Small reserves as hotspots for Fungi preservation in Brazil

Pequenas reservas como hotspots para preservação de fungos no Brasil

Pequeñas reservas como hotspots para la preservación de hongos en Brasil

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Abstract
Small conservation areas have been created in many countries usually to protect plants and animals, but no priorities are deserved in protecting fungi. The creation of preservation areas is meeting a new problem: there are only small remaining areas, since exploration is destroying large forests. Applying the technique of the transects in three different areas in Brazil (Pampa and Cerrado biomes and Amazonian Forest), diversity and ecological data were collected for Agaricomycetes fungi, mainly order Agaricales, and compared to the fungi already known and their conservation status to understand how fungi are protected indirectly with the creation of small protected areas. The samples were collected in differents permanent protected areas (APP – permanent protected areas) in river margins in southern Brazil (RPAS), Saint Hilaire Forest in the Universidade de Goiás (MSH - ca. 20 ha) in Goiânia/GO and in the Universidade Federal do Amazonas Protected Forest (Manaus/AM - MUFAM), all located in Brazil. In MUFAM, 140 specimens were collected in 2014 and 2018 resulting in 47 species. In MSH 86 specimens were collected in 2019 and 2020 with 31 species identified. In RPAS 278 new species records for the Brazilian Pampa biome were cataloged, 23 new records for the state of Rio Grande do Sul and 4 new registrations for Brazil. This demonstrates the importance of small forest fragments to fungi preservation and maintenance, being efforts in that direction important in future studies of new conservation areas implementation.
Keywords: Mycogeography; Mushrooms; Agaricales; Agaricomycetes; Basidiomycota; Protection areas.

Resumo
Pequenas áreas de conservação foram criadas em muitos países geralmente para proteger plantas e animais, mas nenhuma prioridade é direcionada à proteção de fungos. A criação de áreas de preservação está enfrentando um novo problema: restam apenas pequenas áreas, já que a exploração está destruindo grandes florestas. Aplicando a técnica dos transectos em três diferentes áreas do Brasil (biomas Pampa e Cerrado e Floresta Amazônica), foram coletados

dados ecológicos e de diversidade para os fungos Agaricomycetes, principalmente ordem Agaricales, e comparados com os fungos já conhecidos e seu estado de conservação para entender como os fungos são protegidos indiretamente com a criação de pequenas áreas protegidas. As amostras foram coletadas em diferentes áreas de proteção permanente (APP – áreas de proteção permanente) nas margens de rios no sul do Brasil (RPAS), Floresta Saint Hilaire na Universidade de Goiás (MSH - ca. 20 ha) em Goiânia/GO e na Floresta Protegida da Universidade Federal do Amazognas (Manaus/AM - MUFAM), todas localizadas no Brasil. No MUFAM, foram coletados 140 exemplares em 2014 e 2018 resultando em 47 espécies. No MSH foram coletados 86 exemplares em 2019 e 2020 com 31 espécies identificadas. No RPAS foram catalogados 278 novos registros de espécies para o bioma Pampa brasileiro, 23 novos registros para o estado do Rio Grande do Sul e 4 novos registros para o Brasil. Isso demonstra a importância de pequenos fragmentos florestais para a preservação e manutenção de fungos, sendo os esforços nesse sentido importantes em estudos futuros de implantação de novas áreas de conservação.
Palavras-chave: Micogeografia; Cogumelos; Agaricales; Agaricomycetes; Basidiomycota; Áreas de proteção.

Resumen
Se han creado pequeñas áreas de conservación en muchos países, generalmente para proteger plantas y animales, pero no se da prioridad a la protección de los hongos.. La creación de áreas de preservación está encontrando un nuevo problema: solo quedan pequeñas áreas remanentes, ya que la exploración está destruyendo grandes bosques. Aplicando la técnica de los transectos en tres áreas diferentes de Brasil (biomas de Pampa y Cerrado y Selva Amazónica), se recolectaron datos de diversidad y ecológicos para los hongos Agaricomycetes, principalmente del orden Agaricales, y se compararon con los hongos ya conocidos y su estado de conservación para comprender cómo los hongos se protegen indirectamente con la creación de pequeñas áreas protegidas. Las muestras fueron recolectadas en diferentes áreas protegidas permanentes (APP – áreas protegidas permanentes) en márgenes de ríos en el sur de Brasil (RPAS), Bosque Saint Hilaire en la Universidade de Goiás (MSH - ca. 20 ha) en Goiânia/GO y en el Bosque de Protección de Universidade Federal do Amazonas (Manaus/AM - MUFAM), todos ubicados en Brasil. En el MUFAM se recolectaron 140 ejemplares en 2014 y 2018 dando como resultado 47 especies. En MSH se recolectaron 86 especímenes en 2019 y 2020 con 31 especies identificadas. En RPAS se catalogaron 278 nuevos registros de especies para el bioma pampeano brasileño, 23 nuevos registros para el estado de Rio Grande do Sul y 4 nuevos registros para Brasil. Esto demuestra la importancia de los pequeños fragmentos de bosque para la preservación y el mantenimiento de hongos, siendo los esfuerzos en esa dirección importantes en futuros estudios de implementación de nuevas áreas de conservación.
Palabras clave: Micogeografía; Hongos; Agaricales; Agaricomycetes; Basidiomycota; Áreas de protección.

1. Introduction

Even though small reserves are extremely common around the world, studies on their conservational value are disproportionally uncommon in scientific works, which usually focus on defining their value relative to one large reserve, to one or two taxa or ecosystem types (Volenec & Dobson, 2019). Despite many efforts being done in Europe and North America to preserve fungi biodiversity, few initiatives are under course in South America, except for creation of preservation areas but without referring to fungi species. Most European countries have generated red lists for fungi but this is not true for countries in Latin America (Senn-Irlet et al., 2007).

The lack of knowledge is one of the major problems relating to fungi preservation, especially in South America, where countries with high biodiversity numbers like Brazil and Colombia, which have incomplete fungal species lists, are still beginning to study the complex ecological role of this group (Putzke & Putzke 2017; Putzke et al. 2020, 2021). But it is also a problem to all the world since only 56 species of fungi have their status evaluated globally by the UCN red list (Hawksworth et al. 2017).

Habitat reduction and pollution are considered the most important causes of worldwide loss of biodiversity, being the creation of small reserves also of huge importance (Serengil et al., 2011; Avigliano et al., 2019). Agaricales fungi are generally annual and popularly known as mushrooms. They began to be studied by specialists in Brazil mostly in the XIX century (Fidalgo, 1985). The list counts for 1.011 species (Putzke, 1994) increased to ca. 1800 in 2018 (Putzke & Putzke, 2018). The studies done so far are essentially taxonomic, and rarely ecological/conservational or involving relationships between the fungi and the forest and rarely on preservation of fungi.

There are also citations of introduced fungi in this country and preoccupations are related to the fact that those species could contact native plants to form mycorrhiza, competing with the native fungi species. One recent example of such invasion is cited in South America were *Amanita muscaria* (L.) Lam., usually associated with pine plantations is now found associated with a native oak species of Colombia (Vargas et al. 2019). The impact of these exotic species to this exclusive forest and over other native fungi needs to be better studied.

