






Notes on *Fomitiporia* Murrill in Amazon region: a list of species and new records

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Abstract

Twenty-three specimens of the fungi genus *Fomitiporia* Murrill collected during the rainy season in the Amazonian region of Amazonas and Roraima states, Brazil. Eight species were listed, namely *F. apiahyna* s. l. (Speg.) Robledo, Decock & Rajchenb., *F. calkinsii* (Murrill) Vlasák & Kout, *F. conyana* Alves-Silva & Drechsler-Santos, *F. impercepta* Morera, Robledo & Urcelay, *F. langloisii* Murrill, *F. maxonii* Murrill, *F. murrillii* Alves-Silva, R.M. Silveira & Drechsler-Santos, and *F. neotropica* Camp.-Sant., Amalfi, R.M. Silveira, Robledo & Decock. Our new data includes the first records of species from the Amazonian region, Brazil, and the Americas.

Keywords

Brazil, Hymenochaetaceae, Neotropical species, taxonomy

Academic editor: Claudia López Lastra | Received 26 November 2020 | Accepted 31 December 2020 | Published 1 March 2021

Citation: Silva MA, Jesus MA, Peres RS, Sales-Campos C (2021) Notes on *Fomitiporia* Murrill in Amazon region: a list of species and new records. *Check List* 17 (2): 323–331. <https://doi.org/10.15560/17.2.323>

Introduction

The fungi genus *Fomitiporia* Murrill was proposed by Murrill (1907) with *F. langloisii* Murrill as its type species. *Fomitiporia* was later synonymized with *Phellinus* Quél. (Rivarden 1991). Using morphological and molecular data, Fischer (1996) proposed giving generic status for the group containing *P. robustus* (P. Karst.) Bourdot & Galzin and used *Fomitiporia* as the genus for this group. Thus, *Fomitiporia* is distinct from *Phellinus*. Later studies by Wagner and Fischer (2001, 2002) confirmed that European *Phellinus* was polyphyletic and

that *P. robustus* belongs to a separate genus, *Fomitiporia*, as proposed by Fischer (1996).

Several poroid macrofungi taxa have been reclassified based on morphological and molecular data (Fiasson and Niemelä 1984; Fischer 1996, 2002; Wagner and Fischer 2001, 2002; Decock et al. 2005; Decock et al. 2007). Macrofungi presenting resupinate, effused-reflexed or pileate basidiomata, a poroid hymenophore with or without hymenial setae, a dimitic hyphal system, and cynophylous, dextrinoid, and thick-walled basidiospores were

reclassified as *Fomitiporia* (Fischer 1996; Decock et al. 2005, 2007). Species of this genus grow on wood of both live and dead trees in temperate or tropical regions and cause white rot (Fischer 2002; Raymundo et al. 2012; Cloete et al. 2014; Ota et al. 2014).

There are currently about 90 species names catalogued in the Index Fungorum (2020), although 20 names are synonymized in other genera. Of the accepted species, 16 occur in Brazil: *F. atlantica* Alves-Silva, Reck & Drechsler-Santos, *F. apiahyna* (Speg.) Robledo, Decock & Rajchenb., *F. bambusarum* (Rick) Camp.-Sant. & Decock, *F. bambusipileata* Alves-Silva, Drechsler-Santos & R.M.B. Silveira, *F. conyana* Alves-Silva & Drechsler-Santos, *F. elegans* (J.E. Wright & Blumenf.) Alves-Silva, Robledo & Drechsler-Santos, *F. flavomarginata* Murrill, *F. maxonii* Murrill, *F. murrillii* Alves-Silva, R.M. Silveira & Drechsler-Santos, *F. neotropica* Camp.-Sant., Amalfi, R.M. Silveira, Robledo

& Decock, *F. nubicola* Alves-Silva, Bittencourt & Drechsler-Santos, *F. sanctichampagnatii* G. Coelho, R.M. Silveira & Rajchenb., *F. subtilissima* Alves-Silva, Reck & Drechsler-Santos, *F. spinescens* J.E. Wright & G.Coelho, *F. uncinata* (Rajchenb.) G. Coelho, Guerrero & Rajchenb., and *F. undulata* Murrill; the most occurrence in the Northeast, Southeast, and South regions (Loguercio-Leite et al. 2008; Baltazar and Gibertoni 2009; Coelho et al. 2009; Westphalen and Silveira 2012; Campos-Santana et al. 2014; Li et al. 2016; Alves-Silva et al. 2020a, 2020b). Prior to 2010, Brazilian species of *Fomitiporia* were known only by morphological data, and *F. flavomarginata*, *F. punctata* (P. Karst.) Murrill, and *F. undulata* were wrongly reported. These two species do not belong to the Neotropical species clade in fact have a restricted geographic distribution (Decock et al. 2007; Amalfi and Decock 2013; Alves-Silva et al. 2020a, 2020b). In the Amazonia region, Gomes-Silva

