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New records of *Cyathus* (Nidulariaceae, Basidiomycota) from conservation units in Northeastern Brazil

Novos registros de *Cyathus* (Nidulariaceae, Basidiomycota) em unidades de conservação no nordeste do Brasi

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Abstract

The genus *Cyathus* (Nidulariaceae) disperses its basidiospores passively through the force of raindrops on the peridioles. These fungi play essential ecological roles in nutrient cycling and plant organic matter decomposition. Despite their wide distribution in Brazil, information on the occurrence of the genus *Cyathus* is still limited. In this study, new records of *Cyathus* were identified for the Northeast region of Brazil. Seventeen samples collected between June and August 2022 in five Atlantic Forest conservation areas in Paraíba and Rio Grande do Norte were analyzed. Four species of *Cyathus* were identified: *C. earlei*, *C. limbatus, C. triplex*, and *C. poeppigii*. *Cyathus poeppigii* represents the first record for the state of Rio Grande do Norte, and *C. triplex* represents the first records for the states of Rio Grande do Norte and Paraíba.

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The new records identified in this study reveal the potential distribution of the genus in the region and highlight the need for further studies, especially in poorly explored areas such as semi-arid regions.

Keywords: Gasteroid fungi; Bird's nest fungi; Taxonomy; Biodiversity; Atlantic Forest.

Resumo

O gênero *Cyathus* (família Nidulariaceae) dispersa seus basidiosporos passivamente através da força das gotas de chuva sobre os peridíolos. Esses fungos desempenham papéis ecológicos essenciais na ciclagem de nutrientes e na decomposição da matéria orgânica vegetal. Apesar de sua ampla distribuição no Brasil, as informações sobre a ocorrência e distribuição de *Cyathus* ainda são limitadas. Neste estudo, foram identificados novos registros de *Cyathus* para a região Nordeste do Brasil. Foram analisadas 17 amostras coletadas em cinco unidades de conservação da Mata Atlântica nos estados da Paraíba e Rio Grande do Norte entre junho e agosto de 2022. Foram identificadas quatro espécies de *Cyathus*: *Cyathus earlei*, *C. limbatus*, *C. triplex* e *C. poeppigii*. O *Cyathus poeppigii* representa o primeiro registro para o estado do Rio Grande do Norte e o *C. triplex* representa os primeiros registros para os estados do Rio Grande do Norte e da Paraíba. Os novos registros identificados neste estudo revelam o potencial de distribuição do gênero na região e destacam a necessidade de mais estudos, principalmente em áreas pouco exploradas.

Palavras-chave: Fungos gasteroides; Fungos ninhos-de-passarinho; Taxonomia; Biodiversidade; Mata Atlântica.

INTRODUCTION

Gasteroid fungi exhibit significant morphological diversity and are defined by the internal development of basidiospores within angiocarpic basidiomata, needing external factors for basidiospore dispersal (Alexopoulos *et al.*, 1996; Miller & Miller, 1988; Calonge, 1998). Studies have shown that gasteroid fungi constitute an artificial and polyphyletic group, encompassing several lineages within Agaricomycetes Doweld (Hibbett *et al.*, 1997; Gube & Dörfelt, 2011; Hibbett *et al.*, 2014).

Cyathus Haller is characterized by the development of the basidiospores internally in small discoid structures fixed in the inner wall of the basidiomata, named peridioles (Brodie, 1975). The dispersion of peridioles occurs through a mechanism called "splash-cup", where the force of raindrops is used to launch the peridioles to adjacent areas and nearby forests, dispersing the basidiospores in the environment (Brodie, 1975; Money, 2014).

The genus occurs on diverse substrates, such as decaying wood, leaves, and dung, and is distributed across a wide range of habitats on all continents, except Antarctica (Brodie, 1975). *Cyathus* plays an important role in ecosystems by decomposing plant organic matter and contributing to nutrient cycling in the soil (Brodie, 1975; Miller & Miller, 1988; Shinners-Carnelley *et al.,* 2002; Keller *et al.,* 2003; Blenis & Chow, 2005).

Phylogenetic studies have indicated that *Cyathus* belongs to the family Nidulariaceae, along with *Nidula* V.S. White, *Nidularia* Fr., *Mycocalia* J.T. Palmer, *Crucibulum* Tul. & C. Tul., and *Retiperidiolia* Kraisit., Cheoyklin, Boonprat. & M.E. Sm. (Brodie, 1975; Kraisitudomsook *et al.,* 2021, 2022; Cruz *et al.,* 2023). Recently, a study conducted exclusively on type specimens of *Cyathus* confirmed the monophyly of the genus and proposed a new classification for the group based on morphological and phylogenetic characteristics (Cruz *et al.*, 2023).

Cyathus is the most representative and diverse genus of the family Nidulariaceae (He *et al.*, 2019). Over the past decades, research on this genus has increased significantly (Trierveiler-Pereira & Baseia, 2011; Cruz *et al.*, 2012; Barbosa *et al.*, 2014; Cruz & Baseia, 2014; Crous *et al.*, 2017a; Crous *et al.*, 2017b; Góis *et al.*, 2020; Nascimento *et al.*, 2022). Góis *et al.* (2021) listed the occurrence of 84 species for the genus, and later, 8 new taxa were published, totalizing 92 species from world, (Duan *et al.*, 2022; 2023a, 2023b; Góis *et al.*, 2024, 2025). In Brazil, 35 species were registered, of which 23 species occur in the Atlantic Rainforest (Góis *et al.*, 2021; Nascimento *et al.*, 2022).

Global biodiversity *hotspots* are regions with the highest levels of biological diversity and significant rate of endemism (Myers *et al.*, 2000; Cunha & Guedes, 2013). The Atlantic Rainforest is considered one of the world 's major biodiversity hotspots (Rezende *et al.*, 2018), with endemic species and endangered species. More than 3.000 species of fungi have been identified for the Atlantic Rainforest (Pinto *et al.*, 2006; Maia *et al.*, 2015), however, this biome is one of the most threatened biomes, due to the urbanization process that fragments the forest, causing biodiversity loss (Ferreira *et al.*, 2019; Safar *et al.*, 2020). The biome is composed of various phytophysiognomies, in addition to others formations such as Seasonal Semideciduous Forest; Seasonal Deciduous Forest; Mixed Rainforest (Araucaria Forest); Open Rainforest; Dense Rainforest; Altitude Fields and Wetlands characterized by humid forests (Câmara, 2003). This mosaic of ecosystems comprises closed forests, open fields, sandbanks, and mangroves (Silva & Castaleti, 2003). Despite all this importance, the current Atlantic Rainforest corresponds to only 24% of its original coverage (Fundação SOS MA & INPE, 2024).

