Contribution to the knowledge of Polypores (Agaricomycetes) in the Amazonian Forest, with 16 new records for the state of Pará, Brazil

Contribuição ao conhecimento dos Políporos (Agaricomycetes) na Floresta Amazônica, com 16 novos recordes para o estado do Pará, Brasil

Contribución al conocimiento de los Polipores (Agaricomycetes) en la Amazonia, con 16 nuevos registros para el estado de Pará, Brasil

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Abstract
We present an inventory of polypore fungi (Basidiomycota; Hymenochaetales and Polyporales) with the aim of knowing the diversity of an area of 8 km^2 of Brazilian Amazon rainforest, in the surroundings of HPP Sílvio Braga, in the west of Pará, where 91 species were collected (545 specimens), with 16 of these new records for the state of Pará, and 1 for America. These numbers tend to increase, given the projected occurrence of 118 species for the area. 87 species were considered occasional or rare, with only four considered frequent and none abundant. The richness observed in the study area was similar to other conservation units in the Amazon, for example, Caxiuanã National Forest (74 species). This observation, added to the potential increase in the number of species, the number of species with low representativeness (relative frequency) and the number of new records for the state, demonstrate the need to expand studies on polypore fungi in the region to learn about their biodiversity and the need for conservation of that area.
Keywords: Basidiomycota; Brazilian Amazonian; Fungi; Polyporales; Hymenochaetales.

Resumo
Apresentamos um inventario de fungos políporos (Basidiomycota; Hymenochaetales e Polyporales) com o intuito de conhecer a diversidade de uma área de 8 km^2 de Floresta Amazônica brasileira, no entorno da UHE Sílvio Braga, no Oeste paraense, onde foram coletadas 91 espécies (545 espécimes), sendo 16 destes novos registros para o estado do Pará, e 1 para América. Estes números tendem a aumentar, visto a projeção de ocorrência de 118 espécies para a área. A maioria das espécies, 87 foram consideradas ocasionais ou raras, sendo somente quatro consideradas frequentes e nenhuma abundante. A riqueza observada na área estudada foi semelhante a outras unidades de conservação na Amazônia, como por exemplo, Floresta Nacional de Caxiuanã (74 espécies). Essa observação, somada ao potencial incremento no número de espécies, e número de espécies com baixa representatividade (frequência relativa) e número de novos registros para o estado, demonstram a necessidade de ampliação dos estudos sobre os fungos políporos na região para conhecimento de sua biodiversidade e a necessidade de conservação dessa área.
Palavras-chave: Basidiomycota; Amazônia brasileira; Fungi; Polyporales; Hymenochaetales.

Resumen
Presentamos un inventario de hongos políporos (Basidiomycota; Hymenochaetales y Polyporales) con el objetivo de conocer la diversidad de un área de 8 km^2 de Selva Amazónica brasileña, en los alrededores de la UHE Sílvio Braga, en el oeste de Pará, donde se encontraron 91 especies. recolectados (545 especímenes), con 16 de estos nuevos registros para el estado de Pará y 1 para América. Estos números tienden a aumentar, ya que se proyecta que 118 especies se encuentren en el área. De la mayoría de las especies, 87 fueron consideradas ocasionales o raras, con solo cuatro consideradas frecuentes y ninguna abundante. La riqueza observada en el área de estudio fue similar a otras

unidades de conservación en la Amazonía, como el Bosque Nacional Caxiuanã (74 especies). Esta observación, sumada al aumento potencial en el número de especies, y el número de especies con baja representación (frecuencia relativa) y el número de nuevos registros para el estado, demuestran la necesidad de ampliar los estudios sobre hongos poliporosos en la región para comprender su biodiversidad y la necesidad de conservación de esta área.
Palabras clave: Basidiomycota; Amazonía brasileña; Fungi; Polyporales; Hymenochaetales.

1. Introduction

Brazilian biodiversity is valued at approximately four trillion dollars, twice the value of the country's gross domestic product (Costanza et al., 2014). The Amazon includes a considerable share of this biodiversity, which is being reduced with the devastation of protected and unprotected areas (Ritter et al., 2017; Singh et al., 2021).

Tropical forests such as the Amazon are ecosystems conducive to the development of a rich assemblage of fungi (Hawksworth & Lücking, 2017), still very little studied, mainly due to the restriction of access to many locations and the limited number of researchers working in the region. Species and their medical and biotechnological properties are disappearing even before they are discovered, causing an inestimable impact on human knowledge (Tabarelli et al., 2004). Thus, a considerable sampling effort is necessary in order to identify ecological patterns and interactions of species of fungi in the Amazon (Gibertoni, 2008; Gibertoni et al., 2016).

Of the 1,050 species of fungi listed for the Brazilian Amazon, 252 are polypores (Basidiomycota, Agaricomycetes), and of these, only 148 species are registered for the state of Pará (Maia et al., 2015). These species are presented by Gomes-Silva et al. (2009) and make up the continuously updated list of Flora do Brasil species (http://floradobrasil.jbrj.gov.br).

