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## Novelties in *Funalia* and the status of *Fomitella* (Polyporaceae, Basidiomycota)

### Authors

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## Novelties in *Funalia* and the status of *Fomitella* (Polyporaceae, Basidiomycota)

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**Abstract:** During studies on the taxonomical delimitation of some species of *Funalia*, some inconsistencies were observed in the genus. Based on morphological and phylogenetic analyses, the generic type *Fomitella supina* was positioned within the *Funalia* clade; thus, the synonymization of the genus and the new combination of *Funalia supina* are proposed. *Funalia glabrorigens* is also combined in the genus, while *F. hainanensis* is suggested as a synonym of *F. floccosa*, and *F. rigida* is assumed as a distinct species geographically separated from *F. floccosa*. A table with morphological comparison of the 10 *Funalia* species confirmed by molecular analyses is also presented.

**Key words:** *Corioloropsis*, phylogeny, taxonomy, trametoid fungi

### 1. Introduction

*Funalia* Pat. belongs to Polyporaceae and is characterized by basidiomata that are annual, effuse-reflexed to pileate, with yellowish to brown, usually tomentose to hispid pileal surface, cream to brown pore surface with round to angular pores, white to rusty umber brown context, tissues darkening or not in KOH, trimitic hyphal system with clamped generative hyphae and cyanophilous skeletal hyphae, and cylindrical, hyaline and thin-walled, IKI- basidiospores (Ryvarden and Gilbertson, 1993; Dai and Yuan, 2010; Zmitrovich and Malysheva, 2013; Li et al., 2016; Cui et al., 2019). The presence of binucleate basidiospores and heterocyclic nuclear behavior also differs *Funalia* from other trametoid genera in Polyporaceae (David and Rajchenberg, 1992). The typification of *Funalia* is not yet fully resolved, since *F. mons-veneris* (Jungh.) Pat. collected in Indonesia and *F. funalis* (Fr.) Pat. in Guinea (Patouillard, 1900) are both accepted as type species as they were published in the same year (Fries, 1838; Junghuhn, 1838); *F. mons-veneris*, however, is the most commonly used name (Li et al., 2016; Cui et al., 2019). Sequencing the types or reference materials is desirable to taxonomically place these species.

*Funalia* has been treated as either a synonym of *Trametes* Fr. (Bondartsev and Singer, 1941; Ryvarden, 1991) or, more recently, as an accepted genus, given that phylogenetic studies showed that *Funalia* species form a distinct group within the trametoid clade in Polyporaceae (Welti et al., 2012; Zmitrovich and Malysheva, 2013; Li et al., 2014, 2016; Uetele et al., 2018). Nonetheless, the type species have not yet been sequenced, preventing a better circumscription of the genus.

*Funalia* has 12 accepted species (Catalogue of Life<sup>1</sup>; Index Fungorum<sup>2</sup>; Mycobank<sup>3</sup>), six of which have also been delimited by molecular data, leaving the remnant in dubious placement (Justo and Hibbett, 2011; Zmitrovich and Malysheva, 2013; Li et al., 2016; Cui et al., 2019). Our goal is, therefore, to provide information that would improve the understanding of the genus and its species.

### 2. Materials and methods

#### 2.1. Morphological analysis

The basidiomata were analyzed according to the length, width, thickness, insertion in the substrate, consistency, color and characteristics of the abhymenial and hymenial

<sup>1</sup>Catalogue of Life (2024). Find taxon. [online]. Website <https://www.catalogueoflife.org/> [accessed 12 February 2024].

<sup>2</sup>Index Fungorum (2024). Search form. [online]. Website <https://www.indexfungorum.org/> [accessed 16 February 2024].

<sup>3</sup>Mycobank (2024). Simple searching on MycoBank. [online]. Website <https://www.mycobank.org/> [accessed 16 February 2024].

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surfaces, the context, and the margin (Kornerup and Wanscher, 1978; Fidalgo and Bononi, 1989). The microscopic analyses were performed by preparing sections mounted in 3 % KOH and stained with 1 % phloxin to observe hyphae and spores. Melzer's reagent was used to observe amyloid or dextrinoid reactions (IKI+/IKI-). The presence or absence of cyanophilic reaction was observed in preparations with lactophenol cotton blue (CB+/CB-).

## 2.2. Molecular genetic analyses

Fragments from the basidiomata were removed before drying and placed in 1.5 mL tubes and stored at -20 °C or stored at room temperature until DNA extraction. The fragments were homogenized in 2 mL tubes with CTAB and glass beads. DNA was extracted using a modified method described in Góes-Neto et al. (2005). PCR amplification of the ITS and LSU region was performed using the primer pairs ITS4-ITS5 and LR0R-LR5, respectively (White et al., 1990; Lima-Júnior et al., 2014).

The PCR products were purified using the enzyme NucleoSAP CELLCO (500 preps), following the manufacturer's recommendations. Samples were sequenced at the Plataforma Tecnológica de Genômica e Expressão Gênica do Centro de Biociências, in the Universidade Federal de Pernambuco (UFPE), Brazil, or at Stab Vida Lda, Madan Parque, Caparica, Portugal. The cycle sequencing was conducted with the same primers of amplification reactions (Moncalvo et al., 2000). All newly generated sequences were deposited in GenBank<sup>4</sup> (Table 1).

## 2.3. Phylogenetic analyses

The sequences obtained were compared with those deposited in GenBank<sup>4</sup> using the BLASTn tool. They were then aligned and edited using MAFFT and MEGA7 software (Tamura et al., 2011). The best-fit evolutionary model was estimated for the combined dataset using the standard model selection (Kalyaanamoorthy et al., 2017) implemented in IQ-TREE v. 1.6.12 to the maximum likelihood analyses (ML) and ModelTest on TOPALi 2.5 to Bayesian analysis (BI). Phylogenetic trees were developed using maximum likelihood (ML) and Bayesian analysis (BI). For ML, W-IQ-TREE with 1000 bootstrap resampling was used (Trifinopoulos, 2016), and the construction of the BI analysis was performed using MrBayes v.3.1.2 (Ronquist and Huelsenbeck, 2003) runs for  $5 \times 10^6$  generations. Statistical support for branches was considered informative with Bayesian posterior probabilities (pp)  $\geq 0.9$  and bootstrap (bs) and values  $\geq 70\%$ . *Earliella scabrosa* (Pers.) Gilb. & Ryvarden was used as the outgroup for phylogenetic inferences following Li et al. (2016).

