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A first review of Gasteroid fungi (Agaricomycetes, Basidiomycota) in Paraguay

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Título resumido: Gasteroid fungi in Paraguay: a checklist

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ABSTRACT – (A first review of Gasteroid fungi (Agaricomycetes, Basidiomycota) in Paraguay). Based on the available literature, a list of 40 gasteroid species recorded in Paraguay since the earliest known collection is presented. A total of forty species are reported, distributed among 16 genera and 4 families. This work represents the first compilation of data available on this group of fungi for Paraguay. These numbers reveal the scarce amount of species formally cited for the Paraguayan Funga.
Keywords: bird-nest fungi, earth-stars, neotropical fungal diversity, puffballs, stinkhorns

RESUMEN – (Una primera revisión de los hongos gasteroides (Agaricomycetes, Basidiomycota) en Paraguay). Con base en la literatura disponible, se presenta una lista de 40 especies de gasteroides registradas en Paraguay desde los primeros registros conocidos. Se reporta un total de cuarenta especies, distribuidas en 16 géneros y 4 familias. Este trabajo representa la primera compilación de datos disponibles de este grupo de hongos para Paraguay. Estos números nos revela la escasa cantidad de especies citadas formalmente para la Funga del país.
Palabras clave: diversidad de Funga neotropical, estrellas de tierra, falo hediondo, hongos nido de pájaro, hongos polvera

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Introduction

Gasteroid fungi present a wide range of basidiomata structure and these distinctive characteristics lead to the designation of many genera as monotypic or with few species represented.

The existing bibliographic information on the group of gasteroid Funga in the last century was limited to a few citations made by Spegazzinii (1884, 1888, 1891) who recorded 12 species from the country:*Geastrum saccatum* Fr. [as *Geaster saccatus*], *Tulostoma cyclophorum* Lloyd [as *Tylostoma berteroanum*], *Lycoperdon lilacinum* (Mont. & Berk.) Speg., *Lycoperdon pseudo-lilacinum* Speg., *Lycoperdon pseudogemmatum* Speg., *Simblum sphaerocephalum* Schltdl., *Geastrum saccatum* [*Geaster spegazzinianus*], *Lanopila guaranitica* Speg., *Bovista dubiosa* Speg. and *Lycoperdon scleroderma* Speg.

Most of the new citations were made by contemporary mycologists since the last publication of Spegazzini, 122 years ago. The next recording of gasteroid fungi in the country occurred in 2013 (Campi *et al.* 2013), and more recent studies have been carried out by Campi and collaborators (Campi *et al.* 2015, Campi & Maubet 2015a, 2015b, Campi *et al.* 2017, Maubet *et al.* 2018)

In the last decade the record of gasteroid fungi has increased but despite the efforts of mycologists in recent years, knowledge about the gasteroid mycobiota in Paraguay remains scattered and incomplete since the collections have been made sporadically and in very few areas.

Paraguay comprises two distinct geographical regions, the eastern and western, which are separated by the Paraguay River. The western region is also known as the Chaco. Which include 3 ecoregions: Humid Chaco, Dry Chaco, and Pantanal. The ecoregions of eastern Paraguay includes the Humid Chaco, Atlantic Forest, and Cerrado (Dinerstein *et al.* 1995).

This study is a revision of the available data and an update of the records of species of gasteroid fungi from Paraguay.

Materials and methods

This checklist has been compiled based on literature records of gasteroid fungi recorded from Paraguay. The information retrieved from the literature includes distribution records per department (figure 1), notes about habitat and substrate, and detailed descriptions and remarks of the basidiomata. The current taxonomic position is indicated, as have been described in previous publications and a brief introduction of the most outstanding characteristics of each species is provided. The classification and nomenclature followed the database Mycobank (http://www.mycobank.org).

Genera and species are listed alphabetically (table 1) and the authorities for the binomials, as well as the author names and spellings, are in accordance to Robert *et al.* (2005) database.

Results and Discussion

The 40 gasteroid fungi species recorded in Paraguay are distributed among 16 genera and four families. The most highly represented family is Agaricaceae with 14 species (39%), followed by Phallaceae and Geastraceae (with 10 species each respectively, 28%). *Geastrum* is the genus with the highest number of species with nine taxa (25%). The departments with the most records were the Central department, corresponding to the humid Chaco ecoregion, with 19 records (47.5%) and the Paraguarí department, corresponding to the transition ecoregion between humid Chaco and Atlantic Forest, with 15 records (37.5%), two species of gasteroid fungi were cited for the Atlantic Forest ecoregion (5%), eight species for the Pantanal ecoregion (20%) and two species for the dry Chaco (5%).

It is not possible to speak of the most represented species in terms of distribution since the country lacks extensive samplings to represent all the ecoregions appropriately. Dring (1973) and Miller & Miller (1988) estimated a hundred genera of gasteromycetes, therefore the diversity of this group is still not well represented in Paraguay, since only 15 genera are recorded in the literature.

Checklist for the gasteroid species in Paraguay

Agaricaceae Chevall.

Battarrea phalloides (Dicks.) Pers.

Basionym: *Lycoperdon phalloides* Dicks.

Locality: BO (Campi *et al.* 2016b).

Identification. Species easily recognizable for presenting a high basidiome about 10-30 cm including the spore sac, rapid development, rust in color, stipe expending up to 25 cm in length and bearing a spore sac; exoperidium remaining as a volva and apically as scales on the endoperidium; endoperidium and spore sac hemispherical to conical, 2.8 cm to 7.2 cm in diam., later splitting circular along the middle and deteriorating. Volva membranous up to 15 cm in diameter, presenting similar color and surface as the stipe, partially adhered to the stipe base (Rea 1942, Garrido-Benavent 2014, Campi *et al.* 2016b).

