

Gasteroid *Phallomycetidae* (*Basidiomycota*) from the Parque Estadual São Camilo, Paraná, Brazil

Camila R. Alves¹ & Vagner G. Cortez²

¹Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, Campus do Vale, CEP 91501-970, Porto Alegre, RS, Brazil.
camila_biograndensis@yahoo.com.br

²Universidade Federal do Paraná, Campus Palotina, Rua Pioneiro 2153, CEP 85950-000, Palotina, PR, Brazil. cortezvg@yahoo.com.br

Recebido em 22.VIII.2013

Aceito em 17.III.2016

ABSTRACT. The gasteroid *Phallomycetidae* from the Parque Estadual São Camilo were surveyed. This is a fragment of the Atlantic Forest in the municipality of Palotina, in western Paraná State, Brazil. Collections were made from June 2011 to July 2012 and comprised 77 specimens. Thirteen species were identified, which belong to the genera *Geastrum* Pers (12 species) and *Mutinus* Fr. (1). Among these, three are new records for the state of Paraná: *Geastrum coronatum* Pers, *G. lageniforme* Vittad. and *G. rufescens* Pers.. An identification key to the species of *Geastrum* collected in the park, descriptions, illustrations and comments for each taxon are provided.

KEYWORDS: Gasteromycetes, *Geastraceae*, mycobiota, *Phallaceae*, taxonomy

RESUMO. Gasteroides *Phallomycetidae* (*Basidiomycota*) do Parque Estadual São Camilo, Paraná, Brasil. Foram estudados os fungos gasteroides *Phallomycetidae* do Parque Estadual São Camilo, um fragmento de floresta estacional semidecidual situado no município de Palotina, oeste do estado do Paraná, sul do Brasil. As amostras foram coletadas entre junho de 2011 e julho de 2012 totalizando 77 espécimes. Foram identificadas 13 espécies sendo 12 de *Geastrum* Pers e uma de *Mutinus* Fr.. Dessas, três constituem novos registros para o estado do Paraná: *Geastrum coronatum* Pers, *G. lageniforme* Vittad e *G. rufescens* Pers. São apresentados chave de identificação para as espécies de *Geastrum* coletadas no Parque, descrições, ilustrações e comentários para cada táxon descrito.

PALAVRAS-CHAVE: Gasteromicetos, *Geastraceae*, micobiota, *Phallaceae*, taxonomia

INTRODUCTION

The gasteroid fungi that belong to the subclass *Phallomycetidae* K. Hosaka *et al.* are currently classified in the orders *Gastrales* K. Hosaka & Castellano, *Hysterangiales* K. Hosaka & Castellano and *Phallales* E. Fisch. (Hosaka *et al.* 2006). The family *Geastraceae* Corda, which previously belonged to *Agaricales* Underw., is now accepted as an independent order according to the latest classification. Members of *Hysterangiales*, which were previously accepted as a family in *Phallales*, are now placed in the families *Hysterangiaceae* E. Fisch., *Protophallaceae* Zeller and *Gelopellaceae* Zeller., and the order *Phallales* is currently divided into the families *Clathraceae* Chevall., *Claustulaceae* G. Cunn. and *Phallaceae* Corda (Hosaka *et al.* 2006).

Although several recent publications have improved the knowledge about these fungi in Brazil (Baseia & Calonge 2005 2006, Baseia & Galvão 2002, Baseia & Milanez 2002, Baseia *et al.* 2003, Cortez *et al.* 2011a, 2011b, 2011c; Fazolino *et al.* 2008, Leite *et al.* 2007, Sulzbacher *et al.* 2013, Trierveiler-Pereira & Baseia 2009, 2010, Trierveiler-Pereira *et al.* 2009, 2011), data about species distributions and diversity in the country are fragmented.

Most of the 44 species of gasteroid fungi known from the State of Paraná have been reported from coastal areas

in an ecosystem known as ombrophilous forest, which is part of the Atlantic Forest *sensu lato* (Meijer 2006, 2010). Within Paraná, little is known about the mycobiota from the western region of the state (Trierveiler-Pereira & Silveira 2012), but 11 species of gasteroid *Phallomycetidae* have been reported on the Argentinean side of Parque Nacional do Iguaçu (Wright & Wright 2005), an adjacent area of seasonal semideciduous forest, including *Dictyophora indusiata* (Vent.) Desv., *Geastrum saccatum* Fr., *G. schweinitzii* (Berk. & M.A. Curtis) Zeller and *Geastrum* sp. With this perspective, a survey of the gasteroid fungi was made in a fragment of seasonal semideciduous forest within the Atlantic Forest domain in western Paraná. Other studies about gasteroid fungi from the same area have been recently published (Alves & Cortez 2013a, 2013b); however, this work presents the identified taxa that belong to *Phallomycetidae*.

MATERIAL AND METHODS

Fieldwork was conducted at Parque Estadual São Camilo (abbreviated as PESC), within the municipality of Palotina, in the western region of Paraná State, in southern Brazil (Fig. 1). PESC comprises an ecosystem of seasonal semideciduous forest where there is a dry season in the winter and rainy season in the summer (Roderjan *et al.*

2002), as well as abundant lianas, few epiphytes, and scattered but typical palms, such as *Syagrus romanzoffiana* (Cham.) Glassman.

Specimens were collected along trails and inside the forest at PESC and then morphologically analyzed following standard procedures for gasteroid fungi (Miller & Miller 1988). Colors of macroscopic features were determined according to Kornerup & Wanscher (1978). For microscopic descriptions, colors are based on preparations made in 5% KOH. For basidiospore measurements, the complex ornamentation (when present) was considered. Scanning electron micrographs (SEM) were taken with a Jeol JSM-6360LV at the Centro de Microscopia Eletrônica of the Universidade Federal do Paraná (CME/UFPR). All specimens were deposited in the herbarium at UFPR, Campus Palotina (HCP).

RESULTS AND DISCUSSION

Thirteen species distributed in two genera (*Geastrum* with 12 taxa and *Mutinus* with one) were identified. In the state of Paraná, Meijer (2006, 2010) reported the occurrence of the following species: *Geastrum* cf. *minimum* Schwein., *G. ovalisporum* Calonge & Mor.-Arr., *G. cf. pectinatum* Pers., *G. saccatum*, *G. schweinitzii* (Berk. & M.A. Curtis) Zeller, *G. triplex* Jungh. and *G. velutinum* Morgan. More recently, Trierveiler-Pereira & Silveira (2012) reported *G. hariotii* Lloyd from Parque Nacional do Iguaçu.

Geastrum coronatum Pers., Synop. Meth. Fungorum 1: 132, 1801.

(Figs. 2A, B, 7A)

Basidiomes up to 18 × 70 mm when expanded. Exoperidium formed by 13 arched rays, nonhygroscopic. Mycelial layer yellowish gray (2B3), covered with abundant debris adhered to surface. Fibrous layer brownish orange (5C4) when dry, smooth. Pseudoparenchymatous layer smooth and fleshy, brownish orange (5C3) when fresh, then yellowish brown (5E4) after drying. Endoperidium 10 × 14 mm, subglobose, yellowish brown (5F5), presenting a 2.5 mm high pedicel, apophysis smooth, 3 mm high. Peristome 3 mm high, fibrillose, not well defined. Gleba cottony, brown (5F4). Basidiospores 4.9–5 µm, globose, ornamentation verrucose to shortly columnar under LM, verrucose, irregular to globose, sometimes covered by a mucilaginous matrix under SEM. Eucapillitium 6.2–8.5 µm diam., pale green, walls thick, with a reduced lumen, amorphous matter absent. Endoperidium hyphae 3.0–4.1 µm diam., hyaline to pale brown, thick-walled, lumen reduced.

Habitat and distribution: Solitary, on litter. Americas, Africa, Europe, Australasia (Ponce de Leon 1968, Sunhede 1989). Brazil: Rio Grande do Sul (Rick 1961) and Pernambuco (Leite *et al.* 2007).

Key to *Geastrum* species from Parque Estadual São Camilo

1. Basidiomes up to 20 mm diam. when expanded 2
1. Basidiomes larger than 20 mm diam. when expanded 3
2. Endoperidium pedicellate, grayish brown *G. minimum*
2. Endoperidium sessile, globose to ovoid, lilac to reddish brown *G. violaceum*
3. Endoperidium pedicellate 4
3. Endoperidium sessile 8
4. Apophysis present, peristome sulcate 5
4. Apophysis absent, peristome fibrillose 6
5. Apophysis smooth, endoperidium dark brown *G. lloydianum*
5. Apophysis sulcate, endoperidium covered by a grayish to whitish pruina *G. pectinatum*
6. Rays arched, mycelial layer bearing abundant debris *G. coronatum*
6. Rays involute 7
7. Mycelial and pseudoparenchymatous layers pinkish, basidiospores globose *G. rufescens*
7. Mycelial and pseudoparenchymatous layers grayish and brown, basidiospores ovoid *G. ovalisporum*
8. Basidiomes arachnoid, mycelial layer longitudinally striate *G. lageniforme*
8. Basidiomes non-arachnoid 9
9. Mycelial layer cracked and cleft, in plates, surface subvelutinous *Geastrum* sp.
9. Mycelial layer with an homogeneous surface 10
10. Mycelial layer hirsute *G. javanicum*
10. Mycelial layer smooth 11
11. Pseudoparenchymatous layer forming a collar surrounding the endoperidium *G. triplex*
11. Pseudoparenchymatous layer not forming a collar, pale pink *G. saccatum*

