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SHORT COMMUNICATION

New records of *Geastrum* (Geastrales, Basidiomycota) for the Amazon

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ABSTRACT

Fungi of the genus *Geastrum* are known as earthstar fungi, due to the stelliform morphology of their basidiomes. In the Amazon domain, there are 25 catalogued species of *Geastrum*, with several new records in recent years. Here we report three new species records of *Geastrum* for the Brazilian Amazon. *Geastrum calycicoriaceum* and *G. rubropusillum* were recorded in the southwestern transition zone between Amazon forest and Cerrado savanna. *Geastrum calycicoriaceum* was recorded for the first time in Brazil.

KEYWORDS: Brazilian funga, biodiversity, neotropical fungi, taxonomy, gasteroid fungi

Novos registros de *Geastrum* (Geastrales, Basidiomycota) para a Amazônia

RESUMO

Os fungos do gênero *Geastrum* são conhecidos como fungos estrela-da-terra, devido à morfologia esteliforme de seus basidiomas. No domínio amazônico, existem 25 espécies catalogadas de *Geastrum*, com vários novos registos nos últimos anos. Aqui relatamos três novos registos de espécies de *Geastrum* para a Amazônia brasileira. *Geastrum calycicoriaceum* e *G. rubropusillum* foram registrados na zona de transição sudoeste entre a floresta amazônica e o Cerrado. *Geastrum calycicoriaceum* foi registado pela primeira vez no Brasil.

PALAVRAS-CHAVE: fungos brasileiros, biodiversidade, fungos neotropicais, taxonomia, fungos gasteróides

The genus *Geastrum* Pers. is characterized by star-shaped (or stelliform) basidiomes and by passive dispersal of spores through a single apical pore, depending on external factors for dispersion (Sunhede 1989). It has a cosmopolitan distribution (Kasuya *et al.* 2012) and is considered one of the most diverse genera of gasteroid fungi, with 100 to 120 currently valid species worldwide (Zamora *et al.* 2014). In Brazil, 67 species of *Geastrum* were recorded in the latest review by Accioly *et al.* (2019), and 30 species were recorded in the Amazon (Assis *et al.* 2022).

Publications on gasteroid fungi in the Amazon are still scarce and concentrate around the research poles in the region (Maia *et al.* 2015), hinting at that there is a large underexplored fungal diversity in this region. Here, we report three new species records from the southwestern Brazilian Amazon.

The specimens were collected in 2017 and 2018 in two areas in Mato Grosso state, Brazil (Figure 1): Estação Ecológica do Rio Ronuro (ESEC) (13°04'37.5"S, 54°32'38.5"W), municipality of Nova Ubiratã, and Fazenda São Nicolau (9°47'27.9"S, 58°16'51.0"W), municipality of Cotriguaçu. The most southern location is inserted in the transition zone between the Amazon Rainforest and the Cerrado savanna biomes, with vegetational types such as semideciduous seasonal forest and forested savanna (Borges *et al.* 2017).

The taxonomic analysis followed Sunhede (1989), Silva *et al.* (2014) and Sousa *et al.* (2014). The macroscopic analysis was conducted by direct visual inspection and under a stereomicroscope. The "Methuen Handbook of Color" color chart (Kornerup and Wanscher 1978) was used for color determination. For microstructure analysis, small portions of

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the specimens were removed and placed on microscope slides containing 3% potassium hydroxide (KOH). The layers were separated using tweezers and then observed under a Nikon Eclipse Ni-U light microscope (LM) with a Nikon DS-Ri1 camera attached (40x and 100x magnification). The size and shape of 30 basidiospores were analyzed and measured under LM and scanned electron microscope (SEM), and checked for the occurrence of apicule and apophysis. The mean ± standard deviation and the ratio between mean height and mean width (Q_m) were calculated. The other microstructures present on the slide were analyzed and measured.

The shape of the basidiospores was determined according to Bas (1969). Species identification followed Sunhede (1989), Sousa *et al.* (2014), Accioly *et al.* (2019) and Crous *et al.* (2020). The materials examined were deposited in the fungi collection of Universidade Federal do Rio Grande do Norte, Brazil (UFRN-Fungos).

