The subfamily Xerocomoideae (Boletaceae, Boletales) in China

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Abstract: Xerocomoideae is an ecologically and economically important Boletaceae subfamily (Boletales) comprising 10 genera. Although many studies have focused on Xerocomoideae in China, the diversity, taxonomy and molecular phylogeny still remained incompletely understood. In the present study, taxonomic and phylogenetic studies on Chinese species of Xerocomoideae were carried out by morphological examinations and molecular phylogenetic analyses. Eight genera in Xerocomoideae, viz. Aureoboletus, Boletellus, Heimiporus, Hemileccinum, Hourangia, Phylloporus, Pulchroboletus, and Xerocomus were confirmed to be distributed in China; 97 species of the subfamily were accepted as being distributed in China; one ambiguous taxon was tentatively named Bol. aff. putoensis; two synonyms, viz. A. marronius and P. dimorphus were defined. Among the Chinese accepted species, 13 were newly described, viz. A. albipes, A. conicus, A. ornatipes, Bol. erythroplepis, Bol. rubidus, Bol. sincryphenteroides, Bol. subglobosus, Bol. zenghuoxingii, H. squamipes, P. hainanensis, Pul. erubescentes, X. albotomentosus, and X. fuscatus, were defined

Key words: Bolete, molecular phylogeny, morphology, new taxon, taxonomy.


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INTRODUCTION

Ongoing phylogenetic studies have confirmed that the subfamily Xerocomoideae (Boletaceae, Boletales) includes 10 genera, viz. Alessioporus, Aureoboletus, Boletellus, Heimiporus, Hemileccinum, Hourangia, Phylloporus, Pulchroboletus, Rubinosporus, and Xerocomus (Nuhn et al. 2013, Gelardi et al. 2014, Halling et al. 2015, Zhu et al. 2015, Wu et al. 2016, Loizides et al. 2019, Wagensommer et al. 2021, Vadhanarat et al. 2022). Two additional genera, Coreroboletus and Sinoboletus, were initially described in the subfamily but were later synonymised with Hemileccinum and Aureoboletus, respectively (Wu et al. 2016, Vadhanarat et al. 2022). Xerocomoideae has received much attention, and abundant species within the subfamily have been elucidated (Pouzar 1957, Horak 1977, Pegler & Young 1981, Luis & Gómez 1996, Fulgenzi et al. 2008, Štúr 2008, Kason & Karadelev 2012, Husband et al. 2013, Gelardi et al. 2014, Ayala-Vásquez et al. 2018, Loizides et al. 2019, Wagensommer et al. 2021, Vadhanarat et al. 2022). Besides species richness, the medicinal values, edibility, and poisonoussness of Xerocomoideae have also been noted by mycologists. For example, H. depilatum was shown to have antioxidant activity (Alkan et al. 2020); one lectin from X. chrysenteron showed potent insecticidal activity (Birck et al. 2004, Karimi et al. 2008); wild basidiocarps of P. luxiensis were sold as edibles in the markets (Wu et al. 2021); and Hei. japonicus was believed to be poisonous, causing gastroenteritis (Wang et al. 2022).

In China, mycologists have also carried out a series of in-depth studies on the species of Xerocomoideae, resulting in the discovery of numerous new taxa that have significantly enriched the species diversity of this subfamily (Chiu 1948, 1957, Teng 1963, Bi et al. 1982, Zang 1985, Li et al. 1992, Chen et al. 2002, Wang & Liu 2002, Zeng & Yang 2011, Zeng et al. 2013, 2015, Zhu et al. 2015, Wu et al. 2016, Zhang et al. 2019a, Li et al. 2021, Wu et al. 2021, Lin et al. 2022). Despite these findings, the diversity, taxonomy, and molecular phylogeny remain incompletely understood. This study aimed to improve our understanding of Xerocomoideae by examining collections from various regions of China, re-examining...
holotypes of previously described species, and conducting phylogenetic analyses using multilocus DNA sequence data. The study described new taxa of Xerocomoideae in China and re-evaluated previously described/reported species, with the goal of contributing to our knowledge of this subfamily.