## 3. Results

The combined dataset of ITS + nLSU + RPB1 + RPB2 + TEF1 regions included 62 sequences with 3355 nucleotide sites, which 2209 are constant sites and 879 parsimony-informative. *Funalia* was recovered with 10 species (Figure 1) with the newly generated sequences clustered in clades identified as *F. rigida*, *F. floccosa*, and *F. fulvocinerea*. In addition, sequences of *Fomitella supina* and *Corioloopsis glabrorigens* were also placed in *Funalia*, and two synonymization and two new combinations are proposed below. The best evolutionary model estimated for the alignment with combined dataset was TIME+I+G4 for ML and SYM+G for BI. The ML and BA analyses produced similar topologies, and the ML tree was chosen to represent the phylogenetic placement of the specimens (Figure 1). *Funalia* species confirmed by molecular phylogenetic analyses are morphologically compared (Table 2).

### 3.1. Taxonomy

*Funalia* Pat., Essai taxonomique sur les familles et les genres des Hyménomycètes: 95 (1900)  
= *Fomitella* Murrill, Bull. Torrey bot. Club 32(7): 365 (1905).

Description: Dai and Yuan (2010), Zmitrovich and Malysheva (2013), Li et al. (2016), Cui et al. (2019).

Notes: *Funalia* is a genus with characteristics similar to the trametoid polypores, but it can be differentiated by the presence of binucleate basidiospores and heterocyclic nuclear behavior in at least four species (David and Rajchenberg, 1992). *Funalia* is a cosmopolitan genus (Figure 1; Tables 1 and 2; Ryvarden and Johansen, 1980).

*Fomitella*, typified by *Boletus supinus* Sw. and originally collected in Jamaica, has basidiomata annual or perennial, sessile to effused-reflexed, pilei dimidiate, applanate, with upper surface becoming crustose or reddish and laccate, pore surface purplish brown to smoky, circular pores, 5–7 per mm, context pale brown, zonate, hyphal system trimitic, generative hyphae with clamps, cystidia lacking, basidiospores cylindrical, negative in Melzer's reagent (Gilbertson and Ryvarden, 1986). Despite never being included in *Trametes*, *Fomitella* species clearly have morphological characteristics of trametoid species, as well as being considered a white-rotter (Gilbertson and Ryvarden, 1986; Ryvarden, 2015; Li et al., 2016; Cui et al., 2019). Until now, *Fomitella* has two accepted species, *Fo. supina* and *Fo. malaysiana* (Li et al., 2014, Index Fungorum<sup>2</sup>; MycoBank<sup>3</sup>), but Li et al. (2014) suggested *Fo. malaysiana* as a species of *Neofomitella* Y.C. Dai, Hai J. Li & Vlasák, and sequencing is desirable to confirm this placement.

*Funalia supina* (Sw.) Targino de Oliveira & Gibertoni comb. nov.

<sup>4</sup>Genbank (2024). Bethesda (MD): National Library of Medicine (US), National Center for Biotechnology Information. [online]. Website <https://www.ncbi.nlm.nih.gov/genbank/> [accessed 16 February 2024].

Table 1. Data of specimens and sequences included in the molecular genetic analyses.

Species	Voucher	Country	ITS	nLSU	RPB1	RPB2	TEF	Reference
<i>Coriopsis aspera</i> (Jungb.) Teng	NP170-8	Thailand	MK589269	-	-	-	-	Thampraphaphon et al. (2022)
<i>C. aspera</i> (Berk.) Murrill	Cui 6725	China	KC867356	KC867477	-	KF274659	-	Li et al. (2014)
<i>C. caperata</i> (Berk.) Murrill	LE(BIN)-0677	Cuba	AB158316	-	-	-	-	Unpublished
<i>C. gallica</i> (Fr.) Bondartsev and Singer	MOGU 086-19	Italy	OM422731	-	-	-	-	Cartabia et al. (2021)
<i>C. gallica</i>	CBS:547.50	France	MH856754	-	-	-	-	Vu et al. (2019)
<i>C. glabrorigens</i> (Lloyd) Núñez & Ryvarden	Cui 13868	China	MK192427	MK192446	MK192505	MK204694	-	Ji et al. (2019)
<i>C. glabrorigens</i>	Dai 7894	China	KC867395	-	-	-	-	Li et al. (2016)
<i>C. hainanensis</i> Hai J. Li, Y.C. Dai and B.K. Cui	Dai 10738	China	KC867377	KC867450	-	-	-	Cui et al. (2019)
<i>C. sanguinaria</i> (Klotzsch) Zmitr. and Malysheva	Cui 5296	China	KC867388	KC867465	-	-	-	Li et al. (2016)
<i>C. sanguinaria</i>	Dai 9314	China	KC867390	KC867467	-	-	-	Li et al. (2016)
<i>C. trogii</i> (Berk.) Bondartsev and Singer	LG1	Italy	KJ093492	-	-	-	-	Gonthier et al. (2015)
<i>C. trogii</i>	BRFM<FRA>:974	France	JN645099	-	-	JN645141	-	Welti et al. (2012)
<i>Dichomitus squalens</i> (P. Karst.) D.A. Reid	Cui 9639	China	JQ780407	JQ780426	KX838471	KX838478	KX838436	Li and Cui (2013)
<i>Fomes fasciatus</i> (Sw.) Cooke	52FA_PSRB	USA	JX126905	-	-	JX163064	-	McCormick et al. (2013)
<i>F. fomentarius</i> (L.) Fr.	BRNM 840314	Slovakia	OQ474932	-	OQ514046	OQ514026	OQ514036	Tomšovský et al. (2023)
<i>F. inzengae</i> (Ces. & De Not.) Cooke	BRNM 840289	Czech Republic	OQ474920	-	OQ514041	OQ514021	OQ514031	Tomšovský et al. (2023)
<i>Fomitella stipina</i> (Sw.) Murrill	JV0610	Guatemala	KF274645	KF274646	-	-	-	Li et al. (2014)

Table 1. (Continued.)

