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# Ectomycorrhizal fungi from southern Brazil – a literature-based review, their origin and potential hosts

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A first list of ectomycorrhizal and putative ectomycorrhizal fungi from southern Brazil (the states of Rio Grande do Sul, Santa Catarina and Paraná), their potential hosts and origin is presented. The list is based on literature and authors observations. Ectomycorrhizal status and putative origin of listed species was assessed based on worldwide published data and, for some genera, deduced from taxonomic position of otherwise locally distributed species. A total of 144 species (including 18 doubtful species) in 49 genera were recorded for this region, all accompanied with a brief distribution, habitat and substrate data. At least 30 collections were published only to the genus level and require further taxonomic review.

**Key words** – distribution – habitat – mycorrhiza – neotropics – regional list

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## Introduction

Ectomycorrhizal fungi (ECM) and their partner trees are well studied around the globe. Nevertheless, Europe, North America and several tropical regions have been considerably more explored while ECM dominated habitats in South America, Southeast Asia, Africa, and Australia remain relative undersampled (Tedersoo et al. 2010). In Brazil little is known about the ECM communities. Among the sporocarp-based studies of ECM conducted in Brazil, focusing both on native as well as exotic woody plants, we refer mainly to the

work of Singer & Araújo (1979), Singer et al. (1983) and Singer & Aguiar (1986) in the Amazon region. Recent publications with surveys of putative ECM in exotic and native plantations throughout the country have contributed to the knowledge of this group in different areas, producing new records and newly described species (Baseia & Milanez 2000, 2002, Gurgel et al. 2008, Menolli et al. 2009a, 2009b, Wartchow & Maia 2007, Wartchow et al. 2009, Wartchow & Cavalcanti 2010, Wartchow et al. 2012a, Wartchow 2012a, 2012b). All of these works are

taxonomic and they do not confirm the association between plant and fungi.

Henkel et al. (2012) presented a comprehensive study of the diversity of ectomycorrhizal fungi sporocarps in the Guiana Shield. Neves & Capelari (2007) published a Brazilian checklist of Boletales, reporting 20 genera and 70 species belonging to Boletales *sensu* Kirk et al. (2001), excluding the Sclerodermataceae. In a recent checklist Trierveiler-Pereira & Baseia (2009) reported 232 taxa of Brazilian gasteroid fungi. In southern Brazil, the first contributions were made by Johannes Rick during the first half of the twentieth century (reviewed in Fidalgo 1962, Mauhs 2000). In the 1950s, Rolf Singer reviewed some of the species collected by Rick, named *Fungi Rickiani* (Singer 1953a). Several studies have added to the knowledge of ECM fungi in Brazil. Putzke (1994) has provided a checklist for the Brazilian Agaricales, listing 1,011 taxa. Many genera published by Putzke remain unresolved and need additional taxonomic confirmation.

Most of these contributions were checked by means of morphological features of the sporocarps. Nowadays, however, systematics and taxonomy of ECM fungi have been under profound changes, mainly due to the use of molecular tools (Binder & Hibbett 2002, Binder & Hibbett 2006, Hibbett et al. 1997, Hibbett 2006, Hosaka et al. 2006, Matheny et al. 2006, Miller et al. 2006, Moncalvo et al. 2002, 2006). Despite the fact, data on tropical and subtropical fungi were rarely included in DNA-based studies, compromising the knowledge about the identification and phylogenetic placement of those fungi (Rinaldi et al. 2008).

Brazil is the fifth largest country in the world, with more than 8.5 million km<sup>2</sup>, with two recognized hotspots for the conservation of biodiversity, the Atlantic Forest and the Cerrado (Myers et al. 2000). The southern part of Brazil is characterized by two domains, Atlantic Forest and Campos Sulinos or southern grasslands (Fiaschi & Pirani 2009). The Atlantic forest is characterized by high species diversity and endemism. It includes different forest types: dense ombrophilous forest, mixed ombrophilous forest (including *Araucaria* forest), seasonal deciduous and

semi-deciduous forest, as well as pioneer vegetation (de Meijer 2008, Veloso et al. 1991). The Campos Sulinos (or Pampa) biome is covered by open grassy formations, used as natural pastures (Fiaschi & Pirani 2009). It is estimated that there are around 3,000 grassland species which belong mainly to the botanical families Poaceae, Asteraceae, Cyperaceae, Fabaceae, Apiaceae, Oxalidaceae, Verbanaceae, and Iridaceae. The main forest formations in Campos Sulinos are found at the Northern limit of the biome, in the transition area to Atlantic Rain Forest. In other regions, plant formations with trees are found mainly as gallery forests (islands of trees within the grassland) and shrub forests (Overbeck et al. 2006, 2007). A particular habitat for ECM fungi is forest tree plantations. Currently more than 5.98 Mha are planted with pine, eucalypts and acacia monocultures in Brazil (SBS 2008).

The central, western and northern regions of Brazil have a tropical climate with high annual temperatures averaging near 25° C with rainfall characterized by a wet season from October to March and a dry season from April to September (Rocha et al. 2009, Vourlitis et al. 2002). In the south of Brazil the subtropical climate is defined by four seasons and uniform annual rainfall. In this region, maximum average temperatures reach 30° C, and average minimum temperatures in the winter are around 5° C (annual averages near 18° C). As a consequence of its subtropical climate, this region has less intemperized soil than tropical Brazil and higher organic carbon content (Dieckow et al. 2009).

In view of the differences in climate, soil and vegetation in the Southern part of Brazil, this survey aimed to provide information on the diversity of ECM fungi in Southern Brazil (Paraná, Santa Catarina and Rio Grande do Sul), including a summary of information on putative hosts, nativeness, and a literature-based review of the area of origin. This study will, potentially, facilitate future studies on the systematics and biogeography of ECM fungi in Brazil.

## Methods

The checklist and meta-analyses were based on a literature survey of scientific papers citing species of putative ectomycorrhizal fungi

from Southern Brazil. The following information was retrieved: distribution of each recorded species (per state), potential ECM partners, the nativeness or potential origin, general habitat requirements and known substrates. The ectomycorrhizal status for each species is based either on the available description of ectomycorrhizae or on the taxonomic position of the species (Rinaldi et al. 2008, Tedersoo et al. 2010). The list and correlations also include several records by Rick (1961a, b) which may represent *nomina dubia*, synonyms or species of other genera.

Genera and species are listed alphabetically according to the MycoBank database (<http://www.mycobank.org/MycoTaxo.aspx>), and the Index Fungorum (<http://www.indexfungorum.org/names/names.asp>). The authority of the species names are given as in the original publications. The area of ‘Southern Brazil’ included in the study is represented by the States of Rio Grande do Sul (RS), Santa Catarina (SC) and Paraná (PR).

## Results and Discussion

The following ECM fungi have been recorded from Southern Brazil.

### *Alnicola spadicea* (D.A. Reid) Bon

Distribution – PR – Rio Negro.

Habitat and substrate – planted *Salix*; terricolous.

Literature – de Meijer (2001: 113, 2006: 11).

Comments – The genus *Alnicola* Kühner, includes 60 specific taxa, all mycorrhizal and mainly associated with Betulaceae and Salicaceae, most species originally described from Europe and later revised by Moreau (2005). The number of endemic species is undoubtedly large. Although, with our growing knowledge of the tropical fungi of other continents, the ‘neotropical’ and endemic element is bound to become gradually less conspicuous in the lists of native South American species. Examples of truly native species of the La Plata region seem to be *Alnicola devia*, *Crepidotus tigrisensis*, *Paxillus argentinus*, *Friesula platensis*, but their precise area in South America cannot yet be determined (Singer 1953b, Moreau 2005).

### *Amanita chrysoleuca* Pegler

Distribution – PR – Antonina.

Habitat and substrate – dense ombrophilous forest; terricolous.

Literature – de Meijer (2006: 11).

Comments – this species is apparently distributed in (sub) tropical America. It was cited from the US Virgin Islands (Miller et al. 2000).

### *Amanita grallipes* Bas & de Meijer

Distribution – PR – Curitiba.

Habitat and substrate – mixed ombrophilous forest, seasonal semi-deciduous alluvial forest; terricolous.

Literature – Bas & de Meijer (1993: 345), de Meijer (2001: 112, 2006: 11, 2008: 44, 140).

Comments – de Meijer (2008) refers that *A. grallipes* belongs to sect. *Lepidella* subsect. *Vittadiniae* Bas. It is not known if *A. grallipes* is ectomycorrhizal, but many species in the subsect. *Vittadiniae* are most certainly non-ectomycorrhizal. Wolfe et al. (2012) have shown that some species of *Amanita* (*A. thiersii* Bas) present saprotrophic nutrition.

### *Amanita muscaria* (L.: Fr.) Lam. sensu lato

Distribution – PR – Colombo; SC – Correia Pinto, Joinville, Três Barras; RS – Nova Petrópolis.

Habitat and substrate – plantations of *Pinus taeda* L.; terricolous.

Literature – de Meijer (2001: 113, 2006: 11, 2008: 142), Giachini et al. (2000: 1168), Guerrero & Homrich (1999: 39), Karstedt & Stürmer (2008: 1039), Sobestiansky (2005: 442), Stijve & de Meijer (1993: 322).

Comments – this species has a global distribution, at least for the Southern hemisphere, due to human activities. As suggested by Wartchow (pers. comm.), *A. muscaria* growing under *P. taeda* corresponds to ‘ssp. flavivolvata’.

### *Amanita multisquamosa* Peck

Distribution – SC – Correia Pinto.

Habitat and substrate – plantations of *Pinus taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168, as *A. pantherina* var. *multisquamosa* (Peck) Jenkins).

Comments – *Amanita multisquamosa* occurs in mixed coniferous and deciduous forest. In North America it occurs in the eastern parts and it may have been found in the Pacific Northwest as well (Jenkins 1986). This species appear to have mesophilous distribution in both Americas (continents).

***Amanita petalinivola*** Wartchow

Distribution – RS – Viamão.

Habitat – subtropical rain forest ‘restinga’; terricolous.

Literature – Wartchow et al. (2012b).

Comments – The type for this taxon was collected in Brazil.

***Amanita rubescens*** Pers.

Distribution – RS – Gramado.

Habitat and substrate – *Pinus* plantations; terricolous.

Literature – Sobestiansky (2005: 443).

Comments – It is common throughout much of Europe and eastern North America, growing on poor soils as well as in deciduous or coniferous woodlands. It has also been recorded from South Africa, where it is thought to have been accidentally introduced with trees imported from Europe (Reid & Eicker 1991).

***Amanita spissa*** (Fr.) Bertill.

Distribution – RS – locality unknown.

Habitat and substrate – unknown habitat; terricolous

Literature – Rick (1961a: 301).

Comments – *Amanita spissa* (and allies) is commonly found in Europe and eastern North America growing with both broad leaved as well as coniferous trees (Phillips 2006).

***Amanita strobiliformis*** (Paulet ex Vittad.) Bertill.

Distribution – RS – locality unknown.

Habitat – unknown.

Literature Rick (1930, 1937, 1961a) – all cited in Menolli et al. (2009b).

Comments – This species is predominantly distributed in Europe. It is more common in the Mediterranean region.

***Austroboletus festivus*** (Singer) Wolfe

Distribution – PR – Paranaguá.

Habitat and substrate – ‘restinga’; terricolous.

Literature – de Meijer (2001: 112), Singer et al. (1983: 137), Watling & de Meijer (1997: 232).

Comments – The ectomycorrhizal status is based on it fruiting close to *Ocotea pulchella* (Nees & Mart.) Mez, but a mycorrhizal connection has not been determined (Watling & de Meijer 1997). Other potential plant hosts are *Guettardia angelica* Martius, *Eschweilera ovata* (Cambess.) Mart. ex Miers., and in particular, *Hymenaea microphylla* Barb. Rodr. (Singer et al. 1983). The genus *Austroboletus* is treated by Tedersoo et al. (2010) as potentially ectomycorrhizal based in its phylogenetic placement.

***Boletinellus exiguus*** (Singer & Digilio) Watling

Distribution – PR – Piraquara; RS – Sapiroanga.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; terricolous, occurring on dead as well as living wood.