MATERIALS AND METHODS

Abbreviations of generic names used in the study

The abbreviations of Alessioporus, Aureoboletus, Boletus, Bol., Boletellus, Heimioporus, Hemileccinum, Hourangia, Phylloporus, Pulchrboletus, Xerocomus, mentioned in this work are: Ale., A., B., Bol., H., H., Hou., P., Pul. and X., respectively.

Morphological studies

The fresh basidiomata were described and photographed in the field, then dried at about 60 °C for 12 h. The dried specimens were deposited at the Fungarium of Hainan Medical University, Haikou City, Hainan Province, China (FHMU), the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences (HKAS), the Fungarium of Mycology, Chinese Academy of Sciences (HMAS), or the Fungarium of the Guangdong Institute of Sciences (HMAS). The fresh basidiomata were described and photographed in the field, then dried at about 60 °C for 12 h. The dried specimens were deposited at the Fungarium of Hainan Medical University, Haikou City, Hainan Province, China (FHMU), the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences (HKAS), the Fungarium of Mycology, Chinese Academy of Sciences (HMAS), or the Fungarium of the Guangdong Institute of Sciences (HMAS). All microscopic structures were drawn freehand from materials rehydrated in 5 % KOH. Microscopic structures were examined under a compound light microscope (CX23, Olympus, Tokyo, Japan), and the light micrographs of basidiospores were taken under a compound light microscope (DM2500, Leica, Germany). Basidiospores of dried specimens were examined with a Hitachi S-4800 (Tokyo, Japan) or a Zeiss Sigma 300 (Germany) scanning electron microscope (SEM) (Zeng et al. 2013). The number of measured basidiospores is given as ‘nmnp’, indicating that the measurements were taken on ‘n’ basidiospores from ‘m’ basidiomata of ‘p’ collections. The basidiospore dimensions are given as ‘(a–b–c–d)’, where the range ‘b–c’ represents a minimum of 90 % of the measured value (5th to 95th percentile), and extreme values (‘a’ and ‘d’) (a < 5th percentile, d > 95th percentile) are in parentheses. ‘Qm’ refers to the average Q of the basidiospores and is given with a sample standard deviation.

DNA extraction, primers, PCR and sequencing

Total genomic DNA was obtained with Plant Genomic DNA Kit (TIANGEN, China) from materials dried with silica gel according to the manufacturer’s instructions. The primers used were LR0R/LR5 (Vilgalys & Hester 1990, James et al. 2006) for amplifying the nuclear ribosomal large subunit RNA (28S, ITS5/ITS4 (White et al. 1990) for the nuclear rDNA region encompassing the internal transcribed spacers 1 and 2, along with the 5.8S rDNA (ITS), EF1-2F/EF1-2R (Zeng et al. 2013) for the translation elongation factor 1-α gene (tef1), and bRPB2-6F/bRPB2-7.1R (Matheny 2013) for the RNA polymerase II second largest subunit gene (rpb2). PCR products were checked in 1 % (w/v) agarose gels, and positive reactions with a bright single band were purified and directly sequenced using an ABI 3730xl DNA Analyzer (Guanzhou Branch of BGI, China) with the same primers used for PCR amplifications. Assembled sequences were deposited in GenBank (Table 1).

Dataset assembly

For the concatenated multilocus dataset of Aureoboletus, 68 sequences (43 of 28S, 22 of tef1, and three of rpb2) from 47 specimens were newly generated (Table 1), and then combined with sequences of described/undescribed Aureoboletus species (Supplementary Table S1). Phylloporus imbricatus, X. aff. subetomentosus and Xerocomus sp. were used as outgroups following Zhang et al. (2019a). For the concatenated multilocus dataset of Boletellus, 139 sequences (67 of 28S, 57 of tef1, and 15 of rpb2) from 74 collections were newly generated (Table 1), and then combined with sequences of described/undescribed Boletellus species (Supplementary Table S1). Heimioporus subretispors was chosen as the outgroup from Wu et al. (2022). For the concatenated multilocus dataset of Hemileccinum, 22 sequences (eight of 28S, eight of ITS, and six of tef1) from eight collections were newly generated (Table 1), and then combined with sequences of described/undescribed Phylloporus species (Supplementary Table S1). Hourangia cheoi was chosen as the outgroup from Wang et al. (2020). For the concatenated dataset of Phylloporus, 67 sequences (33 of 28S, 18 of ITS, and 16 of tef1) from 35 collections were newly generated (Table 1), and then combined with sequences of described/undescribed Phylloporus species (Supplementary Table S1).

