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Rediscovery of *Clathrus argentinus* and new contributions to the gasteroid mycobiota of Paraguay

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Abstract

Clathrus argentinus was described as a new species from central and northern Argentina in 1985. Thirty-five years later, we report *C. argentinus* from Paraguay. Along with this interesting discovery, eight other new records of gasteroid fungi viz. *Blumenavia rhacodes*, *Calvatia cyathiformis*, *Cyathus earlei*, *Geastrum pusillipilosum*, *Lysurus sphaerocephalum*, *Myriostoma calongei*, *Phallus campanulatus* and *Tulostoma pygmaeum* are reported from the country. In addition, the distribution of *Calvatia rugosa*, *Cyathus limbatus*, *Cyathus poeppigii* and *Podaxis pistillaris* is extended for Paraguay. Descriptions and photographs of the fresh specimens are included along with comments on their taxonomy and ecology.

Key words – Agaricomycetes – fungal diversity – fungal taxonomy – gasteromycetes – Neotropical fungi

Introduction

Paraguay is divided into two broad regions by the Paraguay River: the Occidental Region and the Oriental Region (Marchi et al. 2018). Within these two geographical regions, five ecoregions have been described: Pantanal, Humid Chaco and Dry Chaco in the Occidental Region and Atlantic Forest and Cerrado in the Oriental Region (Dinerstein et al. 1995). The most studied ecoregion with respect to fungal diversity has been the humid Chaco, with most of the country remaining without fungal records. The study of gasteroid funga in Paraguay began with identifications provided by the Argentinean mycologist Carlos Spegazzini, who recorded 10 species from the country (Spegazzini 1884, 1888, 1891). After his valuable contributions, some other works were published regarding the genera *Cyathus* Haller (Campi & Maubet 2015a, Maubet et al. 2017), *Geastrum* Pers. (Campi et al. 2013, Campi & Maubet 2015b), *Phallus* Junius ex L. and *Clathrus* P. Micheli ex L. (Campi et al. 2017a, Maubet et al. 2018); scattered records for other genera also exist (Campi et al. 2015, Campi & Maubet 2016, Campi et al. 2016, Campi et al. 2017b). However, no systematic collection effort has been carried out to study the diversity of fungi throughout Paraguay; most collecting has been done near the capital city and populated areas or elsewhere has been occasional.

The neotropics have a high diversity of gasteroid mycobiota, motivating study by several South American research groups. Each year new species and new taxonomic positions are elucidated (Hernández Caffot et al. 2018, Cabral et al. 2019, Sousa et al. 2019b, Melanda et al.

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2020).

The objective of this work is to contribute to the knowledge of neotropical gasteroid fungi and share knowledge about the gasteroid mycobiota of Paraguay. Nine new records of gasteroid fungi are reported: *Blumenavia rhacodes*, *Calvatia cyathiformis*, *Clathrus argentinus*, *Cyathus earlei*, *Geastrum pusillipilosum*, *Lysurus sphaerocephalum*, *Myriostoma calongei*, *Phallus campanulatus* and *Tulostoma pygmaeum.* In addition, the distribution of *Calvatia rugosa*, *Cyathus limbatus*, *Cyathus poeppigii* and *Podaxis pistillaris* is extended in the country.

Materials & Methods

Study area

The studied materials were collected in five ecoregions: Atlantic Forest, Humid Chaco, Dry Chaco, a transition area between Atlantic Forest and Humid Chaco, and Pantanal. The collections are from Reserva Natural Laguna Blanca, some anthropologically modified areas in the cities of Central and Paraguarí Departments, a cattle ranch in Boquerón Department, Parque Nacional Ybycuí (Paraguarí Department), and Estación Biológica Tres Gigantes (Alto Paraguay Department).

Morphological analysis

Morphologial studies were conducted at the mycology area of the 'Laboratorio de Análisis de Recursos Vegetales' in the Department of Biology, Universidad Nacional de Asunción (UNA), San Lorenzo. The specimens were analyzed macroscopically with the unaided eye or with a BOECO BSZ-405 stereoscope. Slides were prepared with 3% KOH and observed through a BOECO BM-800 optical microscope coupled with a B-CAM14 camera. Dyes such as phloxine and congo red were used to visualize specific structures, following Miller & Miller (1988). Measurements were made under the 100× objective using the Boeckel B-View version x64, 3.7.5415 software. Thirty measurements (basidiospores with ornamentation, capillitium, peridial hyphae and rhizomorphs) and extreme values were recorded. Spore size description followed Bates (2004) where size range = ($height_{min}$ – $height_{max}$) × ($width_{min}$ – $width_{max}$). Thus, Q_m = mean of the quotient of basidiospores' width and length, and n = number of randomly measured basidiospores. The quotient Q = ℓ/w describes the shape of the basidiospores.

Studied specimens are kept at the herbarium of the Laboratorio de Análisis de Recursos Vegetales, Área Botánica, Universidad Nacional de Asunción. Facesoffungi numbers (FoF) were obtained as described in Jayasiri et al. (2015).

Results & Discussion

Taxonomy

Clathrus argentinus L.S. Domínguez, Boletín de la Sociedad Argentina de Botánica 24 (1-2): 131 (1985) Fig. 1a–d

Index Fungorum number: IF104934; Facesoffungi number: FoF09291

Description − Unexpanded basidiome not seen. Immature basidiomata epigeous, subglobose to ovoid, 33–47 × 25 mm, attached to the substrate by abundant whitish rhizomorphs, forming a white mycelium net. *Peridium* of two layers, the outer coriaceous, <1 mm thick, whitish, covered with grayish to brown scales, smooth, covering the inner gelatinous layer, colorless, thickening (≤40 mm thick) towards the apex. Dehiscing by irregular tears from the apex. *Receptacle* 95–115 mm high, clathrate with a more or less symmetrical arrangement of the arms to give an irregular network of about twenty meshes (not counting the ones formed by the basal arms), arms 7–9, pinkish to salmon, not fused at the base; transverse section of an arm shows several tubes, six towards the outside and two larger ones towards the inside surface where the gleba sits. *Gleba* borne on the inner face of the intersection of the meshes, olivaceous, odour of rotten fruit. *Columns*

composed of pseudoparenchymatous hyphae, irregularly rounded structures, 23.6–45 × 15–25(–38) µm. *Exoperidium* composed of septate hyphae, 3–4 µm diam., thin-walled, branched; the inner gelatinous layer composed of thin-walled hyphae, 2.5–3.5 µm, some inflated at the septa, hyaline; septa with clamp connections. *Basidiospores* 4.3–4.7 × 1.8–2.0 µm (Qx = 2.36; Q = 2.35–2.37; N = 2; n = 30), cylindric-ellipsoid, faintly greenish tinted (chlorohyaline), smooth.

Habitat – Solitary to gregarious, growing in leaf litter and in a pot of *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. Found; and soil in urban area in the Humid Chaco ecoregion.

Distribution in South America – Argentina (Domínguez de Toledo 1985), Paraguay (present study).

Material examined – PARAGUAY. Central Department, Villa Elisa City, Ypati neighborhood, 25°21'28,8"S 57°34'47,7"W, 29 April 2020, leg. Y. Maubet 126 (FACEN 004565), Central Department, Villa Elisa City, 29 de Septiembre neighborhood, 25°20,5'5,4"S 57°35'07,4"W, 2 May 2020, leg. Y. Maubet 127 (FACEN 004566).

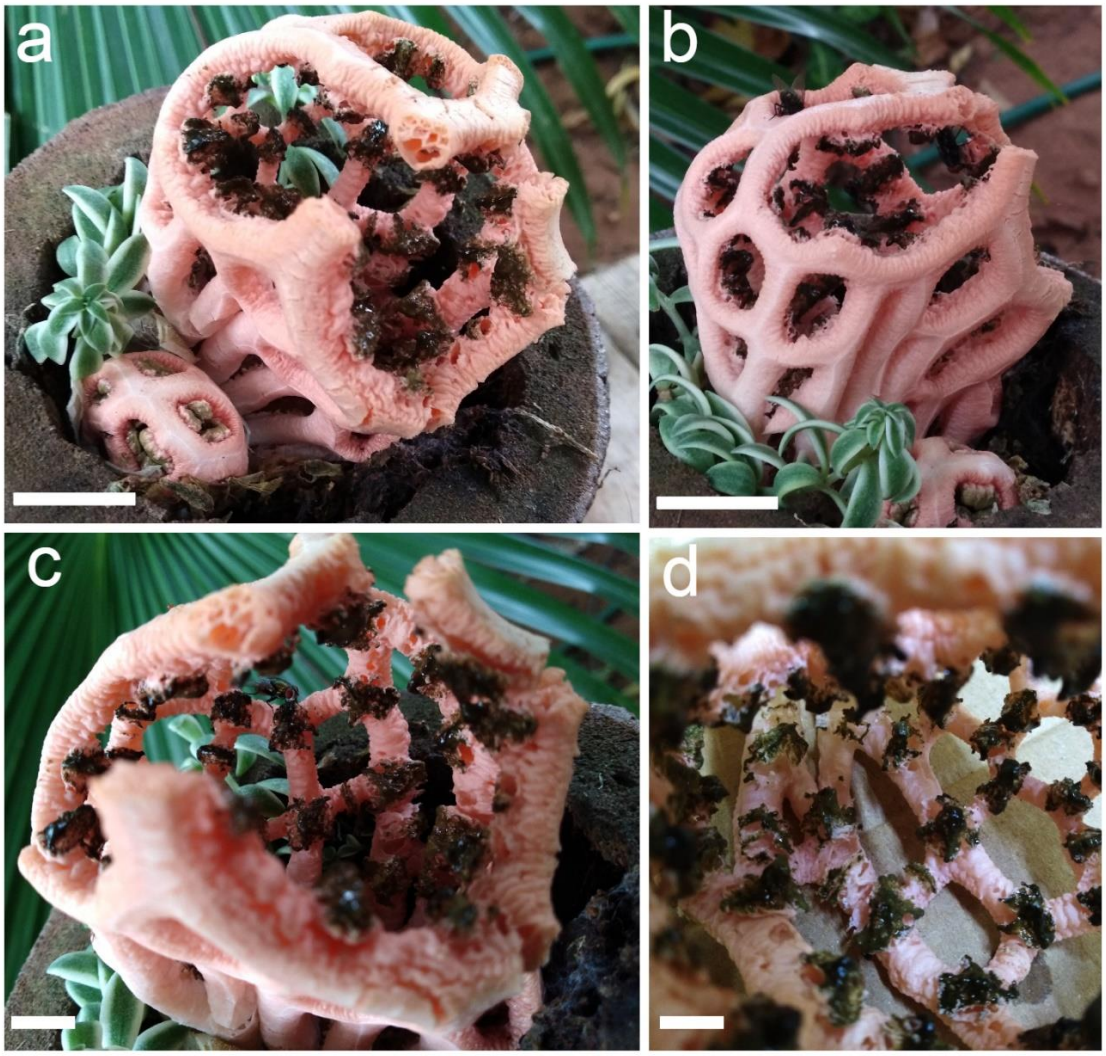

Fig. 1 – a, b, c, d *Clathrus argentinus* (leg. Y. Maubet 126). a-b Basidiomata clathrate, with seven to nine pinkish arms, not fused at the base. c-d Close view of the internal face of the meshes, showing the gleba. Scale bars: a = 25 mm, b = 3 mm, c, d = 10 mm.

Notes – *Clathrus argentinus* was described based on four specimens found in central and northern Argentina (Domínguez de Toledo 1985). Basidiomata of this new species were characterized by the pinkish/salmon coloured receptacle, and free columns (meshes arms) at the base. Basidiospores are long, according to original description (3.9–6 µm in length). Meshes

columns are more robust when just expanded, but they tend to elongate as the basidiome expands. Glebifers are numerous and are located inner face of the intersection of the meshes. When just expanded (young basidiome), the glebifers are turgid and they can be seen filling the meshes, somewhat resembling *Clathurs crispus* Turpin, a Neotropical species found especially on warm areas. Basidiomata of *C. crispus* are reddish and the gleba is spread on a corrugate membrane that covers the meshes holes (Trierveiler-Pereira et al. 2019). *C. argentinus* is macromorphologically similar to *C. transvaalensis* Eicker & D.A. Reid, described from South Africa, which also has a rotten fruit odor (Eicker & Reid 1990, Coetzee 2010). Further molecular studies are necessary to better circumscribe both species.

