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NEW RECORDS OF GEASTRACEAE (BASIDIOMYCOTA: PHALLOMYCETIDAE) FROM ATLANTIC RAINFOREST REMNANTS AND RELICTS OF NORTHEASTERN BRAZIL

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Abstract. Sousa, J. O.; B. D. B. Silva; D. S. Alfredo & I. G. Baseia. 2014. New records of Geastraceae (Basidiomycota, Phallomycetidae) from Atlantic Rainforest remnants and relicts of Northeastern Brazil. *Darwiniana*, nueva serie 2(2): 207-221.

This work presents records of Geastraceae for northeastern Brazil, collected in remnants of the Atlantic Rainforest and Atlantic Rainforest relicts "Brejo de Altitude". The species were identified based on macro- and micromorphology with the aid of specific literature. Eleven species of the family are distributed into two genera: *Geastrum fimbriatum*, *G. javanicum*, *G. lageniforme*, *G. lloydianum*, *G. minimum*, *G. pectinatum*, *G. rusticum*, *G. schweinitzii*, *G. setiferum*, *G. triplex*, and *Myriostoma coliforme*. Nine of these records are new for Rio Grande do Norte state, five for Paraíba and five for Ceará. *Geastrum minimum* is the first record for Northeastern Brazil; *G. rusticum* is the first report for the semiarid region, while *G. pectinatum* and *M. coliforme* are the first records for the Northeastern Atlantic rainforest and "Brejo de Altitude" vegetation. We also provide observations, habitat, and species distribution in Brazil.

Keywords. Distribution; gasteroid fungi; Geastrales; neotropics; taxonomy.

Resumen. Sousa, J. O.; B. D. B. Silva; D. S. Alfredo & I. G. Baseia. 2014. Nuevos registros de Geastraceae (Basidiomycota, Phallomycetidae) en remanentes y relictos de Mata Atlántica del nordeste de Brasil. *Darwiniana*, nueva serie 2(2): 207-221.

En este trabajo se presentan registros de Geastraceae en el noreste brasileño, recolectados en los remanentes de las formaciones vegetales de la Mata Atlántica y los relictos de Mata Atlántica "Brejo de Altitude". Las especies se han identificado sobre la base de la macro y micro morfología con ayuda de la literatura específica. Once especies se distribuyen en dos géneros: *Geastrum fimbriatum, G. javanicum, G. lageniforme, G. lloydianum, G. minimum, G. pectinatum, G. rusticum, G. schweinitzii, G. setiferum* y *G. triplex* y *Myriostoma coliforme*. Nueve de estos registros son nuevos para Rio Grande do Norte, cinco para Paraíba y cinco para Ceará. *Geastrum minimum* es el primer registro para el nordeste de Brasil, *G. rusticum* es la primera cita para la región semiárida, mientras que *G. pectinatum* y *M. coliforme* son los primeros registros para el nordeste de la Mata Atlántica y los relictos de Mata Atlántica " Brejo de Altitude". También se incluyen observaciones taxonómicas del hábitat y la distribución de las especies en Brasil.

Palabras clave. Distribución; Geastrales; hongos gasteroides; neotrópico; taxonomía.

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INTRODUCTION

Gasteroid Basidiomycota is a polyphyletic group consisting of taxa characterized by angiocarpic basidiomata and passively released basidiospores (Wilson et al., 2011). The family Geastraceae encompasses two gasteroid genera, *Geastrum* Pers. and *Myriostoma* Desv., both saprophytic and popularly known as "earth-stars", a reference to the star-like aspect of the basidiomata (Jeppson et al., 2013).

Geastraceae is considered the second most representative family of gasteroid fungi in Brazil, with an estimated 50 recorded species, *Geastrum* being the most diverse genus in the country (Trierveiler-Pereira & Baseia, 2009; Leite et al., 2011; Trierveiler-Pereira et al., 2011; Silva et al., 2011, 2013). However, there are large gaps in the distribution and occurrence of this family in Brazil, remarkably in the northeastern states of the country, such as Ceará (CE), Paraíba (PB) and Rio Grande do Norte (RN), where there are less than 26% (13 species) of Geastraceae records for Brazil (Baseia & Galvão, 2002; Leite & Baseia, 2007; Leite et al., 2007a, 2007b; Fazolino et al., 2008; Silva et al., 2011; Cabral et al., 2014; Sousa et al., 2014).

Thus, the aim of this study was to broaden the knowledge about the richness and distribution of Geastraceae species in Brazil. The records presented here increased to 16 (33% of Geastraceae species found in Brazil) the number of Geastraceae species from these three states (CE, PB, RN).

MATERIALS AND METHODS

Specimens were collected during the rainy seasons of 2010 to 2013, at five protected areas in northeastern Brazil: 1) Parque Estadual Dunas de Natal (PEDN), Natal - RN, Atlantic Rainforest vegetation, 5°50'31"S, 35°11'39"W; 2) Reserva Particular do Patrimônio Natural Mata Estrela (RPPN Mata Estrela), Baía Formosa - RN, Atlantic Rainforest vegetation, 6°22'27"S, 35°1'24"W; 3) Parque Estadual Mata do Pau Ferro, Areia - PB, Atlantic Rainforest relicts "Brejo de Altitude", 6°59'28"S, 35°45'4"W; 4) Reserva Biológica de Guaribas, Mamaguape - PB, Atlantic Rainforest vegetation, 6º44'02"S, 35º10'32"W; and 5) Área de Proteção Ambiental de Ibiapaba (APA Ibiapaba), Tianguá - CE, Atlantic Rainforest Relicts "Brejo de Altitude", 3°46'0"S, 40°54'0"W (Fig. 1). All geographic coordinates were taken using datum WGS84 and the standards of geographic coordinates were based on Braga-Neto et al. (2013), with some modifications. Taxonomy analysis was based on Ponce de León (1968), Sunhede (1989), Calonge (1998), Bates (2004), Silva et al. (2013) Cabral et al. (2014b) and Sousa et al. (2014). Color descriptions were based on Kornerup & Wanscher (1978). Scanning electron microscopy (SEM) studies were performed following Silva et al. (2011). All specimens were deposited in the Herbarium of the Universidade Federal do Rio Grande do Norte (UFRN), Brazil, and all specimens data are available in the internet. The herbarium acronym followed Thiers (2014).