Literature – de Meijer (2001: 112, 2006: 12, 2008: 44, 130), Putzke et al. (1994: 82, as *Gyrodon exiguus* Singer & Digilio), Watling & de Meijer (1997: 243).

Comments – This species is putative ectomycorrhizal. It grows on soil, often in disturbed sites and it appears widely distributed in tropical America (Halling & Mueller 1998, 2005). Also treated as *Gyrodon exiguus* (Singer et al. (1983) in Watling & de Meijer (1997). Several species from the genus can alter root morphology (Gruhn et al. 1992) or are mycorrhizal (*Gyrodon*). However, to the best of our knowledge, no ectomycorrhizal association has been described for *B. exiguus*. The non obligatory ectomycorrhizal status of *B. exiguus* is discussed in de Meijer (2008).

***Boletinellus rompelii*** (Pat. & Rick) Watling

Distribution – PR – Curitiba, Piraquara, São José dos Pinhais; RS – Liberato Salzano,

Nova Petrópolis, Parecí, São Leopoldo, Viamão.

Habitat and substrate – mixed ombrophilous forest, seasonal semi-deciduous alluvial forest; terricolous.

Literature – de Meijer (2001: 112, 2006: 12, 2008: 44, 128), Putzke, et al. [1994: 81, as *Gyrodon rompelii* (Pat. & Rick) Sing.], Singer (1953a: 101, as *Phylloporus rompelii* Pat. & Rick, 117 and 128, as *Gyrodon rompelii* (Pat. & Rick) Sing., Singer & Digilio (1957: 256, as *Gyrodon rompelii* (Pat. et Rick) Sing.), Singer [1964: 118, as *Gyrodon rompelii* (Pat. & Rick) Sing.], Sobestiansky (2005: 443), Watling & de Meijer (1997: 243).

Comments – This species is facultatively ectomycorrhizal with *Allophylus*. It was recorded near *Allophylus edulis* (A.St.-Hil. et al.) Hieron. ex Niederl., *Trichilia elegans* A. Juss. (Watling & de Meijer 1997, de Meijer 2008), and near an *Inga* and *Allophylus edulis* site (Putzke et al. 1994). Singer (1953) referred to this species as occurring near *Acacia* woods, while its mycorrhizal condition was discussed by Singer et al. (1983). *Boletinellus rompelii* occurs in South Texas, Mexico and South America (Bessette et al. 2000). No records have been published for Asia or Europe.

### ***Boletus edulis* Bull.**

Distribution – RS – Gramado.

Habitat and substrate – *Pinus* plantations; terricolous.

Literature – Sobestiansky (2005: 443).

Comments: *Boletus edulis* is widely distributed in the Northern Hemisphere across Europe, Asia, and North America. It does not occur naturally in the Southern Hemisphere, although it has been introduced to Southern Africa, Australia and New Zealand. In North America this species was described as *Boletus edulis* var. *grandedulis* with distribution linked to *Pinus*, *Quercus* and *Abies* spp. (Arora 2008). This species forms ectomycorrhizae with a range of conifer and hardwood species (Agerer 1987–2006).

### ***Brauniella alba* (Rick) Rick ex Singer**

Distribution – RS – Cacequí, São Leopoldo.

Habitat and substrate – on sandy earth.

Literature – Singer (1953a: 102 as *Braunia alba* Rick), Singer (1962: 66).

Comments: *Brauniella* is a South American genus and its mycorrhizal status remains unknown.

### ***Calostoma zanchianum* (Rick) Baseia & Calonge**

Distribution – RS – Cachoeira do Sul.

Habitat and substrate – unknown habitat; roots.

Literature – Baseia et al. (2006: 114, 2007: 278), Cortez (2009: 03), Rick (1961b: 456, as *Mitremyces zanchianus* Rick).

Comments – This species is considered putative ectomycorrhizal since its close relative *C. cinnabarinum* was proven to be mycorrhizal with oaks (Wilson et al. 2007). However, no direct evidence exists for the ectomycorrhizal status of *C. zanchianum*.

### ***Cantharellus guyanensis* Mont.**

Distribution – PR – Campina Grande do Sul, Colombo, São José dos Pinhais.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; unknown substrate.

Literature – de Meijer (2006: 13, 2008: 372).

Comments – *Cantharellus guyanensis sensu* Singer et al. (1983) form ECM (a typical mantle and Hartig-net was observed) with the roots of *Glycoxylon inophyllum* (Mart. ex Miq.) Ducke and *Aldina heterophylla* Spruce ex Benth., and possibly also with *Psychotria* and some Sapindaceae (Singer et al. 1983). This species was recorded in Guiana Shield region (Henkel et al. 2012). There are no records available on the distribution of this species for other continents.

### ***Cantharellus xanthoscyphus* R. H. Petersen**

Distribution – PR – Antonina, Quatro Barras.

Habitat and substrate – dense ombrophilous forest; terricolous, occurring on dead wood.

Literature – de Meijer (2001: 112, 2006: 13).

### ***Chalciporus piperatus* (Bull.) Bataille**

Distribution – PR – Curitiba; SC –

Joinville, Três Barras.

Habitat and substrate – plantations of *P. taeda*; terricolous.

Literature – de Meijer (2001: 113, 2006: 13), Giachini et al. (2000: 1168); Karstedt & Stürmer (2008: 1039, as *Chalciporus* cf. *piperatus* (Bull.: Fr.) Bat.); Watling & de Meijer (1997: 233).

Comments – This species is potentially ectomycorrhizal (Rinaldi et al 2008, Watling & de Meijer 1997). However, Tedersoo et al. (2010), suggest that there is no evidence that *C. piperatus* is ectomycorrhizal. *Chalciporus piperatus*, also frequently recorded as *Boletus piperatus* Bull. ex Fr., is distributed in America and Europe (Phillips 2006). It occurs in coniferous, beech and oak forests, while in New Zealand it was recorded with *Nothofagus* (Fuhrer & Robinson 1992).

***Chondrogaster angustisporus*** Giachini, Castellano, Trappe & V.L. Oliveira

Distribution – SC – Correia Pinto, Três Barras.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid.; terricolous with hypogeous sporocarps.

Literature – Giachini et al. (2000: 1168).

Comments – *Chondrogaster angustisporus* is a hypogeous ectomycorrhizal fungus described from fruiting bodies collected under *Eucalyptus* spp. in Brazil, Uruguay and Australia (Giachini et al. 2000). In Europe this species was recorded in Spain (Lago & Castro 2004) next to *Eucalyptus globulus* Labill.

***Chondrogaster pachysporus*** Maire

Distribution – RS – Santa Maria.

Habitat and substrate – plantations of *Eucalyptus saligna* Sm.; terricolous with hypogeous sporocarps.

Literature – Sulzbacher et al. (2010: 378).

Comments – This species was recorded in Spain (Lago & Castro 2004) next to *Eucalyptus* sp.

***Clavulina puiggarii*** (Speg.) Corner

Distribution – PR – Antonina.

Habitat and substrate – dense ombrophilous forest; ‘restinga’; terricolous.

Literature – de Meijer (2006: 14).

Comments: *Clavulina puiggarii* (Speg.) Corner is also known from the West Indies, South America, Malaysia and Australia (Henkel et al. 2011).

***Coltricia barbata*** Ryvarden & de Meijer

Distribution – PR – Antonina, Morretes, Paranaguá.

Habitat and substrate – dense ombrophilous forest; unknown substrate.

Literature – de Meijer (2006: 15).

Comments: *Coltricia barbata* is only known from the type locality in the State of Paraná (Baltazar et al. 2010).

***Coltricia cinnamomea*** (Jacq.) Murrill

Distribution – PR – Curitiba, Guaraqueçaba, São Mateus do Sul.

Habitat and substrate – mixed ombrophilous forest, seasonal semi-deciduous alluvial forest, ‘restinga’ seasonal semi-deciduous alluvial forest; terricolous, occurring also in living wood.

Literature – de Meijer (2001: 113, 2006: 15, 2008: 372), Rajchenberg & de Meijer (1990: 177, as *Coltricia duportii*).

Comments – *Coltricia cinnamomea* is a common and cosmopolitan polypore with records in North America (Phillips 2006), South America (Baltazar et al. 2010), Europe and Asia (Jülich 1984, Ryvarden 1976). This species is recorded as ectomycorrhizal (Tedersoo et al. 2010, Thoen 1993).

***Coltricia duportii*** (Pat.) Ryvarden

Distribution – PR – Morretes.

Habitat and substrate – dense ombrophilous forest; unknown substrate.

Literature – de Meijer (2006: 15).

Comments – This species is putative ectomycorrhizal (Tedersoo et al. 2008).

***Coltricia perennis*** (L.) Murrill

Distribution – PR – Lapa.

Habitat and substrate – *Pinus* plantations; terricolous.

Literature – de Meijer (2001: 113, 2006: 15).

Comments – In Brazil, this species is only known from a *Pinus* plantation in the State of Paraná (Baltazar et al. 2010).

***Coltriciella oblectabilis*** (Lloyd) Kotl., Pouzar & Ryvardeen

Distribution – PR – Paranaguá.

Habitat and substrate – dense ombrophilous forest, ‘restinga’; terricolous.

Literature – de Meijer (2001: 113, 2006: 15), Rajchenberg & de Meijer (1990: 178).

Comments – Known from Brazil (de Meijer 2001, 2006, Rajchenberg & de Meijer 1990) and the South-Eastern United States (Kotlába et al. 1984). Recent records were also published for China (Dai et al. 2001).

***Cortinarius castaneofulvus*** Cleland

Distribution – SC – Três Barras.

Habitat and substrate – plantations of *Eucalyptus dunnii*; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – This species was first described from an eucalypt site in Australia (Cleland 1928). The only other collections known are from Brazil (Giachini et al. 2000).

***Descomyces albellus*** (Masse & Rodway) Bougher & Castellano

Distribution – SC – Correia Pinto; RS – Santa Maria.

Habitat and substrate – plantations of *Eucalyptus dunnii* and *Eucalyptus* spp.; terricolous.

Literature – Cortez et al. (2008a: 514), Giachini et al. (2000: 1168).

Comments – This species was originally delimited from *Hymenogaster* by Bougher and Castellano in Australia. Additional locations are also known for New Zealand (Bougher & Castellano 1993). The species was formerly restricted to Australasia. Nowadays, however, it spreads to areas covered by *Eucalyptus* forest (Kirk et al. 2008).

***Descomyces albus*** (Klotzsch) Bougher & Castellano

Distribution – SC – Correia Pinto.

Habitat and substrate – plantations of *Eucalyptus dunnii*; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Descomyces albus* is recorded in Australia, Germany, New Zealand,

North Africa, Spain, UK and the USA (Keane et al. 2000, Moreno-Arroyo et al. 2005).

***Descomyces giachinii*** Trappe, V.L. Oliveira, Castellano & Claridge

Distribution – SC – Correia Pinto.

Habitat and substrate – plantations of *Eucalyptus dunnii*; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – The species is recorded from Australia, Brazil, the USA and New Zealand (Giachini et al. 2000).

***Entoloma bloxamii*** (Berk. & Broome) Sacc.

Distribution – PR – São José dos Pinhais, São Mateus do Sul.

Habitat and substrate – mixed ombrophilous alluvial forest, mixed ombrophilous montane forest; terricolous.

Literature – de Meijer (2006: 19, 2008: 271, 372).

Comments – In Europe, Asia and North America this species inhabits unimproved grasslands such as old meadows and hayfields and is known for its indication value of extensive grasslands (Newton et al. 2003). It is rare throughout Europe (ECCF 2001). Records were published also from other areas (e.g. Japan – Kasuya et al. 2010). In general this species is regarded as saprobic, although there are several representatives of this genus that can form mycorrhizae (Kasuya et al. 2010) or transitional structures as describes by Agerer & Waller (1993). Species of *Entoloma* sect. *Entoloma* are suspected to be ectomycorrhizal (Noordeloos 2002, in de Meijer 2008).