The Polypores are macroscopic fungi such as tubular/poroid hymenophore (Ryvarden, 2004; Justos et al. 2017), commonly known as shelf-fungi or as polyporoid fungi, the last one is the most common among specialists in the group. This characteristic has evolved several times within the group, being an example of morphological convergence on the hymenial surface (Hibbett & Binder, 2002), in addition to making them key elements in the dynamics and health of any type of forest ecosystem worldwide from the main function to nature which is the decomposition of dead trees standing or fallen (Boddy & Heilmann-Clausen, 2008; Londsdale et al., 2008; Yang et al. 2021).

Besides the ecological importance, polypores demonstrate biotechnological importance, through the production of cellulose and lignin degrading enzymes, these fungi are used in the textile industry, cleaning tributaries and soil contaminated by oil, pesticide production, among others (Maciel et al., 2010; Lomascolo et al., 2011; Bekai et al. 2012; Tsigain et al. 2022).

Polypore studies in Brazilian Amazon were conducted in the states of Amapá, Amazonas, Pará, Roraima and Rondônia. In Pará, although there are studies on these fungi, all were concentrated at the Estação Científica Ferreira Penna (Caxiuanã National Forest) (1°47′32.3″ S, 51°26′2.5″ W) (e.g., Sotão et al., 1997, 2003, 2009; Gibertoni, 2008; Gibertoni et al., 2013, and Medeiros et al., 2013, 2015), leaving other areas equally important, little or not sampled and, consequently, there is no study of the diversity of polypores in a forest fragment area. Thus, the present study aimed to inventory the species of polypores and determine the frequency of these species in a fragment of Amazon forest in the western state of Pará, Brazil.

2. Methodology

2.1 Study area

The collections were carried out in a fragment of Amazonon forest, along the PA-370 highway, near the Silvio Braga Hydropower Plant (HPP) (2°49'11.49" S, 54°17'56.64" W), popularly known as Curuá-Una hydropower, 68 km southeast of the city center of Santarém, Pará state, northern Brazil.

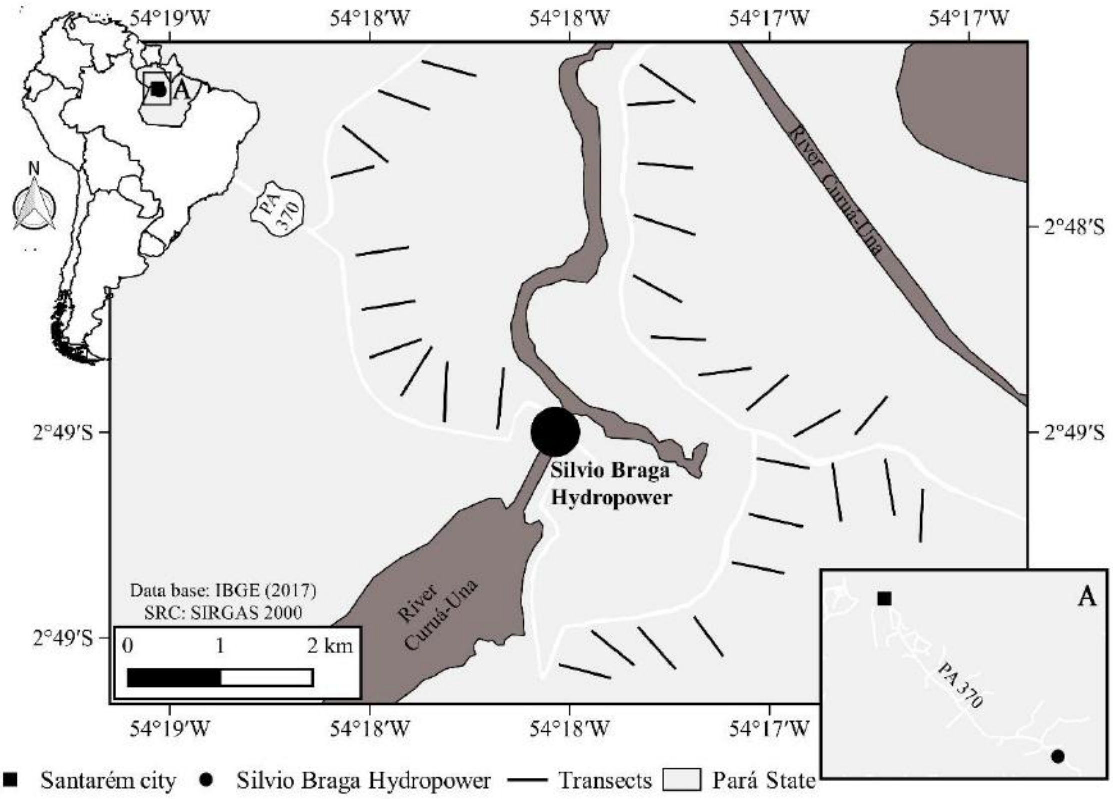
The study area has vegetation cover of dense ombrophylous forest (Veloso et al. 1991) and yellow latosol (Jati & Silva, 2017). Humid tropical climate, with an average temperature of 27 ºC (± 5 ºC). The average relative humidity of the air is

88% and the average annual rainfall is 2,200 mm, with highest rainfall between the months of January to May (rainy season; monthly average of 231 mm) and lower rainfall from August to November (period dry; 61 mm monthly average) (Alvares et al., 2013).