Phylogenetic analyses

The six combined datasets (Aureoboletus, Boletellus, Hemileccinum, Phylloporus, Pulchrboletus, Xerocomus) were all analysed by using maximum likelihood (ML) and Bayesian inference (BI). Maximum likelihood tree generation and bootstrap analyses were performed with the program RAxML v. 7.2.6 (Stamatakis 2006) running 1 000 replicates combined with an ML search. Bayesian analyses with MrBayes v. 3.1 (Huelsenbeck & Ronquist 2005) implementing the Markov Chain Monte Carlo (MCMC) technique and parameters predetermined with MrModeltest v. 2.3 (Nylander 2004) were performed.
Table 1. Taxa, vouchers, locations, and GenBank accession numbers of newly generated sequences used in this study.

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The subfamily Xerocomoideae (Boletaceae, Boletales) in China

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</tbody>
</table>
For the combined dataset of *Aureoboletus*, the best-fit likelihood models of 28S, tef1, and rpb2 were GTR + I + G, GTR + G, and SYM + I + G, respectively; for the combined dataset of *Boletellus*, the best-fit likelihood models of 28S, tef1, and rpb2 were GTR+I+G, K80+I+G, and SYM+I, respectively; for the combined dataset of *Hemileccinum*, the best-fit likelihood models of 28S, ITS, and tef1 were GTR+I+G, GTR+G, and SYM+G, respectively; for the combined dataset of *Phylloporus*, the best-fit likelihood models of 28S, ITS, and tef1 were GTR + I + G, GTR + I + G, and K80 + I + G, respectively; for the combined dataset of *Pulchroboletus*, the best-fit likelihood models of 28S and ITS were GTR + I + G and HKY + G, respectively; for the combined dataset of *Xerocomus*, the best-fit likelihood models of 28S, ITS, and tef1 were GTR + I + G, GTR + I + G, and SYM + I + G, respectively. Bayesian analysis of the six datasets were run for 30, 40, 0.2, 30, 0.8, and 8 million generations, respectively, and sampled every 100. Trees sampled from the first 25% of the generations were discarded as burn-in, and Bayesian posterior probabilities (PP) were then calculated for a majority consensus tree of the retained Bayesian trees. Runs were terminated once the average standard deviation of split frequencies dropped below 0.01.

### RESULTS

#### Molecular data

The combined dataset (28S + tef1 + rpb2) of *Aureoboletus* included 250 taxa with 2,262 nucleotide sites. Tree topologies generated by BI and ML analyses were identical, albeit there were slight differences in statistical support for some relationships. Figure 1 shows a branch-length phylogram inferred with RAxML with support values. The collections of *Aureoboletus* in China were grouped into 31 independent species-level lineages (Fig. 1).

The combined dataset (28S + tef1 + rpb2) of *Boletellus* included 168 taxa with 2,165 nucleotide sites. Tree topologies generated by BI and ML analyses were identical, albeit there were slight differences in statistical support for some relationships. Figure 2 shows a branch-length phylogram inferred with RAxML with support values. The collections of *Boletellus* in China were grouped into 15 independent species-level lineages (Fig. 2).

The combined dataset (28S + ITS + tef1) of *Hemileccinum* included 43 taxa with 2,457 nucleotide sites. Tree topologies generated by BI and ML analyses were identical, albeit there were slight differences in statistical support for some relationships. Figure 3 shows a branch-length phylogram inferred with RAxML with support values. The collections of *Hemileccinum* in China were grouped into 12 independent species-level lineages (Fig. 3).