RESULTS

Key to the Geastraceae species from Ceará, Paraíba and Rio Grande do Norte states

1. Endoperidial body supported by multiple pedicels; endoperidium opening by several stomata; basidiospores reticulate ..... *Myriostoma coliforme*

1. Endoperidial body sessile or supported by a single pedicel; endoperidium opening by a single apical stomata; basidiospores verrucose 2

2 (1). Unexpanded basidiomata hypogeous; exoperidium encrusted with debris 3

2. Unexpanded basidiomata epigeous; exoperidium not encrusted with debris 11
3 (2). Plicate peristome 4
3. Non plicate peristome 7
4(3). Endoperidium with crystalline matter (pruinose); delimited peristome; long pedicel (up to 13 mm high); plicate apophysis ..... *Geastrum pectinatum*
4. Endoperidium without crystalline matter; non-delimited peristome; short pedicel (up to 2 mm high); not plicate apophysis 5
5 (4). Rays involute; exoperidium sub-hygroscopic; endoperidium surface furfuraceous; xerophytic habitat ..... *Geastrum xerophilum*
5. Rays arched or revolute; exoperidium non- hygroscopic; endoperidium surface setose or asperulate; non- xerophytic habitat 6
6 (5). Endoperidium surface setose, covered by cymbiform setae; basidiospores up to 4 µm diam ..... *Geastrum setiferum*
6. Endoperidium surface asperulate, not covered cymbiform setae; basidiospores up to 5,5 µm diam ..... *Geastrum lloydianum*
7 (3). Delimited peristome; endoperidial body distinct pedicellate; endoperidium with crystalline matter (pruinose) 8
7. Non-delimited peristome; endoperidial body sessile or sub sessile; endoperidium without crystalline matter 9
8 (7). Basidiospores subglobose to oval, up to 3 µm diam. ..... *Geastrum ovalisporum*
8. Basidiospores globose to subglobose, up to 6 µm diam. ..... *Geastrum minimum*
9 (7). Endoperidium dark brown, covered by vermiform hyphae pseudoparenchymatous layer rimose ..... *Geastrum entomophilum*
9. Endoperidium brownish grey to brownish beige, not covered by vermiform hyphae; pseudoparenchymatous layer not rimose 10
10 (9). Endoperidium surface covered by protruding hyphae; pedicel short when present; basidiospores up to 4 µm diam., with columnar warts ..... *Geastrum fimbriatum*
10. Endoperidium surface glabrous; pedicel never present; basidiospores up to 5,1 µm diam., with short warts ..... *Geastrum rusticum*
11(2). Plicate, non-delimited peristome; exoperidium and endoperidium pinkish to lilac; basidiospores up to 3,2 µm diam. ..... *Geastrum violaceum*
11. Fibrillose, delimited peristome; exoperidium and endoperidium brownish to beige; basidiospores greater than 3,2 µm diam. 12
12 (11). Subiculum present; exoperidium surface tomentosus or velutinous 13
12. Subiculum absent; exoperidium surface glabrous or scaly 14
13 (12). Basidiomata up to 20 mm wide; exoperidium surface velutinous; mycelial layer ephemerous with age, coriaceous, forming a cup under the basidioma; endoperidium dark brown ..... *Geastrum javanicum*
13. Basidiomata greater than 20 mm wide; exoperidium surface tomentous; mycelial layer persistent with age, papery, not forming a cup under the basidiome; endoperidium light brown ..... *Geastrum schweinitzii*
14 (12). Presence of distinct pseudoparenchymatous collar-like structure around the endoperidium; exoperidium scaly; large basidiomata, up to 150 mm wide ..... *Geastrum triplex*
14. Absence of distinct pseudoparenchymatous collar-like structure around the endoperidium; small to medium basidiomata, less than 150 mm wide 15
15 (14). Mycelial layer with distinct longitudinal cracks; rays with slender tips, arachnoid-like rays ..... *Geastrum lageniforme*
15. Mycelial layer without distinct longitudinal cracks; rays triangular, non- arachnoid-like rays ..... *Geastrum saccatum*

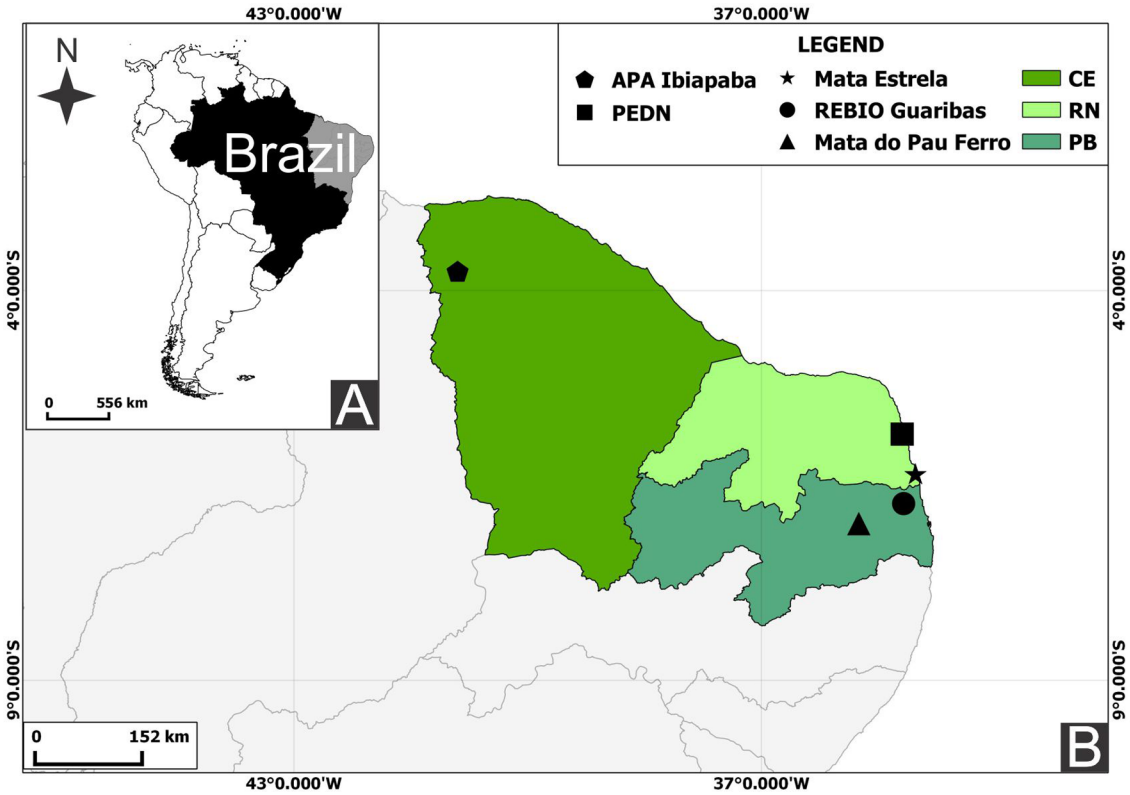

Fig. 1. A, map of South America. **B,** collection sites in Northeastern Brazil. Brazillian states: Ceará (CE), Rio Grande do Norte (RN) and Paraíba (PB). Figura en color en la versión en línea http://www.ojs.darwin.edu.ar/index.php/darwiniana/article/view/595/617.

Geastrum fimbriatum Fr., Syst. mycol. (Lundae) 3(1): 16. 1829. TYPE: Sweden, Gotland, 4-VI-1970, among needles in *Pinus sylvestris* wood on calcareous sand, *S. Sunhede s.n.* (neotype GB 7592! designated by Sunhede, Synopsis Fungorum 1: 180. 1989). Figs. 2A-B.

Reference. Sunhede (1989: 180) and Leite et al. (2007a: 106) for species description.