2.2 Colleting, herborizing and identifying of polypores

Excursions to collect polypores fungi were carried out between January 29 to February 4, April 23 to 29, July 28 to August 1 and, October 30 to 31, 2018. In each excursion 30 perpendicular transects of 300 m long were covered, equidistant 250 m from each other from the starting point (Figure 1).

Figure 1 - Location of Silvio Braga HPP (Curuá-Una) with established transects (georeferenced) for the collection of fungi. **A)** Distance Santarém city for Silvio Braga (HPP).



Source: Authors.

The polypore fungi specimens were photographed with the aid of a digital camera (Nikon COOLPIX L820) still on the occurring substrates (living wood, dead wood and soil) to later be removed manually with the aid of chisels, packed individually in paper bags, with date recording, collector type of substrate and collecting coordinates (Garmin GPS, GPSMAP 64S model).

In the Laboratory, the specimens were dehydrated at 35 °C (± 5 °C) in an oven (Ethik, model 404/1D) for a period of two to three days (Fidalgo & Bononi, 1999) and mounted on exsiccates. The polypores were identified by macro and microscopic analysis.

Macroscopic analysis consisted of detailed observations of the basidiomes with the naked eye and/or with the aid of a stereoscopic microscope (Diagtech, model XLT6445T-B2), being analyzed its insertion in the substrate, size (length, width and thickness), color, consistency, characteristics of the surfaces of the pileus and pores, the tubes, context and margin of the basidioma. The color of the basidioma was determined by comparisons with Kueppers' color chart (Kueppers, 1982). Morphological measurements were carried out with an analog caliper.

For microscopic analysis, sections of different parts of the basidiomes (pileus, context and tubes) were made with the aid of a steel blade, under a binocular optical microscope (Nova, model 107-T). The cuts were arranged between slides and coverslips immersed in different aqueous solutions: 3% potassium hydroxide (hydrating), phloxine, methylene blue (dyes) and Melzer reagent to show the reactions of the walls of the microstructure, which can be positive or negative and, which vary according to each species: hyaline (colorless tone, with visible cell wall), amyloid (blue to purple/violet tone) or dextrinoid (gold to reddish tone) (Teixeira, 1995; Ryvarden, 2004). The hyphalic system (monomitic, di-trimitic), reproductive structures (basidia and basidiospores) and sterile structures (cystidia, cystidioles, setae, among others), were also analyzed.

After analysis, the characteristics were compared with the literature in this group of fungi (e.g., Reid, 1965; Ryvarden & Johansen, 1980; Furtado, 1981; Núñez, 1995; Ryvarden, 2004; Dai, 2010; Gomes-Silva et al., 2014, 2015; Ryvarden, 2015, 2016; Costa-Rezende et al., 2016, Palacio et al., 2017). The species classification has been continuously updated according to the Index Fungorum (http://www.indexfungorum.org). The identified fungi were deposited at the HSTM Herbarium of the Universidade Federal do Oeste do Pará (UFOPA).

2.3 Data analysis

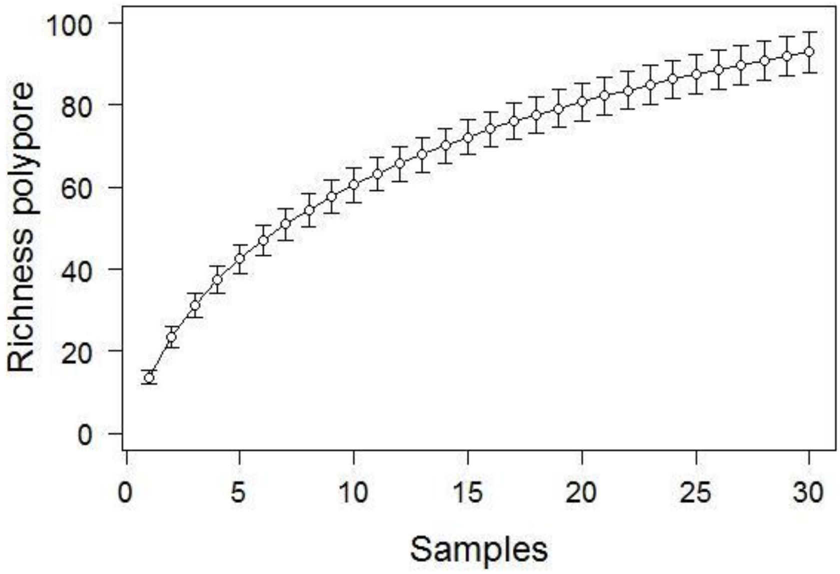
The total and transect diversity was estimated using the Shannon-Wiener index, for reducing the effects of rare species in the sample, considering the relative abundances of individuals per species (Magurran, 2004), the Vegan package (Oksanen et al., 2015) in R 3.5.2 (R Core Team, 2012) was used.