<i>Fo. supina</i>	Nunez 1183	Panama	KF274644	-	-	-	Li et al. (2014)
<i>Fo. supina</i>	Ryvarden 39027	Puerto Rico	KF274643	-	-	-	Li et al. (2014)
<i>Fo. supina</i>	BRFM 1125	French Guiana	JX082370	-	-	-	Berrin et al. (2012)
<i>Funalia cystidiata</i> Hai J. Li, Y.C. Dai and B.K. Cui	Dai 12093	China	NR169652	NG075185	-	-	Cui et al. (2019)
<i>F. cystidiata</i>	Cui 8396	China	KC867392	KC867455	OK665279	OK665204	Cui et al. (2019)
<i>F. floccosa</i> (Jungb.) Zmitr. & Malysheva	O-F-308196	Indonesia	OR892706	OR896863	-	-	This study
<i>F. fulvocinerea</i> (Murrill) A. David & Rajchenb.	JV1207 5.1 JC	USA	OR911809	OR911803	-	-	This study
<i>F. rigida</i> (Berk. and Mont.) Peck	CL101 (URM 86029)	Brazil	OQ697702	-	-	-	This study
<i>F. rigida</i>	VRTO89 (URM 94081)	Brazil	OQ702339	OR333969	-	-	This study
<i>F. rigida</i>	VRTO956 (URM 94082)	Brazil	OQ702342	OR333971	-	-	This study
<i>F. rigida</i>	CL636 (URM 83674)	Brazil	OQ697703	-	-	-	This study
<i>F. rigida</i>	AN TO18 (URM 85575)	Brazil	OQ697704	-	-	-	This study
<i>F. rigida</i>	I1713 (URM 90357)	Brazil	OQ697705	OR896865	-	-	This study
<i>F. rigida</i>	VRTOB09 (URM 93661)	Brazil	OQ702341	OR333970	-	-	This study
<i>F. rigida</i>	VRTOB6 (URM 93658)	Brazil	OQ702340	-	-	-	This study
<i>F. rigida</i>	VRTO62 (URM 95589)	Brazil	OR892710	OR896866	PP819403	PP819401	This study
<i>F. rigida</i>	VRTO75 (URM 95590)	Brazil	OR892709	-	PP819404	PP819402	This study
<i>F. rigida</i>	FLAS-F-60496	USA	MH211656	-	-	-	Unpublished

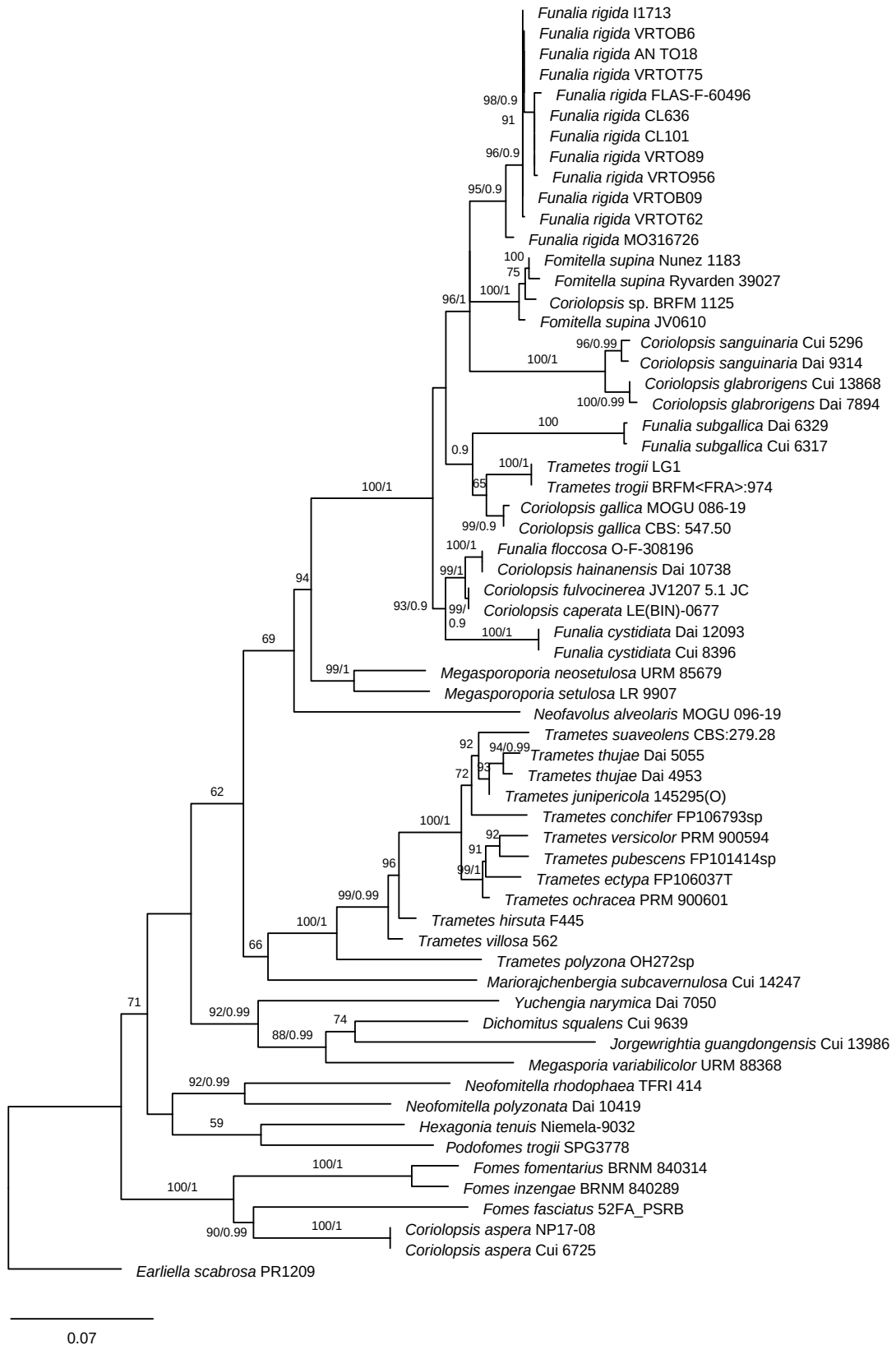
Table 1. (Continued.)