***Gloeocantharellus corneri*** (Singer) Corner

Distribution – PR – Campina Grande do Sul.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; terricolous.

Literature – de Meijer (2001: 112, 2006: 23, 2008: 372), Watling & de Meijer (1997: 245).

Comments – The type for *Gloeocantharellus corneri* was collected in Brazil. The genus has been recorded in North and South America (Corner 1969).

***Gyroporus castaneus*** (Bull) Quél.

Distribution – RS – Pelotas.

Habitat and substrate – planted *Quercus*; terricolous.

Literature – Putzke et al. (1994: 79).

Comments: The species is commonly found in oak forests in continental Europe and in eastern North America while rare in western North America (Arora 1986, Phillips 2006).

***Hebeloma sacchariolens*** Quél.

Distribution – PR – Almirante Tamandaré, Rio Negro; RS – Nova Petrópolis.

Habitat and substrate – pasture, *Pinus* plantations, planted *Salix*; terricolous.

Literature – de Meijer (2001: 113, 2006: 24), Sobestiansky (2005: 447, as *Hebeloma* cf. *sacchariolens* Quél.).

Comments – *Hebeloma sacchariolens* is ectomycorrhizal (Marmeisse et al. 1997). In general *Hebeloma* species are rare in the tropics but common in temperate Northern hemisphere (Singer 1986) with *Salix* and other broadleaf species.

***Hydnodon thelephorus*** (Lév.) Banker

Distribution – PR – Antonina, Campina Grande do Sul, Curitiba, General Carneiro, Mandirituba, Morretes, Piraquara, São José dos Pinhais, São Mateus do Sul; RS – Nova Petrópolis.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous montane forest, gallery forest in area of savanna; terricolous.

Literature – de Meijer (2001: 113, as *Phellodon tenuis* Baird, 2006: 24, 2008: 89, 372), Sobestiansky (2005: 447).

Comments: This species is putative ectomycorrhizal. It was noted as “ectomycorrhizal?” (Sobestiansky 2005).

***Hymenogaster vulgaris*** Tul. & C. Tul.

Distribution – RS – locality unknown.

Habitat and substrate – unknown habitat; terricolous.

Literature – Rick (1961b: 456).

Comments – In Spain this species occurs under *Quercus ilex* L. (Moreno-Arroyo et al. 2005).

***Hysterangium affine*** Masee & Rodway

Distribution – RS – Santa Maria.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Cortez et al. (2011a: 221).

Comments – *Hysterangium affine* is recorded from Australia (Beaton et al. 1985), North (Zeller & Dodge 1929) and South America. It is widespread in *Eucalyptus* plantations (Cortez et al. 2011a).

***Hysterangium australe*** Spig.

Distribution – RS – São Leopoldo.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Rick (1961b: 457).

***Hysterangium inflatum*** Rodway

Distribution – RS – Santa Maria.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Cortez et al. (2011a: 221).

Comments – *Hysterangium inflatum* is frequently found in *Eucalyptus* forest in Australia (Beaton et al. 1985), New Zealand (Castellano & Beever 1994), France and Ecuador (Castellano & Muchovej 1996), Spain (Lago & Castro 2004, Moreno-Arroyo et al. 2005), United States (Zeller & Dodge 1929), South Europe (Montecchi & Sarasini 2000). This species is widespread in *Eucalyptus* plantation (Cortez et al. 2011a).

***Hysterangium gardneri*** E. Fisch.

Distribution – SC – Correia Pinto, Três Barras.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Hysterangium gardneri* has a wide distribution, growing especially in *Eucalyptus* plantations. Nouhra et al. (2008) cited this species from Argentina in plantations of *Eucalyptus camaldulensis* and *E. cinerea*.

***Inocybe australiensis*** Cleland & Cheel

Distribution – PR – São José dos Pinhais; SC – Correia Pinto.

Habitat and substrate – *Eucalyptus* plantations, plantations of *Eucalyptus dunnii* Maid.; terricolous.

Literature – de Meijer (2001: 113,



2006: 26, both as *Inocybe* cf. *australiensis* Cleland & Cheel), Giachini et al. (2000: 1168).  
Comments: *Inocybe australiensis* occurs in Australia (Grgurinovic 1997).

***Inocybe curvipes* P. Karst.**

Distribution – PR – Colombo, Curitiba; RS – Nova Petrópolis, Santa Maria.

Habitat and substrate – *Pinus* plantations; terricolous.

Literature – Cortez & Coelho (2005: 71), de Meijer (2001: 113, 2006: 26), Sobestiansky (2005: 448), Stijve & de Meijer (1993: 321).

Comments – In Europe, *Inocybe curvipes* occurs with broadleaf species (birch, poplar, hazel) in rich, humic soils (Stangl 1991). In Africa it is seen close to exotic pine plantations (Buyck & Eyssartier 1999), and in Australia on soil under introduced *Quercus* sp., *Pinus radiata* D. Don., and probably *Salix* sp. (Bougher & Matheny 2011).

***Inocybe hyperythra* Rick**

Distribution – RS – São Leopoldo.

Habitat and substrate – subtropical forest; terricolous.

Literature – Rick (1961a: 406, as *I. hypererythra* Rick), Singer (1953a: 94), Singer et al. (1983: 181).

Comments – Mycorrhizal. However, association and accompanying trees are unknown (Singer et al. 1983).

***Inocybe violaceolamellata* Rick**

Distribution – RS – São Leopoldo.

Habitat and substrate – unknown habitat; terricolous, mossy trunk.

Literature – Rick (1961a: 407), Singer (1953a: 94).

***Labyrinthomyces varius* (Rodway) Trappe**

Distribution – SC – Correia Pinto.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – The whole genus is primarily distributed in Australia in association with *Eucalyptus* spp. (Kirk et al. 2008).

***Laccaria amethystina* Cooke**

Distribution – SC – Correia Pinto.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid. and *Pinus taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Laccaria amethystina* is a common species in most temperate zones of Europe, Asia, Central, South, and eastern North America. It forms ectomycorrhiza with a variety of deciduous and coniferous trees, though it most commonly occurs associated with Fagales (Laessle 1998, Mueller 1992).

***Laccaria bicolor* (Maire) P.D. Orton**

Distribution – SC – Correia Pinto, Três Barras.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid. and *Pinus taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Laccaria bicolor* is found throughout the temperate zones of the world (Phillips 2006), and also in Australia (Dunstan et al. 1998).

***Laccaria laccata* (Scop.) Cooke var. *laccata***

Distribution – SC – Correia Pinto, Três Barras; RS – Canela, Ijuí, Pelotas, Porto Alegre, Rio Pardo, Santa Maria, Santa Vitória do Palmar, Vera Cruz.

Habitat and substrate – *Pinus* plantations, and plantations of *P. taeda* L., and *Eucalyptus dunnii* Maid.; terricolous.

Literature – Giachini et al. (2000: 1168); Guerrero & Homrich (1999: 41); Putzke (1999: 09; 2003: 286, as *Laccaria laccata* (Scop.:Fr.) Ber. & Br.).

Comments – *Laccaria laccata* is found often in poor soil. It is very common for the Northern temperate zones. It is ectomycorrhizal with Pinaceae, Fagaceae and Betulaceae across Europe and North America (Mueller 1991). It is recorded also from Australia, Costa Rica, South Africa and New Zealand (Arora 1986, Dunstan et al. 1998).

***Laccaria laccata* var. *pallidifolia* (Peck) Peck**

Distribution – SC – Córrego Grande,

Rio Vermelho, Três Barras.

Habitat and substrate – *Eucalyptus* plantations, plantations of *Pinus elliottii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

***Laccaria lateritia*** Malençon

Distribution – PR – Colombo, Curitiba, São José dos Pinhais; SC – Três Barras; RS – Barros Cassal, Nova Petrópolis, Porto Alegre, Rio Pardo, Salvador do Sul, São Francisco de Paula, Santa Cruz do Sul, Sinimbu, Vale do Sol, Venâncio Aires, Vera Cruz.

Habitat and substrate – *Eucalyptus* plantations, plantations of *E. dunnii*; terricolous.

Literature – de Meijer (2001: 113, 2006: 27, both as *Laccaria fraterna* (Cooke & Masee) Pegler), Giachini et al. (2000: 1168), Guerrero & Homrich (1999: 41, as *L. fraterna*), Putzke (1999: 08, 2003: 283, both as *L. fraterna*), Rick (1961a: 329, as *Clitocybe laccata* Scop.), Singer (1953a: 110, as *L. tetraspora* Sing.), Sobestiansky (2005: 448, as *L. fraterna*).

Comments – The *Laccaria lateritia* group is common in Australia forming mycorrhizas with a number of plants, but frequently associated with eucalypts ([http://www.blueswami.com/laccaria\\_lateritia.html](http://www.blueswami.com/laccaria_lateritia.html)).

***Laccaria proxima*** (Boud.) Pat.

Distribution – PR – Colombo; SC – Três Barras; RS – Nova Petrópolis.

Habitat and substrate – *Pinus* plantations, plantations of *P. taeda* L.; terricolous.

Literature – de Meijer (2001: 113, 2006: 27), Giachini et al. (2000: 1168), Sobestiansky (2005: 448).

Comments – *Laccaria proxima* is ectomycorrhizal with pines in North America. It is also common in Europe and was introduced in New Zealand and Australia (Dunstan et al. 1998).

***Laccaria pumila*** Fayod

Distribution – SC – Correia Pinto, Três Barras.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Laccaria pumila* is recorded from Europe, North America (Mueller 1991, 1992) and from Australasia (Vellinga 1986).

***Laccaria tetraspora*** (Scop.) Fr.

Distribution – SC – Joinville; RS – São Leopoldo.

Habitat and substrate – *Pinus* plantations; terricolous.

Literature – Karstedt & Stürmer (2008: 1039), Putzke (1999: 06, 2003: 280).

***Laccaria tortilis*** (Bolton) Cooke

Distribution – SC – Correia Pinto, Três Barras.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid. and *Pinus taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Laccaria tortilis* is a common species in North America and Europe (Phillips 2006), but also recorded from Australia and New Zealand (Dunstan et al. 1998).

***Lactarius argillaceifolius*** Hesler & A.H. Sm. var. *argillaceifolius*

Distribution – SC – Joinville, Rio Vermelho.

Habitat and substrate – plantations of *Pinus elliottii* Engelm.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Lactarius argillaceifolius* occurs in North America (USA, Canada) and Mexico, mainly associated with oaks (Hesler & Smith 1979).

***Lactarius braunii*** Rick

Distribution – RS – Porto Alegre, São Leopoldo.

Habitat and substrate – unknown habitat; terricolous.

Literature – Raithelhuber (1991: 190), Rick (1961a: 365), Singer (1953a: 84).

***Lactarius deliciosus* (L.) Gray**

Distribution – PR – Colombo; SC – Correia Pinto; RS – “highlands” as Sobestiansky (2005: 448).

Habitat and substrate – *Pinus* plantations and *P. taeda* L.; terricolous.

Literature – de Meijer (2006: 27), Giachini et al. (2000: 1168), Guerrero & Homrich (1999: 40), Sobestiansky (2005: 448).

Comments – *Lactarius deliciosus* is widely distributed in Europe, Asia and North America (Hesler & Smith 1979). It has been introduced in Chile, Australia and New Zealand in association with *Pinus radiata* D. Don. plantations (Phillips 2006, Dunstan et al. 1998).

***Lactarius fragilis* (Burl.) Hesler & A.H. Sm.**

var. *fragilis* Distribution: SC – Correia Pinto, Joinville, Três Barras.

Habitat and substrate – *Pinus* plantations, plantations of *P. elliottii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168), Karstedt & Stürmer (2008: 1039, as *Lactarius* cf. *fragilis*).

Comments – *Lactarius fragilis* is found in North America, frequently with Douglas fir (Hesler & Smith 1979).

***Lactarius paulensis* Singer**

Distribution – PR – locality unknown.

Habitat and substrate: dense ombrophilous forest; terricolous, occurring on dead wood.

Literature – de Meijer (2001: 113).