***Calvatia cyathiformis* (**Bosc) Morgan

Basionym: *Lycoperdon cyathiforme* Bosc

Localities: CE (Campi *et al.* in press)

Identification. The main characteristic of this species is a globose, compact basidiome when young, which develop a basal portion like an inverted pear or a loaf of bread at maturity. The surface can be commonly brown and broken up into mosaic-like scales. The gleba is purplish and pulverulent at maturity (Zeller & Smith 1964, Morales & Kimbrough 1978).

Calvatia rugosa (Berk. & M.A. Curtis) D.A. Reid

Basionym: *Lycoperdon rugosum* Berk. & M.A. Curtis

Locality: SP, AP (Campi & Maubet 2016, Campi *et al.* in press)

Identification. The main characteristic is the presence of the orange pigment that stains the basidioma 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 rhizomorphs (Wright & Albertó 2006).

Calvatia lilacina (Mont. & Berk.) Henn

Basionym: Bovista lilacina Berk. & Mont.

Locality: PR (Spegazzini 1884, 1888).

Identification. Bates *et al.* (2009) reported *Calvatia lilacina* as a synonym of *Calvatia fragilis* in Arizona, USA. On the other hand both species are treated as independent by Trierveiler-Pereira & Baseia (2009) in Brazil. Cortez *et al.* (2012) consider this species a synonym of *C. cyathiformis* but other authors differ and consider *C. cyathiformis* as a different species (Verma *et al.* 2018).

Comments: *C. lilacina* was recorded for Spegazzinii (1884) as *Lycoperdon lilacinum.*

Cyathus earlei Lloyd

Locality: PR (Campi *et al.* in press).

Identification. This species 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 and peridioles with a double-layer cortex (Cruz et al. 2014).

Cyathus limbatus Tul. & C. Tul

Basionym: *Cyathodes limbatum* (Tul. & C. Tul.)

Localities: AP, CE, PR (Maubet *et al.* 2017, Campi *et al.* in press).

Identification. 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 a woolly golden brown subicule is formed (Brodie & Dennis 1954, Trierveiler-Pereira & Baseia 2010).

Cyathus poeppigii Tul. & C. Tul

Basionym: *Cyathodes poeppigii* (Tul. & C. Tul.)

Localities: CE (Campi & Maubet 2015a, Maubet *et al.* 2017).

Identification. The most remarkable diagnostic characteristics of the species are the large size of the basidiospores (20-28 × 30-42 µm) and the deep internal and external striations of the peridium (Brodie and Dennis 1954).

Cyathus setosus H.J. Brodie

Localities: PR (Maubet *et al.* 2017).

Identification. *C. setosus* is characterized by a conical peridium, of intense dark brown coloration, smooth external surface and a slightly plicated internal surface, with dark conspicuous setae 0.5-1 mm long, large peridioles without a tunic, double cortex, and a small subiculum (Brodie 1967, Trierveiler-Pereira & Baseia 2013).

Cyathus stercoreus (Schwein.) De Toni

Basionym: *Nidularia stercorea* Schwein.

Locality: CG, PR, SP (Maubet *et al.* 2017, Campi *et al.* 2013b).

Identification. The morphological characteristics of the species are the absence of folds, either internal or external, in the peridium, the presence of hairs grouped into golden brown strands covering the entire basidioma in the immature state, these hairs fall with age leaving the peridium with smooth appearance at maturity and taking a dark color ranging from light brown to gray (Maubet *et al.* 2017).

Cyathus striatus (Huds.) Willd.

Basionym: *Peziza striata* Huds.

Locality: AR (Gullón 2011).

Identification. Easy to recognize by the hirsute exoperidium with a shiny and striate inner surface. Microscopically, it has large ovoid basidiospores (14-17 × 7-9) (Baseia & Milanez 2001).

Podaxis pistillaris (L.) Fr.

Basionym: *Lycoperdon pistillare* L.

Localities: BO, CR (Campi *et al.* 2015b, Campi *et al.* in press).

Identification. This species is characterized by the hard and fibrous pseudostipe that penetrates the gleba. The gleba is covered by a scaly, sub-cylindrical peridium which turns dark and powdery in the mature stage (Morse 1933).

Lycoperdon pseudogemmatum Speg.
Locality: PR (Spegazzinii 1884).
Identification. Cortez *et al*. (2013) consider this species a possible synonym of *Lycoperdon perlatum*, a highly variable species, which is characterized by the presence of spines in the conical exoperidium with a rounded apex.

Lycoperdon pseudolilacinum Speg.
Locality: PR (Spegazzinii 1884).
Identification. This species resembles *L. lilacinum* but differs in the color of the gleba and the very fragile peridium (Spegazzini 1884).

Tulostoma cyclophorum Lloyd
Basionym: *Tulostoma berteroanum* f. *pampeanum* Speg.
Locality: CE, PR (Spegazzini 1884, Campi *et al.* 2016a).
Identification. This species is easily distinguishable by persistent membranous exoperidium in old specimens, endoperidium with a velvety texture and abundant mycosclereids well visible to the stereoscope on its surface, a mamiform and fimbriated mouth, and by the globose basidiospores with ridges which offer a characteristic cross-linked to sub-crosslinked morphology (Campi *et al.* 2016a).
Comments: This species was recorded as *Tulostoma berteroanum* by Spegazzini (1884).