<i>F. rigida</i>	MO316726	USA	MT551931	-	-	-	-	-	Unpublished
<i>F. subgallica</i> Hai J. Li and S.H. He	Cui 6317	China	KC867384	KC867460	MG867665	-	MG867695	-	Li et al. (2016)
<i>F. subgallica</i>	Dai 6329	China	KC867386	KC867462	KX885078	KX885086	-	-	Li et al. (2016)
<i>Hexagonia tenuis</i> (Fr.) Fr.	Niemela-9032	Zambia	KY948738	KY948842	KY949042	-	-	-	Justo et al. (2017)
<i>Jorgewrightia guangdongensis</i> (B.K. Cui & Hai J. Li) Gibertoni & C.R.S. Lira	Cui 13986	China	MG847208	MG847217	-	MG867680	MG867699	-	Cui et al. (2019)
<i>Mariorajchenbergia subcavernulosa</i> (Y.C. Dai & Sheng H. Wu) Gibertoni & C.R.S. Lira	Cui 14247	China	MG847213	MG847222	MG867673	MG867685	MG867705	-	Cui et al. (2019)
<i>Megasporia variabilicolor</i> Lira & Gibertoni	URM 88368	Brazil	KX584448	KX619574	-	MT984344	MW161496	-	Lira et al. (2021)
<i>Megasporoporia neosetulosa</i> C.R.S. Lira & Gibertoni	URM 85679	Brazil	KX584459	OL684780	-	-	-	-	Lira et al. (2021)
<i>M. setulosa</i>	LR 9907	Tanzania	OL678508	OL684780	-	-	-	-	Lira et al. (2021)
<i>Neofavolus alveolaris</i> (DC.) Sotome & T. Hatt.	MOGU 096-19	Italy	OM530253	-	-	-	-	-	Cartabia et al. (2021)
<i>Neofomitella polyzonata</i> Y.C. Dai, Hai J. Li & Vlasák	Dai 10419	China	JX569738	JX569745	-	-	-	-	Li et al. (2014)
<i>N. rhodophaea</i> (Lév.) Y.C. Dai, Hai J. Li & Vlasák	TFRI 414	-	EU232216	EU232300	-	-	-	-	Unpublished
<i>Podofomes trogii</i> (Fr.) Pouzar	SPG3778	Spain	MT216864	-	-	-	-	-	Gorjón et al. (2020)
<i>Trametes conchifer</i> (Schwein.) Pilát	FP106793sp	USA	JN164924	JN164797	JN164823	JN164849	JN164887	-	Justo and Hibbett (2011)
<i>T. ectypa</i> (Berk. & M.A. Curtis) Gilb. & Ryvarden	FP106037T	USA	JN164929	JN164803	JN164824	JN164848	JN164888	-	Justo and Hibbett (2011)
<i>T. hitsuta</i> (Wulfen) Lloyd	F445	Czech Republic	OR625697	OR602385	-	-	-	-	Unpublished
<i>T. junipericola</i> Manjón, G. Moreno & Ryvarden	145295(O)	-	KC017758	KC017763	-	-	-	-	Unpublished

Table 1. (Continued.)

<i>T. ochracea</i> (Pers.) Gilb. & Ryvarden	PRM 900601	Czech Republic	AY684177	AY855908	-	-	-	Tomšovský et al. (2006)
<i>T. polyzona</i> (Pers.) Justo	OH272sp	Venezuela	JN164979	-	KF573171	KF573130	-	Justo and Hibbett (2011)
<i>T. pubescens</i> (Schumach.) Pilát	FP101414sp	USA	JN164963	JN164811	JN164827	JN164851	JN164889	Justo and Hibbett (2011)
<i>T. suaveolens</i>	CBS:279.28	Germany	MH855012	MH866480	-	-	-	Vu et al. (2019)
<i>T. thujiae</i> J.D. Zhao	Dai5055	China	KC848286	KC848371	-	-	-	Cui et al. (2019)
<i>T. thujiae</i>	Dai 4953	China	KX880756	KC848373	-	-	-	Cui et al. (2019)
<i>T. versicolor</i> (L.) Lloyd	PRM 900594	Czech Republic	AY684179	AY855914	-	-	-	Tomšovský et al. (2006)
<i>T. villosa</i> (Sw.) Kreisel	562	Colombia	OM400538	MZ424280	-	-	-	Sánchez-Quitian et al. (2022)
<i>Yuchengia narymica</i> (Pilát) B.K. Cui, C.L. Zhao & K.T. Steffen	Dai 7050	China	JN048776	JN048795	-	-	KF181147	Zhao et al. (2013)
Outgroup								
<i>Eariteilla scabrosa</i> (Pers.) Gilb. & Ryvarden	PR1209	Puerto Rico	JN165009	JN164793	JN164819	JN164866	JN164894	Justo and Hibbett (2011)





**Figure 1.** Maximum likelihood (ML) tree of some genus in Polyporaceae from a dataset of ITS + nLSU + RPB1 + RPB2 + TEF1 sequences. Bootstrap values above 60 % and Bayesian posterior probability above 0.9 are shown.

Table 2. Species of *Funalia* confirmed by molecular phylogenetic analysis, compared morphologically.

Species	Basidioma	Pileal surface	Pores/ mm	Basidiospore size ( $\mu\text{m}$ )	Basidiospore shape	Skeletal hyphae cyanophily	References
<i>Funalia cystidiata</i>	Effused-reflexed to pileate	Velutinate to tomentose	1–2.5	(8.5–)9–12(–13.8) $\times$ (3–)3.1–4(–4.5) $\mu\text{m}$	Cylindrical	CB+	Cui et al. (2019)
<i>F. floccosa</i>	Resupinate to effused-reflexed	Velutinate	3–4	8–11 $\times$ (3–)3.3–4.4(–5) $\mu\text{m}$	Cylindrical	CB-	Cui et al. (2019, as <i>C. hainanensis</i> )
<i>F. fulvocinerea</i>	Dimidiate	–	4–6	7.5–10.5 $\times$ 3.5–5 $\mu\text{m}$	Cylindrical	CB+	Fidalgo and Fidalgo (1967); This study
<i>F. gallica</i>	Effused resupinate	Hirsute to hispid	1–3	10–16 $\times$ 3–5 $\mu\text{m}$	Cylindrical	CB(+)	Ryvarden and Gilbertson (1993); This study
<i>F. glabrorigens</i>	Pileate to effused-reflexed	Snuff brown, glabrous to radially appressed-strigose	(5–)6–7	(4.8–)6.5–7 $\times$ (–1.9)2.5–3 $\mu\text{m}$	Cylindrical to narrowly ellipsoid	CB-	Núñez and Ryvarden (2001); Cui et al. (2019)
<i>F. rigida</i>	Effused-reflexed to resupinate	Hirsute to tomentose, scrupeuse to glabrous	2–5	(6,25–)7,5–8,75(–10) $\times$ 1,25–2,5(–3,75) $\mu\text{m}$	Cylindrical	CB-	Abrahão et al. (2009); This study
<i>F. sanguinaria</i>	Pileate to effused-reflexed	Glabrous to roughened	5–8(–10)	(3.8–)5–8 $\times$ 2–3.5 $\mu\text{m}$	Oblong-ellipsoid to subellipsoid	CB-	Núñez and Ryvarden (2001); Cui et al. (2019)
<i>F. supina</i>	Pileate to effused-reflexed	Minutely tomentose	5–7	7–9 $\times$ 3–3.5 $\mu\text{m}$	Cylindrical	CB-	Ryvarden (2015); This study
<i>F. subgallica</i>	Sessile to effused-reflexed	Strongly hispid to strigose	1–3	11–15(–17) $\times$ 4–5 $\mu\text{m}$	Cylindrical	CB+	Li et al. (2016)
<i>F. trogii</i>	Effused-reflexed to resupinate	Coarsely hispid	1–2	(8)10–12 $\times$ 2.5–4 $\mu\text{m}$	Cylindrical	CB+	Ryvarden and Gilbertson (1993)

