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First record of *Badhamia gigantospora* from Brazil

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Abstract: During the study of the mycobiota of the Auguste Saint-Hilaire Forest, an area of the Cerrado biome in Goiânia, Goiás, Brazil, sporocarps of *Badhamia gigantospora* were collected. A sample was incorporated into the Herbarium collection of the Universidade Estadual de Goiás (HUEG). This rare species was previously reported only for Argentina, Ecuador, Tanzania, and now for Brazil, so this is the second record for the Neotropical region. In addition to expanding the known geographical distribution of *B. gigantospora*, we provide detailed morphological descriptions, illustrations, and a identification key for the species of the genus that occur in Brazil.

Keywords: Brazilian savanna, Cerrado, geographical distribution, new records, slime molds

Badhamia Berk. is a genus proposed in 1852 by Berkeley and encompasses 34 species, belonging to the family Physaraceae (Lado 2005-2021). The genus is characterized by the absence of a columella, a simple – rarely double or triple – peridium, and a columnar capillitium without connecting filaments. There are calcareous granules on the outer surface of the peridium and within the capillitial threads, a character usually known as a badhamioid capillitium (Hatano and Keller 2008; Poulain et al. 2011).

The genus is widely distributed in the Neotropical region (Lado and Basanta 2008). In Brazil it is represented by eight species. These are *Badhamia affinis* Rostaf., *B. calcaripes* Gottsb., *B. macrocarpa* (Ces.) Rostaf., *B. melanospora* Speg., *Badhamia nitens* Berk., *B. panicea* (Fr.) Rostaf., *B. papaveracea* Berk. & Ravenel, and *B. viridescens* Meyl., which are distributed in the Atlantic Forest, the Caatinga and the Pampa (Cavalcanti 2021). *Badhamia gigantospora* Ukkola & Härk. is a rare tropical species, first described in 1996 from the African continent in a forest fragment of the Sokoine University of Agriculture in Tanzania (Ukkola et al. 1996). The species was subsequently reported in South America, in Ecuador, in the Amazonian forest (Lado et al. 2017) and in unidentified localities (Lado and Basanta 2008), and in Argentina in grassland areas (Moreno et al. 2020). All these records were on decaying wood.

In March 2014, sporocarps of *B. gigantospora* were found in the Bosque August Saint-Hilarie (16°36′27″S, 49°15′52″W), in a mesophilic forest (also known as semideciduous dry forest) of the Cerrado biome in the Goiás State, Brazil, occurring on fragments of decaying leaves and dead wood. Thus, the

species is being reported for the first time for Brazil and for the Cerrado biome. A detailed morphological description, illustrations, and an identification key for the species of the genus that occur in Brazil, have been included herein.

The identification of the species was carried out from an analysis of macro- and microstructures, using optical and scanning electron microscopy, and reference to the appropriate literature (Ukkola and Härkönen 1996; Poulain et al. 2011; Lado et al. 2017; Moreno et al. 2020). Color classification was based on Kornreup and Wanscher (1978). The voucher was deposited at the Herbarium of the Universidade Estadual de Goiás (HUEG), Anápolis, Goiás, Brazil. Due to the morphological similarity of this species with *Physarum pezizoideum* (Jungh.) Pavill. & Lagarde, especially in the field (Ukkola and Härkönen 1996; Lado et al. 2017; Moreno et al. 2020), herbarium specimens of both species were comparatively analysed.

Badhamia gigantospora Ukkola & Härk., Karstenia 36(1): 43 (1996) (Fig. 1).

Sporocarps stalked, gregarious, 2.0-2.7 mm tall. Sporotheca discoid, greenish grey (1D2) to light grey (1D1), with a small brownish orange (6C8) disk in the basal portion of the sporotheca up to 0.5 mm in diameter. Peridium membranous, covered with lime nodes, breaking into small patches remaining attached to the capillitium. Stalk striate, reddish brown (8E7), 1.5-2.3 mm in diameter. Hypothallus brown (7E8). Capillitium formed by columns filled with lime that connect the upper and lower surface of the sporotheca. Columella absent. Spores in mass brownish grey (8F2) to dark brown (8F4) by transmitted light, strongly spinulose,15-18 µm in diameter including the spines that are up to 1.5 µm long.