Blumenavia rhacodes Möller, Bot. Mitt. Trop. 7: 57 (1895) Fig. 2a–c

Index Fungorum number: IF241046; Facesoffungi number: FoF09292

Description − Unexpanded basidiomata not seen. Basidiomata growing in small groups, 64–70 mm high. Volva 15–25 mm high, whitish, with a compact outer layer and a gelatinous inner layer, attached to the substrate by a whitish rhizomorphs. Receptacle formed 3–5 narrowing columns that are free at the base and united above, columns 5–10 mm in diam. in the largest dimension, white to pale yellow, multi-tubular formed by up to 6 tubes, regular in shape and position, the innermost very large and forming the glebiferous crest. Gleba mucilaginous, fetid, spread on lateral projection or lacerations of the receptacle's columns. Basidiospores hyaline, ellipsoid, usually attenuate at one side, 4–4.5 × 1–1.5 µm, smooth, faintly greenish. Exoperidium formed by three layers, outer layer composed of septate hyphae, up to 11 µm in diam., yellowish to hyaline, branched, strongly interwoven; medium layer gelatinous, formed by hyaline hyphae, 2.5–3.5 µm, simple septate, some with clamp connections, thin-walled showing irregular content. Inner layer composed of the same hyphae as the medium layer but more tightly intertwined. Receptacle formed by pseudoparenchymatous hyphae, 30–60 × 25–40 µm, hyaline, thin-walled.

Habitat – Two or more specimens, growing on litter and decomposing wood. Found on forest in the Humid Chaco ecoregion.

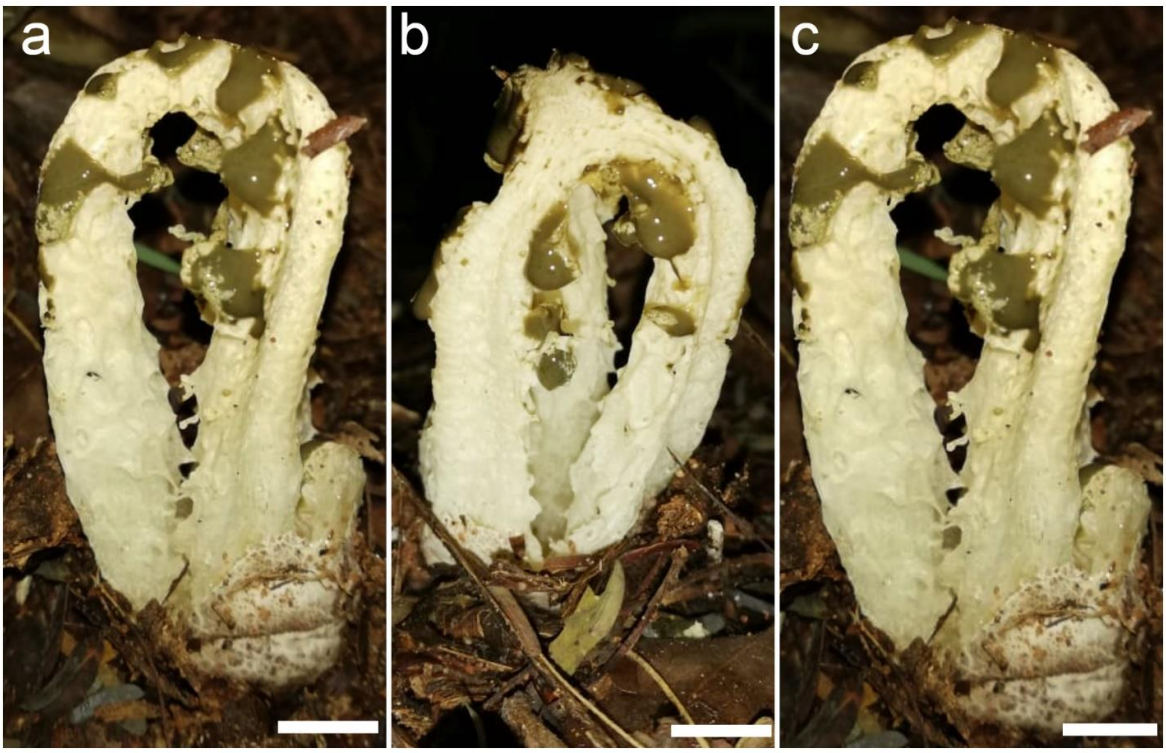

Fig. 2 – a, b, c *Blumenavia rhacodes* (Leg. Y. Maubet 129). a-b Basidiomata columnar, with three to five whitish arms, free at the base. c Close view of the internal face of the meshes, showing the gleba. Scale bars: a = 20 mm, b = 20 mm, c = 10 mm.

Material examined – PARAGUAY, Cordillera Department, Piribebuy City, Granja Yrokẽ, 25°30'47,08"S, 57°04'17,51"W, 10 July 2020, Y. Maubet 129 (FACEN 004567).

Distribution in South America – Argentina-Provinces: Córdoba and Santa Fé (Domínguez de Toledo 1995). Brazil-States: Southern Brazil (Möller 1895, Rick 1929, Trierveiler-Pereira et al. 2014).

Notes – The species is characterized by a yellowish to beige receptacle consisting of 3–5 columns, and glebifers occurring on lateral expansions ("teeth") distributed along the column's margins (Trierveiler-Pereira et al. 2019). This species has shown to have a high morphological variation (Rodrigues & Baseia 2013, Trierveiler-Pereira et al. 2014, Hernández Caffot et al. 2018, Trierveiler-Pereira et al. 2019). Variations in colour and size have been seen, the colour of the receptacle was reported as orange fading to yellow or white (Dring 1980), but Trierveiler-Pereira et al. (2014) has cited the color usually as pale yellow and Melanda et al. (2020) cited whitish yellow to light orange.

A similar species is *Blumenavia angolensis* (Welw. & Curr.) Dring, but can be differentiate due to size and coloration of basidiomata (Trierveiler-Pereira et al. 2019). *B. rhacodes* has more robust, large basidiomata (up to 130 mm high), while *B. angolensis* is fragile and small (up to 60 mm) (Trierveiler-Pereira et al. 2019). As for the colour, B. *rhacodes* presents pale orange to yellow colors while *B. angolensis* whitish tones (Vargas-Rodriguez & Vázquez-García 2005). *B. rhacodes* is also morphologically similar to *B. baturitensis* and *B. toribiotalpaensis* by the arm color; but, *B. toribiotalpaensis* and *B. baturitensis* have irregularly shaped glebifers along the arms, only filamentous hyphae in the apical exoperidium and the arms are thinned from the middle to the top of the basidiomata (Melanda et al. 2020).

Calvatia cyathiformis (Bosc) Morgan, Journal of the Cincinnati Society of Natural History 12: 168 (1890) Fig. 3a–d

Index Fungorum number: IF356862; Facesoffungi number: FoF09301

Description – Basidiomata 30–75 mm high and 35–75 mm in diam. when mature; globose when young, subpiriform to turbinate when mature. Exoperidium smooth to slightly rough or floccose, slightly scaly, thin and fragile, the upper part breaking into large irregular areas, yellowish-white to pale brown, becoming membranous and fragile at maturity and finally disappearing completely, exposing the gleba after spore release. Endoperidium grey when young, brown when mature, thin and delicate, evanescent. Sterile base well developed, with a robust sterile base bearing one or a few thick rhizomorphs at the base, spongy in appearance, chambered, remaining intact as a persistent dark cup-like structure, diaphragm absent. Gleba at first white, then changing to a dark purple, spongy powder, cottony to pulverulent at maturity, then gradually disappearing. Subgleba brownish, shortly subcylindrical, spongy and rigid, persistent after maturity. Basidiospores 7–8 × 6.7–7.7 µm with ornamentation, (Qx = 1.02; Q = 1.00–1.03; N = 2; n = 30), globose, strongly echinate, with broad spines up to 2 µm long, brown under KOH; Eucapillitium 2.5–4.6 µm diam., smooth and thick walled, dichotomously branched and septate, yellowish brown under KOH. Exoperidium composed by yellowish elements of variable shape (subglobose, fusoid, lageniform, subcylindrical, 17–43 × 9–19 µm, with smooth and little thickened walls.

Habitat – Growing in small groups. On soil and litter in urban area, found on the Humid Chaco ecoregion and in xerophytic environment in the Dry Chaco ecoregion.

Distribution in South America – Argentina-Provinces: Buenos Aires (Spegazzini 1898 as *L. pseudolilacinum*, Wright & Albertó 2006); Catamarca (Dios et al. 2011), Chubut (Spegazzini 1902 as *L. pseudolilacinum*), Córdoba (Spegazzini 1898 as *L. pseudolilacinum*, Domínguez de Toledo 1989), Jujuy (Fries 1909); Santiago del Estero (Domínguez de Toledo 1989). Brazil-States: Rio Grande do Sul, São Paulo, Minas Gerais, Rio de Janeiro, Pernambuco (Silveira 1943, Bononi et al. 1981, Guerrero & Homrich 1999, Baseia 2004, Sobestiansky 2005, de Meijer 2006, Wartchow & Silva 2007, Drechsler-Santos et al. 2008), Bolivia- Department: Tarija (Fries 1909).

Material examined – PARAGUAY. Central Department, Areguá City, Cocué Guazú Locality, 25°20'49,58"S, 57°22'17,70"W, 2 March 2020, M. Campi 516 (FACEN 004568); Boquerón Department, Montanía Country House, 9 January 2016, A. Weiler 062 (FACEN 003459).

Notes – *Calvathia cyathiformis* is well characterized due to its purple gleba, by the coloration of the basidiome, the long persistent chambered sterile base, and basidiospores ornamented measuring about 4–7 µm in diam. (Zeller & Smith 1964, Morales & Kimbrough 1978). A related species is *C. fragilis* (Vittad.) Morgan, but they differ in that *C. cyathyformis* has a large sterile base and on basidiospore ornamentation (Wright & Albertó 2006).

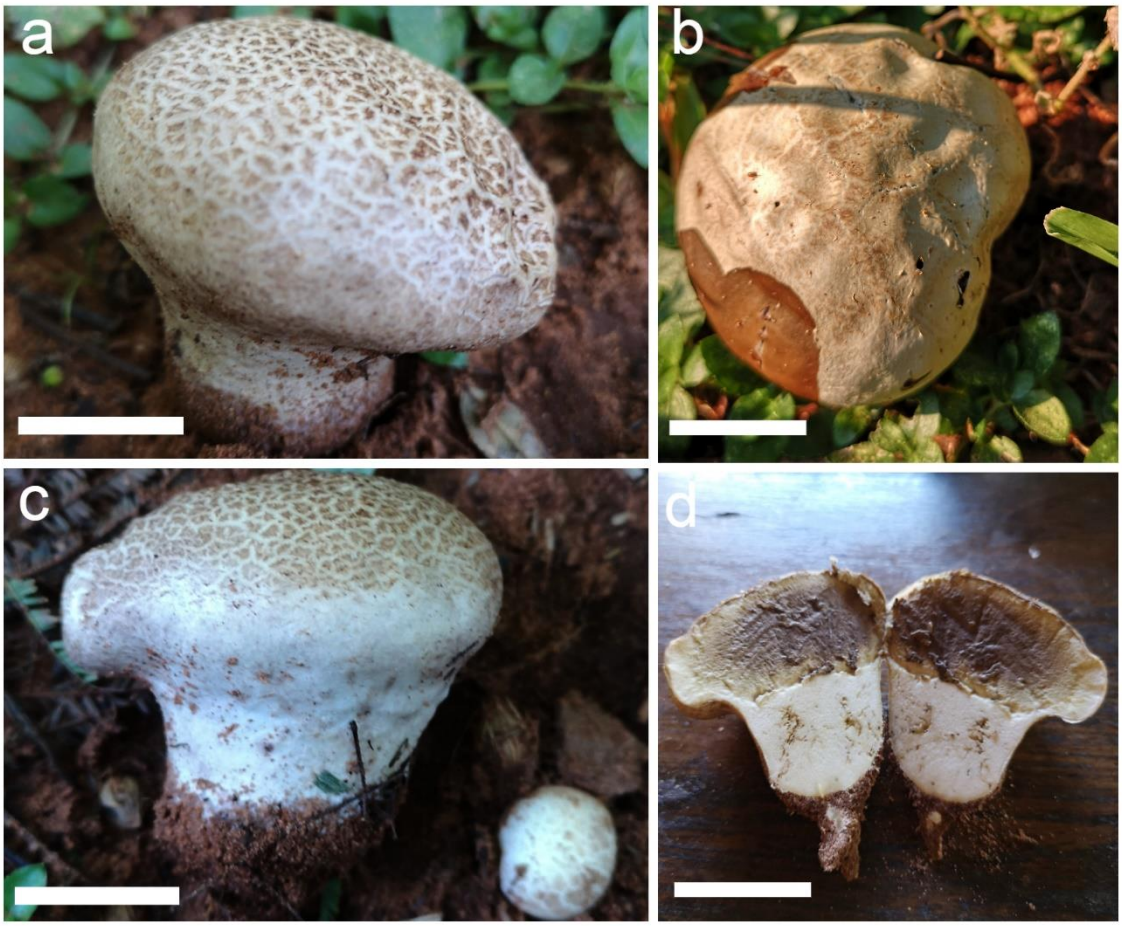

Fig. 3 – a, b, c, d *Calvatia cyathiformis* (leg. M. Campi 516). a-c Subpiriform to turbinate basidiomata. b Smooth, slightly scaly, thin and fragile exoperidium. d Well developed sterile base with a few thick rhizomorphs at the base. Scale bars: a, c = 15 mm, b = 10 mm, d = 50 mm.