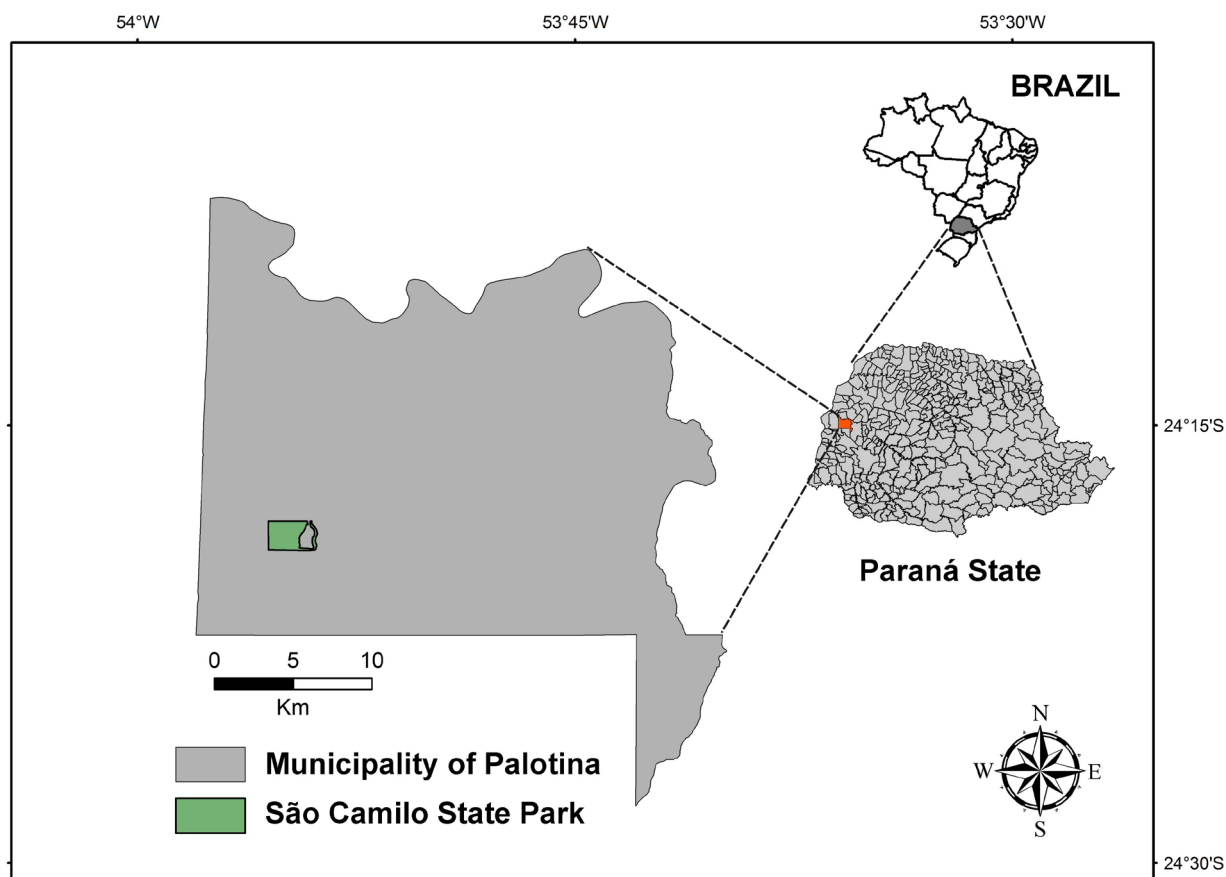


Fig. 1. Location of Parque Estadual São Camilo, Paraná, Brazil.

Examined material: BRAZIL, Paraná, Palotina, PESC, 15.VI.2011, V.G. Cortez 007/11 (HCP).

Observations: *Geastrum coronatum* is recognized by its mycelial layer with abundant debris on the surface, arched rays, globose to subglobose endoperidial body with or without apophysis and crystalline pruina, which can be absent in fully mature specimens (Sunhede 1989). This species is sometimes confused with *G. smardae* V.J. Stanek, which differs by its smooth mycelial layer, without adhered debris, occasionally pseudofornicate basidiomes, and basidiospores with columnar ornamentation when observed under SEM (Sunhede 1989). *Geastrum minimum* is also similar to *G. coronatum*, but presents smaller and paler basidiomes (Sunhede 1989). *Geastrum coronatum* is a poorly known species in Brazil that was previously reported only for the states of Pernambuco and Rio Grande do Sul. This is the first record from Paraná State.

Geastrum javanicum Lév., Ann. Sci. Nat., Bot. Ser. III 5: 161, 1846.

(Figs. 2C, D, 7B)

Basidiomes 10 × 30–45 mm when expanded. Exoperidium 8–11 rays, arched to involute when fresh. Mycelial layer hirsute, grayish yellow (4B3), with scattered debris, flaking off with maturity. Fibrous layer light brown

(7D5) to orange-gray (5B2). Pseudoparenchymatous layer persistent, dark brown (7F4) to light brown (7D5) when fresh, dark brown (6F5) after drying. Endoperidium 12 × 15–20 mm, subglobose, sessile, pale orange (6A4) to light brown (6D4) when fresh. Peristome 3 mm high, fibrillose, brown (6F4). Gleba powdery, dark brown (6F4). Basidiospores 4.2–5.2 µm, globose, with columnar ornamentation, brown; under SEM, the ornamentation is columnar with flattened apex and irregular surface. Eucapillitium 4.3–5.8 µm diam., thick-walled, with a reduced lumen, dark green to brown, with amorphous matter. Endoperidium hyphae 3.1–4.9 µm diam., hyaline, thick-walled, lumen reduced, with amorphous matter.

Habitat and distribution: Solitary, on litter. Widely distributed, except in Europe (Smith & Ponce de Leon 1982). Brazil: Minas Gerais, Paraíba, Rio de Janeiro (Trierweiler-Pereira *et al.* 2011), Paraná (Meijer 2006), and Santa Catarina (Sobestiansky 2005).

Examined material: BRAZIL, Paraná, Palotina, PESC, 24. III. 2011, V.G. Cortez 21-26 (HCP); 15.VI. 2011, V.G. Cortez 005/11 (HCP).

Observations: *Geastrum javanicum* is characterized by its mycelial layer, velutinous, blackish and sessile endoperidium, as well as its fibrillose and non-delimited peristome (Trierweiler-Pereira *et al.* 2011). According to

Hemmes & Desjardin (2011) this species can be recognized by the presence of a basal subicular mycelium; however, this structure was poorly developed in our specimens. *Geastrum fimbriatum* Fr. is similar to *G. javanicum*, but the former has abundant debris covering the mycelial layer (Ponce de Leon 1968). *Geastrum javanicum* occurs on rotting wood (Ponce de Leon 1968; Hemmes & Desjardin 2011) but our specimens were found on litter. This species was reported for Paraná by Meijer (2006) as *G. velutinum* Morgan.

Geastrum lageniforme Vittad., Monogr. Lycoperd.: 16, 1842.

(Figs. 2E, F, 7C)

Immature basidiomes 10–30 × 5–20 mm, subglobose to lageniform, with an acute umbo (5 mm high), grayish yellow (4C4) to light brown (7A2), basal white rhizomorphs up to 1 mm thick. Mature basidiomes 8–15 × 20–45 mm when expanded. Exoperidium split in 7–10 slightly to non-recurved rays, with a spider-shape (arachnoid) aspect. Mycelial layer yellowish brown (5D5) when fresh, smooth and with few debris adhered to surface, usually presenting longitudinal fissures, but somewhat inconspicuous in some specimens. Fibrous layer yellowish white (2A2). Pseudoparenchymatous layer persistent, fleshy, with few fissures, gray (7B1) to pale red (7B2) when fresh, yellowish brown (5D5) when dry. Endoperidium 8–13 mm diam., sessile, gray (5B1) to brownish gray (5C2) when fresh, light brown (5D4) after drying. Peristome 3–4 mm high, fibrillose, delimited by a grayish line. Gleba powdery, grayish brown (6F3). Basidiospores 5.2–5.9 µm, globose, echinate under LM, brown; distinct columnar ornamentation and flattened apex under SEM. Eucapillitium 3.2–6.5 µm diam., pale green to brown, thick-walled, with a reduced lumen and with little amorphous substance. Endoperidium hyphae 3.2–3.6 µm diam., hyaline, sinuous, with thick walls, reduced lumen and no amorphous matter.

Habitat and distribution: Gregarious or solitary, on litter and rotten wood. Occurs on all continents (Soto & Wright 2000). Brazil: Rio Grande do Sul (Cortez *et al.* 2008), Paraíba (Trierveiler-Pereira & Baseia 2010), Pernambuco and Rio de Janeiro (Trierveiler-Pereira *et al.* 2011).

Examined material: BRAZIL, Paraná, Palotina, PESC, 02.I.2011, *V.G. Cortez* 16-18 (HCP); 27.I.2011, *V.G. Cortez* 17-34 (HCP), 17-35 (HCP); 16.II.2011, *V.G. Cortez* 18-23 (HCP), 18-26 (HCP); 14.III.2011, *V.G. Cortez* 20-20 (HCP); 01.IV.2011, *V.G. Cortez* 22-16 (HCP); 23.IV.2011, *C.R. Alves* 50 (HCP), 51 (HCP), 52 (HCP), 54 (HCP); 27-IV.2011, *V.G. Cortez* 23-16 (HCP); 15.VI.2011, *V.G. Cortez* 010/11 (HCP); 23.XI.2011, *C.R. Alves* 05 (HCP), 08 (HCP); 02.III.2012, *V.G. Cortez* 19-12 (HCP), 19-43 (HCP); 17.IV.2012, *C.R. Alves* 29 (HCP); 28.VI.2012, *C.R. Alves* 70 (HCP).

Observations: *Geastrum triplex* and *G. saccatum* are similar to *G. lageniforme*, but the latter presents a longitudinally cleft mycelial layer and immature basidiomes that have a lageniform shape (Soto & Wright 2000). *Geastrum*

lageniforme is one of the most common species of the genus in the area and occurs mostly on litter and rotting wood. In the South Region of Brazil, this species was only known from Rio Grande do Sul (Rick 1961, Cortez *et al.* 2008); this is its first record from Paraná.