Specimens examined: Brazil. Goiás: Municipality of Goiânia, Bosque Auguste Saint-Hilaire located on the premises of Campus II of the Universidade Federal de Goiás, 29/III/2014, on decaying leaves and dead wood, Naves, LR and Moreira, IC 456 (HUEG 9555).

Geographical distribution: Thus far the species is restricted to Africa and South America, with five records in Argentina, Brazil (present study), Ecuador, and Tanzania.

The macro- and micromorphological characteristics observed in the studied specimens corresponded with the original description by Ukkola and Härkönen (1996), except for the spore size (including the spines). These authors described a size between 19-22 (24) µm in diameter and we recorded a size between 15-18 µm, similarly to Poulain et al. (2011). We remark the prominent spiny ornamentation of the spores as a highlight among the species of the genus. In our scanning electron microscopy analysis, we observed this characteristic despite the spores being dehydrated and with the loss of the globose form in the process (Fig. 1). The species can be compared to *P. pezizoideum* but differs from it by the presence of a small brownish orange disk in the basal portion of the peridium, a capillitium with a thick column connecting the upper and lower surface of the sporocarp, and more prominent spines on the spores (Table 1).

The present study contributes to expand the knowledge of the geographical distribution of this species by documenting the first record in Brazil, the second in the Neotropical region and the first of the genus in the Cerrado biome. This record demonstrates the importance of protecting and studying forest

fragments in understudied regions. In addition, it is a species with few known records worldwide, and the basis of such rarity is an interesting aspect to address in future studies.

