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GEOSCIENCES

Distribution of *Badhamiopsis* and *Badhamia* (Physaraceae, Myxomycetes) in brazilian Biomes

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Abstract: The family Physaraceae (Physarales, Myxomycetes) is represented in Brazil by eight genera and 75 species. Based on data obtained from the GBIF, SpeciesLink, Flora and Funga do Brasil platforms, collections from the IPA and URM Herbaria and material collected since 1960 deposited in the UFP Herbarium, the microhabitats and distribution of *Badhamiopsis* (1sp.) and *Badhamia* (10 spp.) in Brazilian biomes are commented. An identification key for the species and the first report of *B. melanospora* from the state of Paraíba, *B. panicea* from the state of Paraná and *B. ovispora* from Brazil are presented.

Key words: Atlantic Rainforest, Caatinga, Cerrado, Pampa, Physarales, Myxogastria.

INTRODUCTION

Myxomycetes (Amoebozoa) are also known as mucilaginous fungi because their life cycle presents an amoeboflagellate, uninucleate, haploid phase followed by a plasmodial, multinucleate, diploid phase, both mobile, without a defined form and free-living. The cycle is completed with a sporulating phase, in which the individuals are fixed to the substrate and produce sporocarps with a well-defined shape, allowing the morphological identification of the species (Rojas & Stephenson 2022). Myxomycetes are included among the terrestrial organisms with the widest distribution worldwide, although placed in the group of the least known (Aguilar et al. 2014). They are predominantly bacterivorous, phagotrophic, non-pathogenic organisms of about 1000 known species distributed in six orders and 12 families (Poulain et al. 2011, Lado 2005-2022, Keller et al. 2022, Novozhlov et al. 2022).

The family Physaraceae comprises nine genera and 228 species characterized by sporocarps with dark spores in different shades of brown and capillitial filaments completely or partially filled with calcium granules (Martin et al. 1983, Lado 2005-2022). In Brazil, Physaraceae is represented by eight genera, including *Badhamiopsis* (Yamash.) T. E. Brooks & H. W. Keller and *Badhamia* Berk., and 74 species distributed across the different regions and vegetation domains of the country (BFG 2021, Moreira et al. 2021). *Badhamiopsis* is distinguished by the absence of a capillitial network and a capillitial system that consists of simple or bifurcated spike-like invaginations of the peridium completely filled with calcium granules, held at the base of the sporocarp by short hyaline filaments. The type species of the genus, *Badhamia ainoae* Yamash., was initially described in *Badhamia* due to some characters shared with this genus, but the species lacks the network of filaments (Keller & Brooks 1976). In turn, the 36 species recognized for *Badhamia* share the presence of a capillitial network with different levels of calcium impregnation. *Badhamia* species are distributed in the two hemispheres, in almost all continents, while the six species of *Badhamiopsis* have few records

in the Southern Hemisphere (Poulain et al. 2011, Lado 2005-2022).

Farr (1976) listed 10 species of *Badhamia* for the Neotropics and included Brazil in the range of three of them (*B. affinis* Rostaf., *B. calcaripes* Gottsb. and *B. papaveracea* Berk & Rav.). Based on exsiccates from Brazil and Dominica, she also included in the list, but as doubtful, the occurrence of *B. ainoe*, described in 1936 from the island of Kyushu, Japan. In their literature review of Neotropical species, Lado & Basanta (2008) added *B. macrocarpa* (Ces.) Rostaf., *B. melanospora* Speg., *B. nitens* Berk. and *B. panicea* (Fr.) Rostaf. Except for *B. calcaripes*, the locations in Brazil, environments of occurrence, and sporulation substrates of the species, were not reported by Farr (1976) and Lado & Basanta (2008). Information on localities, environments where the species were recorded in Brazil, and substrates where sporulation occurred were absent in the list of Farr (1976) and were provided only for *B. calcaripes* by Lado & Basanta (2008).

The present work reports the first record of *Badhamia ovispora* Racib. from Brazil and expands the knowledge about the distribution of *B. melanospora* Speg. and *B. panicea* (Fries) Rostaf. in the Brazilian territory. We present the distribution of *Badhamia* and *Badhamiopsis* species in different Brazilian biomes and ecological groups and provide an identification key for species with known occurrence in the country.