Calvatia rugosa (Berk. & M.A. Curtis) D.A. Reid Fig. 4a–c

Index Fungorum number: IF310113; Facesoffungi number: FoF04982

Description in – Campi & Maubet (2016).

Material examined – PARAGUAY, Alto Paraguay Department, Bahía Negra City, Estación Biológica Tres Gigantes, 20°4'35.31"S, 58°9'23.75"W, 28 April 2017, M. Campi 229 (FACEN 004579), San Pedro Department; Santa Rosa de Aguaray Guazú City; Reserva Natural Laguna Blanca; Kurupay'ty path; 23°49'17.1"S 56°17'52.6"W; 3 April 2012; M. Campi 025 (FACEN 003345); Central Department, San Lorenzo City, Universidad Nacional de Asunción, 21 December 2016, Y. Maubet 036 (FACEN 004343), Paraguarí Department, Ybycuí City, Parque Nacional Ybycuí, 26°04'56"S, 56°50'44"W, 14 May 2019, M. Campi 408 (FACEN 004344)

Notes – The main characteristic of this species is the presence of orange/yellowish pigment that stains the fresh mature basidiome when it is cut (Cortez et al. 2008). Another distinctive feature is its long rhizomorphic extension of 20–200 mm in diameter and 10–100 mm high, which folds at

the base and is attached by one or more thin to thick rhizomorphs (Wright & Albertó 2006). For Paraguay it was reported from San Pedro Department (Campi & Maubet 2016). Here its distribution is expanded, being reported from Alto Paraguay, Central and Paraguarí Department.

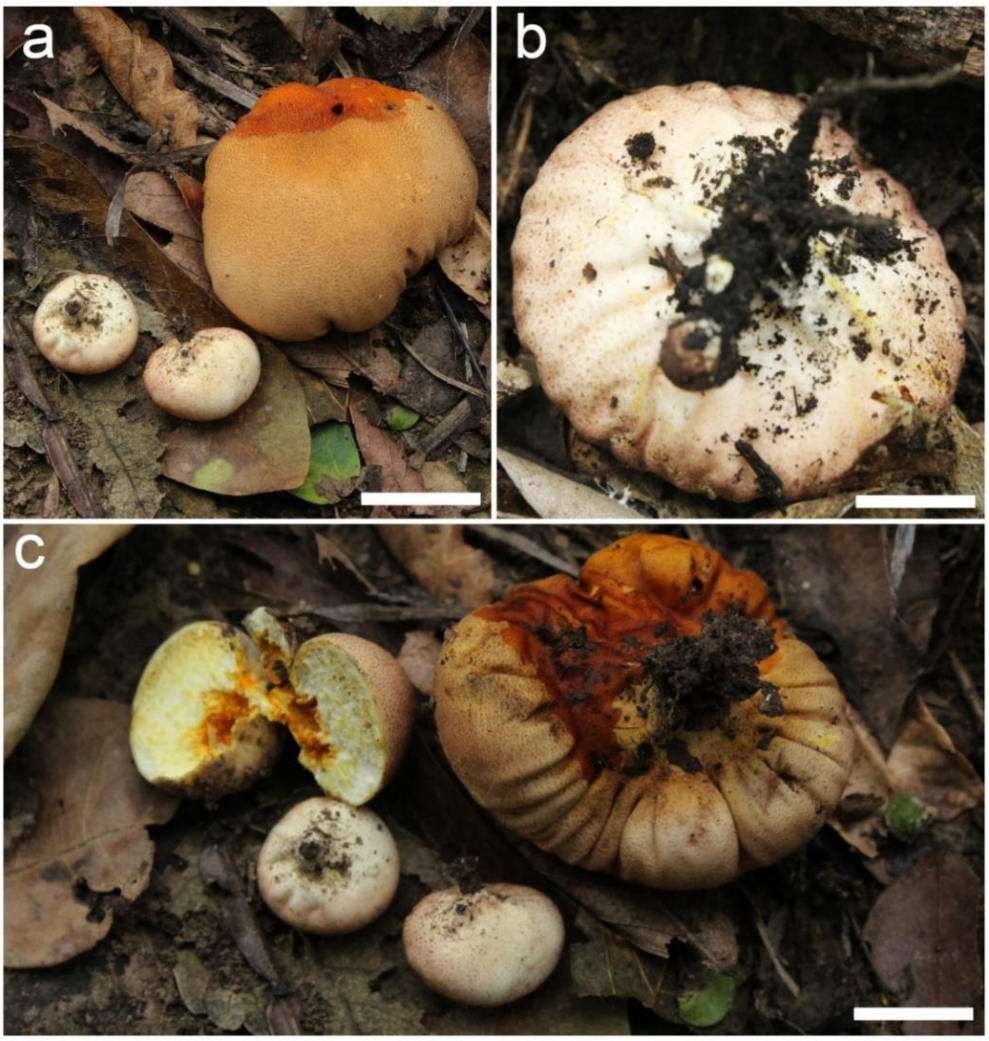

Fig. 4 – a, b, c *Calvatia rugosa* (leg. M. Campi 229). a-c Depressed subglobose basidiomata with orange pigments. b. Basal rhizomorphs c. Lanose gleba persistent in mature specimens, white and compact when young. Scale bars: a = 20 mm, b = 5 mm, c = 25 mm.

Cyathus earlei Lloyd, The Nidulariaceae or "bird's nest fungi" (7): 26 (1906) Fig. 5a–b

Index Fungorum number: IF237768; Facesoffungi number: FoF09300

Description − Basidiomata infundibuliform, 6–8 high × 4–5 mm at the mouth when completely opened, attached to the substrate by a constricted pseudostipe 4–6 mm wide, covered in a chestnut subiculum. Exoperidium brown, smooth and covered with fine hairs in irregular hirsute triangular clusters. Mouth in young specimens smooth, turning distinctly fimbriate when fully open, tomentum up to 0.4 mm high. Inner surface smooth, whitish to cream when fresh turning light chestnut when dry, shiny. Stipe up to 1 mm high, cream to light chestnut. Peridioles 8–10 per basidioma, lenticular, 0.5–1.7 mm, black to grey covered by the thick and whitish tunic, more evident when young. Cortex double-layered. Basidiospores 17–20 × 12–14 µm (Qx = 1.45; Q = 1.40–1.51; N = 2; n = 30), smooth and hyaline, ellipsoid to ovoid, some subglobose, apiculus present in some spores.

Habitat – Gregarious, found in remains of decomposing branches, collected in Parque Nacional Ybycuí, transition between Atlantic Forest and Humid Chaco.

Distribution in South America – Brazil: State of Rio Grande del Norte (Cruz et al. 2012) and Amazonas (Accioly et al. 2018). This is the third record of the species from South America.

Material examined – PARAGUAY, Paraguarí Department, Ybycuí City, Parque Nacional Ybycuí, 26°4'57"S, 56°50'43"W, 15 January 2020, M. Campi 453 (FACEN 004569).

Notes – *Cyathus earlei* is characterized by an exoperidium without plication, covered by a light color tomentum, organized in small tufts, endoperidium smooth or inconspicuously plicate, with a light, shiny color, contrasting with the exterior layer, peridioles with double-layered cortex and tunic, basidiospores 12.7–17.8 (–34) × 8.9–12 μm, ellipsoid to subglobose, with apiculus and walls 1.9–3.8 μm thick (Brodie & Dennis 1954, Cruz et al. 2012, Accioly et al. 2018). According to Accioly et al. (2018), some species related to *C. early* are: *C. triplex* Lloyd, which differs mainly by the smaller basidiomes (4–6 mm high), and smaller peridioles (1.5–2 mm long) and a more hirsute exoperidium (Brodie 1975, Cruz et al. 2012, Accioly et al. 2018), *C. pallidus* Berk. & M.A. Curtis has smaller peridioles with single-layered cortex, and smaller basidiospores (5–10 × 4–6.3 μm) (Baseia & Milanez 2001, Cruz et al. 2012, Accioly et al. 2018). Another similar species is *Cyathus olla*, which exhibits similar basidiospore shape to those of *C. earlei*, but differs by having a darker endoperidium (brownish), bigger peridioles (2–3.5 mm long) with single-layered cortex, and smaller basidiospores (6–13 × 6–8 μm) (Baseia & Milanez 2001, Accioly et al. 2018).

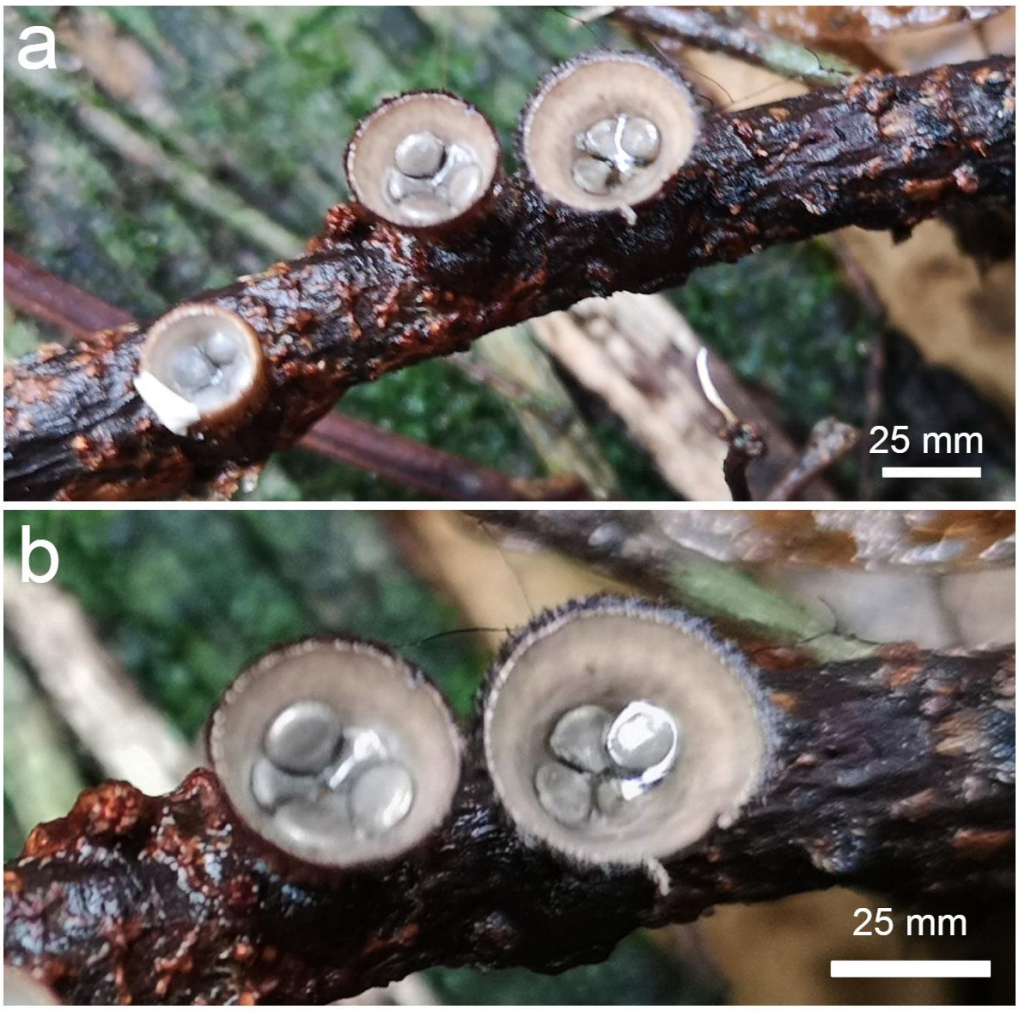

Fig. 5 – a, b *Cyathus earlei* (Leg. M. Campi 453) a Infundibuliform basidiomata. b Lenticular peridioles, grey-colored, covered by the thick and whitish tunic. Scale bars: a, b = 25 mm.

Cyathus poeppigii Tul. & C. Tul., Annales des Sciences Naturelles Botanique 1: 77 (1844)
Fig. 6a–b

Index Fungorum number: IF205559; Facesoffungi number: FoF01072

Description in – Maubet et al (2017).

Material examined – PARAGUAY, Paraguarí Department, Ybycuí City, Parque Nacional Ybycuí, 26°4'57"S, 56°50´43"W, 16 January 2020, M. Campi 444 (FACEN 004570). Central Department, Asunción City, Jardín Botánico, 25°19'39,7"S, 57°31"11,19"W, 3 August 2013, M. Campi 039 (FACEN 03350).