There are six terrestrial biomes recognized in Brazil: Pampa, Cerrado, Amazônia, Caatinga, Mata Atlântica and Pantanal. The first three are among the less studied in relation to their biodiversity. The Brazilian Pampa biome covers an average area of 176,496 km² and is characterized by being restricted only to Rio Grande do Sul State (southern Brazil), Uruguay and parts of Argentina. The biome is formed by the phytogeographic regions Contact Savana-Steppe, Steppe, Deciduous Seasonal Forest, Semi-deciduous Seasonal Forest and Pioneer Vegetation Areas (IBGE, 2012). The forest formations are basically found along the watercourses in the region, and must host an unknown biodiversity since they correspond to the last remnants of natural forest (Metzger, 2003).

The Cerrado is considered the largest hotspot in the Western Hemisphere, and the most biodiverse tropical savanna in the world, with an approximate extension of 2 million km2, with about 99.3% of its area is in Brazil (Sawyer et al., 2016). The cerrado is formed by a complex vegetation, including forest, grassland, and savannah formations, with a high number of endemic species (Ribeiro & Walter, 2008). The Atlantic Forest has the largest number of fungi records (3,017 species), followed by Amazonia (1,050), Caatinga (999), Cerrado (638) and Pampa (84) and Pantanal (35) (Maia et al. 2015). This shows that the 3 biomes selected for this study are poorly surveyed. In a recently published work on fungi in Brazil (BFG et al. 2021), 1461 species of fungi were reported for the state of Rio Grande do Sul, 867 species for the Amazon and 189 species for Goiás, characterizing Goiás as the seventh Brazilian state with lower occurrence of Fungi in the country. The states of Rio Grande do Sul and Amazonas stand out as the third and fourth, respectively, with more species of fungi in Brazil, however, in Rio Grande do Sul, most of the work was carried out in the Atlantic Forest biome, highlighting the importance of carrying out work in the Pampa biome (Silva et al., 2020).

Many initiatives to preserve the biodiversity in Brazil have been done by universities, many of them creating and maintaining forests inside their campus or creating and managing small areas outside. This is the case of forest inside the Universidade Federal do Amazonas (northern Amazonian Forest), in the Universidade Federal de Goiás (UFG - Middle West region - Bosque Auguste Saint Hilaire of the UFG has 27 hectares). It is important also the forest relicts in the river margins, called Permanent Protected Areas and that sometimes are small forest but its fungi composition is still not well studied. In order to better understand the importance of small areas in preserving fungi, specially Agaricomycetes, this work is proposed, dealing with the taxonomy and distribution of this group in the small natural reserves of Brazil, choosing areas in Southern, Central and northern Brazil.

2. Methodology

There were chosen two small reserves (one in Amazonia and other in central Brazil) and Permanent Protected Areas near rivers in Southern Brazil. The areas are described below:

2.1 Sampling in the Amazonas (Northern Brazil):

The area of the UFAM campus is 6.7 million meters square, with a perimeter of 16.9km of land. This area is the third largest natural fragment in an urban area in the world and the first in the country, which contributed for the creation of the Environmental Protection Area - APA UFAM. The APA was created in 2012, totaling 759.15ha, encompassing fragments of the Amazonian Forest, now totally isolated (Caldas, 2016). The field survey was done from February 19 to 24 2018, in the forest preserved inside the campus of the Universidade Federal do Amazonas (UFAM). The samples were collected using the "walking methodology" (Filgueiras et al., 1994), searching for Agaricomycetes fungi. The samples were studied in the Mycology Laboratory of the UFAM and all collections dehydrated and deposited in the JP herbarium.

2.2 Sampling in Goiás (Center Brazil):

Samples were collected during the rainy seasons 2018/2019 and 2020/2021 in the Bosque Auguste Saint Hilaire of the Universidade Federal de Goiás (UFG - Campus II), located in Goiânia city, the capital of Goiás state in the coordinates 16º 36'11" S and 49º15'39" W, at 695 m alt. and has ca. 20 ha. One of the few areas with primitive vegetation in the municipality of Goiânia, it is located on Campus II of the UFG. It is a remnant of the semideciduous forest of the Cerrado biome plant formation. The site, which is protected by a screen and has ecological trails, and is used for the development of Environmental Education activities, visitation of students of different levels and development of numerous scientific researches. The samples were also collected using the walking methodology and were dehydrated and deposited in the Herbarium of the UFG.

2.3 Sampling in Rio Grande do Sul (Southern Brazil):

The collections in the Pampa biome were carried out in the state of Rio Grande do Sul, southern Brazil, in all seasons of the year 2019. 10 collection points were selected in a longitudinal gradient between the municipalities of São Gabriel and Porto Alegre (the capital), in which riparian vegetation occurs, with an approximate distance of 20 km from one point to another. In all three areas the samples were collected using the walking methodology. All the mushrooms found were collected and taken to the local laboratories for identification and samples were dehydrated and deposited in the herbarium housed in each university. All samples from these three collecting areas photographed following the Macrofunge Image Capture Protocol (Bittencourt et al., 2022) and the identification was made using microscopes and usual morphological/anatomical techniques, as well as the specific bibliography available for the area (Putzke & Putzke, 2018).

3. Results

3.1 Manaus – MUFAM

There were collected 140 specimens, being identified 41 species (29.3%) (Table 1). The list is incomplete mostly because of the poorly known large genera like *Marasmius, Marasmiellus* and *Mycena* abundant in the mentioned forest. The 12 taxa (29.2%) not identified to species level are not cited to the country or represent new species to science. The Agaricales fungi have received little attention in the Amazon region, especially in relation to basic taxonomic surveys. The works of Singer (1973; 1976; 1989), Singer and Araujo (1979), Araújo (1984) and Singer & Aguiar (1986) demonstrate that diversity is very large and adapted to regional conditions, but since then few studies have dedicated greater attention to this giant Brazilian region (despite disperse in other surrounding countries). In the beginning of this century, basic agaricology has returned to be the subject of studies, especially from the surveys carried out by Souza and Aguiar (2004) involving the Agaricales of the Walter Egler Reserve, where 39 species are mentioned, but only 6 have been identified to the specific level, being many specimens identified with a cf., aff. or sp.. Souza and Aguiar (2007) describe Marasmius species to the same area. Oliveira et al. (2009) neotypify *Marasmius amazonicus* Henn. Since then, few surveys have been carried out, leaving the immense agaricine flora of the state of Amazonas largely ignored.

3.2 Riparian Vegetation in Southern Brazil - RPAS

The riparian vegetation of the Brazilian Pampa Biome has been scarcely studied in terms of its agaricobiota, with forest formations remaining rare in a predominantly herbaceous/shrub ecosystem. Studying these areas may allow establishing new parameters for the distribution of Fungi. In this sense, 10 riparian forest formations were studied along a 200 km (east to west) transect in the center of Rio Grande do Sul state – Southern Brazil, in seasonal expeditions in 2019 to collect and identify the agaricoid fungi species. 278 new species records for the Brazilian Pampa biome were cataloged, 23 new records for the state of Rio Grande do Sul and 4 new registrations for Brazil (Table 2). Among the families found, there was a higher incidence of *Marasmiaceae* (77 species), followed by *Agaricaceae* (45 species), *Tricholomataceae* (30 species) and *Mycenaceae* (30 species), covering a total of approximately 65% of the collected species (Table 2).