The knowledge about fungal diversity, in the Neotropics, remains underestimated (Maia *et al.*, 2015). Several factors contribute to gaps in distribution data, including lack of taxonomists specialized in fungal groups (Maia *et al.*, 2015), difficulty in identifying *Cyathus* species due to the lack of standardization of descriptions, leading to misidentification (Góis *et al.*, 2021) and, habitat degradation, which threatens fungal diversity and the survival of other organisms (Singh *et al.*, 2018). In this context, further studies on fungi are necessary to support the expansion and conservation of protected areas (Antonelli *et al.*, 2020). Therefore, this study aims to contribute to the knowledge of *Cyathus* occurrence in the Northeast region of Brazil, and improve our understanding of the genus in the country.

MATERIALS AND METHODS

Ten samples were analyzed and has unknown collection dates due to poorly herborization: *Cyathus poeppigii* UFRN-Fungos 3709, *Cyathus triplex* UFRN-Fungos 3708, UFRN-Fungos 3697; *Cyathus limbatus* UFRN-Fungos 3698, UFRN-Fungos 3702, and *Cyathus earlei* UFRN-Fungos 3705, UFRN-Fungos 3704, UFRN-Fungos 3703, UFRN-Fungos 3696 and UFRN-Fungos 3711. The other 7 samples (*Cyathus triplex* UFRN-Fungos 3689 and UFRN-Fungos 3699, *Cyathus limbatus* UFRN-Fungos 3690, UFRN-Fungos 3695 and UFRN-Fungos 3693, and *Cyathus earlei* UFRN-Fungos 3694 and UFRN-Fungos 3706 were collected between June and July 2022 using the methodology proposed by Silva *et al.*, (2014) from five conservation areas of the Atlantic Forest biome in northeastern Brazil: Parque Estadual Dunas do Natal , Reserva do Patrimônio Natural Mata Estrela, Floresta Nacional Nísia Floresta, Trilha dos Saguis at the Universidade Federal do Rio Grande do Norte (UFRN), located in the state of Rio Grande do Norte, and Reserva Biológica Guaribas, located in Paraíba (Fig. 1).

The standard methodology for analyses and description of Nidulariaceae fungi was used (Lloyd, 1906; Brodie, 1975, 1984; Cruz, 2017). A Nikon SMZ1500 stereomicroscope with a Nikon Ds-Ril camera attached was used for the morphological description. The basidiomata shape was observed, and the height and width of the upper portion were measured using NIS-elements AR 4.13.00 software, along with the tomentum type and their size, as well as the hyphae at the mouth, emplacement diameter, and pedicel size. The spacing between the internal and external striae were measured and the peridioles were analyzed regarding their shape, surface type, length, width, and the number of cortical layers. For the colors, Methuen Handbook of Color (Kornerup & Wanscher, 1978) was used.

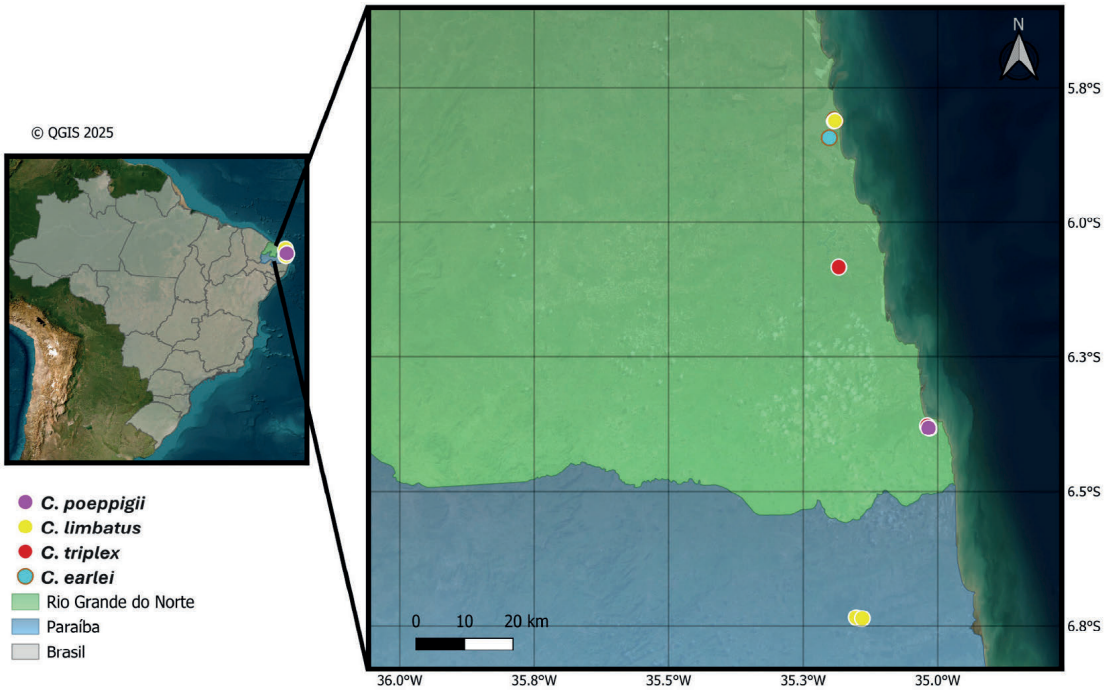

Fig. 1. Collection sites in the states of Rio Grande do Norte and Paraíba, northeastern Brazil. The numbers indicate the conservation unit where the samples were found.

Fig. 1. Locais de coletas nos estados do Rio Grande do Norte e Paraíba no nordeste do Brasil. Os números indicam as unidades de conservação onde as amostras foram coletadas.