Geastrum calycicoriaceum Freitas-Neto, J.O. Sousa, Ovrebo, M.P. Martín & Baseia, 2020

(Figures 1 and 2)

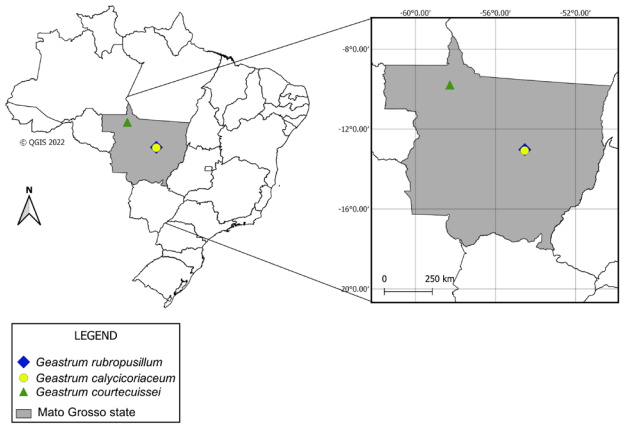

Figure 1. Location of Mato Grosso state in Brazil, and of the three new species records of *Geastrum*. This figure is in color in the electronic version.

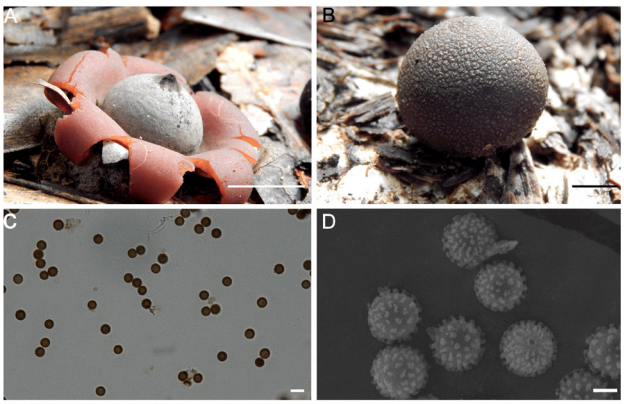

Figure 2. *Geastrum calycicoriaceum*. A – expanded basidiomes *in situ*; B – unexpanded basidiomes; C – basidiospores; D – basidiospores under SEM. Scale bars: A = 10 mm; B = 5 mm; C = 5 µm; D = 2 µm. This figure is in color in the electronic version.

Description – Unexpanded basidiomes epigeous, greyish yellow (4B4), globose to subglobose, 17 mm high × 11 mm wide, surface not encrusted, coriaceous, apex rounded. Rhizomorphs present, encrusted. Expanded basidiomata saccate, forming a calyx or cup under the basidiomes, 13.8 mm high (including peristome) × 30 mm wide. Exoperidium splitting into 6 triangular rays, revolute, non-hygroscopic, non-encrusted. Mycelial layer greyish yellow (4B4), not encrusted with debris, coriaceous, non-persistent, ephemeral, forming a cup under basidiomes. Fibrous layer greyish orange (5B4), coriaceous. Pseudoparenchymatous layer brown (6E5), persistent. Endoperidial body black (6C3), subglobose to pyriform, 11 × 16 mm, sessile, surface glabrous, non-pruinose. Apophysis absent. Peristome fimbriate, distinctly delimited by greyish brown (6E3) line, mammiform, lighter than endoperidium < 1 mm high. Gleba brown greyish (6D3). Rhizomorphs composed of hyaline, thin hyphae, surface not encrusted, lumen evident.

Mycelial layer composed of hyaline to yellowish, thick-walls (1.0–3.5 µm) hyphae, 4.3–9.8 µm diam, surface slightly encrusted, branched, lumen evident. Fibrous layer composed of yellowish to hyaline hyphae, thick walled (0.8–2.4 µm) hyphae 3.5–5.4 µm diam, surface non-encrusted, non-branched, lumen evident. Pseudoparenchymatous layer composed of yellowish, thick walled (0.8–1.7 µm) hyphal cells, subglobose, ovoid to elongated, 21.6–50.1 µm × 17.1–34.6 µm. Eucapillitium brownish, thick walls (1.2–2.7 µm), 3.1–6.4 µm diam, surface encrusted, covered by warts, branched, lumen evident. Basidiospores brownish, globose to subglobose, 3.2–4.2 µm × 3.1–4.3 µm [x = 3.6 µm ± 0.27 µm x 3.6 µm ± 0.2 µm, Q_m = 1.01 µm, n = 30], ornamentation conspicuous under LM. Verrucose under SEM; warts columnar (0.51–0.76 µm high), flat apex, apiculus conspicuous.