Tulostoma pygmaeum Lloyd
Locality: PR (Campi *et al.* in press)
Identification. This species is characterized by its tubular mouth, hyphal exoperidium, and basidiospores with a distinct verrucose ornamentation (Moreno *et al.* 1995).

Vascellum pampeanum (Speg.) Homrich, in Homrich & Wright
Basionym: *Lycoperdon pampeanum* Speg.
Locality: CE (Campi & Maubet 2016).
Identification. *V. pampeanum* is characterized by having a diaphragm that separates the gleba from the subgleba, the presence of mycosclereids on the surface of the exoperidium and the presence of eucapilicium (Homrich & Wright 1988).

Geastraceae Corda

Geastrum argentinum (Speg.)

Basionym: *Geastrum argentines* Speg.

Locality: AP (Campi *et al.* 2018).

Identification. *G. argentinum* is characterized by emerging from a whitish subicule and by an external surface of the velvety mycelial layer which is detached from fibrous tissue (Zamora *et al.* 2014).

Geastrum coronatum Pers.

Basionym: *Geastrum limbatum* Fr.

Locality: CE (Campi & Maubet 2015b).

Identification. This species is mainly characterized by arched basidiomata, dark brown and asperulate endoperidium, a myceliar layer covered with abundant debris, a fibrillose peristome, larger pedicel (up to 4 mm high), and basidiospores with prominent truncate warts (Sunhede 1989, Soto & Wright 2000, Alves & Cortez 2016).

Geastrum hariotii Lloyd

Basionym: *Geaster harioti* Lloyd

Locality: AP (Campi *et al*. 2018).

Identification. The species is characterized by having non-hygroscopic exoperidium, endoperidium sessile or with a very short stipe, peristoma strongly plicated and well defined. (Trierveiler-Pereira & Silveira 2012).

Geastrum minimum Schwein.

Locality: CE (Campi *et al.* 2015a).

Identification. *G. minimum* is normally treated as a single, rather variable species, mostly small-sized and often showing quite large crystals of calcium oxalate on the endoperidial surface (Zamora *et al.* 2014)

Geastrum pampeanum var. ***pallidum*** Speg.

Basionym: *Geastrum pampeanus* var. *pallidus* Speg.

Locality: AP (Campi *et al.* 2018).

Identification. This species is characterized by a small basidiomata (17-30 mm wide), non-hygroscopic exoperidium, sessile endoperidium and basidiospores of 3.5-5 μm diam. (Campi *et al.* 2018).

Geastrum pusillipilosum J.O. Sousa, Alfredo, R.J. Ferreira, M.P Martín & Baseia

Locality: PR (Campi *et al.* in press).

Identification. Recognized 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 diam (Crous *et al.* 2016, Lima & Baseia 2018).

Geastrum saccatum Fr.

Localities: AP, CE, PR (Spegazzini 1884, Campi *et al.* 2018).

Identification. This species is characterized by a large basidiomata (up to 8 cm in diameter), involute lacinias, non-hygroscopic, a prominent conspicuous collar around the endoperidium from the pseudoparenchymal layer of exoperidium, sessile endoperidium, delimited or unbounded fibrous peristoma (Sunhede 1989).

Geastrum schweinitzii (Berk. & M.A. Curtis) Zeller

Basionym: *Coilomyces schweinitzii* Berk. & M.A. Curtis

Locality: CE (Campi & Maubet 2015b).

Identification. This species is recognized by small cespitose basidiomata and by the presence of a white to yellowish, subiculum that spreads throughout the substrate, which is generally decomposing wood (Baseia *et al.* 2003). Some specimens previously identified as *G. schweinitzii* for the neotropics were different species based on phylogenetic analysis and thus the species could be endemic of the region were the type material was collected (Accioly *et al.* 2019)

Geastrum triplex Jungh. in Tijdschr

Locality: SP, CE, AP (Campi *et al.* 2013b, Campi *et al.* 2018).

Identification. This species is characterized by large basidiomata (up to 8 cm in diameter), involute lacinias, non-hygroscopic, prominent conspicuous collar around the endoperidium from the pseudoparenchymal layer of exoperidium, sessile endoperidium, delimited or unbounded fibrous peristoma. (Campi *et al*. 2018). Recent phylogenetic studies suggest that the morphological concept of the species actually represents an assemblage of closely related species which vary in the distribution patterns (Kasuya *et al.* 2012).

Geastrum violaceum Rick

Locality: AR (Campi *et al.* 2013a).

Identification. This species is mainly distinguished by the pink, red to pale violet color of the exoperidium, a character that easily separates it from other species of the genus (Trierveiler-Pereira & Silveira 2012).

Myriostoma calongei Baseia, J.O. Sousa & M.P. Martín

Locality: PR (Campi *et al*. in press).

Identification. This species is characterized by a verrucose endoperidium, with prominent triangular processes and could be restricted to South America (Sousa *et al.* 2017).

Phallaceae Corda

Blumenavia rhacodes Möller

Locality: CR (Campi *et al*. in press).

Identification. The species is characterized by a pale orange to greyish orange (beige) receptacle consisting of 3-5 columns, and glebifers occuring on lateral expansions (“teeth”) distributed along the column’s margins (Trierveiler-Pereira *et al.* 2019, Melanda *et al.* 2020).

Clathrus argentinus Domínguez

Locality: CE (Campi *et al.* in press).