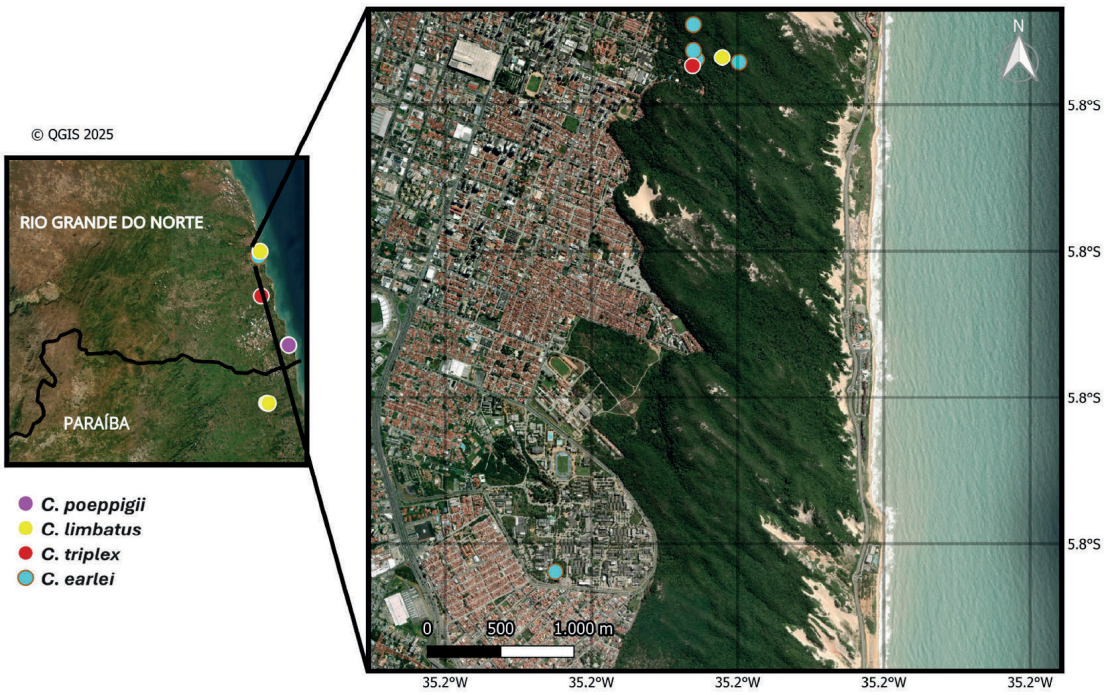

Fig. 2. Collection areas of the *Cyathus* species located in Natal, Rio Grande do Norte. The numbers indicate the conservation unit where the samples were found.

Fig. 2. Áreas de coleta das espécies de *Cyathus* localizadas em Natal, Rio Grande do Norte. Os números indicam a unidade de conservação onde as amostras foram encontradas.

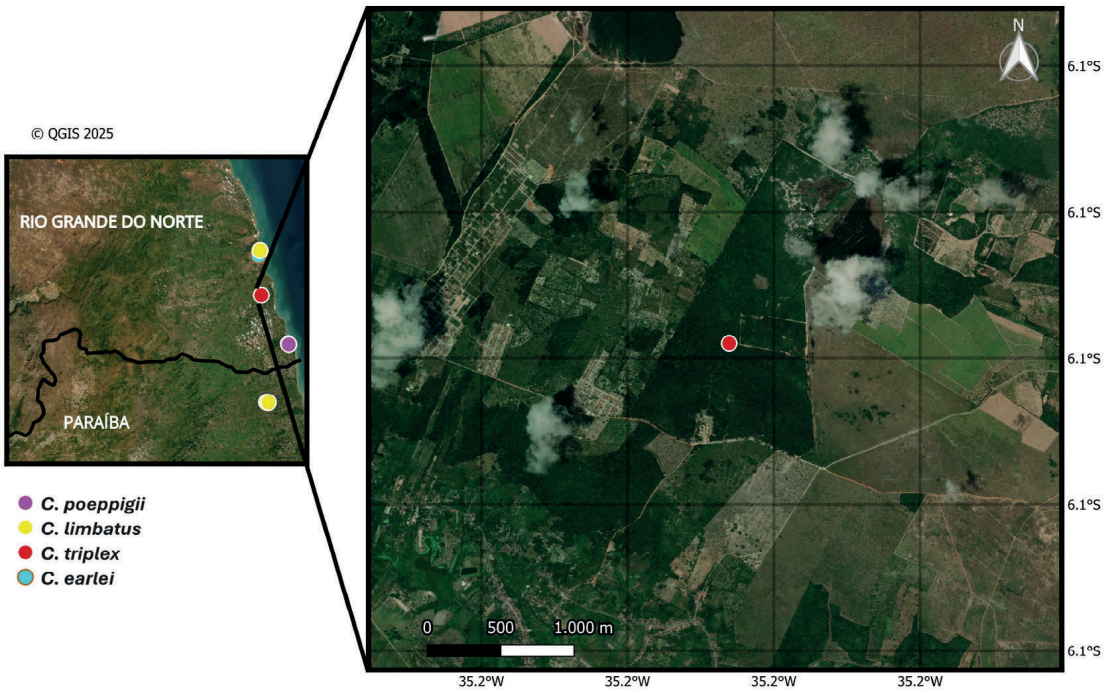

Fig. 3. Collection areas of the *Cyathus* species located in Nísia Floresta, Rio Grande do Norte. The specimens were collected at the Floresta Nacional Nísia Floresta.

Fig. 3. Áreas de coleta das espécies de *Cyathus* localizadas em Nísia Floresta, Rio Grande do Norte. Os espécimes foram coletados na Floresta Nacional Nísia Floresta.

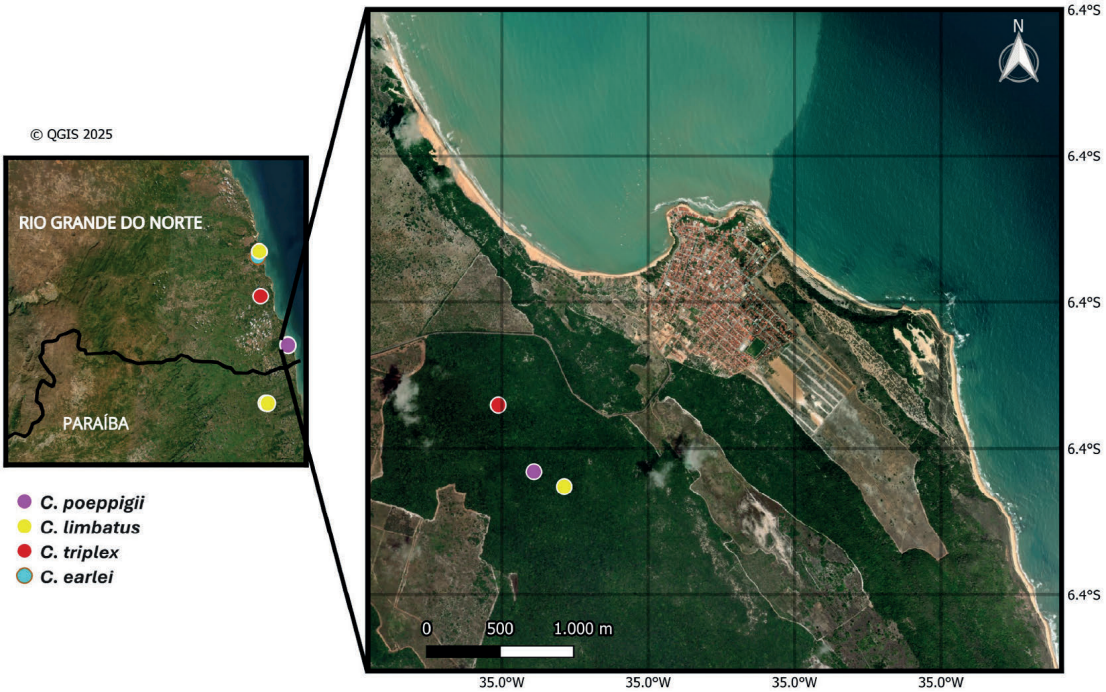

Fig. 4. Collection areas of the *Cyathus* species located in Baía Formosa, Rio Grande do Norte. The specimens were collected at the Reserva do Patrimônio Natural Mata Estrela.

