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Gasteroid mycobiota of Rio Grande do Sul, Brazil: Boletales

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Boletales is an order of the subclass Phallomycetidae, which comprises of a wide variety of morphological types of macrofungi, including the boletes and earthballs. In this paper, the gasteroid members of the Boletales from Rio Grande do Sul State, in southern Brazil, were revised. Specimens were collected during the years 2006 to 2009, analyzed macro and microscopically and the collections are preserved at the herbarium ICN. The following taxa were recorded: *Rhizopogon roseolus* (*Rhizopogonaceae*), *Calostoma zanchianum*, *Pisolithus arhizus*, *Scleroderma albidum*, *Scleroderma bovista, Scleroderma citrinum*, *Scleroderma dictyosporum*, *Scleroderma fuscum*, *Scleroderma laeve* and *Scleroderma verrucosum* (*Sclerodermataceae*). *Scleroderma dictyosporum* and *S. laeve* are reported for the first time from Brazil. A key for the identification of the species of *Scleroderma* is provided and colour photographs and line drawings of the basidiospores are presented for all taxa studied.

Key words: Basidiomycota, calostomataceae, ectomycorrhizal fungi, *Eucalyptus*, *Pinus*, pisolithaceae, taxonomy.

INTRODUCTION

The order Boletales E. J. Gilbert comprises a wide grouping of macrofungi of several morphological typologies, such as boletoid (poroid and lamellate), gasteroid, secotioid, agaricoid, corticioid, merulioid, hydroid, and polyporoid (Binder and Hibbett, 2006). The phylogeny of this group has been investigated in recent years by a number of authors (Høiland, 1987; Kretzer and Bruns, 1999; Jarosch, 2001; Binder and Bresinsky, 2002), and the current trend in their classification is the recognition of six well-supported lineages within *Boletales*, considered at the subordinal level: Boletineae, Coniophorineae, Paxillineae, Sclerodermatineae, Suillineae, and Tapinellineae (Binder and Hibbett, 2006). Although some taxa are saprotrophs or even mycoparasites, the mycorrhizal association with a large number of plant families is a noteworthy feature in the group, and genera such as *Boletus* Dill. Ex. Fr., *Rhizopogon* Fr. and Nordholm, *Scleroderma* Pers. and *Suillus* Gray, play an important role in natural forest ecosystems and forestry (Cairney and Chambers, 1999; Futai et al., 2008).

In Brazil, the knowledge of the *Boletales* is almost limited to surveys of boletoid members (Putzke et al., 1994; Watling and Meijer, 1997; Giachini et al., 2000), and little information on the other representatives is available. In a recently published Brazilian checklist, Neves and Capelari (2007) reported 20 genera and 70 species (seven *Rhizopogon* species) belonging to the *Boletales sensu* Kirk et al. (2001), thus not including the Sclerodermataceae. The gasteroid genera of *Boletales* are currently classified in to the *Diplocystaceae Kreisel*

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(Astraeaceae Zeller ex. Jülich.), Rhizopogonaceae Gäum. and C.W. Dodge, and *Sclerodermataceae* Corda (*Calostomataceae* E. Fisch., Pisolithaceae Ulbrich), and other unknown families in Brazil. *Scleroderma* is the largest and best known genus, with approximately 30 species, 13 of which are known from Brazil (Guzmán, 1970; Baseia and Milanez, 2000; Giachini et al., 2000; Meijer, 2006; Gurgel et al., 2008). A number of *Pisolithus*, *Rhizopogon*, and *Scleroderma* species were reported from Rio Grande do Sul State by Rick (1961), Guzmán (1970), Sobestiansky (2005) and Cortez et al. (2008a). This study aimed to provide information on the diversity of the gasteroid members of the Boletales in Rio Grande do Sul State, southern Brazil, and comprises partial results of a comprehensive survey of the gasteroid fungi of the state (Cortez et al*.,* 2008a, b, 2009, 2010, 2011a, b; Sulzbacher et al., 2010).