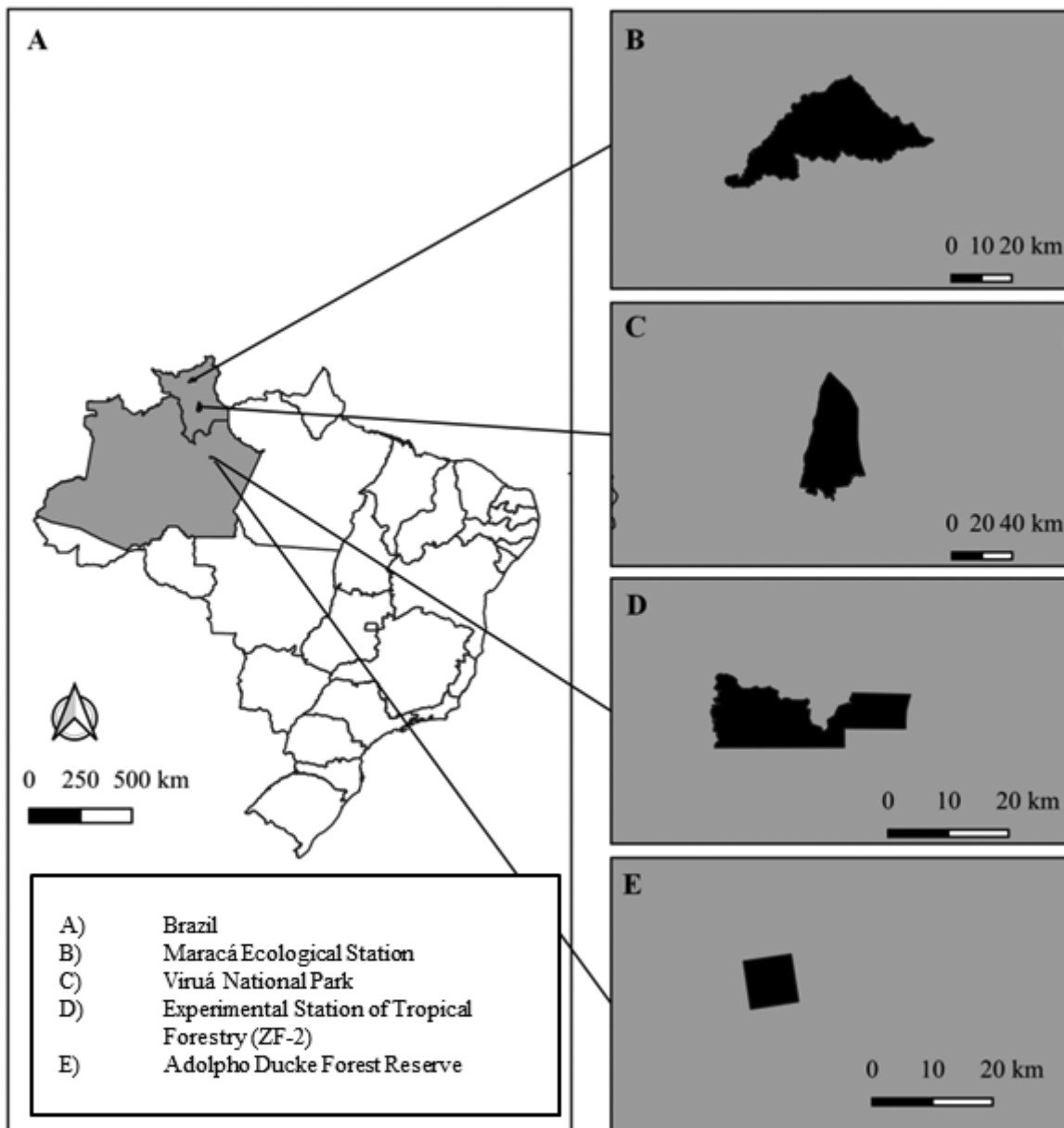


Figure 1. The sampling sites in the Maraca Ecological Station, Virúá National Park, Experimental Station of Tropical Forestry (ZF-2), and Adolpho Ducke Forest Reserve, Brazil.

and Gibertoni (2009) continued to consider *P. punctata* as occurring in Amapá state, but this species was wrongly identified and is not a Neotropical species. The occurrence of *Fomitiporia* in the Amazonian region is still mostly unknown.

The Amazon region has an extensive, humid, highly biodiverse, broadleaf forest which is one of the six major biomes in Brazil. The Amazon biome, with half of the remaining tropical forests anywhere, is the largest biome and bears the greatest biodiversity on Earth (Aragão 2012). Nevertheless, there are few studies on poroid macrofungi from the Amazon region. To increase knowledge of *Fomitiporia* species in the Amazonian region, Brazil, we report new occurrence data on eight species from the states of Amazonas and Roraima.

