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ORIGINAL ARTICLE

Three new *Coltricia* (*Hymenochaetaceae, Basidiomycota*) species from China based on morphological characters and molecular evidence

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Abstract

Three new species of *Coltricia*, *C. fimbriata*, *C. lenis*, and *C. tenuihypha*, are described from China based on both morphological and molecular data. Phylogenetic analyses based on rDNA ITS1-5.8S-ITS2 (ITS), 28S rDNA (LSU), 18S rDNA (SSU), mitochondrial 12S rDNA (mtSSU), RNA polymerase II subunits 1 (*RPB1*), and EF-1α (*TEF1*) confirmed the generic placement of the three new species. *Coltricia fimbriata* is characterized by centrally stipitate basidiocarps, thin and curled pileal margin with tufts of hairs, 1–3 pores per mm, and ellipsoid to broadly ellipsoid basidiospores (6.3–8.0 × 4.3–5.3 μm). *Coltricia lenis* is characterized by centrally stipitate basidiocarps, distinctly concentrically zonate and sulcate pileal surface, soft to spongy stipes when dry, 0.5–2 pores per mm, oblong-ellipsoid to ellipsoid basidiospores (7.0–9.3 × 4.5–5.8 μm). *Coltricia tenuihypha* is characterized by eccentrically to centrally basidiocarps, fan-shaped to circular pilei, 1–3 pores per mm, narrow and skeletal-alike hyphae present in the stipe, ellipsoid to broadly ellipsoid basidiospores (7.3–9.3 × 5.5–6.8 μm). An identification key to the species of *Coltricia* recorded in China is also provided.

Keywords *Hymenochaetales* · Phylogeny · Polypore · Taxonomy · Molecular

Introduction

The genus *Coltricia* Gray was established in 1821 by the type species *C. perennis* (L.) Murrill and is a cosmopolitan genus of *Hymenochaetales* (Larsson et al. 2006). This genus is characterized by mostly poroid and stipitate basidiocarps, a monomitic hyphal system lacking clamp connections and colored, ellipsoid to subglobose, smooth basidiospores (Dai 2010). The complex habitat and exceedingly close morphological characteristics make this genus easy to be confused with *Coltriciella* Murrill which differs from *Coltricia* by the ornamented vs. smooth basidiospores (Ryvarden 1991), and molecular data indicated that the two genera were sister clades, forming a single lineage (Wagner and Fischer 2002; Larsson et al. 2006; Tedersoo et al. 2007; Bian and Dai 2017). Based on the above conclusions, *Coltriciella* was treated as a synonym of *Coltricia*, and all species of *Coltriciella* were combined in *Coltricia* (Wu et al. 2022).

Coltricia has been extensively studied worldwide, and about 27 new species (including 9 new species in the original *Coltriciella*) were reported in the last decade (Baltazar et al. 2010; Dai 2010; Baltazar and Silveira 2012; Dai and Li 2012; Valenzuela et al. 2012; Zhou and Tedersoo 2012; Decock 2013; Ryvarden and Melo 2014; Bian and Dai 2015; Bian et al. 2016; Vasco-Palacios 2016; Bian and Dai 2017; Susan et al. 2018; Bian and Dai 2020; Valenzuela et al. 2020; Vlasák et al. 2020; Wu et al. 2022). The diversity of *Coltricia* is being systematically studied, especially in south China (Dai et al. 2010; Wu et al.

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2020; Dai et al. 2021). However, due to the absence of specialized hymenial structures, a similar morphology is shared in most *Coltricia* species, which make species in this genus hard to be distinguished only by morphological studies. Therefore, the diversity of *Coltricia* is higher than presumed.

During investigations of *Coltricia* in China, several collections were found and could not be assigned to any described species, also forming distinct clades in multilocus phylogenetic inferences. They are described as new species. An identification key of *Coltricia* observed in China is provided.

Materials and methods

Morphological studies

The studied specimens are deposited in the herbarium of the Institute of Microbiology, Beijing Forestry University (BJFC). Macromorphological descriptions were based on field notes and laboratory observations. Microscopic routine used in this study followed Dai (2010). Drawings were made with the aid of a drawing tube. Microscopic measurements were made from slide preparations stained with Cotton Blue and Melzer's reagent. Spores were measured from section cuts from tubes. In presenting variation in basidiospore size, 5% of measurements were excluded from each end of the range and are given in parentheses. In the text, the following abbreviations were used: KOH, 5% potassium hydroxide; IKI, Melzer's reagent; IKI–, neither amyloid nor dextrinoid; CB, Cotton Blue; CB–, acyanophilic; L, mean basidiospore length (arithmetic average of all basidiospores); W, mean basidiospore width (arithmetic average of all basidiospores); Q, variation in the ratios of L/W between specimens studied; n, number of basidiospores measured from given number of specimens. Color terms followed Kornerup and Wanscher (1978).

Molecular phylogeny

The collections and sequences of the three new species and other fungal taxa used in this study are listed in Table 1. Twenty-seven new sequences were generated for this study and deposited to GenBank. The methods of DNA extraction and amplification in this study followed Chen et al. (2016). The CTAB rapid plant genome extraction kit-DN14 (Aidlab Biotechnologies Co., Ltd, Beijing) was used to extract total genomic DNA from dried specimens according to the manufacturer's instructions. The primers ITS5/ITS4 for rDNA ITS1-5.8S-ITS2 (ITS), LR0R/LR7 for 28S rDNA (LSU), NS1/NS4 for 18S rDNA (SSU), MS1/MS2 for mitochondrial 12S rDNA (mtSSU), RPB1-A_f /RPB1-C_r for RNA polymerase II subunit 1 (*RPB1*), and EF1-983F/EF1-1567F for EF-1α (*TEF1*) were used for PCR amplifications (Vilgalys and Hester 1990; White et al. 1990; Matheny 2005). The PCR products were sequenced in Beijing Genomics Institute, China, with the same primers. The newly generated sequences were deposited at GenBank.

For the phylogenetic analyses, the combined dataset of ITS, LSU, SSU, mtSSU, *RPB1*, and *TEF1* included 78 sequences representing 41 taxa, in which 39 taxa of *Coltricia* are involved. *Fomitiporella chinensis* (Pilát) Y.C. Dai, X.H. Ji & Vlasák and *Inonotus griseus* L.W. Zhou were chosen as the outgroup. Sequences were aligned with MAFFT (Katoh and Toh 2008), BioEdit (Hall 1999) and Clustal X (Thompson et al. 1997). Sequence alignments were deposited at TreeBASE (submission ID 29082, www.treebase.org). The best-fit evolutionary model was estimated using MrModeltest 2.3 (Posada and Crandall 1998) as GTR + I + G for the combined dataset.