Basionym: *Boletus supinus* Sw., Fl. Ind. Occid. 3: 1926 (1806).

$\equiv$  *Fomitella supina* (Sw.) Murrill, Bull. Torrey bot. Club 32(7): 365 (1905).

Mycobank: MB851236

Description. — Ryvarden (2015).

Notes: — Morphologically, *F. supina* has the characteristics of *Fomitella* described above. In addition, the basidiospores are hyaline, 7–9  $\times$  3–3.5  $\mu\text{m}$  (Ryvarden, 2015). The examined material agrees with Ryvarden (2015).

Material examined. — Brazil. Amapá, Porto Grande, Floresta Nacional do Amapá, Oct 2014, leg. A. M. Soares, (AS1823), URM 89380; 06 July 2017, leg. V.

Xavier de Lima, (PPT269), URM 92650; Sep 2014, leg. A. M. Soares, (AS1588), URM 90977; leg. T. B. Gibertoni, URM 76743; Guatemala. Lago Atitlán, on hard wood, (J. Vlasák JV0610); Panama. Ensenada de Santa Cruz. Parque Nac. de Coiba, 17 Nov 1996, (M. Nunez 1183), O 10770; Puerto Rico. Toro Negro, Commonwealth For., on deciduous wood, 24 Jun 1996, (L. Ryvarden 39 027), O 10772.

*Funalia glabrorigens* (Lloyd) Vlasák & Targino de Oliveira comb. nov.

Basionym: *Polystictus glabrorigens* Lloyd [as '*glabrorigens*'] (1922).

$\equiv$  *Coriopsis glabrorigens* (Lloyd) Núñez & Ryvarden], Syn. Fung. (Oslo) 14: 256 (2001)

≡ *Trametes glabrorigens* (Lloyd) Zmitr., Wasser & Ezhov, in Zmitrovich, Ezhov & Wasser, International Journal of Medicinal Mushrooms (Redding) 14(3): 315 (2012)

Mycobank: MB851381

Description: — Núñez and Ryvarden (2001); Cui et al. (2019).

Notes: *Funalia glabrorigens* is characterized by basidiomata annual and effused-reflexed, pileal surface glabrous to radially appressed-strigose, semiglossy, margin deflexed, 5–7 pores per mm, context soft fibrous, snuff brown to isabelline, up to 2 mm thick near the base, basidiospores narrowly ellipsoid, 5–7 × 2–3 µm (Núñez and Ryvarden, 2001; Cui et al., 2019). It is reported in subtropical and tropical Asia (Núñez and Ryvarden, 2001; Cui et al., 2019).

*Funalia floccosa* (Jungh.) Zmitr. & Malysheva, Mikol. Fitopatol. 47(6): 375 (2013)

Basionym: *Polyporus floccosus* Jungh., Verh. Batav. Genootsch. Kunst. Wet. 17(2): 49 (1838).

= *Corioloopsis hainanensis* Hai J. Li, Y.C. Dai and B.K. Cui, in Cui, Li, Ji, Zhou, Song, Si, Yang and Dai, Fungal Diversity 97: 170 (2019).

Description: — Cui et al. (2019).

Material examined. — Indonesia. Sumbawa, Tambore Mt., Kawinda, 24 Oct 1996, leg. M. Nunez (MN 569), F-308196.

Notes. — *Funalia floccosa* is characterized by its resupinate to effused-reflexed basidiomata, pale yellowish-brown to yellowish-brown, velutinate pileus surface (Ryvarden and Johansen, 1980; Cui et al., 2019, as *C. hainanensis*). The synonym *C. hainanensis* was described as having dextrinoid skeletal and binding hyphae (Cui et al., 2019), but we examined microscopic images of the type species sent by Y.C. Dai and the dextrinoid reaction is absent.

*Funalia rigida* (Berk. & Mont.) Peck, N.Y. St. Mus. Bull. 197: 38 (1917)

Basionym: *Trametes rigida* Berk. & Mont., Anns Sci. Nat., Bot., sér. 3 11: 240 (1849).

Description. — Gilbertson and Ryvarden (1986), Abrahão et al. (2009).

Notes. — *Funalia rigida* is characterized by basidiomata annual, pilei effused reflexed to resupinate, flexible when fresh and rigid when dry, ochraceous to deep hazel brown or frequently greyish-brown, hirsute to tomentose, also hispid, circular to angular pores, 2–5 pores per mm, beige to yellowish-brown, basidiospores cylindrical, hyaline, nonamyloid or dextrinoid, with thin, smooth wall (6.25–) 7.5–11 (14) × 1.25–4(5) µm (Gilbertson and Ryvarden, 1986; Abrahão et al., 2009), characteristics observed in our specimens. *Funalia rigida* was considered a synonym of

the Asian *F. floccosa*, apparently a morphologically similar species, but the pore surface in *F. floccosa* is grayish-brown with a distinct bluish-ashy gray tint (Ryvarden and Johansen, 1980; Abrahão et al., 2009).