Distribution and habitat. Cosmopolitan (Ponce de Léon, 1968). The specimens were collected on sandy soil covered by leaf-litter, with gregarious growth. According to Agerer & Beenken (1998), *Geastrum fimbriatum* exhibits thin mantle and Hartig net when associated with *Fagus sylvatica* L, suggesting an ectomycorrhizal association. *Geastrum fimbriatum* was previously recorded in Brazil for the states of Bahia (Trierveiler-Pereira et al., 2009), Pará (Leite et al., 2011; Trierveiler-Pereira et al., 2011); Paraíba (Trierveiler-Pereira et al., 2011), Pernambuco (Leite et al., 2007a; Trierveiler-Pereira et al., 2011), Rio de Janeiro (Berkeley & Cooke, 1876), and Rio Grande do Sul (Rick, 1961). This is the first time that *G. fimbriatum* is reported for Rio Grande do Norte state.

Observations. The main characteristics of *Geastrum fimbriatum* are mycelial layer encrusted with debris, sub sessile endoperidium with hyphal protrusions and non- delimited fibrilous peristome. *Geastrum elegans* Vittad. is similar to *G. fimbriatum*, but differs in its delimited and plicate peristome (Leite et al., 2007a). Some basidiomata of *G. fimbriatum* display a pseudoparenchymatous collar-like structure around the endoperidium as in *G. triplex*, but the latter is distinguished by the delimited fibrilous peristome and larger basidiomata

(up to 150 mm wide) (Sunhede, 1989). According to Bates (2004) and Soto & Wright (2000), *G. fimbriatum* also resembles *G. rufescens* Pers., but the latter is distinguished by the distinct pedicellate endoperidium and larger basidiospores, up to 6 µm diam. (Sunhede, 1989).

Specimens examined

BRAZIL. **Rio Grande do Norte**. Baía Formosa, RPPN Mata Estrela, 6°22'47,35"S, 35°0'44.9"W, 55 m s. m., 14-VII-2011, *Silva & Sousa 1780* (UFRN-Fungos).

Geastrum javanicum Lév., Annls Sci. Nat., Bot., sér. 3, 5: 161. 1846. TYPE: Indonesia, Java, III-1846, on wood, *H. Zollinger 2053* (holotype PC). Figs. 2C-D.

Reference. Leite et al. (2011: 386) for species description.

Distribution and habitat. Pantropical (Ponce de León, 1968). The specimens were collected on sandy or clayey soil covered by leaf-litter, or on deciduous wood, as reported by Hemmes & Desjardin (2011) and Leite et al. (2011). Our specimens exhibited gregarious to solitary growth. *Geastrum javanicum* was previously recorded in Brazil for the states of Minas Gerais (Trierveiler-Pereira et al., 2011), Pará (Leite et al., 2011), Paraíba (Trierveiler-Pereira et al., 2011), Pernambuco (Trierveiler-Pereira et al., 2011), and Rio de Janeiro states (Trierveiler-Pereira et al., 2011). This is the first record for Ceará and Rio Grande do Norte states.

Observations. *Geastrum javanicum* is characterized primarily by the velutinous, ephemeral mycelial layer, forming a cup under the saccate basidioma, fibrillose delimited peristome and subiculum. *Geastrum schweinitzii* (Berk. & M.A. Curtis) Zeller is similar to *G. javanicum*, but *G. schweinitzii* has smaller basidiomata (up to 20 mm wide), persistent mycelial layer and basidiospores with prominent warts (Baseia et al., 2003; Cortez et al., 2008). *Geastrum argentinum* Speg. is also a closely related species, differentiated by non-delimited peristome and basidiospores with prominent cylindrical warts (Zamora et al., 2013b).

Specimens examined

BRAZIL. **Ceará**. Tianguá, APA Ibiapaba, Trilha do Riacho, 03º43'1"S, 41º5'0"W, 423 m s. m., 18-IV-2012, *Alfredo 1851* (UFRN-fungos). **Paraíba.** Areia, Parque Estadual Mata do Pau Ferro, Trilha Boa Vista, 6°57'55"S, 35°44'52"W, 631 m s. m., 17-VII-2012, *Alfredo 1863* (UFRN-Fungos); 6°58'1"S, 35°44'55"W, 598 m s. m., 16-VII-2013, *Sousa & Alfredo 2134* (UFRN Fungos); Mamaguape, REBIO Guaribas, SEMA II, , 6°44'20"S, 35°8'17"W, 180 m s. m., 11-VII-2013, *Sousa et al. 2133* (UFRN Fungos). **Rio Grande do Norte**. Baía Formosa, RPPN Mata Estrela, 6°23'7"S, 35°0'49"W, 54 m. s. m., 12-VII-2010, *Silva et al. 1782* (UFRN Fungos).

Geastrum lageniforme Vittad., Monograph Lyc.: 16. 1842. TYPE: Italy, Rome, IX-1845, Bequeathed s.n. (neotype K 1886! designated by Sunhede, Synopsis Fungorum 1:180. 1989). Figs. 2E-F.

Reference. Sunhede (1989: 242) and Leite et al. (2011: 387) for species description.

Distribution and habitat. Africa (Dissing & Lange, 1962; Dring, 1964), America (Calonge et al., 2005; Bates, 2004; Trierveiler-Pereira et al., 2011; Cortez et al., 2008; Rick, 1961), Europe (Calonge, 1998; Sunhede, 1989). The specimens were collected on sandy or clayey soil covered by leaf-litter, as reported by Calonge et al. (2005). Our specimens exhibited gregarious growth. *Geastrum lageniforme* is previously recorded in Brazil for the states of Amazonas (Cabral et al., 2014a), Bahia (Trierveiler-Pereira et al., 2009), Pará (Leite et al., 2011), Pernambuco (Trierveiler-Pereira et al., 2011), Rio de Janeiro (Hennings, 1904), and Rio Grande do Sul (Rick, 1961; Cortez et al., 2008). This is the first report for Ceará, Paraíba and Rio Grande do Norte states.

Observations. *Geastrum lageniforme* is mainly characterized by a mycelial layer with distinct longitudinal cracks, rays with slender tips (arachnoid-like rays), saccate basidiomata and distinctly delimited fibrillose peristome. *Geastrum morganii* Lloyd resembles *G. lageniforme*, clearly differing in its plicate, non delimited and conical peristome