Maximum parsimony (MP) analyses were applied to the combined dataset. The construction was performed in PAUP* version 4.0b10 (Swofford 2002). All characters were equally weighted, and gaps were treated as missing data. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Max-trees was set to 5000, branches of zero length were collapsed, and all parsimonious trees were saved. Clade robustness was assessed by a bootstrap (BT) analysis with 1000 replicates (Felsenstein 1985). Descriptive tree statistics, i.e., tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI), were calculated for each Maximum Parsimonious Tree (MPT) generated.

RAxML v.7.2.8 was used to construct maximum likelihood (ML) trees with the GTR+I+G model of site substitution including estimation of Gamma-distributed rate heterogeneity and a proportion of invariant sites (Stamatakis 2006). The branch support was evaluated with a bootstrapping method of 1000 replicates (Hillis and Bull 1993).

BI analyses were calculated with MrBayes3.1.2 with a general time reversible (GTR) model of DNA substitution and a gamma distribution rate variation across sites (Ronquist and Huelsenbeck 2003). Four Markov chains were run for 2 runs from random starting trees for 500000 generations, and trees were sampled every 100 generations. The first 25% of sampled trees were set as burn-in. A majority rule consensus tree of all remaining trees was calculated. BS (bootstrap support for MP and ML) values and BPPs (Bayesian posterior probabilities for BI) simultaneously not less than 75 % and 0.95, respectively, are shown at the nodes.

Results

Phylogenetic inference

The combined dataset had an aligned length of 6245 characters, of which 3461 characters are constant, 406 are variable

Table 1 List of species, specimens, and GenBank accession numbers of sequences used in this study

Species name	Localities	Substrate	Sample no.	GenBank accession no.					
				ITS	LSU	SSU	mtSSU	*RPB1*	*TEF1*
Coltricia abieticola	China	Ground	Cui 12276	KU360673	KU360643	KY693762	KY693824	KX364829	KY693912
C. abieticola	China	Ground	Cui 12312	KU360674	KU360644	KY693763	KY693825	KX364830	—
C. australica	Australia	Ground	TU 103694	—	AM412243	—	—	—	—
C. austrosinensis	China	Ground	Dai 13093	KU360670	KU360640	KY693764	KY693826	KX364824	KY693913
C. austrosinensis	China	Ground	Dai 13098	KU360671	KU360640	KY693765	KY693827	KX364825	—
C. barbata	Colombia	Ground	AMV 1866	KT724137	—	—	—	—	—
C. barbata	Colombia	Ground	AMV 1925	KT724136	KT724149	—	—	—	—
C. baoshanensis	China	Rotten wood of *Castanopsis*	Cui 8147	KX364799	KX364819	—	—	KX364864	—
C. baoshanensis	China	Rotten wood of *Castanopsis*	Dai 13075	KX364800	KX364820	KY693812	KY693870	KX364865	KY693953
C. cinnamomea	China	Ground	Cui 12549	KY693728	KY693742	KY693769	KY693830	KY693882	KY693916
C. cinnamomea	China	Ground	Cui 12584	KY693729	KY693743	KY693770	KY693831	KY693883	KY693917
C. cinnamomea	Finland	Ground	TN 8199	—	MF318906	—	—	—	—
C. confluens	Estonia	Ground	TAA 181460	AM412241	AM412241	—	—	—	—
C. confluens	USA	Ground	TF 072287	MN121008	MN121008	—	—	—	—
C. crassa	China	Ground	Cui 10255	KU360678	KU360647	KY693777	KY693836	KX364834	KY693921
C. crassa	China	Ground	Dai 15163	KU360679	KU360648	KY693778	KY693837	KX364835	KY693922
C. dependens	China	Rotten wood	Dai 10944	KY693737	KY693757	KY693813	KY693871	—	—
C. dependens	China	Rotten wood	Cui 9210	KY693738	KY693758	KY693814	KY693872	—	—
C. fimbriata	China	Ground	Dai 22300	OL691607[a]	OL691616[a]	OL691612[a]	OL691604[a]	OL689389[a]	OL689394[a]
C. focicola	China	Ground	Dai 16090	KX364786	KX364805	—	—	KX364836	KY693923
C. globosa	China	Ground	Cui 7545	KJ540930	KJ000226	KY693815	KY693873	KX364866	KY693954
C. globosa	Vietnam	Ground	Dai 18420	MT174245	MT174238	—	—	—	—
C. hamata	Brazil	Ground	3947	MZ484545	MZ437402	—	—	—	—
C. hamata	Brazil	Ground	4054	MZ484546	—	—	—	—	—
C. hamata	Colombia	Ground	AMV 1897	KT724146	KT724150	—	—	—	—
C. hamata	Colombia	Ground	AMV 2076	KT724142	KT724151	—	—	—	—
C. hirtipes	Thailand	Ground	Dai 16647	KY693734	KY693750	—	KY693838	KY693889[a]	—
C. hirtipes	Thailand	Ground	Dai 16651	—	KY693751	—	—	—	—
C. kinabaluensis	Thailand	Fallen wood	Dai 13957	KX364787	KX364806	KY693780	—	KX364837	KY693924
C. kinabaluensis	Thailand	Fallen wood	Dai 13958	KX364788	KX364807	KY693781	KY693839	KX364838	KY693925
C. lateralis	China	Ground	Cui 12563	KX364789	KX364808	KY693782	KY693840	KX364839	KY693926
C. lateralis	China	Ground	Dai 13564	KX364790	KX364809	—	KY693841	KX364840	KY693927
C. lenis	China	Ground	Dai 22367	OL691608[a]	OL691617[a]	OL691613[a]	—	OL689390[a]	—
C. lenis	China	Ground	Dai 22373	—	OL691618[a]	OL691614[a]	OL691605[a]	OL689391[a]	OL689395[a]
C. lenis	China	Ground	Dai 22374	OL691609[a]	OL691619[a]	OL691615[a]	OL691606[a]	OL689392[a]	OL689396[a]
C. macropora	China	Ground	Cui 9019	KU360680	KJ000220	KY693783	KY693842	KX364841	—
C. macropora	China	Ground	Cui 9039	KU360681	KJ000221	KY693784	KY693843	—	KY693928
C. minima	China	Ground	Dai 15206	KU360682	KU360649	KY693785	KY693844	KX364842	KY693929
C. minima	China	Ground	Dai 15222	KU360683	KU360650	KY693786	KY693845	KX364843	KY693930
C. minor	China	Rotten wood	Dai 16088	KU360684	KU360651	KY693787	KY693846	KX364844	KY693931
C. montagnei	China	Ground	Cui 10169	KU360685	KU360652	KY693788	KY693847	KX364845	KY693932
C. montagnei	China	Ground	Dai 12137	—	KX364810	KY693789	KY693848	KX364846	KY693933
C. montagnei	USA	Ground	MF 96-96	—	AY039683	—	—	—	—
C. navispora	Guyana	Fallen wood	MCA 3921	KC155387	KC155386	—	—	—	—
C. navispora	Guyana	Fallen wood	TH 9529	KT339262	—	—	—	—	—

Table 1 (continued)