Material examined. — Brazil. Alagoas, Quebrangulo, Reserva Biológica de Pedra Talhada, 09°15'23.0" S, 36° 24' 47.0" W, 683 m a.s.l., 20 July 2018, leg. V. R. T. Oliveira, (VRTO89), URM 94081; 09°15'21.0" S, 36°24'47.0" W, 654 m a.s.l., 19 July 2018, leg. V. R. T. Oliveira, (VRTO159), URM 94080; 09°14'57.7" S, 36°25'39.7" W, 724 m a.s.l., 15 May 2019, leg. V. R. T. Oliveira, (VRTO618), URM 93931; 09°15'27.4" S, 36°25'09.1" W, 592 m a.s.l., 15 May 2019, leg. V. R. T. Oliveira, (VRTO660), URM 93932; 09°15'23.0" S, 36°24'47.0" W, 542 m a.s.l., 07 October 2019, leg. V. R. T. Oliveira, (VRTO956), URM 94082; Bahia, Itamaraju, Parque Nacional e Histórico de Monte Pascoal, 16°51'03.9" S, 39°24'10.2" W 36 m a.s.l., 25 May 2019, leg. R. L. M. Alvarenga, (RLMA594), URM 93662; 16°51'53.6" S, 39°24'54.5" W, 118 m a.s.l., 29 May 2019, leg. R. L. M. Alvarenga, (RLMA722), URM 94001; 16°51'55.6" S, 39°24'54.7" W, 131 m a.s.l., 29 May 2019, leg. R. L. M. Alvarenga, (RLMA733), URM 93999; 16°51'57.3" S, 39°24'59.7" W, 128 m a.s.l. 18 February 2019, leg. R. L. M. Alvarenga, (DBPMA1P111), URM 93655; 16°51'57.3" S, 39°24'59.7" W, 128 m a.s.l. 18 February 2019, leg. R. L. M. Alvarenga, (DBPMA1P112), URM 93658; Ceará, Nova Olinda, 7°5'30.012" S, 39°40'50.157" W, 27 January 2011, leg. T. B. Gibertoni (TB 110), URM 83213; Pará, Portel, Floresta Nacional de Caxiuanã, 1°42'24.091" S, 51°27'34.351" W, January 2014, leg. A. M. Soares (AS1347), URM 89425; Paraíba, Areia, Mata do Pau Ferro, 6°57'47.987" S, 35°41'30.119" W, 16 April 2012, leg. C. R. S. Lira (CL636), URM 83674; Pernambuco, Triunfo, Sítio Carro Quebrado, 7°50'17.016" S, 38°6'6.119" W, 31 May 2012, leg. R. C. S. Lira, (CL101), URM 86029; Rio de Janeiro, Angra dos Reis, 23°0'24.122" S, 44°19'5.159" W, 03 October 2017, leg. T. B. Gibertoni, (TB PEIG2), URM 90357; Tocantins, Carrasco Bonito, Resex do Extremo Norte do Tocantins, 5°19'18.984" S, 48°2'4.914" W, 26 June 2013, leg. L. S. Araújo-Neta, (NA TO18), URM 85575.

#### 4. Discussion

Although the type species of *Funalia* were not sequenced yet, the species identified so far for this genus cluster in an isolated clade with strong support (Figure 1), and similar results have already been shown in previous studies (Zmitrovich and Malysheva, 2013; Li et al., 2016; Cui et al., 2019).

According to Li et al. (2014), *Fomitella* sequences were placed in the *Funalia* clade; however, based on the morphological characteristics of *Funalia*, the authors opted for not proposing the synonymization. The specimens JV0610 (Guatemala), Nuñez 1183 (Panama) and Ryvarden

39027 (Puerto Rico) identified as *Fo. supina* and BRFM 1125 (French Guiana) identified as *Corioloopsis* sp. clustered in the *Funalia* clade with strong support (Figure 1). Considering the morphological characteristics discussed above and phylogenetic analyses, the synonymization of *Fomitella* to *Funalia* and the combination of *Boletus supinus* (= *Fomitella supina*) to *Funalia* proposed above are supported.

*Funalia glabrorigens* is currently accepted both in *Trametes* (Index Fungorum 561992) and in *Corioloopsis* (Mycobank 539387), but it was positioned within the *Funalia* clade and phylogenetically close to *F. sanguinaria* (Figure 1). Morphologically, *F. glabrorigens* and *F. sanguinaria* share the pileate effused-reflexed basidiomata with reddish to pinkish color, but the pores and basidiospores are smaller in *F. sanguinaria* (Table 2) (Núñez and Ryvarden, 2001; Zmitrovich et al., 2012; Cui et al., 2019). *Funalia glabrorigens* was originally described from Borneo (Lloyd, 1922) and reported from tropical and subtropical Asia (Núñez and Ryvarden, 2001). The sequences used in our phylogeny are from material collected in subtropical and tropical China (Fujian and Hainan) (Cui et al., 2019), but it would be desirable to use molecular data of the type specimen or of specimens from the type locality for a better delimitation of this species.

*Funalia rigida* was synonymized by Peck (1917) and has been accepted as a synonym of *F. floccosa* (Zmitrovich and Malysheva, 2013; Index Fungorum<sup>2</sup>; Mycobank<sup>3</sup>). Apparently, the species share the effused-reflexed, coriaceous, ochraceous to deep hazel brown frequently greyish-brown pileus and small rounded pores (Junghuhn, 1838; Montagne, 1849; Ryvarden and Johansen, 1980; Gilbertson and Ryvarden, 1986) (Figure 2). Nevertheless, *F. rigida* was described from material collected in the state of Bahia, Brazil (Berkeley and Montagne, 1849), while *F. floccosa* was originally collected in Java, Indonesia (Junghuhn, 1838). In our results, *F. rigida* (including URM 93661 collected in the state of Bahia) and *F. floccosa* (O-F-308196 from Indonesia) were positioned in separate clades (Figure 1), being considered, thus, as two different species, *F. rigida* with American distribution, and *F. floccosa* with Asian and African (Ryvarden and Johansen, 1980; Ryvarden et al., 2022), possibly paleotropical, distribution. We also suggest that, in the failure to obtain molecular data of the type specimens of *F. rigida* and *F. floccosa*, URM 93661 and O-F-308196 could be designated as epitypes for these species, respectively.

The holotype of *C. hainanensis* (Dai 10738) from China was placed within the sequence of *F. floccosa* with a good support (Figure 1) in an isolated position, reinforcing the synonymization suggested above.