Notes – The most remarkable diagnostic characteristics of the species are the large size of the basidiospores and the deep internal and external striations of the peridium, but with significant variation in spore size and shape (Brodie & Dennis 1954). It is considered a recurring species in tropical climates (Cruz et al. 2014). For Paraguay it is cited for the Central Department (Campi & Maubet 2015a); its distribution is now expanded and cited for the Paraguarí Department.

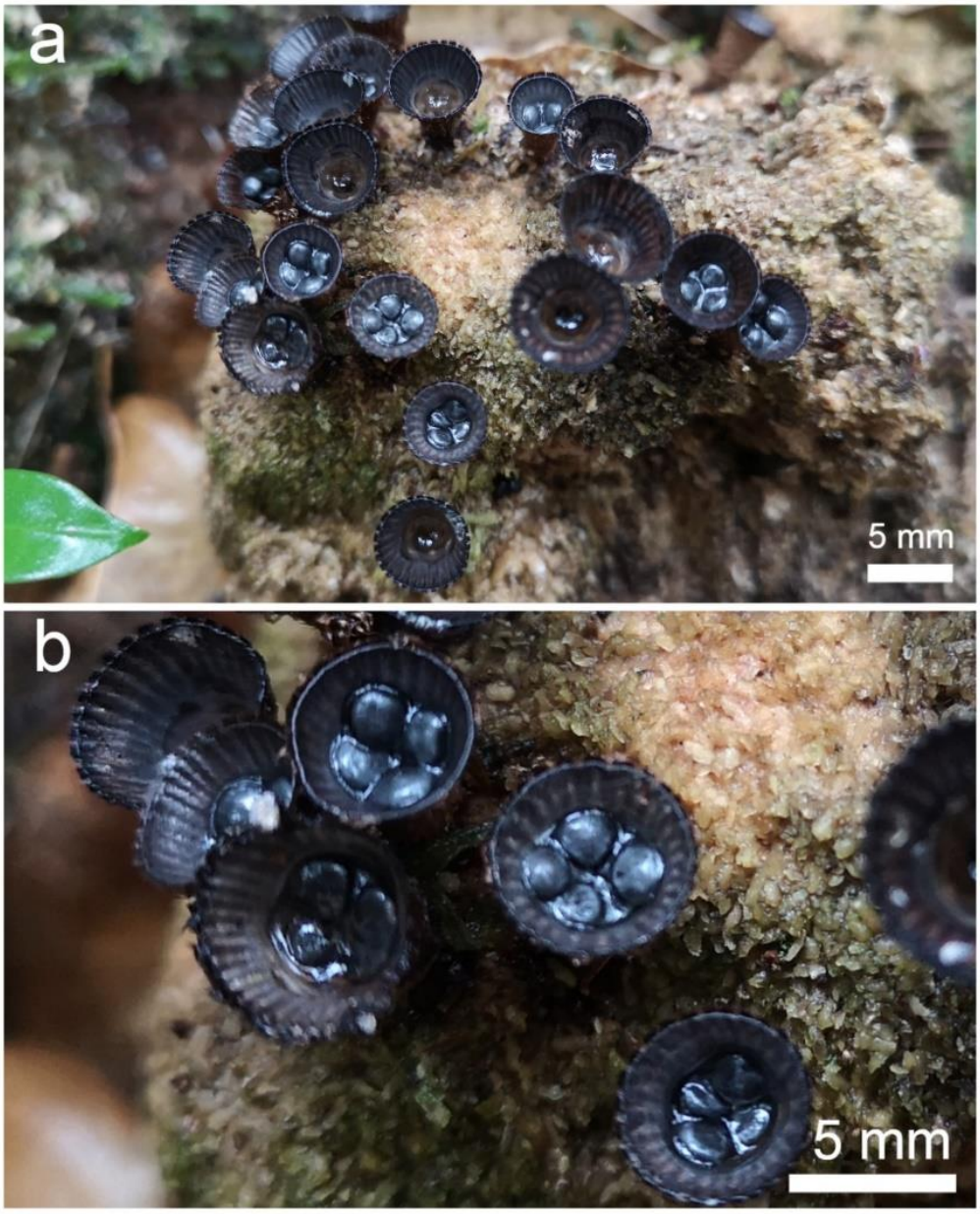

Fig. 6 – a, b *Cyathus poeppigii* (Leg. M. Campi 444). a Infundibuliform basidiomata. b Irregular to angular in outline and dark grey peridioles. Scale bars: a, b = 5 mm.

Cyathus limbatus Tul. & C. Tul., Annales des Sciences Naturelles Botanique 1: 78 (1844)

Fig. 7a–c

Index Fungorum number: IF240889; Facesoffungi number: FoF01071

Description in – Maubet et al (2017)

Material examined – PARAGUAY, Paraguarí Department, Ybycuí City, Parque Nacional Ybycuí, 26°04´79"S, 56°50´87"W, 14 May 2019, M. Campi 389 (FACEN 004571). Central Department, San Lorenzo City, Campus Universitario, 25°20'2,3"S 57°30'58,5"W, 10 February 2017, Y. Maubet 041 (FACEN 003781); Alto Paraguay Department, Estación Biológica Tres Gigantes, 20°43'5,31"S 58°9'23,75"W, 29 January 2017, M. Campi 151 (FACEN 003777).

Notes – This species is characterized by having plicate peridium on the internal and external surface, large peridioles (7–10 mm × 6–7 mm) with bilayered cortex, dark brown to black peridioles and basidiospores of 10–12 × 16–22 µm. Another distinctive feature of the species is that at the base of the pseudostipe, at the junction with the substrate, a woolly golden brown subiculum is formed (Brodie & Denis 1954, Trierveiler- Pereira & Baseia 2009).

For Paraguay it has been previously cited for the Alto Paraguay and Central Departments (Maubet et al. 2017); its distribution is expanded and by its discovery in cited for the Paraguarí Department.

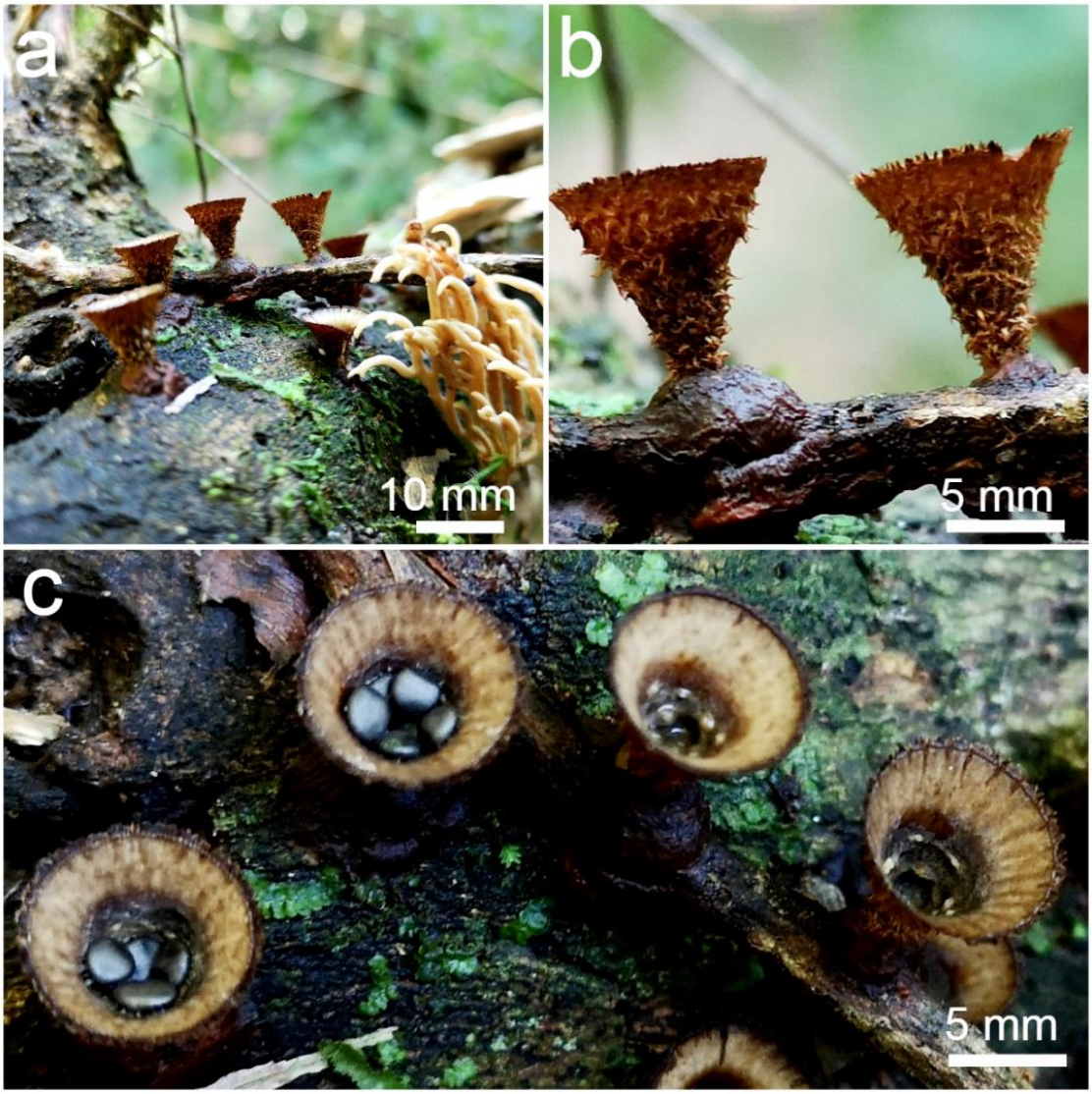

Fig. 7 – a, b *Cyathus limbatus* (FACEN 004571) a Basidiomata infundibuliform. b Peridioles with bilayered cortex, dark brown to black. Scale bars: a = 10 mm, b, c = 5 mm.

Geastrum pusillipilosum J.O. Sousa, Alfredo, R.J. Ferreira, M.P. Martín & Baseia, Persoonia 37: 235 (2016) Fig. 8a–c

Index Fungorum number: IF812875; Facesoffungi number: FoF09299

Description − Inmature basidiomata subglobose to oval, 2–3 mm wide × 2–4 mm tall, on wood, surface covered with hyphal tufts, light brown to ocre, attached to the substrate with a wide white subiculum. Expanded basidiomata 9–15 mm wide × 4–6 mm tall. Exoperidium splitting into 6–8 rays, saccate, nonhygroscopic. Mycelial layer light brown, persistent, hyphal tufts separate in the base (≤ 1 mm). Fibrous layer yellowish white. Pseudoparenchymatous layer cream to dark beige when fresh, becoming dark brown, persistent, fragmenting when fresh. Endoperidium 4–5 mm wide × 2 mm tall (including peristome), sessile, subglobose, glabrous, brownish gray. Apophysis not seen. Peristome fibrillose, not delimited, concolorous with endoperidium. Columella white, rounded to columnar in section, gleba dark brown. Mycelial layer composed of sinuous-walled hyphae, 5.5–7.5 µm diam., hyaline to yellowish. Fibrous layer composed of straight and thin walled hyphae, 5.5–7 µm diam., hyaline to yellowish. Pseudoparenchymatous layer composed of irregular cells, 19–36 µm × 15–26 µm, hyaline to yellowish. Eucapillitium 2.5–4 µm diam., slightly rough, encrusted with amorphous substance, without pores, without septa, yellowish. Basidiospores brown, globose, coarsely verrucose under MO, 4–5(–5.5) µm, (Qx = 1.04, Q_x = 1.02–1.07 n = 30, N = 3).