Species name	Localities	Substrate	Sample no.	GenBank accession no.					
				ITS	LSU	SSU	mtSSU	*RPB1*	*TEF1*
C. oblectabilis	Colombia	Ground	AMV 2255	KT354690	—	—	—	—	—
C. oblectabilis	Guyana	Ground	TH 9187	KC155387	KC155387	—	—	—	—
C. perennis	China	Ground	Cui 10318	KU360686	KJ000224	KY693790	KY693849	KX364847	KY693934
C. perennis	China	Ground	Cui 10319	KU360687	KU360653	KY693791	KY693850	KX364848	KY693935
C. perennis	USA	Ground	JV 0809/66	KX364791	KX364811	KY693792	KY693851	KX364849	KY693936
C. pseudodependens	China	Rotten wood	Cui 8138	KJ540931	KJ000227	KY693816	KY693874	KX364867	—
C. pseudodependens	China	Rotten wood	Cui 12582	KX364801	KX364821	KY693817	KY693875	KX364868	KY693955
C. pusilla	China	Rotten wood	Dai 15168	KU360701	KU360667	KY693818	KY693876	KX364869	KY693956
C. pusilla	Japan	Rotten wood	MN 26.7.95	—	AY059060	—	—	—	—
C. rigida	China	Ground	Dai 13622a	KX364793	KX364813	KY693796	—	KX364853	KY693940
C. rigida	China	Ground	Dai 16322	KX364794	KX364814	KY693797	KY693855	KX364854	KY693941
C. sinoperennis	China	Ground	Dai 11625	KY693735	KY693753	KY693804	KY693862	KY693890	KY693948
C. sinoperennis	China	Ground	Dai 13095	KY693736	KY693754	KY693805	KY693863	KY693891	—
C. sonorensis	Mexico	Ground	RV 13144	—	HQ439179	—	—	—	—
C. strigosipes	China	Ground	Dai 15145	KX364795	KX364815	KY693798	KY693856	KX364855	KY693942
C. strigosipes	China	Ground	Dai 15586	KU360692	KU360658	KY693799	KY693857	KX364856	KY693943
C. subcinnamomea	China	Ground	Dai 17016	KY693740	KY693755	KY693810	KY693868	KY693892	—
C. subcinnamomea	China	Ground	Dai 17022	—	KY693756	KY693811	KY693869	KY693893	—
C. subglobosa	China	Rotten wood	Dai 15158	KU360702	KU360669	KY693820	KY693878	—	—
C. subglobosa	China	Rotten wood	Yuan 6253	—	KX364822	KY693821	KY693879	KX364870	—
C. subverrucata	China	Ground	Dai 12919	MT174242	MT174235	MT174233	MT174240	—	MT133895
C. subverrucata	China	Ground	Dai 15600	MT174243	MT174236	MT174234	MT174241	MT133893	MT133896
C. tenuihypha	China	Ground	Dai 22684	OL691610[a]	OL691620[a]	—	—	OL689393[a]	OL689397[a]
C. tenuihypha	China	Ground	Dai 22690	OL691611[a]	OL691621[a]	—	—	—	—
C. tibetica	China	Dead tree of *Picea*	Cui 12208	MZ484551	MZ437407	—	—	—	—
C. velutina	China	Ground	Dai 16980	—	KY693752	—	—	—	—
C. verrucata	China	Ground	Dai 15120	KU360694	KU360660	KY693801	KY693859	KX364858	KY693945
C. verrucata	China	Ground	Dai 15125	KU360695	KU360661	KY693802	KY693860	KX364859	KY693946
C. weii	China	Ground	Cui 12624	KX364796	KX364816	KY693807	KY693865	KX364861	KY693950
C. weii	China	Ground	Dai 13422	KX364797	KX364817	KY693808	KY693866	KX364862	KY693951
C. wenshanensis	China	Ground	Dai 15585	KX364798	KX364818	KY693809	KY693867	KX364863	KY693952
Fomitiporella chinensis	China	Rotten wood of *Quercus*	Cui 11230	KX181309	KY693759	—	KY693880	KY693894	KY693958
Inonotus griseus	China	Rotten wood	Dai 13436	KX364802	KX364823	—	KY693881	KX364871	KY693959

[a] Newly generated sequences for this study

and parsimony uninformative, and 2378 are parsimony informative. MP analysis yielded four equally most-parsimonious trees (TL = 10232, CI = 0.444, RI = 0.722, RC = 0.321, HI = 0.556). Bayesian analysis and ML analysis resulted in a similar topology to MP analysis. The MP tree is provided in Fig. 1.

The phylogeny analysis revealed that species of *Coltricia* formed three clades, and the newly sampled species nested within the three clades, respectively. The sampled specimens of *Coltricia lenis* and *C. tenuihypha* formed well-supported lineages respectively (*C. lenis* 100% in MP, 100% in ML, 1 in BI; *C. tenuihypha* 100% in MP, 100% in ML, 1 in BI). *C. fimbriata* grouped with *C. hamata* and formed a well-supported lineage with *C. lateralis*, *C. rigida* and *C. velutina* (95% in MP, 96% in ML, 1 in BI).

According to the phylogenetic analyses, the three new species are distinctive from the other sampled species.