***Lactarius rufus* (Scop.) Fr.**

Distribution – PR – Mandirituba, Piraquara; SC – Correia Pinto, Três Barras; RS – Nova Petrópolis.

Habitat and substrate – *Pinus* plantations; plantations of *P. taeda* L.; terricolous.

Literature – de Meijer (2001: 114, 2006: 27), Giachini et al. (2000: 1168, as *L. rufus* var. *rufus*), Sobestiansky (2005: 448).

Comments – *Lactarius rufus* is frequent in Europe and North America, mostly with pines, birch, or spruce (Arora 1986).

***Lactarius rufus* var. *parvus* Hesler & A.H. Sm.**

Distribution – SC – Correia Pinto, Três Barras.

Habitat and substrate – plantations of *Pinus taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

***Lactarius russula* Rick**

Distribution – RS – São Leopoldo.

Habitat and substrate – forest; terricolous.

Literature – Rick (1961a: 364), Singer (1953a: 83), Singer et al. (1983: 311).

***Lactarius venezuelanus* Dennis**

Distribution – PR – Antonina, Campina Grande do Sul, Morretes, Quatro Barras.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; occurring on dead wood, terricolous.

Literature – Buyck & de Meijer (1999: 270), de Meijer (2001: 113, 2006: 27, 2008: 372).

Comments – The species occurs under leguminous trees of campinarana vegetation (Buyck & de Meijer 1999). The ectomycorrhizal status of this species is not clear. It also grows on the bases of living trees such as *Sloanea* (Elaeocarpaceae) and *Talauma* (Magnoliaceae) (Singer et al. 1983).

***Leucogaster braunii* Rick**

Distribution – RS – São Leopoldo.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Rick (1961b: 455).

Comments – The genus was recognised as ectomycorrhizal from Australia (<http://mycorrhizas.info/ecmf.html>).

***Modicella reniformis* (Bres.) Gerd. & Trappe**

Distribution – SC – locality unknown.

Habitat and substrate – on or just under the leaf cover.

Literature – Thaxter (1922: 321, as *Endogone reniformis* Bres.).

Comments – This species forms endomycorrhiza (Trappe & Schenck 1982).

***Neopaxillus echinospermus* (Speg.) Singer**

Distribution – PR – Colombo, General Carneiro, São José dos Pinhais; RS – Couto

(this locality is not in RS state, but probably in the state of Minas Gerais. Minas Gerais has the town of Couto de Magalhães de Minas, as referred by Maria Marchioretto from Instituto Anchieta de Pesquisas/UNISINOS (pers. com.).

Habitat and substrate – mixed ombrophilous montane forest and upper-montane and dense ombrophilous submontane forests; terricolous.

Literature – de Meijer (2001: 112, 2006: 35, 2008: 44, 131, 373), Singer (1950: 221, as *Naucoria echinosperma* Speg, 231, 1953a: 92, as *Tubaria crobula* Fr., 108, 1964: 114), Singer & Digilio (1951: 436), Watling & de Meijer (1997: 241).

Comments – Singer et al. (1983) noted that “this species is terrigenous and there is reason to believe that it is facultatively ectomycorrhizal although no convincing ecological or experimental data are available”. Based on general observation on the genus *Neopaxillus*, de Meijer (2008) stated that it is not known if it is ectomycorrhizal or not. The genus is a member of Paxillaceae, associated with *Araucaria* forest (Issac et al. 1993). It has also been recorded from Sri Lanka (Issac et al. 1993). A similar species (*N. dominicanus* Angelini & Vizzini) was described recently from the Dominican Republic (Vizzini et al. 2012).

***Octaviania carnea*** (Wallr.) Corda.

Distribution – RS – locality unknown.

Habitat and substrate – unknown habitat; terricolous.

Literature – Rick (1961b: 457).

***Octaviania radicans*** Rick

Distribution – RS – locality unknown.

Habitat and substrate – unknown habitat; dead wood.

Literature – Rick (1961b: 457).

***Octaviania stillingerii*** Lloyd

Distribution – RS – locality unknown.

Habitat and substrate – unknown habitat; terricolous.

Literature – Rick (1961b: 457).

***Paxillus alexandri*** Gillet.

Distribution – RS – locality unknown.

Habitat and substrate – unknown habitat; pasture.

Literature – Rick (1961a: 405).

Comments – *Paxillus alexandri* was reported from several areas in Europe and North America published as a synonym *Clitocybe alexandri* (Gillet) Gillet. (Bigelow & Smith 1962).

***Paxillus involutus*** (Batsch) Fr.

Distribution – RS – São Salvador, São Leopoldo.

Habitat and substrate – subtropical forest; terricolous.

Literature – Guerrero & Homrich (1999: 40), Rick (1961a: 404), Singer (1964: 112, as *Paxillus* aff. *involutus*).

Comments – *Paxillus involutus* is widely distributed across the Northern Hemisphere (incl. China, India, Japan and North America (Breitenbach & Kränzlin 1991). It was also recorded in Greenland (Knudson 2006). It has been introduced to Australia, New Zealand, and South America with European trees. *Paxillus involutus* is treated as ectomycorrhizal with a range of coniferous and deciduous tree species (Taylor et al. 2000).

***Phaeoclavulina cyanocephala*** (Berk. & M.A. Curtis) Giachini

Distribution – PR – Colombo, Piraquara, Quatro Barras, São José dos Pinhais.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; terricolous.

Literature – de Meijer (2001: 112, as *Ramaria grandis* (Peck) Corner f. *cyanocephala* (Berk. & Curtis) R.H. Petersen, 2006: 41, 2008: 99, 373, both as *Ramaria cyanocephala* (Berk. & M.A. Curtis) Corner).

***Phaeoclavulina pancaribbea*** (R.H. Petersen) Giachini

Distribution – PR – Piraquara.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; terricolous.

Literature – de Meijer (2001: 112, 2006: 41, as *Ramaria* cf. *pancaribbea* R.H. Petersen f. *caerulea* R.H. Petersen).

Comments – Petersen (1988) described *Ramaria pancaribbea* var. *zealandica* which

was recently renamed as *Phaeoclavulina zealandica* (R.H. Petersen) Giachini (Giachini & Castellano 2011). *Phaeoclavulina pancaribbea* is considered putative ectomycorrhizal, yet likely to be ectomycorrhizal as other species from the genus (Agerer & Rambold 2004-2010).

***Phaeoclavulina subclaviformis*** (Berk.) Giachini

Distribution – PR – Campina Grande do Sul, Quatro Barras, Piraquara, São José dos Pinhais.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest, ‘restinga’; terricolous.

Literature – de Meijer (2001: 112, 2006: 23, both as *Gomphus subclavaeformis* (Berk.) Corner, de Meijer 2008: 97, 372, as *Gomphus cf. subclaviformis* (Berk.) Corner.

***Phlebopus beniensis*** (Singer & Digilio) Heinem. & Rammeloo

Distribution – PR – Paranaguá, Pontal do Paraná, Vera Cruz do Oeste.

Habitat and substrate – seasonal semi-deciduous submontane/montane forest, ‘restinga’; terricolous.

Literature – de Meijer (2001: 112, 2006: 36), Watling & de Meijer (1997: 235).

Comments – *Phlebopus beniensis* has been reported from Argentina, Bolivia, Brazil, Costa Rica, Ecuador and Martinique, in the neotropics, and from Liberia in Africa (Guzmán et al. 2007). In Brazil, specimens are found growing close to *Laguncularia racemosa* (L.) C.F. Gaertn. and *Hibiscus tiliaceus* L. (Watling & Meijer 1997). Its mycorrhizal association remains doubtful (Singer et al. 1983). As Tedersoo et al. (2010), suggested that *Phlebopus*, as well as *Boletinellus* and *Phylloboletellus* are not ectomycorrhizal but facultatively or obligately biotrophic taxa.

***Phlebopus braunii*** (Bres.) Heinem.

Distribution – RS – São Leopoldo, Vera Cruz.

Habitat and substrate – subtropical forest; terricolous.

Literature – Putzke et al. (1994: 84).

Comments – The genus has a widespread distribution in subtropical and

tropical regions, and contains 12 species. The species are saprobic, although some may be potentially able to form mycorrhizae with exotic trees in certain conditions (Kirk et al. 2008).

***Phlebopus tropicus*** (Rick) Heinem. & Rammeloo

Distribution – RS – São Leopoldo, Vera Cruz; SC – Itapiranga.

Habitat and substrate – subtropical forest; terricolous.

Literature – Putzke et al. (1994: 86), Singer (1950: 233, 1953a: 101, as *Boletus tropicus* Rick), Singer & Digilio (1957: 253, as *Phaeogyroporus tropicus* (Rick) Singer).

Comments – This species is putative ectomycorrhizal, forming mycorrhiza with *Allophylus* spp. (Putzke et al. 1994). There is no evidence that this species forms typical ectomycorrhizae (Singer et al. 1983).

***Phyllobolites miniatus*** (Rick) Singer

Distribution – RS – locality unknown.

Habitat and substrate – subtropical forest; terricolous.

Literature – Rick (1961a: 405 as *Paxillus miniatus* Rick), Singer (1953a: 93, 1964: 131), Singer et al. (1983: 30).

Comments – Singer et al. (1983) refer it under Leguminosae trees, as a putative ectomycorrhizal species. This is the only species in the genus found in tropical South America (Kirk et al. 2008).

***Phylloporia spathulata*** (Hook.) Ryvardeen

Distribution – PR – Campina Grande do Sul, Quatro Barras, São Mateus do Sul.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest, mixed ombrophilous alluvial forest, mixed ombrophilous montane forest; terricolous and on decayed wood, sometimes on the trunk base of an unidentified living Cyatheaceae tree.

Literature – de Meijer (2006: 37, 2008: 373).

Comments – This species is putative ectomycorrhizal (de Meijer, 2008). *Phylloporia spathulata* has a pantropical distribution (Wagner & Ryvardeen 2002).

***Pisolithus albus*** (Cooke & Masee) Priest

Distribution – SC – Correia Pinto.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid.; terricolous.

Literature – Giachini et al. (2000:1168).

Comments – *Pisolithus albus* is a eucalyptus symbiont and has been found predominately in Europe and North America, even though it originated from Australia (Bougher & Syme 1998, Martin et al. 2002).***Pisolithus arhizus*** (Scop.) Rauschert

Distribution – RS – Capão do Leão, Porto Alegre, Rio Grande, Santa Maria, Viamão.

Habitat and substrate – *Eucalyptus* plantations, plantations of *Pinus elliottii* Engelm., near *Tabebuia heptaphylla* (Vell.) Toledo; terricolous.Literature – Guerrero & Homrich (1999: 48, as *Pisolithus tinctorius*), Cortez (2011b: 45).Comments – This species was referred by Cortez et al. (2011b) growing in eucalypt and pine (*Pinus elliottii* Engelm.) plantations as well near a native *Tabebuia heptaphylla* (Vell.) Toledo. The species is distributed in the Northern Hemisphere (Europe and North America). *P. arhizus* can be also found in the Southern Hemisphere, growing with introduced pine species (Martin et al. 2002).***Pisolithus microcarpus*** (Cooke & Masee) G. Cunn.

Distribution – PR – Curitiba, São José dos Pinhais; SC – Córrego Grande, Rio Vermelho, Três Barras.

Habitat and substrate – *Eucalyptus* plantations, plantations of *E. citriodora* Hook., *E. dunnii* Maid., *E. robusta* Sm.; terricolous.Literature – Giachini et al. (2000: 1169), de Meijer (2001: 114, as *Pisolithus* sp., 2006: 37, as *Pisolithus* cf. *microcarpus* (Cooke & Masee) G. Cunn.).Comments – Although now distributed with *Eucalyptus* plantations worldwide, *P. microcarpus* is considered to be a native Australian taxon (Martin et al. 2002).***Pisolithus pisiformis*** (Lloyd) Rick

Distribution – RS – locality unknown.

Habitat and substrate – unknown

habitat; occurring on dead wood.

Literature – Rick (1961b: 459).

