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

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

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

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Douglas de Moraes Couceiro
ORCID: https://orcid.org/0000-0003-4189-7478
Universidade Federal do Oeste do Pará, Brazil
E-mail: douglasmcouceiro@gmail.com

Adriene Mayra Silva Soares
ORCID: https://orcid.org/0000-0002-1143-0706
Universidade Federal Rural da Amazônia, Brazil
E-mail: adriene_soares@yahoo.com.br

Sheyla Regina Marques Couceiro
ORCID: https://orcid.org/0000-0001-8186-4203
Universidade Federal do Oeste do Pará, Brazil
E-mail: sheylacouceiro@yahoo.com.br

Abstract
We present an inventory of polypore fungi (Basidiomycota; Hymenochaetales and Polyporales) with the aim of knowing the diversity of an area of 8 km² 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 inventário de fungos políporos (Basidiomycota; Hymenochaetales e Polyporales) com o intuito de conhecer a diversidade de uma área de 8 km² 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 km² 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 Caxiuana (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 políporos 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 (Caxiuana 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 °C (± 5 °C). 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 Collecting, 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).

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 hyphal 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.

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. |    |         |     |                |
| Hymenochaetaeae Donk |    |         |     |                |
| *Coltricia barbata* Ryvarden & A.de Meijer | 1  | Rare    | SO  | HSTM 12674     |
| *Coltricia cf. ficicola* (Berk. & Curt.) Murrill | 2  | Rare    | SO  | HSTM 12679-12680 |
| *Coltricia cinnaeomea* (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     |
| *Fusccoporia callimorphia* (Lév.) Groppo, Log.-Leite & Gôés-Neto | 4  | Rare    | DW  | HSTM 12765-12768 |
| *Fusccoporia chrysea* (Lév.) Baltazar & Gibertoni | 1  | Rare    | DW  | HSTM 12608     |
| *Fusccoporia rhabarbarina* (Berk.) Groppo, Log.-Leite & Gôés-Neto | 4  | Rare    | DW, LW | HSTM 12769-12772 |
| *Fusccoporia undulata* (Murrill) Bondartseva & S. Herrera | 1  | Rare    | DW  | HSTM 12817     |
| *Fusccoporia walhbergii* (Fr.) T. Wagner & M. Fisch. | 1  | Rare    | DW  | HSTM 12818     |
| *Hymenochaetae damicorns* (Link) Lév. | 28 | Frequent | SO  | HSTM 12773-12800 |
| *Hymenochaetae lateobadia* (Fr.) Höhn. & Litsch. | 11 | Occasional | DW  | HSTM 12801-12811 |
| *Hymenochaetae 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     |
| *Phlyloporia chrysitis* (Berk.) Ryvarden | 11 | Occasional | LW  | HSTM 12819-12829 |
| *Phylloporia spathulata* (Hook.) Ryvarden | 3  | Rare    | SO  | HSTM 12830-12832 |
| Polyponales Gäum. |    |         |     |                |
| Cerrena Mettinen, 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 biokoenis* (Bres. ex Lloyd) Ryvarden | 16 | Occasional | DW  | HSTM 12833-12848 |
| *Rigidoporus lineatus* (Pers.) Ryvarden | 30 | Frequent | DW  | HSTM 12849-12878 |
| Meruliaceae Jülich |    |         |     |                |
| *Flavodon flavus* (Klotzsch) Ryvarden | 14 | Occasional | DW  | HSTM 10790-12368 |
| *Myccorrhaphium adustum* (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 |
| Species                                                      | Frequency | Host Type | Accession Number |
|--------------------------------------------------------------|-----------|-----------|-----------------|
| Stereopsis radicans (Berk.) Reid                             | Rare      | SO        | HSTM 12887      |
| Panaceae Miettinen, Justo & Hibbett                          |           |           |                 |
| Microporellus obovatus                                      |           |           |                 |
| Microporellus dealbatus                                      |           |           |                 |
| Lentinus velutinus                                           |           |           |                 |
| Lentinus crinit                                              |           |           |                 |
| Haddowia longipes                                            |           |           |                 |
| Ganoderma australi-a                                         |           |           |                 |
| Fomes fomentarius                                            |           |           |                 |
| Earliella scabrosa                                           |           |           |                 |
| Cerioporus cavernulosus                                     |           |           |                 |
| Cerioporus flavus                                            |           |           |                 |
| Cerioporus mollis                                            |           |           |                 |
| Cerioporus varius (Pers.) Zmitr.                            |           |           |                 |
| Earliella scabrosa                                           |           |           |                 |
| Favolus brasiliensis                                        |           |           |                 |
| Favolus grammaocephalus                                      |           |           |                 |
| Fomes fasciatus (Sw.) Cooke                                 |           |           |                 |
| Fomes fomentarius                                            |           |           |                 |
| Fanalia caperata (Berk.) Zmitr.                             |           |           |                 |
| Ganoederma amazonense                                        |           |           |                 |
| Ganoederma australe                                          |           |           |                 |
| Ganoederma resinaeum                                         |           |           |                 |
| Haddowia longipes (Lév.) Steyaert                           |           |           |                 |
| Lentinus crinit                                              |           |           |                 |
| Lentinus velutinus                                           |           |           |                 |
| Lenzites betulina                                            |           |           |                 |
| Lopharia cinerascens                                         |           |           |                 |
| Megasporoporia setulosa                                      |           |           |                 |
| Microporellus dealbatus                                      |           |           |                 |
| Microporellus ignazensis                                    |           |           |                 |
| Microporellus obovatus                                       |           |           |                 |
| Neodictyopus atlanticae                                      |           |           |                 |

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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. gagliottae*, 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. Discussion

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; Schwarzmüller & Kastner, 2022), electrical transmission network passages that depart from HPP Silvio Braga and opening of roads.

The families Polyporaceae and Hymenochaetaeae 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 Hymenochaetaeae families, are saprobes and degrade dead trees (Deacon, 2006; Dawson & Jónsson, 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, Fuscospora callimorpha and F. chrysea 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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