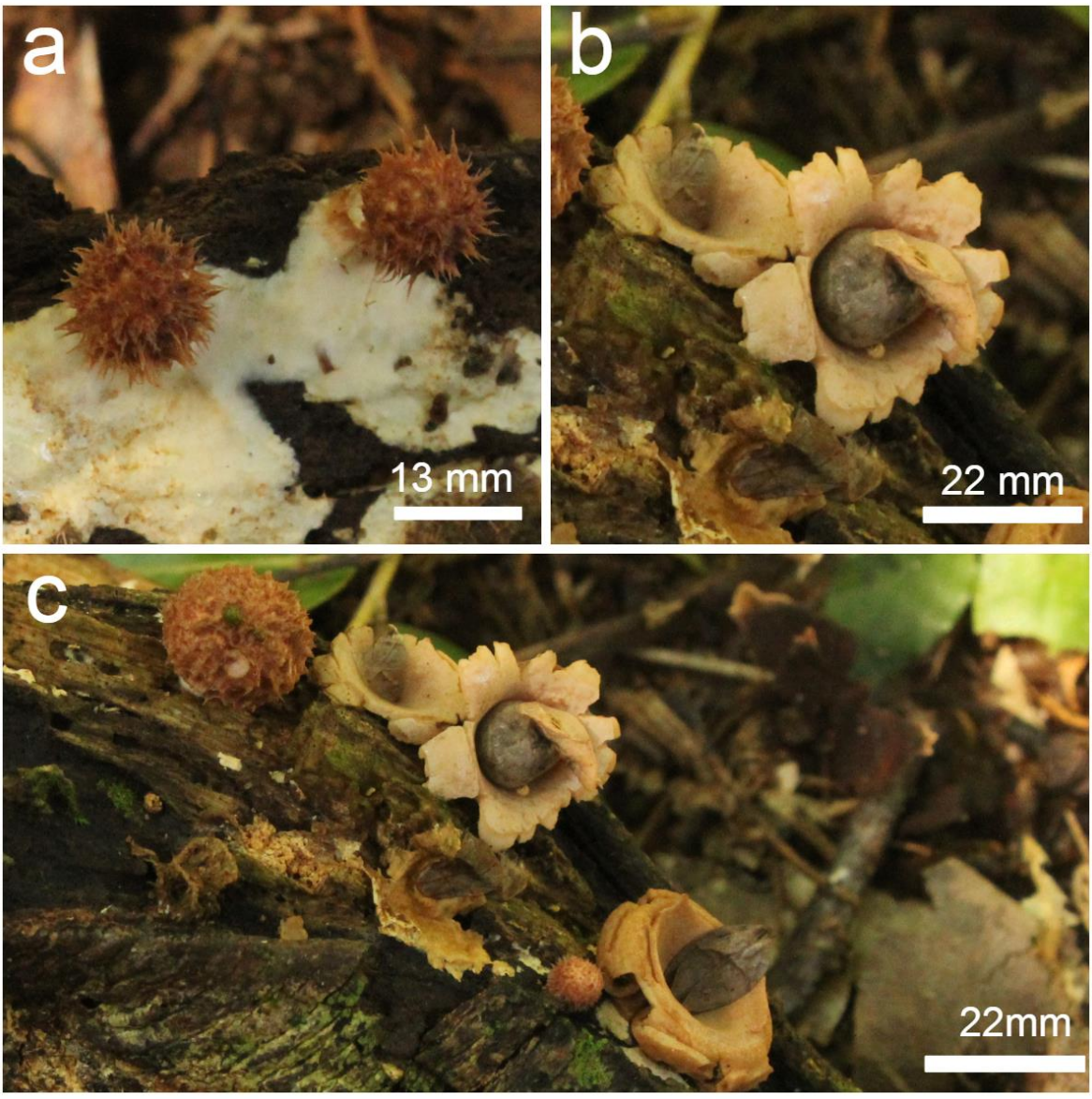

Fig. 8 – a, b, c *Geastrum pussillipilosum* (Leg. M. Campi 369). a Unexpanded basidiomata with echinulate exoperidium, growing on a white subiculum. b-c Expanded basidiomes. Scale bars: a = 13 mm, b, c = 22 mm.

Habitat – Gregarious, found growing on twigs, collected in Parque Nacional Ybycuí, transition between Atlantic Forest and Humid Chaco and a forest in the Humid Chaco.

Distribution in South America – Brazil-States: Amazonas and Bahia (Silva et al. 2013).

Material examined – PARAGUAY, Paraguarí Department, Ybycuí City, Parque Nacional Ybycuí, 26°0,4'6,63"S, 56°50'8,94"W, 16 January 2020, M. Campi 369 (FACEN 004341). Cordillera Department, Piribebuy City, Granja Yrokẽ, 25°32'48"S, 57°10'17.50"W, 13 June 2018, Y. Maubet 093 (FACEN 004572).

Notes – This species is characterized by a small basidiomata (up to 17 mm wide), an exoperidium covered with short hairs (up to 1 mm), a fibrillose peristome and basidiospores of 4.4–6 × 4.3–5.9 (–6.8) µm in diam. (Crous et al. 2016, Lima & Baseia 2018). A closely related species is *G. hirsutum*, but differs in the size of the basidiomata (15–20 mm wide), a subiculum at the base, longer hairs (1.5–3 mm) and smaller basidiospores (only 2.5–3 µm diam) (Baseia & Calonge 2006, Crous et al. 2016). Another similar species is *G. rubellum* P.-A. Moreau & C. Lécuru., but is distinguished by the longer exoperidium hairs (up to 0.68 mm long) which are sparsely distributed in the exoperidium and the strong reddish colour of the pseudoparenchimatous layer (Accioly et al. 2019).

Lysurus sphaerocephalum (Schltdl.) Hern. Caff. et al., Mycologia 110 (2): 423 (2018)

Fig. 9a–c

Index Fungorum number: IF829068; Facesoffungi number: FoF09298

Description − Immature basidioma not observed. Basidiomata 140 mm high. Receptacle formed by a stipe with a basal volva and a clathrate receptacle in the upper portion the apex, bearing the gelatinous gleba inside meshes. Receptacle 25 mm high, 30 mm diam., reddish to pinkish, clathrate, composed by united, red arms. Immature gleba formed by labyrinthine chambers lined by the hymenium, mature gleba inside the meshes, slimy, olive brown at maturity, fetid odor. Pseudostipe 110 × 20 mm, broad at the apex, tapering towards the base cylindrical to slightly fusiform, pinkish towards the apex and whitish towards the base, hollow, consistency spongy wall and surface slightly rugulose or reticulate. Volva present at the base of the stipe, 30 × 28 mm, saccate, whitish, smooth, with basal rhizomorphs up to 30 mm long. Sterile and fertile portions formed by globose and subglobose pseudoparenchymatous tissue, hyaline, variable in size and shape, thin walled. Volva of two layers: inner mucilaginous layer composed of two different hypha types: hyaline hyphae, up to 2 µm diam, branched and swollen towards the clamp connections up to 12 µm; and storage hyphae, up to 6 µm diam, branched and swollen towards the clamp connections, with homogeneous deuteroplasm, bright yellow in KOH. Outer layer of volva composed of 1.5–5 µm hyphae. Basidiospores hyaline to pale yellowish, ellipsoid with rounded ends in side view, globose in polar view, 3.5–4 × 1.5–2 µm (Qx = 2.19, n = 30, N = 1).

Habitat – Solitary, on soil and humus. Collected in Parque Nacional Ybycuí, transition between Atlantic Forest and Humid Chaco

Distribution in South America – Argentina-Provinces: Buenos Aires (Spegazzini 1881, 1898), Catamarca (Hernández Caffot et al. 2018), Córdoba (Spegazzini 1898, Domínguez de Toledo 1995), Chaco (Hernández Caffot et al. 2018), Formosa (Hernández Caffot et al. 2018), Tucumán (Spegazzini 1898, 1916, Wright 1960), Salta (Wright 1960), Santiago del Estero (Domínguez de Toledo 1995), and La Rioja (Kuhar et al. 2012). Bolivia-Department: (as *Lysurus periphragmoides*) Tarija (Fries 1909). Brazil-States: (as *Simblum sphaerocephalum*) Rio Grande do Sul (Lloyd 1906, 1909, Braun 1932, Wright 1960, Rick 1961, Guerrero & Homrich 1999, Cortez et al. 2008).

Material examined – PARAGUAY, Paraguarí Department, Ybycuí City, Parque Nacional Ybycuí, 26°4'44,89"S, 56°50'59"W, 16 January 2020, M. Campi 472 (FACEN 004573).

Notes – *L. sphaerocephalum* is recognized by the white immature basidiome/volva, reddish and stylized, length clearly exceeds width, not striate stipe, fertile portion forming an irregular net, reddish, enclosing the stipe (Hernández Caffot et al. 2018). This species was identified and synonymized to *Lysurus periphragmoides* (Klotzsch) Dring by Dring (1980), nevertheless Hernández Caffot et al. (2018) emended as *L. sphaerocephalum*, based on morphological and

molecular data. In that study, it was confirmed that the collections belonging to South America corresponded to *L. sphaerocephalum* and is phylogenetically different from the Eurasian species *L. periphragmoides.* The most relevant morphological differences are that in *L. periphragmoides*, the stipe is yellow and chubby, little difference between length and width, longitudinally striate and the fertile portion is regular, symmetric, pentagonal net, yellow, same width as stipe (Hernández Caffot et al. 2018).

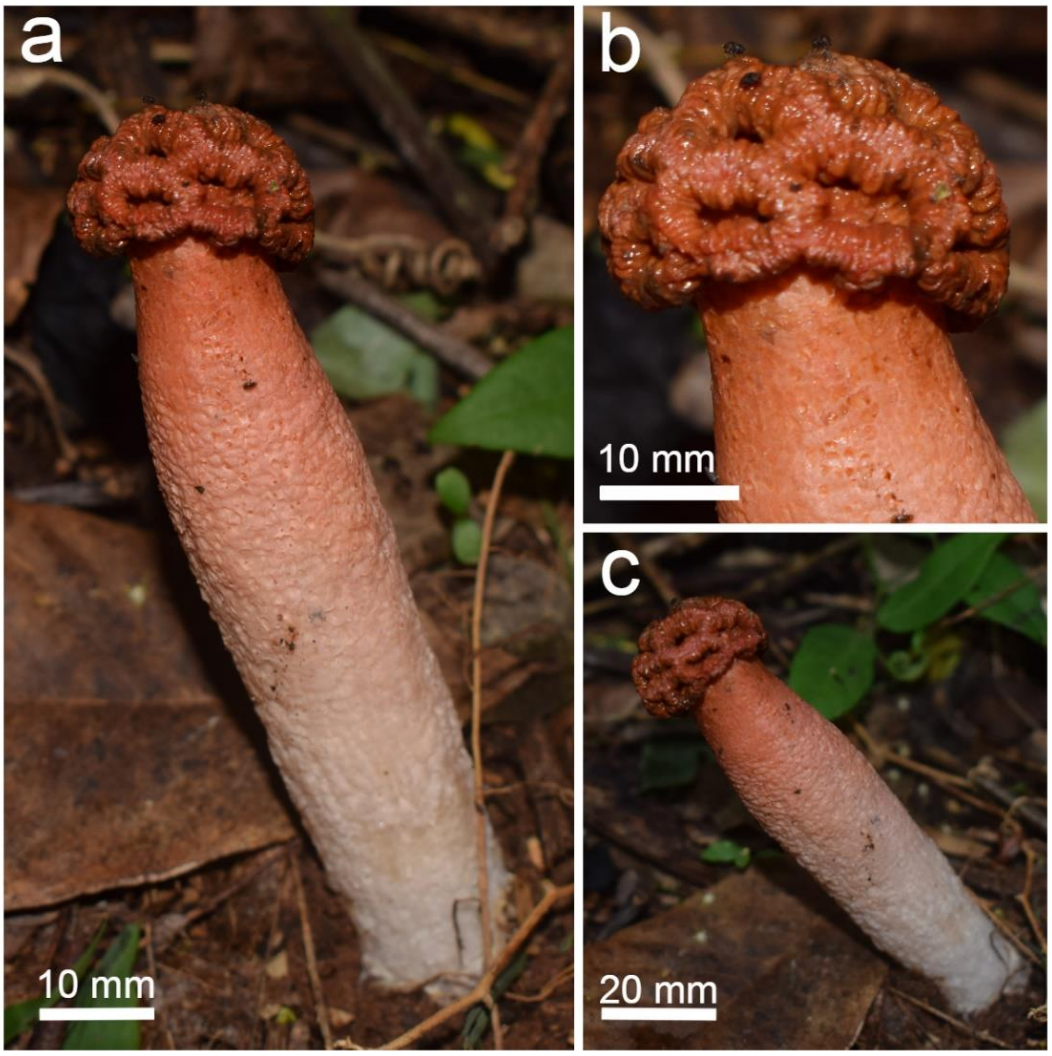

Fig. 9 – a, b, c *Lysurus sphaerocephalum* (Leg. M. Campi 472). a-c Close up of the basidiomata. b Upper portion the apex, bearing the gelatinous gleba. Scale bars: a, b = 10 mm, c = 20 mm.

Myriostoma calongei Baseia, J.O. Sousa & M.P. Martín, PloS ONE 12 (6): e0177873, 9 (2017)
Fig. 10a–e

Index Fungorum number: IF818593; Facesoffungi number: FoF09295

Description − Expanded basidiomata arched, 50–55 mm in diam. Exoperidium brown to dark brown, splitting into 6–8 rays of different diameters, arched to involute, rolling up under the endoperidial body, semi-hygroscopic. Mycelial layer brown papery, not encrusted with debris, peeling off in longitudinal cracks or in irregular patches. Fibrous layer brownish orange to chessnut, coriaceous. Pseudoparenchymatous layer dark brown persistent or peeling off in irregular patches. Endoperidial body greyish, depressed globose to globose, 25–32 mm diam., surface grayish, metallic, verruculose. Endoperidium with multiple pedicels (5±13), 1.6±3.6 mm high, concolorous with the endoperidium, laterally compressed and multiple stomata (3–8), fibrillose, scattered across the surface of the endoperidial body, slightly delimited, non-depressed on the

endoperidium, lacerate with age, 2.5–3.8 mm diam. Gleba brown. Endoperidial surface with prominent triangular warts. Mycelial layer composed of hyaline to yelowish hyphae, 6–9.5 µm diam, thin-walled, non-incrusted. Fibrous layer composed of hyaline sinuous hyphae 3.5–5.5 µm diam, thin-walled to thick-walled. Pseudoparenchymatous layer composed of hyaline to yellowish, thin to thick-walled irregularly shaped hyphal cells, 30–40.5 × 17–26 µm. Eucapillitium of brownish hyphae 2.5–3.4 µm diam, thick-walled, sinuous, encrusted to smooth, wide lumen. Basidiospores brownish, globose to subglobose, 6–7.5 × 5.5–7 µm [Qx = 1.05, n = 30, N = 2], warts prominent (1–1.5 µm high).