MATERIALS AND METHODS

The list of species and information on sporulation substrate distribution in different states, biomes and vegetation types are mainly based on specimens of *Badhamiopsis* and *Badhamia* collected by the research team of the Myxomycetes Laboratory at the Federal University of Pernambuco (UFPE) since 1970 and deposited in the Geraldo Mariz (UFP) Herbarium of the UFPE, and material deposited in the Pe. Camille Torrend Herbarium (URM), in the UFPE, and Dárdano de Andrade Lima (IPA) Herbarium of the Agronomic Institute of Pernambuco. The identification of the species was based on the keys and descriptions of Martin & Alexopoulos (1969), Farr (1976) and Poulain et al. (2011), and the taxonomic nomenclature and abbreviation of authors' names followed by Lado (2005-2022). Data on collection sites, biomes, vegetation types and sporulation substrates were complemented by consulting online databases of the Flora and Funga do Brasil (floradobrasil.jbrj.gov.br), SpeciesLink (2021), Global Biodiversity Information Facility - GBIF (2021) platforms, as well as scientific articles and book chapters. A map of the distribution of the species in Brazil was prepared using the software QGIS Desktop 3.16.15.

The acronyms of the herbaria mentioned throughout the work followed the standard nomenclature of the Index Herbariorum (Thiers 2022): Geraldo Mariz Herbarium (UFP), Pe. Camille Torrend Herbarium (URM), Dárdano de Andrade Lima Herbarium (IPA), Instituto de Pesquisas Ambientais Herbarium (SP), U.S. National Fungus Collections, USDA-ARS (BPI herbarium), Meise Botanic Garden Herbarium (BR), Herbarium of the Universidade Estadual de Goiás (HUEG), Real Jardín Botánico (MA-Fungi Herbarium), Herbarium of the Universidad de Buenos Aires (BAFC).

The acronyms for Brazilian regions and states presented in Table I and II are in accordance with the Brazilian Institute of Geography and Statistics (IBGE) as follows: Northeast - Alagoas (AL), Bahia (BA), Ceará (CE), Paraíba (PB), Pernambuco (PE), Rio Grande do Norte (RN), Midwest – Goiás (GO), Southeast– Rio de Janeiro (RJ), São Paulo (SP), South – Paraná (PR), Rio Grande do Sul (RS).

Table I. Distribution of *Badhamiopsis* and *Badhamia* species in different biomes and states of Brazil. *Abbreviations according to IBGE (2021). ** First record from the state. * First record from Brazil.**

Genus/Species	Biomes/States*			
	Caatinga	Cerrado	Atlantic Rainforest	Pampa
Badhamia				
B. affinis	BA[11, 12,25], CE[8, 9, 12, 15,25]	SP[6]	PE [3,7, 25] SP[20, 25]	RS[21, 22]
B. calcaripes	-	-	SP[4, 25]	-
B. gigantospora	-	GO[24]	-	-
B. macrocarpa	CE[9, 12, 15, 25]		PE[25] SP[23,25]	-
B. melanospora	AL[20,25],CE[15, 25], PB**,PE[12, 17, 18, 25]	SP[23]**	RN[13, 25],SE[14] SP[1]**	RS[10, 21, 22, 25]
B. nitens	-	-	PB[16, 25],PE [7,16, 25], RJ [16, 25], RS [16, 25], SP [16, 25]	-
B. ovispora	-	-	SP[23]***	-
B. panicea	BA[11,25],CE[15,25]	-	PE [7,25] PR[23]**	-
B. papaveracea	-	-	RJ[2, 25]	-
B. viridescens	-	-	PE[19, 25]	-
Badhamiopsis				
B. ainoae	-	-	PE[5, 25]	-

1.Spegazzini (1889), 2. Torrend (1915), 3.Farr (1960), 4.Gottsberger (1971), 5.Cavalcanti (1976), 6.Cavalcanti (1978), 7.Cavalcanti et al. (1985), 8.Alves & Cavalcanti (1996), 9. Cavalcanti & Putzke (1998), 10.Putzke (2002), 11.Gusmão et al. (2005), 12.Cavalcanti et al. (2006), 13.Bezerra et al. (2007), 14.Bezerra et al. (2008), 15.Alves et al. (2010), 16. Cavalcanti & Trierveiler-Pereira (2010), 17. Ferreira & Cavalcanti (2011), 18. Silva & Cavalcanti (2012), 19. Agra et al. (2014), 20. Bezerra et al. (2014), 21. Xavier de Lima & Cavalcanti (2017), 22. Velloso et al. (2020), 23. GBIF (2022), 24. Moreira et al. (2021), 25. BFG (2021).