3.3 Saint Hilaire Forest in the Universidade de Goiás (MSH) in Goiânia municipality - Goiás State

From the 86 samples collected, 31 were identified to species level and 51 to genus, the remaining only to family rank (Table 1). The unidentified species were probably new citations or new species to science. Identified species related to the place of occurrence. Table 1 - List of species collected in the forest preserved inside the campus of the Universidade Federal de Manaus (UFAM) and Saint Hilaire Forest in the Universidade de Goiás (MSH) in Goiânia municipality - Goiás State.

3.4 Identified species related to the place of occurrence

Table 1 - List of species collected in the forest preserved inside the campus of the Universidade Federal de Manaus (UFAM) and Saint Hilaire Forest in the Universidade de Goiás (MSH) in Goiânia municipality - Goiás State.

Species	Family	UFAM	MSH
Agaricus dulcidulus Schulz.	Agaricaceae		X
Agaricus sp. 1	Agaricaceae		X
Agaricus sp. 2	Agaricaceae		X
Agaricus sp. 3	Agaricaceae		X
Agaricus sp. nov. 1	Agaricaceae	X	
Agaricus sp. nov. 2	Agaricaceae	X	
Agaricus porphyrizon P.D. Orton	Agaricaceae		X
Agrocybe sp. nov.	Strophariaceae	X	
Bolbitius mexicanus (Murrill) Murrill	Bolbitiaceae		X
Callistosporium luteoolivaceum (Berk. & M.A. Curtis) Singer	Callistosporiaceae	X	
Callistosporium sp.	Callistosporiaceae	X	
Camarophyllopsis tetraspora (Singer) Raithelh.	Clavariaceae	X	
Collybia sp.1	Tricholomataceae		X
Collybia sp.2	Tricholomataceae		X
Collybia sp.3	Tricholomataceae		X
Crinipellis perpusilla (Speg.) Singer	Marasmiaceae		X
Cyptotrama asprata (Berk.) Redhead & Ginns	Physalacriaceae		X
Cystoderma sp. 1	Agaricaceae		X
Cystoderma sp. 2	Agaricaceae		X

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Cystolepiota sp. 1	Agaricaceae		X
Cystolepiota sp. 2	Agaricaceae		X
Entoloma sp. 1	Entolomataceae		X
Filoboletus gracilis (Klotzsch ex Berk.) Singer	Mycenaceae	X	
Filoboletus sp. 1	Mycenaceae		X
Filoboletus sp. 2	Mycenaceae		X
Gerronema sp. 1	Marasmiaceae		X
Gymnopus dryophilus (Bull.) Murrill	Omphalotaceae		X
Hohenbuehelia paraguayensis (Speg.) Singer	Pleurotaceae	X	
Hohenbuehelia testudo (Berk.) Pegler	Pleurotaceae	X	
Hydropus floccipes (Fr.) Singer	Marasmiaceae		X
Hydropus sp. 1	Marasmiaceae		X
Hydropus sp. 2	Marasmiaceae		X
Hydropus sp. 3	Marasmiaceae		X
Hygrocybe sp. 1	Hygrophoraceae		X
Lactocollybia epia (Berk. & Broome)	Marasmiaceae		X
Lactocollybia sp.	Marasmiaceae	X	
Lentinus crinitus (L.) Fr.	Polyporaceae		X
Lentinus sp1	Polyporaceae		X
Lepiota azurea Singer	Agaricaceae	X	
Lepiota brunneoannulata Rick	Agaricaceae	X	
Lepiota colorada A.B. Pereira	Agaricaceae		X
Lepiota micropholis (Berk. & Broome) Sacc.	Agaricaceae	X	X
Lepiota rickiana Speg.	Agaricaceae	X	
Lepiota sp. 1	Agaricaceae		X
Lepiota sp. 2	Agaricaceae		X
Lepista glabella (Speg.) Singer	Tricholomataceae		X
Lepista sordida	Tricholomataceae	X	
Lepista sp. 1	Tricholomataceae		X
Leucoagaricus confusus (Rick) Singer	Agaricaceae	X	X
Leucoagaricus lilaceus Singer	Agaricaceae		X
Leucoagaricus sp. 1	Agaricaceae		X
Leucocoprinus sp. 1	Agaricaceae		X
Leucocoprinus sp. 2	Agaricaceae		X

Leucopaxillus gracillimus Singer & A.H. Sm.	Tricholomataceae		X
Macrolepiota sp.	Agaricaceae	X	
Marasmiellus schiffneri (Bres.) Singer	Omphalotaceae	X	
Marasmiellus spp.	Omphalotaceae	X	
Marasmius bambusiniformis Singer	Marasmiaceae	X	
Marasmius cecropiae Dennis	Marasmiaceae	X	
Marasmius cladophyllus Berk.	Marasmiaceae		X
Marasmius ferrugineus Berk. & Broome	Marasmiaceae		X
Marasmius haematocephalus (Mont.) Fr.	Marasmiaceae		X
Marasmius inaequalis Berk. & M.A. Curtis	Marasmiaceae	X	
Marasmius spp.	Marasmiaceae	X	X
Melanoleuca sp.1	Tricholomataceae		X
Melanophyllum sp.1	Agaricaceae		X
Mycena arcangeliana Bres.	Mycenaceae		X
Mycena epipterygia (Scop.) Gray	Mycenaceae	X	
Mycena sp. 1	Mycenaceae	X	
Mycena sp. 2	Mycenaceae	X	
Mycena spinosissima (Singer) Desjardin	Mycenaceae	X	
Mycobonia flava (Sw.) Pat.	Polyporaceae	X	
Nalonea sp. 1	Entolomataceae		X
Nalonea sp. 2	Entolomataceae		X
Neoclitocybe byssiseda (Bres.) Singer	Tricholomataceae		X
Neopaxillus dominicanus Angelini & Vizzini	Serpulaceae		X
Nolanea pinna (Romagn.) Dennis	Entolomataceae		X
Nothopanus candidissimus (Sacc.) Kühner	Pleurotaceae	X	
Nothopanus eugrammus (Mont.) Singer	Pleurotaceae	X	
Oudemansiella canarii (Jungh.) Höhn.	Physalacriaceae	X	
Oudemansiella steffenii (Rick) Singer	Physalacriaceae		X
Panellus pusillus (Pers. ex Lév.) Burds. & O.K. Mill.	Mycenaceae		X
Panus neostrigosus Drechsler-Santos & Wartchow	Panaceae	X	
Pleurotus albidus (Berk.) Pegler	Pleurotaceae	X	
Pleurotus macropus Bagl.	Pleurotaceae	X	
Pluteus sp. 1	Pluteaceae	X	

Pluteus sp. 2	Pluteaceae		X
Psilocybe sp. 1	Strophariaceae		X
Rhodocybe gilvoides (Rick) Singer	Entolomataceae	X	
Ripartitella brasiliensis (Speg.) Singer	Agaricaceae		X
Rugosospora pseudorubiginosa (Cifuentes & Guzmán) Guzmán & Bandala	Agaricaceae		X
Schizophyllum commune Fr.	Schizophyllaceae	X	X
Schyzophyllum sp.	Schizophyllaceae	X	
Stropharia sp.	Strophariaceae	X	
Tetrapyrgos nigripes (Fr.) E. Horak	Marasmiaceae	X	X
Trichopilus sp. 1	Entolomataceae		X
Trogia cantharelloides (Mont.) Pat	Marasmiaceae	X	X
Volvariella sp. 1	Pluteaceae		X

Source: Authors (2022).