Methods

Fomitiporia specimens were collected from 2016 to 2017, in the Brazilian states of Amazonas and Roraima at four localities: Adolph Ducke Forest Reserve and Tropical Silviculture Experimental Station (Zona Franca-2) in Amazonas, and Maracá Ecological Station and Viruá Nacional Park in Roraima (Fig. 1). Specimens were photographed with a scale, then removed by hand or with the aid of a pocketknife (Fidalgo and Bononi 1989). They were packed in separate paper bags, and site data, include date, collector, habitat, and characters of the basidiomata (shape, consistency, mode of insertion in the substrate, color, and dimensions) were recorded following Robledo and Urcelay (2009). The specimens were dried at ca. 40 °C for 48–72 h. We deposited all fungal exsiccates at the Instituto Nacional de Pesquisas da Amazônia Herbarium (INPA).

After drying, the length, width, and thickness of basidiomata was noted, as well as characters of the hymenophore, including pileus surface, pores, the number of tube layers, and the consistency of the basidiomata. Measurements were made with a ruler or calipers, and the color was determined with the aid of Kueppers' (1982) Color Atlas.

Microscopic structures, including hyphal system, basidiospores, and sterile elements (setae, cystidia), were characterized and measured under a micrometer eyepiece (Teixeira 1995). Melzer's reagent (IKI) was used to check the dextrinoid or amyloid reaction of basidiospores and/or hyphae. The slides were mounted with KOH 3% to determine the xanthochroic condition. Additionally, the slides were pigmented with cotton blue to confirm the cyanophilic reaction. Microstructure was illustrated from photographs taken with a microscope-coupled camera (LEICA DM500).

Results

Twenty-three specimens were collected in the Brazilian Amazon. They are represented by eight species of *Fomitiporia*: *F. apiahyna*, *F. calkinsii* (Murrill) Vlasák

& Kout., *F. conyana*, *F. impercepta* Morera, Robledo & Urcelay, *F. langloisii* Murrill, *F. maxonii*, and *F. murrillii*, *F. neotropica*.

Fomitiporia apiahyna (Speg.) Robledo, Decock & Rajchenb. (s.l.)

Material examined. BRAZIL – Amazonas • Manaus, Adolph Ducke Forest Reserve; 03°00'27"S, 059°53'59"59"W, 92 m alt.; 23.IV.2016; M.A. Silva leg.; INPA 286222.

Identification. This species is easily identified as *F. apiahyna* s.l. by the following characters: basidiome perennial, ungluate (Fig. 2A) with hymenophoral surface and pores circular to angular, 5–7 per mm (Fig. 2A); context woody, yellowish brown (Fig. 2A); hyphal system dimitic, with generative hyphae hyaline, thin-walled, septate (Fig. 4A); skeletal hyphae abundant, yellowish, thick-walled, nonseptate (Fig. 4A); basidiospores dextrinoid, subglobose, hyaline, thick-walled, 6–7.5 × 5.8–6 µm (Fig. 4A).

Remarks. *Fomitiporia apiahyna* is a worldwide species, but curiously there are few records in Neotropics (Ryvarden 2004). Alves-Silva et al. (2020b) corroborated this hypothesis and found that the geographical distributions of species in this complex are extremely important in their classification. *Fomitiporia apiahyna* (sensu stricto) is not part of the clade of species in the Amazon region; it is restricted to Araucária Moist Forest ecoregion. Our specimens have a basidiospores that are larger on average (6–7.5 × 5.8–6 µm) than in *F. conyana* (5–5.5 × 4–5 µm), *F. murrillii* (5–6 × 5–6), and *F. nubicola* (5–6 × 5–6). Thus, we classify our specimens as *F. apiahyna* s.l., as *F. apiahyna* s.s. is not part of the clade containing Amazonian species. Our specimens may represent a distinct lineage and potentially a new species in the complex, but phylogenetic studies are needed to prove this hypothesis.

Distribution. *Fomitiporia apiahyna* s.l. was reported from southern Brazil, Argentina, Ecuador, Panama, Costa Rica, Mexico, and Florida (Amalfi and Decock 2013). According Amalfi and Decock (2013) there is one record in the Amazon region, in French Guiana. However Alves-Silva et al. (2020b) had shown that this record was actually *F. conyana*.

Fomitiporia calkinsii (Murrill) Vlasák & Kout.

Material examined. BRAZIL – Amazonas • Manaus, Adolph Ducke Forest Reserve; 03°00'27"S, 059°53'59"59"W, 92 m alt.; 28.IV.2017; M.A. Silva leg.; INPA 286221.