Table II. Distribution of *Badhamia* species in different ecological groups according to substrate on which they sporulated, collected in Brazilian biomes.

Ecological group	Species
Corticolous	*B. affinis; B. macrocarpa; B. panicea.*
Fimicolous	*B. ovispora.*
Foliicolous	*B. affinis; B. calcaripes; B. gigantospora.*
Lignicolous	*B. affinis; B. gigantospora; B. macrocarpa; B. melanospora; B. nitens; B. panicea; B.papaveracea; B . viridescens.*
Muscicolous	*B. affinis.*
Suculenticulous	*B. melanospora.*

RESULTS AND DISCUSSION

The present study revealed that one species of *Badhamiopsis* and ten species of *Badhamia* occur in Brazil (Figure 1). They are distributed in Caatinga, a biome composed of steppe-savanna vegetation covering about 862,818 km², ca. 10.1% of the national territory; Cerrado, recognized as the richest savanna in the world, occupying an area of 1,983,017 km², ca. 23.3% of the national

territory; Atlantic Forest, a biome that extends over most of the Brazilian coast and occupies 1,000,000 km², which corresponds to only ca. 29% of its original coverage due to land occupation and human activities; and Pampa, a biome restricted to the state of Rio Grande do Sul, occupying an area of 193,836 km², ca. 69% of the territory of the state and 2.3% of the Brazilian territory (MMA 2022) (Table I). They were found predominantly on dead trunks and branches (lignicolous), followed by soil litter (foliicolous) and bark of living trees (corticolous), and one species, *B. melanospora*, was predominantly succulenticolous (Table II). An annotated list of the 11 species and an identification key for the 10 species of *Badhamia* are presented below.

***Badhamiopsis* T.E. Brooks & H.W. Keller**

B. ainoae (Yamash.) T.E. Brooks & H.W. Keller, in Keller & Brooks, Mycologia 68(4):836 (1976)

The first record of the genus *Badhamiopsis* from Brazil was made by Cavalcanti (1976), with the report of *B. ainoae* sporulating on living trunk of *Cassia* sp., used in urban afforestation in the northern area of the city of Recife (PE). Collections were made between 1970-1980 on living trunks of Leguminosae (*Cassia* sp.), Annonaceae (*Annona* sp.) and Anacardiaceae (*Mangifera indica* L.) in public squares and residential backyards in Recife, with exsiccates deposited in the UFP (2739, 3354, 3355, 3411, 4997) and BPI (743124, 743276) herbaria. The species was recorded again, after three decades, sporulating in a moist chamber with the bark of a living tree from the Mata de São José Wildlife Refuge, a fragment of dense ombrophilous forest in the municipality of Igarassu, North Zone of the humid forest of Pernambuco State (Coelho & Cavalcanti 2009). Apart from these records in the Atlantic Forest of Pernambuco, *B. ainoae* is not known from other states and regions of Brazil.

Based on the analysis of a specimen collected in Japan, originally identified as a variety of *B. ainoae*, Kuhnt (2021) proposed the new combination *B. macrospora* (Y. Yamam.) Kunht & Meckes and described, in the same article, *B. praetermissa* Kunht & Meckes and *B. scripta* Kunht & Meckes, occurring in Germany and some neighboring countries. The three species are corticolous and the last two were classified as bryocorticolous, because they commonly develop on living trunks covered by mosses. As observed for *B. ainoae* in Brazil, the specimens of these species were mostly found in urban environments, sporulating on mosses and bark of the trunks of living trees frequently used in landscaping, such as *Acer platanoides* L. (Sapindaceae), *Carpinus betulus* L. (Betulaceae) and *Populus nigra* L. (Salicaceae).

***Badhamia* Rostaf.**

B. affinis Rostaf., Sluzowce monogr. 143 (1874)

Badhamia affinis was first reported from Brazil by Farr (1960), who in 1958 collected a specimen on bark from the living trunk of *Polyscias guilfoylei* Bail. (Araliaceae), in the gardens of the Mycology Institute, in Recife (PE). The species has a wide distribution in the Neotropics and in Brazil (Lado & Basanta 2008, BFG 2021) and is present in different biomes and vegetation types, occupying a wide range of microhabitats as corticolous, lignicolous, foliicolous, and muscicolous (Table II).