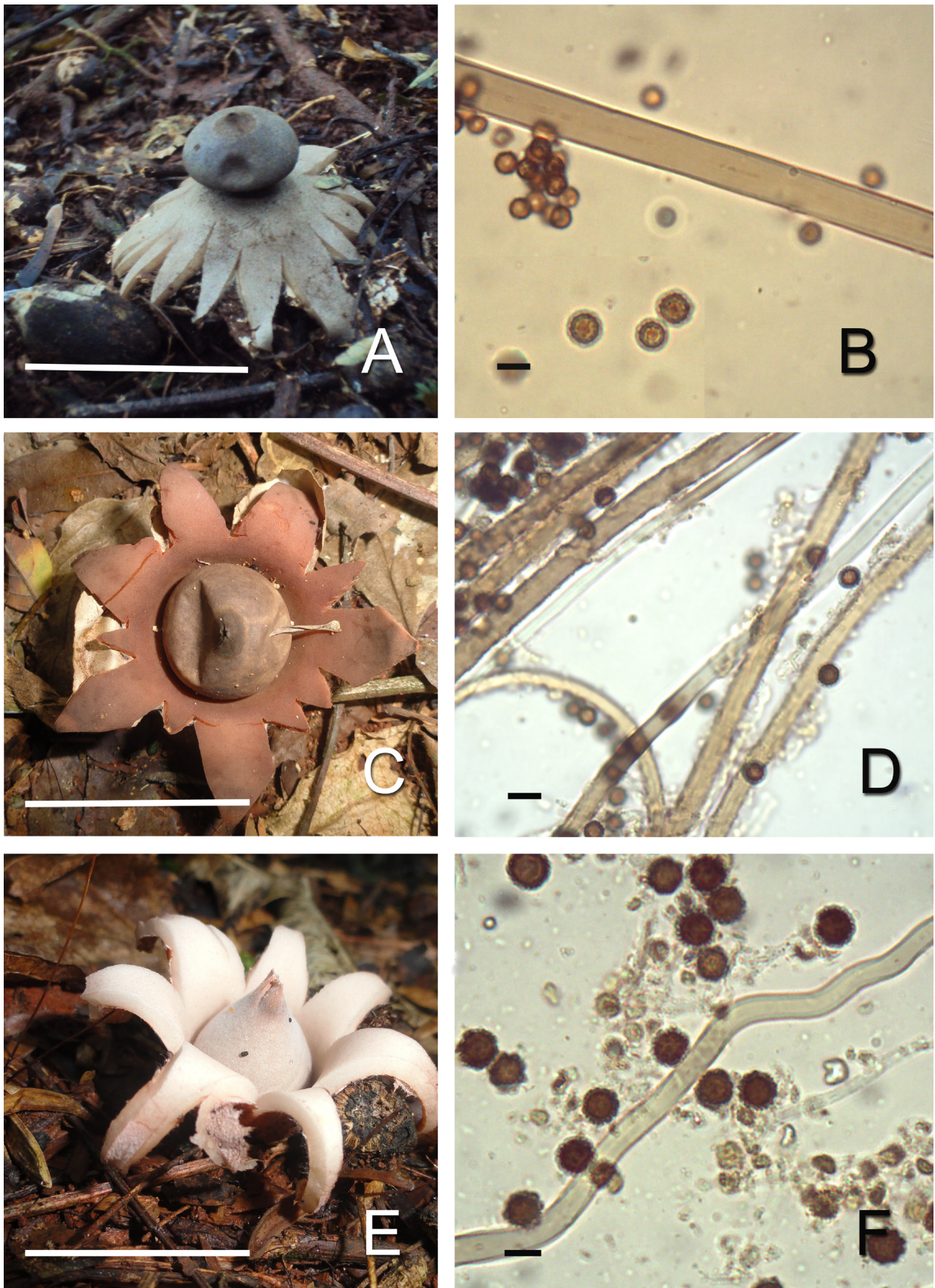
Geastrum lloydianum Rick, Brotéria, Sér. Bot. 5: 27, 1906. (Figs. 3A-B, 7D)

Basidiomes 10–15 × 30–45 mm when expanded. Exoperidium composed of 5–7 arched rays. Mycelial layer with abundant adhered debris, brownish gray (5C2). Fibrous layer light brown (5D4). Pseudoparenchymatous layer smooth, not persistent at maturity, grayish brown (5E3) to dark brown (6F4) in older specimens. Endoperidium 7–10 × 12–14 mm, subglobose, sessile, grayish yellow (4B3) when young, dark brown (6F4) when older, surface velutinous to smooth, with a short pedicel (up to 3 mm high), apophysis present but inconspicuous, grayish yellow (1B3). Peristome 3 mm high, conical, sulcate, dark brown (6F4). Gleba powdery, light brown (5D4). Basidiospores 4.5–4.9 µm, globose, brown, spiny under LM, with a distinct columnar ornamentation and flattened apex under SEM. Eucapillitium 3.5–5.8 µm wide, hyaline to pale brown, thick-walled, lumen reduced, with amorphous matter. Endoperidium hyphae 5.5–6.6 µm diam., hyaline to brown, sinuous, thick-walled, with scattered amorphous matter.

Habitat and distribution: Gregarious, on litter and rotten wood. Known from Australia and tropical America (Ponce de Leon 1968; Trierveiler-Pereira & Silveira 2012). Brazil: Rio de Janeiro, Pernambuco, Paraná and Rio Grande do Sul (Trierveiler-Pereira & Silveira 2012).

Examined material: BRAZIL, Paraná, Palotina, PESC, 05.X.2012, *L.S. Lettrari* 22 (HCP).

Observations: This species is similar to *G. elegans* Vittad. and *G. morgani* Lloyd, but can be distinguished from both by its larger basidiomes (up to 50 mm diam.), nonhygroscopic rays, and sulcate and well-delimited peristome (Calonge & Mata 2006). Trierveiler-Pereira *et al.* (2011) asserted that *G. setiferum* Baseia is also similar to *G. lloydianum*, but differs by its arched exoperidium and fibrillose (setoid) endoperidium. According to Trierveiler-Pereira & Silveira (2012), *G. hariotti* Lloyd is a synonym of *G. lloydianum* because it is very similar macroscopically, despite the fact that these authors considered the types of both species to be distinct microscopically. *Geastrum lloydianum* has larger basidiospores (5–6 µm) with taller columnar ornamentation compared to the basidiospores of *G. hariotti* (3–4 µm) with shorter columnar ornamentation (Trierveiler-Pereira & Silveira 2012). The material collected at PESC has basidiospores with intermediate dimensions (4.5–4.9 µm) compared to *G. hariotti* and other descriptions of *G. lloydianum*. We conclude that the specimens represent *G. lloydianum* because the basidiospores have a tall



Figs. 2 A-F. A, B. *Geastrum coronatum*. A. Basidioma; B. Capillitium and basidiospores; C, D. *G. javanicum*. C. Basidioma; D. Capillitium and basidiospores. E, F. *G. lageniforme*. E. Basidioma; F. Capillitium and basidiospores. Scale bars: **Figs. 2 A, C, E** = 20 mm; **2 B, D, F** = 5 μ m.

columnar ornamentation, which is a diagnostic feature of the species. This species is widely distributed in Brazil, including Paraná (Meijer 2006). However, it is not common in the study area or the Atlantic Forest of Rio de Janeiro and northeastern Brazil (Trierveiler-Pereira *et al.* 2011).

Geastrum minimum Schwein., *Schriften Naturf. Ges. Leipzig* 1: 58, 1822.

(Figs. 3C-D, 7E)

Basidiomes expanded up to 7×13 –20 mm. Exoperidium formed of 9–10 strongly recurved and nonhygroscopic rays. Mycelial layer yellowish brown (5D5), covered by abundant debris. Fibrous layer grayish yellow (4B3). Pseudoparenchymatous layer fleshy, brownish orange (5C4) when fresh, yellowish brown (5D5) when dry. Endoperidium 4 – 6×4 –10 mm diam., globose to subglobose, grayish brown (5C3), pedicellate, apophysis present, smooth, 1 mm high. Peristome up to 3 mm high, fibrillose, brown (5D2), slightly delimited. Gleba powdery, brown (5F7). Basidiospores 5.2 – 5.8 μm , globose, with a verrucose ornamentation, spore wall wrinkled under SEM, with irregularly columnar or shortly warted, with a short pedicel (up to 1 μm long). Eucapillitium 2.8 – 3.9 μm diam., pale green, thick-walled, with a reduced lumen and scattered amorphous matter. Endoperidium hyphae 2.4 – 3.6 μm diam., hyaline, thick-walled and without amorphous matter.

Habitat and distribution: On soil. Cosmopolitan (Soto & Wright 2000). Brazil: only known from the South Region (Trierveiler-Pereira & Baseia 2009).

Examined material: BRAZIL, Paraná, Palotina, PESC, 02.VI.2010, A.J. Ferreira & R.L. Dias 12/2010 (HCP).

Observations: *Geastrum minimum* is recognized by its small basidiomes and white and abundant pruina that cover the endoperidium, which can disappear with age (Pegler *et al.* 1995). As mentioned, *G. minimum* is similar to *G. coronatum* (see discussion for this species). *Geastrum quadrifidum* DC. ex Pers. is also a similar species, but it has fornicate basidiomes with four rays (Pegler *et al.* 1995, Soto & Wright 2000). *Geastrum minimum* is found on sandy soil, under conifers and on litter, and is a common earthstar in Europe (Calonge 1999), but is poorly known in Brazil where it has been reported only from the South Region (Trierveiler-Pereira & Baseia 2009).

Geastrum ovalisporum Calonge & Mor-Arr., *Bol. Soc. Micol. Madrid* 25: 273, 2000.

(Figs. 3E, F, 7F)

Basidiomes 26 – 40×20 –40 mm when expanded. Exoperidium splitting in 6–8 rays, incurved and nonhygroscopic. Mycelial layer yellowish white (4A2) to grayish yellow (4C5) when dry, covered by abundant

debris. Fibrous layer smooth, pale yellow (1A3). Pseudoparenchymatous layer fleshy, brown (6F4). Endoperidium 9 – 14×9 –17 mm, globose to subglobose, grayish brown (6F3), pedicel up to 4×3 mm, apophysis smooth, 2–3 mm high. Peristome 2–4 mm high, fibrillose, well delimited. Basidiospores 3.2 – 4.2×2.8 – 3.4 μm , ovoid, ornamentation composed of warts up to 1 μm long, dark green, shortly pedicellate (<1 μm); basidiospore surface wrinkled and with an irregular, verrucose ornamentation covered by a mucilaginous matter under SEM. Eucapillitium 3.6 – 5.9 μm diam., thick-walled, lumen reduced, brown. Endoperidium hyphae 2.4 – 4 μm diam., hyaline to pale yellow, thick-walled.

Examined material: BRAZIL, Paraná, Palotina, PESC, 27.I.2011, V.G. Cortez 17-58 (HCP).

Habitat and distribution: On litter, in forest, gregarious. South America (Calonge *et al.* 2000, Cortez *et al.* 2008). Brazil: Rio Grande do Norte (Leite *et al.* 2007), Paraná (Meijer 2010), Santa Catarina (Leite *et al.* 2007) and Rio Grande do Sul (Cortez *et al.* 2008).