MATERIALS AND METHODS

Fresh material was collected from March 2006 to 2009 during gasteromycete surveys in Rio Grande do Sul State, southern Brazil. Collected specimens are preserved in the ICN herbarium (Instituto de Biociências, Universidade Federal do Rio Grande do Sul). Macroscopical analysis comprised the study of external and internal features of the peridium (color, texture, thickness) and the gleba (color, consistency) and also peristome and rhizomorphs. Microscopical study was done with free-hand sections of the basidiomata mounted on slides in 5% KOH (potassium hydroxide) or 1% Congo Red. Measurements and line drawings were made with a light microscope equipped with a camera lucida; 25 measurements for each microstructure were considered. In all basidiospore measurements, the diameter of the complex ornamentation is included. Morphology and taxonomy followed BY Kirk et al. (2008) and for identification of *Scleroderma* $_{spp.}$, Guzmán's (1970) monograph and the revised key by Sims et al. (1995) were followed. Colour terminology is according to Kornerup and Wanscher (1978).

RESULTS AND DISCUSSION

Rhizopogonaceae Gäum. and C.W. Dodge

Rhizopogon roseolus (Corda) Th. Fr., Svensk Bot. Tidskrift 1: 282, 1909. Figures 1a and 2a. Basidiomata 14 to 44 mm diam., 19 to 40 mm high, subglobose to broad pyriform, with basal rhizomorphs attached to soil and roots. Peridium 1 to 1.5 mm thick, white (5A1), reddish blond (5C3) to brownish orange (5C6) with pastel red (9A4) spots where handled. Gleba loculate, with a slightly gelatinous consistency but very hard when dried, white (5A1) when young, becoming greyish yellow (5C5) to yellowish brown (5D5) at maturity. Basidiospores (7–) 8.5–10 x (3.5–) 4.2–5 µm, ellipsoid, with a slightly truncate apex, guttulate, walls smooth and thickened, hyaline to pale greenish. Basidia 21–29.5 x 5–9.2 µm, ventricose to sublageniform, bearing six sterigmata, hyaline. Peridium composed of prostrate to interwoven hyphae, 3.5 to 7.5 µm diameter, yellowish brown, walls thin but encrusted with abundant brown crystals. Hyphae of the trama 2.5 to 5 µm diameter, hyaline, smooth and thin-walled, simple-septate, gelatinized and interwoven.

Examined specimens: BRAZIL. Rio Grande do Sul State. Itaara, 10/V/2006, *V.G. Cortez 043/06* (ICN); 27/IV/2007, *V.G. Cortez 069/07* (ICN). Santa Maria, 15/V/2007, *V.G. Cortez 096/07* (ICN); 16/V/2008, *V.G. Cortez 099/08* (ICN); 18/VI/2008, *V.G. Cortez 118/08* (ICN).

Distribution: widespread in *Pinus* spp. plantations worldwide. Brazil: São Paulo (Baseia and Milanez, 2002), Paraná (Meijer, 2006) and Rio Grande do Sul.

Discussion: *Rhizopogon* is an ectomycorrhizal genus introduced in Brazil through seedlings of exotic North American *Pinus* spp. (Baseia and Milanez, 2002). The basidiomata grow semi-hypogeously around *Pinus* trees, associated with their roots, especially in autumn. The specimens from a *Pinus* plantation reported by Sobestiansky (2005) in Rio Grande do Sul possibly belong to this species, but that material was not included in this study. Giachini et al. (2000) reported the following species from the neighboring state of Santa Catarina: *Rhizopogon fuscorubens* A.H. Sm., *Rhizopogon nigrescens* Coker and Couch, *Rhizopogon rubescens* Tul., *Rhizopogon vulgaris* (Vittad.) M. Lange, and *Rhizopogon zelleri* A.H. Sm. *Rhizopogon roseolus* is a new record from Rio Grande do Sul.