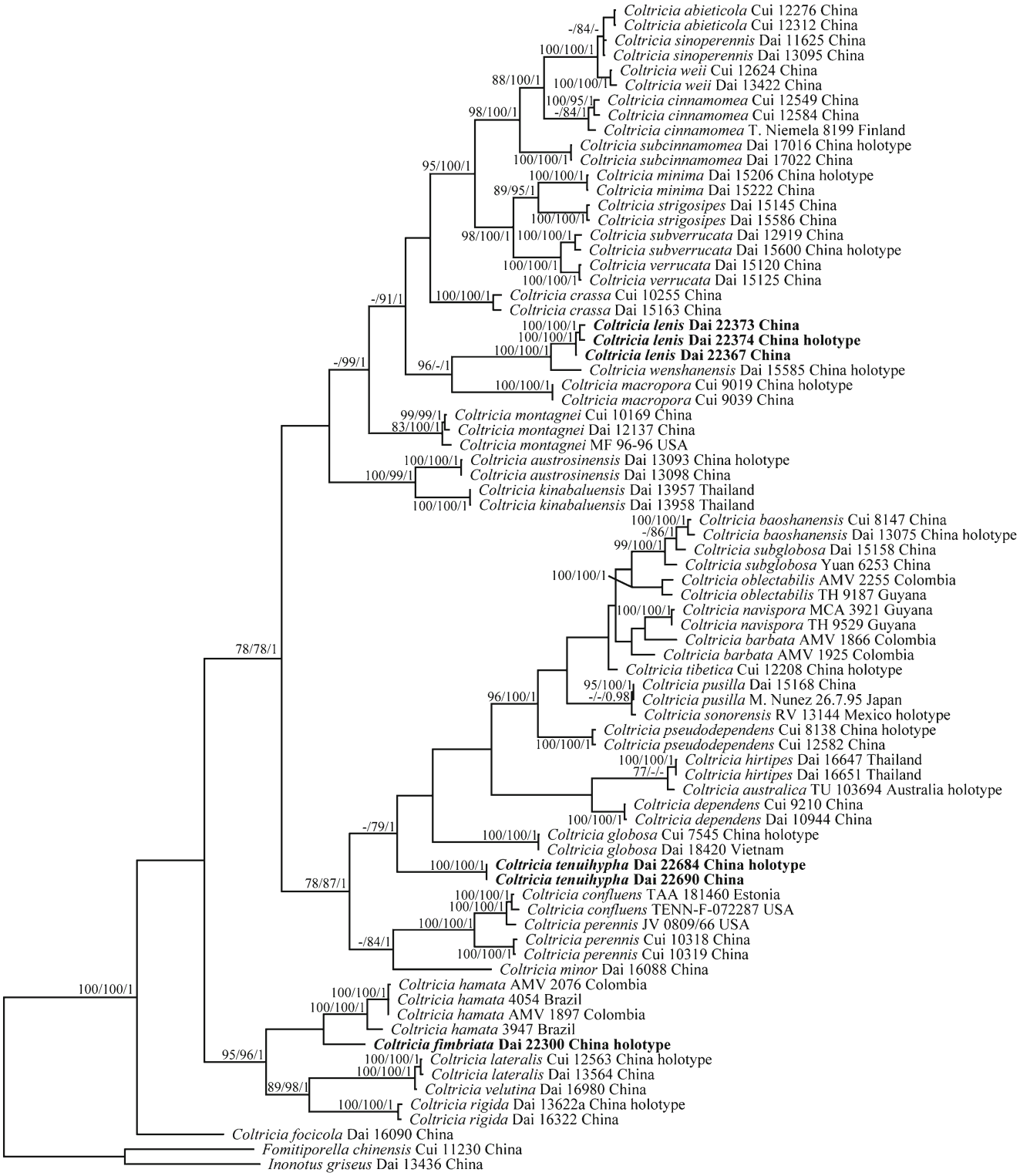

Fig. 1 Strict consensus tree illustrating the phylogeny based on the combined dataset. Branches are labeled with parsimony bootstrap proportions high than 75%, maximum likelihood bootstrap higher than 75% and Bayesian posterior probabilities more than 0.95

Taxonomy

Coltricia fimbriata L.S. Bian, M. Zhou & J. Yu, sp. nov. Fig. 2A, Fig. 3

MycoBank no.: MB 842181

Diagnosis: this species is characterized by centrally stipitate basidiocarps, thin and curled pileal margin with tufts of hairs, 1–3 pores per mm, 5–9 μm wide contextual hyphae, 3–7 μm wide tramal hyphae and ellipsoid to broadly ellipsoid basidiospores, 6.3–8.0 × 4.3–5.3 μm (average).

Holotype: **CHINA**. Zhejiang Province, Hangzhou, Huanggongwang Nature Reserve, on ground of angiosperm forest, 2 June 2021, Dai 22300.

Etymology: *fimbriata* (Lat.): referring to the species having velutinate and lacerate pileal margin.

Basidiocarps: annual, centrally stipitate, solitary, soft and without odor or taste when fresh, becoming soft corky when dry. Pilei more or less circular, flat, thin, up to 1.5 cm in diam and 1 mm thick at center. Pileal surface greyish brown to deep olive when dry, hirsute in the center, radially aligned fine hair extending to the margin, with indistinct concentric zones; margin thin, curled, velutinate and lacerate with tufts of hairs when dry. Pore surface cream to honey-yellow upon drying; pores angular, 1–3 per mm; dissepiments thin, entire, sterile margin distinct. Context deep olive, leathery, up to 0.5 mm thick. Tubes cream, distinctly paler than context, fragile or slightly brittle when dry, up to 0.5 mm long. Stipe fuscous, corky, finely velutinate to smooth, up to 2 cm long, 1.2 mm in diam, swollen near the base.

Hyphal structure: hyphal system monomitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

Context: contextual hyphae yellowish brown to honey-yellow, thick-walled with a wide lumen, occasionally branched, frequently simple septate, straight, more or less regularly arranged, 5–9 μm in diam; hyphae in stipe similar to those in context, parallel along the stipe, occasionally branched, 3–6 μm in diam.

Tubes: tramal hyphae cinnamon-buff to fawn, thin- to slightly thick-walled with a wide lumen, moderately branched, frequently simple septate, straight, subparallel along the tubes, 3–7 μm in diam. Cystidia and cystidioles absent, basidia barrel-shaped, thin-walled, with four sterigmata and a simple septum at the base, 15–18 × 8–10 μm; basidioles similar like basidia in shape, but slightly smaller.

Spores: basidiospores ellipsoid to broadly ellipsoid, buff-yellow, thick-walled, smooth, IKI–, CB–, 6.3–8.0(–8.5) × 4.3–5.3(–5.5) μm, L = 7.08 μm, W = 4.80 μm, Q = 1.48 (n=30/1).

Habitat: on ground of angiosperm forest, known only from the type locality in southern China.

Coltricia lenis L.S. Bian, M. Zhou & J. Yu, sp. nov. Fig. 2B, Fig. 4

MycoBank no.: MB 842182

Diagnosis: this species is characterized by centrally stipitate basidiocarps, distinctly concentrically zonate and sulcate pileal surface, soft to spongy stipes when dry, 0.5–2 pores

Fig. 2 Basidiocarps of the new species. **A***Coltricia fimbriata* (Dai 22300, holotype); **B***Coltricia lenis* (Dai 22374, holotype); **C***Coltricia tenuihypha* (Dai 22684, holotype). Bars = 1 cm