Fig. 4. Áreas de coleta das espécies *Cyathus* localizadas em Baía Formosa, Rio Grande do Norte. Os espécimes foram coletados na Reserva do Patrimônio Natural Mata Estrela.

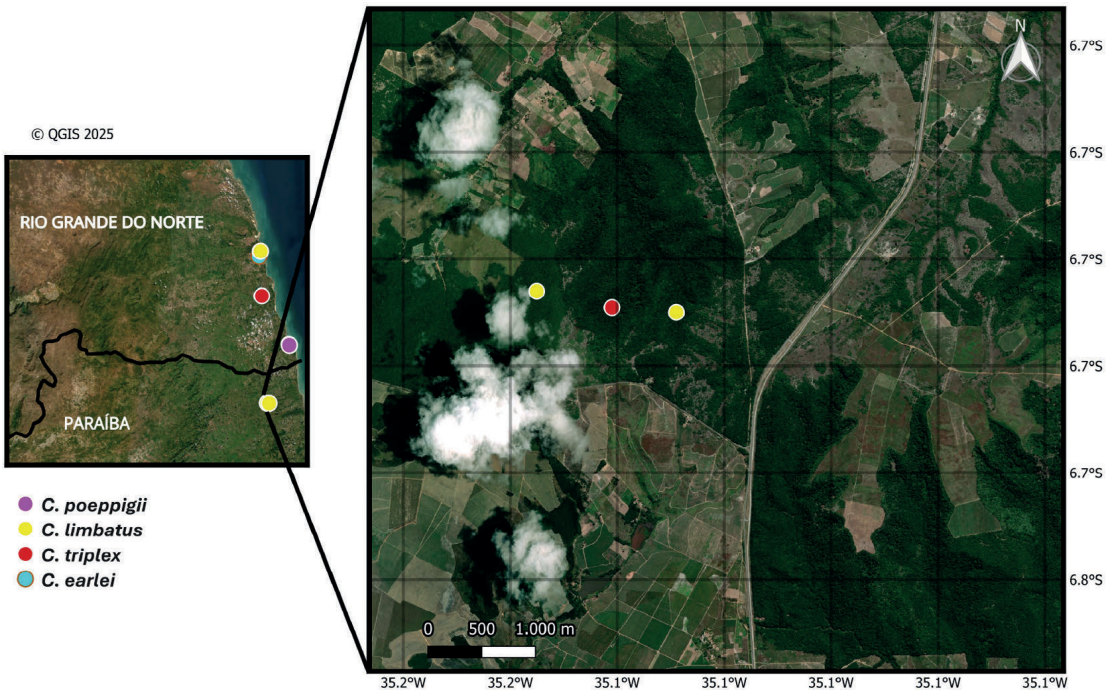

Fig. 5. Collection areas of the *Cyathus* species located in Mamanguape, Rio Grande do Norte. The specimens were collected at the Reserva Biológica Guaribas.

Fig. 5. Áreas de coleta das espécies *Cyathus* localizadas em Mamanguape, Rio Grande do Norte. Os espécimes foram coletados na Reserva Biológica Guaribas.

For the microscopic analyses, a Nikon Eclipse Ni-U optical microscope with an attached DS-Ril camera was used with NIS-elements AR 4.00.03.64bit software. The peridioles were cut and then macerated in a 5% Potassium Hydroxide (KOH) solution to create a homogeneous mixture. 30 basidiospores were analyzed for their shape (by measuring the width and length of the basidiospores), using the Qm value (Bas, 1969; Kirk *et al.*, 2008), as well as wall thickness, apical structure, coloration, and quantity of basidiospores. The average length (L), average width (W), and the length-to-width ratio were calculated for comparison between species. The descriptions and identification of the species followed the specific literature (Lloyd, 1906; Brodie, 1984; Cruz, 2017; Góis *et al.*, 2021).

RESULTS AND DISCUSSION

Four species were identified: *Cyathus earlei* Lloyd, *C. limbatus* Tul. & C. Tul., *C. triplex* Lloyd and *C. poeppigii* Tul. & C. Tul. *Cyathus poeppigii* represent the first record for the state of Rio Grande do Norte, *C. triplex* represent the first records for the states of Rio Grande do Norte and Paraíba, *C. limbatus* represent the second records for the states of Rio Grande do Norte and Paraíba, and *C. earlei* represent the third records for the states of Rio Grande do Norte and Paraíba (Trierveiler-Pereira & Baseia, 2011; Cruz *et al.*, 2012; Cruz *et al.*, 2014; Baseia *et al.*, 2014; Góis *et al.*, 2021).

Taxonomic Treatment

Cyathus poeppigii Tul. & C. Tul.
Annales des Sciences Naturelles Botanique 3(1): 77 (1844).
(Fig. 6)

Peridium infundibuliform, 7.79–9.48 mm in height, 4.12–7.49 mm in width at the upper portion, not expanded at the mouth or tapering at the base. Pedicel absent. Emplacement not observed. Exoperidium hirsute, brown (6F5), with 0.23–0.30 mm in lenght tomentum, arranged in regular and flexible tufts. External wall conspicuously plicated, with 0.33–0.55 mm between the folds. Mouth slightly fimbriated in a continuous pattern, 0.18–0.23 mm in height, dark brown (6F5). Endoperidium brownish grey (6E2), conspicuously plicated with 0.30–0.47 mm between the folds. Perceptible bright, contrasting with the exterior. Basal triangle 0.56–1.38 mm in height, grey (6F1). Epiphragm absent. Peridioles 2.02–2.40 × 1.80–2.06 mm in diameter, black, angular to elliptical at the borders, smooth surface. Tunic indistinct. Double-layered cortex, exocortex and endocortex black, and mesocortex with white loose hyphae. Basidiospores smooth, hyaline, in a regular amount, 17.48–41.32 × 13.60–26.99 μm (L= 33.12 μm; W= 22.71 μm; n=30), globose to elongated (Q= 1.02–1.85), elliptical in average (Qm = 1.45), apicule absent and basidiospore wall 0.76–3.92 μm in thickness.

Examined material.— BRAZIL. Rio Grande do Norte, Baía Formosa, Reserva do Patrimônio Natural Mata Estrela, 6°22'56.8"S 35°01'01.3"W, unknown collection date. **(UFRN-Fungos 3709)**. Unknown growth pattern, on decaying wood.