Habit and habitat – Gregarious, growing on leaf-litter.

Known distribution - BRAZIL, Rio Grande do Norte; PANAMA, Panama Province; PERU, Cuzco (Crous *et al.* 2019).

Specimens examined - BRAZIL, Mato Grosso, Cotriguaçu, Fazenda São Nicolau, 11/Mar/2018, leg. Assis, NM (NMA_97) (UFRN-Fungos 3080).

Diagnosis – *Geastrum calycicoriaceum* is characterized by an ephemeral mycelial layer, which detaches with maturation and forms a calyx or cup under the basidiomes, which gives the species its name (Crous *et al.* 2020).

Similar species - *Geastrum calycicoriaceum* morphologically resembles *G. velutinum* Morgan due to the presence of a yellowish mycelial layer, delimited and fimbriated peristome and the subiculum presence, but *G. velutinum* differs by the absence of an ephemeral and coriaceous mycelial layer and the lighter colors in the peridium layers (Dissing and Lange 1962). *Geastrum argentinum* Speg. differs from *G. calycicoriaceum* by

having an undelimited peristome and larger basidiospores (4.8–5.6 mm in diam) (Zamora *et al.* 2013).

Geastrum courtecuissei P.-A. Moreau & C. Lécuru, 2019

(Figures 1 and 3)

Description – Unexpanded basidiomes epigeous, pale orange (5A4) when fresh, orange white (5A2) when dried, subglobose, 6.3 mm high × 5.8 mm wide, surface lightly encrusted, tomentose. Subiculum pale yellow (4A2), covering the substrate. Expanded basidiomes saccate, 3.6–4.1 mm high (including peristome) × 4.1–6.7 mm wide. Exoperidium splitting into 6-8 triangular rays, revolute, not hygroscopic. Mycelial layer echinulate with short, whitish hairs, pale yellow (4A3), not encrusted, tomentose, persistent. Fibrous layer pale yellow (4A3), coriaceous. Pseudoparenchymatous reddish white (7A2) when fresh, dark blonde (5D4) when dried, persistent. Endoperidial body black (6F3), globose to subglobose, 2.7–3.7 mm × 3.7–4.5 mm, sessile, with protruding hyphae. Apophysis absent. Peristome fimbriate, black (6F3), delimited, mammiform, lighter than endoperidium, <1 mm high, depressed on endoperidial body. Gleba brown greyish (6D3).

Mycelial layer composed of hyaline, thick walled (0.9-3,0 µm) hyphae, 3.7-7.4 µm diam, surface not encrusted, not branched, lumen evident. Fibrous layer composed of hyaline, thick-walled (1.1–4.0 µm) hyphae, 3.6–8.4 µm diam, surface encrusted, not branched, lumen evident. Pseudoparenchymatous layer composed of yellowish, thick walled (1.1–4.1 µm) hyphal cells, subglobose to oval, 29.0–62.0 µm × 21.8–45.9 µm. Eucapillitium light brown, thin walls (0.63-2.53 µm), 2.4–6.1 µm diam, surface not-encrusted, sinuous, lumen evident. Basidiospores brownish, subglobose, 3.5–4.5 µm × 3.47–4.58 µm [x = 4.0 µm ± 0.3 µm × 4.0 µm ± 0.3 µm, Q_m = 1.0 µm, n = 30], ornamentation slightly conspicuous under LM. Verrucose under SEM; warts cylindrical (0.5–1.03 µm high), apiculus conspicuous.