***Ramaria anziana*** R.H. Petersen

Distribution – SC – Correia Pinto, Rio Vermelho.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – This species is native to Australia and New Zealand (<http://www.gwannon.com/species/Ramaria-anziana>).***Ramaria geesterani*** de Meijer

Distribution – PR – São José dos Pinhais.

Habitat and substrate – mixed ombrophilous montane forest; terricolous.

Literature – de Meijer (2008: 44, 101, 373).

Comments – de Meijer (2008: 103) concluded that the ectomycorrhizal status of all ten native species of *Ramaria* occurring in the state of Paraná is unknown despite the fact that the genus is generally considered ectomycorrhizal in Europe and North America (Agerer & Rambold 2004–2010).***Ramaria junquilleovortex*** R.H. Petersen

Distribution – SC – Rio Vermelho.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – Found in New Zealand, as native, on the ground under *Leptospermum* sp. and *Nothofagus* sp. Nationally critically threatened in New Zealand (McKenzie et al. 2006).***Ramaria moelleriana*** var *moelleriana* (Bres. & Roum.) Corner

Distribution – PR – São José dos Pinhais.

Habitat and substrate – mixed ombrophilous montane forest; decayed dicotyledonous branch.

Literature – de Meijer (2008: 44, 373).

Comment – The species was also recorded in Malaysia (<http://malaysianfungi.webs.com>).

**Ramaria toxica** Toledo & R.H. Petersen

Distribution – PR – Curitiba; RS – Porto Alegre, “highlands and interior of Rio Grande do Sul” as Sobestiansky (2005: 453).

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – de Meijer (2001: 113, 2006: 41), Guerrero & Homrich (1999: 51), Sobestiansky (2005: 453).

Comments – *Ramaria toxica* is referred to Argentina and Brazil under *Eucalyptus* (Toledo & Petersen 1989).

**Redeckera fulvum** (Berk. & Broome) C. Walker & A. Schüßler

Distribution – (?) RS – locality unknown.

Habitat and substrate – occurring on dead bamboo debris, as well as under the leaf cover.

Literature – Thaxter (1922: 319, as *Endogone fulva* (Berk. & Broome) Pat.

Comment: This species forms endomycorrhiza (Trappe & Schenck 1982).

**Rhizopogon fuscorubens** A. H. Sm.

Distribution – SC – Correia Pinto, Rio Vermelho, Três Barras.

Habitat and substrate – plantations of *P. elliotii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Rhizopogon fuscorubens* has been found in the United States (Smith & Zeller 1966) under conifers especially pines (*Pinus rigida* Miller and *P. contorta* Douglas ex Loudon). Molina & Trappe (1994) mentioned other probable ectomycorrhizal hosts: *Arbutus menziesii* Pursh, *Arctostaphylos uva-ursi* (L) Sprengel, *Pinus monticola* Douglas ex D. Don, *P. ponderosa* Douglas ex Lawson & C. Lawson and *P. serotina* Michaux. The species was also recorded in Spain with an unknown host (Martín 1996).

**Rhizopogon nigrescens** Coker & Couch

Distribution – SC – Rio Vermelho, Três Barras.

Habitat and substrate – plantations of *P. elliotii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Rhizopogon nigrescens* was found in sandy soil under pines in the Southeastern USA (Bessette et al. 2007).

**Rhizopogon roseolus** (Corda) Th. Fr.

Distribution – PR – Colombo, Curitiba; SC – Correia Pinto, Três Barras; RS – Itaara, Santa Maria.

Habitat and substrate – *Pinus* plantations, plantations of *P. taeda* L.; terricolous.

Literature – Cortez (2011b: 45), de Meijer (2001: 113, as *R. luteorubescens* A.H. Sm.; 2006: 41, as *Rhizopogon roseolus* (Corda) Th. Fr. sensu Martín (1996) or *R. luteorubescens* A.H. Sm.), Giachini et al. (2000: 1168, as *Rhizopogon rubescens* (Tul. & C. Tul.) Tul. & C. Tul. and *Rhizopogon vulgaris* (Vittad.) M. Lange).

Comments – *Rhizopogon roseolus* is the species most common in Europe. The basidiomes are semihypogeous on sandy or calcareous soil in association with *Abies* spp., *Picea* spp., *Pinus* spp. and also under *Quercus* spp. (Martín et al. 2000). *R. roseolus* (synonym *Rhizopogon rubescens* Tul.), an economically important edible mushroom associated with the Pinaceae (mostly *Pinus* sp.), has a global distribution. In the Southern Hemisphere it results from the introduction of exotic trees in reforestation programs (Visnovsky et al. 2010).

**Rhizopogon zelleri** A.H. Sm.

Distribution – SC – Três Barras.

Habitat and substrate – plantations of *P. taeda*; terricolous.

Literature – Giachini et al. (2000: 1168).

Comments – *Rhizopogon zelleri* is native to North America where the type was collected by Zeller in 1966 in pure or mixed pine forests (Martín 1996).

**Russula consobrina** (Fr.) Fr.

Distribution – PR – São José dos Pinhais; RS – Nova Petrópolis.

Habitat and substrate – *Pinus* plantations; terricolous.

Literature – de Meijer (2001: 114, 2006: 42), Sobestiansky (2005: 453).

Comments – It grows in coniferous forests, in association with *Picea*. Widespread in Europe. In the USA known from the

Northwest under conifers. Also recorded in China (Zhishu et al. 1993).

***Russula puiggarii*** (Speg.) Singer

Distribution – PR – Campina Grande do Sul, Quatro Barras, Morretes, Piraquara; RS – São Leopoldo.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; terricolous, sandy soil, occurring on dead or rotten wood.

Literature – de Meijer (2001: 113, 2006: 42, 2008: 373), Rick (1961a: 363, as *R. pectinata* (Bull.) Fr.), Singer & Digilio (1951: 442), Singer (1953a: 83, as *R. pectinata* (Bull.) Fr.), Singer et al. (1983: 214).

Comments – Occurring in all types of rain forests, mainly in the tropical lowlands, probably non-mycorrhizal or only facultatively mycorrhizal (Singer et al. 1983). Haug et al. (2005) observed *R. puiggarii* forming a mantle and a Hartig's net in roots of *Neea* sp. (Nyctaginaceae).

***Russula riograndensis*** Singer

Distribution – RS – São Leopoldo.

Habitat and substrate – forest; terricolous.

Literature – Rick (1961a: 363, as *R. subfragilis* Rick), Singer (1953a: 81, as *R. subfragilis*), Singer et al. (1983: 236, as *R. subfragilis*).

***Russula theissenii*** Rick

Distribution – PR – Morretes; RS – São Leopoldo.

Habitat and substrate – dense ombrophilous forest; terricolous.

Literature – de Meijer (2001: 113, 2006: 42, 2008: 373, both as *Russula* aff. *theissenii* Rick), Rick (1961a: 363), Singer (1953a: 81), Singer et al. (1983: 209).

Comments: The position and ecological significance of this species is not clear (Singer et al. 1983: 211).

***Russula velenovskyi*** Melzer & Zvára

Distribution – PR – locality unknown.

Habitat and substrate – planted *Castanea sativa* Mill.; terricolous.

Literature – de Meijer (2001: 114, 2006: 42).

Comments – The habitat of *Russula velenovskyi* is under broad-leaved trees and pine. It is found in Europe (Phillips 2006) with holarctic, subboreal and suboceanic species. The species is mycorrhizal with Fagales (*Betula*, *Fagus*, *Carpinus*, *Quercus*) and only rarely with conifers (Krieglsteiner et al. 2000).

***Sarcodon atroviridis*** (Morgan) Banker

Distribution – PR – Colombo, General Carneiro, Quatro Barras, Morretes, Piraquara, São José dos Pinhais.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous montane forest; terricolous.

Literature – de Meijer & Baird (1992: 639), de Meijer (2001: 113, 2006: 42, 2008: 373, both as *Sarcodon bambusinus* (R.E.D. Baker & W.T. Dale) Maas Geest.

Comments – Ectomycorrhizal with leguminous trees (Singer et al. 1983). *Sarcodon atroviridis* occurs in mixed woods. Found in eastern and southeastern North America (Phillips 2006). Collections also known from Japan and India but probably introduced since collected in a botanical garden (Leelavathy et al. 1986).

***Scleroderma albidum*** Pat. & Trab.

Distribution – SC – Córrego Grande, Correia Pinto, Rio Vermelho, Três Barras; RS – Capitão, Minas do Leão, Pareci Novo, Rio Grande, Santa Cruz do Sul, Santa Maria, São Leopoldo, Viamão.

Habitat and substrate – *Eucalyptus* plantations, plantations of *Pinus elliottii* Engelm. and *P. taeda* L.; terricolous.

Literature: Cortez et al. (2008b: 293), Cortez (2011b: 47), Giachini et al. (2000: 1169), Guzmán (1970: 301).

Comments – *Scleroderma albidum* occurs in SW Australia (<http://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:apni.taxon:268116>) and Argentina with introduced pine and eucalypts species (Nouhra et al. 2012). In Brazil this species is frequently collected under *Eucalyptus* spp., and according to Cortez et al. (2011b) is apparently associated with several other tree species.

***Scleroderma areolatum*** Ehrenb.

Distribution – SC – Córrego Grande,



Correia Pinto, Rio Vermelho, Três Barras.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Giachini et al. (2000: 1169).

Comments – This species is mycorrhizal with hardwoods and conifers in moist, shady woods. *S. areolatum* is widely distributed in Europe (*Fagus*, *Pinus*) and North America (*Castanea*) (Phillips 2006). In Argentina recorded under planted *Pinus* spp., *Populus* sp. and *Quercus* sp. (Nouhra et al. 2012).

***Scleroderma bougheri*** Trappe, Castellano & Giachini

Distribution – SC – Correia Pinto, Rio Vermelho, Três Barras.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Giachini et al. (2000: 1169).

Comments – *Scleroderma bougheri* is a hypogeous ectomycorrhizal fungus described from Australia and Brazil (Giachini et al. (2000).

***Scleroderma bovista*** Fr.

Distribution – SC – Córrego Grande, Correia Pinto, Joinville, Rio Vermelho, Três Barras; RS – Porto Alegre, Santa Maria.

Habitat and substrate – *Eucalyptus* plantations, plantations of *Pinus elliottii* Engelm., and *P. taeda* L.; terricolous.

Literature – Cortez (2011b: 47), Giachini et al. (2000: 1169), Guzmán (1970: 344, the author did not mention the name of the state but the collector is Rick).

Comments – *Scleroderma bovista* occurs in Europe and North America usually in hardwood forests. In Argentina it has been observed with exotic planted trees (Nouhra et al. 2012). The species was also recorded in New Zealand (Dunstan et al. 1998). In Brazil the species was found growing associated with a native tree (*Gomidesia spectabilis* [DC.] Berg.) in the northeast (Gurgel et al. 2008).

***Scleroderma cepa*** Pers.

Distribution – SC – Correia Pinto.

Habitat and substrate – plantations of *Eucalyptus dunnii* Maid.; terricolous.

Literature – Giachini et al. (2000: 1169).

Comments – *Scleroderma cepa* is a widespread ectomycorrhizal species on hardwoods (*Quercus*, *Populus*), found in North America (Coker & Couch 1928), South Africa (Bottomley 1948) and Australia (under *Eucalyptus* - <http://australianfungi.blogspot.com/2010/07/39-scleroderma-cepa.html>).

***Scleroderma citrinum*** Pers.

Distribution – PR – Castro; SC – Córrego Grande, Correia Pinto, Joinville, Rio Vermelho, Três Barras; RS – Nova Petrópolis, Santa Maria, São Francisco de Paula, São Leopoldo.

Habitat and substrate – *Pinus* plantations, plantations of *P. elliottii* Engelm. and *P. taeda* L.; occurs in living wood, terricolous.

Literature – Cortez (2011b: 47), de Meijer (2001: 114, 2006: 43), Giachini et al. (2000: 1169), Rick (1961b: 458, as *Scleroderma vulgare* Hornem.), Sobestiansky (2005: 453).

Comments – *Scleroderma citrinum* is common in Europe, also recorded in South America, South Africa and New Zealand (Dunstan et al. 1998). The species is ectomycorrhizal with a range of broadleaf species and conifers.