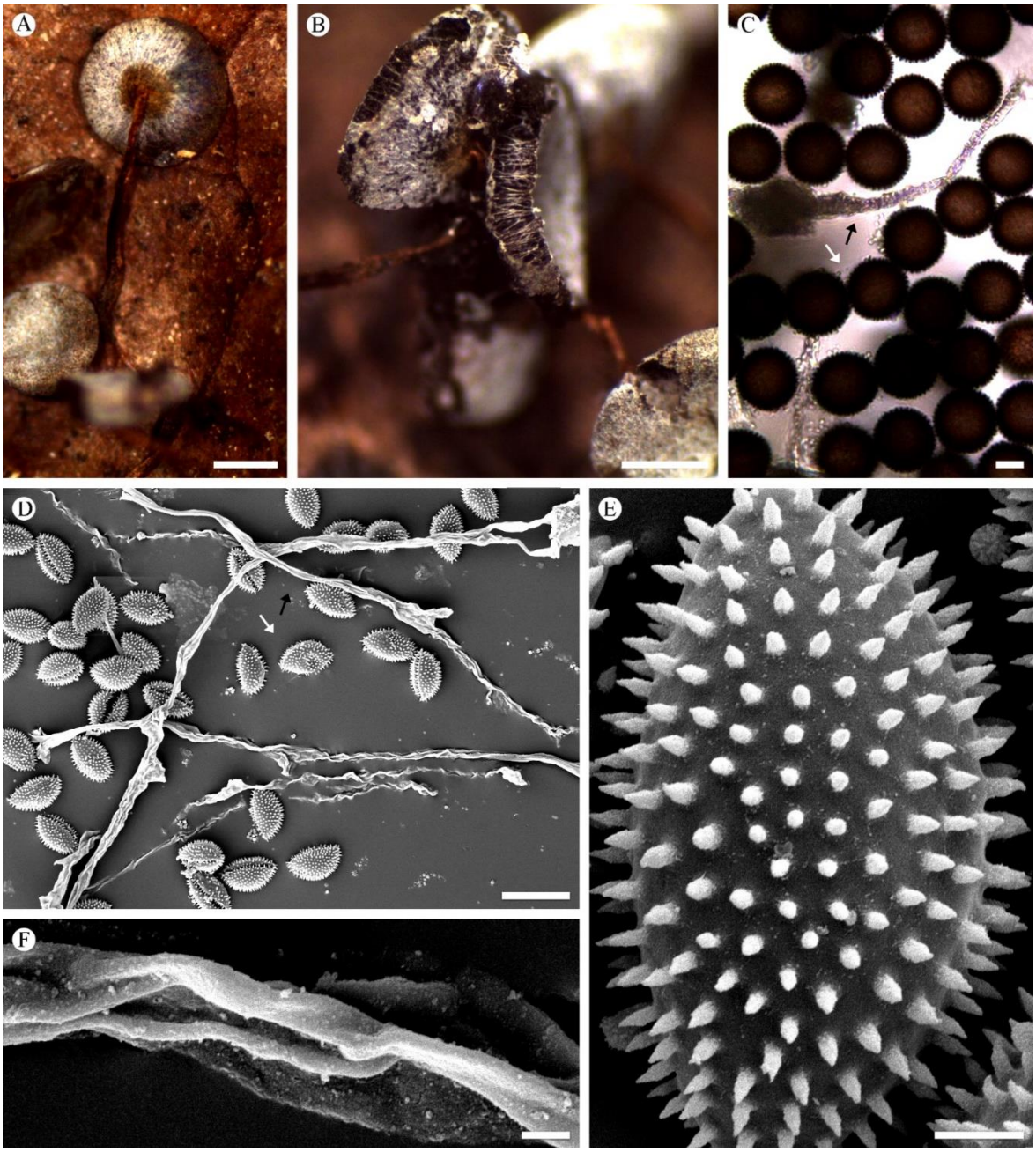

Figure 1. *Badhamia gigantospora*: **A)** Sporocarp highlighting the basal region of the sporotheca, **B)** Sporocarp in section showing the capillitium like thick columns, **C)** Spores (white arrow) and capillitium (black arrow) under an optical microscope, **D)** Spores (white arrow) and capillitium (black arrow) under scanning electron microscopy, **E)** Spore highlighting the spines ornamentation under scanning electron microscopy, **F)** Capillitium under scanning electron microscopy**.** Scale bars = 0.5 mm (A, B); 5 µm (C); 20 µm (D); 2 µm (E); 1 µm (F).

Table 1. Characteristics that distinguish *Badhamia gigantospora* from *Physarum pezizoideum.*

Characteristics		***Badhamia gigantospora***	***Physarum pezizoideum***
Stalk	Shape	Slender, striate	Slender, striate
	Color	Reddish brown	Reddish brown
Sporotheca	Shape	Discoid	Discoid to cup-shaped
	Color	Greyish white with small orange disc on base	Greyish white without the disc orange on base
Capillitium	Shape	Slightly branched, forming a dense column without intercalations by lime nodules	Branched, dense, but never column-shaped connected with some small, lime nodules
	Color	White	Hyaline
Spore	Size	15-18 µm	8.0-9.5 µm
	Ornamentation	Strongly spinulose, including the spines up to 1.5 µm long	Minutely spinulose with clusters of more prominent spines
	Color	In mass brownish grey to dark brown	In mass dark brown to light brown

Key to *Badhamia* species from Brazil

1. Spores in clusters ……..……..…… 2
1′. Spores free ……..……...…… 3
2. Peridium double ….....…… *Badhamia nitens*
2′. Peridium single …..…… 4
3. Sporocarps usually stalked …..……...……...…… 5
3′. Sporocarps usually sessile or with short stalks …..……...…… 6
4. Capillitium typically consisting of lime nodes and more or less reticulate tubules (badhamioid capillitium) ……...…….. *B. papaveracea*
4′. Capillitum with thickened nodules and lime tubules (approaching the physaroid condition) ……. *B. calcaripes*
5. Sporotheca globose or oblate ……..…….……. *B. melanospora*
5′. Sporotheca subglobose to slightly pear-shaped or discoid …...…….…… 8
6. Sporocarps globose to subplasmodiocarpous ……....…… 7
6′. Sporocarps subglobose, often depressed in the center…….....……...……. *B. affinis*
7. Spores moderately dark or rather dark, 11-15 µm, with conspicuous spinules ……..... *B. macrocarpa*
7′. Spores pale, 10-14 µm, minutely punctate with groups of darker warts ……..….. *B. panicea*
8. Sporotheca subglobose to slightly pear-shaped, spores pale, between 8-13 µm in diameter, very minutely warted ..... *B. viridescens*
8′. Sporotheca discoid to saucer-shaped, spores strongly spinulose, between 15–18 µm in diameter, including the spines .....…… *B. gigantospora*

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