Distribution in Brazilian states.— Bahia (Góis *et al.*, 2020); Ceará (Baseia *et al.*, 2014); Paraíba (Baseia *et al.*, 2014); Pernambuco (Cruz *et al.*, 2014); Paraná (De Meijer, 2006; Alves & Cortez, 2014); Rio de Janeiro (Berkeley, 1842; Berkeley & Cooke, 1876); Rio Grande do Sul (Rick, 1961; Baseia & Milanez, 2001; Trierveiler-Pereira & Baseia, 2009a; Cortez *et al.*, 2014); Santa Catarina (Hennings, 1904); São Paulo (Bononi *et al.*, 1981; Baseia & Milanez, 2001).

Comments.— *Cyathus poeppigii* is widely distributed in Brazil, and is characterized by dark peridioles, giant basidiospores, and double-layered cortex (Tulasne & Tulasne, 1844). *Cyathus magnomuralis* R. Cruz & Baseia is a similar species that also has giant basidiospores; however, it differs from *C. poeppigii* by having ovoid and slightly elliptical basidiospores (which are ellipsoid in *C. poeppigii*, on average), as well as thicker basidiospore walls (4-3.35 μm) (Cruz & Baseia, 2014), the tomentum and peridioles of *C. poeppigii* are smaller than *C. magnomuralis* (Brodie, 1975; Cruz & Baseia, 2014; Góis *et al.*, 2020).

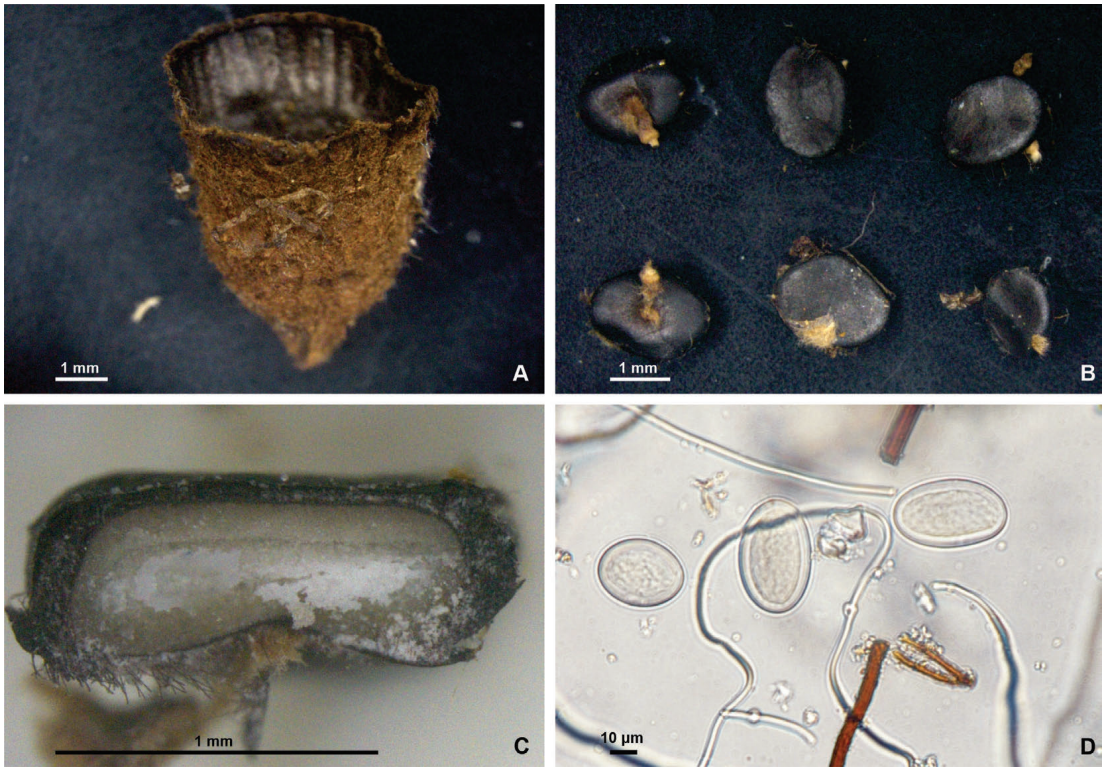

Fig. 6. *Cyathus poeppigii.* A) Exoperidium hirsute. B) Upper view of the peridioles with a smooth surface. C) Double-layered cortex. D) Basidiospores.

Fig. 6. *Cyathus poeppigii*. A) Exoperídio hirsuto. B) Vista superior dos peridiólios com superfície lisa. C) Córtex de camada dupla. D) Basidiósporos.

Cyathus triplex Lloyd
The Nidulariaceae or "bird's nest fungi" (7):
23, t. 109:12–14 (1906).
(Fig. 7)

Peridium infundibuliform, 4.62–6.76 mm in height, 3.65–5.71 mm in width at the upper portion, not expanded at the mouth or tapering at the base. Pedicel absent. Emplacement 2.88–3.47 mm in diameter, dark brown (6F6), inconspicuous, smooth. Exoperidium hirsute, dark brown (6F6), with 0.33–0.52 mm in length tomentum, arranged in regular and flexible tufts. External wall inconspicuously plicated to smooth, with 0.30–0.53 mm between the folds. Mouth slightly fimbriated in a continuous pattern, 0.17–0.22 mm in height, dark brown (6F6). Endoperidium grey (8F3), conspicuously plicated to smooth with 0.31–0.59 mm between the folds. Perceptible bright, contrasting with the exterior. Basal triangle 0.77–1.21 mm in height, light brown (4E7). Epiphragm light brown, rigid. Peridioles 1.56–1.98 × 1.69–2.18 mm in diameter, brownish grey (8F2), elliptical at the borders, smooth surface. Tunic indistinct. Double-layered cortex, exocortex and endocortex brown, and mesocortex compact with white hyphae. Basidiospores smooth, hyaline, in a regular amount, 14.22–17.60 × 8.49–11.34 μm (L= 15.97 μm;