Table 2 – Species collected in the riparian vegetation point 1 to 10 with new citations to the state to Rio Grande do Sul (*) and to Brazil (**).

Species	Family	Autum	Winter	Spring	Summer
Agaricus bisporus (J.E. Lange)	Agaricaceae			1	
Agaricus dennisii Heinem.*	Agaricaceae			4,8	
Agaricus endoxantus Berk. & Br.	Agaricaceae			6,9	
Agaricus purpurellus (Muell.) Muell.*	Agaricaceae			3,5,9	
Agaricus sp	Agaricaceae	5			
Agrocybe puiggarii (Speg.) Singer	Strophariaceae	6			
Agrocybe underwoodii (Murrill) Singer*	Strophariaceae			1	
Agrocybe sp. 1	Strophariaceae			10	
Agrocybe sp. 2	Strophariaceae		2		
Armillariella puiggarii (Speg.) Singer	Physalacriaceae	4		3,6	
Bolbitius mesosporus Singer*	Bolbitiaceae			3	
Bolbitius vitelinus (pers.) Fr.	Bolbitiaceae	4			
Camarophyllus sp. 1	Hygrophoraceae	8			
Campanella alba (Berk. Curt.) Singer	Marasmiaceae			3,9	
Campanella aeruginosa Sing.*	Marasmiaceae			6	
Cantharellus sp..	Cantharellaceae	2			

Chaetocalathus liliputianus (Mont.) Singer	Marasmiaceae	7		4,6	
Cheimonophyllum candidissimum (B. & C.) Sing.	Marasmiaceae	9		3,5,7,10	
Clitocybe dealbata (Sow. ex Fr.) Kummer	Tricholomataceae			5	
Clitocybe radicellata Godey**	Tricholomataceae		2		
Clitopilus scyphoides (Fr.) Singer	Entolomataceae	4			
Clitopilus sp. 1	Entolomataceae	8			
Collybia apiahyna Speg.	Tricholomataceae		6		
Collybia dryophila (Bull. ex Fr.) Kummer	Tricholomataceae			3,4,6,7,8,10	
Collybia jamaicensis (Murr.) Murr.*	Tricholomataceae			4,5,9	
Collybia johnstonii (Murr.) Dennis *	Tricholomataceae			8,9	
Collybia subfumosa Speg.	Tricholomataceae			4,5,6,7,8,10	
Collybia sp. 1	Tricholomataceae		10		
Collybia sp.2	Tricholomataceae	8			
Collybia sp. 3	Tricholomataceae		7		
Collybia sp. 4, sp.5, sp.6, sp.7	Tricholomataceae	5			
Collybia sp. 8	Tricholomataceae	4			
Conocybe pubescens (Gillet) Kuehner	Bolbitiaceae			5	
Conocybe tenera (Schaeff. ex Fr.) Kuehner	Bolbitiaceae			5,6	
Conocybe sp. 1	Bolbitiaceae			2	2
Copelandia sp. 1	Bolbitiaceae	7			
Coprinus disseminatus (Pers.) Gray	Agaricaceae			1,2,3,4,7,8,9	
Coprinus jamaicensis Murr.	Agaricaceae			6	
Coprinus (*Parasola*) *plicatilis* (Curt.: Fr.) Fr.*	Agaricaceae			5,6,7,9,10	
Coprinus sp. 1	Agaricaceae	9			
Coprinus sp. 2	Agaricaceae	6			
Coprinus sp. 3	Agaricaceae	5			
Coprinus sp. 4	Agaricaceae		3		
Crepidotus albidus Ellis & Everh.*	Inocybaceae	7			
Crepidotus quitensis Pat.	Inocybaceae			4,7	
Crepidotus sp. 1	Inocybaceae	9			
Crinipellis macrosphaerigera Singer	Marasmiaceae	6,10			
Crinipellis myrti Pat.	Marasmiaceae			7	
Crinipellis stupparia (Berk. & Curtis) Pat.	Marasmiaceae	3			

Crinipellis sp. 1	Marasmiaceae	10			
Crinipellis sp. 2	Marasmiaceae	7			
Crinipellis sp. 3	Marasmiaceae	1			
Crinipellis stupparia (Berk. & Curtis) Pat	Marasmiaceae	1			
Cyptotrama asprata (Berk.) Redhead & Ginns	Physalacriaceae	3,6,7,8,9		3,4,5,7,8,9	
Cyptotrama sp. 1	Physalacriaceae	5			
Cystoderma sp. 1	Agaricaceae	6			
Cystolepiota albogilva Sing. *	Agaricaceae			3,4,7	
Cystolepiota sp. 1	Agaricaceae	7			
Cystolepiota sp. 2	Agaricaceae	5			
Cystolepiota sp. Nov.	Agaricaceae	5			
Dictyopanus pusillus (Lév.) Singer	Mycenaceae			3,4,5,7,8,9,10	
Dictyopanus sp. 1	Mycenaceae		9		
Entocybe haastii (G. Stev.) Largent	Entolomataceae	8			
Entoloma lampropus (Fries) Hesler	Entolomataceae			6	
Entoloma ripartitoides Horak*	Entolomataceae	6			
Entoloma sp. 1	Entolomataceae	10			
Entoloma sp. 3	Entolomataceae	9			
Entoloma sp. 4	Entolomataceae		8		
Entoloma sp. 5	Entolomataceae		2		
Fayodia sp. 1	Marasmiaceae	5			
Filoboletus gracilis (Klotzsch ex Berk.) Singer	Mycenaceae			2,3,5,6,8	
Filoboletus sp. 1	Mycenaceae	4			
Flammulina velutipes (Curt. ex. Fr.) Singer	Physalacriaceae			8	
Galerina stylifera (Atk.) A.H.Sm. & Sing.*	Hymenogastraceae	4			
Galerina sp. 1	Hymenogastraceae		3		
Gerronema fibula (Fr.) Singer	Marasmiaceae			3,5,10	
Gerronema icterinum (Singer) Singer	Marasmiaceae	8			
Gerronema stuckertii (Speg.) Singer	Marasmiaceae	4			
Gerronema sp. 1	Marasmiaceae	10			
Gerronema sp. 2	Marasmiaceae	4			
Gymnopilus earlei Murrill	Hymenogastraceae		4		
Gymnopilus pampeanus (Speg.) Singer	Hymenogastraceae			3	