In the study by Cavalcanti (1974, 1978) in the Cerrado of Emas (Pirassununga, SP), *B. affinis* was recorded as corticolous based on a specimen that sporulated on living trunk of *Vochysia tucanorum* Mart. (Vochysiaceae), with the typical characteristics of the species, differing only by the larger diameter of the spores (15-19 µm). *Badhamia affinis* occurs as lignicolous and muscicolous in different phytophysiognomies

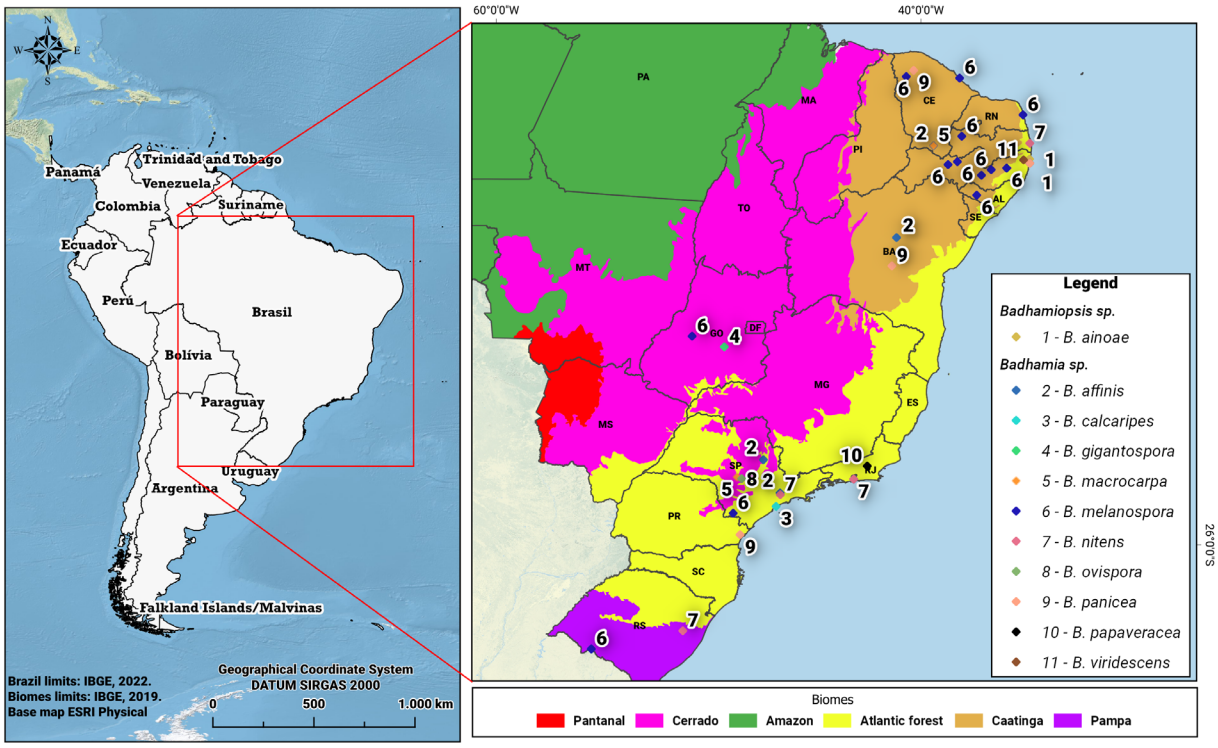

Figure 1. Distribution of *Badhamiopsis* and *Badhamia* species in different biomes and states of Brazil.

of the Atlantic Forest in Pernambuco, Rio de Janeiro and São Paulo states and has one record as lignicolous in a riparian forest in the Pampa biome (Cavalcanti et al. 1985, Cavalcanti 2002, Maimoni-Rodella 2002, Xavier de Lima & Cavalcanti 2017, Velloso et al. 2020). In Caatinga, it was recorded as foliicolous in the municipality of Crato, in the southern mesoregion of Ceará (Alves & Cavalcanti 1996, Cavalcanti & Putzke 1998, Cavalcanti et al. 2006, Alves et al. 2010) and as corticolous in a shrubby Caatinga in the municipality of Morro do Chapéu, North-Central mesoregion of Bahia (Gusmão et al. 2005, Cavalcanti et al. 2006).