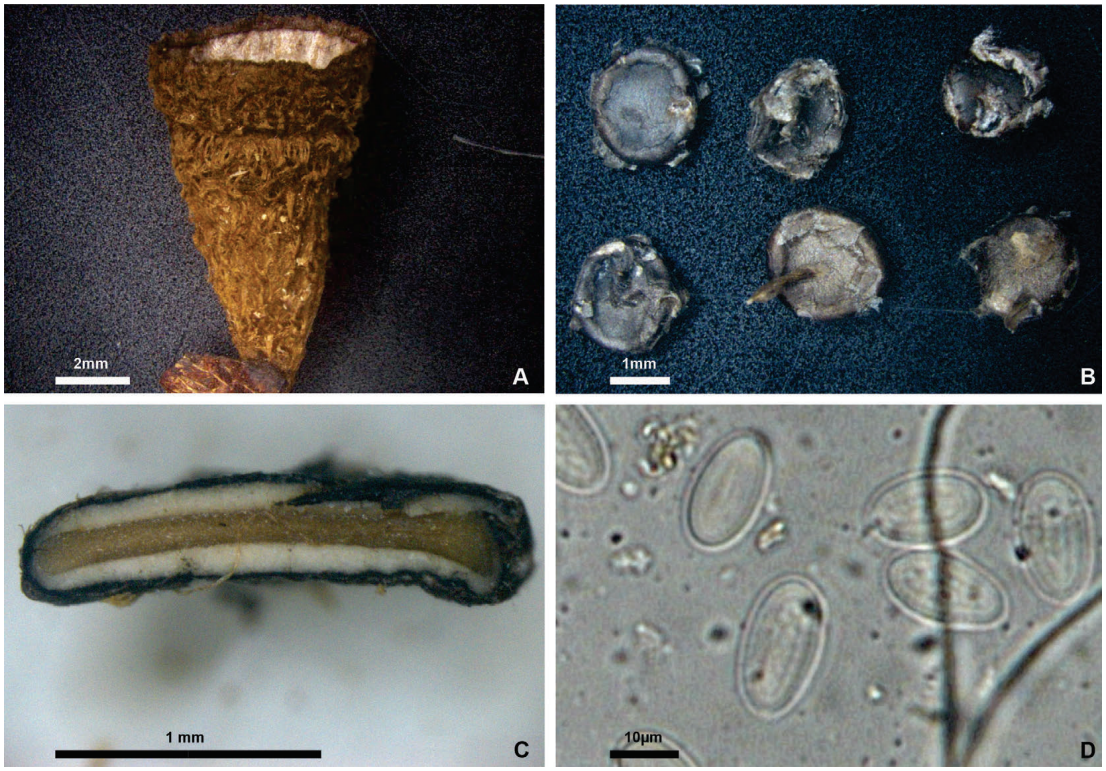

Fig. 7. *Cyathus triplex*. A) Exoperidium hirsute. B) Upper view of the peridioles with smooth surface. C) Double-layered cortex. D) Basidiospores.

Fig. 7. *Cyathus triplex*. A) Exoperídio hirsuto. B) Vista superior dos peridiólios com superfície lisa. C) Córtex de camada dupla. D) Basidiósporos.

W= 9.60 μm; n = 30), slightly elliptical to elongated (Q= 1.31–1.92), elongated in average (Qm = 1.60), apicule present in some basidiospores and basidiospore wall 1.91–3.06 μm in thickness.

Examined materials.— BRAZIL. Rio Grande do Norte, Baía Formosa, Reserva do Patrimônio Natural Mata Estrela, 6°22'42.0"S 35°01'09.2"W, unknown collection date. **(UFRN-Fungos 3708).** Unknown growth pattern, on decomposing wood; Rio Grande do Norte, Natal, Parque Estadual Dunas do Natal, 5°48'41.7"S 35°11'34.0"W, unknown collection date. **(UFRN-Fungos 3697).** Unknown growth pattern, on decomposing wood; Paraíba, Mamanguape, Reserva Biológica Guaribas, 6°44'09.9"S 35°08'43.6"W, 31-VII-2022. *Morais, V.S.; Junior, F.A.A.M., J.S. Góis; Freitas, I.F.S., Nascimento, P.H.G.* **(UFRN-Fungos 3689).** Aggregate, on decomposing wood; Rio Grande do Norte, Nísia Floresta, Floresta Nacional Nísia Floresta, 6°04'59.1"S 35°11'01.5"W, -VI-2022. *J.S. Góis; Freitas-Neto, J.F*, **(UFRN-Fungos 3699).** Unknown growth pattern, on decomposing wood.

Distribution in Brazilian states.— Amazonas (Accioly *et al.*, 2018); Pará (Sotão *et al.*, 2009); Pernambuco (Trierveiler-Pereira & Baseia, 2009b; Trierveiler-Pereira & Baseia, 2013); São Paulo (Baseia & Milanez, 2001).

Comments.— *Cyathus triplex* is characterized by having a hirsute basidiomata up to 7 mm in height, external wall inconspicuously plicated to smooth and double-layered cortex (Brodie, 1975). This species is commonly confused with *Cyathus striatus* (Huds.), but differs in that *C. striatus* has both external and internal walls conspicuously plicated, while *C. triplex* has both walls inconspicuously plicated (Brodie, 1975). Another similar species is *Cyathus pallidus* Berk. & M.A. Curtis due to the smooth endoperidium, but *C. pallidus* differs because it has a single-layered cortex (Berkeley & Curtis, 1869).

Cyathus limbatus Tul. & C. Tul.
Annales des Sciences Naturelles Botanique 3(1): 78 (1844).
(Fig. 8)

Peridium infundibuliform, 6.98–8.19 mm in height, 4.89–6.95 mm in width at the upper portion, not expanded at the mouth or tapering at the base. Pedicel absent. Emplacement 2.95–3.41 mm in diameter, brownish grey (6F8), conspicuous, smooth. Exoperidium hirsute, brownish grey (6F8), with 0.51–0.67 mm tomentum, arranged in regular and flexible tufts. External wall smooth to inconspicuously plicated, with 0.43–0.73 mm between the folds. Mouth slightly fimbriated in a continuous pattern, 0.24–0.36 mm in height, dark brown (7F8). Endoperidium brownish grey (6B1), conspicuously plicated with 0.41–0.64 mm between the folds. Perceptible bright, contrasting with the exterior. Basal triangle 0.73–1.30 mm in height, grey (6F1). Epiphragm brown, rigid. Peridioles 1.99–2.47 × 1.61–2.15 mm in diameter, greyish brown (7F3), elliptical at the borders, smooth surface. Tunic present, hyalin. Double-layered cortex, exocortex and endocortex black, and mesocortex compact with greyish white hyphae. Basidiospores smooth, hyaline, numerous, 14.23–19.09 × 8.39–12.48 μm (L= 16.22 μm; W= 10.18 μm; n= 30), elliptical to elongated (Q= 1.35–1.91), elongated in average (Qm= 1.51), apicule present in some basidiospores and basidiospore wall 1.45–2.82 μm in thickness.

Materials examined.— BRAZIL. Paraíba, Mamanguape, Guaribas Biological Reserve, 6°44'05.0"S 35°09'06.4"W, 31-VII-2022, *Morais, V.S.; Junior, F.A.A.M.; J.S. Góis; Freitas, I.F.S., Nascimento, P.H.G.* (**UFRN-Fungos 3690**); 6°44'11.4"S 35°08'24.1"W, 31-VII-2022. *Morais, V.S.; Junior, F.A.A.M.; J.S. Góis; Freitas, I.F.S.; Nascimento, P.H.G,* (**UFRN-Fungos 3695**). Aggregate, on decaying wood; 6°44'11.4"S 35°08'24.1"W, 31-VII-2022. *Morais, V.S.; Junior, F.A.A.M.; J.S. Góis; Freitas, I.F.S.; Nascimento, P.H.G,* (**UFRN-Fungos 3693**); Rio Grande do Norte, Natal, Parque Estadual Dunas do Natal, 5°48'39.9"S 35°11'27.4"W, unknown collection date. (**UFRN-Fungos 3698**). Unknown growth pattern, on decaying wood; Rio Grande do Norte, Baía Formosa, Reserva Natural Mata Estrela, 6°23'00.1"S 35°00'54.6"W, unknown collection date. (**UFRN-Fungos 3702**). Unknown growth pattern, on decaying wood.

