithamnus*
Fistulina hepatica	*Nothofagus nitida*	*Rigidoporus microporus*	*Drimys*
Fistulina hepatica	*Weinmannia trichosperma*	*Rigidoporus microporus*	*Myrceugenia fernandeziana*
Fuscoporia senex	*Saxegothaea conspicua*	*Fomitiporia chilensis*	*Cryptocarya alba*
Fuscoporia senex	*Myrceugenia*	*Fomitiporia chilensis*	*Lithraea caustica*
Fuscoporia senex	*Blepharocalyx cruckshanksii*	*Fomitiporia chilensis*	*Peumus boldus*

Apéndice 3. continuación

Nombre científico	Hospederos	Nombre científico	Hospederos
Spongipellis chubutensis	*Saxegothaea conspicua*	*Antrodia xantha*	*Pinus radiata*
Spongipellis chubutensis	*Notohfagus*	*Ganoderma lobatum*	*Amomyrtus luma*
Oligoporus pelliculosus	*Nothofagus pumilio*	*Ceriporiopsis subvermispora*	*Drimys winteri*
Oligoporus pelliculosus	*Nothofagus dombeyi*	*Irpex lacteus*	*Nothofagus*
Rubellofomes minutisporus	*Nothofagus dombeyi*	*Phellinus rhabarbarinus*	*Cryptocarya alba*
Rubellofomes minutisporus	*Nothofagus obliqua*	*Phellinus ferruginosa*	*Drymis winteri*
Fulvifomes inermis	*Eucryphia cordifolia*	*Phellinus ralunensis*	*Eucryphia cordifolia*
Fulvifomes inermis	*Drymis winteri*	*Phellinus adamantinus*	*Nothofagus*
Arambarria cognata	*Baccharis*	*Pseudoinonotus crustosus*	*Nothofagus antarctica*
Arambarria cognata	*Vitis vinifera*	*Inonotus tabacinus*	*Ovidia pillo-pillo*
Trametes leptaula	*Cryptocarya alba*	*Phellinus*	*Peumus boldus*
Polyporus dictyopus	*Drimys confertifolia*	*Phylloporia boldo*	*Peumus boldus*
Fomes fasciatus	*Nothofagus*	*Phellinus igniarius*	*Pyrus communis*
Polyporus albus	*Nothofagus*	*Inonotus patouillardii*	*Quillaja saponaria*
Trametes albidorosea	*Nothofagus*	*Fomitiporella*	*Vitis vinifera*
Pycnoporus cinnabarinus	*Nothofagus dombeyi*	*Echinoporia aculeifera*	*Persea lingue*
Bresadolia uda	*Nothofagus nitida*	*Schizopora paradoxa*	*Quillaja saponaria*
Perenniporia medulla-panis	*Quillaja saponaria*	*Gloeophyllum abietinum*	*Cupressus*
Laetiporus sulphureus	*Nothofagus*	*Gloeophyllum protractum*	*Pinus radiata*
Fomitopsis betulina	*Nothofagus Alesandrii*	*Gloeophyllum*	*Prunus cerasifera*
Postia punctata	*Nothofagus pumilio*	*Bondarzewia guaitecasensis*	*Nothofagus obliqua*