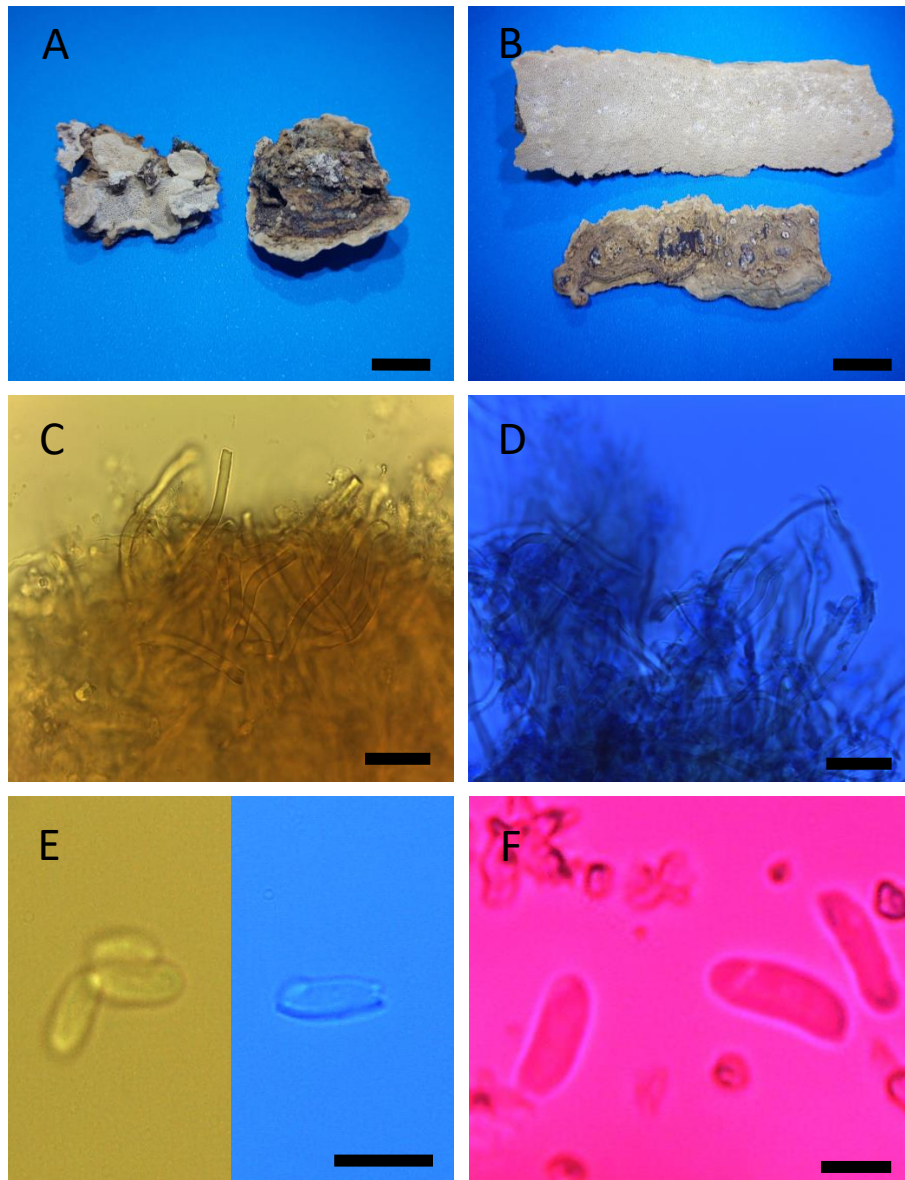
*Funalia floccosa* was placed close to *F. fulvocinerea* (= *Corioloopsis fulvocinerea* Murrill) and *F. cystidiata* (Figure

1), but the latter are easily differentiated by the sessile, dimidiate and imbricate basidiomata in *F. fulvocinerea* and the presence of encrusted and branched cystidia in *F. cystidiata* (Murrill, 1908; Cui et al., 2019). *Corioloopsis fulvocinerea* was combined to *Funalia* by David and Rajchenberg (1985) based on the binucleate basidiospores and a heterocyclic nuclear behavior, features found in *Funalia*, and later transferred to *Cerrena* by Zmitrovich (2001) without justification. The species was originally described from Cuba and the sequence LEBIN0677 used in our work, also from that country, is named *C. caperata* (Berk.) Murrill in GenBank<sup>4</sup>, but the website informs that it was previously identified as *C. fulvocinerea*. The two sequences were positioned within the *Funalia*-core clade with good support (Figure 1), which confirms the species in *Funalia* and not in *Cerrena*.

Of the remnant species of *Funalia* delimited by molecular analyses (Table 2), *F. gallica* is close to *F. trogii*, both positioned with good support within the *Funalia* clade (Figure 1) and originally collected in Europe (France and Switzerland, respectively) (Fries, 1821; Berkeley, 1850). The species share sessile basidiomata with effused and hispid pilei but differ by the brownish to dirty gray pileus and brown context in *F. gallica* and cream-buff to ochraceous-buff pileus and cream-buff context in *F. trogii* (Ryvarden and Gilbertson, 1993). Previous studies have already shown the placement of the species within the *Funalia*-core (David and Rajchenberg, 1992; Zmitrovich and Malysheva, 2013; Li et al., 2016; Cui et al., 2019); however, they are still considered representatives of *Corioloopsis* Murrill and *Trametes* Fr. respectively by some databases and authors (Justo and Hibbett, 2011; Index Fungorum<sup>2</sup>; Mycobank<sup>3</sup>).

Bondartsev and Singer (1941) combined *Polyporus gallicus* Fr. in *Funalia* based on pore size and the characteristic color of the genus. The species is morphologically similar to *F. subgallica* as they share similar hispid basidiomata and basidiospores, but *F. gallica* has a distinctly darker pileal surface than *F. subgallica* (Li et al., 2016). In addition, they were not phylogenetically close (Figure 1), and *F. gallica* mainly occurs in temperate zones, while *F. subgallica* is found in tropical climates of southern China (Li et al., 2016).

Zmitrovich and Malysheva (2013) proposed the combination of *F. sanguinaria* based on phylogenetic analysis but characterized its placement as uncertain in the genus. The species was originally described from Mauritius Islands (Eastern Africa), while the sequences of *F. sanguinaria* used in our phylogeny are from China (Table 1). Since there are no available sequences of specimens collected at the type locality, it is possible that Asian specimens identified as *F. sanguinaria* belong to a different species. Similarly, the authors also suggested



**Figure 2.** Basidiomata of *F. rigida* (A–B). Skeletal hyphae: IKI– (C) and CB– (D). Basidiospores: IKI– and CB– (E) and Floxina B (F). Bars: A–B: 1 cm, C–D: 20  $\mu$ m, E: 10  $\mu$ m, F: 5  $\mu$ m.

the combination *F. aspera* ( $\equiv$  *Polyporus asper* Jungh.). However, in our results, *F. aspera* is placed within *Fomes* (Fr.) Fr. (Figure 1), and a more detailed morphological and molecular analysis and broader sampling of the species are necessary to support our observations. *Funalia aspera* is characterized by basidiomata annual to perennial, solitary or imbricate, often effused reflexed, pileus surface dark fulvous to reddish brown with warts and scrupose tufts of agglutinated hairs, while species in *Fomes* present basidiomata perennial, ungulate, pileus surface gray to blackish with a hard smoot crust (Núñez and Ryvar den, 2001; Ryvar den, 2015; Ryvar den et al., 2022).