***Scleroderma dictyosporum*** Pat.

Distribution – RS – Santa Maria.

Habitat and substrate – near *Acacia caven* (Molina) Molina; terricolous.

Literature – Cortez et al. (2011b: 49).

Comments – Cortez et al. (2011b) reported this species distributed across dry regions of Africa, Asia and America, as well as the subtropical zone. The Brazilian specimens were found growing near the base of *Acacia caven* (Molina) Molina, a native species from Southern South America. Authors also reported that in Africa *S. dictyosporum* has been found as an ectomycorrhizal partner of other acacia species, such as *A. holosericea* A.Cunn. ex G. Don, and *A. mangium* Willd. (see also Founoune et al. 2002, Duponnois et al. 2005, Sanon et al. 2009). *Scleroderma dictyosporum* is ectomycorrhizal with *Afzelia africana* Sm.

from West Africa (Ba & Thoen 1990) and with *Uapaca guineensis* Müll. Arg., from Southern Senegal (Thoen & Ba 1989). It has also been described associated with *Eucalyptus* from Congo (Garbaye et al. 1988).

***Scleroderma floridanum*** Guzmán

Distribution – SC – Córrego Grande, Correia Pinto, Rio Vermelho, Três Barras.

Habitat and substrate – *Eucalyptus* plantations, plantations of *Pinus elliottii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1169).

***Scleroderma fuscum*** (Corda) E. Fisch.

Distribution – RS – Porto Alegre, Santa Maria; SC – Correia Pinto, Joinville, Rio Vermelho, Três Barras.

Habitat and substrate – plantations of *Pinus elliottii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1171), Cortez (2011b: 49).

Comments – *Scleroderma fuscum* forms ectomycorrhizae with *Pinus* spp. and is reported from several regions, including South America (Cortez et al. 2011b).

***Scleroderma laeve*** Lloyd

Distribution – RS – Porto Alegre.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Cortez et al. (2011b: 49).

Comments – This species forms ectomycorrhizae with *Eucalyptus* spp. (Cortez et al. 2011b) in a non-specific manner (Malajczuk et al. 1982).

***Scleroderma uruguayense*** (Guzmán) Guzmán

Distribution – SC – Córrego Grande, Correia Pinto, Rio Vermelho.

Habitat and substrate – plantations of *Pinus elliottii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1169).

***Scleroderma verrucosum*** (Bull.) Pers.

Distribution – PR – Colombo, Curitiba, São José dos Pinhais; SC – Córrego Grande;

RS – Nova Petrópolis, Santa Maria.

Habitat and substrate – pasture, plantations of *Pinus elliottii* Engelm., *Eucalyptus* plantations; terricolous.

Literature – Cortez et al. (2011b: 50), de Meijer (2001: 114, 2006: 43, as *Scleroderma* cf. *verrucosum*), Giachini et al. (2000: 1169), Rick (1961b: 458), Sobestiansky (2005: 454, as *Scleroderma* cf. *verrucosum*).

Comments: *Scleroderma verrucosum* is a cosmopolitan species (Guzmán 1970). It is commonly found in Europe in mixed or broadleaf forests. The species was introduced to New Zealand with *Quercus* spp. and *Pinus radiata*. *S. verrucosum* is ectomycorrhizal with *Azelia africana* Sm., in West Africa (Ba & Thoen 1990) and cultivated in Burkina Faso with the native vegetation - *Uapaca somon* (<http://senegal.ird.fr>). In Brazil it was reported from several States (Cortez 2011b).

***Sclerogaster luteocarneus*** (Bres.) Zeller & C.W. Dodge

Distribution – PR – Fênix; RS – Poço das Antas.

Habitat and substrate – seasonal semi-deciduous submontane/montane forest; on dead wood, terricolous.

Literature – de Meijer (2001: 113, 2006: 43), Dodge & Zeller (1936: 570), Rick (1961b: 457, as *Octaviania luteocarnea* Bres.), Singer (1962: 54, as *Sclerogaster* cf. *luteocarneus*).

Comments – *Sclerogaster luteocarneus* is found in tropical America (Dodge & Zeller 1936).

***Setchelliogaster tenuipes*** (Setch.) Pouzar

Distribution – SC – Correia Pinto; RS – Guaíba, Viamão.

Habitat and substrate – *Eucalyptus* plantations, plantations of *E. dunnii* Maid.; terricolous.

Literature – Cortez et al. (2008a: 514), Giachini et al. (2000: 1168).

Comments – *Setchelliogaster tenuipes* occurs in Argentina (Nouhra et al. 2008), Australia (Grgurinovic 1997) and Europe (Montecchi & Sarasini 2000). This species is associated with *Eucalyptus* spp. (Lago & Castro 2004).

***Suillus cothurnatus*** Singer

Distribution – SC – Correia Pinto, Rio Vermelho, Três Barras; RS – Nova Petrópolis; PR – Colombo.

Habitat and substrate – *Pinus* plantations, plantations of *P. elliottii* Engelm., *P. patula* Schiede ex Schltdl. & Cham. and *P. taeda* L.; terricolous.

Literature – de Meijer (2001: 113, 2006: 44), Giachini et al. (2000: 1168), Sobestiansky (2005: 454), Watling & de Meijer (1997: 236).

Comments – Occurring in the vicinity of *Pinus palustris* Mill. or *P. taeda* L., though occasionally as far as 11 m from the nearest pine tree (Singer et al. 1983). *S. cothurnatus* is native to North America (Singer 1945).

***Suillus granulatus*** (L.) Kuntze

Distribution – PR – Colombo; SC – Córrego Grande, Correia Pinto; RS – Santa Cruz do Sul, Venâncio Aires.

Habitat and substrate – *Pinus* plantations, plantations of *P. elliottii* Engelm., *P. patula* Schiede ex Schltdl. & Cham., *P. taeda* L.; terricolous.

Literature – de Meijer (2001: 113, 2006: 44), Giachini et al. (2000: 1168), Putzke et al. (1994: 90), Watling & de Meijer (1997: 238).

Comments – *Suillus granulatus* grows with *Pinus* spp. on calcareous and acid soils, sometimes in large numbers. It is native to the Northern hemisphere and common in Britain, continental Europe, and North America. It has also been introduced to Australia (Phillips 2006), South Africa and New Zealand (Dunstan et al. 1998), probably with *Pinus radiata* D. Don.

***Suillus luteus*** (L.) Roussel

Distribution – PR – Colombo; RS – Canela, Nova Petrópolis, Pelotas.

Habitat and substrate – *Pinus* plantations, plantations of *P. elliottii* Engelm.; terricolous.

Literature – de Meijer (2001: 113, 2006: 44), Putzke et al. (1994: 88), Sobestiansky (2005: 454), Watling, de Meijer (1997: 238).

Comments – *Suillus luteus* is found in the Northern hemisphere. It is common in pine

plantations, especially young forests. The species forms mycorrhizal with various *Pinus* species, including *P. sylvestris* L., *P. nigra* J.F. Arnold or *P. peuce* Griseb. in Europe, and *P. resinosa* Sol. ex Aiton and *P. strobus* L. in North America. It has also been introduced with pines to Australia, New Zealand and Argentina (Moser 1980). Singer (1945, 1949) and Putzke et al. (1994) refer this species as occurring only in *P. nigra* J.F. Arnold, *P. pinea* L., *P. sylvestris* L. and *P. resinosa* Sol. ex Aiton.

***Suillus subaureus*** (Peck) Snell

Distribution – RS – Vera Cruz.

Habitat and substrate – *Pinus* plantations; terricolous.

Literature – Putzke et al. (1994: 91).

Comments – *Suillus subaureus* is mycorrhizal with *Populus* spp., *Quercus berberidifolia* Liebm and *Pinus strobus* L. in North America (Roody 2003).

***Thelephora americana*** Lloyd

Distribution – SC – Rio Vermelho, Três Barras.

Habitat and substrate – *Eucalyptus* plantations, plantations of *Pinus elliottii* Engelm. and *P. taeda* L.; terricolous.

Literature – Giachini et al. (2000: 1169).

Comments – *Thelephora americana* is ectomycorrhizal with *Abies alba* Mill. based on a sequence similarity search (Grebenc et al. 2009). The species occurs in Canada, USA, Mexico, Japan and China (Corner 1968).

***Thelephora griseozonata*** Cooke

Distribution – SC – Rio Vermelho.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – Giachini et al. (2000: 1169).

Comments – *Thelephora griseozonata* is indigenous to New Zealand, but also found in North America under pines.

***Thelephora palmata*** (Scop.) Fr.

Distribution – PR – Pontal do Paraná.

Habitat and substrate: ‘restinga’; occurring on dead wood.

Literature – Meijer (2001: 113, 2006:

44).

Comments – *Thelephora palmata* is common in Europe and North America (Phillips 2006), mainly in coniferous woods. It is regarded as common in the North temperate zone. According to Chen et al. (2001), the species is ectomycorrhizal.

***Thelephora terrestris* Ehrh.**

Distribution – PR – General Carneiro; SC – Rio Vermelho, Três Barras.

Habitat and substrate – *Eucalyptus* plantations, *Pinus* plantations, plantations of *P. taeda* L.; terricolous, occurring on dead wood. Literature: de Meijer (2001: 114, 2006: 44), Giachini et al. (2000: 1169), Guerrero & Homrich (1999: 46).

Comments – *Thelephora terrestris* is known from Europe, North America, Japan, China, Jamaica, Brazil, Uruguay, Australia, New Zealand and South Africa. It occurs either on the ground in coniferous woods, saprophytic, mycorrhizal on *Betula*, *Picea*, *Pinus* and *Eucalyptus* (Agerer 1987-2008) or semi-parasitic (*sensu* Corner 1968). *Thelephora terrestris* was introduced to Australia during the establishment of exotic pines (Corner 1968). Malajczuk et al. (1982) reviewed host-sporocarp records and concluded that several fungal associates of pine, such as *T. terrestris*, were absent from eucalypt stands.

***Tricholoma atosquamosum* Sacc.**

Distribution – PR – Colombo.

Habitat and substrate – *Eucalyptus* plantations; unknown substrate.

Literature – de Meijer (2006: 45).

Comments – *Tricholoma atosquamosum* is native in Europe and has been also collected in North America (Phillips 2006). This species can be found in deciduous (*Fagus* spp., *Quercus* spp.) and coniferous (*Pinus* spp., *Picea* spp.) stands, mainly on calcareous soils. The species was also identified from roots of the heterotrophic plant *Pityopus californicus* (Eastwood) H. F. Copel., and from California, USA (Bidartondo & Bruns 2001).

***Tricholoma sulphurellum* Rick**

Distribution – RS – Esmeralda.

Habitat and substrate – *Araucaria* forest; terricolous.

Literature – Putzke (2003: 579); Rick (1961a: 304); Singer (1953a: 64); Singer et al. (1983: 173), Sulzbacher et al. (2007: 146).

Comments: Singer et al. (1983) pointed out the possibility of this species being ectomycorrhizal since it is a member of the section *Sericella* (Fr.) Quél. (= *Sericeocutis* Singer), a section known to contain ectomycorrhizal species.

***Tricholoma vaccinum* (Schaeff.) P. Kumm.**

Distribution – RS – locality unknown.

Habitat and substrate – forest; unknown substrate.

Literature – Rick (1961: 304).

Comments – *Tricholoma vaccinum* is mycorrhizal with conifer, especially *Picea* spp. and *Pinus* spp. It is common in Europe and widely distributed in the Northern portion of the Northern Hemisphere. In North America it is common in the Rockies and the Pacific Northwest (Trudell & Ammirati 2009).

***Xerocomus basius* de Meijer & Watling**

Distribution – PR – Campina Grande do Sul, Colombo, Curitiba, São José dos Pinhais.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous montane forest; terricolous.

Literature – de Meijer (2008: 44, 125, 373).

Comments – the species ectomycorrhizal status is unknown (de Meijer 2008). According to Tedersoo et al. (2010), *Xerocomus* is an ectomycorrhizal genus.