The expected species richness was estimated by Jackknife 1 (Efron & Tibshirani, 1993, Santos, 2004), using the BiodiversityR package (Kindt & Coe 2005) and the *Mao Tau* resampling method (Colwell et al., 2004) to perform the species accumulation curve in the Vegan package (Oksanen et al., 2015). The relative frequency of species (F) was calculated using the function: $F = n / N \times 100$, where (n) is the number of specimens of a species and (N) is the total number of specimens found (Urcelay & Robledo, 2004), considering the following classes frequency: $0.5 \geq F \leq 1.5\%$ = rare; $1.6 \geq F \leq 5\%$ = occasional; $5.1 \geq F \leq 9.9\%$ = frequent; $F \geq 10\%$ = abundant (Soares et al., 2014; Medeiros et al., 2015).

3. Results

A total of 545 polypore specimens were collected. In total 8 families, 45 genera and 91 species were represented (Table 1), of which 16 species are new records for the state of Pará, one of them registered for the first time in America (Table 2). The number of records for the state, considering the study area, tends to increase, since the Jackknife 1 richness estimator predicts the occurrence of 118 species in the study area (24% more than was collected) (Figure 2). Shannon's diversity was 3.30, this diversity is more expressive in the transect 2 with a value reaching 3.12 and lower in the transect 16 with a value of 1.10, revealing the distribution of frequent species.

Figure 2 - Accumulation curve of species of polypore fungi in relation to the number of samples based on the *Mao Tao* method with a 95% confidence interval.



Source: Authors.

Table 1 lists the families and genera with the largest number of representatives, with Polyporaceae being the most representative with 43 species followed by Hymenochaetaceae with 23 species. The most representative genus was *Amauroderma* Murril (Polyporaceae), with 11 species.

The relative frequency of each species indicates 16 species (41%) as occasional and 71 species (40%) as rare. Of these, 30 species (31%) were represented by a single individual. Four species (19%) were classified as frequent and none was considered abundant (Table 1). The four most frequent species were: *Cerrena hydnoides* (Sw.) Zmitr., with 34 specimens, *Trametes elegans* (Spreng.) Fr. with 31 specimens, *Rigidoporus lineatus* (Pers.) Ryvarden with 30 specimens and *Hymenochaete damicornis* (Link) Lév. with 28 specimens. The four species together represent only 23% of the collected specimens.

Table 1 - Number of individuals (N) species classification according to frequency (FC) and type of substrate (SU) observed (LW = living wood, DW=dead wood, SO = soil) referring to polypore from a stretch of Amazon forest, near Silvio Braga HPP (Curuá-Una), Wester of Pará state, Brazil.