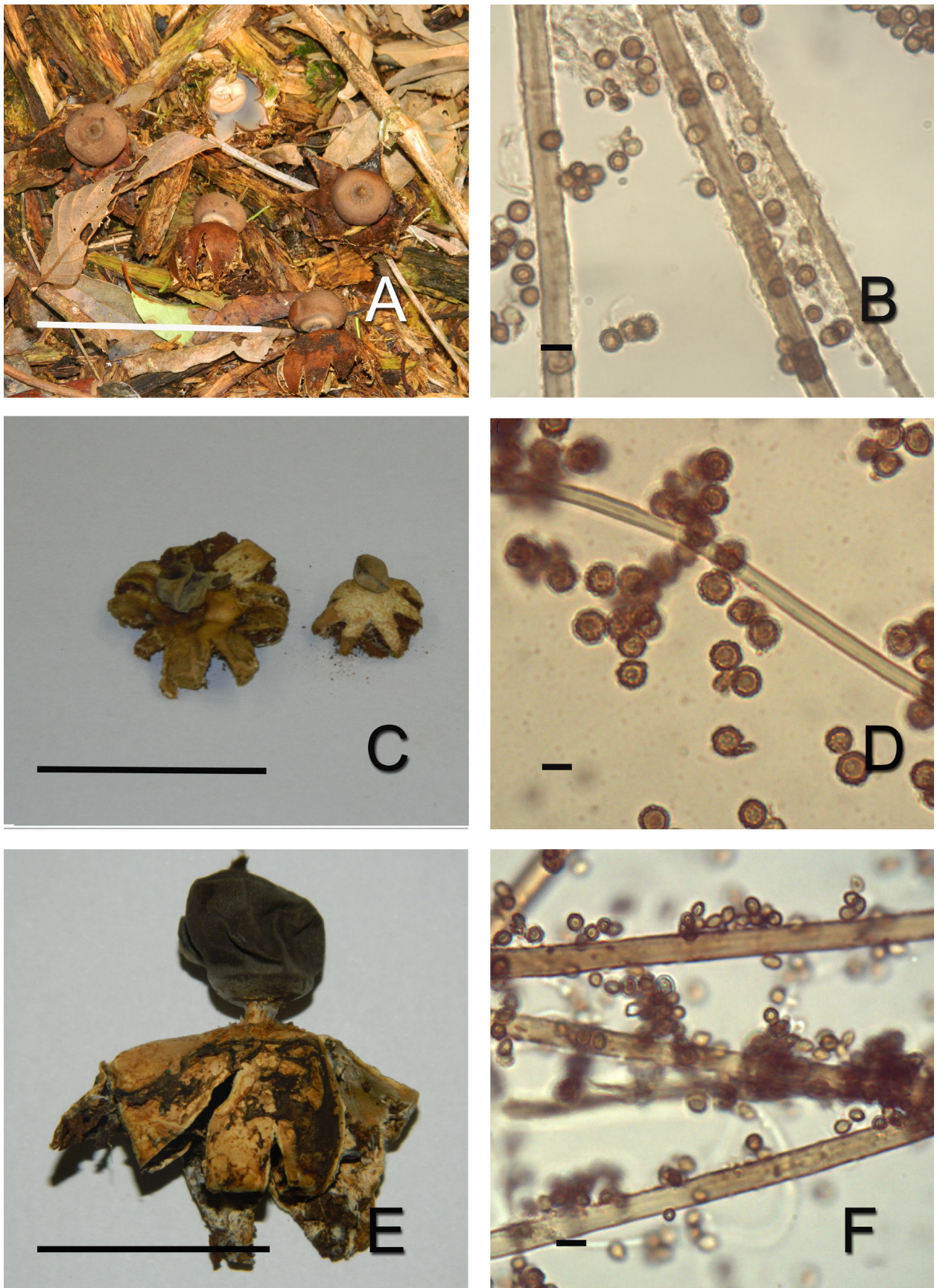
Observations: *Geastrum ovalisporum* is an uncommon species in the study area and is morphologically diagnosed by the presence of a stipitate endoperidium and ovoid basidiospores that are unique in the genus (Calonge *et al.* 2000). In South America, *Geastrum ovalisporum* occurs in several habitats, including tropical and subtropical forests, and on sandy soil, litter and rotten wood (Calonge *et al.* 2000, Cortez *et al.* 2008).

Geastrum pectinatum Pers., *Synop. Meth. Fungorum* 1: 132, 1801.

(Figs 4A, B, 8A)

Basidiomes 25×25 –40 mm when expanded. Exoperidium composed of 7–10 incurved rays. Mycelial layer pale yellow (4A3) to brownish when dry, with numerous debris covering the surface. Fibrous layer pale yellow (1A3). Pseudoparenchymatous layer non-persistent, somewhat gelatinous when fresh, yellowish brown (5F6). Endoperidium 10×13 –15 mm, subglobose, brown (6F4), pedicel, pale yellow (4F3), 6 mm high and 3 mm diam., apophysis sulcate. Peristome sulcate. Gleba powdery, brown (6F4). Basidiospores 6.2 – 6.8 μm , globose, echinate, brown; under SEM, distinct columnar to spines ornamentation. Eucapillitium 5.1 – 8.8 μm diam., brown, thick-walled with reduced lumen. Endoperidium hyphae 3.9 – 4.9 μm diam., hyaline to pale yellow, thick-walled, without amorphous matter.

Habitat and distribution: Solitary, on litter. Cosmopolitan (Baseia *et al.* 2003). Brazil: Pernambuco, São Paulo (Baseia *et al.* 2003), Paraná (Meijer 2006) and Rio Grande do Sul (Cortez *et al.* 2008).



Figs. 3 A-F. A, B. *Geastrum lloydianum*. A. Basidiomata; B. Capillitium and basidiospores. C, D. *G. minimum*. C. Basidiomata; D. Capillitium and basidiospores; E-F. *G. ovalisporum*. E. Basidioma; F. Capillitium and basidiospores. Scale bars: 3 A, C, E = 20 mm; 3 B, D, F = 5 µm.

Examined material: BRAZIL, Paraná, Palotina, PESC, 02.IV.2010, *V.G. Cortez* 3-17 (HCP); 16.II.2011, *V.G. Cortez* 18-24 (HCP).

Observations: This species is similar to *G. schmidelli* Vittad. and *G. striatum* DC., but can be distinguished by its stipitate endoperidium and strongly sulcate apophysis, as well as its acute and conical peristome (Baseia *et al.*, 2003). According to Hemmes & Desjardin (2011), *G. pectinatum* is similar to *G. berkeleyi* Massee, but the latter does not have the globose and densely pruinose endoperidium found in *G. pectinatum*. This earthstar seems to be common in Brazilian forests (Trierveiler-Pereira & Baseia 2009), although it has been rarely collected in seasonal semideciduous forest.

Geastrum rufescens Pers., Neues. Mag. Bot. 1: 86, 1794. (Figs. 4C, D, 8B)

Basidiomes 25–35 × 20–40 mm when expanded, growing on a scattered, cottony and white subiculum. Exoperidium composed of 6–8 involute rays. Mycelial layer reddish gray (7B3), bearing debris on the surface. Fibrous layer pale red (7A3) when fresh, brownish gray (6C3) when dry. Pseudoparenchymatous layer sometimes persistent, dull red (8B3) when fresh and brown (6F4) when dry, surface cracked. Endoperidium 10–15 mm high, 13–20 mm diam., subglobose, grayish brown (5D3), apophysis 3 mm high, smooth, inconspicuous to absent in some basidiomes. Peristome 4 mm high, fibrillose, orange white (6A2) to grayish brown (5D3). Gleba powdery, brown (6E4). Basidiospores 5.1–5.7 µm diam., globose, weakly verrucose to echinulate, brown, ornamentation composed of subcylindrical colums with a flattened apex under SEM. Eucapillitium 3.3–6.5 µm diam., pale green or brown, with hyaline tips, thick walls and reduced lumen, with amorphous matter. Endoperidium 3.6–4.9 µm diam., sinuous, thick-walled.

Habitat and distribution: On litter. Known from North and South America, Europe and Japan (Ponce de Leon 1968, Sunhede 1989). Brazil: Rio Grande do Sul (Rick 1961) and São Paulo (Bononi *et al.* 1981).

Examined material: BRAZIL, Paraná, Palotina, PESC, 31.VII.2012, *V.G. Cortez* 15 (HCP).

Observations: *Geastrum rufescens* has an exoperidium with arched or involute rays, usually covered by debris, a pinkish pseudoparenchymatous layer and a stipitate endoperidium covered with hirsute hairs (Sunhede 1989). *Geastrum fimbriatum* is a similar species, but differs from *G. rufescens* by its larger basidiomes and smaller spores (Hemmes & Desjardin 2011). In spite of being widely distributed, the species is poorly known in Brazil; this is the first record from the State of Paraná.

Geastrum saccatum Fr., Syst. Mycol. 3(1): 16, 1829. (Figs. 4E, F, 8C)

Basidiomes 10–13 × 10–16 mm when immature, subglobose, yellowish brown (5D5). Basidiomes 10–20 mm high and 15–38 mm diam. when expanded. Exoperidium formed of 6–9 rays, usually arched, sometimes with abundant, thin (<1 mm thickness) and white rhizomorphs. Mycelial layer yellowish brown (5D5), glabrous, with few debris on the surface. Fibrous layer yellowish white (2A2). Pseudoparenchymatous layers persistent, without or with few fissures, grayish orange (5C3) to brownish gray (7C3) when fresh. Endoperidium 8–10 × 8–13 mm, globose to subglobose, sessile, grayish brown (5C3) to brownish gray (7D2). Peristome 3–4 mm high, fibrillose, delimited, less pale than endoperidium. Gleba powdery, brownish gray (7F2). Basidiospores 4.1–5.1 µm, globose, spiny, golden brown, ornamentation conspicuously columnar, with the apex flattened under SEM. Eucapillitium 3.0–5.1 µm diam., hyaline to pale brown, with little amorphous matter, walls thick and with reduced lumen. Endoperidium hyphae 2.7–3.6 µm diam., hyaline, sinuous, walls thick, lumen present, amorphous matter absent.