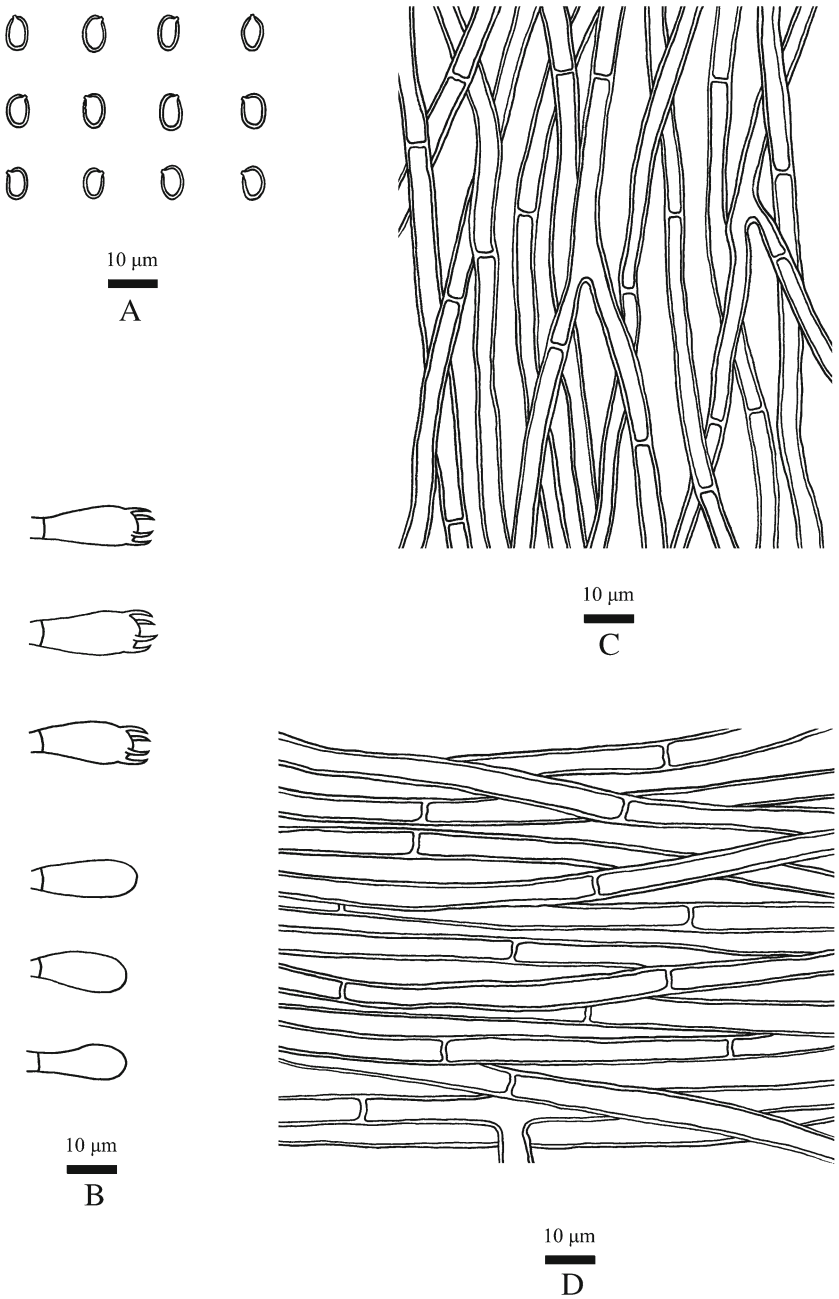

Fig. 3 Microscopic structures of *Coltricia fimbriata* (drawn from the holotype). **A** Basidiospores; **B** Basidia and basidioles; **C** Hyphae from trama; **D** Hyphae from context

per mm, oblong-ellipsoid to ellipsoid basidiospores, 7.0–9.3 × 4.5–5.8 μm (average).

Holotype: **CHINA**. Fujian Province, Yongtai County, Tianmen Moutain National Forest Park, on ground of angiosperm forest, 5 June 2021, Dai 22374.

Etymology: *lenis* (Lat.): referring to the species having soft stipes when dry.

Basidiocarps: Annual, centrally stipitate, solitary, soft and without odor or taste when fresh, becoming soft and corky when dry. Pilei more or less circular, flat to infundibuliform, up to 3 cm in diam and 2 mm thick at center. Pileal surface fawn to orange-brown, velutinate to glabrous, distinctly concentrically zonate and sulcate; bristles erect in the center; magin thin and obtuse, curving down upon drying. Pore surface curry-yellow to honey-yellow upon drying; pores angular, 0.5–2 per mm; dissepiments thin, entire. Context fawn to orange-brown, leathery, up to 0.5 mm thick. Tubes curry-yellow, distinctly paler than context, fragile or slightly brittle when dry, up to 1.5 mm long. Stipe reddish brown, soft to spongy, irregular when dry, finely velutinate, up to 3.5 cm, 4 mm in diam, swollen near the base.

Hyphal structure: hyphal system monomitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

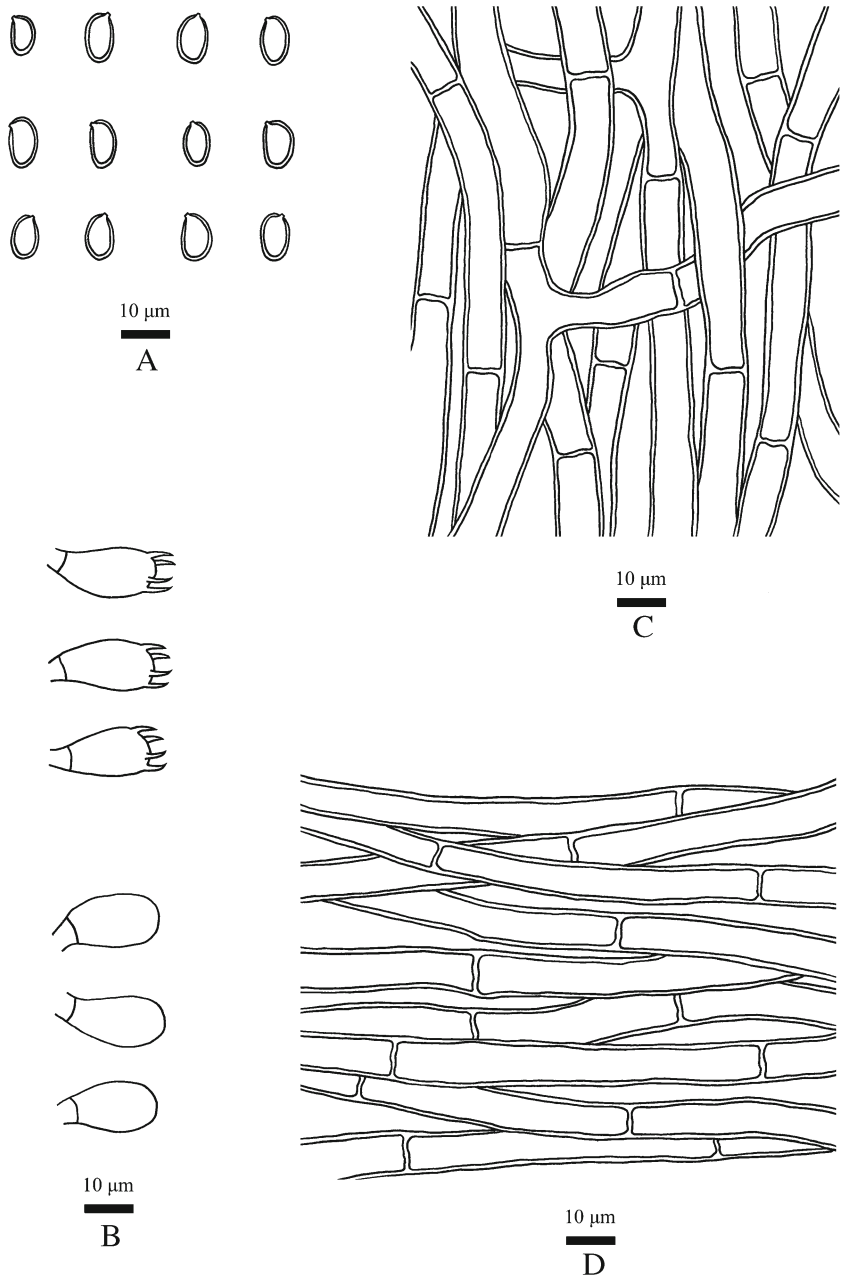

Fig. 4 Microscopic structures of *Coltricia lenis* (drawn from the holotype). **A** Basidiospores; **B** Basidia and basidioles; **C** Hyphae from trama; **D** Hyphae from context

Context: contextual hyphae cinnamon-buff to reddish brown, thick-walled with a wide lumen, unbranched, frequently simple septate, straight, more or less regularly arranged, 8–13 μm in diam; hyphae in stipe similar to those in context, parallel along the stipe, moderately branched, 10–16 μm in diam.