Order/Family/Species	N	FC	SU	Voucher Number
Hymenochaetales Oberw.				
Hymenochaetaceae Donk				
Coltricia barbata Ryvarden & A.de Meijer	1	Rare	SO	HSTM 12674
Coltricia cf. *focicola* (Berk. & Curt.) Murrill	2	Rare	SO	HSTM 12679-12680
Coltricia cinnamomea (Jacq.) Murrill	4	Rare	SO	HSTM 12675-12678
Coltricia globispora Gomes-Silva, Ryvarden & Gibertoni	1	Rare	SO	HSTM 12681
Fomitiporia maxonii Murrill	1	Rare	DW	HSTM 12685
Fomitiporia punctata (P. Karst.) Murrill	8	Rare	DW	HSTM 12757-12764
Fomitiporia robusta (P. Karst.) Fiasson & Niemelä	3	Rare	DW	HSTM 12815-13043
Fulvifomes imbricatus L.W. Zhou	1	Rare	DW	HSTM 13133
Fuscoporia callimorpha (Lév.) Groposo, Log.-Leite & Góes-Neto	4	Rare	DW	HSTM 12765-12768
Fuscoporia chrysea (Lév.) Baltazar & Gibertoni	1	Rare	DW	HSTM 12608
Fuscoporia rhabarbarina (Berk.) Groposo, Log.-Leite & Góes-Neto	4	Rare	DW, LW	HSTM 12769-12772
Fuscoporia undulata (Murrill) Bondartseva & S. Herrera	1	Rare	DW	HSTM 12817
Fuscoporia wahlbergii (Fr.) T. Wagner & M. Fisch.	1	Rare	DW	HSTM 12818
Hymenochaete damicornis (Link) Lév.	28	Frequent	SO	HSTM 12773-12800
Hymenochaete luteobadia (Fr.) Höhn. & Litsch.	11	Occasional	DW	HSTM 12801-12811
Hymenochaete rubiginosa (Dicks.) Lév.	1	Rare	DW	HSTM 12812
Inonotus tabacinus (Mont.) G. Cunn.	3	Rare	DW	HSTM 12682-12684
Phellinus fastuosus (Lév.) S. Ahmad	2	Rare	DW, LW	HSTM 12813-12814
Phellinus gilvus (Schwein.) Pat.	20	Occasional	DW	HSTM 12617-12628
Phellinus sp.	1	Rare	DW	HSTM 12629
Phylloporia chrysites (Berk.) Ryvarden	11	Occasional	LW	HSTM 12819-12829
Phylloporia spathulata (Hook.) Ryvarden	3	Rare	SO	HSTM 12830-12832
Polyporales Gäum.				
Cerrena Miettinen, Justo & Hibbett				
Cerrena hydnoides (Sw.) Zmitr.	34	Frequent	DW	HSTM 12914-12947
Fomitopsidaceae Jülich				
Fomitella supina (Sw.) Murrill	1	Rare	DW	HSTM 12913
Fomitopsis roseoalba A.M.S. Soares, Ryvarden & Gibertoni	6	Rare	DW, LW	HSTM 12599-12604
Ranadivia modesta (Kunze ex Fr.) Zmitr.	18	Occasional	DW	HSTM 13107-13124
Meripilaceae Jülich				
Rigidoporus biokoensis (Bres. ex Lloyd) Ryvarden	16	Occasional	DW	HSTM 12833-12848
Rigidoporus lineatus (Pers.) Ryvarden	30	Frequente	DW	HSTM 12849-12878
Meruliaceae Jülich				
Flavodon flavus (Klotzsch) Ryvarden	14	Occasional	DW	HSTM 10790-12368
Mycorrhaphium adustulum (Banker) Ryvarden	1	Rare	DW	HSTM 12888
Podoscypha nitidula (Berk.) Pat.	2	Rare	DW	HSTM 12882-12883
Podoscypha parvula (Lloyd) D.A. Reid	2	Rare	DW	HSTM 12630-12639
Stereopsis hiscens (Berk. & Ravenel) D.A. Reid	3	Rare	SO	HSTM 12884-12886

Stereopsis radicans (Berk.) Reid	1	Rare	SO	HSTM 12887
Phanerochaetaceae Jülich				
Inflatostereum glabrum (Lév.) D.A. Reid	1	Rare	DW	HSTM 12640
Mycorrhaphium adustulum (Banker) Ryvarden	1	Rare	DW	HSTM 12888
Panaceae Miettinen, Justo & Hibbett				
Cymatoderma caperatum (Berk. & Mont.) D.A. Reid	3	Rare	DW	HSTM 12879-12881
Panus neostrigosus Drechsler-Santos & Wartchow	1	Rare	DW	HSTM 13021
Polyporaceae Corda				
Amauroderma aurantiacum (Berk.) Torrend	1	Rare	SO	HSTM 12689
Amauroderma calcigenum (Berk.) Torrend	6	Rare	SO	HSTM 12690-12695
Amauroderma elegantissimum Ryvarden & Iturriaga	1	Rare	SO	HSTM 12696
Amauroderma laccatostiptatum Gomes-Silva, Ryvarden & Gibertoni	1	Rare	SO	HSTM 12605
Amauroderma omphalodes (Berk.) Torrend	8	Rare	SO	HSTM 12697-12704
Amauroderma partitum (Berk.) Wakef.	7	Rare	SO	HSTM 12705-12711
Amauroderma praetervisum (Pat.) Torrend	16	Occasional	DW, SO	HSTM 12712-12727
Amauroderma rude (Berk.) Torrend	3	Rare	SO	HSTM 12728-12730
Amauroderma schomburgkii (Mont. & Berk.) Torrend	12	Occasional	SO	HSTM 12731-12740
Amauroderma sprucei (Pat.) Torrend	9	Occasional	SO	HSTM 12741-12749
Amauroderma subsessile Gomes-Silva, Ryvarden & Gibertoni	1	Rare	DW	HSTM 12606
Atroporus diabolicus (Berk.) Ryvarden	12	Occasional	DW	HSTM 12641-12652
Atroporus rufoatratus (Berk.) Palacio, Reck & Robledo	8	Rare	DW	HSTM 12653-12659
Bresadolia uda (Jungh.) Audet	4	Rare	DW, SO	HSTM 13062-13065
Cerioporus cavernulosus (Berk.) Zmitr.	3	Rare	DW	HSTM 12903-12905
Cerioporus flavus (Sw.) Zmitr.	4	Rare	DW	HSTM 13016-13019
Cerioporus mollis (Sommerf.) Zmitr. & Kovalenko	1	Rare	DW	HSTM 12902
Cerioporus varius (Pers.) Zmitr. & Kovalenko	3	Rare	DW	HSTM 13066-13068
Earliella scabrosa (Pers.) Gilb. & Ryvarden	2	Rare	DW	HSTM 12909-12910
Favolus brasiliensis (Fr.) Fr.	3	Rare	DW	HSTM 12660-12662
Favolus grammocephalus (Berk.) Imazeki	2	Rare	DW	HSTM 13046-13047
Fomes fasciatus (Sw.) Cooke	2	Rare	DW	HSTM 12911-12912
Fomes fomentarius (L.) Fr.	1	Rare	DW	HSTM 12663
Funalia caperata (Berk.) Zmitr. & Malysheva	14	Occasional	DW	HSTM 12889-12901
Ganoderma amazonense Weir	1	Rare	SO	HSTM 12750
Ganoderma australe (Fr.) Pat.	2	Rare	DW	HSTM 12751-12752
Ganoderma resinaceum Boud.	5	Rare	DW	HSTM 12668-12756
Haddowia longipes (Lév.) Steyaert	2	Rare	SO	HSTM 12669-12670
Lentinus crinitus (L.) Fr.	10	Occasional	DW	HSTM 12686-12971
Lentinus velutinus Fr.	7	Rare	DW	HSTM 12972-12978
Lenzites betulina (L.) Fr.	19	Occasional	DW	HSTM 12979-12997
Lopharia cinerascens (Schwein.) G.Cunn.	1	Rare	DW	HSTM 12998
Megasporoporia setulosa (Henn.) Rajchenb.	3	Rare	DW	HSTM 12906-12908
Microporellus dealbatus (Berk. & M.A. Curtis) Murrill	8	Rare	SO	HSTM 12999-13006
Microporellus iguazuensis Rajchenb.	2	Rare	SO	HSTM 13007-13008
Microporellus obovatus (Jungh.) Ryvarden	7	Rare	DW	HSTM 13009-13015
Neodictyopus atlanticae (Mont.) Palacio, Robledo & Drechsler-Santos	2	Rare	DW	HSTM 12664-12665