B. calcaripes Gottsb., Nova Hedwigia 22(1-2):491 (1972)

This is the only species of the genus that has Brazil as the type locality. It was described by Gerard Gottsberger during the time he worked in the country (Gottsberger 1971), with one exsiccate deposited in the SP Herbarium and a slide in the BR Herbarium of the Meise Botanic Garden (Barcode BR5020054738303). The species is known only from the type material, collected in 1969 on roots and scaly parts of *Vriesia ensiformis* (Vell.) Beer, an epiphytic bromeliad, in Itanhaém (SP), in a sandbank environment, one of the ecosystems associated with the Atlantic Forest.

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

First reported for Brazil by Moreira et al. (2021), sporocarps of *B. gigantospora* were collected on dead leaves and decaying wood in Bosque Auguste Saint-Hilaire, a semi-deciduous dry forest in Goiânia (GO), with exsiccates deposited in the HUEG Herbarium. This is the most recent record of a species of *Badhamia* in Brazil and the first to report the presence this genus in the Midwest region of the country.

The type material of *B. gigantospora*, initially identified as *Physarum pezizoideum* (Jungh) Pavill. & Lagard, was collected by M. Harkönen in 1989 in Tanzania, on decaying wood of *Cupressus lusitanica* Mill., in Arucha National Park, Mount Meru (1700-4566 m alt.), whose hillside forests are surrounded by savannas. In Africa, there is also one record from Congo, collected in 2013 in the Yangambi Biosphere Reserve, and another from Madagascar, with a specimen collected in 1928 in a highland forest in Ambohimanga, identified by M. Meyer in 2005 (GBIF 2022).

Stephenson et al. (2004) included *B. gigantospora* among the species reported for the first time for the Neotropics based on a specimen collected in 2000 on decaying wood in lowland rainforest of the Amazon basin, in the Yasuni National Park (310 m alt.), Ecuador. The exsiccate, which consisted of about 200 sporangia, was deposited in the MA-Fungi Herbarium and the identification was confirmed by Lado et al. (2017), despite the smaller diameter of the spores (13-16 µm). In a revision of the collection of the BAFC Herbarium, Moreno et al. (2020) reported the first record of *B. gigantospora* from Argentina. They found it when analyzing the exsiccate 51240, collected in 2002 by Sannazzarok & E. Albertó on a palm tree, in Buenos Aires. The authors commented that the specimen had initially been identified as *P. pezizoideum* and, like the one collected in Ecuador, it had spores with diameters in the range of 13-16 µm, and other characters in agreement with the description of the species. Moreira et al. (2021) described the spores as strongly spinulose, 15-18 µm in diameter, including the spines which are 1.5 µm in length; this suggests that, without the spines, the spore size of the Brazilian material is closer to that of the material collected in Ecuador and Argentina than to the material described from Tanzania (19-24 µm), even without the 2 µm of length corresponding to the spines reported by Ukkola & Härkönen (1996) in the original description of the species.

B. macrocarpa (Ces.) Rostaf. Sluzowce monogr. 143 (1874)

This species was collected for the first time in Brazil in Chapada do Araripe, municipality of Crato (422 m alt.), state of Ceará, on dead trunks of unidentified palm trees in Caatinga (Cavalcanti & Putzke 1998). There is a record in the GBIF platform (Dueñas 2021) of one exsiccate deposited in the MA-Fungi Herbarium, collected in 2004 in Cerrado by C. Lado and R. C. S. Maimoni-Rodella, on a living tree trunk in the Palmeiras da Serra Reserve (728 m alt.), in the municipality of Pratânia, state of São Paulo.

Badhamia macrocarpa has a wide distribution in the world, occurring in different climates and vegetation types and occupying different microhabitats in America, Africa, Asia, Europe and Oceania. In Brazil, in addition to areas of Caatinga (CE) and Cerrado (SP), *B. macrocarpa* occurs as lignicolous and corticolous in the Atlantic Forest of Pernambuco (Cavalcanti 2002, Cavalcanti & Trierveiler-Pereira 2010, Agra et al. 2022).