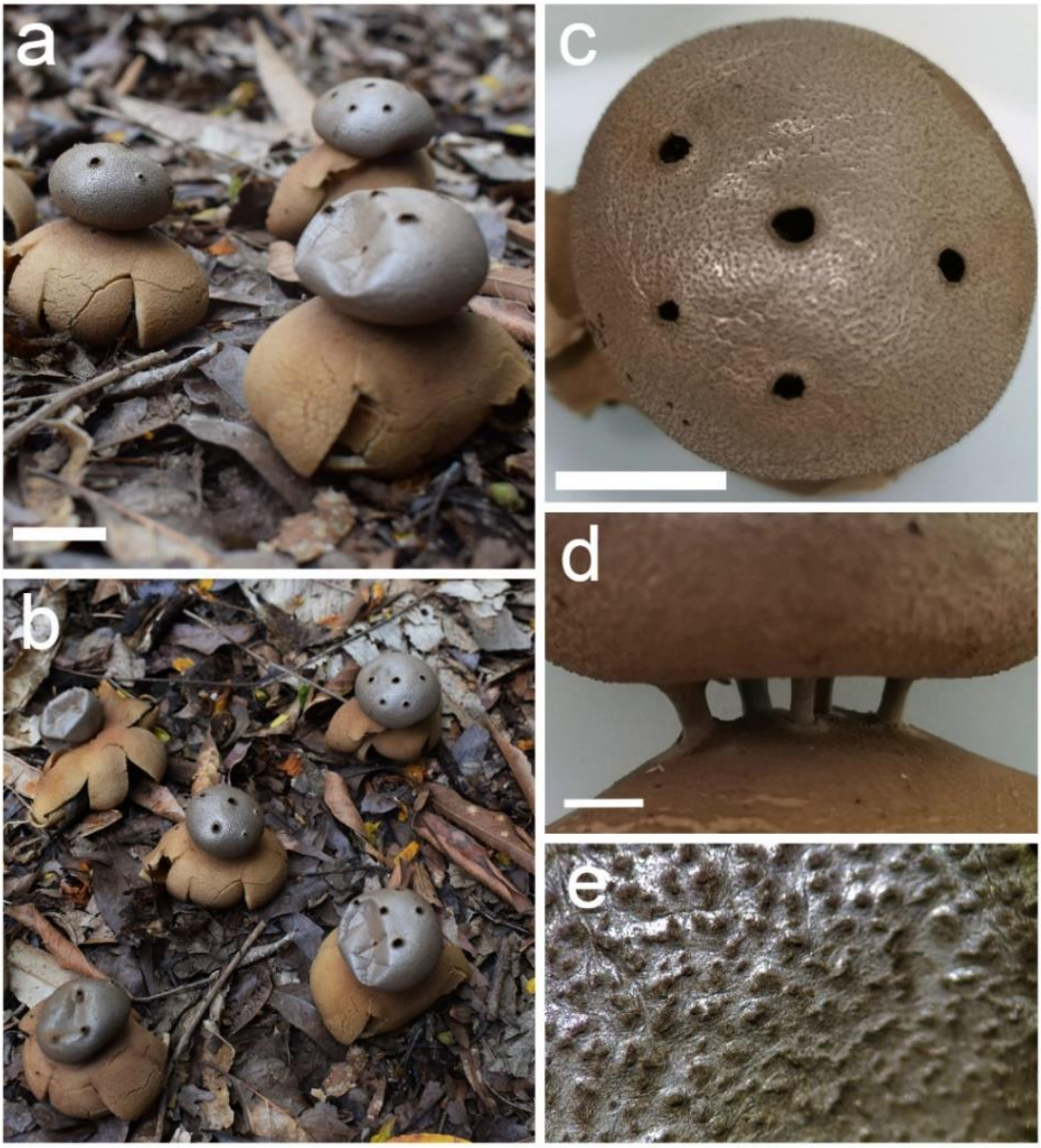

Fig. 10 – a, b, c, d, e *Myriostoma calongei* (Leg. M. Campi 459). a-b Expanded basidiomata. c Endoperidial body. d Multiple pedicels. e Endoperidial body surface metallic and shiny and verrucose. Scale bars: a = 1.5 mm, b = 1 mm, c = 2 mm.

Habitat – Gregarious, growing on litter. Collected in Parque Nacional Ybycuí, transition between Atlantic Forest and Humid Chaco

Distribution in South America – Argentina-Provinces: (as *M. coliforme*) Buenos Aires (Spegazzini 1906, 1927, Raithelhuber 1987, 2004, Wright & Albertó 2006), Catamarca (Dios et al. 2000), Córdoba (Domínguez de Toledo 1989), Formosa (Spegazzini 1906), Salta (Spegazzini 1906), Santiago Del Estero (Spegazzini 1927), Tucumán (Spegazzini 1912), Entre Ríos (Sousa et

al. 2017). Brazil-States: (as *M. coliforme*) Rio Grande do Sul (Rick 1961, Homrich 1973, Guerrero & Homrich 1999), Rio Grande do Norte (Sousa et al. 2017), São Paulo (Homrich 1973, Trierveiler-Pereira & Gugliotta 2020), Pernambuco (Baseia & Galvão 2002, Leite & Baseia 2007), Paraíba (Baseia & Galvão 2002) as *M. calongei*: Pernambuco (Sousa et al. 2017), Santa Catarina (Sousa et al. 2017), Goiás (Camilo-Cotrim et al. 2020).

Material examined – PARAGUAY, Paraguarí Department, Ybycuí City, Parque Nacional Ybycuí, 26°4'44,89"S, 56°50'59"W, 16 January 2020, M. Campi 459 (FACEN 004574).

Notes – *M. calongei* is characterized by the strongly verrucose exoperidium, with warts > 0.1 mm and basidiospores of 5.6–8.7 µm (Sousa et al. 2017). It is closely related to *M. capillisporum*, but *M. calongei* has smaller basidiospores (5.9±8.7 µm diam) with less prominent ornamentation (1.0±2.3 µm high) (Sousa et al. 2017). Up until recently the genus was thought to be monotypic, typified by the cosmopolitan species *M. coliforme*; however, Sousa et al. (2017), based on phylogenetic evidence and some morphological characteristics, described four species; Sousa et al. (2019a) later added a fifth. Additionally, it is likely that all the collection from South America described as *M. coliforme* are *M. calongei* since the first is restricted to the northern hemisphere (Sousa et al. 2017).

Phallus campanulatus Berk., Annals and Magazine of Natural History 9: 446 (1842)

Fig. 11a–c

Index Fungorum number: IF140424; Facesoffungi number: FoF09296

Description – Inmature basidiome subglobose to ovoid, 28–32 × 20–26 mm, whitish to beige with reddish tints due to soil attached. Basidiomata 55–62 mm high when fully expanded. Receptacle 22 × 16 mm, narrow campanulate, surface granular to slightly rugulose, beige, covered by the glebal mass, apex showing a large pore up to 12 mm in diam. when fully expanded; margin cogged to uneven. Pseudostipe 52–60 × 13 mm, subcylindrical, white to beige, surface spongy, internally hollow; base with a saccate volva, 20 × 26 mm, whitish to beige, covered with grains of sand, bearing abundant rhizomorphs whitish attached to the soil. Gleba olive green, slimy, fetid. Basidiospores 4.3–5 × 2.5–3 µm, (Qx = 1.61; Q = 1.57–1.71; N = 3; n = 30), ellipsoid, hyaline to greenish, smooth, with slightly thickened walls, guttulate.

Habitat – Gregarious, growing on soil in urban area of the Humid Chaco ecoregion.

Distribution in South America – Argentina-Provinces: Buenos Aires (Spegazzini 1927, Wright 1949), Chaco (Spegazzini 1927, Wright 1949); Jujuy (Spegazzini 1906, 1927, Wright 1949); Salta (Domínguez de Toledo 1995); Santiago Del Estero (Spegazzini 1927, Wright 1949, Domínguez de Toledo 1995). Brazil-States: Rio Grande do Sul (Braun 1932, Cortez et al. 2011, Trierveiler-Pereira et al. 2016). Uruguay-Department: Maldonado (Berkeley 1842).

Material examined – PARAGUAY, Central Department, Capiata City, 25°24'16.1"S 57°29'04.5"W, 14 February 2020, Y. Maubet 118 (FACEN 004575).

Notes – This species is characterized by its whitish pseudostipe, lack of indusium, and whitish receptacle with rugulose surface. When the receptacle is mature, a large pore is observed at the receptacle apex. The basidiospores are large for a *Phallus* species (Cortez et al. 2011). According to Trierveiler-Pereira et al. (2016), it is synonym with *P. granulosodenticulatus* B. Braun, described from Southern Brazil (Braun 1932). The species is known from Uruguay, Argentina and Brazil (Trierveiler-Pereira et al. 2016). This is the first record of *P. campanulatus* from Paraguay

Podaxis pistillaris (L.) Fr. (L.) Fr., Systema Mycologicum 3: 63 (1829) Fig. 12a

Index Fungorum number: IF356687; Facesoffungi number: FoF09293

Description in – Campi et al. (2015)

Material examined – PARAGUAY, Cordillera Department, Piribebuy City, Yrokẽ country house, 26°4'44,89"S, 56°50'59"W, 23 April 2020, M. Campi 432 (FACEN 004577). Boquerón Department, San Juan cattle ranch, 21°06' S 60°27' W, February 2015, A. Weiler 064 (FACEN 004577).

Notes – This species is characterized by the hard and fibrous pseudostipe that penetrates the gleba, while the gleba is covered by a scaly, sub-cylindrical peridium. The gleba turns dark and powdery in the mature stage (Morse 1933). The specimen was found growing on the top of a termite nest.

Tulostoma pygmaeum Lloyd. The Tylostomae (7): 16 (1906) Fig. 13a–d

Index Fungorum number: IF146034, Facesoffungi number: FoF09294

Description – Basidiomata 20–22 mm high. Spore sac 7–8 mm diam, depressed-subglobose. Mouth tubular well developed, with entire margin. Exoperidium incrusted with soil particles giving a verrucose aspect, hyphae 2,4–4 µm diam, thin-walled, septate, branched, hyaline to pale yellow, clamps absent. Endoperidium papery, with a smoot surface, grayish white, consisting of hyphae 4–6 diam, intermingled, thickness of walls variable, septate, branched, hyaline, broadened at the more or less colored frequent septa, clamps absent. Socket inconspicuous, very close to the stipe. Gleba light brown. Pseudostipe 11–19 mm × 2 mm diam., cylindric, brown, very fragile, surface with longitudinal striate, base with a bulbous up to 3 mm diam. Basidiospores 4.5–5.5 µm diam, (including ornamentation), subglobose to globose, with verrucose ornamentation, pale yellow. Capillitium 2–7.9 µm diam. hyphae, with thickened walls, branched, hyaline, broadened at the pale yellow septa (up to 9 µm diam).

Ecology – growing on sandy soil in the Humid Chaco ecoregion.

Distribution in South America – Argentina (Wright 1987). Mexico-State: Sonora (Moreno et al. 1995). Brazil-State: Rio Grande do Sul (Rick 1961, Cortez et al. 2009).

Material examined – PARAGUAY, Paraguarí Departament, Quiindy City, 25°54'26.9"S, 57°15'56.1"W, 3 July 2020, Y. Maubet 128 (FACEN 004576).