Tubes: tramal hyphae buff-yellow to yellowish brown, thin- to slightly thick-walled with a wide lumen, moderately branched, frequently simple septate, straight, subparallel along the tubes, 6–12 μm in diam. Cystidia and cystidioles absent, basidia barrel-shaped, thin-walled, with four sterigmata and a simple septum at the base, 17–20 × 10–12 μm; basidioles similar like basidia in shape, but slightly smaller.

Spores: basidiospores oblong-ellipsoid to ellipsoid, yellowish, thick-walled, smooth, IKI–, CB–, (6.8–)7.0–9.3(–9.5) × 4.5–5.8(–6.3) μm, L = 8.28 μm, W = 5.13 μm, Q = 1.56–1.63 (n=60/2).

Habitat: on ground of angiosperm forest, known only from the type locality in southern China.

Additional material (paratype) examined: **CHINA**. Fujian Province, Yongtai County, Tianmen Moutain National Forest Park, on ground of angiosperm forest, 5 June 2021, Dai 22373.

Coltricia tenuihypha L.S. Bian, M. Zhou & J. Yu, sp. nov. Fig. 2C, Fig. 5

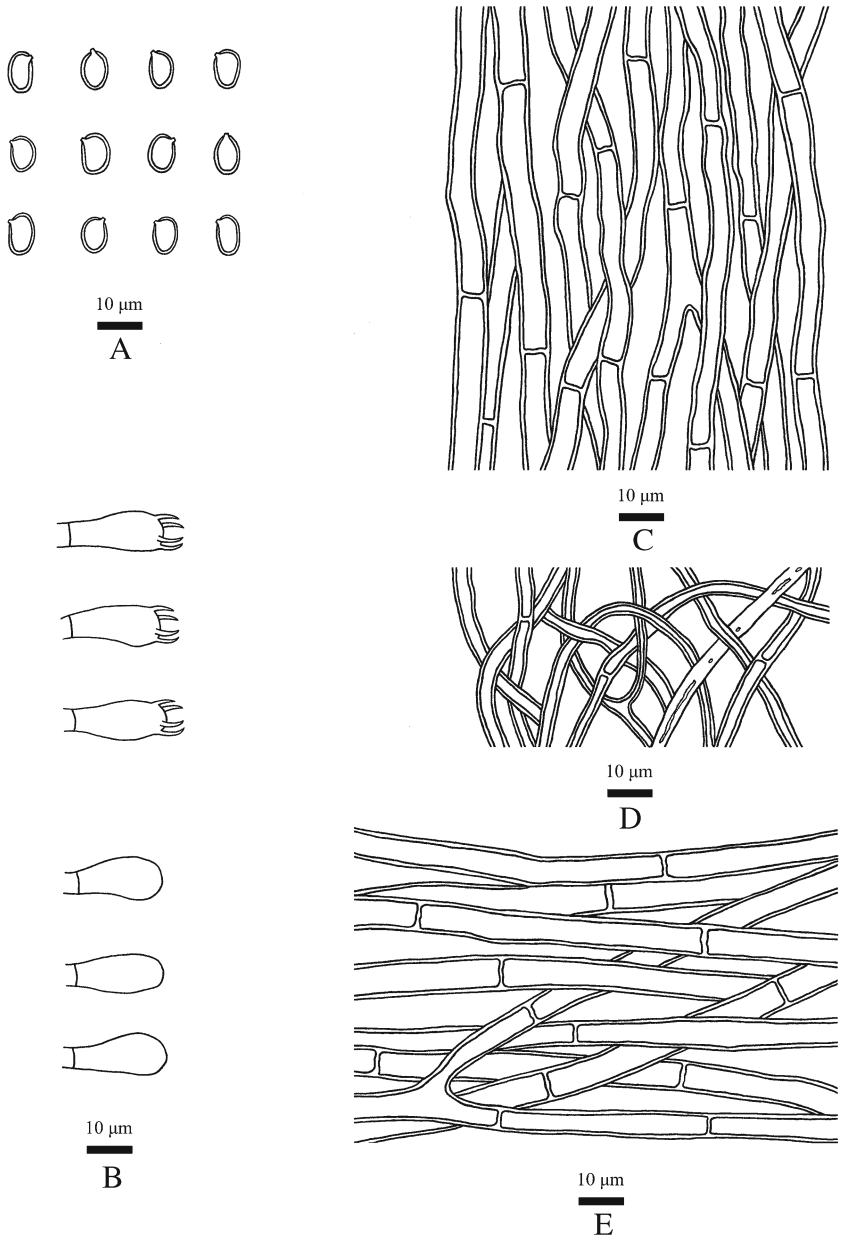

Fig. 5 Microscopic structures of *Coltricia tenuihypha* (drawn from the holotype). **A** Basidiospores; **B** Basidia and basidioles; **C** Hyphae from trama; **D** Hyphae from stipe; **E** Hyphae from context

MycoBank no.: MB 842183

Diagnosis: this species is characterized by eccentrically to centrally basidiocarps, fan-shaped to circular pilei, lacerate pileal margin, 1–3 pores per mm, narrow and skeletal-alike hyphae present in the stipe, ellipsoid to broadly ellipsoid basidiospores, 7.3–9.3 × 5.5–6.8 μm (average).

Holotype: **CHINA**. Yunnan Provice, Jianchuan County, Jizu Moutain Nature Reserve, on ground of angiosperm forest, 1 Sep 2021, Dai 22684.

Etymology: *tenuihypha* (Lat.): referring to the species having narrow hyphae in the stipe.

Basidiocarps: annual, eccentrically to centrally stipitate, solitary, soft and without odor or taste when fresh, becoming soft corky when dry. Pilei fan-shaped to more or less circular, flat to infundibuliform, up to 2.5 cm in diam and 1.5 mm thick at center. Pileal surface greyish brown to deep olive when dry, hirsute in the center with bristles erected, velutinate, with indistinct concentric zones; margin thin, lacerate, curving down upon drying. Pore surface greyish brown to fuscous upon drying; pores angular, 1–3 per mm; dissepiments thin, lacerate, sterile margin distinct. Context fawn, leathery, up to 0.3 mm thick. Tubes bluish grey to honey-yellow, distinctly paler than context, fragile or slightly brittle when dry, up to 1.2 mm long. Stipe greyish brown to deep olive, corky, smooth, up to 4 cm long, 1.5 mm in diam, sometimes branched, swollen near the base.