Neodictyopus gugliottae Palacio, Grassi & Robledo	1	Rare	DW	HSTM 12666
Neofavolus alveolaris (DC.) Sotome & T. Hatt.	2	Rare	DW	HSTM 13044-13045
Nigrofomes melanoporus (Mont.) Murrill	1	Rare	DW	HSTM 13020
Perenniporia medulla-panis (Jacq.) Donk	14	Occasional	DW, LW	HSTM 13022-13035
Perenniporia ochroleuca (Berk.) Ryvarden	4	Rare	DW	HSTM 13036-13039
Perenniporia stipitata Ryvarden	4	Rare	DW	HSTM 13040-13042
Polyporus guianensis Mont.	11	Occasional	DW	HSTM 13048-13058
Polyporus leprieurii Mont.	3	Rare	DW	HSTM 13059-13051
Porogramme albocincta (Cooke & Massee) Gibertoni	3	Rare	LW	HSTM 12671-12673
Pycnoporus sanguineus (L.) Murrill	7	Rare	DW	HSTM 13069-13075
Ranadivia modesta (Kunze ex Fr.) Zmitr.	18	Occasional	DW	HSTM 13107-13124
Trametes elegans (Spreng.) Fr.	31	Frequent	DW	HSTM 13076-13106
Trametes leonina (Klotzsch) Imazeki	1	Rare	DW	HSTM 12667
Trametes pubescens (Schumach.) Pilát	1	Rare	DW	HSTM 13125
Trametes variegata (Berk.) Zmitr., Wasser & Ezhov	17	Occasional	DW	HSTM 12948-12964
Trametes versicolor (L.) Lloyd	4	Rare	DW	HSTM 13126-13129
Trichaptum byssogenum (Jungh.) Ryvarden	2	Rare	DW	HSTM 13130-13131
Trichaptum perrottetii (Lév.) Ryvarden	1	Rare	DW	HSTM 13132

Source: Authors.

The substrates most used by the polypores collected were dead trees, associated with 68 species (70%), the species observed in the soil totaled 23 (24%) and six species (6%) occur in live trees. Five species, which together make up 5% of the samples, were found to colonizing two types of substrates (Table 1).

The 16 new occurrences of polypores for the state of Pará are shown in Table 2 and Figure 3A-O. One of these records is also new for America (Figure 4). They are three species of Hymenochaetales and 13 of Polyporales. Of these, 13 species occur in the domain of the Brazilian Amazon.

Table 2 - New records of polypore fungi for Pará state and their distribution in other Brazilian states and outside America. **States:** AC= Acre, AM = Amazonas, AP = Amapá, BA = Bahia, CE = Ceará, GO = Goiás, MA = Maranhão, MS = Mato Grosso do Sul, MT = Mato Grosso, PE = Pernambuco, PI = Piauí, PR = Paraná, RJ = Rio de Janeiro, RN = Rio Grande do Norte, RO = Rondônia, RR = Roraima, RS= Rio Grande do Sul, SC = Santa Catarina, SE = Sergipe, SP = São Paulo, TO = Tocantins.