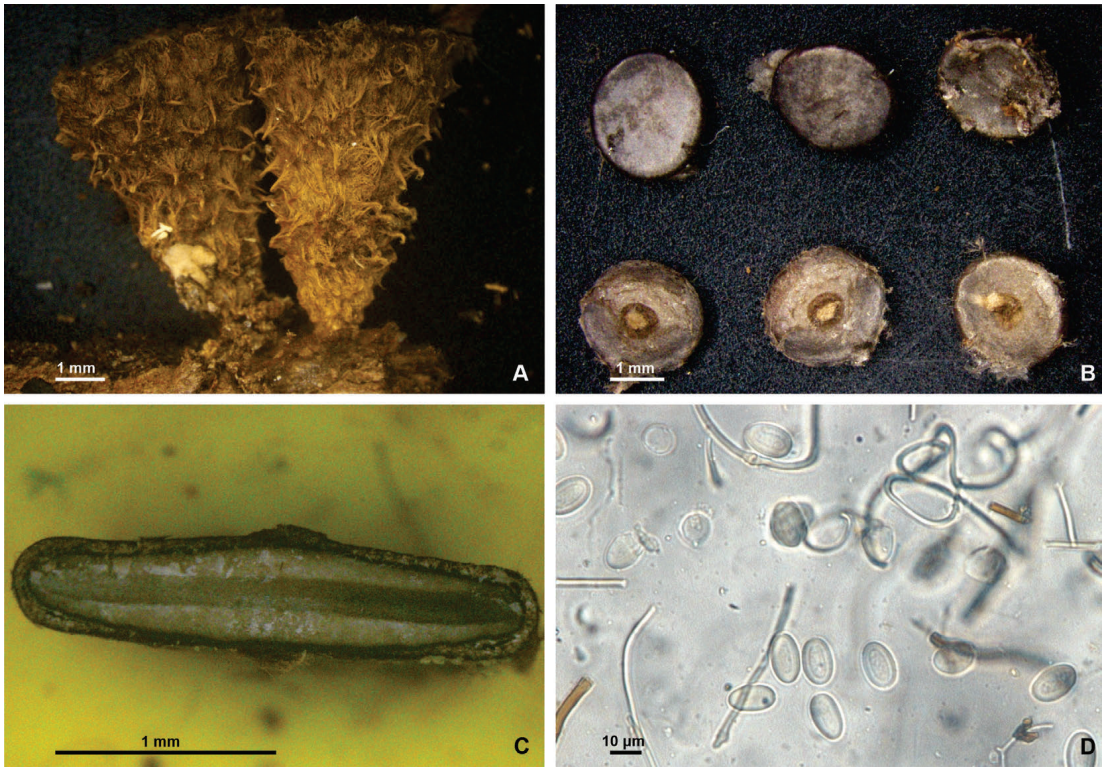

Fig. 8. *Cyathus limbatus.* A) Exoperidium hirsute. B) Upper view of the peridioles with smooth surface. C) Double-layered cortex. D) Basidiospores.

Fig. 8. *Cyathus limbatus*. A) Exoperídio hirsuto. B) Vista superior dos peridiólios com superfície lisa. C) Córtex de camada dupla. D) Basidiósporos.

Distribution in Brazilian states.— Amazonas (Berkeley & Cooke, 1876; Accioly *et al.*, 2018); Bahia (Góis *et al.*, 2020); Ceará (Baseia & Milanez, 2001); Pernambuco (Trierveiler-Pereira & Baseia, 2009b; Cruz *et al.*, 2014); Paraíba (Trierveiler-Pereira & Baseia, 2011); Paraná (De Meijer, 2006); Rio Grande do Norte (Cruz *et al.*, 2014); Rio Grande do Sul (Cortez *et al.*, 2014); Rondônia (Trierveiler-Pereira *et al.*, 2011).

Comment.— *Cyathus limbatus* is characterized by having a double-layered cortex, an external and internal wall with striae, exoperidium tomentum up to 0.70 mm in length and mouth hyphae in a continuous pattern, which may break at the folds (Tulasne & Tulasne, 1844; Góis *et al*. 2021). *C. limbatus* is often confused with *C. montagnei* Tul. & C. Tul. and *C. striatus*, due to the peridium size; however, these species are differentiated by having a single-layered cortex (Lloyd, 1906; Brodie, 1975; Brodie, 1984).

Cyathus earlei Lloyd
The Nidulariaceae or "bird's nest fungi" (7): 26 (1906).
(Fig. 9)

Peridium infundibuliform, 7.30–9.1 mm in height, 4.64–6.78 mm in width at the upper portion, not expanded at the mouth or tapering at the base. Pedicel absent. Emplacement 3.92–4.69 mm in diameter, concolor to the exoperidium, conspicuous, smooth. Exoperidium hirsute, dark brown (7F6), with 0.37–0.57 mm in lenght tomentum, arranged in regular and flexible tufts. External wall smooth to inconspicuously plicated, with 0.43–0.66 mm between the folds. Mouth slightly fimbriated in a continuous pattern, 0.27–0.37 mm in height, concolor to the exoperidium. Endoperidium brownish grey (6B1), conspicuously plicated with 0.41–0.64 mm between the folds. Perceptible bright, contrasting with the exterior. Basal triangle and epiphragm not observed. Peridioles 1.95–2.31 × 1.71–2.04 mm in diameter, reddish brown (6F3), elliptical to slightly irregular at the borders, smooth surface. Tunic present, hyalin. Double-layered cortex, exocortex and endocortex black, and mesocortex compact with greyish white hyphae. Basidiospores smooth, hyaline, in a regular amount, 14.44–18.61 × 8.77–11.69 μm (L= 16.67 μm; W= 9.93 μm; n = 30), elliptical to cylindrical (Q= 1.43–2), elongated in average (Qm= 1.68), apicule present in some basidiospores and basidiospore wall 1.39–2.76 μm in thickness.