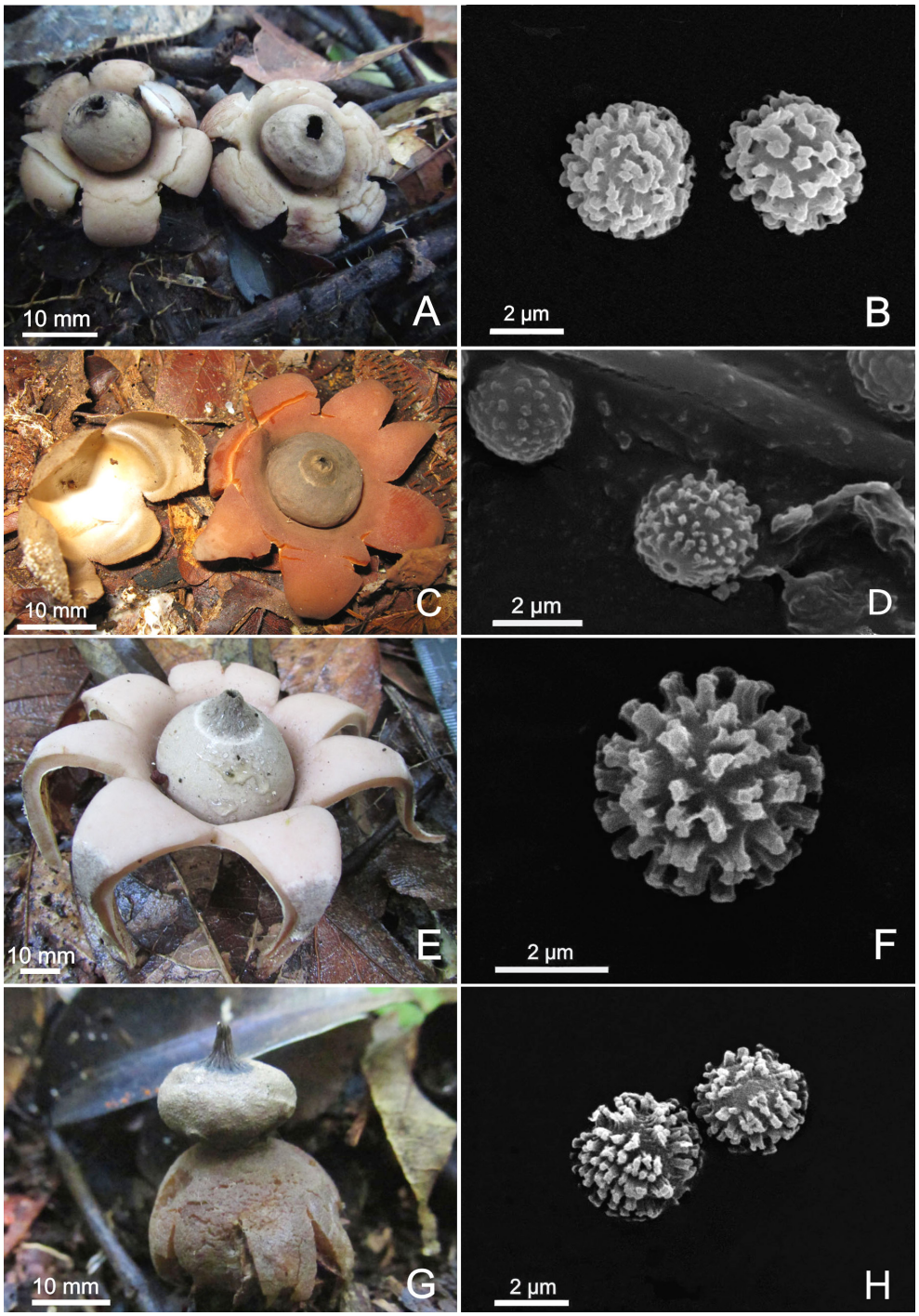

Fig. 2. *Geastrum fimbriatum.* **A,** basiomata. **B,** basidiospores under SEM. *Geastrum javanicum***. C,** basidioma. **D,** basidiospores under SEM. *Geastrum lageniforme*. **E,** basidioma. **F,** basidiospore under SEM. *Geastrum lloydianum*. **G,** basidioma. **H,** basidiospore under SEM. A-B, *Silva & Sousa 1780* (UFRN-Fungos); C-D, *Silva et al. 1782* (UFRN Fungos); E-F, *Sousa et al. 2139* (UFRN Fungos); G-H, *Silva et al. 1787* (UFRN Fungos). Figura en color en la versión en línea http://www.ojs.darwin.edu.ar/index.php/darwiniana/article/view/595/617.

(Sunhede, 1989). Historically, *Geastrum saccatum* Fr. and *Geastrum triplex* Jungh. have been confused with *G. lageniforme* (Zamora et al., 2013a). However, *G. saccatum* does not have a mycelial layer with distinct longitudinal cracks and arachnoid rays, while *G. triplex* has larger basidiomata (up to 150 mm wide), a distinct pseudoparenchymatous collar-like structure around the endoperidium, and triangular rays (Sunhede, 1989; Bates, 2004).

Specimens examined

BRAZIL. **Ceará**. Tianguá, APA Ibiapaba, Trilha do Riacho, 3º43'1"S, 41º5'0"W, 423 m s. m. 18-IV-2012, *Alfredo 1846* (UFRN-fungos); Trilha Pindoguaba, 3º39'8"S, 40º57'6"W, 761 m s. m., 18-IV-2012, *Alfredo 1847* (UFRN-fungos); 3º39'8"S, 40º57'6" W, 761 m s. m., 19-IV-2012, *Alfredo 1848* (UFRN-fungos). **Paraíba**. Areia, Parque Estadual Mata do Pau Ferro, Trilha do Cumbe, 6°58'14,15"S, 35°44'51"W, 572 m s. m., 15-VII-2013, *Sousa & Alfredo 2135* (UFRN Fungos); 6º57'54"S, 35º45'03"W, 636 m s. m., 16-VII-2013, *Sousa & Alfredo 2136* (UFRN Fungos); Trilha Boa Vista, 6°57'56"S, 35°44'58"W, 628 m s. m., 16-VII-2013, *Sousa & Alfredo 2137* (UFRN Fungos); Mamanguape, REBIO Guaribas, SEMA I, 6°48'17"S, 35°5'10"W, 70 m s. m., 1-VII-2013, *Sousa et al. 2138* (UFRN Fungos); SEMA II, 6°44'16"S, 35°8'24"W, 163 m s. m. 11-VII-2013, *Sousa et al. 2139* (UFRN Fungos). **Rio Grande do Norte**. Baía Formosa, RPPN Mata Estrela, 6°23'6"S, 35°0'54"W, 57 m s. m., 14-VII-2010, *Sousa et al.1784* (UFRN Fungos-1784); 6°23'3"S, 35°0'53"W, 55 m s. m., 14-VII-2012, *Sousa et al. 1785* (UFRN Fungos).

Geastrum lloydianum Rick, Brotéria, sér. bot. 5: 27. 1906. TYPE: Brazil, sine data, *J. Rick s.n.* (lectotype BPI 841471! designated by Trierveiler-Pereira & Silveira, Phytotaxa 61: 38. 2012). Figs. 2 G-H.

Reference. Ponce de León (1968: 326) for species description.

Distribution and habitat. Tropical America, Australia, and Spain (Ponce de Léon, 1968). The specimens were found on sandy or clayey soil covered by leaf-litter, as reported by Calonge et al. (2005). The basidiomata exhibited gregarious growth. *Geastrum lloydianum* was previously recorded in Brazil for the states of Amazonas (Cabral et al., 2014a), Ceará (Trierveiler-Pereira et al., 2011) and Pernambuco (Trierveiler-Pereira et al., 2011). This is the first record for Paraíba and Rio Grande do Norte states.