Identification. This species is characterized by having the receptacle arms not joined at the base and a strongly yellow basal mycelium, and glebiferous zones with digitiform extensions, are at the intersection of the arms that form the network (Domínguez de Toledo 1985).

Clathrus chrysomycelinus Möller

Basionym: *Clathrella chrysomycelina* (Möller) E. Fisch.

Locality: PR (Maubet *et al.* 2018).

Identification. This species is characterized by obovoid, perforate, white to yellowish receptacle, isodiametric meshes, having the receptacle arms joined at the base and a strong yellow basal mycelium. In addition, the glebe is confined to glebifers at the inner side of the arm’s intersections (Dring *et al.* 1971, Dring 1980).

Comments: Maubet *et al.* (2018) mention that the material was collected in Ybycui city, reviewing the herbarium material, the right collection site corresponds to Piribebuy city, Cordillera Department.

Clathrus columnatus Bosc

Basionym: *Laternea columnata* (Bosc) Nees

Locality: CE (Campi *et al.* 2017).

Identification. Species characterized by having 2-5 robust spongy reddish to orange columns free at the base and fused at the apex. The gleba is spread on the internal portion of the columns and not confined to a glebifer (Sandoval-Leiva *et al*. 2014, Magnago *et al*. 2013).

Clathrus crispus Turpin

Basionym: *Clathrella crispa* (Turpin) E. Fisch.

Locality: AP (Maubet *et al.* 2018).

Identification. This species is characterized by having a small receptacle (5 cm or less, some larger up to 15 cm), globose to subglobose of reddish coloration, with somewhat regular meshes (usually round at the apex and more elongated towards the base) and with a corrugated and folded membrane surrounding the meshes where the gleba is located (Dring 1980).

Itajahya galericulata Möller, Bras.

Localities: CE, PR (Campi *et al.* 2017, in press).

Identification. Characterized by massive ‘eggs’ (3–8 cm high), a white pseudostipe, a hemispherical, wig-like receptacle with a flat apex that is covered with a calyptra (membranous cap) (Trierveiler-Pereira *et al.* 2019).

Itajahya rosea (Delile) E. Fisch.

Basionym: *Phallus roseus* Delile

Localities: CE (Campi *et al.* 2017)

Identification. This species, which has a phalloid shape, is characterized by the presence of a calyptra at the apex of the receptacle and the pinkish pseudostipe (Ottoni *et al.* 2010).

Lysurus sphaerocephalum (Schltdl.) Hern. Caff., Urcelay, Hosaka & L.S. Domínguez

Basionym: *Simblum sphaerocephalum* Schltdl.

Localities: CE, PR (Spegazzini 1891, Campi *et al.* in press)

Identification. The diagnostic features of the species are the fertile portion of the receptacle that is an irregular net, reddish, enclosing the stipe, which exceeds the stipe width. Stipe reddish and stylized, length clearly exceeds width, not striate (Hernández-Caffot *et al.* 2018).

Mutinus argentinus Speg.

Localities: CE, CR (Campi *et al.* 2017, Maubet *et al.* 2018).

Identification. The species is characterized by a pinkish pseudostipe that tapers towards the apex, and a granulose, bright red fertile part with a small pore at the tip when mature (Trierveiler-Pereira *et al.* 2019).

Comments: Maubet *et al.* (2018) mention that the material was collected in Ybycui city, reviewing the herbarium material the right collection site corresponds to Piribebuy city, Cordillera Department.

Phallus campanulatus Berk.

Locality: CE (Campi *et al.* in press)

Identification. The species is characterized by a whitish pseudostipe with small perforations, an off white, perforate, narrow campanulate, wrinkled to minutely rugulose receptacle with a toothed margin. The pore at the receptacle apex is so prominent that a ring-like structure can be observed around it (Trierveiler-Pereira *et al.* 2019).

Phallus indusiatus Vent.

Localities:CE (Maubet *et al.* 2018).

Identification. The species is characterized by a whitish pseudostipe, a reticulate, white receptacle and the long, white indusium. Mycelial strands are often abundant and have purplish pigments (Trierveiler-Pereira *et al.* 2019).

Sclerodermataceae Corda

Pisolithus arhizus (Scop.) Rauschert

Basionym: *Lycoperdon arrizon* Scop.

Locality: CE (Campi *et al.* 2015a)

Identification. This species is recognized by its epigeous, globose basidiomata, echinate basidiospores (Campi *et al.* 2015a).

Scleroderma bovista Fr.

Locality: CE (Campi *et al.* 2015a)

Identification. The species is characterized by the presence of a smooth yellowish-brown peridium, with some reddish dark brown areas, basidiospores (11–) 12–14 (–16) µm in diameter, with a well-developed crosshair (Nouhra *et al.* 2012).

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Author Contributions

Yanine Maubet Cano: Conceptualization of manuscipt draft, Contribution to critical revision; Contribution to data collection.

Michelle Campi Gaona: Contribution to data collection; Contribution to critical revision; Contribution to manuscript preparation.

Larissa Trierveiler-Pereira: Contribution to manuscript preparation; Contribution to data collection, Contribution to critical revision, adding intellectual content.

Conflicts of interest

The authors declare there is no conflict of interest.

Literature cited

Accioly, T., Sousa, J.O., Moreau, P.A., Lécuru, C., Silva, B.D., Roy, M., Gardes, M., Baseia, I.G. & Martín, M.P. 2019. Hidden fungal diversity from the Neotropics: *Geastrum hirsutum*, *G. schweinitzii* (Basidiomycota, Geastrales) and their allies. PloS one 14(2): e0211388.