Materials examined.— BRAZIL. Paraíba, Mamanguape, Guaribas Biological Reserve, 31-VII-2022. *Morais, V.S.; Junior, F.A.A.M.; J.S. Góis; Freitas, I.F.S.;Nascimento, P.H.G,* **(UFRN-Fungos 3694)**. Aggregate, on decaying wood; Rio Grande do Norte. Natal. Trilha dos Saguis, Universidade Federal do Rio Grande do Norte, 5°50'33.8"S 35°12'04.4"W, 22-VI-2022. *Morais, V.S., Medeiros Junior, F.A.A,* **(UFRN-Fungos 3706)**. Aggregate, on decaying wood; Parque Estadual Dunas do Natal, 5°48'32.6"S 35°11'33.8"W, unknown collection date. **(UFRN-Fungos 3705)**. Unknown growth pattern, on decaying wood; 5°48'40.3"S 35°11'33.1"W, unknown collection date. **(UFRN-Fungos 3704)**. Unknown growth pattern, on decaying wood; 5°48'40.9"S 35°11'23.7"W, unknown collection date. **(UFRN-Fungos 3703)**. Unknown growth pattern, on decaying wood; 5°48'38.4"S 35°11'33.8"W, unknown collection date. (**UFRN-Fungos 3696**). Unknown growth pattern, on decaying wood; Rio Grande do Norte, Tibau do Sul, Parque Estadual Mata da Pipa, 6°13'44.6"S 35°03'54.2"W, unknown collection date. **(UFRN-Fungos 3711)**. Unknown growth pattern, on decaying wood.

Distribution in Brazilian states.— Amazonas (Accioly *et al.*, 2018); Ceará (Baseia *et al.*, 2014); Pernambuco (Cruz *et al.*, 2014); Paraíba (Baseia *et al.*, 2014; Cruz *et al.*, 2014); Rio Grande do Norte (Cruz *et al.*, 2012; Cruz *et al.*, 2014).

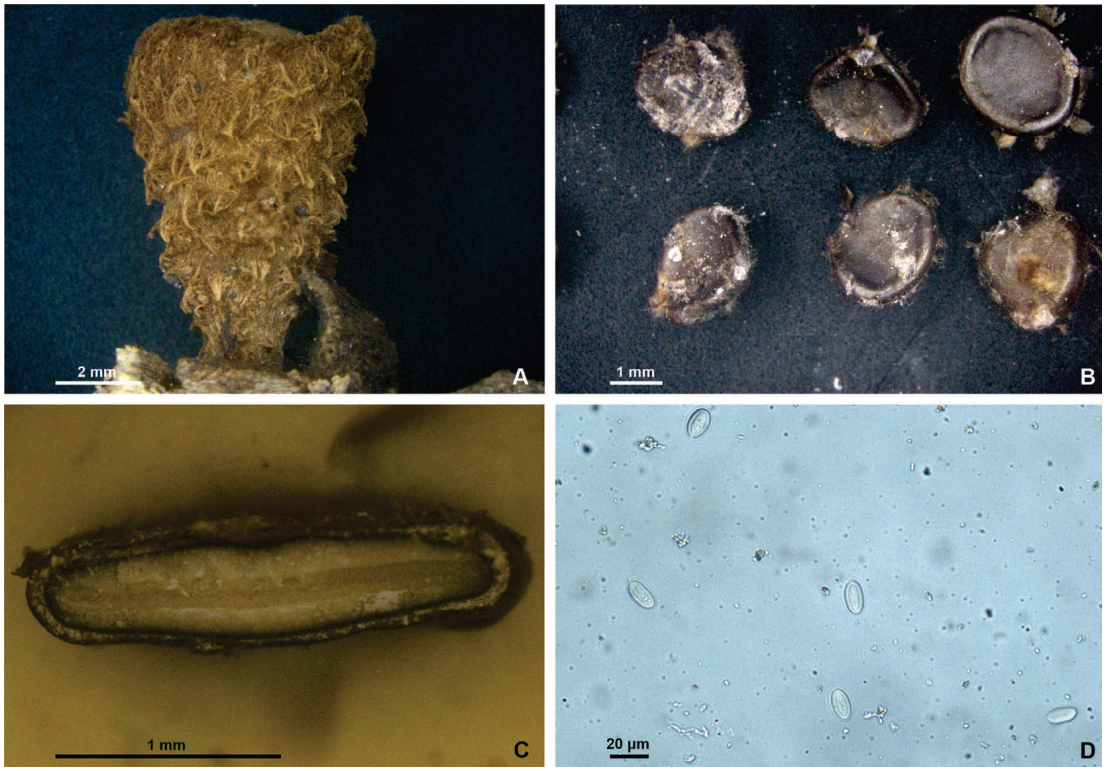

Fig. 9. *Cyathus earlei*. A) Exoperidium hirsute. B) Upper view of the peridioles with smooth surface. C) Double-layered cortex. D) Basidiospores.

Fig. 9. *Cyathus earlei.* A) Exoperídio hirsuto. B) Vista superior dos peridiólios com superfície lisa. C) Córtex de camada dupla. D) Basidiósporos.

Comments.— *Cyathus earlei* is a species widely distributed in Brazil, occurring on various substrates and almost all Brazilian biomes (Góis *et al*., 2021). The specimens analyzed for Brazil by Cruz (2017) and Góis *et al*., (2021) show significant variations from the type species by presenting a distinctly double-layered cortex along the entire length of the peridium, conspicuously plicate to inconspicuously plicate endoperidium, larger peridioles (1.95–2.31 × 1.71–2.04 mm), while the holotype exhibits a subhomogeneous single-layered cortex, smooth to inconspicuously plicate endoperidium and smaller peridioles (1.6–1.97 × 1.45–1.87 mm) (Lloyd, 1906; Cruz, 2017; Góis *et al.*, 2021). *Cyathus earlei* can be confused with *C. triplex* due to the similar size of the tomentum, however, *C. earlei* differs due to the smaller size of the basidiomata and peridioles, peridiole smooth surface and lighter colors in the mesocortex (Lloyd, 1906; Brodie, 1975; Góis *et al.*, 2021).

Taxonomic discussion

Cyathus poeppigii and *Cyathus limbatus* are included in the *gigasporum group*, characterized by species with basidiospores above 20 μm, which can reach 30 μm to 40 μm, with a slightly elliptical to elongated shape, peridioles with a smooth surface and double-layered cortex and peridium conspicuously plicated (Cruz *et al.*, 2023).

Cyathus triplex and *C. earlei* are included in the *minimum* group, characterized by basidiospores between 15 and 20 μm, absence of an apical, short peridium tomentum between 0.2 and 0.8 mm long, which can be woolly and hirsute, finely fimbriated mouth with torments below 0.5 mm and peridioles with double-layered cortex (Cruz *et al.*, 2023).

CONCLUSION

In this study, new records of *Cyathus* were identified for the states of Paraíba and Rio Grande do Norte. However, there is still a need for more sampling efforts to better understand the distribution of *Cyathus* in areas that have not yet been explored or are poorly studied. Even in regions with frequent collections, such as the Atlantic Forest areas of Paraíba and Rio Grande do Norte, taxonomic novelties were still found. The data generated in this work shows that even with recent discoveries in the Atlantic Forest areas there is still potential for new discoveries. In this context, this study contributes to filling some of the gaps in the distribution of the genus *Cyathus* in northeastern Brazil.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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