Sclerodermataceae Corda

(i) *Calostoma zanchianum* (Rick) Baseia and Calonge, Mycotaxon 95: 114, 2006.
≡ *Mitremyces zanchianus* Rick, Iheringia, Série Botânica 9: 456, 1961.

Examined specimen: Brazil. Rio Grande do Sul State. São João do Polêsine (formerly Cachoeira do Sul), III.1943, *R. Zanchi* (PACA 19673, holotype).

Discussion: This is the only known *Calostoma* from southern Brazil. The type and only preserved specimen was described by Rick (1961) as *Mitremyces zanchianus.* Descriptions, illustrations (including SEM images of the basidiospores) and a discussion on this species are found in Baseia et al. (2006, 2007).

(ii) *Pisolithus arhizus* (Pers.) Rauschert, Zeitschrift für Pilzkunde 25: 50, 1959.
= *Pisolithus tinctorius* (Pers.) Coker and Couch, Gasterom. East. USA and Canada: 170, 1928 Figures 1b and 2b. Basidiomata globose, subglobose to hemispheric, 40 to 64 mm diamater, 44 to 129 mm high, with a

Figure 1. Basidiomata of gasteroid *Boletales.* (a) *Rhizopogon roseolus*. (b) *Pisolithus arhizus*. (c) *Scleroderma albidum*. (d) *S. bovista*. (e) *S. citrinum*. (f) *S. fuscum*. (g) *S. laeve.* (h) *S. verrucosum.* Scale bar = 20 mm. Photos: (a-c, e-f, h) by Vagner G. Cortez, (d) by M.A. Sulzbacher, (g) by M.A. Reck.

distinct rhizomorphic base, commonly forming pseudo-stipe in larger and older specimens. Peridium thin (<0.5 mm thick), smooth, greyish yellow (4C5) olive brown (4E8) when young to olive brown (4F8) when mature;

dehiscence irregular, exposing the mature gleba and peridioles. Gleba composed of irregular shaped peridioles, 2 to 4.5 mm diam., which mature from the base toward the top of the basidioma, mature gleba pulverulent, olive brown (4E8). Basidiospores 7.5 to 11 µm diam., globose, yellowish brown in KOH, echinate, with spines 1 to 1.7 µm long.

Examined specimens: Brazil. Rio Grande do Sul State. Capão do Leão, 06/V/1996, *C. Rodrigues 355* (PEL 15419); Porto Alegre, 18/VI/1965 (SP 91481); Rio Grande, 25/V/1992, V.L.N. Susin (HURG 3732); 25/VI/1990, V.L.N. Susin et al. (HURG 3530); 27/IX/1993, C.M. Abreu and M.S. Farias (HURG 3008); 07/VI/2008, V.G. Cortez 108/08 (ICN); Santa Maria, 23/III/2007, V.G. Cortez 025/07 (ICN); 24/III/2008, V.G. Cortez 066/08 (ICN); Viamão, 13/IX/1967, O. Dieffenbach (ICN 5818).

Distribution: cosmopolitan in *Eucalyptus* plantations worldwide. Brazil: known records from the States of Espirito Santo (Vinha, 1988), São Paulo (Bononi et al., 1981), and Rio Grande do Sul (Guerrero and Homrich, 1999).

Discussion: *P. arhizus* (often referred as *P. tinctorius*) is recognized by its globose, echinate basidiospores, which are larger than those of *P. microcarpus* [5–7 µm diameter. sensu Cunningham (1942)]. This is the best known species of the genus and has been intensively studied due to its importance in forestry as an ectomycorrhizal partner of eucalypts and other cultivated trees (Cairney and Chambers, 1997, 1999). In Rio Grande do Sul, specimens were collected in eucalypt and pine (*Pinus elliottii* Engelm.) plantations and near native pink trumpet trees [*Tabebuia heptaphylla* (Vell.) Vell.].