Observations. This species is mainly characterized by arched basidiomata, dark brown and asperulate endoperidium, regularly plicate and strongly conic peristome. It differs from *Geastrum setiferum* Baseia in its setose endoperidium, irregularly plicate peristome, and smaller basidiospores, up to 3 µm diam. (Baseia & Milanez, 2002). *Geastrum coronatum* Pers. is also similar to *G. lloydianum*, but differs in its fibrillose peristome, larger pedicel (up to 4 mm high), and basidiospores with prominent truncate warts (Sunhede, 1989; Pegler et al., 1995; Soto & Wright, 2000). Another closely related species is *Geastrum pouzarii* Stanek, differing in its verrucose endoperidium and larger basidiospores in the range of 5,5-7 µm diam. (Sunhede, 1989).

Specimens examined

BRAZIL. **Paraíba**. Parque Estadual Mata do Pau Ferro, Trilha Engenho Triunfo, 6º59'04"S, 35º44'42", 586 m s. m., 17-VII-2013, *Sousa & Alfredo 2140* (UFRN Fungos); 6º58'51"S, 35º44'43", 600 m s. m., 18-VII-2013, *Sousa & Alfredo 2141* (UFRN Fungos); Mamaguape, REBIO Guaribas, SEMA II, 6°44'12"S, 35°8'25"W, 150 m s. m., 1-VII-2013, *Silva et al. 2142* (UFRN Fungos). **Rio Grande do Norte**. Baía Formosa, RPPN Mata Estrela, 6°23'19"S, 35°0'53"W, 66 m s. m., 14-VII-2010, *Silva et al. 1787* (UFRN Fungos); 6°22'53"S, 35°0'48"W, 56 m s. m., 14-VII-2012, *Sousa et al. 1789* (UFRN-Fungos); Natal, PEDN, Trilha Peroba, 5°48'40"S, 35°11'25"W, 77 m s. m., 27-VIII-2012, *Sousa et al. 1790.* (UFRN Fungos).

Geastrum minimum Schwein., Schr. naturf. Ges. Leipzig 1: 58. 1822. TYPE: at bare land on grass, sine data, *L. D. von Schweinitz s.n.*, *H.W. Ravenel's herbarium.- Recd. 1891* (holotype K). Figs. 3A-B.

Reference. Sunhede (1989: 256) and Bates (2004: 115) for species description.

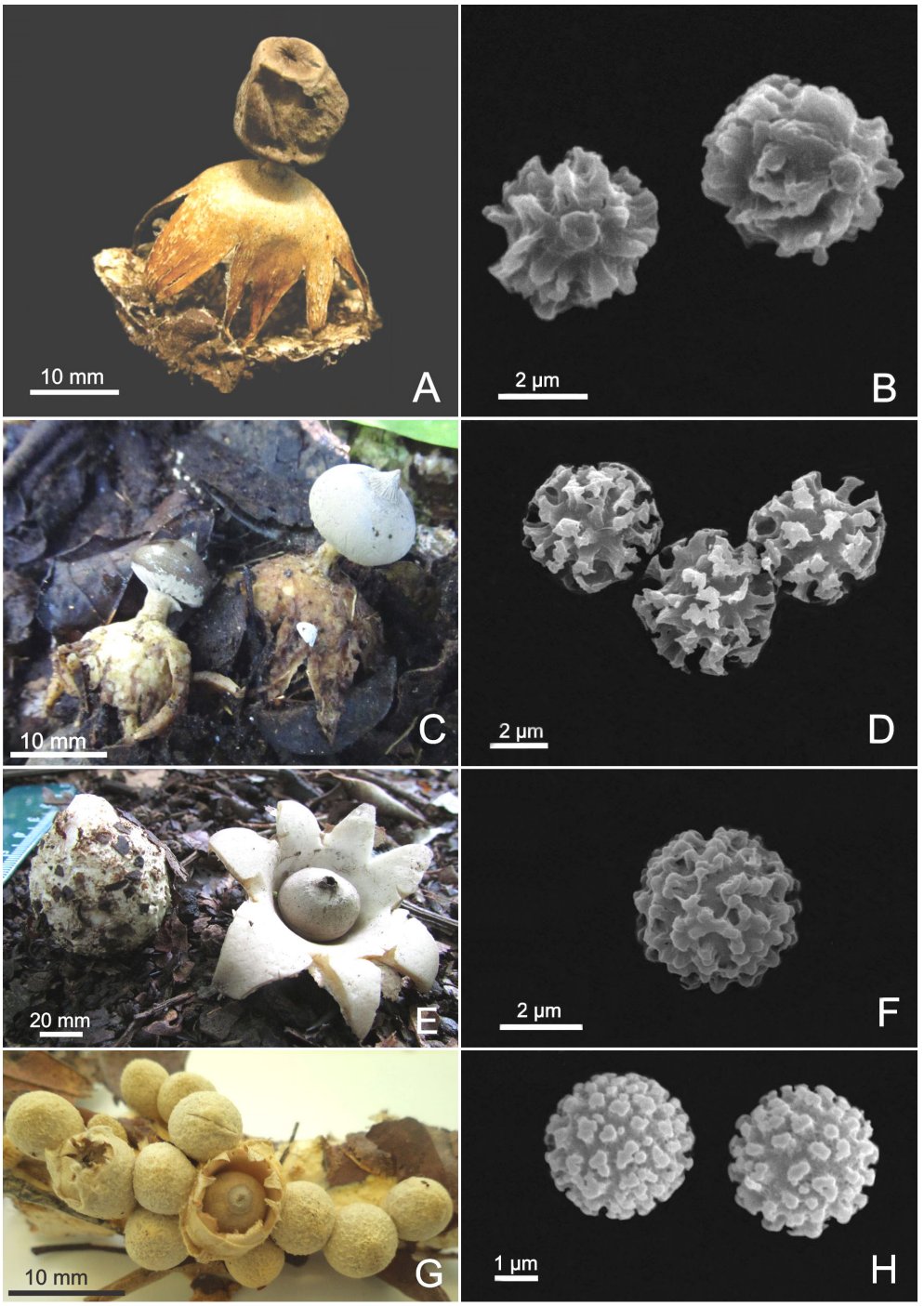

Fig. 3. *Geastrum minimum.* **A,** basidioma. **B,** basidiospores under SEM. *Geastrum pectinatum.* **C,** basidiomata. **D,** basidiospores under SEM. *Geastrum rusticum*. **E,** basidiomata. **F,** basidiospore under SEM. *Geastrum schweinitzii*. **G,** basidiomata. **H,** basidiospores under SEM. A-B, *Silva et al. 1791* (UFRN-Fungos); C-D, *Silva & Sousa 1796* (UFRN-Fungos); E-F, *Sousa & Alfredo 2146* (UFRN-Fungos); G-H, *Sousa et al. 10803* (UFRN-Fungos). Figura en color en la versión en línea http://www.ojs.darwin.edu.ar/index.php/darwiniana/article/view/595/617.

Distribution and habitat. Cosmopolitan (Ponce de León, 1968. Our specimens were collected on deciduous wood or termite nests. It exhibits gregarious growth, as reported by Grgurinovic (1997). According to Hemmes & Desjardin (2011), *Geastrum minimum* can be found in duff, exhibiting scattered growth. *Geastrum minimum* was previously recorded in Brazil for the states of Paraná (de Meijer, 2006) and Rio Grande do Sul (Rick, 1961). This is the first record for Northeastern Brazil.