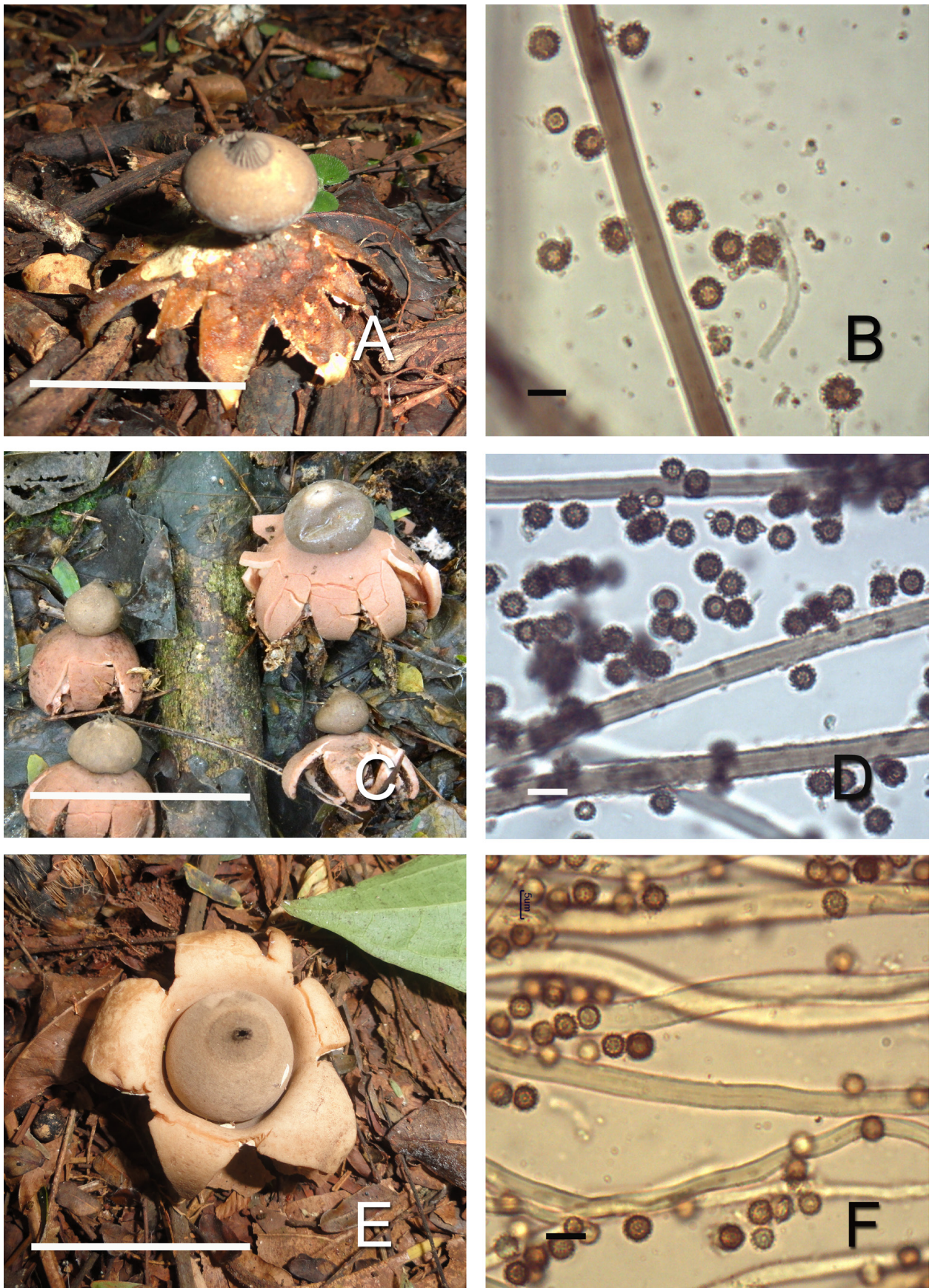
Habitat and distribution: Solitary or in small groups, on soil and litter. Cosmopolitan (Gube & Piepenbring 2009). Brazil: Paraíba (Trierveiler-Pereira & Baseia 2010), Pernambuco (Trierveiler-Pereira *et al.* 2011), São Paulo (Bononi *et al.* 1984, Baseia *et al.* 2003), Paraná (Meijer 2006), and Rio Grande do Sul (Rick 1961, Sobestiansky 2005, Cortez *et al.* 2008).

Examined material: BRAZIL, Paraná, Palotina, PESC, 19.V.2010, *A.J. Ferreira & R.L. Dias* 2-8 (HCP); 18.XI.2010, *A.J. Ferreira & R.L. Dias* 14-16 (HCP); 10.XII.2010, *A.J. Ferreira & R.L. Dias* 15-40 (HCP); 02.III.2011, *V.G. Cortez* 19-44 (HCP), 19-45 (HCP); 14.III.2011, *V.G. Cortez* 20-4 (HCP), 20-2 (HCP), 20-7 (HCP); 24.III.2011, *V.G. Cortez* 21-9 (HCP), 21-11 (HCP); 01.IV.2011, *V.G. Cortez* 22-12 (HCP); 15.VI.2011, *V.G. Cortez* 008/11 (HCP), 009/11 (HCP); 23.XI.2011, *C.R. Alves* 7 (HCP); 27.II.2012, *C.R. Alves* 18 (HCP); 03.IV.2012, *C.R. Alves* 21 (HCP); 17.IV.2012, *C.R. Alves* 27 (HCP), 28 (HCP), 30 (HCP), 31 (HCP), 32 (HCP), 34 (HCP), 36 (HCP), 37 (HCP); 23.IV.2012, *C.R. Alves* 53 (HCP), 55 (HCP); 28.VI.2012, *C.R. Alves* 69 (HCP).

Observations: *Geastrum saccatum* is characterized by having a mycelial layer that is smooth or with a small amount of debris, exoperidium with 5–8 rays, sessile endoperidium, and fibrillose and well-delimited peristome (Sunhede 1989). As previously discussed, this species is related to *G. lageniforme* and *G. triplex*. It is a common earthstar in the study area, as well in Brazil, and it grows mainly on litter and occasionally on rotten wood and clay. ***Geastrum triplex*** Jungh., Tijdschr. Nat. Gesch. Physiol. 7: 287, 1840.

(Figs. 5A, B, 8D)

Immature basidiomes 25 × 27 mm, subglobose, umbonate (5 mm), yellowish brown (5D5), with small but conspicuous scales. Mature basidiomes 20–25 mm high, 40–60 mm diam. when expanded. Exoperidium formed of 4–7 rays, little to strongly incurved. Mycelial layer yellowish brown (5D6), scaly, glabrous, with debris on the surface. Fibrous layer yellowish white (4C5) to light



Figs. 4 A-F. A, B. *Gaeastrum pectinatum*. A. Basidioma; B. Capillitium and basidiospores. C, D. *G. rufescens*. C. Basidiomata; D. Capillitium and basidiospores. E, F. *G. saccatum*. E. Basidioma; F. Capillitium and basidiospores. Scale bars: 4 A, C, E = 20 mm; 4 B, D, F = 5 µm.

brown (5D6). Pseudoparenchymatous layer disappearing with age, with horizontal scales, forming a collar around the endoperidium, light orange (5A5) to yellowish brown (5E6) when fresh. Endoperidium 20–23 mm diam., subglobose, sessile, dark brown (6F5) to yellowish brown (5D6). Peristome 3–4 mm high, fibrillose, delimited, somewhat paler than the endoperidium. Gleba powdery, brown (6E4) to yellowish brown (5F6). Basidiospores 5.2–6.4 μm , globose, brown, echinate, ornamentation columnar, 0.7–1 μm long, with flattened apex under SEM. Eucapillitium 3.2–6.2 μm diam., golden brown to brown, thick-walled, lumen reduced, amorphous matter present. Endoperidium hyphae 3.2–4.6 μm diam., hyaline, thick-walled, without amorphous matter.

Habitat and distribution: Gregarious on litter and rotten wood. Presumably cosmopolitan (Kasuya *et al.*, 2012). Brazil: Pernambuco (Trierweiler-Pereira *et al.* 2011), São Paulo (Baseia *et al.* 2003), Paraná (Meijer 2006), Santa Catarina (Sobestiansky 2005) and Rio Grande do Sul (Rick 1961).

Examined material: BRAZIL, Paraná, Palotina, PESC, 16.II.2011, *V.G. Cortez* 18-46 (HCP); 23.XI.2011, *C.R. Alves* 06 (HCP); 15.VI.2011, *V.G. Cortez* 006/11 (HCP); 28.VI.2012, *C.R. Alves* 68 (HCP), 71 (HCP), 72 (HCP), 73 (HCP), 74 (HCP).

Observations: *Gastrum triplex* is a common species. However, recent molecular phylogenetic studies have shown that the morphological concept of *G. triplex* represents an assemblage of several closely related species with distinct biogeographical patterns (Kasuya *et al.* 2012). The presence of a collar around the endoperidium is the most conspicuous feature of this species, but the distinct basidiome size and some morphological differences indicate that specimens from the Southern Hemisphere differ from those of the Northern Hemisphere (Kasuya *et al.* 2012). Until formal names are proposed, we are referring to the specimens from southern Brazil as *G. triplex*, which is one of the most common earthstars in the study area, where it fruits abundantly on rotten wood and litter.

Gastrum violaceum Rick, Brotéria, Sér. Bot. 5: 26, 1906. (Figs. 5C, D, 8E)

Basidiomes 10–13 $\times$ 15–20 mm when expanded. Exoperidium composed of 6–8 involute rays, nonhygroscopic. Mycelial layer reddish brown (9D4) when fresh, brown (7E8) when dry, subvelutinous, with little debris on the surface, abundant rhizomorphs at the attachment point. Fibrous layer grayish yellow (1B4). Pseudoparenchymatous layer smooth, reddish brown (9E7) when fresh and reddish brown (8E7) when dry, gradually disappearing with maturity. Endoperidium 5–7 $\times$ 5–9 mm, globose to ovoid, smooth, reddish brown (8E5) when fresh and dark brown (6F5) in the exsiccates. Peristome fibrillose, 1–3 mm high, dark brown (6F5), little delimited. Gleba powdery, dark brown (6F5). Basidiospores 3.2–4.2

μm diam., globose, slightly verrucose, pale green; under SEM, distinct ornamentation is formed high warts (up to 3 μm). Eucapillitium 3.3–5.4 μm diam., thick-walled, dark green to brown. Endoperidium hyphae 2.4–3.5 μm diam., hyaline, thick-walled, with a reduced lumen and scattered amorphous matter.

Habitat and distribution: Solitary, on litter. Known from subtropical Argentina and Brazil (Kuhar & Papinutti 2009, Trierweiler-Pereira & Silveira 2012). Brazil: Paraná and Rio Grande do Sul (Trierweiler-Pereira & Silveira 2012).

Examined material: BRAZIL, Paraná, Palotina, PESC, 02.VI.2010, *V.G. Cortez* 3-19 (HCP); 18.XII.2012, *M. Teixeira-Silva* 51 (HCP).

Observations: *Gastrum violaceum* can be identified by its reddish-brown to pinkish-lilac basidiomes (Trierweiler-Pereira & Silveira 2012). It was recently described from Argentina as *G. episcopale* (Kuhar & Papinutti 2009), but a revision of *Gastrum* species described by J. Rick from Rio Grande do Sul showed that this is a synonym of *G. violaceum* (Trierweiler-Pereira & Silveira 2012). *Gastrum violaceum* was treated as a synonym of *G. lloydianum* by Ponce de Leon (1968), but the dark color of the exoperidium, the strongly arched rays and sulcate peristome of *G. lloydianum* are noteworthy differences between these species (Trierweiler-Pereira & Silveira 2012). According to Kuhar & Papinutti (2009), *G. violaceum* is a rare species that produces no more than two basidiomes in the field. This species was previously reported from Parque Nacional do Iguaçu, Paraná (Trierweiler-Pereira & Silveira 2012).