Identification. Vlasák and Kout (2011) described *F. calkinsii* as follows: basidiome perennial, flattened (Fig. 2B), surface hymenophoral with circular pores 6–8 per mm (Fig. 2B); context zoned, reddish-brown (Fig. 2B); hyphal system dimitic, with generative hyphae hyaline, thin-walled, septate (Fig. 4 B); skeletal hyphae yellowish, thick-walled, nonseptate (Fig. 4B); basidiospores

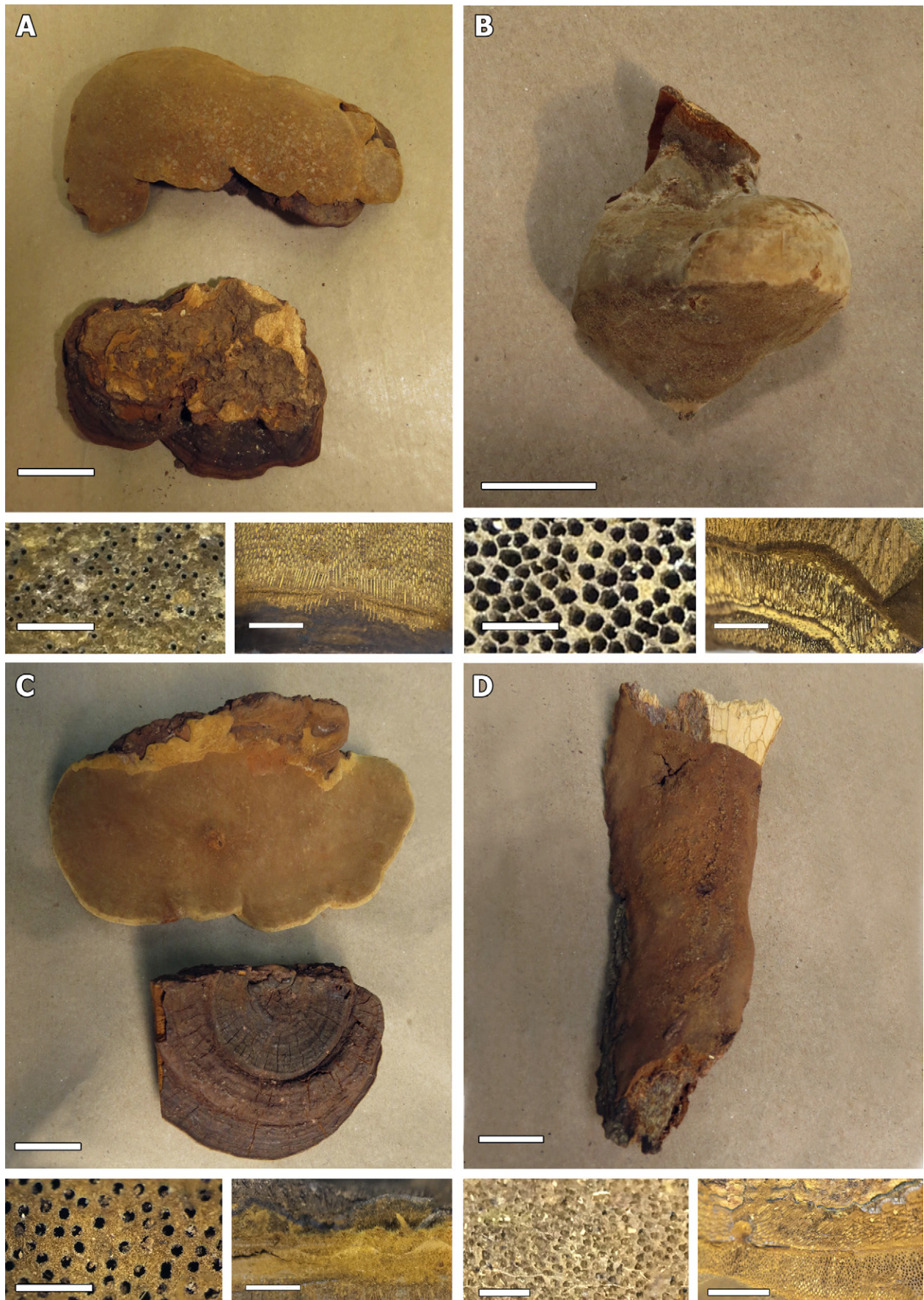


Figure 2. Macroscopic structures (hymenophore, pileal region, pores of hymenophore, tubes and context). **A.** *Fomitiporia apiahynat*. **B.** *F. calkinsii*. **C.** *F. conyana*. **D.** *F. impercepta*.

dextrinoid, subglobose, hyaline, thick-walled, $5\text{--}6.5 \times 5\text{--}6 \mu\text{m}$ (Fig. 4B).

Remarks.. *Fomitiporia calkinsii* is morphologically and physiologically very close to *F. apiahyna* and *F. castilloi* Decock & Amalfi (Amalfi and Decock 2013). However, some characteristics distinguish them. In *F. castilloi* arrows and black lines are present on the hymenial surface, while in *F. apiahyna* has smaller basidiospores ($5\text{--}6 \times 4\text{--}5 \mu\text{m}$ vs. $5\text{--}6.5 \times 5\text{--}6 \mu\text{m}$ in *F. calkinsii*) (Ryvarden 2004; Decock and Amalfi 2013). Our specimen has 5–6 pores per mm, while Amalfi and Decock (2013) reported 7–8 pores per mm, Vlasák and Kout (2011) reported 6–8 pores per mm. The context in our specimen presents some discontinuous black lines, as noted by Vlasák and Kout (2011), which corroborates the identification of our material. Recent studies show that this species has a geographical distribution restricted to Mexico and the USA (Decock and Amalfi 2013). The morphological characteristics of our samples are consistent with *F. calkinsii*; however, the molecular study by Decock and Amalfi (2013) has shown that *F. calkinsii* does not belong to the Neotropical species clade, which is crucial, as biogeography is an important criterion of classification (Alves-Silva et al. 2020a). Therefore, a more indepth study, including molecular data, might show that our sample actually represents a new species.