(iii) *Scleroderma albidum* Pat. and Trab. emend. Guzmán, Darwiniana 16: 295, 1970.

Figures 1c and 2c. Basidiomata 14 to 24 mm diameter, 17 to 40 mm high, depressed globose to pyriform, with a small rhizomorphic base. Peridium <1 mm thick when fresh, leathery, surface partially smooth with scattered, small and thin scales, greyish yellow (4C5) to brownish orange (5C5). Gleba olive brown (4F8), compact to pulverulent at maturity. Basidiospores 12 to 17 µm diam., globose, brown, densely echinate and not reticulate, the spines are pointed and slightly curved. Peridium formed by an external layer composed of orange brown, clavate hyphae, 13–21 x 5–9 µm, and an internal layer formed by interwoven, yellowish to hyaline hyphae, 4–7.5 µm diameter, not clamped.

Examined specimens: Brazil. Rio Grande do Sul State. Capitão, 30/V/2007, V.G. Cortez 117/07 (ICN); Minas do Leão, 26/V/2008, V.G. Cortez 093/08 (ICN); 18/VI/2008, V.G. Cortez 121/08 (ICN); Rio Grande, 23/V/1997, A.C.S. Campos (HURG 1669); Santa Cruz do Sul, 19/05/2008, M.A. Sulzbacher (ICN); 03/VI/2007, M.A. Sulzbacher and V.G. Cortez 122/07 (ICN); 29/VII/2007, V.G. Cortez 149/07 (ICN); Santa Maria, 03/VI/2006, V.G. Cortez 053/06 (ICN, UFRN-Fungos), G. Coelho and V.G. Cortez 011/08 (ICN); 14/III/2008, V.G. Cortez 058/08 (ICN), São Leopoldo, 07/V/1960 (SP 61721); Viamão, 22/V/2004, V.G. Cortez 024/04 (ICN).

Distribution: common in southern hemisphere, Asia and North America, but infrequent in Europe (Guzmán, 1970). In Brazil it is known from the states of Pernambuco (Gurgel et al., 2008), Minas Gerais, Rio de Janeiro, São Paulo (Guzmán, 1970), Santa Catarina (Giachini et al.,2000) and Rio Grande do Sul (Cortez et al., 2008a).

Discussion: *Scleroderma albidum* belongs to *Scleroderma* section *Aculeatispora* because of the spiny and non-reticulate basidiospores and absence of clamp connections in the hyphae (Guzmán, 1970; Sims et al., 1995). This is one of the most common species of the genus in Rio Grande do Sul, apparently associated with several trees, although more frequently collected under *Eucalyptus* spp., where it sometimes grows sub-hypogeously.

(iv) *Scleroderma bovista* Fr., Syst. Mycol. 3: 48, 1829. Figures 1d and 2d. Basidiomata 13–24 mm diam., 10–16 mm high, depressed subglobose to subglobose, with a short rhizomorphic base (<7 mm high). Peridium <1 mm thick when dried, fleshy and soft when fresh, surface partially smooth towards the base and cracked on top, reddish blond (4C3) to brownish orange (4C4). Gleba pulverulent when mature, olive (3E5). Basidiospores 12–14.4 µm diam., globose, orange brown to dark brown, reticulate-echinate, the reticulation not continuous, and the spines are pointed to slightly curved. Peridium formed by yellowish to hyaline, prostrate to more or less interwoven, clamped hyphae.

Examined specimens: Brazil. Rio Grande do Sul State. Santa Maria, 03/II/2009, M.A. Sulzbacher and V.G. Cortez 002/09 (ICN).

Distribution: known from all continents, mostly distributed in the Americas (Guzmán, 1970). Brazil: known from the states of Pernambuco, São Paulo (Gurgel et al., 2008), Santa Catarina (Giachini et al., 2000), and Rio Grande do Sul.