Alves, C.R. & Cortez, V.G. 2016. Gasteroid Phallomycetidae (Basidiomycota) from the Parque Estadual São Camilo, Paraná, Brazil. Iheringia Série Botânica 71: 27-42.

Baseia, I.G. & Milanez, A.I. 2001. *Cyathus* (Gasteromycetes) in areas of the Brazilian cerrado region, São Pau-lo State. Mycotaxon 80: 493-502.

Baseia, I.G., Cavalcanti, M.A. & Milanez, A.I. 2003. Additions to our knowledge of the genus *Geastrum* (Phallales: Geastraceae) in Brazil. Mycotaxon 85: 409-416.

Bates, S.T., Roberson, R.W. & Desjardin, D.E. 2009. Arizona gasteroid fungi I: Lycoperdaceae (Agaricales, Basidiomycota). Fungal Diversity 37: 153-207.

Brodie, H. & Dennis, R. 1954. The Nidulariaceae of the West Indies. Transactions of the British Mycological Society 37(2): 151-160.

Brodie, H.J. 1967. *Cyathus setosus*, a new member of the Nidulariaceae from Jamaica. Canadian Journal of Botany 45: 1-3.

Campi, M.G., De Madrignac, B., Flecha, A.M. & Gullón, M. 2013a. *Geastrum violaceum* Rick (Geastraceae, Basidiomycota) nuevo registro para Paraguay. Reportes Científicos 4(2): 15-18.

Campi, M.G., De Madrignac, B., Flecha, A.M. & Ortellado, A. 2013b. Hongos de la Reserva Natural Laguna Blanca. Salpa SA, Paraguay.

Campi, M.G. & Maubet, Y. 2015a. *Cyathus poeppigii* (Agaricales, Basidiomycetes): nuevo registro para Paraguay. Steviana 7: 74-78.

Campi, M.G. & Maubet, Y. 2015b. Especies de *Geastrum* (Geastraceae, Basidiomycota) nuevos registros para Paraguay. Steviana 7: 79-88.

Campi, M.G., Maubet, Y. & Britos, L. 2015a. Mycorrhizal fungi associated with plantations of *Pinus taeda* L. from the National University of Asunción, Paraguay. Mycosphere, 6(4), 486-492.

Campi, M.G., Maubet, Y. & Weiler, A. 2015b. *Podaxis pistillaris* (Basidiomycota, Agaricomycetes) nuevo registro para el Chaco paraguayo. Boletín de la Sociedad Micológica de Madrid 39: 77-81.

Campi, M.G. & 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.G., Maubet, Y., Moreno, G. & Altés, A. 2016a. *Tulostoma cyclophorum* (Basidiomycota, Agaricomycetes) new record for Paraguay. Bol. Soc. Micol. Madrid 40: 129-132.

Campi, M.G., Maubet, Y. & Weiler, A. 2016b. Nueva cita de hongo xerófito para el Chaco paraguayo: *Batarrea phalloides* (Basidiomycota, Agaricomycetes). Bol. Soc. Micol. Madrid 41: 47-52.

Campi, M.G., Trierveiler-Pereira, L. & Maubet, Y. 2017. New records of Phallales from Paraguay. Mycotaxon, 132(2): 361-372.

Campi, M., Maubet, Y. & Trierveiler-Pereira, L. 2018. "Estrellas de tierra" Geastrum (Geastraceae, Basidiomycota): nuevas citas para el Pantanal paraguayo. Steviana 10(2): 3-16.

Campi, M., Maubet, Y. & Trierveiler-Pereira, L. (in press). Rediscovery of *Clathrus argentinus* and new contributions to the gasteroid mycobiota of Paraguay. Current Research in Environmental & Applied Mycology.

Cortez, V.G., Baseia, I.G. & Silveira, R.M. 2008. Gasteromicetos (Basidiomycota) no Parque Estadual de Itapuã, Viamão, Rio Grande do Sul, Brasil. Biociências (Porto Alegre) 6(3): 291-299.

Cortez, V.G., Baseia, I.G. & da Silveira, R.M.B. 2012. Gasteroid mycobiota of Rio Grande do Sul, Brazil: *Calvatia*, *Gastropila* and *Langermannia* (Lycoperdaceae). Kew Bulletin, 67(3): 471-482.

Cortez, V.G., Baseia, I.G. & da Silveira, R.M. 2013. Gasteroid mycobiota of Rio Grande do Sul, Brazil: *Lycoperdon* and *Vascellum.* Mycosphere 4(4): 745-758.

Crous, P.W., Wingfield, M.J., Burgess, T.I., Hardy, G.S.J., Crane, C., Barrett, S., ... Stchigel A.M. 2016. Fungal Planet description sheets: 469-557. Persoonia: Molecular Phylogeny and Evolution of Fungi, 37: 218.

Cruz, R.H., Assis, S.F., Silva, M.A. & Baseia, I.G. 2014. Revision of the genus *Cyathus* (Basidiomycota) from the herbaria of northeast Brazil. Mycosphere, 5(4): 531-540.

Dinerstein, E., Olson, D.M., Graham, D.J, Webster, A.L., Primm, S.A, Bookbinder, M.P. & Ledec, G. 1995. Una Evaluación del Estado de Conservación de las Eco-regiones Terrestres de América Latina y el Caribe. Banco Mundial, Washington DC.

Domínguez de Toledo, L.S. 1995. Gasteromycetes (Eumycota) del Centro y Oeste de la Argentina. II. Orden Phallales. Darwiniana. 32(1-4): 195-210.