Distribution. *Fomitiporia calkinsii* was described only for Mexico and USA (Vlasák and Kout 2011; Decock and Amalfi 2013). Our new data represents the first record from South America.

Fomitiporia conyana Alves-Silva & Drechsler-Santos

Material examined. BRAZIL – Amazonas • Manaus, Tropical Silviculture Experimental Station ZF-2; $02^{\circ}35'29.0''\text{S}$, $060^{\circ}12'54.4''\text{W}$, 92 m alt.; 21.VI.2016; M. A. Silva leg.; INPA 226229, INPA 226230 – Roraima • Caracarái, Viruá National Park; $01^{\circ}30'36''\text{N}$, $060^{\circ}42'59''\text{W}$, 85 m alt.; 10.VII.2017; M.A. Silva leg.; INPA 286210, 226211 • ibid., 21.VIII.2018; M.A. Silva leg.; INPA 286228 • ibid., 22.VIII.2018; M.A. Silva leg.; INPA 286212.

Identification. As in the description by Alves-Silva et al. (2020b), our specimens present the following: basidiome perennial and appanate to convex (Fig. 2C); hymenophoral surface with circular pores 7–8 per mm (Fig. 2C); context homogeneous, yellowish-brown (Fig. 2C); hyphal system dimitic, with generative hyphae hyaline, thin-walled, simple-septate (Fig. 4C); hyphae skeletal, thick-walled, nonseptate (Fig. 4C); basidiospores dextrinoid, hyaline, globose, thick-walled, $5\text{--}6 \times 4\text{--}5 \mu\text{m}$ (Fig. 4C).

Distribution. *Fomitiporia conyana* is reported for Ecuador, French Guiana, and Brazil, where it occurs in the states of Mato Grosso (Cerrado and the Xingu-Tapajos), Santa Catarina, and Bahia. There is no record from Amazonas and Roraima, and our records are the first from these states.

Fomitiporia impercepta Moreira, Robledo & Urcelay

Material examined. BRAZIL – Roraima • Caracarái, Viruá National Park; $01^{\circ}30'36''\text{N}$, $060^{\circ}42'59''\text{W}$, 85 m alt.; 11.VII.2017; M.A. Silva leg.; NPA 286215 • ibid., 10.VII.2018; M.A. Silva leg.; INPA 286214 – Amazonas • Manaus, Tropical Silviculture Experimental Station ZF-2; $02^{\circ}35'29.0''\text{S}$, $060^{\circ}12'54.4''\text{W}$, 92 m alt.; 02.III.2016; M.A. Silva leg.; INPA 286224 • 03.III.2016; M.A. Silva leg.; INPA 286223, INPA 286227 • ibid., 08.VI.2016; M.A. Silva leg.; INPA 286226.

Identification. Our specimens were identified as *F. impercepta* based on the characters given by Moreira et al. (2017): basidiome perennial, resupinate (Fig. 2D); hymenophoral surface with circular to ellipsoid pores, 6–8 per mm (Fig. 2D; context homogeneous, golden (Fig. 2D); hyphal system dimitic, with generative hyphae hyaline to slightly yellowish, thin-walled, septate (Fig. 4D); skeletal hyphae pale brown, thick-walled, nonseptate (Fig. 4D); basidiospores dextrinoid, globose to obvoid, Cyaline, thick-walled, $4\text{--}6 \times 3\text{--}5 \mu\text{m}$ (Fig. 4D).

Remarks.. According to Moreira et al. (2017). *F. impercepta* is morphologically similar to *F. neotropica* and part of the “Neotropical resupinate” clade, but *F. neotropica* is annual and *F. impercepta* is perennial. *Fomitiporia impercepta* is also morphologically similar to *F. punctata*; however, this species is not a Neotropical species.

Distribution. *Fomitiporia impercepta* is only reported from Argentina and French Guiana, so our records are the first from Brazil.

Fomitiporia langloisii Murrill

Material examined. BRAZIL – Roraima • Caracarái, Viruá National Park; $01^{\circ}30'36''\text{N}$, $060^{\circ}42'59''\text{W}$, 85 m alt.; 06.X.2017; M.A. Silva leg.; INPA 286209.

Identification. This species is characterized by the following: basidiome perennial, effused-reflexed (Fig. 3A); hymenophoral surface with circular to angular pores, 6–7 per mm (Fig. 3A); context homogeneous, thin, yellowish brown (Fig. 3A); hyphal system dimitic, with generative hyphae hyaline, thin-walled, septate (Fig. 4E); skeletal hyphae yellowish, thick-walled, nonseptate (Fig. 4E); basidiospores dextrinoid, globose, hyaline, thick-walled, $6.5\text{--}5 \times 6\text{--}6.2 \mu\text{m}$ (Fig. 4E).