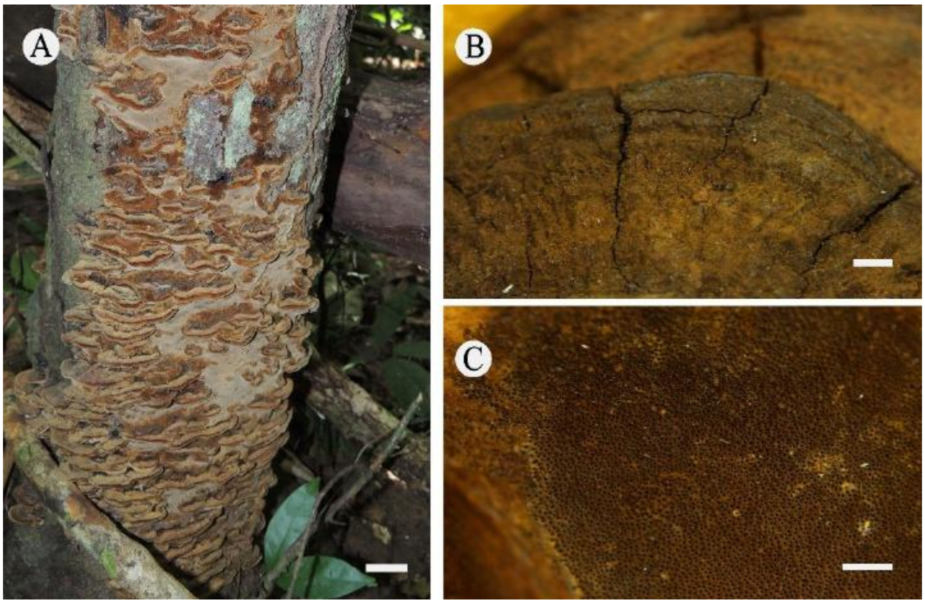
Species	Distribution	Fig.
Amauroderma aurantiacum	GO, RO, SP	3A
Cerioporus mollis	AC, PR, RS, SC, SP	3B
Cymatoderma caperatum	AM, BA, PR, RO, RS, SC, SP	3C
Flavodon flavus	AM, BA, CE, MA, PE, PI, TO	3D
Fomes fomentarius	AM, MG, PE, RJ, SC	3E
Fomitiporia maxonii	AM, PE, RO, RS, SC, SP	3F
Fuscoporia callimorpha	AP, BA, MT, PE, PR, RJ, RO, SC, SE	3G
Fuscoporia chrysea	PE, RO, SC	3H
Inflatostereum glabrum	AM, RR	3I
Lenzites betulina	AP, PR, RS, SC, SP	3J
Neodictyopus atlanticae	PR, SC	3K
Neodictyopus gugliottae	SC	3L
Neofavolus alveolares	RN, RR, RS	3M
Perenniporia ochroleuca	AM, MS, PE, RS, SC, SP	3N
Stereopsis hiscens	AM, PE, PR, RJ, RS, SP	3O
Fulvifomes imbricatus	Thailand	4A-C

Source: Authors.

Figure 3: Basidiomes of the polypores registered for the first time for the state of Pará. A) *Amauroderma aurantiacum*, B) *Cerioporus mollis*, C) *Cymatoderma caperatum*, D) *Flavodon flavus*, E) *Fomes fomentarius*, F) *Fomitiporia maxonii*, **G)** *Fuscoporia callimorpha*, **H)** *F. chrysea*, **I)** *Inflatostereum glabrum*, **J)** *Lenzites betulina*, K) *Neodictyopus atlanticae*, **L)** *N. gugliottae*, **M)** *Neofavolus alveolares*, **N)** *Perenniporia ochroleuca*, **O)** *Stereopsis hiscens*. **Scale bars:** 1 cm.

Source: Authors.

Figure 1: *Fulvifomes imbricatus*, first record for America. **A)** Imbricate basidiomes in the forest, **B)** upper surface, **C)** pore surface poroid. **Scale bars: A =** 5 cm; **B, C =** 1 mm.



Source: Authors.

4. Discusion

Fungal conservation will always be a challenge, given the enormous mycodiversity associated with its undoubted importance for the functioning of ecosystems (Willis, 2018). Although the sampling efforts and the information produced by this study contribute to the knowledge about the diversity, distribution and ecology of the polypores in Amazon, it is still of great importance and need to expand the studies and intensify the collecting and of the taxonomic and systematic studies.

The intensive training of human resources specialized in mycology should be considered to cover the areas insufficiently studied (Maia et al., 2015). Like this study, which registers 51% of the species known in the state of Pará considering the latest surveys such as Flora do Brasil (http://floradobrasil.jbrj.gov.br), Maia et al. (2015), Medeiros et al. (2015). This perspective demonstrates the importance of inventories and incentives for research, especially in areas that have never been explored, such as the one in study.

Shannon index points to a high diversity when compared to other studies in tropical forests, such as Lindblad (2001), Hattori (2005) and Adarsh et al. (2019). In another biome, as in the Atlantic Forest, the diversity is lower according to Komone et al. (2018) in the only study on alpha diversity in Brazil so far.