Dring, D.M., Meeker, J. & Goos, R. 1971. *Clathrus oahuensis*, a new species from Hawai. Mycologia 63(4): 893-897.

Dring, D.M. 1973. Gasteromycetes. In: Ainsworth GC, Sparrow FK, Sussman AS (Eds) The fungi. An advanced treatise. Academic Press, New York and London, 451-478.

Dring, D.M. 1980. Contributions towards a rational arrangement of the *Clathraceae.* Kew Bulletin 35(1): 1-96.

Garrido-Benavent, I. 2014. The Battarrea phalloides-stevenii complex: multiple sources of evidence as a strategy to unveil cryptic species within poorly characterized taxa. Bull.Soc. Micol. Valenciana 19: 17-35.

Gullón, M. 2011. Hongos Superiores del Refugio biológico Tati Yupi. Hernandarias. Paraguay. Biota 15: 1-68.

Hernandez Caffot, M.L., Hosaka, K., Domínguez, L.S. & 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.

Homrich, M.H. & Wright, J.E. 1988. South American Gasteromycetes. II. The genus Vascellum. Canadian Journal of Botany 66: 1285-1307.

Lima, A.A. & Baseia, I.G. 2018. Gasteroid fungi (Basidiomycota) from two protected natural areas in Rio Grande do Norte State, Brazil. Journal of Fungal Biology, 8(6): 585-605.

Kasuya, T., Hosaka, K., Uno, K. & Kakishima, M. 2012. Phylogenetic placement of *Geastrum melanocephalum* and polyphyly of *Geastrum triplex*. Mycoscience 53: 411-426.

Magnago, A.C., Trierveiler-Pereira, L. & Neves, M.A. 2013. *Phallales* (Agaricomycetes, Fungi) from the tropical Atlantic Forest of Brazil. Journal of the Torrey Botanical Society 140 (2): 236-244.

Maubet, Y., Campi, M.G., 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, M.G., Trierveiler-Pereira, L. & Moreno, G. 2018. Contribución a la Micobiota Gasteroide de Paraguay. Nuevas citas. Bol. Soc. Micol. Madrid 42: 119-128.

Melanda, G.C., Accioly T., Ferreira, R.J., Rodrigues, A.C., Cabral, T.S., Coelho, G., ... & Baseia, I.G. 2020. Diversity trapped in cages: Revision of *Blumenavia* Möller (Clathraceae, Basidiomycota) reveals three hidden species. PloS one 15(5): e0232467.

Miller, H.R. & Miller, O.K. 1988. Gasteromycetes: Morphological and Developmental Features, with Keys to the Orders, Families, and Genera. Eureka Mad River Press, California-USA.

Moreno, G., Altés, A., Ochoa, C. & Wright, J.E. 1995. Contribution to the study of the *Tulostomataceae* in Baja California, Mexico. I. Mycologia 87(1): 96-120.

Morales, M.I., Kimbrough, J.W. 1978. The Lycoperdaceae of North Central Florida I. The genera *Calvatia* and *Disciseda*. Revista de Biologia Tropical 26(1): 227-236.

Morse, E.E. 1933. A study of the genus *Podaxis*. Mycologia 25(1): 1-31.

Nouhra, E., Hernandez Caffot, M., Pastor, N. & Crespo, E. 2012. The species of *Scleroderma* from Argentina, including a new species from the Nothofagus forest. Mycologia 104(2): 488-495.

Ottoni, B.S., Silva, B.D.B., Fazolino, E.P. & Baseia, I.G. 2010. *Phallus roseus*, first record from the neotropics. Mycotaxon 112: 5-8.

Rea, P.M. 1942. Fungi of southern California. I. Mycologia 34: 563-574.

Robert, V., Stegehuis, G. & Stalpers, J. 2005. The MycoBank engine and related databases. Available at http://www.mycobank.org (access 14-XII-2019).

Sandoval-Leiva, P., Henríquez, J.L. & Trierveiler-Pereira, L. 2014. Additions to the Chilean phalloid mycota. Mycotaxon 128: 45-54.

Sousa, J., Suz, L.M., García, M.A., Alfredo, D.S., Conrado, L.M., Marinho, P., Ainswoth, A.M., Baseia, I.G. & Martín, M.P. 2017. More than one fungus in the pepper pot: Integrative taxonomy unmasks hidden species within *Myriostoma coliforme* (Geastraceae, Basidiomycota). PloS one 12(6): e0177873.

Soto, M. & Wright, J.E. 2000. Taxonomía del género *Geastrum* (Basidiomycetes, Lycoperdales) en la provincia de Buenos Aires, Argentina. Boletín de la Sociedad Argentina de Botánica 34: 185-
Spegazzini, C. 1884. Fungi Guaranitici. Pugillus 1. Anales de la Sociedad Científica Argentina 17(3): 119-134.

Spegazzini, C. 1888. Fungi Guaranitici. Pugillus II. Anales de la Sociedad Científica Argentina 26(1): 5-74.

Spegazzini, C. 1891. Fungi Guaranitici nonnulli novi vel critici. Revista Argentina de Historia Natural 1(3): 168-177.

Sunhede, S. 1989. *Geastraceae* (Basidiomycotina) morphology, ecology and systematics with emphasis on the north Europearn species. Synopsis Fungorum 1. Oslo: Fungiflora.

Trierveiler-Pereira, L. & Baseia, I.G. 2009. A checklist of the Brazilian gasteroid fungi (Basidiomycota). Mycotaxon 108: 441-444.