Discussion: *S. bovista* has been differently interpreted by many authors and the taxonomic problems have been discussed in detail by Guzmán (1970). The *S. bovista* material reported from Brazil by Guzmán (1970) was probably collected by J. Rick in Rio Grande do Sul.

(v) *Scleroderma citrinum* Pers., Syn. Meth. Fung. 153,

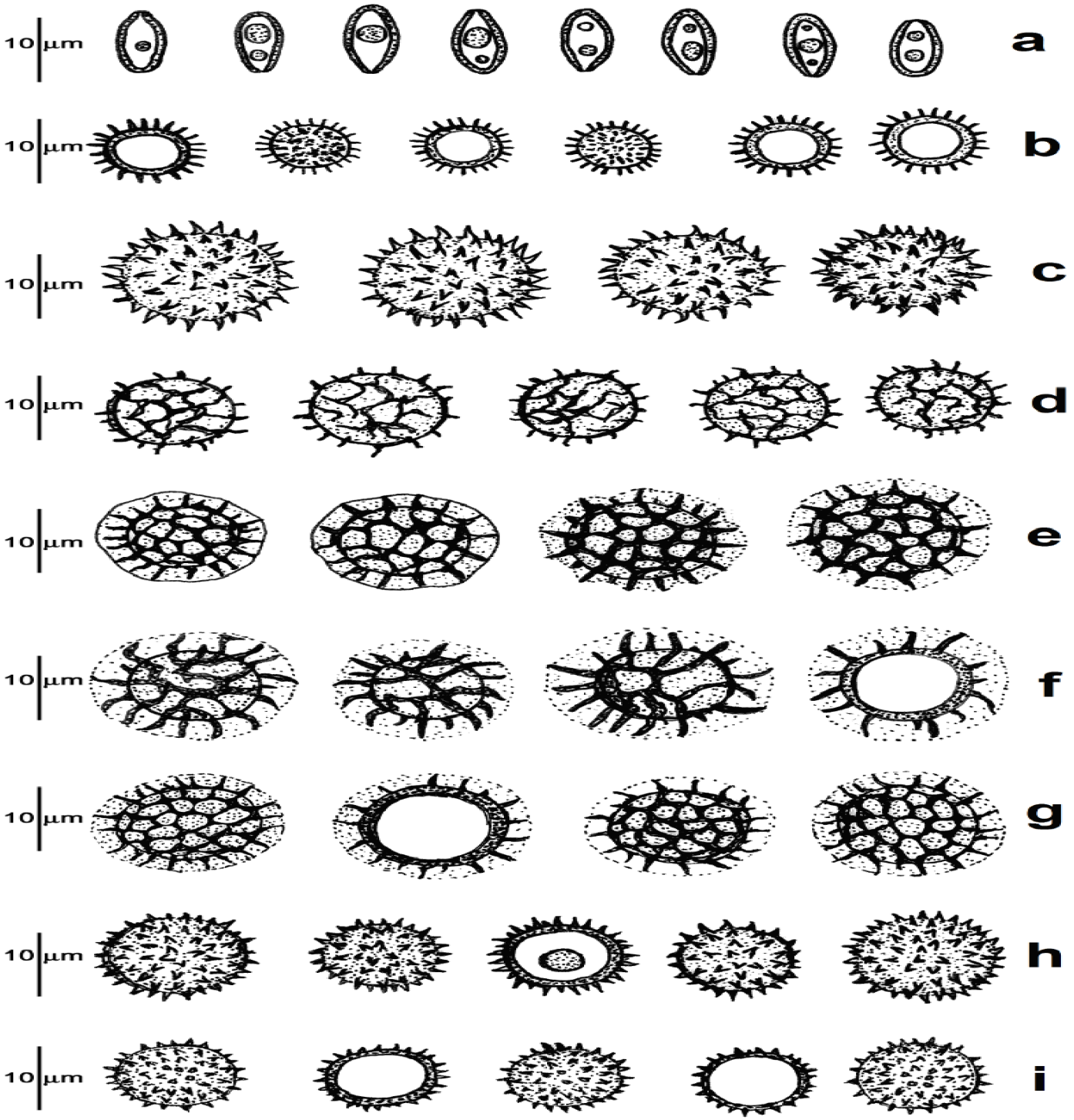

Figure 2. Basidiospores of gasteroid *Boletales.* (a) *Rhizopogon roseolus.* (b) *Pisolithus arrhizus.* (c) *Scleroderma albidum.* d) *S. bovista*. (e) *S. citrinum*. (f) *S. dictyosporum.* (g) *S. fuscum.* (h) *S. laeve.* (i) *S. verrucosum*. All line drawings by Vagner G. Cortez.

1801. Figures 1e and 2e. Basidiomata 31–72 mm diameter, 24–52 mm high, depressed globose to subglobose, with a small to often large and fasciculate rhizomorphic base, not forming a pseudostipe. Peridium <2 mm thick when dried, fleshy when fresh, drying very hard, surface scaly and cracked in small yellowish

brown (5E6) scales on a greyish yellow (3C5) background. Gleba olive brown (4F8) to black, compact to pulverulent. Basidiospores 12.5–16 µm diameter, globose, dark brown, reticulate, with spines <2 µm long. Peridium composed externally by fascicles of erect, orange brown, cystidioid terminal hyphae, arising from a pseudoparenchymatic internal layer composed of hyaline to pale yellow, smooth-walled,
clamped hyphae.

Examined specimens: Brazil. Rio Grande do Sul State. Santa Maria, 22/I/2008, G. Coelho and V.G. Cortez 010/08 (ICN); 08/V/2008, V.G. Cortez 075/08 (ICN); São Francisco de Paula, 08/IV/2006, V.G. Cortez 015/06 (ICN); 21/IV/2007, V.G. Cortez 051/07 (ICN).