***Xerocomus brasiliensis* (Rick) Singer**

Distribution – RS – Nova Petrópolis, São Leopoldo.

Habitat and substrate – open places among Gramineae, subtropical and tropical forest, *Eucalyptus* plantations; terricolous, on rotten wood.

Literature – Gómez (1996: 61), Putzke et al. (1994: 92), Singer & Digilio (1957: 260), Singer et al. (1983: 65), Singer (1953a: 100, as *Boletus brasiliensis* Rick, 101, as *Phylloporus flavipes* Rick), Sobestiansky (2005: 443, as *Boletus brasiliensis*).

Comments – *Xerocomus brasiliensis* forms mycorrhiza with *Eucalyptus* (Singer et al. 1983) or is regarded as a putative

ectomycorrhizal fungus (Sobestiansky 2005). According to Tedersoo et al. (2010) the genus is ectomycorrhizal.

### Doubtful and undescribed taxa cited from Southern Brazil

#### *Amanita* cf. *crebresulcata* Bas

Distribution – PR – Antonina.

Habitat and substrate – dense ombrophilous forest; terricolous.

Literature – de Meijer (2006: 11).

Comments – Wartchow & Maia (2007) recorded this species from the state of Pernambuco in a tropical rain forest. The mycorrhizal association was not observed (Bas 1978).

#### *Amanita* sp. “A” subg. *Amanita* sect. *Ovigerae*

Distribution – PR – locality unknown.

Habitat and substrate – ‘restinga’; probably terricolous.

Literature – de Meijer (2001: 112, as *Amanita* sp. “A” subg. *Amanita* sect. *Ovigerae*).

#### *Cantharellus* cf. *cinnabarinus* (Schwein.) Schwein.

Distribution – PR – Antonina, Morretes, São José dos Pinhais.

Habitat and substrate – mixed ombrophilous forest, dense ombrophilous forest, ‘restinga’; standing trunks of living dicotyledonous trees.

Literature – de Meijer (2001: 112, 2006: 13, 2008: 44, 372).

Comments – *Cantharellus cinnabarinus* is native or common in eastern North America, Mexico (Pilz et al. 2003), Europe, Africa and Asia (Watling et al. 2002). Pilz et al. (2003) also noted that *C. cibarius* is likely to include multiple cryptic species in different regions. According to Wartchow et al. (2012a), it is highly unlikely that the material with the epithet ‘*cinnabarinus*’ occurs naturally in tropical South America. For more information see Buyck et al. (2011) and Buyck & Hofstetter (2011).

#### *Clavulina* aff. *rugosa* (Bull.) J. Schröt.

Distribution – PR – Curitiba.

Habitat and substrate – mixed ombrophilous forest; terricolous.

Literature – de Meijer (2006: 14, 2008: 372).

Comments – *Clavulina rugosa* is putative ectomycorrhizal (de Meijer 2008). This species is frequently found under conifers and hardwoods. It is presumably mycorrhizal. Its close relatives in the genus *Clavulina* were confirmed to be mycorrhizal with *Abies* in Europe (Grebenc et al. 2009). The *Dicymbe* forest in South America has several *Clavulina* reported species (Henkel et al. 2012). It is widely distributed in North America and Europe (Kuo 2007 – [http://www.mushroomexpert.com/clavulina\\_rugosa.html](http://www.mushroomexpert.com/clavulina_rugosa.html)).

#### *Cortinarius* spp. /records from de Meijer (2001, 2006)

Distribution – PR – Cerro Azul, Cornélio Procópio, Tunas do Paraná.

Habitat and substrate – dense ombrophilous forest, seasonal semi-deciduous submontane/montane forest, and mixed ombrophilous forest; terricolous, occurring on dead wood.

Literature – de Meijer (2001: 112, as *Cortinarius* sp. A (subg. *Sericeocybe* sect. *Pallidoviolaceae*), de Meijer (2001: 112, as *Cortinarius* sp. B (subg. *Sericeocybe* sect. *Sericeocybe*), de Meijer (2001: 112, as *Cortinarius* sp. C (subg. *Telamonia*), de Meijer (2001: 112, as *Cortinarius* sp. D (subg. *Telamonia*), de Meijer (2001: 112, as *Cortinarius* sp. E (subg. *Telamonia*), de Meijer (2006: 16, as *Cortinarius* sp. A (subg. *Sericeocybe* sect. *Sericeocybe*), de Meijer (2006: 17, as *Cortinarius* sp. B (subg. *Sericeocybe* sect. *Pallidoviolaceae*).

#### *Inocybe* aff. *cingulatipes* (Corner & E. Horak) Garrido

Distribution – PR – São José dos Pinhais.

Habitat and substrate – mixed ombrophilous forest; unknown substrate.

Literature – de Meijer (2006: 26).

#### *Inocybe* aff. *conspicuospora* Buyck & Eyssart.

Distribution – PR – Fênix.

Habitat and substrate – seasonal semi-deciduous, alluvial forest; unknown substrate.  
Literature – de Meijer (2006: 26).

***Inocybe* aff. *crassicystidiata*** Pegler  
Distribution – PR – Antonina.  
Habitat and substrate – dense ombrophilous forest; unknown substrate.  
Literature – de Meijer (2006: 26).

***Inocybe* aff. *incognita*** (E. Horak) Garrido  
Distribution – PR – Morretes.  
Habitat and substrate – dense ombrophilous forest; unknown substrate.  
Literature – de Meijer (2006: 26).

***Inocybe* cf. *matrisdei*** Singer  
Distribution – PR – locality unknown.  
Habitat and substrate: ‘restinga’; terricolous.  
Literature – de Meijer (2001: 112).  
Comments – Its association with any particular host tree and the full characteristics of the forest type have not been described (Singer et al. 1983).

***Inocybe* aff. *pahangi*** (Corner & E. Horak) Garrido  
Distribution – PR – Guaraqueçaba.  
Habitat and substrate – ‘restinga’; unknown substrate.  
Literature – de Meijer (2006: 26).

***Inocybe* aff. *xerophytica*** Pegler  
Distribution – PR – Paranaguá.  
Habitat and substrate – ‘restinga’; unknown substrate.  
Literature – de Meijer (2006: 26).

***Inocybe* spp.**/records from de Meijer (2001)  
Distribution – PR – locality unknown.  
Habitat and substrate – dense ombrophilous forest, ‘restinga’, seasonal semi-deciduous submontane/montane forest; terricolous.  
Literature – de Meijer (2001: 112, as *Inocybe* sp. A (subg. *Inocybe* sect. *Inocybe*), as *Inocybe* sp. B (subg. *Inocybe* sect. *Inocybe*), as *Inocybe* sp. C (subg. *Inocybe* sect. *Petiginosae*), as *Inocybe* sp. D (subg. *Inocybe* sect. *Petiginosae*).

***Lactarius* aff. *necator*** (Bull.) Pers.  
Distribution – RS – locality unknown.  
Habitat and substrate – forest; terricolous.

Literature – Rick (1961a: 364, as *L. adustus* Rick), Singer (1953a: 83 as *L. aductus*).  
Comments – As Singer (1953) noted, no specimens are preserved in Rick’s herbaria.

***Lactarius* spp.**/records from de Meijer (2001)  
Distribution – PR – locality unknown.  
Habitat and substrate – dense ombrophilous forest; terricolous.  
Literature – de Meijer (2001: 113), as *Lactarius* sp. “A” (aff. *venezuelanus* Dennis), as *Lactarius* sp. “B”).

***Phaeoclavulina* cf. *camellia*** (Corner) Giachini  
Distribution – PR – Campina Grande do Sul, Colombo, Piraquara, São José dos Pinhais.  
Habitat and substrate: dense ombrophilous forest, mixed ombrophilous forest; terricolous, occurring on dead wood.  
Literature – de Meijer (2001: 112, 2006: 41, 2008: 373, all as *Ramaria* cf. *camellia* Corner).

***Phaeoclavulina* aff. *eumorpha*** (P. Karst.) Giachini  
Distribution – PR – Fênix, Morretes, Paranaguá, Rio Branco do Sul, São José dos Pinhais.  
Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest, seasonal semi-deciduous submontane/montane forest; unknown substrate.

Literature – de Meijer (2006: 41, as *Ramaria* aff. *patagonica* (Speg.) Corner).

***Phaeoclavulina* spp.** / records from de Meijer (2006)  
Distribution – PR: São José dos Pinhais.  
Habitat and substrate – mixed ombrophilous forest; terricolous.  
Literature – de Meijer (2006: 41, as *Ramaria* sp. “A” (subgen. *Echinoramaria* ser. *Grandisporae*).

**Ramaria cf. aureofulva** Corner

Distribution – PR – São José dos Pinhais.

Habitat and substrate – mixed ombrophilous forest; unknown substrate.

Literature – de Meijer (2006: 41, 2008: 44, 373).

**Ramaria cf. reticulata** (Berk. & Cooke) Corner var. *macrospora* Corner

Distribution – PR – Cornélio Procópio.

Habitat and substrate – seasonal semi-deciduous submontane/montane forest; unknown substrate.

Literature – de Meijer (2006: 41).

**Russula cf. dennisii** Singer ex Buyck

Distribution – PR – Antonina.

Habitat and substrate – dense ombrophilous forest; unknown substrate.

Literature: de Meijer (2006: 42).

**Russula spp.**/records from de Meijer (2001)

Distribution – PR – locality unknown.

Habitat and substrate: dense ombrophilous forest, gallery forest in area of savanna, ‘restinga’; terricolous.

Literature – de Meijer (2001: 113, as *Russula* sp. “A”, as *Russula* sp. “B”, as *Russula* sp. “C”, as *Russula* sp. “D”).

**Thelephora spp.**/records from de Meijer (2001)

Distribution – PR – locality unknown.

Habitat and substrate – mixed ombrophilous forest; occurring on dead wood.

Literature – de Meijer (2001: 113, as *Thelephora* sp. “A”).

**Tricholoma cf. eucalypticum** A. Pearson

Distribution – PR – Curitiba.

Habitat and substrate – *Eucalyptus* plantations; terricolous.

Literature – de Meijer (2001: 113, 2006: 45).

**Tricholoma spp.**/records from de Meijer (2001)

Distribution – PR – locality unknown.

Habitat and substrate – mixed ombrophilous forest, *Eucalyptus*-plantations,

*Pinus*-plantations, seasonal semi-deciduous alluvial forest; terricolous.

Literature – de Meijer (2001: 112-113, as *Tricholoma* sp. “A” aff. *imbricatum* (Fr.: Fr.) Kummer; *Tricholoma* sp. “B” subg. *Tricholoma* sect. *Genuina*, and *Tricholoma* sp. “C”. subg. *Tricholoma* sect. *Tricholoma*.”).

**Tylopilus spp.**/records from de Meijer (2001, 2006), Watling & de Meijer (1997)

Distribution – PR – locality unknown.

Habitat and substrate – dense ombrophilous forest; terricolous or growing at the base of a living tree-fern trunk (Watling & de Meijer 1997: 240).

Literature – de Meijer (2001: 112, 2006: 45, both as cf. *Tylopilus* sp.), Watling & de Meijer (1997: 240).

Comments – Putative ectomycorrhizal, based on the fact that several species from the genus are known to be ectomycorrhizal (Halling et al. 2008, Tedersoo et al. 2010).