Trierveiler-Pereira, L. & Baseia, I.G. 2010. Contribution to the knowledge of gasteroid fungi (Agaricomycetes, Basidiomycota) from the state of Paraíba, Brazil. Revista Brasileira de Biociências, 9(2):167-173.

Trierveiler-Pereira, L. & Silveira, R.M.B. 2012. On the *Geastrum* species (Geastraceae, Basidiomycota) described by Rick. Phytotaxa, 61(1): 37-46.

Trierveiler-Pereira, L. & Baseia, I.G 2013. *Cyathus* species (Basidiomycota: Fungi) from the Atlantic Forest of Pernambuco, Brazil: taxonomy and ecological notes. Revista Mexicana de Biodiversidad, 84(1): 1-6.

Trierveiler-Pereira, L., Meijer, A.A.R. & Silveira, R.M.B. 2019. Phallales (Agaricomycetes, Fungi) from Southern Brazil. Studies in Fungi 4(1): 162-184.

Verma, R.K., Mishra, S.N., Pandro, V. & Thakur, A.K. 2018. Diversity and distribution of *Calvatia* species in India: a new record from central India. International Journal of Current Microbiology and Applied Science 7(9): 2540-2551.

Wright, J.E. & Albertó, E. 2006. Guía de los hongos de la Región Pampeana II. Hongos sin laminillas. Editorial L.O.L.A, Buenos Aires-Argentina.

Zamora, J.C., Calonge, F.D. & Martín, M.P. 2014. Integrative taxonomy reveals an unexpected diversity in *Geastrum* section *Geastrum* (Geastrales, Basidiomycota). Persoonia 34: 130-165.

Zeller, S.M., Smith, A.H. 1964. The genus *Calvatia* in North America. Lloydia 27(3): 148-186.

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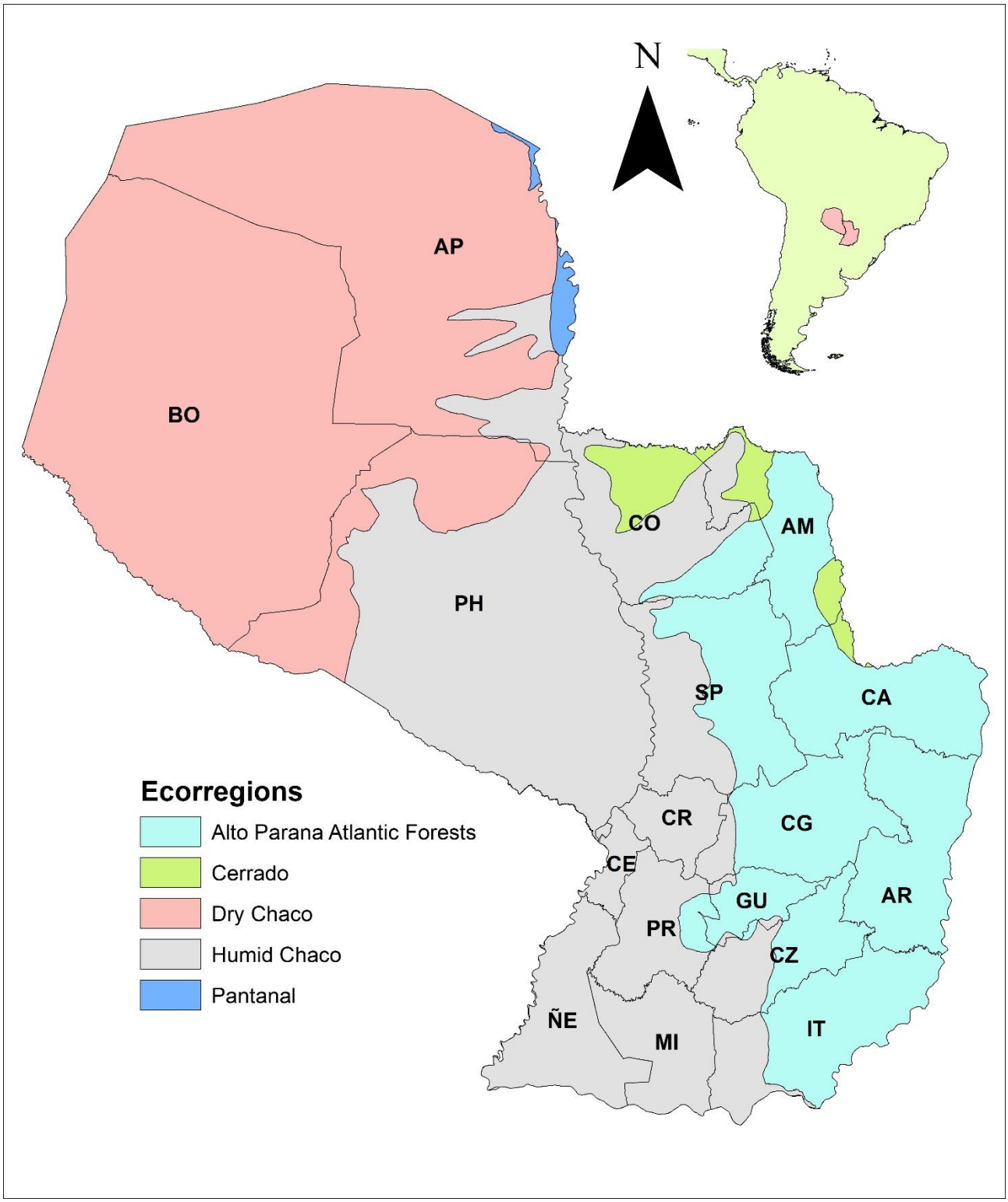

Figure 1. Map of Paraguay with the Departments where gasteroid mushrooms have been collected are. AP: Alto Paraguay, AR-Alto Paraná, AM: Amambay, BO: Boquerón, CG: Caaguazú, CZ: Caazapá, CA: Canindeyú, CE: Central, CO: Concepción, CR: Cordillera, GU: Guairá, IT: Itapúa, MI: Misiones, ÑE: Neembucú, PR: Paraguarí, PH: Presidente Hayes, SP: San Pedro.