B. melanospora Speg., Anales Soc. Ci. Argent. 10:150 (1880)

Among the *Badhamia* species listed by Farr (1976) for the Neotropics are *B. gracilis* (T. Macbr.) T. Macbr., with *B. macrocarpa* var. *gracilis* T. Macbr. as a synonym, and *B. melanospora* Speg., treated as a synonym of *B. macrocarpa* (Ces.) Rostaf. According to Lado (2005-2022), *B. gracilis* and *B. macrocarpa* var. *gracilis* are synonyms of *B. melanospora*, described by C.L. Spegazzini in 1880 from Argentina. Brazil was not mentioned as part of the distribution area of the two species by Farr (1976) although she cites, throughout her monograph, the work of

Spegazzini (1889), in which there is a reference (on page 474) to a specimen of *B. melanospora* collected on decaying wood in Apiaí (ca. 1000 m alt.), a municipality located in the state of São Paulo that still has extensive areas of Atlantic Forest. Therefore, the oldest record of the genus in Brazil can be attributed to Spegazzini (1889), and the specimen of *B. melanospora* from São Paulo is, in this case, the first collected in the country. The species was not included by Hochgesand & Gottsberger (1996), Maimoni-Rodella (2002) and BFG (2021) among those with known occurrence in the state of São Paulo.

Putzke (2002) included *B. melanospora* in the list of Myxomycetes with records for the South region of Brazil under the binomial *B. gracilis* (T. Macbr.) T. Macbr., informing its occurrence in Rio Grande do Sul but no data on locality and substrate upon which sporulation occurred is provided. Xavier de Lima & Cavalcanti (2017) commented that in the collections carried out in 2013-2015 by the first author in the Ibirapuitã Environmental Protection Area, *B. melanospora* was very frequent and abundant on cacti in the typical grasslands of Pampa. In the Northeast region, *B. melanospora* has records in typical vegetation of Caatinga, in the municipalities of Águas Belas, Caruaru, Fazenda Nova and Pesqueira, located in the Agreste region of Pernambuco (Cavalcanti et al. 2006). In an investigation of the presence of Myxomycetes on cacti in the municipalities of Serra Talhada and Mirandiba, Sertão mesoregion of Pernambuco, and Buíque, Agreste mesoregion of Pernambuco, Ferreira & Cavalcanti (2011) and Silva & Cavalcanti (2012) observed that *B. melanospora* was the most abundant and frequent species, characterizing the succulenticolous myxobiota.

In the present survey of herbarium collections, one voucher specimen collected on a cactus of the genus *Opuntia* in the municipality of Aparecida, in the semi-arid region of Paraíba, was found in the UFP herbarium, constituting the first record of the species from this state. Still in the Caatinga biome, *B. melanospora* was recorded in the municipality of Pacujá, Northwest mesoregion of Ceará (Alves et al. 2010), and in the municipality of São José da Tapera, Sertão mesoregion of Alagoas (Bezerra et al. 2014). *Badhamia melanospora* also stood out in the succulenticolous myxobiota of the coastal dune forest explored by Bezerra et al. (2007), in the Atlantic Forest of Northeast Brazil, representing the first record from Rio Grande do Norte.

According to Aguilar et al. (2014), *B. melanospora* constitutes a geographically structured cryptic species complex, most likely originating in South America and with long-distance dispersion facilitated by human action, by the introduction of American succulent plants in Old World countries. Limited dispersion, isolation by distance, and specificity for host plants (succulents) allied to other ecological factors are thought to have given rise to at least two cryptic species. The study of the Brazilian material showed, for example, that one of the sequences was of the same ribotype that was introduced in the Canary Islands and Madagascar. Furthermore, the introduction of host plants, such as *Opuntia* species in Brazil, is thought to have facilitated the colonization of geographically distant areas, from the Americas to Europe, and from Mexico to Brazil.

B. nitens Berk., Proc. Linn. Soc. London 2:200 (1852)

The first report on the presence of the species in Brazil is the one published by Bononi et al. (1981), based on a specimen collected in 1966 on decaying wood by B. Skvortzov in a dense ombrophilous forest on the slopes of Fontes do Ipiranga State Park, an Atlantic Forest conservation unit located in the city of São Paulo. In the literature review for the Midwest

and Southeast regions, Maimoni-Rodella (2002) cited *B. nitens* for Rio de Janeiro and São Paulo, without indication of collection site and substrate upon which sporulation occurred. Cavalcanti et al. (1985), Cavalcanti (2002) and Cavalcanti & Trierveiler-Pereira (2010) cite the occurrence of the species in the Atlantic Forest of the states of Paraíba, Pernambuco and Rio Grande do Sul, also without indication of microhabitats.