The studied area shows a great potential for the occurrence of polypores fungi, given the registration of 91 species, 16 of which are new records for Pará state. This Number may be even greater considering the value of 118 estimated. It is worth mentioning that Sotão et al. (2009), Gibertoni et al. (2013) and Medeiros et al. (2015) performed a greater sampling effort in Caxiuanã National Forest, in the same Brazilian state, revealing 87, 96 and 74 species of polypores, respectively. These observations are also important due to the human threat that exists in the study area, such as increasing deforestation in favor of agriculture (Domingues et al., 2014; Villela & Bueno, 2017; Schwarzmueller & Kastner, 2022), electrical transmission network passages that depart from HPP Silvio Braga and opening of roads.

The families Polyporaceae and Hymenochaetaceae are the most diverse among the polypores (Wijayawardene et al., 2020; 2022) and in this study the richest, which corroborates with referenced studies. This result was also corroborated by Gibertoni (2008), Sotão et al. (2009), Gibertoni et al. (2013) and Medeiros et al. (2015) for Caxiuanã National Forest and Xavier et al. (2018), for Serra do Návio, both in Pará and by Soares et al. (2014) for Amapá National Forest, Amapá state.

In tropical areas, polypores are considered to be a diverse group, however, most species can be considered rare or occasional (e.g., Nuñez, 1996; Lindblad, 2001; Gibertoni et al., 2008; Yamashita et al., 2009; Soares et al., 2014; Medeiros et al., 2015). The less abundant or rare species in this study 71 (40%), can be threatened with the risk of disappearing due to the advancement of human activities over natural ecosystems, which highlights the need to conserve the areas where they occur (Raphael et al., 2007; Molina et al., 2011), denoting the growing importance fungal monitoring, particularly from countries with high biodiversity and disproportionate data gaps (Stephenson et al., 2022).

It is convenient to understand the way of life of polypores, as it significantly impacts mycodiversity and its relationship with ecosystems. Although the majority of polypores, mainly from the Polyporaceae and Hymenochaetaceae families, are saprobes and degrade dead trees (Deacon, 2006; Dawson & Jönsson, 2020), some species can be parasitic on live trees, and may even switch to saprobes when they kill the sapwood of the live tree (Agrios, 2005). The species found in the soil, can be associated with the roots of the trees and form ectomycorrhizae (Tedersoo et al., 2007).

Eleven species of *Amauroderma* found in the study area occur in the Amazon domain (Gomes-Silva et al., 2015), being the first report of *A. aurantiacum* for Pará state. *Inflatostereum glabrum*, *Cymatoderma caperatum* and *Stereopsis hiscens* also occur in the Amazon domain (Reid, 1965), but had not been registered in Pará yet. *Neodictyopus atlanticae* and *N. gugliottae* are part of a cryptic species of *Polyporus dictyopus* Mont. with distribution in the Atlantic Forest (Palacio et al., 2017), thus expanding its distribution to the Amazon. *Fomitiporia maxonii*, *Fuscoporia callimorpha* and F. *chryseus* are the only species of new Hymenochaetales records for Pará state, with records in the Atlantic Forest domains (Gomes-Silva &

Gibertoni, 2009; Baltazar & Gibertoni, 2006; Groposo et al., 2007; Westphalen & Silveira, 2013).

Cerioporus mollis, *Flavodon flavus*, *Fomes fomentarius*, *Lenzites betulina*, *Perenniporia ochroleuca*, *Neofavolus alveolaris* are species with wide occurrence in states that contemplate the Atlantic Forest and Caatinga biome (Baltazar & Gibertoni, 2009; Drechsler-Santos et al., 2009), of which the first five occur in the Brazilian Amazon (Gomes-Silva & Gibertoni, 2009).

Fulvifomes imbricatus is mainly distinguished by its imbricated basidiome and double context with a black cuticle, pores of 7–9 per mm and yellow basidiospores, ellipsoids 3.2–4.5 µm. The species examined macroscopically resembles *F. johnsonianus* (murrill) Y.C. Dai and *F. collinus* (Y.C. Dai & Nimeda) Y.C. Dai (Dai, 2010). They differ from *F. collinus* by presenting a substrate projection from 10 to 15 cm while *F. collinus* has a projection of a maximum of 5 cm, in addition it has 5−6 pores on the hymenial surface, whereas in F. imbricatus this variation is up to 9 pores/mm, in addition *F. collinus* does not present a double context.

5. Conclusion

The present study represents an increment to the knowledge of polypores in Pará state, and offer an important contribution to future studies, especially in support of the elaboration of a management and conservation plan for the areas where species occur, an important fact in view of the sustainable exploitation of the areas and tropical forest species.

We observed that the standardization of the sampling effort is a point that must be considered in studies with taxonomic approaches and fungal diversity, and even so, this type of study comes up against difficulties, which reaffirms the importance and need for resampling in the study areas.

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