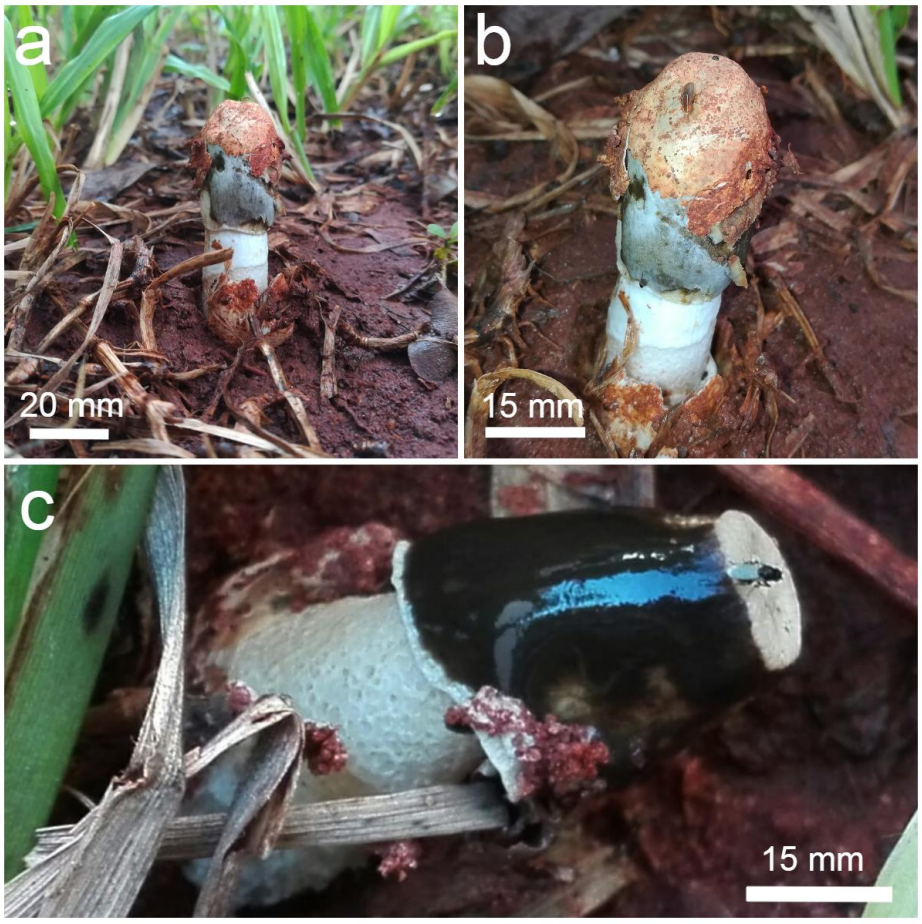

Fig. 11 – a, b, c *Phallus campanulatus* (leg. Y. Maubet 118). a-b Expanded basidiomata. c Campanulate receptacle with pore at the apex. Scale bars: a = 20 mm, b, c = 15 mm.

Fig. 12 – *Podaxis pistillaris* (leg. M. Campi 342). Basidiomata with an oval-shaped periodium, rigid and woody stipe. Scale bars = 50 mm.

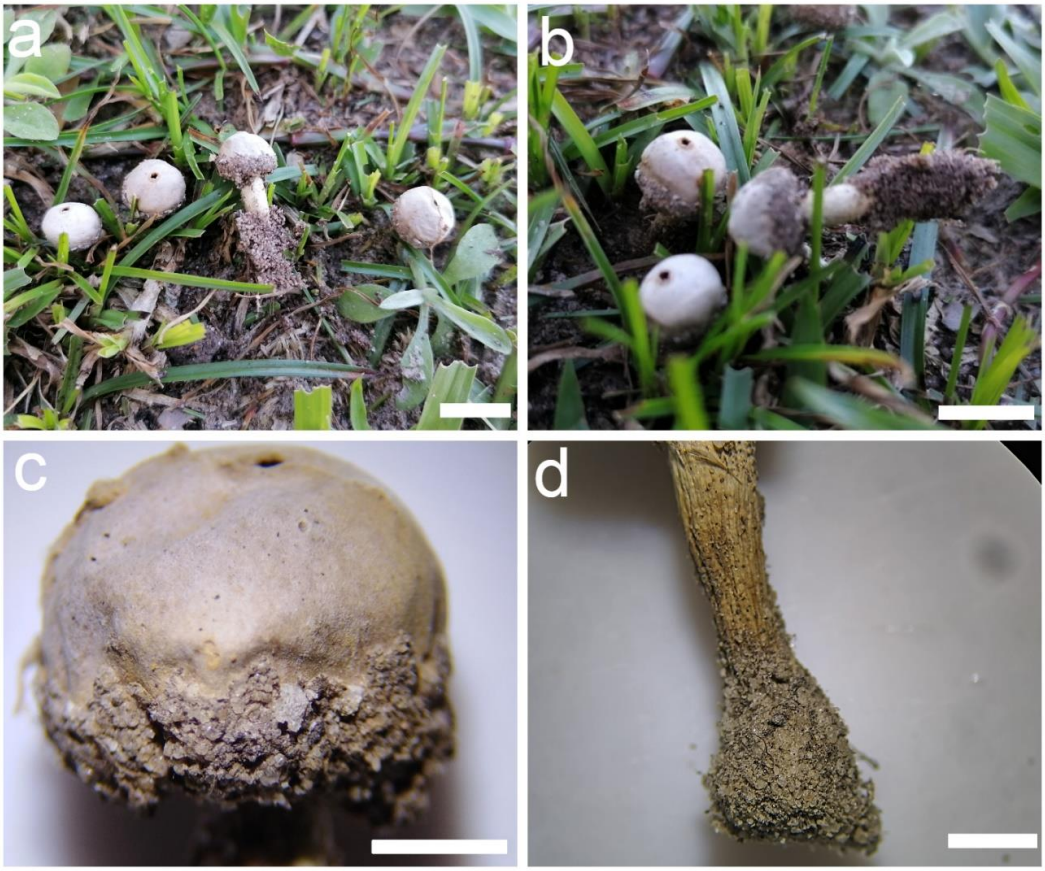

Fig. 13 – a, b, c, d *Tulostoma pygmaeum* (leg. Y. Maubet 118). a-b Expanded basidiomata. c Exoperidial body. d Stipe with longitudinal striae. Scale bars: a = 8 mm, b = 8 mm, c = 2.5 mm, d = 2 mm.

Notes – The name refers to the small-sized basidiomata (Wright 1987). This species is characterized by its tubular mouth, hyphal exoperidium, and basidiospores with a distinct verrucose ornamentation (Moreno et al. 1995). Regarding the basidiospores, the Paraguayan samples studied coincide with the size range noted by Wright (1987) and Moreno et al. (1995) from 4.5–5.9 µm in diam.; however Cortez et al. (2009) reported somewhat larger basidiospores, 5.5–7.5 µm, from Brazilian specimens

Conclusion

Thirteen species of gasteroid fungi are reported in this study. Some commonly Neotropical species such as *Blumenavia rhacodes* (Trierveiler-Pereira et al. 2019, Melanda et al. 2020), *Calvatia cyathiformis* (Zeller & Smith 1964, Wright & Albertó 2006) and *Lysurus sphaerocephalum* (Hernández Caffot et al. 2018) are recorded for the first time in Paraguay, mitigating a lack of surveys in the country.

Clathrus argentinus was described from the provinces of Jujuy and Córdoba in Argentina (Domínguez de Toledo 1985). The species is variable in size of the receptacle and basidiospores, but it is uniform in the color of the receptacle and the form and configuration of the glebifer zone. After its original description, the species was never mentioned again in the world. Thirty-five years later it was found again in Paraguay in the ecoregion of Humid Chaco in urban areas and its description is presented herein.

Other interesting reports in this study are *Myriostoma calongei* and *Phallus campanulatus. Myriostoma* is a rare genus believed to be monotypic up until 2017 when four new species were described based on molecular data (Sousa et al. 2017). *Phallus campanulatus* was originally described based on a specimen collected by Charles Darwin in 1833 in Uruguay, and it has also been recorded from Argentina and Brazil; however, this is the first record from Paraguay (Trierveiler-Pereira et al. 2016). Regarding the genera *Calvatia, Cyathus, Geastrum* and *Podaxis* new additions are also presented in this work.

These results suggest that gasteroid diversity in Paraguay is largely underestimated. Future studies concerning this important group may uncover additional information regarding ranges of species known in the country, if not also locate species heretofore unknown nationally.

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References

Accioly T, Cruz RH, Assis NM, Ishikawa NK et al. 2018 – Amazonian bird's nest fungi (Basidiomycota): Current knowledge and novelties on *Cyathus* species. Mycoscience 59(5), 331–342. Doi 10.1016/j.myc.2017.11.006

Accioly T, Sousa JO, Moreau PA, Lécuru C et al. 2019 – Hidden fungal diversity from the Neotropics: *Geastrum hirsutum, G. schweinitzii* (Basidiomycota, Geastrales) and their allies. PloS ONE, 14(2), 1–25. Doi 10.1371/journal.pone.0211388

Bates ST. 2004 – Arizona members of the Geastraceae and Lycoperdaceae (Basidiomycota, Fungi). Master Thesis, Arizona State University, U.S.A.

Baseia IG. 2004 – Contribution to the study of the genus *Calvatia* (Lycoperdaceae) in Brazil. Mycotaxon 88: 107–112.
Baseia IG, Calonge FD. 2006 – *Geastrum hirsutum*: a new earthstar fungus with a hairy exoperidium. Mycotaxon 95, 301–304.
Baseia IG, Galvão TCO. 2002 – Some interesting Gasteromycetes (Basidiomycota) in dry areas from Northeastern Brazil. Acta Bot. Brasil. 16(1), 1–8.
Baseia IG, Milanez AI. 2001 – *Cyathus* (Gasteromycetes) in areas of the Brazilian cerrado region, São Paulo State. Mycotaxon 80, 493–502.
Berkeley MJ. 1842 – XLVII. – Notice of some Fungi collected by C. Darwin, Esq., in South America and the Islands of the Pacific.Annals and Magazine of Natural History 9 (60), 443–448. Doi 10.1080/03745484209445362
Bononi VLR, Trufen SFB, Grandi RAP. 1981 – Fungos macroscópicos do Parque Estadual das Fontes do Ipiranga depositados no Herbário do instituto de Botânica. Rickia 9: 37–53.
Braun B. 1932 – Estudo sobre as Phalloideas Riograndenses. Lajeado: Relatório do Ginásio Anchieta, 5–28.
Brodie HJ. 1975 – The bird's nest fungi. Toronto, University of Toronto Press.
Brodie HJ, Dennis R. 1954 – The Nidulariaceae of the West Indies. Transactions of the British Mycological Society 37(2), 151–160.
Cabral TS, Silva BD, Martín MP, Clement CR et al. 2019 – Behind the veil–exploring the diversity in *Phallus indusiatus* sl (Phallomycetidae, Basidiomycota). MycoKeys, 58, 103–127. Doi 10.3897/mycokeys.58.35324
Camilo-Cotrim CF, Leonardo-Silva L, Xavier-Santos S. 2020 – First records of *Myriostoma calongei* Baseia, Sousa & Martín (Geastraceae, Basidiomycota) in central Brazil. Check List 16 (1), 53–57. Doi 10.15560/16.1.53
Campi M, Flecha AM, De Madrignac Bonzi BR. 2013 – *Geastrum violaceum* Rick (Geastraceae, Basidiomycota) nuevo registro para Paraguay. Reportes Científicos, 4(2), 15–18.
Campi M, Maubet Y. 2015a – *Cyathus poeppigii* (Agaricales, Basidiomycetes): nuevo registro para Paraguay. Steviana, 7, 74–78.
Campi M, Maubet Y. 2015b – Especies de *Geastrum* (Geastraceae, Basidiomycota) nuevos registros para Paraguay. Steviana 7, 79–88.
Campi M, Maubet Y. 2016 – Nuevos registros de *Calvatia rugosa* (Berk. & M.A. Curtis) D.A. Reid y *Vascellum pampeanum* (Speg.) Homrich (Agaricaceae-Basidiomycota) en Paraguay. Steviana, 8(1), 43–49.
Campi M, Maubet Y, Moreno G, Altés A. 2016 – *Tulostoma cyclophorum* (Basidiomycota, Agaricomycetes) new record for Paraguay. Boletín de la Sociedad Micológica de Madrid 40, 129–132.
Campi M, Maubet Y, Weiler A, Moreno G. 2017b – *Battarrea phalloides* (Basidiomycota, Agaricomycetes) nuevo para el chaco paraguayo. Boletín de la Sociedad Micológica de Madrid 41, 47–51.
Campi M, Maubet Y, Weiler A. 2015 – *Podaxis pistillaris* (Basidiomycota, Agaricomycetes) nuevo para el Chaco paraguayo. Boletín de la Sociedad Micológica de Madrid 39, 77–81.
Campi M, Trierveiler-Pereira L, Maubet Y. 2017a – New records of Phallales from Paraguay. Mycotaxon 132(2), 361–372.
Coetzee JC. 2010 – Taxonomic notes on the Clathraceae (Phallales: Phallomycetidae) sensu Bottomley and a new key to the species in southern Africa. Bothalia 40(2), 155–159. Doi 10.4102/abc.v40i2.205
Cortez VG, Baseia IG, Silveira RM. 2008 – Gasteromicetos (Basidiomycota) no Parque Estadual de Itapuã, Viamão, Rio Grande do Sul, Brasil. Biociências (Porto Alegre) 6(3), 291–299.
Cortez VG, Baseia IG, Silveira RMB. 2009 – Gasteroid mycobiota of Rio Grande do Sul, Brazil: Tulostomaceae. Mycotaxon 108, 373–392.
Cortez VG, Baseia IG, Silveira RMB. 2011 – Two noteworthy *Phallus* from southern Brazil. Mycoscience 52 (6), 436–438. Doi 10.1007/S10267-011-0124-5

Crous PW, Wingfield MJ, Burgess TI, Hardy GSJ et al. 2016 – Fungal Planet description sheets: 469–557. Persoonia: Molecular Phylogeny and Evolution of Fungi 37, 218. Doi 10.3767/persoonia.2018.41.12

Cruz R, Assis N, Silva M, Baseia IG. 2014 – Revision of the genus *Cyathus* (Basisiomycota) from the herbaria of northeast Brazil. Mycosphere 5(4), 531–540. Doi 10.5943/mycosphere/5/4/5

Cruz R, Barbosa M, Baseia IG. 2012 – *Cyathus badius* and *C. earlei* reported from the Brazilian Atlantic rainforest. Mycotaxon, 121(1), 365–369.

de Meijer AAR. 2006 – Preliminary list of the macromycetes from the Brazilian State of Paraná. Boletim do Museu Botanico Municipal 68, 1–55.