Observations. *Geastrum minimum* differs from other congeneric species in its arched basidiomata, strongly encrusted mycelial layer, pedicellate and densely pruinose endoperidium, and fibrillose and distinctly delimited peristome. *Geastrum quadrifidum* DC. ex. Pers is similar to this species, differing in its fornicate basidiomata, fewer rays (up to 6), and non-pruinose endoperidium (Pegler et al., 1995; Calonge, 1998; Soto & Wright, 2000). *Geastrum coronatum* also has pruinose endoperidium; however, it exhibits larger basidiomata (up to 110 mm wide), darker endoperidium, and basidiospores with different ornamentation (Sunhede, 1989; Pegler et al., 1995). Some basidiomata of *G. minimum* analyzed in this study developed a cup under the mycelial layer, as reported by Sunhede (1989).

Specimens examined

BRAZIL. **Rio Grande do Norte**. Baía Formosa, 6°22'56"S, 35°0'48"W, 53 m s. m., RPPN Mata Estrela, 16-VI-2010, *Silva et al. 1791* (UFRN-Fungos); Natal, PEDN, Trilha da Geologia, 5°50'30"S, 35°11'36"W, 68 m s. m., 12-VIII-2012, *Sousa et al. 1792* (UFRN-Fungos).

Geastrum pectinatum Pers., Syn. meth. fung. (Göttingen) 1: 132. 1801.TYPE: sine data, *H.B Persoon s.n.* (neotype L 910.262-391! designated by Palmer, Persoonia 1: 149. 1959). Fig. 3 C-D.

Reference. Sunhede (1989: 294) and Baseia et al. (2003: 410) for species description.

Distribution and habitat. Cosmopolitan (Ponce de León, 1968). The specimens were collected on sandy or clayey soil covered by leaf-litter, as reported by Baseia et al. (2003), Calonge et al. (2005), and Grgurinovic (1997). Our specimens exhibited gregarious growth. *Geastrum pectinatum* was previously recorded in Brazil for the states of Paraíba (Baseia et al., 2003), Paraná (de Meijer, 2006), Pernambuco (Baseia et al., 2003), Rio Grande do Sul (Rick, 1961; Cortez et al., 2008), and São Paulo (Baseia et al., 2003). This is the first record for the Northeastern Atlantic Rainforest and "Brejo de Altitude" vegetation, and the first record for Paraíba, Ceará and Rio Grande do Norte states.

Observations. The main characteristics are pruinose endoperidium with plicate apophysis, regularly plicate and strongly conic peristome, and long pedicel (up to 13 mm high). *Geastrum schmidelii* Vittad. exhibits a morphology similar to the *G. pectinatum*, but has a shorter pedicel (up to 3 mm high), smaller basidiomata (up to 51 mm wide), and basidiospores with different ornamentation (Sunhede, 1989). *Geastrum striatum* DC. also resembles *G. pectinatum*, but displays a non-plicate apophysis with pseudoparenchymatous collar-like structure and smaller basidiomata, up to 65 mm wide (Sunhede, 1989; Pegler et al., 1995; Bates, 2004).

Specimens examined

BRAZIL. **Ceará**. Tianguá, APA Ibiapaba, Trilha do Riacho, 3º43'16" S, 41º05'06" W, 680 m s. m., 18-IV-2012, *Alfredo 1850* (UFRN-Fungos). **Paraíba**. Areia, Parque Estadual Mata do Pau Ferro, Trilha do Cumbe, 6°57'55"S, 35°44'58"W, 627 m s. m., 15-VII- 2013, *Sousa & Lima 2143*(UFRN- Fungos); Trilha Engenho Triunfo, 6º59'5"S, 35º44'39"W, 584 m s. m., 18-VII- 2013, *Sousa & Alfredo 2144* (UFRN-Fungos). **Rio Grande do Norte.** Baía Formosa, RPPN Mata Estrela, 6°23'8"S, 35°0'53"W, 54 m s. m., 14-VII- 2011, *Silva & Sousa 1796* (UFRN-Fungos); 6°22'56"S, 35°0'56"W, 61 m s. m., 14-VII-2012, *Sousa et al. 1799* (UFRN-Fungos); Natal, PEDN, Trilha Peroba, 5°48'42.84"S, 35°11'27.43"W, 65 m s. m., 1-VIII-2012,. *Sousa et al. 1798* (UFRN Fungos).

Geastrum rusticum Baseia, B. D. B. Silva & T. S. Cabral, Nova Hediwigia 98 (1-2): 267. 2014. TYPE: Brasil, Rio Grande do Norte, 9-VI-2009, on decaying wood, *I. G. Baseia 1217* (holotype UFRN Fungos). Fig. 3 E-F.

Reference. Cabral et al. (2014b: 267) for species description.

Distribution and habitat. Brazil (Cabral et al., 2014b). To date the distribution of *Geastrum rusticum* is restricted to the Atlantic Rainforest in Rio Grande do Norte state. The unexpanded basidiomata were found partially covered by substrate with adnate growth. Expanded basidiomata were collected on clayey soil covered by leaf-litter, exhibiting gregarious growth. This is the first record for the semiarid region of Brazil, as well as for Ceará and Paraíba states.

Observations. This species is characterized by unexpanded semi-hypogeous basidiomata, mycelial layer entrusted with debris, fibrillose non-delimited peristome and basidiospores with small warts. It is very similar to *G. fimbriatum*, but the latter exhibits endoperidium with pedicel and hyphal protrusions and basidiospores with larger warts (Sunhede, 1989; Cabral et al., 2014b).

Specimens examined

BRAZIL. **Ceará.** Tianguá, APA Ibiapaba, Trilha Pindoguaba, 3º39'80"S, 40º57'62"W, 161 m s. m., 18-IV-2012, *Alfredo 1852* (UFRN-Fungos). **Paraíba**. Areia, Parque Estadual Mata do Pau Ferro, Trilha do Cumbe, 6º59'19"S, 35º44'49"W, 589 m s. m., 15-VIII-2013, *Sousa & Alfredo 2145* (UFRN-Fungos); Trilha Boa Vista, 6°57'52"S, 35°44'57"W, 629 m s. m., 16-VII-2013, *Sousa & Alfredo 2146* (UFRN-Fungos); Trilha Engenho Triunfo, 6º59'09"S, 35º44'39"W, 592 m s. m., 17-VII-2013, *Sousa & Alfredo 2147* (UFRN-Fungos).

Geastrum schweinitzii (Berk. & M. A. Curtis) Zeller, Mycologia 40(6): 649. 1948. *Coilomyces schweinitzii* Berk. & M. A. Curtis, J. Acad. nat. Sci. Philad., N.S. 2(6): 279. 1854. TYPE: Surinam, 1853, on decaying wood, *M. M. S Schweinitz 34953* (holotype NY). Fig. 3G-H.

Reference. Baseia et al. (2003: 412) for species description.