Some species are currently accepted in *Funalia*, but they are not yet sequenced, preventing phylogenetic evaluation and their better placement within the Polyporaceae. *Polyporus dybowskii* Pat., *Polyporus funalis* Fr., *Polyporus leoninus* Klotzsch and *Polyporus mons-veneris* Jungh. were placed in *Funalia* by Patouillard (1900), who created the genus to accommodate species with sessile, dimidiate, pulvinate and fibrous basidiomata, with large pores. Later, *Trametes hispidula* Berk. and M.A. Curtis and *Polystictus argenteus* Lloyd were transferred to *Funalia* by Murrill (1908) and by Reid (1973), respectively. *Trametes hispidula* Bagl is considered either a species of *Funalia* or

a synonym of *F. gallica* (Chen, 2003; Justo and Hibbett, 2011; Zmitrovich and Malysheva, 2013; Index Fungorum<sup>2</sup>; Mycobank<sup>3</sup>). The placement of the species in the genus is also accepted by David and Rajchenberg (1992).

*Polyporus telfairii* Klotzsch was initially placed in *Corioloopsis* by Ryvar den (1972). However, David and Rajchenberg (1992) later suggested reclassifying it to *Funalia*, supported by its nuclear behavior features related to sexuality. In turn, *Trametes thujae* J.D. Zhao was combined in *Funalia* by Dai and Yuan (2010) based on the cyanophilous skeletal hyphae. The sequences of *F. thujae* Dai 4953 and Dai 5055, however, were positioned into the *Trametes* clade, suggesting that this species belongs to this genus (Figure 1). Sequences of the type species or the type locality (Tibet) are desirable for a better placement of the species.

Several other species were placed in *Funalia*, but they currently belong to other genera. *Funalia aculeifera* (Berk. and M.A. Curtis) Murrill ( $\equiv$  *Trametes aculeifera* Berk. and M.A. Curtis) was combined in *Echinoporia* Ryvar den by Ryvar den (1984) due to the conidiospores produced in the pileus cover, the dimitic hyphal system, and the clamped generative hyphae.

*Funalia bouei* Pat., *F. cladotricha* (Berk. and M.A. Curtis) Murrill ( $\equiv$  *Polyporus cladotrichus* Berk. and M.A. Curtis), *F. trichomalla* (Berk. and Mont.) Pat. ( $\equiv$  *Polyporus trichomallus* Berk. and Mont.), and *F. versatilis* (Berk.) Murrill ( $\equiv$  *Trametes versatilis* Berk.) were transferred to *Trichaptum* Murrill, with *F. bouei* and *F. cladotricha* considered synonyms of *T. byssogenum* (Murrill, 1904; Cunningham, 1965; Ryvar den, 1972; Index Fungorum<sup>2</sup>).

In a phylogenetic work carried out by Tomšovský (2008), *F. cervina* (Schwein.) Y.C. Dai ( $\equiv$  *Boletus cervinus* Schwein.) was positioned in an isolated clade and distant from the other analyzed genera. Thus, *Trametopsis* Tomšovský was described as a new genus, with *T. cervina* (Schwein.) Tomšovský as the type species and morphologically characterized by pinkish buff to cinnamon or clay basidiomata, daedaloid to irpicoid pores, and cylindric basidiospores (Tomšovský, 2008).

Similarly, *Trametes kuzyana* Pilát ex Pilát was initially transferred to *Funalia* by Spirin et al. (2016), based on molecular data. Subsequently, Audet<sup>5</sup> described *Brunneoporus* Audet as a new brown rotting genus and proposed the combination *B. kuzyana* (Pilát) Audet, based on data from other studies that showed that some *Antrrodia* P. Karst. species were positioned in a distinct clade with good support (Ortiz-Santana et al., 2013; Han et al., 2016; Spirin et al., 2016).

*Funalia ostreiformis* (Berk.) Murrill ( $\equiv$  *Polyporus ostreiformis* Berk.) was combined to *Pilatoporus* Kotl.

& Pouzar by Zmitrovich (2018), who did not provide a justification, but the species of the genus are brown rotters and morphologically have white context and hyaline thin-walled cylindrical or narrowly ellipsoid basidiospores (Spirin and Zmitrovich, 2003).

*Polyporus polyzonus* Pers. [ $\equiv$  *F. polyzona* (Pers.) Niemelä] and *Boletus villosus* Sw. [ $\equiv$  *F. villosa* (Sw.) Murrill] were placed in *Funalia* by Härkönen et al. (2003) and Murrill (1905), respectively. Later, *F. villosa* was combined in *Trametes* by Kreisel (1971). More recently, sequences from material of both species collected in regions close to the type localities were placed within the *Trametes* clade (Justo and Hibbett, 2011).

As currently described, cyanophilous skeletal hyphae are considered one of the micromorphological characteristics of *Funalia*. However, this feature is not always included in the descriptions (Table 2) and is often difficult to interpret (Kotlaba and Pouzar, 1964; Singer, 1972). Of the species listed in Table 2, CB+ is mentioned for *F. cystidiata*, *F. fulvocinerea*, *F. subgallica*, and *F. trogii*, while specimens of *F. floccosa*, *F. glabrorigens*, *F. rigida*, *F. sanguinaria*, and *F. supina* are CB-. *Funalia gallica* is reported as faintly CB+. Also, *Trametes thujae* was placed in *Funalia* based on the cyanophilous skeletal hyphae, but sequences of the species were positioned in the *Trametes* clade. These observations indicate cyanophilic as of dubious importance in the genus delimitation.

The results presented here show the urgent need of molecular data of the specimens collected in the type localities or at least reference specimens from the type locality or from similar or close habitats in order to achieve a better delimitation of its species and the genus. Also, careful examination of microcharacteristics and chemical reactions are desirable to update the descriptions of several species and to evaluate if they are important in the circumscription of *Funalia*.

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<sup>5</sup>Audet S (2017). New genera and new combinations in *Antrrodia* s.l. Mushrooms nomenclatural novelties, 1–9 [online]. Website <https://sergeaudet.mycocom/antrrodia/>

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