Distribution: widespread, mostly growing under *Pinus* spp. plantations (Guzmán, 1970). Brazil: known from the states of Paraíba (Gurgel et al., 2008), São Paulo (Bononi et al., 1981), Paraná (Meijer, 2006), Santa Catarina (Giachini et al., 2000), and Rio Grande do Sul (Sobestiansky, 2005).

Discussion: This species is among the most common macrofungi in *Pinus* plantations in southern Brazil. It grows abundantly, solitary or in small groups among the needles. This earthball has been tested for use as an ectomycorrhizal for pines with some good results (Chen et al., 2006). The scaly peridium makes it macroscopically similar to *S. verrucosum*, but this species has echinate and non-reticulate basidiospores in contrast to the reticulate basidiospores of *S. citrinum* (Pegler et al., 1995).

(vi) *Scleroderma dictyosporum* Pat., Bull. Soc. Mycol. Fr. 12: 135, 1896 Figure 2f. Basidiomata 9–15 mm diameter, 11–24 mm high, globose to subglobose, with a small to usually well-developed rhizomorphic base, dehiscence not observed. Peridium <1 mm thickness and leathery when dried, surface partially smooth with scattered small scales at the top, light brown (6D4) to brown (6E4). Gleba when mature olive brown (4F7), fairly pulverulent. Basidiospores 12–16 µm diameter, globose, dark brown, strongly reticulate, with a continuous ornamentation 2–4 µm thick. Peridium composed externally of collapsed, prostrate hyphae, reddish brown with encrusted walls, and internally of interwoven, hyaline to yellowish, smooth-walled, clamped hyphae.

Examined specimens: Brazil. Rio Grande do Sul State. Santa Maria, 03/V/2007, V.G. Cortez 071/07 (ICN); 13/VI/2007, V.G. Cortez 124/07 (ICN).

Distribution: known from tropical areas of Africa, Asia and Americas (Guzmán, 1970). Brazil: only known from Rio Grande do Sul.