Hyphal structure: hyphal system monomitic to pseudodimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

Context: contextual hyphae yellowish brown to greyish brown, thick-walled with a wide lumen, rarely branched, frequently simple septate, straight, more or less regularly arranged, 6–9 μm in diam; hyphae in stipe thick-walled with a narrow lumen, rarely septate and branched, skeletal-alike, sometimes sclerified, distinctly narrower than those in context, loosely interwoven, 2.5–5 μm in diam.

Tubes: tramal hyphae cinnamon-buff to yellowish brown, thin- to slightly thick-walled with a wide lumen, rarely branched, frequently simple septate, more or less straight, subparallel along the tubes, 5–8 μm in diam. Cystidia and cystidioles absent; basidia barrel-shaped, thin-walled, with four sterigmata and a simple septum at the base, 15–20 × 8–10 μm; basidioles similar like basidia in shape, but slightly smaller.

Spores: basidiospores ellipsoid to broadly ellipsoid, yellowish, thick-walled, smooth, IKI–, CB–, (7.0–)7.3–9.3(–9.5) × 5.5–6.8(–7.0) μm, L = 8.20 μm, W = 5.87 μm, Q = 1.32–1.39 (n=60/2).

Habitat: on ground of angiosperm forest, known only from the type locality in Southwest China.

Additional material (paratype) examined: **CHINA**. Yunnan Provice, Jianchuan County, Jizu Moutain Nature Reserve, on ground of angiosperm forest, 1 Sep 2021, Dai 22684.

Discussion

Coltricia fimbriata has centrally stipitate basidiocarps, large pores, and ellipsoid to broadly ellipsoid basidiospores, similar to *C. pyrophila* (Wakef.) Ryvarden and *C. wenshanensis* L.S. Bian & Y.C. Dai. However, *Coltricia pyrophila* can be distinguished from *C. fimbriata* by large basidiocarps (up to 8.5 cm in diam), decurrent pores and distinctly smaller basidiospores (4–5.5 × 3–3.5 μm vs. 6.3–8.0 × 4.3–5.3 μm; Ryvarden 1972). *Coltricia wenshanensis* has larger basidiocarps (up to 5 cm in diam) with distinctly concentrically zonate and sulcate, wider basidiospores (7.5–8 × 6–7 μm vs. 6.3–8.0 × 4.3–5.3 μm; Bian and Dai 2017). In addition, *C. fimbriata* can be also distinguished by the hairy pileal margin. This feature is shared by *C. barbata* Ryvarden & de Meijer and *C. velutina* Baltazar & Gibertoni. But the latter two species have smaller pores (4–9 per mm and 5–7 per mm, respectively, vs. 1–3 per mm in *C. fimbriata*; Ryvarden and de Meijer 2002; Baltazar et al. 2010). *Coltricia fimbriata* is closely related to *C. hamata* (Romell) Ryvarden in the phylogenetic analysis (Fig. 1). However, *C. hamata* has large (3–8 cm in diam) and rigid basidiocarps, setal hyphae in lower context and bigger basidiospores (8–10 × 5.5–6.5 μm vs. 6.3–8.0 × 4.3–5.3 μm; Ryvarden 1974).

Coltricia lenis resembles *C. fragilissima* (Mont.) Ryvarden and *C. permollis* Baltazar et Gibertoni in having centrally stipitate basidiocarps, zonate pileal surface, large pores, and thick stipes. However, *C. fragilissima* has large basidiocarps (8.5 cm in diam, 3 cm thick at the base), solid stipes, and distinctly smaller basidiospores (4–5.5 × 3–3.5 μm vs. 7.0–9.3 × 4.5–5.8 μm; Ryvarden 1982). *Coltricia permollis* differs from *C. lenis* by bigger pores (0.5–1.5 mm in diam), bulbous stipes tapering toward the apex (base up to 1.5 cm in diam), and longer basidiospores (8–9.5 × 5.5–6.5 μm vs. 7.0–9.3 × 4.5–5.8 μm; Baltazar et al. 2010). In the phylogenetic analysis, *Coltricia lenis* and *C. wenshanensis* L.S. Bian & Y.C. Dai formed a well-supported lineage (100% in MP, 100% in ML, 1 in BI) and distinctly differed from other species (Fig. 1). However, *C. wenshanensis* has larger basidiocarps (up to 5 cm in diam and 5.5 mm thick at center), corky stipes, and wider basidiospores (7.5–8 × 6–7 μm vs. 7.0–9.3 × 4.5–5.8 μm; Bian and Dai 2017).

Coltricia tenuihypha resembles *C. austrosinensis* L.S. Bian & Y.C. Dai and *C. progressus* Corner ex Y.C. Dai & Hai J. Li in having eccentrically to centrally stipitate basidiocarps, large spores, velutinate pilei, and ellipsoid to broadly ellipsoid basidiospores. However, *C. austrosinensis* has thicker basidiocarps (5 mm thick at center) and longer basidiospores (8.2–9.8 × 5.5–6.5 μm vs. 7.3–9.3 × 5.5–6.8 μm; Bian et al. 2016). *Coltricia progressus* has imbricate basidiocarps, thicker context (up to 11 mm thick), and slightly longer basidiospores (8–9.8 × 5–6.5 μm vs. 7.3–9.3 × 5.5–6.8 μm; Dai and Li 2012). Actually, *C. tenuihypha* can be readily recognized by the branched stipes and distinctly narrow skeletal-alike hyphae in the stipe. *Coltricia hirtipes* Corner also has branched stipes, but it can be distinguished by smaller pores (4 per mm vs. 1–3 per mm), wider stipe hyphae (up to 8 μm in diam), and smaller basidiospores (5.2–6.2 × 4.7–5.5 μm vs. 7.3–9.3 × 5.5–6.8 μm; Dai and Li 2012). Skeletal-alike hyphae are also present in *C. rigida* L.S. Bian & Y.C. Dai, but the latter has laterally stipitate and woody-hard basidiocarps, smaller pores (7–8 per mm vs. 1–3 per mm), subglobose to globose basidiospores (6–7 × 5–6.5 μm) and skeletal-alike hyphae are also present in pilei. According to the phylogenetic analysis, the sampled specimens of *C. tenuihypha* formed a well-supported lineage which is distinctive from the other sampled species.