Gymnopilus spectabilis (Weinm.) A. H. Smith	Hymenogastraceae			5,6,9	
Gymnopilus sp. 1	Hymenogastraceae	7			
Gymnopilus sp. 2	Hymenogastraceae				4
Gyroporus sp. 1	Gyroporaceae	7			
Hemimycena perone (Berk. & Br.) Pegler	Mycenaceae			5	
Hemimycena sp. 1	Mycenaceae		7		
Hemimycena sp. 2	Mycenaceae		5		
Hohenbuehelia atrocaerulea (Fries) Singer	Pleurotaceae			3,9	
Hohenbuehelia nigra (Schw.) Singer	Pleurotaceae			6	
Hohenbuehelia petalodes (Bull.) Schulzer	Pleurotaceae	3,4,5,8		5	
Hohenbuehelia phalligera (Mont.) Singer	Pleurotaceae			10	
Hohenbuehelia portegna (Spegazzini) Singer	Pleurotaceae			8,10	
Hydropus riograndensis Singer	Marasmiaceae			6	
Hydropus sp. 1, sp. 2	Marasmiaceae	10			
Hydropus sp. 3	Marasmiaceae	7			
Hydropus sp 4, sp.5, sp. 6	Marasmiaceae	5			
Hydropus sp.7	Marasmiaceae	4			
Hydropus sp. 8 Singer	Marasmiaceae	4,7,8,10			
Hygrocybe coccinea (Schaeff.) ex Fr. Kum.*	Hygrophoraceae			4,5,10	
Hygrocybe miniata (Fr.) Kummer	Hygrophoraceae			4,5,6,8	
Hygrocybe viridis Capelari & Maziero *	Hygrophoraceae	3			
Hygrocybe sp. 1, sp. 2, sp. 3	Hygrophoraceae	7			
Hypholoma puiggarii (Speg.) Raithelh.	Strophariaceae	5			
Hypholoma subviride (Berk. & Curt.) Dennis	Strophariaceae	6,7	5	4,7	
Hypholoma sp. 1	Strophariaceae	10			
Hygrocybe viridis (G. Stev.) A.M.	Hygrophoraceae	3			
Laccaria fraterna (Cooke & Mass.) Pegler	Hydnangiaceae			3	
Laccaria laccata (Scop.) Cooke	Hydnangiaceae		9		
Lactocollybia aurantiaca Singer	Marasmiaceae			5,9	
Lactocollybia sp. 1	Marasmiaceae	7			
Lentinus crinitus (L.) Fr.	Polyporaceae			4	
Lentinus velutinus Fr.	Polyporaceae			4,9,10	
Lepiota clypeolaria sensu Rea	Agaricaceae			1,3,6	

Lepiota cf. citrophylla (Berk. & Broome) Sacc	Agaricaceae	5			
Lepiota hypholoma Rick	Agaricaceae	9			
Lepiota lilacea Bres.*	Agaricaceae			9	
Lepiota parvannulata (Lasch. ex Fr.) Gill.	Agaricaceae			3,4,9,10	
Lepiota pseudoignicolor Dennis	Agaricaceae			5,10	
Lepiota serena (Fr.) Sacc.*	Agaricaceae			4,5,6,7,9	
Lepiota sp. 1	Agaricaceae	10			
Lepiota sp 2, sp. 3, sp. 4	Agaricaceae	9			
Lepiota sp. 5, sp. 6	Agaricaceae	8			
Lepiota sp. 7	Agaricaceae	7			
Lepiota sp. 8	Agaricaceae	5			
Lepiota sp. 9	Agaricaceae	4			
Lepiota sp. 10	Agaricaceae			1	
Lepista glabella (Speg.) Sing.	Tricholomataceae		1	4	
Leucoagaricus americanus (Peck) Vellinga*	Agaricaceae			1,4,7	
Leucoagaricus lilaceus Singer	Agaricaceae			3,9	
Leucoagaricus rubrotinctus (Peck) Singer	Agaricaceae	8			
Leucoagaricus sp. 1	Agaricaceae	8			
Leucoagaricus sp. 2	Agaricaceae	7			
Leucocoprinus cepistipes (Sow. ex Fr.) Pat.	Agaricaceae			5	
Leucocoprinus birnbaumii (Corda) Singer	Agaricaceae			9	
Leucocoprinus fragilissimus (Rav.) Pat.	Agaricaceae			5	
Leucocoprinus sp. 1	Agaricaceae	9			
Leucopaxillus brasiliensis (Rick) Sing.&Smith	Tricholomataceae			8	
Leucopaxillus sp. 1	Tricholomataceae		2		
Marasmiellus coilobasis (Berk.) Singer	Marasmiaceae			10	
Marasmiellus defibulatus Sing	Marasmiaceae			3,10	
Marasmiellus eburneus (Theissen) Singer	Marasmiaceae			3,5,7,10	
Marasmiellus inconspicuus Murr.	Marasmiaceae			4,7	
Marasmiellus juniperinus Murr.	Marasmiaceae			5,6,7,8,9	
Marasmiellus picipes (Murr.) Singer	Marasmiaceae			8	
Marasmiellus purpureus (Berk. & Curt.) Murr.	Marasmiaceae			4,8,9	
Marasmiellus pygmaeus (Rick) Sing.	Marasmiaceae			4,6,8,9	

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Marasmiellus subpumilus (Rick) Sing.	Marasmiaceae			9	
Marasmiellus sp. 1	Marasmiaceae	8			
Marasmiellus sp. 2	Marasmiaceae	7			
Marasmiellus sp. 3	Marasmiaceae	3			
Marasmiellus sp. 4	Marasmiaceae	9			
Marasmius asemiformis Singer*	Marasmiaceae	4			
Marasmius berteroi (Lév.) Murr.	Marasmiaceae			3,6,7	
Marasmius cladophyllus Berk.	Marasmiaceae	1		3,5,6,7,8,9	
Marasmius cohortalis Berk.	Marasmiaceae			7,8,9	
Marasmius echinatulus Singer	Marasmiaceae			8,9	
Marasmius ferrugineus (Berk.) Berk. & Curt.	Marasmiaceae	7,8		3,8,9,10	
Marasmius haematocephalus (Mont.)	Marasmiaceae	8		1,2	
Marasmius leoninus Berkeley	Marasmiaceae			5,10	
Marasmius puttemansii Henn.*	Marasmiaceae			5	
Marasmius rhabarbarinus Berk.*	Marasmiaceae			6	
Marasmius rotalis Berk. & Br. **	Marasmiaceae			3,5,9	
Marasmius rubroflavus (Theissen) Singer	Marasmiaceae			4	
Marasmius similis Berk. & Curt.	Marasmiaceae			4	
Marasmius sp. 1, sp. 2, sp. 4	Marasmiaceae	10			
Marasmius sp. 3	Marasmiaceae		10		
Marasmius sp. 5	Marasmiaceae			9	
Marasmius sp. 6	Marasmiaceae	9			
Marasmius sp. 7	Marasmiaceae		8		
Marasmius sp. 8	Marasmiaceae	7			
Marasmius sp. 9, sp. 10	Marasmiaceae		6		
Marasmius sp. 11, sp. 12, sp. 13	Marasmiaceae	5			
Marasmius sp. 14, sp. 15	Marasmiaceae	3			
Marasmius sp. 16	Marasmiaceae	2			
Marasmius sp. 17, sp. 18, sp.19, sp.20	Marasmiaceae	1			
Melanoleuca spegazzinii (Sacc. & Sacc.) Sing.	Tricholomataceae	1			
Melanotus alpiniae (Berk.) Pilát	Strophariaceae	8	4		
Melanotus sp. 1	Strophariaceae	7			
Micromphale sp. 1	Marasmiaceae	7			