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Table 1. List of species cited in Paraguay in alphabetical order, the collection locations and the reference.

	Species	Locality	Reference
1	*Battarrea phalloides* (Dicks.) Pers.	Boquerón	Campi *et al.* 2016b
2	*Blumenavia rhacodes* Möller	Cordillera	Campi *et al.* in press
3	*Calvatia cyathiformis* (Bosc) Morgan	Central, Boquerón	Campi *et al.* in press
4	*Calvatia lilacina* (Mont. & Berk.) Henn.	Paraguarí	Spegazzini 1884, 1888
5	*Calvatia rugosa* (Berk. & M.A. Curtis) D.A. Reid	San Pedro, Alto Paraguay	Campi & Maubet 2016, Campi *et al.* in press
6	*Clathrus argentinus* L.S. Domínguez	Central	Campi *et al.* in press
7	*Clathrus chrysomycelinus* Möller	Cordillera	Maubet *et al.* 2018
8	*Clathrus columnatus* Bosc	Central	Campi *et al.* 2017
9	*Clathrus crispus* Turpin	Alto Paraguay	Maubet *et al.* 2018
10	*Cyathus earlei* Lloyd	Paraguarí	Campi *et al.* in press
11	*Cyathus limbatus* Tul. & C. Tul.	Alto Paraguay, Central, Paraguarí	Maubet *et al.* 2017, Campi *et al.* 2020
12	*Cyathus poeppigii* Tul. & C. Tul.	Central	Campi & Maubet 2015a, Maubet *et al.* 2017
13	*Cyathus setosus* H.J. Brodie	Paraguarí	Maubet *et al.* 2017
14	*Cyathus stercoreus* (Schwein.) De Toni	Caaguazú, Paraguarí, San Pedro	Maubet *et a*l. 2017, Campi *et al.* 2013.
15	*Cyathus striatus* (Huds.) Willd.	Alto Paraná	Gullón 2011
16	*Geastrum argentinum* Speg.	Alto Paraguay	Campi *et al.* 2018
17	*Geastrum coronatum* Pers.	Central	Campi & Maubet 2015b
18	*Geastrum hariotii* Lloyd	Alto Paraguay	Campi *et al*. 2018
19	*Geastrum minimum* Schwein.	Central	Campi *et al*. 2015a

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20	*Geastrum pampeanum var. pallidum* Speg.	Alto Paraguay	Campi *et al.* 2018
21	*Geastrum pusillipilosum* J.O. Sousa, Alfredo, R.J. Ferreira, M.P Martín & Baseia	Paraguarí	Campi *et al.* in press
22	*Geastrum saccatum* Fr.	Alto Paraguay, Central, Paraguarí	Spegazzini (1884) as *Geaster saccatus*, Campi & Maubet 2015b, Campi *et al.* 2018
23	*Geastrum schweinitzii* (Berk. & M.A. Curtis) Zeller	Central	Campi & Maubet 2015b
24	*Geastrum triplex* Jungh.	Central, Alto Paraguay, San Pedro	Campi *et al.* 2013, Campi & Maubet 2015b, Campi *et al.* 2018
25	*Geastrum violaceum* Rick	Alto Paraná	Campi *et al.* 2013a
26	*Itajahya galericulata* Möller	Central	Campi *et al.* 2017
27	*Itajahya rosea* (Delile) E. Fisch.	Central	Campi *et al.* 2017
28	*Lycoperdon pseudogemmatum* Speg.	Paraguarí	Spegazzini (1884)
29	*Lycoperdon pseudolilacinum* Speg.	Paraguarí	Spegazzini (1884)
30	*Lysurus sphaerocephalum* (Schltdl.) Hern. Caff., Urcelay, Hosaka & L.S. Domínguez	Paraguarí	Spegazzini (1891) as *Simblum sphaerocephalum*, Campi *et al.* in press
31	*Mutinus argentines* Speg.	Central, Cordillera	Campi *et al.* 2017, Maubet et al. 2018
32	*Myriostoma calongei* Baseia, J.O. Sousa & M.P. Martín	Paraguarí	Campi *et al.* in press
33	*Phallus campanulatus* Berk.	Central	Campi *et al.* in press
34	*Phallus indusiatus* Vent.	Central	Maubet *et al.* 2018
35	*Pisolithus arhizus* (Scop.) Rauschert	Central	Campi *et al.* 2015a
36	*Podaxis pistillaris* (L.) Fr.	Boquerón, Cordillera	Campi *et al.* 2015b, Campi *et al.* 2020
37	*Scleroderma bovista* Fr.	Central	Campi *et al.* 2015a
38	*Tulostoma cyclophorum* Lloyd	Central, Paraguarí	Spegazzini 1884, 1891 Campi *et al.* 2016a
39	*Tulostoma pygmaeum* Lloyd	Paraguarí	Campi *et al.* in press
40	*Vascellum pampeanum* (Speg.) Homrich	Central	Campi & Maubet, 2016a

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