Type material of *B. nitens* (Kew 1218) was collected in 1851, in East Bergholt, a village in southern Suffolk, England, on dead oak branches (Berkeley 1853) and Lister (1925) and Hochgesand & Gottsberger (1996) indicate its occurrence on decaying wood, leathery fungi and bark of living trees along with mosses and lichens. The species has a wide worldwide distribution, occurring in countries of Europe, Oceania, North America and South America. In the latter, there are records in Argentina, Chile, Bolivia, Brazil, Peru and Venezuela, almost all without indication of collection site and substrate on which the species sporulated (Martin & Alexopoulos 1969, GBIF 2022). In the literature review for the Neotropics, Lado & Basanta (2008) cited *B. nitens* for Mexico, Dominica, Brazil and Bolivia and Lado et al. (2013, 2014) latter recorded it as lignicolous in dry forests of central Chile and on sprigs of *Senecio* sp. (Asteraceae) and *Mulinum spinosum* Pers. (Apiaceae) in the Patagonian steppes of Argentina.

B. ovispora Racib., Rozpr. Spraw. Posiedzen Wydz. Mat.-Przyr. Akad. Umiejetn 12:72 (1884)

In the present survey, one specimen of *B. ovispora* collected in 1968 in the municipality of Botucatu, São Paulo, in the Southeast region of the country, was located in the collection of the Meise Botanic Garden Herbarium (GBIF 2022). The species was not listed by Lado & Basanta (2008) for the Neotropics nor is included in the lists of *Badhamia* species occurring in Brazil prepared by Moreira et al. (2021) and Agra et al. (2022). The present study constitutes, thus, the first report from Brazil and from South America. The specimen was found on rabbit dung, collected by G. Gottsberger at the Botucatu Botanical Garden and deposited in the Myxomycetes collection of the BR Herbarium, identified by the specialist N. E. Nannenga-Bremekamp (Barcode BR5020054746384) (GBIF 2022).

The type material of *B. ovispora* was collected in 1882 near Krakow, Poland, on a cut trunk of *Populus canescens* (Ait.) Sm. However, among the 33 occurrences that appear in the GBIF (2022), only one is from this country, from the city of Brenna, collected and identified in 1995 by M. Meyer. Most (63%) of the exsiccates of the species were obtained in the USA and Canada, between 1911-2007, with six more records in Germany, between 1915-1935, and the rest in Spain (1), Northern Ireland (1) and Sweden (1), in addition to Brazil. Few of these records included information on the substrate on which the species sporulated, mostly on decaying conifer wood and litter, and the specimen from Sweden was obtained in a moist chamber culture of the excrement of the mountain hare *Lepus timidus* L., of the same family of the animal on whose excrement the Brazilian specimen was found. In the world list of coprophilous Myxomycetes prepared by Calaça et al. (2020), *B. ovispora* is included among the less frequent species, with one sample collected in 1916 in Germany, also on rabbit dung, one in England, in 1919, and one in Canada in 1944, on unidentified animal.

B. panicea (Fr.) Rostaf., in Fuckel, Jahrb. Nassauischen Vereins Naturk. 27-28:71 (1873)

In the keys to Myxomycete species from South America, Farr (1968) included *B. panicea* but did not indicate its occurrence in Brazil. The first publication that mentioned its presence in Brazil was Cavalcanti et al. (1985), based

on a specimen collected in an Atlantic Forest area in Pernambuco and deposited in the UFP Herbarium. Currently, the species has records as corticolous in the state of Bahia and lignicolous in the state of Ceará, both in Caatinga (Gusmão et al. 2005, Alves et al. 2010, Cavalcanti 2002, Cavalcanti & Trierveiler-Pereira 2010, BFG 2021).

In Paranaguá, a coastal municipality in the state of Paraná, a specimen of *Badhamia* was collected in 1993 by A.A. R. de Meijer on bark of *Euterpe edulis* Mart. (Arecaceae), a palm tree widely distributed in the Atlantic Forest. The material was identified by N.E. Nannenga-Bremekamp as *B. panicea* var. *heterospora* G.Lister (GBIF 2022) and deposited at that moment in the collection of the Herbarium of the Meise Botanic Garden (BR), but the occurrence of *B. panicea* in Southern Brazil is being reported for the first time only now, in the present study, three decades after its collection.