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Mycena alcalina Fr.	Mycenaceae			3,4,6,8,9,10	
Mycena basibardis Rick	Mycenaceae			6,8,10	
Mycena citrinella Pers.	Mycenaceae			4,5,6	
Mycena dissiliens (Fr.) Quél.	Mycenaceae			5,9	
Mycena epipterygia (Scop.) Gray **	Mycenaceae	5			4
Mycena leptocephala (Fr.) Gill.	Mycenaceae			3,4,5,8	
Mycena nivea Quél.	Mycenaceae			9	
Mycena pura (Pers.: Fr.) Quél.	Mycenaceae			3,5,7,8,9,10	
Mycena sp. 1, sp. 2, sp. 3	Mycenaceae	10			
Mycena sp. 4	Mycenaceae	9			
Mycena sp. 5	Mycenaceae	8			
Mycena sp. 6, sp. 7	Mycenaceae	7			
Mycena sp. 8, sp. 9, sp. 10	Mycenaceae	6			
Mycena sp. 11, sp. 12	Mycenaceae	5			
Mycena sp. 13	Mycenaceae	4			
Mycena sp. 14	Mycenaceae		2		
Mycobonia flava	Polyporaceae	4,6,7,10	10		
Neoclitocybe byssiseda (Bres.) Sing.	Tricholomataceae	10		4,5,7,8,9	
Neoclitocybe sp. 1	Tricholomataceae	10			
Neoclitocybe sp. 2	Tricholomataceae		9		
Neoclitocybe sp. 3	Tricholomataceae		8		
Neoclitocybe sp. 4	Tricholomataceae	5			
Neoclitocybe sp. 5	Tricholomataceae	6			
Neopaxillus echinospermus (Speg.) Singer	Serpulaceae	7,8		8	
Nolanea pinna (Romagn.) Dennis	Entolomataceae	6,10	3	3,5	
Oudemansiella platensis (Speg.) Speg.	Physalacriaceae	2,5,8,9,10		1,2,3,5,8,9	
Oudemansiella steffenii (Rick) Sing.	Physalacriaceae			2,4	
Oudemansiella sp. 1	Physalacriaceae	2			
Pholiota sp. 1	Strophariaceae	10			
Pholiota sp. 2	Strophariaceae		9		
Pholiota sp. 3	Strophariaceae	6			
Pholiota sp. 4	Strophariaceae				5
Pholiota sp. 5	Strophariaceae	2			

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Pleurocollybia apoda Singer	Tricholomataceae	5			
Pleurotus djamor (Fr.) Boedijn	Pleurotaceae			9	
Pleurotus ostreatus (Jacq. ex Fr.) P. Kummer	Pleurotaceae		5,7	4	
Pleurotus sp. 1	Pleurotaceae	9			
Pleurotus sp. 2	Pleurotaceae				3
Pluteus cervinus (Schaeff.: Fr.) Fr.	Pluteaceae			4	4,9,10
Pluteus glaucotinctus Horak	Pluteaceae	2			
Pluteus iguazuensis Singer	Pluteaceae	6			
Pluteus jamaicensis Murr.*	Pluteaceae			4,8	
Pluteus pulverulentus Murr.*	Pluteaceae	2			
Pluteus viscidulus Singer	Pluteaceae		4		
Pluteus sp. 1	Pluteaceae	10			
Pluteus sp. 2, sp. 3	Pluteaceae	9			
Pluteus sp.4	Pluteaceae	8			
Pluteus sp. 5	Pluteaceae	7			
Pluteus sp. 6	Pluteaceae	4			
Polyporus alveolares (DC.) Bond. & Sing.	Polyporaceae	10			
Polyporus biskeletalis Corner*	Polyporaceae	10			
Polyporus ciliatus Fr. ex Fr.	Polyporaceae			4,7	
Polyporus guianensis Mont.	Polyporaceae	10		4,6,7,8,9	
Polyporus tenuiculus (P. Beauv.) Fr.	Polyporaceae	5,10			5
Polyporus tricholoma Mont.	Polyporaceae			8	
Polyporus sp.1	Polyporaceae		8		
Polyporus sp. 2	Polyporaceae		7		
Polyporus sp. 3	Polyporaceae			2	2
Psathyrella candolleana (Fr.) A. H. Smith	Psathyrellaceae			5,7	
Psathyrella coprinoceps (Berk &Curt.) Dennis	Psathyrellaceae	6,8			
Psathyrella lignatilis Sing. *	Psathyrellaceae		5		
Psathyrella sp. 1	Psathyrellaceae	6			
Psathyrella sp. 2	Psathyrellaceae	3			
Resupinatus subrhacodium Sing.	Tricholomataceae			5	
Schizophyllum sp. 1	Schizophyllaceae		2		
Stropharia sp. 1	Strophariaceae		9		

Tetrapyrgos nigripes (Fr.) E. Horak	Marasmiaceae			2,3,5,6	
Tricholoma sulphureum (Bull.) P. Kumm.	Tricholomataceae	8			
T*richoloma* sp. 1	Tricholomataceae	7			
Tricholoma sp. 2	Tricholomataceae	3			
Trogia cantharelloides (Sacc.) Singer	Marasmiaceae			1,6,10	
Xeromphalina tenuipes (Schwein.) A.H. Sm.	Mycenaceae	2,4		2,4,5,7,9,10	

Source: Authors (2022).

4. Discussion

The predominance of individuals of the *Marasmiaceae* in the Brazilian Pampa was expected, since specimens of this family are found in different studies on fungi for Brazil. Coimbra (2013) analyzed the diversity of Agaricales fungi in the Atlantic Forest area of Pernambuco and verified the presence of 17 species, 36% of which belonged to the *Marasmiaceae* family. Drechsler-Santos *et al.* (2007), in studies in native forest areas of Rio Grande do Sul, analyzed the presence of 22 agaricoid specimens, of which about 40% belong to the *Marasmiaceae*. Souza & Aguiar (2004), in collections in the Amazonian Forest, verified the presence of 49 species of Agaricales fungi, most of them individuals of the *Marasmiaceae*, at that time considered members of the *Tricholomataceae*.

In the studies presented here, the organisms of the represented about 30% of the cataloged species, a lower number than other works, but it is still the family with the highest incidence. There are species that are characterized by their greater resistance to drier environments, since they show reactivation, the ability to stop their growth in times of drought and grow again later when the environment presents a certain humidity (Singer 1986). This character may explain the high rate of species of this family in studies on taxonomy and diversity.

In MUFAM and MSH, the family with the highest occurrence was *Agaricaceae*, family that has a considerable rate of specimens in the Brazilian mycota, with 85 genera and about 1340 species distributed throughout the world (Kirk et al., 2008). This family is characterized by hosting a variety of edible individuals, including some species of the genus *Agaricus*, popularly known as champignons (Wartchow, 2018). Rosa & Capelari (2009) identified 109 species of agaricoids from the Atlantic Forest in Minas Gerais, of which 41.3% belong to the *Agaricaceae*. Filho (2017) collected Agaricales fungi in fragments of the seasonal deciduous forest of Paraná and also identified a high rate belonging to the *Agaricaceae* family. The family is so common in surveys that some authors prefer to work only with this family. For example, a list was published with descriptions of edible species of the *Agaricaceae* family found in a natural regeneration area in Rio Grande do Sul, southern Brazil (Putzke & Putzke 2014). Wartchow *et al*. (2008), Rother & Silveira (2008) and Albuquerque et al. (2010) carried out taxonomic studies with this family in Pernambuco, Rio Grande do Sul and Rio de Janeiro, respectively.

The *Agaricaceae* has a worldwide distribution, with a range of representatives in tropical and temperate regions, as well as in arctic-alpine and desert areas. However, the diversity of individuals in the family has a certain disparity in the occurrence from one region to another (Vellinga 2004), which requires more studies on the specimens of this family found in the Brazilian biomes, to elucidate more information on ecology and diversity of this family in the area.