***Gastrum* sp.**

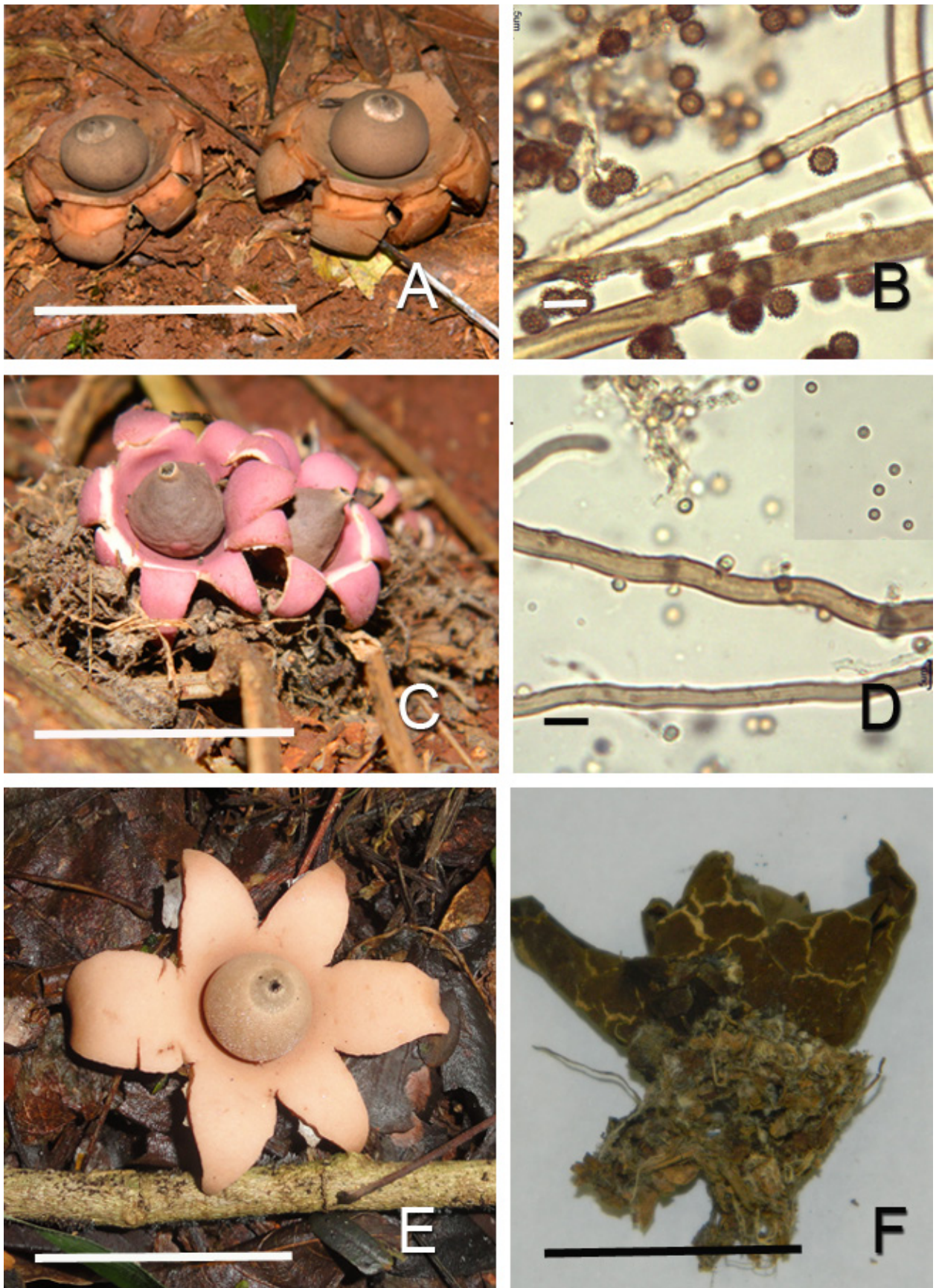
(Figs. 5E, F, 6A, 8F)

Basidiome 23 $\times$ 42 mm when expanded. Exoperidium formed of 6 nonincurved rays. Mycelial layer cleft, producing irregular yellowish-brown (5F5) plates, smooth to velutinous, without incrustated debris. Fibrous layer yellowish white (2A2). Pseudoparenchymatous layer fleshy, with scattered fissures, dull red (8B3). Endoperidium 12 mm high, 14 mm diam., sessile, subglobose, smooth, brownish gray (8C2). Peristome fibrillose, delimited by a circular and slightly depressed zone. Gleba cottony, brown (6F4). Basidiospores 4.8–5.2 μm , globose, spiny, dark green to brown, ornamentation composed of columnar spines with a flattened apex under SEM. Eucapillitium 3.3–6.8 μm diam., thick-walled, dark green to brown, with scattered amorphous matter. Endoperidium hyphae 3.7–4.5 μm diam., sinuous, thick-walled, with reduced lumen, hyaline.

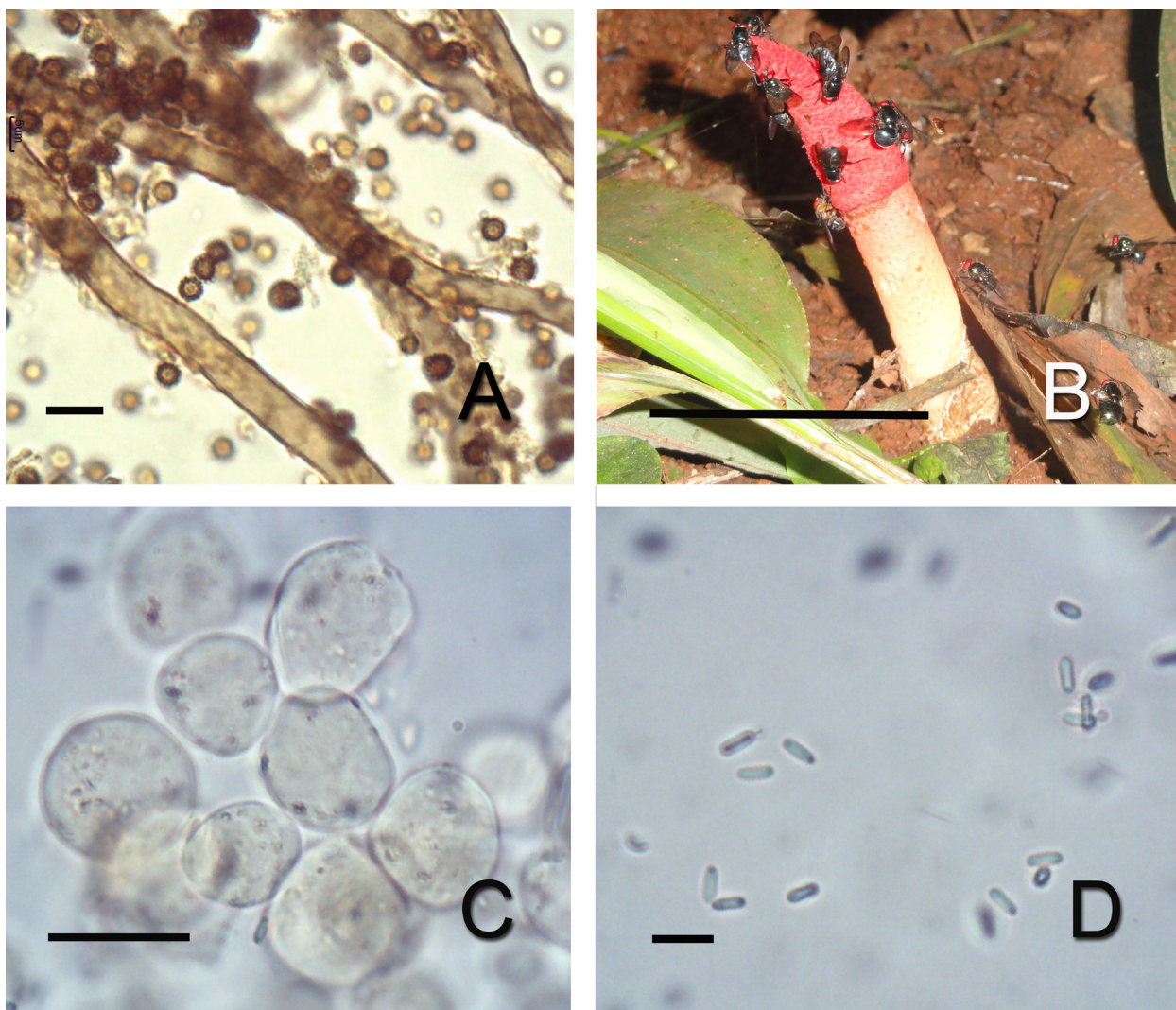
Habitat and distribution: Solitary on litter, in forest.

Examined material: BRAZIL, Paraná, Palotina, PESC, 27.04.2011, *A.J. Ferreira & V.G. Cortez* 23-7 (HCP).

Observations: This species resembles *G. saccatum* due



Figs. 5 A-F. A, B. *Geastrum triplex*. A. Basidiomata; B. Capillitium and basidiospores. C, D. *G. violaceum*. C. Basidiomata; D. Capillitium and basidiospores (Featured photo). E, F. *Geastrum* sp. E. Basidioma; F. Detail of mycelial layer. Scale bars: 5 A, C, E, F = 20 mm and B, D = 5 μ m.



Figs. 6 A-D. A. *Geastrum* sp. Capillitium and basidiospores. B, D. *Mutinus argentinus*. B. Basidioma; C. Receptacle hyphae; D. Basidiospores. Scale bars: 6 A, C, D = 5 μ m; 6 B = 20 mm.

to its saccate basidiome, subglobose endoperidium with delimited peristome, and pinkish pseudoparenchymatous layer. *Geastrum lageniforme* is a similar species because both have a cleft mycelial layer; however, in *Geastrum* sp. the fissures are irregular, velutinous and much more conspicuous, with a cracked appearance, in contrast to the longitudinal, thin fissures of *G. lageniforme*. Microscopically, basidiospores of *Geastrum* sp. are very similar to those of *G. saccatum* and *G. lageniforme*, with subtle differences in size and ornamentation. The single collection did not allow for the conclusion of its identity at the specific level, but the remarkable mycelial layer is a feature that may be of taxonomic value. Additional collections are needed from the study area to better understand this taxon.