B. papaveracea Berk. & Ravenel, in Berkeley, Grevillea 2:66 (1873)

The second record of *Badhamia* and the only one of *B. papaveracea* from Brazil was published by Torrend (1915) based on a specimen sporulating on a tree trunk. The material cited by C. Torrend was collected in Nova Friburgo municipality, in the mountainous region of Rio de Janeiro (ca. 900 m alt.). Farr (1976) included *B. papaveracea* among the Neotropical species based on the citation made by C. Torrend and commented that it was a typical species of temperate zones, but did not inform the municipality or the climatic characteristics of the place of occurrence. The climate in Nova Friburgo is warm temperate (Cfb type) according to Köppen's classification, the average temperature is 18° C, the annual rainfall is around 2000 mm, and there is no dry season. In the analysis of the GIBF database (2022), it appears that, as in Brazil, *B. papaveracea* has few and sporadic records in Asian countries (India, 1, Japan, 2), Europe (Portugal, 1) and Latin America (Mexico, 1, Peru, 1), although it is widely distributed in the United States of North America, with 30 records between 1877 and 2000. The report of *B. Papaveracea* in Spain is not registered in the GBIF (Moreno & Oltra 2010).

B. viridescens Meyl. , Bull. Soc. Vaud. Sci. Nat. 53:452 (1921)

In her revision of the collection of the URM Mycological Herbarium, Farr (1960) did not mention the exsiccate URM 544, which has a duplicate in the IPA Herbarium (39002) identified as *B. viridescens* by Augusto Chaves Batista, and the species was not included in her monograph published in 1976. The sample collected in 1951 by T. Gayão on dead palm trees in the municipality of Paudalho, a humid forest zone of Pernambuco, was in a good state of conservation and the identification was confirmed by Agra et al. (2014).

The specimen collected in the Atlantic Forest of Pernambuco represents the only record of *B. viridescens* from Brazil, which was not included among the 16 species of the genus listed by Lado & Basanta (2008) for the Neotropics. In GBIF (2022), there are only 20 records of preserved material, including the two exsiccates from Brazil and the type material, collected in 1912 in the Jura Mountains, Switzerland, by C. Meylan. Some specimens have information on substrate, such as dead branches of *Acacia* sp. (Australia), *Euphorbia* sp. (Madagascar), *Populus* sp. (USA), and living tree of *Alnus* (Germany).

The identification key presented below is based on literature data and exsiccates from the IPA, URM and UFP Herbaria, collected between 1951-2016. The index numbers placed after the binomials correspond to the publication of the first reference to Brazil.

IDENTIFICATION KEY TO BADHAMIA SPECIES OF BRAZIL

1. Spores in groups of 4 to 20.....**2**
1a. Spores free.....**4**
2. Columella yellow, poorly developed or globular to conical and reaching the center of the sporotheca; peridium with petaloid dehisce nce.....***B. calcaripes***[4]
2a. Columella absent; peridium with irregular dehiscence.....**3**
3. Peridium double; sessile sporangium or plasmodiocarp, yellow to greenish-yellow; capillitial lime nodes yellow to whitish.....
.....***B. nitens***[5]
3a. Peridium simple; sporangium stalked, rarely sessile, gray to white; capillitial nodes white.....
.....***B. papaveracea***[2]
4. Stalk always present, 50% or more of total height.....**5**
4a. Stalk absent, when present, less than 50% of the total height.....**6**
5. Sporotheca discoid, white; spores spinulose, (15)19-24 µm diam.....***B. gigantospora***[9]
5a. Sporotheca globose, subglobose or piriform, yellowish or greenish grey; spores warty (8)9-12(13) µm diam.....
.....***B.viridescens***[8]
6. Sporangia always sessile; spores allantoid, reniform or oval, (14-)16-18(-21) x (5.5-)6-7(-8) µm diam.....***B.ovispora***[10]
6a. Sporangia sessile or short-stalked or plasmodiocarp; spores globose, subglobose or angular, 11-15(18) µm diam.....
.....**7**
7. Spores brown – light violet; stalk, when present, black or reddish.....**8**
7a. Spores very dark brown; stalk, when present, straw yellow, pinkish or brown.....**9**
8. Sporotheca 0.5-1 mm diam.; stalk, when present, black; spores densely covered with dark warts, (12) 14-18 µm diam.....
.....***B. affinis***[3]
8a. Sporotheca 0.4-2 mm diam.; stalk, when present, reddish; spores minutely punctate, 11-14 µm diam. .....
.....***B. panicea***[6]
9. Stalk, when present, straw yellow or pinkish, twisted, grooved; spores densely and irregularly warted, with groups of darker warts and a network with 1-6 meshes per hemisphere.....
.....***B.melanospora***[1]
9a. Stalk, when present, yellowish or brown, darker at the base; spores densely and irregularly faintly warted.....***B. macrocarpa***[7]

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