Distribution. This species is known to occur in North America (Murrill 1907; Decock et al. 2007), and our record, therefore, is first from South America.

Fomitiporia maxonii Murrill

Material examined. BRAZIL – Roraima • Amajari, Maracá Ecological Station, $03^{\circ}23'12.6''\text{N}$, $061^{\circ}41'24.3''\text{W}$, 88 m alt.; 27.X.2009; M.A. Jesus leg.; INPA 286219.

Identification. According to Ryvarden (2004) this species has the following characters: basidiome perennial, resupinate (Fig. 3B); hymenophore with circular to angular pores, 4–7 per mm (Fig. 3B); context homogeneous, thin, yellowish brown (Fig. 3B); hyphal system dimitic, with generative hyphae hyaline, thin-walled, septate

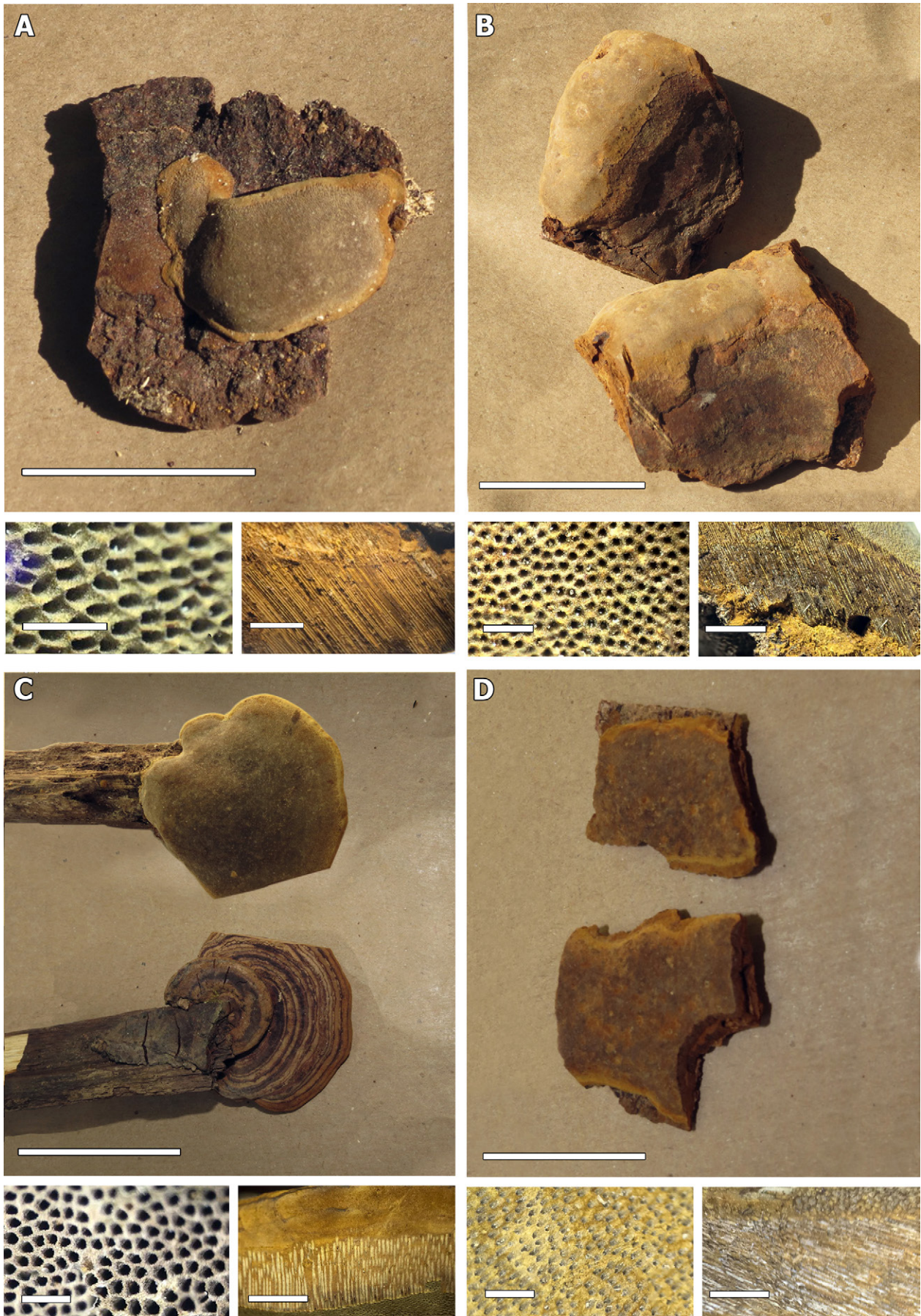


Figure 3. Macroscopic structures (hymenophore, pileal region, pores of hymenophore, tubes and context). **A.** *Fomitiporia langloisii*. **B.** *F. maxonii*. **C.** *F. murrillii*. **D.** *F. neotropica*.