Phallaceae: *Mutinus* Fr.

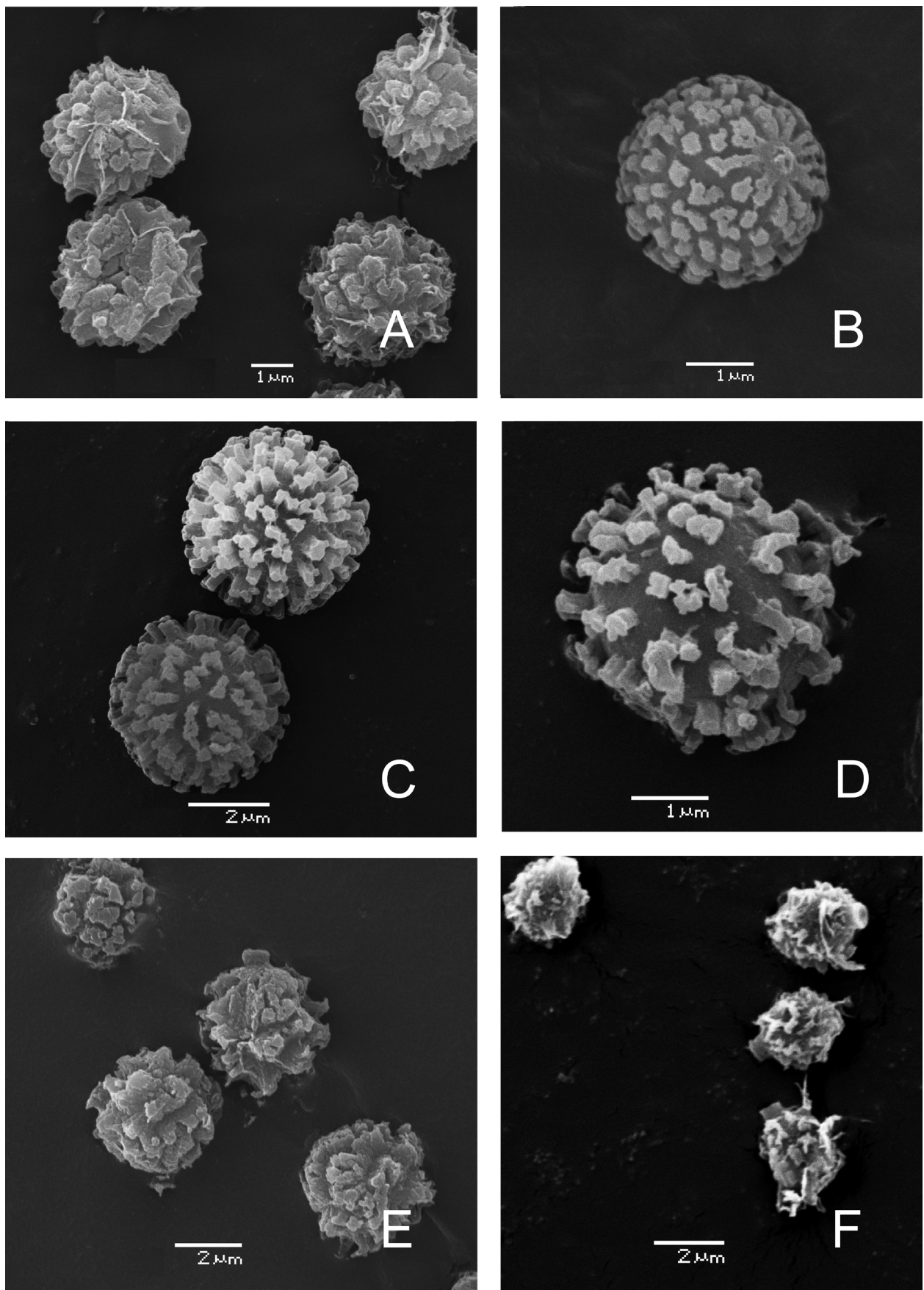
This genus has a fragile and ephemeral basidiomata that makes it more difficult to find. There are few records

of *Mutinus* Fr. for the state of Paraná. *Mutinus argentinus* Speg. is the first record of the group, which was collected by Meijer (2006).

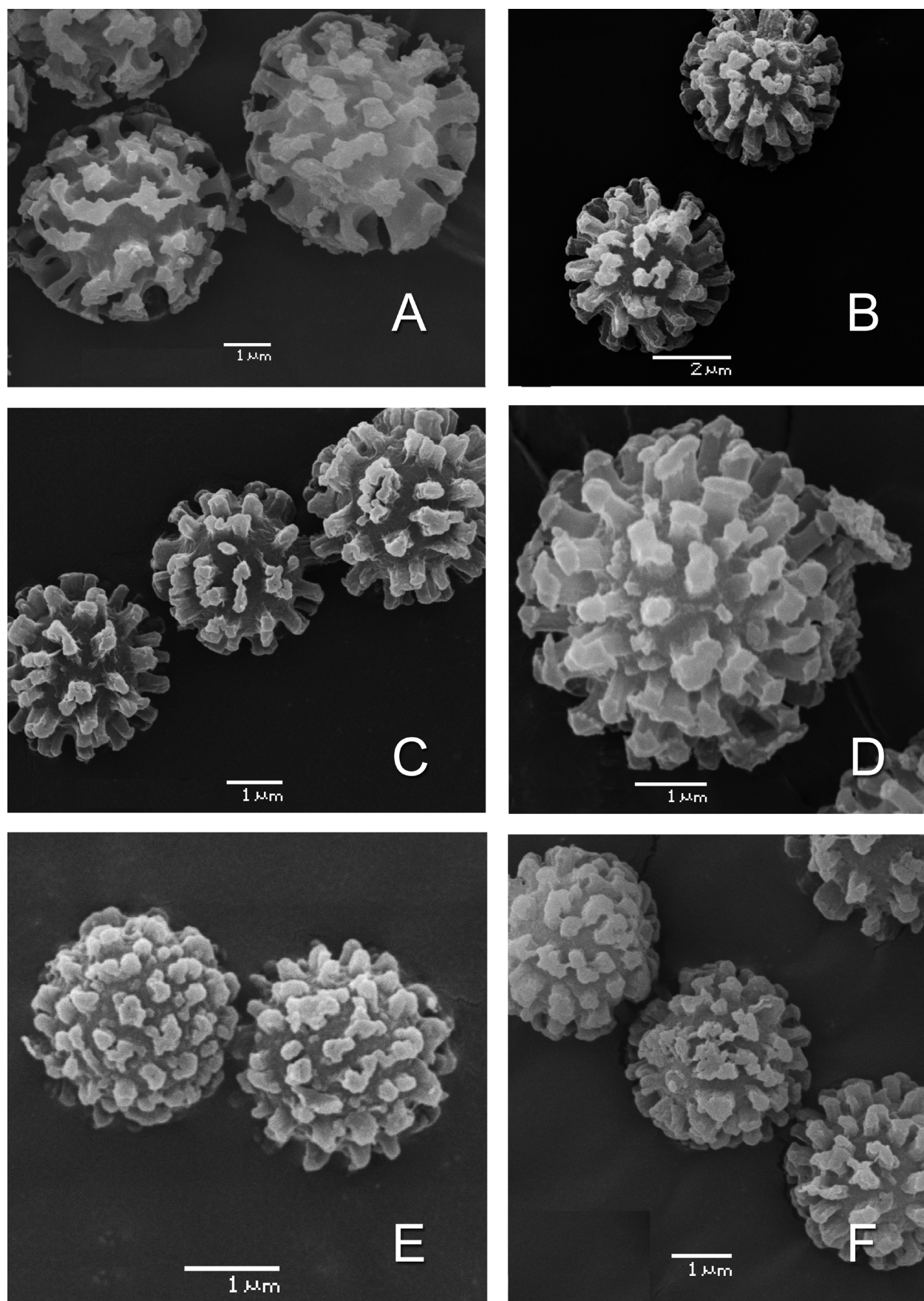
Mutinus argentinus Speg., An. Soc. Cient. Argent. 24: 62, 1887.

(Figs. 6 B-D)

Mycogeggs 20 $\times$ 10 mm, somewhat scaly and yellowish brown (5E7) at the apex, yellowish white (4A2) at base, bearing white, branched and thin (1 mm thickness) rhizomorphs. Receptacle 84 $\times$ 12 mm, subcylindrical, tapering towards the apex, pale orange (5A3) to yellowish brown (5D5), surface wrinkled, hollow. Fertile portion of receptacle 29 mm high, reaching about 1/3 of receptacle length, orange-red (8A7) when fresh, reddish brown (8F8) after drying, surface irregularly wrinkled, margin well-defined, distinctly separated from non-fertile portion, apex perforated. Gleba (immature) yellowish red (8A7)



Figs. 7 A-F. A. Basidiospores under SEM. A. *Geastrum coronatum*; B. *G. javanicum*; C. *G. lageniforme*. D. *G. Lloydianum*; E. *G. minimum*; F. *G. ovalisporum*. Scale bars: 7 A, B, D = 1 µm; 7 C, E, F = 2 µm.



Figs. 8. Basidiospores under SEM. **A.** *Geastrum pectinatum*. **B.** *G. rufescens*. **C.** *G. saccatum*. **D.** *G. triplex*. **E.** *G. violaceum*. **F.** *Geastrum* sp. Scale bars: A - F = 1 µm and B = 2 µm.

in the mycoegg; in the expanded receptacle not abundant, probably not fully developed in the collected material, but producing a strongly fetid odor. Volva membranous, saccate, with basal rhizomorphs. Receptacle hyphae 20–30 µm diam., globose to subglobose, hyaline to pale brownish, walls thin and smooth. Basidiospores 4–7 × 2 µm, ellipsoid, hyaline to pale green, smooth, thin-walled.

Habitat and distribution: Solitary, on litter, in forest, with flies surrounding the receptacle. Pantropical (Gube & Piepenbring 2009). Brazil: Paraná (Meijer 2006).

Examined material: BRAZIL, Paraná, Palotina, PESC, 27.IV.2011, V.G. Cortez 23-3 (HCP); 17.IV.2012, V.G. Cortez 21 (HCP).