The Southeast, Northeast and South regions of Brazil lead numbers of research on Agaricales in Brazil, on the other hand, the North and Midwest regions have a reduced number of research on this group of fungi (Carvalho et al., 2022). Agaricales studies for the Cerrado are rare, highlighting some works at specific level. Calaça et al. (2020) presented the first records of the genus *Agrocybe* for the Cerrado biome, represented by the species *A. pediades* (Fr.) Fayod, found in cattle manure in the state of Goiás, central Brazil.

Bononi *et al.* (2017) reported 18 species of basidiomycete fungi not yet cited or listed nationally and 36 species with first citation for the state in the central region of the state of Mato Grosso do Sul (MS), in the Cerrado biome, Braga & Prado (2020) in a review study of species of the Cerrado biome, verified research with reports of new discoveries especially in the states of Goiás, Minas Gerais, Mato Grosso and Mato Grosso do Sul. Some of the findings showed possible biotechnological properties of the isolates found, indicating the need for actions aimed not only at the conservation of the biome, but also more bioprospective research. This reinforces the importance of fungal conservation and the concentration of mycologists in studying the Cerrado.

The most common genera of fungi recorded in this research were *Marasmius* (40 species), *Mycena* (27 species), *Lepiota* (26 species), *Collybia* (17 species), *Marasmiellus* (14 species) and *Pluteus* (14 species). The genus *Marasmius*, the largest number of species in this study, is one of the most diverse of the Agaricales and plays a fundamental ecological role in the tropical regions, given its potential to litter decomposition (Antonín 2007).

In addition, specimens of *Agaricus*, *Cantharellus*, *Flammulina*, *Gymnopilus*, *Macrolepiota*, *Oudemansiella* and *Pleurotus*, known for their edibility, were also identified in the study areas, highlighting the possible biotechnological application and cultivation of the mycota found in the three biomes studied.

Among the collected species, ca. 50% were identified only to the genus level, which requires further studies to confirm new occurrences or the registration of new species to science. Furthermore, from the list, 10% represents new confirmed occurrences for the state of Rio Grande do Sul or Brazil and 99% are cited for the first time for the Pampa biome.

5. Conclusion or Final Considerations

The high number of species mentioned for the first time for the Pampa and Cerrado biomes, mainly, can be explained because there are only a few studies on the Agaricales fungi in these regions of Brazil. Also, areas with a reasonable number of studies, such as the Amazon biome, presented new occurrences not yet reported to science, showing the need for current studies on Agarics in these areas. Therefore, due to the high number of specimens collected in this work, there are indications that the biomes may have a greater diversity of Agaricales fungi, which requires further studies to estimate the richness and diversity of these organisms in the areas. This corroborates the idea that small areas can resume a great fungal diversity, deserving preservation at any coasts.

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References

Albuquerque, M. P., Pereira, A. B., & Carvalho-Junior, A. A. D. (2010). A família Agaricaceae Chevall. em trechos de Mata Atlântica da Reserva Biológica do Tinguá, Nova Iguaçu, Rio de Janeiro, Brasil: gêneros *Agaricus, Cystolepiota* e *Lepiota*. Acta Botanica Brasilica 24(2): 497-509.

Antonín, V. (2007*).* Fungus Flora of Tropical Africa - Monograph of *Marasmius, Gloiocephala, Palaeocephala* and *Setulipes* in Tropical Africa. Vol. 1. Ed. National Botanic Garden, Meise. 196p.

Araújo, I. J. A. (1984). Contribuição ao conhecimento da família Cortinariaceae Roze ex Heim (Agaricales) na Amazônia Brasileira. Tese de doutorado, Instituto Nacional de Pesquisas da Amazônia, Universidade do Amazonas. Manaus, AM. 212p.

Avigliano, E., Rosso, J. J., Lijtmaer, D., Ondarza, P., Piacentini, L., Izquierdo, M., Cirigliano, A., Romano G., Bustos E. N., Porta A., Mabragana E., Grassi E., Palermo J., Bukowski, B., Tubaro, P., & Schenone, N. (2019). Biodiversity and threats in non-protected areas: A multidisciplinary and multi-taxa approach focused on the Atlantic Forest. Heliyon 5(8):1-13.

Bittencourt, F., Karstedt, F., Pulgarín, M. P., Wangenheim, A., & Drechsler-Santos, E. R. (2022). Protocolo de captura de imagens de macrofungos = Protocol to capture macrofungi images [livro eletrônico] Vol. 1. Ed. Officio, Florianópolis. 35p.

Bononi, V. L. R., Oliveira, A. K. M. D., Gugliotta, A. D. M., & Quevedo, J. R. D. (2017). Agaricomycetes (Basidiomycota, Fungi) diversity in a protected area in the Maracaju Mountains, in the Brazilian central region. Hoehnea, 44, 361-377.

Braga, H. F., & do Prado, H. F. A. (2020) Micodiversidade no Cerrado: relatos nos últimos anos. Journal of Biotechnology and Biodiversity 8(4): 339-348.

Brazil Flora Group, Gomes-da-Silva, J., Filardi, F. L., Barbosa, M. R. V., Baumgratz, J. F. A., Bicudo, C. E., ... & Cabral, T. S. (2021). Brazilian Flora 2020: Leveraging the power of a collaborative scientific network. TAXON.

Calaça, F. J. S., Cortez, V. G., & Xavier-Santos, S. (2020). Dung fungi from Brazil: *Agrocybe pediades* (Fr.) Fayod (Basidiomycota) in Cerrado. Scientia Plena 16:1-6.

Caldas, S. R. (2016) Impactos ambientais sobre a floresta da UFAM. Dissertação de Mestrado. Universidade federal do Amazonas, Manaus. 175 p.

Carvalho, S. K. D. A. A., de Morais, I. L., Calaça, F. J. S., & Hannibal, W. (2022). Agaricales no Brasil: um panorama da produção científica, lacunas e tendências. Research, Society and Development 11(3).

Coimbra, V. R. M. (2013). Fungos agaricóides (Agaricales, Basidiomycota) da reserva biológica saltinho, Pernambuco: diversidade e aspectos moleculares. Dissertação de Mestrado. Universidade Federal de Pernambuco, Recife. 80p.

Drechsler-Santos, E. R., Pastorini, L. H., & Putzke, J. (2007). Primeiro relato de fungos Agaricales em fragmento de mata nativa em Frederico Westphalen - RS. Revista Brasileira de Biociências 5:471-473.

Fidalgo O. (1985) A história da Micologia Brasileira. Anais do II Encontro Nacional de Micologia 47- 51.

Filgueiras, T. S., Nogueira, P. E., Brochado, A. L., & Gualall, G. F. (1994) Caminhamento: um método expedito para levantamentos florísticos qualitativos. Cadernos de Geociências 12:39-347.

Filho, A. G. S. S. (2017). Agaricales (basidiomycota) em fragmentos de floresta estacional semidecidual no Oeste do Paraná, Brasil. Dissertação de Mestrado Universidade Federal do Paraná, Curitiba. 190 p.

Hawksworth, D. L., & Luecking R. (2017) Fungal diversity revisited: 2.2 to 3.8 million species. Microbiol Spectr. 5(4).