Distribution and habitat. Pantropical, North America and Japan (Ponce de Léon, 1968). The specimens were found on decaying wood, as reported by Baseia et al. (2003), Leite & Baseia (2007), and Cortez et al. (2008). However, Ponce de León (1968) and Calonge et al. (2005) reported specimens on leaf-litter. Our specimens exhibited gregarious to caespitose growth. *Geastrum schweinitzii* was previously distributed in Brazil for the states of Amazonas (Cabral et al., 2014a), Paraíba (Trierveiler-Pereira et al., 2011), Pernambuco (Drechsler-Santos et al., 2008; Kimbrough et al., 1994/1995; Trierveiler-Pereira et al., 2011), Bahia (Trierveiler-Pereira et al., 2009; Trierveiler-Pereira et al., 2011), and São Paulo (Bononi et al., 1981; Baseia et al., 2003). This is the first record for Rio Grande do Norte state.

Observations. This species is recognized by its lignicolous habit, presence of prominent yellowish white subiculum, caespitose growth, small saccate basidiomata (up to 20 mm wide), and its fibrillose, distinct, and delimited peristome. *Geastrum hirsutum* Baseia & Calonge and *G. javanicum* also have lignicolous habit and subiculum, but the former differs from *G. schweinitzii* in its ephemerous and velutinous mycelial layer, and darker endoperidium, while the latter differs in its hairy exoperidium and smaller basidiospores, up to 3 µm diam. (Calonge et al., 2005; Baseia & Calonge, 2006). *Geastrum pleosporus* Douanla-Meli is also similar to *G. schweinitzii,* but is recognized by basidiospores with varied shape and reddish basidiomata (Douanla-Meli et al., 2005).

Specimens examined

BRAZIL. **Paraíba**. Areia, Parque Estadual Mata do Pau Ferro, Trilha do Cumbe, 6°58'2"S, 35°44'55"W, 584 m s. m., 17-VII-2012, *Alfredo 1857* (UFRN-Fungos); Trilha da Boa Vista, 6°57'58"S, 35°44'57"W, 609 m s. m., 18-VII-2012, *Alfredo 1858* (UFRN-Fungos); Trilha do Cumbe, 6°57'51"S, 35°44'58"W, 629 m s. m., 15-VII-2013, *Sousa & Alfredo 2148* (UFRN-Fungos); Trilha Engenho Triunfo, 6º58'23"S, 35º44'24"W, 611 m s. m., 18-VII-2013, *Sousa & Alfredo 2149* (UFRN-Fungos). **Rio Grande do Norte.** Natal, PEDN, Trilha Peroba, 5°48'43"S, 35°11'21"W, 80 m s. m., 1-VIII-2012, *Sousa et al. 1803* (UFRN-Fungos).

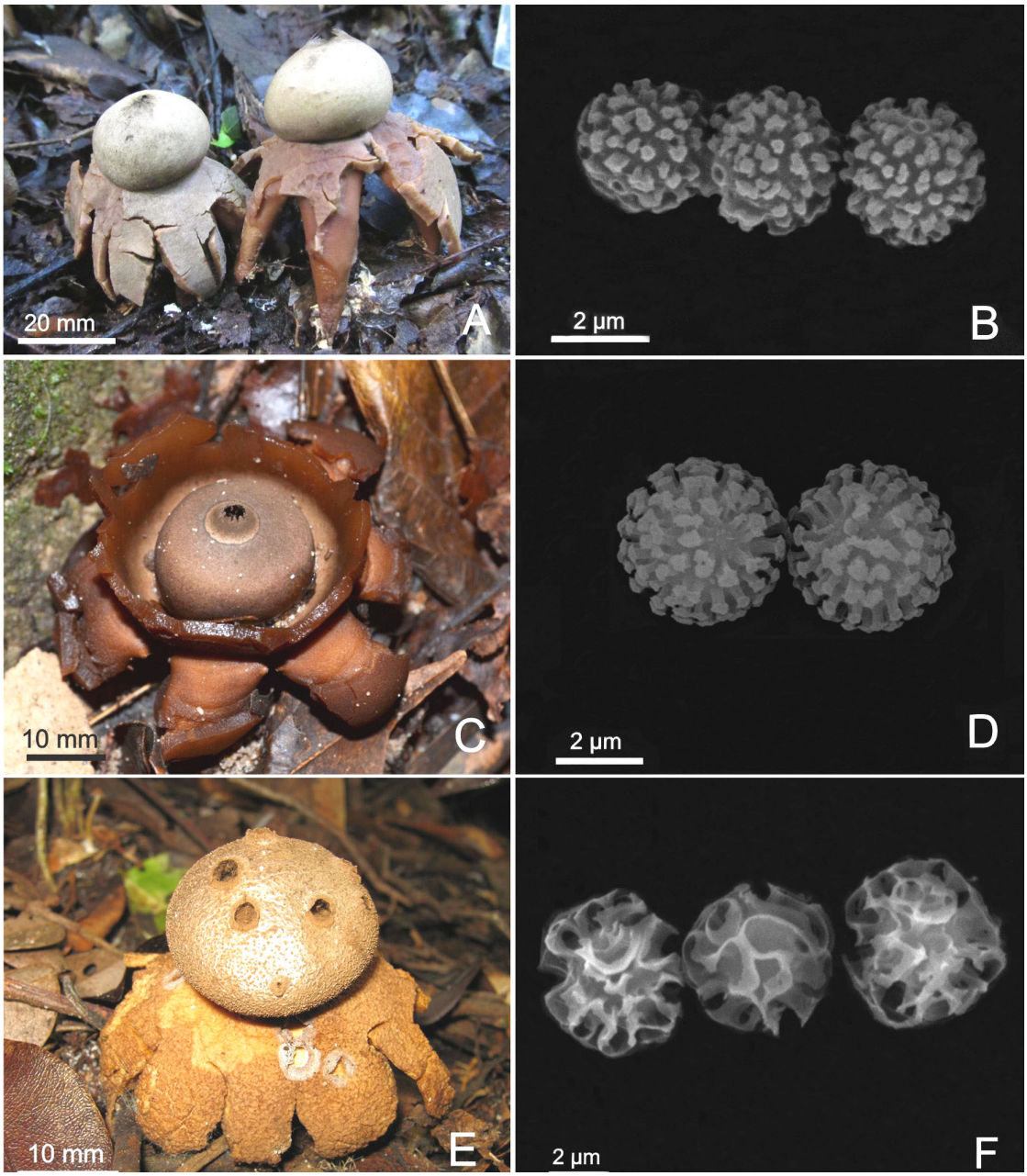

Fig. 4. *Geastrum setiferum*. **A,** basidomata. **B,** basidiospores under SEM. *Geastrum triplex*. **C,** basidioma. **D,** basidiospores under SEM. *Myriostoma coliforme*. **E,** basidoma. **F,** basidiospores under SEM. A-B, *Sousa & Silva 1805*. (UFRN-Fungos); C-D, *Alfredo 1845* (UFRN-Fungos); E-F, *Silva et al. 2020* (UFRN-Fungos). Figura en color en la versión en línea http://www.ojs.darwin.edu.ar/index.php/darwiniana/article/view/595/617.