Dinerstein E, Olson DM, Graham DJ, Webster AL et al. 1995 – (Eds.) A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean. The World Bank.

Dios MM, Albertó E, Moreno G. 2011 – Catálogo de hongos gasteroides (Basidiomycota) de Catamarca, Argentina. Boletín de la Sociedad Argentina de Botánica, 46(1–2), 5–11.

Dios MM, Moreno G, Altés A, Ángelo MVD. 2000 – Algunos Gasteromycetes interesantes de Catamarca, Argentina. Micología. Revista de la Associazione Micológica Bresadola (AMB). Italia, 155–164.

Drechsler-Santos ER, Wartchow F, Baseia IG, Gibertoni TB, Cavalcanti MAQ. 2008 – Revision of the Herbarium URM I. Agaricomycetes from the semi-arid region of Brazil. Mycotaxon 104, 9–18.

Dring DM. 1980 – Contributions towards a rational arrangement of the Clathraceae. Kew Bulletin 35(1), 1–96. Doi 10.2307/4117008

Domínguez de Toledo L. 1989 – Contribución al conocimiento de los Gasteromycetes del centro de la Argentina. Tesis doctoral (inédita). Facultad de Ciencias Exactas, Físicas y Naturales. Universidad Nacional de Córdoba. Argentina. 262 pp.

Domínguez de Toledo L. 1995 – Gasteromycetes (Eumycota) del Centro y Oeste de la Argentina. II. Orden Phallales. Darwiniana 33, 195–210.

Domínguez de Toledo L. 1985 – Una nueva especie de *Clathrus* (Eumycota, Phallales). Boletín de la Sociedad Argentina de Botánica 24(1–2), 131–136.

Eicker A, Reid DA. 1990 – *Clathrus transvaalensis*, a new species from the Transvaal, South Africa. Mycological Research, 94(3), 422–423.

Fries RE. 1909 – Über einige Gasteromyceten aus Bolivia und Argentinien. Ark. Bot. 8(11), 1–34.

Guerrero RT, Homrich MH. 1999 – Fungos Macroscópicos Comuns no Rio Grande do Sul. Guia para identificação.Ed. Universidade/UFRGS: Porto Alegre (Brasil). 124 pp.

Hernández Caffot ML, Hosaka K, Domínguez LS, Urcelay C. 2018 – Molecular and morphological data validate the new combination of *Lysurus sphaerocephalum* from Argentina, with some additional records on Phallales (Agaricomycetes). Mycologia, 110(2), 419–433. Doi 10.1080/00275514.2018.1456834

Homrich MH. 1973 – Nota sobre *Myriostoma coliforme* Desvaux (Lycoperdaceae). Iheringia 18(3), 80–89.

Jayasiri C, Hyde KD, Ariyawansa H, Bhat J et al. 2015 – The Faces of Fungi database: fungal names linked with morphology, phylogeny and human impacts. Fungal diversity 74(1), 3–18.

Kuhar F, Castiglia V, Zamora JC, Papinutti L. 2012 – New records and notes on gasteroid fungi of arid regions in Argentina. Sydowia 64, 233–244.

Leite AG, Baseia IG. 2007 – Novos Registros de Geastraceae Corda para o Nordeste Brasileiro. Sitientibus. Série Ciências Biológicas 7, 178–183.

Lima AA, Baseia IG. 2018 – Gasteroid fungi (Basidiomycota) from two protected natural areas in Rio Grande do Norte State, Brazil. Journal of Fungal Biology 8(6), 585–605.

Lloyd CG. 1906 – Concerning the Phalloids. Mycological Notes 24, 293–301.

Lloyd CG. 1909 – Synopsis of the known phalloids. Cincinnati: The Lloyd Library.

Marchi P, Bauer F, Cacciali P, Yanosky A et al. 2018 – In: Pullaiah, T. (Ed.). Global Biodiversity: Vol 4: Selected Countries in the Americas and Australia. CRC Press.

Maubet Y, Campi M, Armoa J, Cristaldo E. 2017 – Nuevas citas de *Cyathus* Haller (Agaricaceae, Basidiomycetes) para Paraguay y ampliación de la distribución del género. Steviana 9(1), 31–39.

Maubet Y, Campi MG, Trierveiler-Pereira L, Moreno G. 2018 – Contribución a la micobiota gasteroide, nuevas citas. Boletín de la Sociedad Micológica de Madrid 42, 115–124.

Melanda GC, Accioly T, Ferreira RJ, Rodrigues AC et al. 2020 – Diversity trapped in cages: Revision of *Blumenavia* Möller (Clathraceae, Basidiomycota) reveals three hidden species. PloS ONE, 15(5), e0232467. Doi 10.1371/journal.pone.0232467

Miller HR, Miller OK. 1988 – Gasteromycetes: Morphological and Developmental Features, with Keys to the Orders, Families, and Genera. Eureka, California: Mad River Press.

Möller A. 1895 – Brasilische Pilzblumen. Botanishe Mitteilungen aus den Tropen 7, 1–152.

Morales MI, Kimbrough JW. 1978 – The Lycoperdaceae of North Central Florida I. The genera *Calvatia* and *Disciseda*. Revista de Biologia Tropical 26(1), 227–236.

Moreno G, Altés A, Ochoa C, Wright JE. 1995 – Contribution to the study of the Tulostomataceae in Baja California, Mexico. I. Mycologia, 87(1), 96–120.

Morse EE. 1933 – A study of the genus *Podaxis*. Mycologia 25(1), 1–31.

Raithelhuber JH. 1987 – Flora micológica Argentina. Hongos I. Stuttgart. Mycosur.

Raithelhuber JH. 2004 – Nueva Flora Micológica Argentina. Stuttgart.

Rick J. 1929 – Phalloideas riograndenses. Egatea 14, 299–305.

Rick J. 1961 – Basidiomycetes Eubasidii in Rio Grande do Sul, Brasilia – 6. Iheringia (Série Botânica) 9, 451–489.

Rodrigues ACM, Baseia IG. 2013 – *Blumenavia angolensis* (Clathraceae), a rare phalloid reported from Northeastern Brazil. Mycosphere 4(6), 1066–1069. Doi 10.5943/mycosphere/4/6/4

Silveira VD. 1943 – O gênero *Calvatia* no Brasil. Rodriguésia 7, 63–80.

Silva BDB, Cabral TS, Marinho P, Ishikawa NK, Baseia IG. 2013 – Two new species of *Geastrum* (Geastraceae: Basidiomycota) found in Brazil. Nova Hedwigia 96, 445e456. Doi 10.1127/0029-5035/2013/0089.

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.

Sousa JO, Baracho GS, Martín MP, Baseia IG. 2019b – Contribution to Neotropical data of *Geastrum* section (Basidiomycota): Two new earth-stars from Caatinga vegetation, Brazil. Nova Hedwigia 108, 161–175.

Sousa JO, Baseia IG, Martín MP. 2019a – Strengthening *Myriostoma* (Geastraceae, Basidiomycota) diversity: *Myriostoma australianum* sp. nov. Mycoscience, 60(1), 25–30. Doi 10.1016/j.myc.2018.07.003

Sousa JO, Suz LM, García MA, Alfredo DS et al. 2017 – More than one fungus in the pepper pot: Integrative taxonomy unmasks hidden species within *Myriostoma coliforme* (Geastraceae, Basidiomycota). PloS one, 12(6), 1–19. Doi 10.1371/journal.pone.0177873

Spegazzini CL. 1881 – Fungi Argentini Puiggariani. I. Anales de la Sociedad Científica Argentina IV 12, 240–254.

Spegazzini CL. 1884 **–** Fungi Guaranitici. Pugillus 1. Anales de la Sociedad Científica Argentina 17 (2), 69–96.

Spegazzini CL. 1888 – Fungi Guaranitici. Pugillus 2. Anales de la Sociedad Científica Argentina 26 (1), 5–74.

Spegazzini CL. 1891 – Fungi Guaranitici nonnulli novi vel critici [part 2]. Revista Argentina de Historia Natural 1(3), 168–177.

Spegazzini CL. 1898 – Fungi Argentini novi v. critici. Anales del Museo Nacional de Historia Natural de Buenos Aires 6, 6–365.

Spegazzini CL. 1902 – Mycetes Argentinenses. Series II. Anales Museo Nacional de Historia Natural de Buenos Aires 8(3), 49–89.

Spegazzini CL. 1906 – Mycetes Argentinenses. Series III. Anales del Museo Nacional de Historia Natural de Buenos Aires 9(3), 25–33.

Spegazzini CL. 1912 – Mycetes Argentinenses. Series VI. Anales del Museo Nacional de Historia Natural de Buenos Aires 23, 1–146.
Spegazzini CL. 1916 – Hongos del Tucumán. Primera Reunión Nacional, Sociedad Argentina de Ciencias Naturales: Tucumán, 20.
Spegazzini CL. 1927 – Gasteromicetas Argentinas. Physis (Buenos Aires) 8 (31), 421–435.
Trierveiler-Pereira L, Alves CR, Silveira RMB 2014 – The genus *Blumenavia* (Clathraceae, Phallales). Mycosphere 5(3), 496–501. Doi 10.5943/mycosphere/5/3/12
Trierveiler-Pereira L, Baltazar JM, Silveira RMB. 2016 – *Phallus campanulatus* Berk. (Phallaceae, Agaricomycetes), a poorly known species from South America and its synonym *P. granulosodenticulatus* B. Braun. Phytotaxa, 286(2), 127–130. Doi 10.11646/phytotaxa.286.2.9
Trierveiler-Pereira L, Meijer AAR, Silveira RMB. 2019 – Phallales (Agaricomycetes, Fungi) from Southern Brazil. Studies in Fungi 4(1), 162–184. Doi 10.5943/sif/4/1/19
Trierveiler-Pereira L, Baseia IG. 2009 – Revision of the herbarium URM IV. Nidulariaceae (Basidiomycota). Nova Hedwigia, 89(3–4), 361–369.
Trierveiler-Pereira L, Gugliotta A. 2020 – First record of *Myriostoma* (Geastraceae, Basidiomycota) in the Parque Estadual das Fontes do Ipiranga (PEFI), São Paulo, São Paulo State, Brazil. Hoehnea 47(1): e512019. Doi 10.1590/2236-8906-51/2019
Vargas-Rodriguez YL, Vazquez-Garcia JA. 2005 – *Blumenavia toribiotalpaensis*: a new species of Clathraceae from Jalisco, Mexico. Mycotaxon 94, 7–14.
Wartchow F, Silva SM. 2007 – Primeira ocorrência de *Calvatia cyathiformis* (Basidiomycota) em caatinga, Estado de Pernambuco, Brasil. Sitientibus. Série Ciências Biológicas 7, 176–177.
Wright JE. 1949 – Los «Gasteromycetes» del Museo de Ciencias Naturales Bernardino Rivadavia. I Phallales. Comunicaciones del Instituto Nacional de Investigaciones de las Ciencias Naturales anexo al Museo Argentino de Ciencias Naturales "Bernardino Rivadavia." Serie ciencias botánicas. 1(2), 3–15.
Wright JE. 1960 – Notas sobre Faloideas Sud y Centroamericanas. Lilloa 30, 339–359.
Wright JE. 1987 – The genus *Tulostoma* (Gasteromycetes). A world monograph. J. Cramer. Berlin, Stuttgart.
Wright JE, Albertó E. 2006 – Guía de los hongos de la Región Pampeana II. Hongos sin laminillas. Buenos Aires. Editorial L.O.L.A.
Zeller SM, Smith AH. 1964 – The genus *Calvatia* in North America. Lloydia 27(3), 148–186.