**Xerocomus aff. coccolobae** Pegler

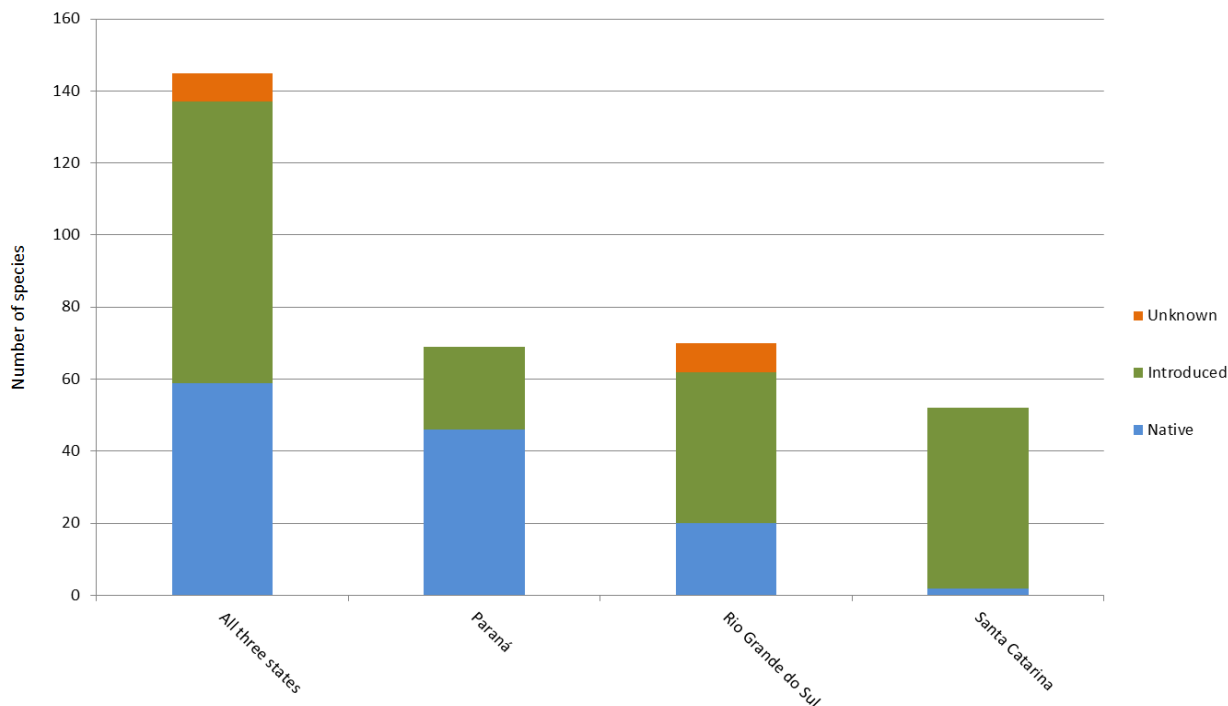
Distribution – PR – Curitiba, Campina Grande do Sul, Mandirituba, São José dos Pinhais.

Habitat and substrate – dense ombrophilous forest, mixed ombrophilous forest; terricolous.

Literature – de Meijer (2001: 112, 2006: 45, as *Xerocomus* sp. “A”), Watling & de Meijer (1997: 239, as *Xerocomus* cf. *coccolobae* Pegler).

**Ectomycorrhizal fungi from Southern Brazil in perspective of the origin and plant partners**

From a list of 144 species and affiliated species, over half (80 species) are considered to be introduced from other continents. In particular, from Santa Catarina and Rio Grande do Sul most of the recorded ECM species were introduced (Fig. 1). In Parana the dominance of native ECM species was observed mainly due to de Meijer’s studies on macromycetes (Buyck & de Meijer 1999, de Meijer 2001, 2006, 2008, Watling & de Meijer 1997). That author described 37 potentially ECM species from mixed ombrophilous forests (including *Araucaria* forest).



**Fig. 1** – Number of introduced or native ectomycorrhizal fungal species recorded from the states of Parana, Rio Grande do Sul and Santa Catarina (Southern Brazil), and the total for all three states.

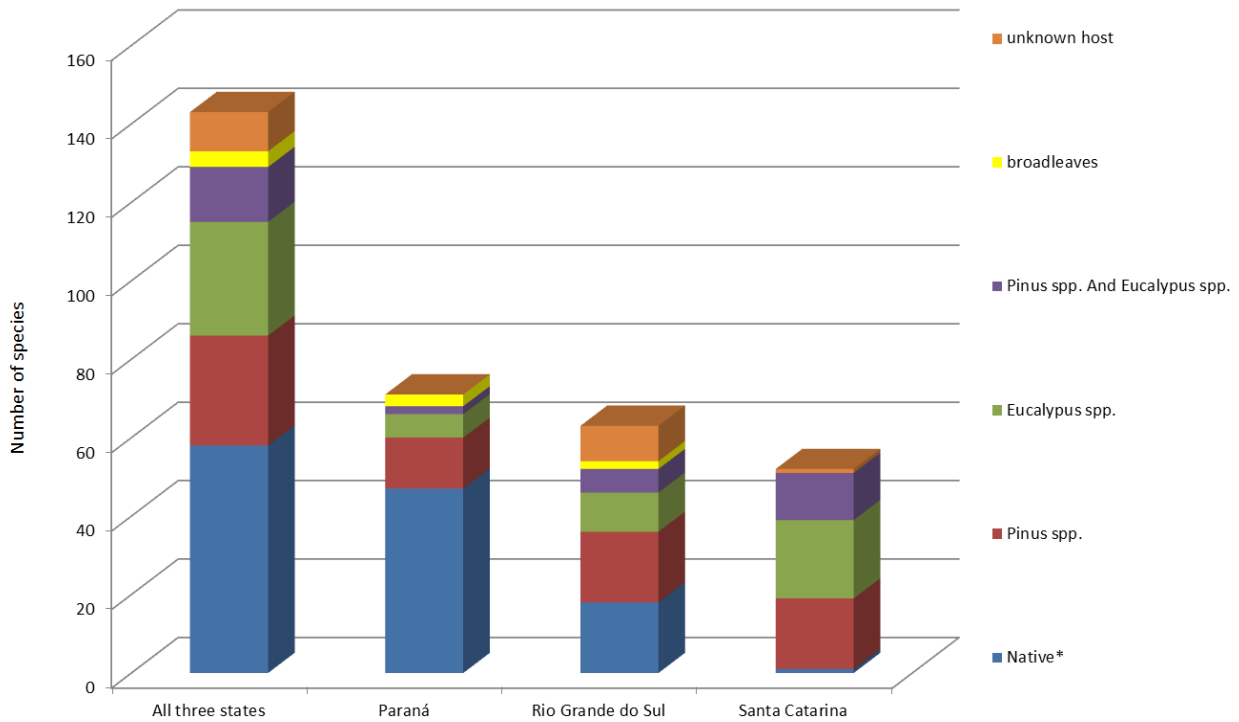
The differences among states (Fig.1) reflect the focus of research in past decades (Fidalgo 1962, 1968, Putzke 1994), in particular the mycological studies of introduced species plantations (Cortez et al. 2008a, Cortez et al. 2011a, Giachini et al. 2000, Giachini et al. 2004, Sulzbacher et al. 2010, Putzke 1999; in parts also Cortez et al. 2008, b, 2009, 2011b, Guzmán 1970, Putzke et al. 1994, Rick 1961a, b, Sobestiansky 2005) and the fact that plantations in the whole country cover about 5.98 million ha. These plantations where *Eucalyptus* spp. and *Pinus* spp. dominated as plant ECM partners, contributed equally to the number of recorded introduced ECM species. Most of the introduced ECM species listed were published in Giachini et al. (2000), who in particular surveyed the ECM fungal communities in the state of Santa Catarina. Their work resulted in 49 reported taxa, including three new described species to Southern Brazil. Other introduced plantation tree species (*Acacia*, *Castanea*, *Populus*, *Salix*) are of minor importance and of a low influence to the recorded ectomycorrhizal diversity and were only rarely available in the analysed references (Fig. 2).

Most of the ECM fungi introduced to Southern Brazil originate from North America and Europe. In Southern Brazil these fungi were found associated with *Pinus* spp. or recorded in association with both *Pinus* and *Eucalyptus*. As expected, most of the species originally known from Australia and New Zealand were found associated with *Eucalyptus* spp. plantations. Most of the ectomycorrhizal fungi associated with other broadleaf hosts were also native to Europe or North America (Fig. 3). As for origin, the rest of the world (Asia, Africa) did not contribute significantly to the number of ectomycorrhizal species observed in Southern Brazil.

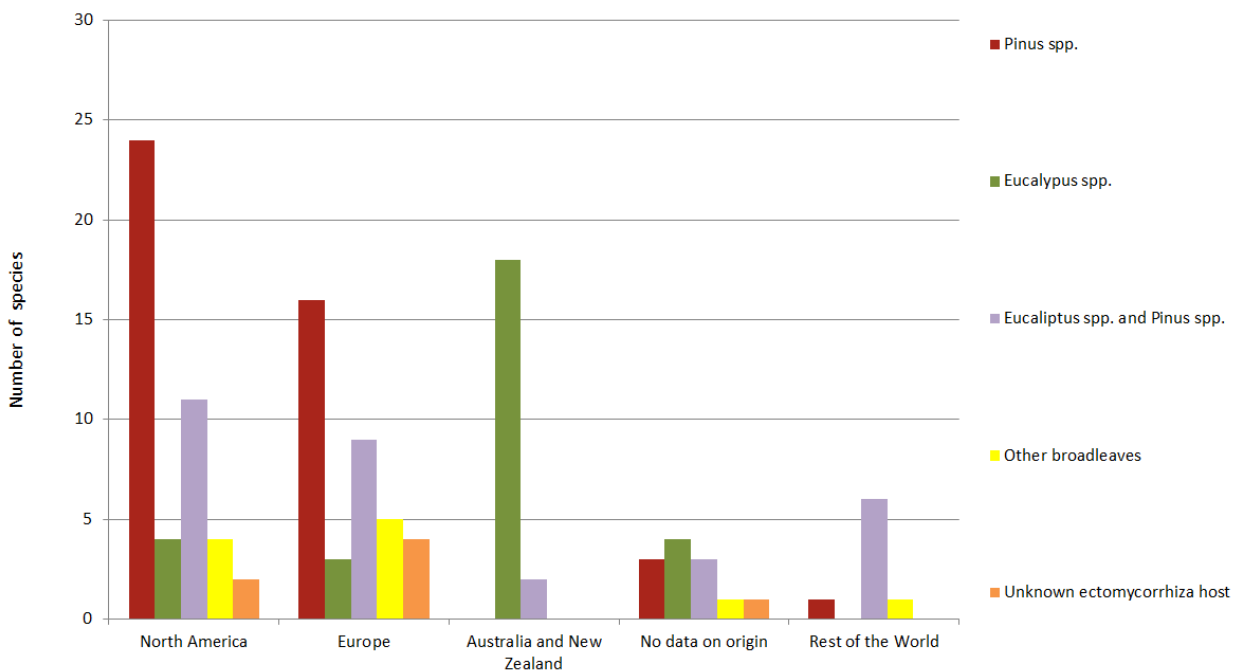
### Conclusion

In total 144 ectomycorrhizal or putatively ectomycorrhizal taxa were recorded in publications for the area of Southern Brazil (states of Rio Grande do Sul, Santa Catarina and Parana). In this region, climate, soil and vegetation are very different from the rest of the country (Dieckow et al. 2009). Thus, these conditions play a particular role in defining the relation between fungi and host. Over half of introduced plant partners (mainly *Eucalyptus*





**Fig. 2** – Number of introduced ectomycorrhizal fungal species recorded and potential ectomycorrhizal plant partners. Data based on published scientific papers summarised for three Southern Brazil states. Some species were found associated with more than one category of ectomycorrhizal partner or the host was unknown.



**Fig. 3** – Global distribution/origin of the ectomycorrhizal fungi recorded in Southern Brazil. Species associated with hosts grouped either at the genus level, or at a higher level if available data were too general. The origin data is based on the combination of host and fungus origin.

spp. and *Pinus* spp.) are well-known ECM in the Northern hemisphere or Australia and were introduced into Southern Brazil by means of the hand. Still, several of the listed species, are found only in South America (including Southern Brazil). For these, the majority has no definite record as being ectomycorrhizal and requires ECM description and/or molecular confirmation (sensu Agerer 1991). Therefore, there is still a need for further investigation in order to provide information on their ECM status, host partners range and ecological and seasonal distribution. Additionally, a number of the species still need more detailed taxonomic revision, including modern morphological analysis, application of molecular markers and phylogenetic species concept as a tool to better support their placement within a taxonomic classification. Future work aims to fill the missing gaps in knowledge of the diversity, mycorrhizal status and general ecology of the species listed here.

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