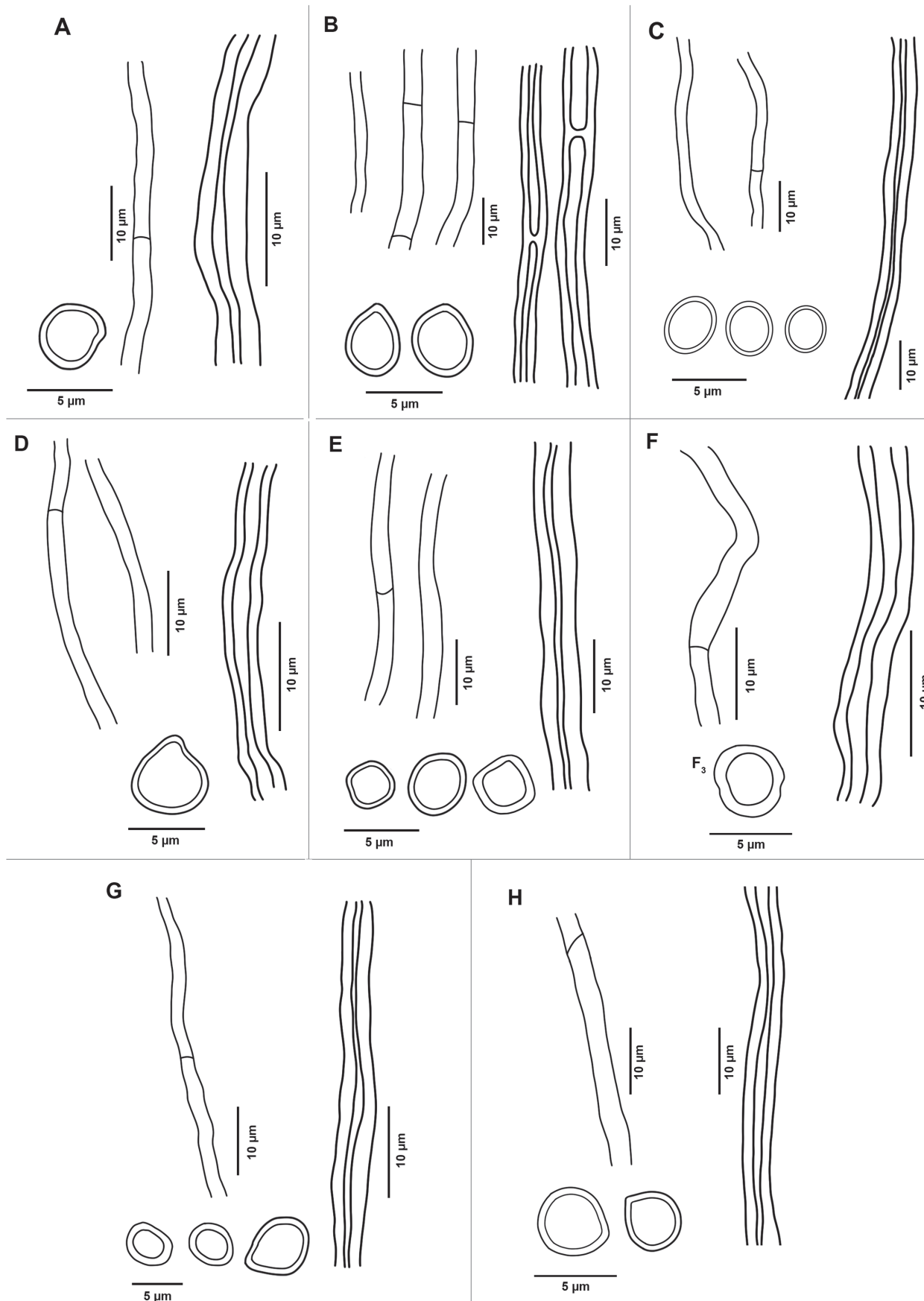


Figure 4. Microscopic structures (generative hyphae - left; skeletal hyphae - right; basidiospores). **A.** *Fomitiporia apiahyna*. **B.** *F. calkinsii*. **C.** *F. conyana*. **D.** *F. impercepta*. **E.** *F. langloisii*. **F.** *F. maxonii*. **G.** *F. murrillii*. **H.** *F. neotropica*.

(Fig. 4F); skeletal hyphae yellowish, thick-walled, non-septate (Fig. 4F); basidiospores dextrinoid, globose to subglobose, hyaline, thick-walled, $5 \times 6 \mu\text{m}$ (Fig. 4F).

Distribution. This species is widely distributed throughout the Americas (Ryvarden 2004; Decock et al. 2007), including in some states of southern Brazil (Ryvarden and Meijer 2002). Our record is the first from northern Brazil.