Discussion: According to Guzmán (1970), *S. dictyosporum* exhibits basidiospores 8.8–13.6 µm, with fully reticulate ornamentation measuring 1.9–3.5 µm long. Our specimens have basidiospores slightly larger, but display the same ornamentation pattern and other macroscopic features as those described by Guzmán (1970). It is similar to *S. bovista*, but the ornamentation of the latter is smaller (<2 µm) and the reticulation is not continuous (Guzmán 1970). This species is distributed across dry regions of Africa, Asia and America, as well the subtropical zone. The Brazilian specimens were found growing near the base of *Acacia caven* (Molina) Molina, a native species from southern South America. In Africa, *S. dictyosporum* has also been found as ectomycorrhizal partner of other acacias, such as *A. holosericea* and *A. mangium* (Founoune et al., 2002; Duponnois et al., 2005; Sanon et al., 2009). This is the first report of this species from Brazil.

(vii) *Scleroderma fuscum* (Corda) E. Fisch., Nat. Pflanz. 1: 336, 1900 Figures 1f and 2g. Basidiomata 26–32 mm diameter, 19–24 mm high, globose to subglobose, with a small but fasciculate rhizomorphic base, dehiscence not observed. Peridium <1.5 mm thick and leathery when dried, surface squamulose, cracking into small yellowish brown (5E8) scales on a greyish yellow (3C4) background. Gleba mature olive brown (4F8) pulverulent. Basidiospores 12–17.5 µm diameter, globose, dark brown, with a reticulate ornamentation, <2.5 µm diam. Peridium composed externally of prostrate orange brown hyphae and internally of interwoven, hyaline to yellowish hyphae, with smooth walls, clamps present.

Examined specimens: Brazil. Rio Grande do Sul State. Porto Alegre, 03/V/1990, *J. Pereira* (ICN ex HASU 1305). Santa Maria, 15/V/2007, V.G. Cortez 083/07 and 088/07 (ICN).

Distribution: widespread, associated with *Pinus* plantations, especially in South America (Guzmán, 1970). Brazil: known from the states of Santa Catarina (Giachini et al., 2000) and Rio Grande do Sul.

Discussion: This species forms an ectomycorrhizal association with *Pinus* spp. and for this reason it has been reported from several regions, including South America. Although *S. fuscum* has been reported from Brazil by Giachini et al. (2000) in the state of Santa Catarina, this is the first record from Rio Grande do Sul.

(viii) *Scleroderma laeve* Lloyd emend Guzmán, Darwiniana 16: 301, 1970 Figures 1g and 2g. Basidiomata 32–58 mm diameter, 32–65 mm high, depressed subglobose to subglobose, finally stellate at maturity, with a distinct and abundant rhizomorphic base but not forming a pseudostipe. Peridium <1.5 mm dried, color greyish yellow (4B4) at the base, light brown (5D5) to a

yellowish brown (5E6) at the top, surface scaly at top of peridium, smooth towards the base, dehiscence stellate. Gleba compact to pulverulent, color yellowish brown (5F8) at mature stage. Basidiospores 9.2–14 µm diameter, globose, echinate, acute spines up to 1.5 µm long, color yellowish brown. Peridium with an external layer formed by yellowish, fairly prostrate and subparallel hyphae, 2.5–7 µm diam., internal layer composed of interwoven, hyaline hyphae, 6.5–12 µm diameter, clamp connections absent.

Examined specimen: Brazil. Rio Grande do Sul State: Porto Alegre, 22/IX/2006, V.G. Cortez 067/06 (ICN); 19/VI/2009, P.S. Silva and M.A. Reck (ICN).

Distribution: North America, Africa (Guzmán, 1970), Australia (Malajczuk et al., 1982), Japan (Kasuya et al., 2002) and Brazil (Rio Grande do Sul).

Discussion: *S. laeve* is similar to *S. albidum* (both members of the *Scleroderma* sect. *Aculeatispora*) but they differ in the scaly peridium and smaller basidiospores of the former (Guzmán, 1970). This is an ectomycorrhizal partner of *Eucalyptus* and possibly of some interest in forestry since it is a non-specific associate (Malajczuk et al., 1982). This is the first record of this species from Brazil.