Geastrum setiferum Baseia, Mycotaxon 84: 136. 2002. TYPE: Brazil, São Paulo, Ecological Station of Jataí, 17-I-2002, next to trees *Chloroleucon foliolosum* (Benth.) G. P. Lewis and *Jacaranda cuspidifolia* Mart., *I. G. Baseia 307595* (holotype SP). Fig. 4 A-B.

Reference. Baseia & Milanez (2002: 336) for species description.

Distribution and habitat. Brazil and Argentina (Castiglia et al., 2013). The specimens were collected on sandy or clayey soil covered by leaf-litter, exhibiting gregarious or solitary growth. *Geastrum setiferum* was previously recorded in Brazil for the states of Paraíba (Leite et al., 2007b; Trierveiler-Pereira & Baseia, 2011), Pernambuco (Baseia & Milanez, 2002), and São Paulo (Baseia & Milanez, 2002). This is the first record for "Brejo de Altitude" vegetation and Rio Grande do Norte state.

Observations. The main characteristics are endoperidium with cymbiform setae, fibrillose to plicate and non-delimited peristome, and small basidiospores, up to 3,7 µm diam., according to our analysis. *Geastrum fornicatum* (Huds.) Hook, *G. rufescens, G. hieronymi* Henn. and *G. welwitschii* Mont. also have endoperidium with hyphal protrusions, but these species do not have cymbiform setae and display larger basidiospores, up to 5 µm, 5,6 µm, 4,8 µm, and 5,5 µm, respectively (Sunhede, 1989; Bates, 2004).

Specimens examined

BRAZIL. **Paraíba**. Areia, Parque Estadual Mata do Pau Ferro, Trilha Engenho Triunfo, 6º59'44"S, 35º44'42"W, 586 m s. m., 17-VII-2013, *Sousa 2150* (UFRN-Fungos). **Rio Grande do Norte**. Baía Formosa, RPPN Mata Estrela, 6°23'2"S, 35°0'53"W, 54 m s. m., 14-VII-2010, *Silva et al. 1804* (UFRN-Fungos); 6°22'58"S, 35°0'59"W, 62 m s. m., 14-VII-2011, *Sousa & Silva 1805.* (UFRN-Fungos).

Geastrum triplex Jungh., Tijdschr. Nat. Gesch. Physiol. 7: 287. 1840. TYPE: Indonesia, Java, mountain Panggerangi, II, in shady wood at an altitude of 1000–1700 m s. m., *F. Junghuhn 4188* nº1 (holotype L). Figs. 4 C-D.

Reference. Sunhede (1989: 445) and Baseia et al. (2003: 414) for species description.

Distribution and habitat. Cosmopolitan (Dissing & Lange, 1962; Sunhede, 1989; Grgurinovic, 1997; Calonge, 1998; Bates, 2004; Leite & Baseia, 2007; Hemmes & Desjardin, 2011). The specimens were collected on clayey soil covered by leaf-litter, as reported by Leite & Baseia (2007), exhibiting gregarious to solitary growth. *Geastrum triplex* was previously recorded in Brazil for the states of Amazonas (Cabral et al., 2014a), Paraná (de Meijer, 2006), Pernambuco (Drechsler-Santos et al., 2008; Trierveiler-Pereira et al., 2011), Rio Grande do Norte (Leite & Baseia, 2007), Rio Grande do Sul (Rick, 1961), Santa Catarina (Sobestiansky, 2005), and São Paulo (Baseia et al., 2003). This is the first record for Ceará and Paraíba states.

Observations. This species is recognized by its distinct pseudoparenchymatous collar-like structure around the endoperidium, fibrillose delimited peristome, sessile endoperidium and large basidiomata, up to 150 mm wide. It is often mistaken for *G. saccatum* and *G. lageniforme*, but these species do not have a distinct pseudoparenchymatous collar-like structure around the endoperidium (Sunhede, 1989). Other species display pseudoparenchymatous collar-like structure around the endoperidium: *Geastrum morganii*, *Geastrum litchiforme* Desjardin & Hemmes and *G. fimbriatum*. Although, *G. morganii* differs in its plicate non-delimited peristome, *G. litchiforme* differs in its ornamented exoperidium and non-delimited peristome, while *G. fimbriatum* differs in its mycelial layer encrusted with debris and non-delimited peristome (Sunhede, 1989; Hemmes & Desjardin, 2011).

Specimens examined

BRASIL. **Ceará**. Tianguá, APA Serra de Ibiapaba, Trilha do Riacho, 3º39'80"S, 40º57'62"W, 161 m s. m., 18-IV-2012, *Alfredo 1844* (UFRN-Fungos); Trilha Pindoguaba, 3º39'80"S, 40º57'62"W, 161 m s. m., 19-IV-2012, *Alfredo 1845* (UFRN-Fungos). **Paraíba**. Areia, Parque Estadual Mata do Pau Ferro, Trilha Boa Vista, 6º57'52"S, 35º44'58"W, 630 m s. m., 16-VII-2013, *Sousa et al. 2151* (UFRN-Fungos).

Myriostoma coliforme (Dicks.) Corda, Anleit. Stud. Mykol., Prag: 131. 1842. *Lycoperdon coliforme* Dicks., Fasc. pl. crypt. brit. (London) 1: 24. 1785. *Geastrum coliforme* (Dicks.) Pers. [as 'Geaster coliforme'], Syn. meth. fung. (Göttingen) 1: 131. 1801. *Polystoma coliforme* (Dicks.) Gray, Nat. Arr. Brit. Pl. (London) 1: 586. 1821. TYPE: England, Norfolk, 1785, on sand, sine collector, *s.n.* (holotype missing) Figs. 4E-F.

Reference. Sunhede (1989: 468) and Leite & Baseia (2007: 182) for species description.

Distribution and habitat. Cosmopolitan (Ponce de Léon, 1968; Sunhede, 1989; Hemmes & Desjardin, 2011) Basidiomata were collected on sandy soil covered by leaf-litter, exhibiting gregarious growth next to *Ficus* sp. According to Baseia & Galvão (2002), specimens were found next to *Spondias tuberosa* Arruda, also displaying gregarious growth. *Myriostoma coliforme* was previously recorded in Brazil for the states of Paraíba (Baseia & Galvão, 2002), Pernambuco (Baseia & Galvão, 2002; Leite & Baseia, 2007), Rio Grande do Sul (Rick, 1961; Homrich, 1973), and São Paulo (Homrich, 1973). To date the occurrence of *Myriostoma* is restricted to semiarid areas of Northeastern Brazil, and this record is the first for the Atlantic Rainforest and Rio Grande do Norte state.

Observations. *Myriostyoma* is a monospecific genus characterized primarily by arched basidiomata, numerous stomata and multiple pedicels, differentiating it from *Geastrum* (Baseia & Galvão, 2002; Leite & Baseia, 2007).

Specimens examined

BRAZIL. **Rio Grande do Norte.** Baía Formosa, RPPN Mata Estrela, 6°22'1"S, 35°0'47"W, 57 m s. m., 15-VII-2012, *Silva et al. 2019* (UFRN-Fungos); 6°22'53"S, 35°0'45"W, 61 m s. m., 12-VI-2011, *Silva et al. 2020* (UFRN-Fungos).

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