***Fomitiporia murrillii* Alves-Silva, R.M. Silveira & Drechsler-Santos**

Material examined. BRAZIL – Roraima • Caracarai, Viruá National Park; $01^{\circ}30'36''\text{N}$, $060^{\circ}42' 59''\text{W}$, 85 m alt.; 26.VIII.2018; M.A. Silva leg.; INPA 286231.

Identification. *Fomitiporia murrillii* was identified by the following characters: basidiome perennial, unguulate (Fig. 3C); hymenophoral surface with circular to angular pores, 4–6 per mm (Fig. 3C); context homogeneous, woody, cinnamon-brown (Fig. 3C); hyphal system dimitic, with generative hyphae hyaline, yellowish, thin-walled, septate (Fig. 4G); skeletal hyphae yellowish, thick-walled, nonseptate (Fig. 4G); basidiospores dextrinoid, subglobose to globose, hyaline, thick-walled, $5.5\text{--}7 \times 4.5\text{--}6 \mu\text{m}$ (Fig. 4G) (Dai et al. 2008).

Distribution. *Fomitiporia murrillii* is reported in Brazil only from the states of Paraná and Rio Grande do Sul. There are no records from the Amazon region, and our record is the first from this region.

***Fomitiporia neotropica* Campos-Santana, Amalfi, R.M. Silveira, Robledo & Decock**

Material examined. BRAZIL – Amazonas, Manaus • Tropical Silviculture Experimental Station ZF-2; $02^{\circ}35' 29.0''\text{S}$, $060^{\circ}12'54.4''\text{W}$, 92 m alt.; 04.III.2016; M.A. Silva leg.; INPA 286225 • Adolph Ducke Forest Reserve, $03^{\circ} 00'27.0''\text{S}$, $059^{\circ}53'59.0''\text{W}$, 92 m alt.; 27.I.2008; M.A. Jesus leg.; INPA 286220 – Roraima • Caracarai, Viruá National Park; $01^{\circ}30'36''\text{N}$, $060^{\circ}42'59''\text{W}$, 85 m alt.; 11.XI.2009; M.A. Jesus leg.; INPA 286216.

Identification. Our specimens were identified as *F. neotropica* based on the characters given by Campos-Santana et al. (2014): basidiome perennial, resupinate to effused-reflexed (Fig. 3D), hymenophoral surface with circular to ellipsoid pores, 5–9 per mm (Fig. 3D), context homogeneous, golden (Fig. 3D); hyphal system dimitic, with generative hyphae hyaline to slightly yellowish, thin-walled, septate (Fig. 4H); skeletal hyphae pale brown, thick-walled, nonseptate (Fig. 4H); basidiospores dextrinoid, subglobose to obvoid, hyaline, thick-walled, $5\text{--}7 \times 4.5\text{--}6 \mu\text{m}$ (Fig. 4H).

Remarks. *Fomitiporia neotropica* is similar to *F. maxonii*, differing mainly by the number of tube layers: in *F. neotropica* there are two layers, while in *F. maxonii* there are up to four (Decock et al. 2007; Campos-Santana et al. 2014).

Distribution. In Brazil, *F. neotropica* is only known from southern Brazil (Campos-Santana et al. 2014), and

our record is the first time this species has been found in the Amazonian region.

Discussion

Our study of 23 specimens of *Fomitiporia* significantly increases the knowledge of the diversity and distribution of this genus in the Amazon region. With six specimens each, *F. conyana* and *F. impercepta* were most common, which suggests that they may be more adapted to the Amazon biome (Gibertoni et al. 2007).

We also found *F. conyana* and *F. murrillii* for the first time in the state of Amazonas, and *F. maxonii* and *F. neotropica* for the first time in northern Brazil. *Fomitiporia impercepta* was recorded for the first time from Brazil, and *F. calkinsii* and *F. langloisii* from South America. Previously, there were 16 species of *Fulvifomes* known to occur in Brazil; however, our study adds three species so that the current number of species is 19 (Loguercio-Leite et al. 2008; Baltazar and Gibertoni 2009; Coelho et al. 2009; Westphalen and Silveira 2012; Campos-Santana et al. 2014; Li et al. 2016; Alves-Silva et al. 2020a, 2020b). We add seven species to the Amazon region which now has 43% of the total number of Brazilian species.

Despite the important contributions of our study, additional studies on the genus in the Amazonian region, including all areas of the Legal Amazon, are needed to get an accurate understanding of the diversity of this.

Acknowledgements

We thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for granting a doctoral scholarship and the PRÓ-AMAZÔNIA 3251/2013 project for financial support. We also thank Luiz Melo for making the illustrations for this work and Genivaldo Alves-Silva for his essential corrections to the taxonomy. We also thank the editors Claudia López Lastra and Robert Forsyth for their important contributions, as well as the reviewer, Georgea Santos Nogueira de Melo.

Authors' Contributions

MAS collected and identified the samples, RSP contributed to the production of the figures as well as the identification of some specimens. All the authors wrote and corrected the text.

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