(ix) *Scleroderma verrucosum* (Bull.) Pers., Syn. Meth. Fung.: 154, 1801 Figures 1h and 2i. Basidiomata (5–)14–20 mm diam., (4–)10–14 mm high, globose to depressed subglobose, with a small rhizomorphic base, dehiscence through a wide irregular to substellate pore. Peridium < 0.5 mm thick and leathery when dried, yellowish white at the base to pastel yellow (2A4) at the top, surface covered by small and thin brown (6E8) scales. Gleba greyish brown (5E3) when mature, compact. Basidiospores 10–12.5 µm diameter, globose, yellowish brown, echinate, spines <1.5 µm long. Peridium composed externally of a layer of interwoven, reddish brown hyphae, and internally by interwoven, hyaline hyphae, with smooth and slightly thickened walls, clamp connections absent.

Examined specimens: Brazil. Rio Grande do Sul State. Santa Maria, 15/V/2007, V.G. Cortez 093/07 (ICN); 03/II/2009, M.A. Sulzbacher & V.G. Cortez 017/09 (ICN).

Distribution: Cosmopolitan (Guzmán, 1970). Brazil: known from the states of Bahia, Rio de Janeiro (Guzmán, 1970), Paraná (Meijer, 2006), and Rio Grande do Sul (Sobestiansky, 2005).

Discussion: Guzmán (1970) described this as a poorly understood species and according to his concept, it is diagnosed by the small, echinate basidiospores and thin peridium (<0.5 mm). This species is widely distributed over every continent, and reported from several regions of Brazil. Wright and Albertó (2006) considered it a poisonous mushroom.

Key for the identification of *Scleroderma* from Rio Grande do Sul:

1. *Basidiospores echinate*……..…2
   Basidiospores reticulate ……..……..…….... 4

2. Peridium smooth to squamulose, basidiospores 12–17 µm …….. *S. albidum*
   Peridium with small to large scales, basidiospores smaller ……. 3

3. Peridium <0.5 mm thick, scales small, dehiscence irregular……..……..*S. verrucosum*
   Peridium <1.5 mm thick, scales large, dehiscence stellate ..... *S. laeve*

4. Basidiospore ornamentation >2 µm long …….. ..... *S. dictyosporum*
   Basidiospore ornamentation <2 µm long 5

5. Peridium smooth to subtly scaly……..…… 6
   Peridium conspicuously scaly, basidiospores 12.5–16 µm.....*S. citrinum*

6. Peridium pale-colored, basidiospores 12–14.4 µm ..... *S. bovista*
   Peridium dark-colored, basidiospores 12–17.5 µm ..... *S. fuscum*

Doubtful or excluded records

Astraeus hygrometricus (Pers.) Morgan – Reported by Rick (1961) as *Geaster hygrometricum*, but no specimens were gathered or preserved by the author. Rick (1961, p. 468) wrote: “quamquam in RGS (Rio Grande do Sul) nondum inventus”. Two specimens preserved at the PACA herbarium are from Germany (Berlin, 26/IX/1930, *B. Hennig*, PACA 12225) and Portugal (J. Rick, PACA 15965). However, its occurrence in southern Brazil can be expected because it is known from Argentina (Nouhra and Dominguez de Toledo, 1998) and Brazil (Baseia and Galvão, 2003; Phosri et al., 2007; Vinha, 1988).

Calostoma cinnabarinum Desvaux: This taxon was not reported by Rick (1961), but one specimen of *C. cinnabarinum* is preserved in the PACA herbarium (*C.G. Lloyd*, PACA 14331). However, the material reveals no information on location and date, except that it was collected by Lloyd, probably in the USA. Baseia et al.

(2007) reported it in Brazil from the states of São Paulo and Pernambuco.

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