IBGE. Instituto Brasileiro de Geografia e Estatística (2012). Manual técnico da vegetação brasileira. 2ª ed. Ed. IBGE, Rio de Janeiro. 272p.

Kirk, P., Cannon, P. F., Minter, D. W., & Stalpers, J. A. (2008). Ainsworth & Bisby's Dictionary of the Fungi. 10ª ed., Ed. CABI, Wallingford, 771 p.

Maia, L. C., Melo A., & Cavalcanti, M. A. (2002). Diversidade de fungos no estado de Pernambuco. *In*: Tabarelli M & Silva JMC (eds.) Diagnóstico da Biodiversidade de Pernambuco. Ed. Massangana, Recife. p.15-50.

Metzger, J. P. (2003) Como restaurar a conectividade de paisagens fragmentadas? *In:* Kageyama PY, Oliveira RE; Moraes LFD, Engel, V. L. & Gandara, F. B. (eds) Restauração Ecológica de Ecossistemas Naturais. Ed. FEPAF, Botucatu. p.49-76.

Oliveira, J. J. S., Puccinelli C., Capelari M., & Baseia I. G. (2009). Neotypification of *Marasmius amazonicus*. Mycotaxon 106:227–232.

Putzke, J. (1994). Lista de fungos Agaricales (Hymenomycetes, Basidiomycotina) referidos para o Brasil. Caderno de Pesquisa, serie Botânica 6 (2): 1-189.

Putzke, J., & Putzke, M. T. L. (2013) Os reinos dos fungos. Vol 1. Editora da Universidade de Santa Cruz do Sul, Santa Cruz do Sul. p.606.

Putzke, J., & Putzke, M. T. L. (2018) Cogumelos (fungos Agaricales) no Brasil. Vol 1. Ed. Lupagraf, Santa Cruz do Sul. 521p.

Putzke, J., Enao-Mejía L., Cañón, E. R. P., Fernández, Y. M. N., & Bedoya, T. C. (2020). New citations to the agaricobiota (Fungi – Basidiomycota) in oak forests of the northeastern Colombia. Hoehnea 47:e422019.

Putzke, J., Enao-Mejía, L., Cañón, E. R. P., Fernández, Y. M. N., & Bedoya, T. C. (2021). Madre Monte Natural Conservation Area in the Colombian Andes as Model for Preservation of Fungi in *Quercus humboldtii* forests. Brazilian Archives of Biology and Technology *64:e21210077.*

Putzke, J., Putzke, M. T. L., & Köhler, A. (2014). Notas sobre os fungos Agaricaceae (Agaricales–Basidiomycota) comestíveis encontrados em área em regeneração natural em Santa Cruz do Sul–RS, Brasil. Caderno de Pesquisa 26(3):44-53.

Ribeiro, J. F., & Walter, B. M. T. (2008). As principais fitofisionomias do Bioma Cerrado. *In:* Sano SM, Almeida SP & Ribeiro JF (eds) Cerrado: ecologia e flora. Ed. Embrapa, Planaltina. p.151 -212.

Rosa, L. H., & Capelari, M. (2009). Agaricales fungi From Atlantic Rain Forest Fragments In Minas Gerais, Brazil. Brazilian Journal of Microbiology 40: 846-851.

Rother, M. S., & Silveira, R. M. B. (2008). Família Agaricaceae (Agaricales, Basidiomycota) no Parque Estadual de Itapuã, Viamão, Rio Grande do Sul, Brasil. Revista Brasileira de Biociências: Brazilian Journal of Biosciences 6(3): 259-268.

Sawyer, D., Mesquita, B., Coutinho, B., Almeira, F. B., Figueiredo, I., Lamas, I., Pereira, L. E., Pinto, L. P., Pires, M. O., & Kasecker, T. (2016). Perfil do ecossistema Hotspot de biodiversidade do Cerrado. Critical Ecosystem Partnershop Fund. 520p.

Senn-Irlet, B., Heilmann-Clausen, J., Genney, D., & Dahlberg, A. (2007). Guidance for Conservation of Macrofungi in Europe. Document prepared for The Directorate of Culture and Cultural and Natural Heritage Council of Europe Strasbourg. 39 p.

Serengil, Y., Augustaitis, A., Bytnerowicz, A., Grulke, N., Kozovitz, A. R., Matyssek, R., Müller, G., Schaub, M., Wieser, G., Coskun, A. A., & Paoletti, E. (2011). Adaptation of forest ecosystems to air pollution and climate change: a global assessment on research priorities. Forest Viterbo 4:44-48.

Silva, F. A. B., Maggio, L. P., & Putzke, J. (2020). First report of *Entocybe haastii* (Entolomataceae, Agaricomycetes) from Brazil. Pesquisas, Botânica 74: 337-342.

Singer, R, & Araujo, I. J. S. (1979). Litter decomposition and Ectomycorrhiza in Amazonian forests. 1. A comparison of litter decomposing and ectomycorrhizal Basidiomycetes in latosol-terra-firme rain forest and white podzol campinarana. Acta Amazonica 9(1): 25-41.

Singer, R. (1973). The genera *Marasmiellus*, *Crepidotus*, and *Simocybe* in the Neotropics. Beihefte zur Nova Hedwigia 44: 1-517.

Singer, R. (1976). Marasmiceae (Basidiomycetes - Tricholomataceae). Flora Neotropica 17:1-347.

Singer, R. (1986). The Agaricales in Modern Taxonomy. 4º ed. Ed. Koeltz Scientific Books, Kenzingen. 981p.

Singer, R. (1989). New taxa and new combinations of Agaricales (Diagnoses Novorum Agaricalium IV). Fieldiana Bot. 21: 1-133.

Singer, R., & Aguiar, I. A. (1986). Litter decomposing and ectomycorrhizal Basidiomycetes in an Igapó Forest. Pl. Syst. Evol. 153: 107–117.

Souza, H. Q. D., & Aguiar, I. D. J. A. (2007). Ocorrência do gênero Marasmius Fr.(Tricholomataceae, Agaricales) na Reserva Biológica Walter Egler, Amazonas, Brasil. Acta Amazonica, 37, 27-35.

Souza, H. Q., & Aguiar, I. J. A. (2004). Diversidade de Agaricales (Basidiomycota) na Reserva Biologica Walter Egler, Amazonas, Brasil. Acta Amazonica 34:43-51.

Vargas, N., Gonçalves, S. C., Franco-Molano, A. E., Restrepo, S., & Pringle, A. (2019). In Colombia the Eurasian fungus *Amanita muscaria* is expanding its range into native, tropical *Quercus humboldtii* forests. Mycologia 13:1–14.

Vellinga, E. C. (2004). Genera in the family Agaricaceae: evidence from nrITS and nrLSU sequences. Mycological Research 108:354-377.

Volnec, Z. M., & Dobson, A. P. (2019). Conservation value of small reserves. Conservation Biology 34(1) 66–79.

Wartchow, F. (2018). Breve história da sistemática de Agaricaceae (Fungi) e distribuição no Brasil. Pesquisa e Ensino em Ciências Exatas e da Natureza 2(2): 130-147.

Wartchow, F., Putzke, J., & Cavalcanti, M. A. Q. (2008). Agaricaceae Fr. (Agaricales, Basidiomycota) from areas of Atlantic Forest in Pernambuco, Brazil. Acta Botanica Brasilica 22(1): 287-299.