Key to species of *Coltricia* in China

1 Basidiospores smooth.....2
1* Basidiospores finely ornamented or verrucose.....27
2 Hymenophore more or less concentrically lamellate..... *C. montagnei* (Fr.) Murrill

2* Hymenophore poroid.....3
3 Basidiocarps pendent.....*C. tsugicola* Y.C. Dai & B.K. Cui
3* Basidiocarps erect.....4
4 Hyphae in stipe distinctly narrower than those in context, skeletal-alike hyphae present.....*C. tenuihypha* L.S. Bian, M. Zhou & J. Yu
4* Hyphae in stipe similar to those in context, skeletal-alike hyphae absent.....5
5 Basidiocarps laterally stipitate.....6
5* Basidiocarps eccentrically to centrally stipitate.....9
6 Mature pilei < 0.5 cm in diam.....*C. minor* Y.C. Dai
6* Mature pilei > 0.5 cm in diam.....7
7 Basidiocarps woody-hard; basidiospores subglobose to globose, < 7 μm long.....*C. rigida* L.S. Bian & Y.C. Dai
7* Basidiocarps soft to corky; basidiospores ellipsoid to broadly ellipsoid, > 7 μm long.....8
8 Basidiocarps up to 1 cm thick; basidiospores 8–10 × 6–7 μm.....*C. duportii* (Pat.) Ryvarden
8* Basidiocarps up to 2 mm thick; basidiospores 7–8 × 5.2–6 μm.....*C. lateralis* L.S. Bian & Y.C. Dai
9 Stipe duplex; on fallen trunk of *Abies*.....*C. abieticola* Y.C. Dai
9* Stipe homogeneous; on ground of mixed forests.....10
10 Pores 0.5–3 per mm.....11
10* Pores 3–6 per mm.....20
11 Hyphae strongly verrucose.....12
11* Hyphae smooth.....13
12 Basidiocarps up to 1 cm in diam, pores 2–3 per mm; basidiospores 7.5–9 × 4.8–5 μm.....*C. verrucata* Aime, T.W. Henkel & Ryvarden
12* Basidiocarps up to 2.5 cm in diam, pores 0.5–2 per mm; basidiospores 7.8–9 × 6–7 μm.....*C. subverrucata* L.S. Bian & Y.C. Dai
13 Context thick, up to 12 mm thick; dendrohyphidia-like hyphae present.....*C. crassa* Y.C. Dai
13* Context thin, up to 1 mm thick; dendrohyphidia-like hyphae absent.....14
14 Basidiocarps eccentrically stipitate, with unpleasant odor.....*C. macropora* Y.C. Dai
14* Basidiocarps centrally stipitate, without odor.....15
15 Stipe soft to spongy when dry.....*C. lenis* L.S. Bian, M. Zhou & J. Yu
15* Stipe corky when dry.....16
16 Basidiospores < 5.5 μm wide.....17
16* Basidiospores > 5.5 μm wide.....18
17 Pileal margin without hairs; basidiospores oblong-ellipsoid, 8–11 × 4–5 μm.....*C. focicola* (Berk. & M.A. Curtis) Murrill
17* Pileal margin with tufts of hairs; basidiospores ellipsoid to broadly ellipsoid, 6.3–8 × 4.3–5.3 μm.....*C. fimbriata* L.S. Bian, M. Zhou & J. Yu
18 Contextual hyphae > 10 μm wide.....*C. subcinnamomea* L.S. Bian & Y.C. Dai
18* Contextual hyphae < 10 μm wide.....19
19 Stipe more or less uniform; basidiospores 7.5–8.2 × 6–6.8 μm.....*C. wenshanensis* L.S. Bian & Y.C. Dai
19* Stipe up to 8 mm diam at the base; basidiospores 8–10 × 5.5–6.5 μm.....*C. austrosinensis* L.S. Bian & Y.C. Dai
20 Stipe bearing numerous spines.....*C. strigosipes* Corner
20* Stipe smooth or velutinate.....21
21 Growing in gymnosperm forests; basidiospores ellipsoid.....*C. perennis* (L.) Murrill
21* Growing in angiosperm forests; basidiospores broadly ellipsoid to globose.....22
22 Tramal hyphae 3–4 μm in diam.....23
22* Tramal hyphae 4–9 in diam.....24
23 Mature pilei > 1.5 cm in diam; basidiospores 7.8–9 × 5.2–6 μm.....*C. sinoperennis* Y.C. Dai & F. Wu
23* Mature pilei < 1.5 cm in diam; basidiospores 6–7 × 4–5 μm.....*C. minima* L.S. Bian & Y.C. Dai
24 Basidiospores < 4 μm wide.....*C. pyrophila* (Wakef.) Ryvarden
24* Basidiospores > 4 μm wide.....25
25 Pileal surface hyphae dichotomously branched.....*C. weii* Y.C. Dai
25* Pileal surface hyphae unbranched.....26
26 Mature pilei > 2 cm in diam; basidiospores 7–8 × 5.5–6.5 μm.....*C. cinnamomea* (Jacq.) Murrill
26* Mature pilei < 2 cm in diam; basidiospores 5.5–6.2 × 4.5–5.8 μm.....*C. velutina* Baltazar & Gibertoni
27 Basidiocarps resupinate to effused-reflexed.....28
27* Basidiocarps stipitate.....29
28 Hyphae at dissepiment edge mostly moniliform; cystidioles present.....*C. subglobosa* (Y.C. Dai) Y.C. Dai & F. Wu
28* Hyphae at dissepiment edge uniform; cystidioles absent.....*C. baoshanensis* (Y.C. Dai & B.K. Cui) Y.C. Dai & F. Wu
29 Basidiocarps pendent.....30
29* Basidiocarps erect.....31
30 Basidiospores 6–9 × 4–5.5 μm.....*C. dependens* (Berk. & M.A. Curtis) Imazeki
30* Basidiospores 9–11.8 × 5–6.2 μm.....*C. pseudodependens* (L.S. Bian & Y.C. Dai) Y.C. Dai & F. Wu
31 Basidiocarps laterally stipitate, pilei fan-shaped.....*C. pusilla* Imazeki & Kobayasi
31* Basidiocarps centrally stipitate, pilei more or less circular.....32
32 Basidiospores ellipsoid.....33
32* Basidiospores naviculate or subglobose to globose.....34
33 Pores 3–4 per mm; basidiospores 6.5–7.8 × 4.8–5.5 μm.....*C. subpicta* (Lloyd) Imazeki & Kobayasi

33* Pores 1–2 per mm; basidiospores 8.5–10.2 × 5–6 μm.....*C. oblectabilis* (Lloyd) Ryvarden
34 Basidiospores naviculate, 8–11 × 5–6.2 μm.....
.....*C. naviculiformis* (Y.C. Dai & Niemelä) Y.C. Dai & F. Wu
34* Basidiospores subglobose to globose, 6–7 × 5.8–7 μm.....
....*C. globosa* (L.S. Bian & Y.C. Dai) Y.C. Dai & F. Wu

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Data availability The sequence data generated in this study are deposited in NCBI GenBank.

Declarations

Competing interests The authors declare no competing interests.

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