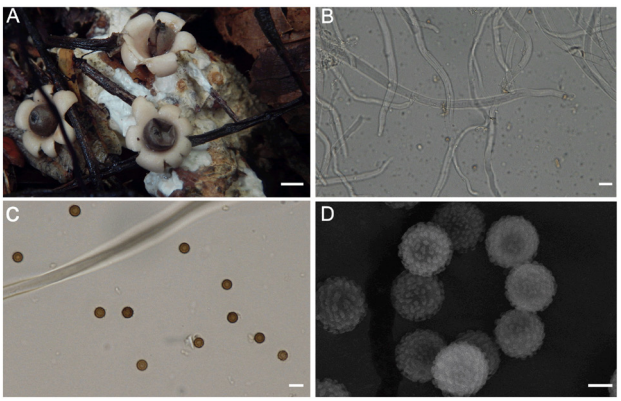

Figure 3. *Geastrum courtecuissei.* A – expanded basidiomes *in situ*; B – mycelial layer; C – basidiospores; D – basidiospores under SEM. Scale bars: A = 2 mm; B = 5 µm; C = 5 µm; D = 2 µm. This figure is in color in the electronic version.

Habit and habitat – Gregarious, growing on decaying wood.

Known distribution – GUADELOUPE, Saint-Claude; ARGENTINA, Puerto Iguazu (Accioly *et al.* 2019).

Specimens examined - BRAZIL, Mato Grosso, Nova Ubiratã, ESEC Rio Ronuro, 22 Fev 2017, leg. Assis, NM; DRESCHLER-SANTOS, E.; Magnago, A. (NMA_002) (UFRN-Fungos 3385).

Diagnosis - *Geastrum courtecuissei* is characterized by having fimbriate peristome delimited by a greyish-white line and depressed on the body of the endoperidium, globose to subglobose basidiospores (3.5–4.5 µm × 3.47–4.58 µm), orange white pseudoparenchymatous layer partially detached from the basidiomes, and a papyraceous whitish fibrous layer (Accioly *et al.* 2019).

Similar species - *Geastrum courtecuissei* morphologically resembles *G. schweinitzii* (Berk. & M.A. Curtis) Zeller, and *G. neoamericanum* J.O. Sousa, Accioly, M.P. Martín & Baseia, which belong to the same species complex in sect. *Myceliostroma* Henn, subsect. *Epigaea* Dissing & M.Lange. However, *G. schweinitzii* lacks an echinulate peridium, which is diagnostic of *C. courtecuissei* (Ponce de Léon 1968; Accioly *et al.* 2019). *Geastrum pusillipilosum* J.O. Sousa, Accioly, M.P. Martín & Baseia differs from *G. courtecuissei* by having larger basidiospores (5–6.5 µm), exoperidium covered with few tomentum, and larger basidiomes (4–10 mm high × 6–17 mm wide) (Crous *et al.* 2016).

Geastrum rubropusillum J.O. Sousa, Accioly, M.P. Martín & Baseia, 2019

(Figures 1 and 4)

Description – Unexpanded basidiomes epigeous, greyish red (5B7) when fresh, pale orange (5A3) when dried, subglobose, 5.1–7.4 mm high × 4.3–6.5 mm wide, not encrusted, papery to cotonous. Subiculum orange white

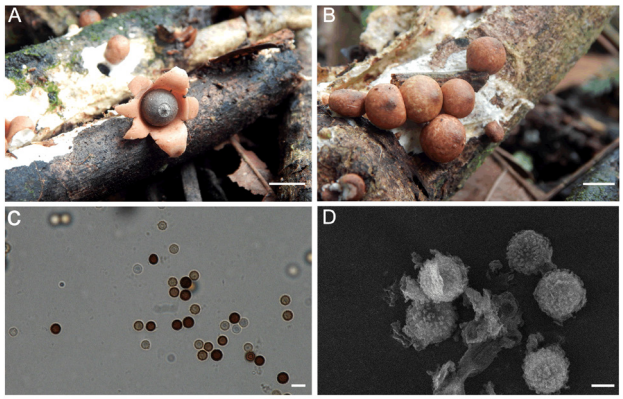

Figure 4. *Geastrum rubropusillum.* A – expanded basidiomes *in situ*; B – unexpanded basidiomes; C – basidiospores; D – basidiospores under SEM. Scale bars: A = 5 mm; B = 5 mm; C = 5 µm; D = 2 µm. This figure is in color in the electronic version.