Observations: *Mutinus argentinus* is recognized by its receptacle with a reddish and well-defined fertile portion, which can be perforated at the apex, and the pale orange color of its pseudostipe (Spegazzini 1887, Reid 1977). *Mutinus bambusinus* (Zoll.) E. Fisch is a very similar species, but it has a whitish pseudostipe, a fertile portion that occupies 2/3 of basidiome size, and a small sterile apical portion with a verrucose surface (Dring & Rose 1977, Hemmes & Desjardin 2009). According to Wright (1960), *M. bambusinus* varies in color and size. Due to strong similarities between these taxa, there are some doubts about their taxonomy. Demoulin & Dring (1975) discussed that *M. bambusinus* presents parenchymatous processes at the fertile zone of receptacle. On the other hand, Dring & Rose (1977) reiterate that useful features used to distinguish these species are the longer and more colored fertile portion and the presence of parenchymatous processes in *M. bambusinus* (which are absent in *M. argentinus*). Gube & Piepenbring (2009) discussed that some records of *M. bambusinus* from the Neotropics are probably misidentified and could be *M. argentinus*.

ACKNOWLEDGEMENTS

The authors thank the Instituto Ambiental do Paraná (IAP, Aut. Pesq. Cient. 212/10) for allowing fieldwork at Parque Estadual São Camilo, Conselho Nacional de Desenvolvimento Científico e Tecnológico (Proc. 478373/2010-4) for financial support, the Centro de Microscopia Eletrônica, Universidade Federal do Paraná, for assistance during the SEM analysis, and Andreas L. Schwarz Meyer for producing the map.

REFERENCES

- Alves, C. R. & Cortez, V. G. 2013a. *Morganella sulcatostoma* sp. nov. (Agaricales, Basidiomycota) from Paraná State, Brazil. Nova Hedwigia 96:409-417.
- _____. 2013b. *Calvatia guzmanii* sp. nov. (Agaricaceae, Basidiomycota) from Paraná State, Brazil. Phytotaxa 85(2):35-40.
- Baseia, I. G. & Calonge, F. D. 2005. *Aseroë floriformis*: a new phalloid with a sunflower-shaped receptacle. Mycotaxon 92:169-172.
- _____. 2006. *Gastrum hirsutum*: a new earthstar fungus with a hairy exoperidium. Mycotaxon 95:301-304.
- Baseia, I. G. & Galvão, T. C. O. 2002. Some interesting Gasteromycetes (*Basidiomycota*) in dry areas from northeastern Brazil. Acta Botanica Brasilica 16:1-8.
- Baseia, I. G. & Milanez, A. I. 2002. *Gastrum setiferum* (Gasteromycetes): a new species with a setose endoperidium. Mycotaxon 54:135-139.
- Baseia, I. G., Cavalcanti, M. A. & Milanez, A. I. 2003. Additions to our knowledge of the genus *Gastrum* (Phallales: Geastraceae) in Brazil. Mycotaxon 55:409-416.
- Bononi, V. L. R., Trufem, S. F. B. & Grandi, R. A. P. 1981. Fungos macroscópicos do Parque Estadual das Fontes do Ipiranga depositados no Herbário do Instituto de Botânica. Rickia 9:37-53.
- Bononi, V. L. R., G. Guzmán & Capelari, M. 1984. Basidiomicetos do Parque Estadual da Ilha do Cardoso V: Gasteromicetos. Rickia 11:91-97.
- Calonge, F. D. 1999. Setas de Madrid y alrededores: Gasteromycetes. Madrid: Sociedad Micológica de Madrid. 159 p.
- Calonge, F. D. & Mata, M. 2006. Adiciones y correcciones al catálogo de Gasteromycetes de Costa Rica. Boletín de la Sociedad Micológica de Madrid 30:111-119.
- Calonge, F. D., Moreno-Arroyo, B. & Gómez, J. 2000. Aportación al conocimiento de los Gasteromycetes, *Basidiomycotina* de Bolivia (América del Sur). *Gastrum ovalisporum* sp. nov. Boletín de la Sociedad Micológica de Madrid 25:271-275.
- Cortez, V. G., Baseia, I. G. & Silveira, R. M. B. 2011a. Gasteroid mycobiota of Rio Grande do Sul State, Brazil: *Lysuraceae* (Basidiomycota). Acta Scientiarum, Biological Sciences 33:87-92.
- _____. 2011b. Two noteworthy *Phallus* from southern Brazil. Mycoscience 52:436-438.
- Cortez, V. G., Sulzbacher, M. A., Baseia, I. G. & Silveira, R. M. B. 2008. Two little known gasteroid fungi from Santa Catarina State, southern Brazil. Mycotaxon 106:297-302.
- Cortez, V. G., Sulzbacher, M. A., Baseia, I. G., Antoniolli, Z. I. & Silveira, R. M. B. 2011c. New records of *Hysterangium* (Basidiomycota) from a Eucalyptus plantation in southern Brazil. Revista Brasileira de Biociências 9:220-223.
- Demoulin, V. & Dring, D. M. 1975. Gasteromycetes do Kivu (Zire), Rwanda and Burundi. Bulletin du Jardin Botanique National de Belgique 45:339-372.
- Dring, D. M. & Rose, A. C. 1977. Additions to West African phalloid fungi. Kew Bulletin 32: 741-751.
- Fazolino, E. P., Calonge, F. D. & Baseia, I. G. 2008. *Gastrum entomophilum*, a new earthstar with an unusual spore dispersal strategy. Mycotaxon 104:449-453.
- Gube, M. & Piepenbring, M. 2009. Preliminary annotated checklist of Gasteromycetes in Panama. Nova Hedwigia 89:519-543.
- Hemmes, D. E. & Desjardin, D. E. 2009. Stinkhorns of the Hawaiian Islands. Fungi 2 (3):8-10.
- _____. 2011. Earthstars (*Gastrum*, *Myriostoma*) of the Hawaiian Islands including two new species, *Gastrum litchiforme* and *Gastrum reticulatum*. Pacific Science 65: 477-496.
- Hosaka, K., Bates, S.T., Beever, E. R., Castellano, M. A., Colgan III, W., Domínguez, L. S., Nouhra, E. R., Geml, J., Giachini, A. J., Kenney, S. R., Simpson, N. B., Spatafora, J. B. & Trappe, J. M. 2006. Molecular phylogenetics of the gomphoid-phalloid fungi with establishment of the new subclass Phallomycetidae and two new orders. Mycologia 98:949-959.
- Kasuya, T., Hosaka, K., Uno, K. & Kakishima, M. 2012. Phylogenetic placement of *Gastrum melanocephalum* and polyphyly of *Gastrum triplex*. Mycoscience 53:411-426.
- Kornerup, A. & Wanscher, J. H. 1978. Methuen handbook of colour. 3rd ed. London: Eyre Methuen.
- Kuhar, F. & Papinutti, L. 2009. *Gastrum episcopale*: a new noticeable species with red-violet exoperidium. Mycologia 101:535-538.
- Leite, A. G., Silva, B. D. B., Araújo, R. S. & Baseia, I. G. 2007. Espécies raras de Phallales (Agaricomycetidae, Basidiomycetes) no Nordeste do Brasil. Acta Botanica Brasilica 21:119-127.
- Meijer, A. A. R. 2006. Preliminary list of the macromycetes from the Brazilian state of Paraná. Boletim do Museu Botânico Municipal, Curitiba 68:1-55.
- _____. 2010. Preliminary list of the macromycetes from the Brazilian state of Paraná: corrections and updating. Boletim do Museu Botânico Municipal, Curitiba 72: 1-10.

- Miller Jr., O. K. & Miller, H. H. 1988. Gasteromycetes: morphological and development features. Eureka: Mad River. 156p.
- Pegler, D. N.; Laessle, T. & Spooner, B. M. 1995. British puffballs, earthstars and stinkhorns. Kew: Royal Botanic Gardens. 255 p.
- Ponce de Leon, P. 1968. A revision of the family *Gastraceae*. Fieldiana, Botany 31:303-349.
- Reid, D. A. 1977. Some gasteromycetes from Trinidad and Tobago. Kew Bulletin 31:657-690.
- Rick, J. 1961. *Basidiomycetes* Eubasidii in Rio Grande do Sul. Brasília. 6. Iheringia, Série Botânica 9:451-480.
- Roderjan, C. V., F. Galvão, Kunyoshi, Y. S. & Hatschbach, G. 2002. As unidades fitogeográficas do Estado do Paraná. Ciência e Ambiente 24:75-92.
- Smith, C. W. & Ponce de Leon, P. 1982. Hawaiian geastroid fungi. Mycologia 74:712-717.
- Sobestiansky, G. 2005. Contribution to a macromycete survey of the States of Rio Grande do Sul and Santa Catarina in Brazil. Brazilian Archives of Biology and Technology 48: 437-457.
- Soto, M. K. & Wright, J. E. 2000. Taxonomia del género *Gastrum* (*Basidiomycetes*, *Lycoperdales*) en la Provincia de Buenos Aires, Argentina. Boletín de la Sociedad Argentina de Botánica 34:185-201.
- Spegazzini, C. 1887. Las Phalloideae Argentinae. Anales de la Sociedad Científica Argentina 24:62-68.
- Sulzbacher, M. A., Cortez, V. G. & Baseia, I. G. 2013. Rediscovery of *Pseudocolus garciae* in southern Brazil. Mycotaxon 123:113-119.
- Sunhede, S. 1989. *Gastraceae* (*Basidiomycota*). Oslo: Fungiflora. 353p.
- Trierveiler-Pereira, L. & Baseia, I. G. 2009. A checklist of the Brazilian gasteroid fungi (*Basidiomycota*). Mycotaxon 108: 441-444.
- _____. 2010. Contribution to the knowledge of gasteroid fungi (*Agaricomycetes*, *Basidiomycota*) from the state Paraíba, Brazil. Revista Brasileira de Biociências 9: 167-173.
- Trierveiler-Pereira, L., Calonge, F. D. & Baseia, I. G. 2011. New distributional data on *Gastrum* (*Gastraceae*, *Basidiomycota*) from Brazil. Acta Botanica Brasílica 25: 577-585.
- Trierveiler-Pereira, L., Loguercio-Leite, C., Calonge, F. D. & Baseia, I. G. 2009. An emendation of *Phallus glutinolens*. Mycological Progress 8:377-380.
- Trierveiler-Pereira, L. & Silveira, R. M. B. 2012. On the *Gastrum* species (*Gastraceae*, *Basidiomycota*) described by J. Rick. Phytotaxa 61:37-46.
- Wright, J. E. 1960. Notas sobre faloideas sudy centroamericanas. Lilloa 30:340-359.
- Wright, J. E. & Wright, A. M. 2005. Checklist of the mycobiota of Iguazú National Park (Misiones, Argentina). Boletín de la Sociedad Argentina de Botánica 40:23-44.