(5A2), rhizomorphs absent. Expanded basidiomes saccate, 4.4–7.8 mm high (including peristome) × 6.4–12.2 mm wide. Exoperidium splitting into 5–6 triangular rays, revolute, not hygroscopic. Mycelial layer pale orange (5A3), not encrusted, papery to cotonous, persistent. Fibrous layer pale orange (5A3), coriaceous. Pseudoparenchymatous caramel brown (6C6) when fresh, dark brown (6F5) when dried, persistent. Endoperidial body brownish orange (5C6), subglobose, 3.7–4.4 mm, sessile, surface with protruding hyphae, not pruinose. Apophysis absent. Peristome fimbriate, brownish grey (6D2), delimited, mammiform, lighter than endoperidium, <1 mm high, depressed on endoperidial body. Gleba brown (5F5).

Mycelial layer composed of hyaline, thick-walled (0.9–3.0 µm) hyphae, 3.7–7.4 µm diam. surface encrusted, not branched, lumen evident. Fibrous layer composed of hyaline hyphae, thick-walled (1.1–3.8 µm) hyphae, 3.6–8.5 µm diam, surface not encrusted, not branched, lumen evident. Pseudoparenchymatous layer composed of brownish, thick-walled (1.1–3.0 µm) hyphal cells, subglobose to ovoid, 29.6–62.4 µm × 21.83–45.9 µm. Eucapillitium dark brown, thick walls (0.6–1.7 µm), 2.4–6.1 µm diam, surface lightly encrusted, lumen evident. Basidiospores yellowish, subglobose to ovoid, 3.5–4.5 µm × 3.8–4.4 µm [x = 4.0 µm ± 0.3 µm × 4 µm.04 µm ± 0.3 µm, Q_m = 1.03 µm, n = 30]. Ornamentation conspicuous under LM. Verrucose under SEM, warts columnar (0.9–2.9 µm high), apiculus conspicuous.

Habit and habitat – Gregarious, growing on decaying wood.

Known distribution – BRAZIL, Paraíba; PANAMA, Coiba Island; MARTINIQUE, Le Robert, bois Pothau, Le Prêcheur, anse Couleuvre (Accioly *et al.* 2019).

Specimens examined – BRAZIL, Mato Grosso, Cotriguaçu, Fazenda São Nicolau, 11 Mar 2018, leg. Assis, NM (NMA_100) (UFRN-Fungos 3104).

Diagnosis - *Geastrum rubropusillum* is characterized by a persistent reddish pseudoparenchymatous layer, fibrillose and mammiform peristome, smaller basidiomes (5.1–7.4 mm high × 4.3–6.5 mm wide when expanded), light brown exoperidium, and subglobose to oval basidiospores (Accioly *et al.* 2019).

Similar species - *Geastrum rubropusillum* resembles *G. pleosporum* Douanla-Meli by the presence of a redish pseudoparenchymatous layer and spores ranging from subglobose to ovoid, however *G. rubropusillum* has larger spores (3.5–4.5 µm × 3.8–4.4 µm), with conspicuous warts under LM, and mammiform peristome. *Geastrum schweinitzii* differs from *G. rubropusillum* mainly by the greyish pseudoparenchymatous layer (reddish in *G. rubropusillum*) (Ponce de León 1968).

Our records increase the number of known *Geastrum* species to 28 in the Brazilian Amazon, to 33 in the whole Amazon region, and to 68 in Brazil. The known distribution range of *G. rubropusilum* is considerably extended south and westwards, while the new localities for *G. courtecuissei* and *G. courtecuissei* fit into ranges formed by otherwise widely disjunct occurrence points. *Geastrum courtecuissei* is recorded for the first time in Brazil.

Geastrum courtecuissei and *G. rubropusilum* are considered as distinct species within the complex characterized by the presence of hairs on the exoperidium, a critical feature for differentiating species in subsect. *Epigaea* (Accioly *et al.* 2019). *Geastrum courtecuissei* had only been recorded in tropical and subtropical humid forests in Argentina and on Guadalupe Island, in the Caribbean (Accioly *et al.* 2019) and now is also known in the Amazon region.

As several neotropical species of *Geastrum* have a very similar morphology, misidentifications have been frequent (Accioly *et al.* 2019). The genus probably contains a species complex formed by cryptic or semi-cryptic species (Vizzini *et al.* 2013). When reviewing sect. *Myceliostroma*, subsect. *Epigaea*, Accioly *et al.* (2019) identified six new species that used to be identified as *Geastrum hirsutum* Baseia & Calonge or *G. schweinitzii*, demonstrating the hidden diversity within *Geastrum* in the Neotropics.

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