The combined dataset (28S + ITS + tef1) of *Phylloporus* included 209 taxa with 2,013 nucleotide sites. Tree topologies generated by BI and ML analyses were identical, albeit there were slight differences in statistical support for some relationships. Figure 4 shows a branch-length phylogram inferred with RAxML with support values. The collections of *Phylloporus* in China were grouped into 31 independent species-level lineages (Fig. 4).

The combined dataset (28S + ITS) of *Pulchroboletus* included 26 taxa with 1,393 nucleotide sites. Tree topologies generated by BI and ML analyses were identical, albeit there were slight differences in statistical support for some relationships. Figure 5 shows a branch-length phylogram inferred with RAxML with support values. The collections of *Pulchroboletus* in China were grouped into one independent species-level lineage (Fig. 5).

The combined dataset (28S + ITS + tef1) of *Xerocomus* included 110 taxa with 2,332 nucleotide sites. Tree topologies generated by BI and ML analyses were identical, albeit there were slight differences in statistical support for some relationships. Figure 6 shows a branch-length phylogram inferred with RAxML with support values. The collections of *Xerocomus* in China were grouped into 12 independent species-level lineages (Fig. 6).

### Taxonomy

**Aureoboletus** Pouzar, Česká Mykol. 11: 48. 1957.

*Aureoboletus*, typified by *A. gentilis*, was initially established to accommodate species with “golden yellow spores” (Pouzar 1957). Based on molecular phylogenetic evidence, the genus now includes taxa with a more diverse range of morphological features. Besides three new species described in the present study, 26 species have been confirmed to be distributed in China (Bi et al. 1982, Li & Song 2003, Shi & Liu 2013, Zeng et al. 2015, Zhang et al. 2014, 2015a, b, 2017, 2019a, 2022, Li et al. 2016, Wu et al. 2016, Wang et al. 2020).


**Etymology:** albipes (Lat.), refers to the white stipe.

**Diagnosis:** Differs from other species of *Aureoboletus* by a medium to large-sized basidioma, a reddish brown, dry pileus, a brilliant yellow hymenophore surface, a white stipe, and an intricate trichodermal pileipellis composed of filamentous hyphae.


**Additional material examined:** China, Fujian Province, Yongan City, Tianbaoyan National Nature Reserve, elev. 350 m, 17 Aug. 2017, N.K. Zeng, Zeng3276 (FHMU2237).

**Description:** Basidiomata medium to large-sized. *Pileus* 5.5–10 cm diam, subhemispherical when young, then convex to applanate; surface dry, submentose, slightly wrinkled, pale reddish brown (6A4), reddish brown (6A6) to brown (6B5); context white (1A1),...
unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular to subround, brilliant yellow (4A5), unchanging in colour when injured; tubes 0.7–1 cm in length, yellow, unchanging in colour when injured. Stipe 7–11 × 1.3–3 cm, central, subcylindrical or subclavate; surface white, sometimes tinged with brownish; context white (1A1) to yellowish white (1A2), unchanging in colour when injured. Basal mycelium white (1A1). Odour indistinct.

Basidia 22–30 × 8–10 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, hyaline or yellowish in KOH; sterigmata 3–4 μm in length. Basidiospores [100/5/3] (9–)10–11(–12) × 4–4.5(–5) μm, Q = (1.78–)1.8–2.6(–2.7), Qm = 2.2 ± 0.2, elongate to cylindrical, slightly thick-walled (up to 1 μm), smooth, yellowish brown in KOH.

Cheilocystidia 24–32 × 8–10.5 μm, clavate to subfusiform, thin- to slightly thick-walled (up to 1 μm), yellowish white or hyaline in KOH.

Pleurocystidia abundant, 30–48 × 7.5–9 μm, clavate to subfusiform, thin- to slightly thick-walled (up to 1 μm), yellowish white or hyaline in KOH.
The subfamily Xerocomoideae (Boletaceae, Boletales) in China

Habitat: Solitary or gregarious on the ground in forests dominated by Castanopsis kawakamii.

Known distribution: Southeastern China (Fujian Province).

Notes: Morphologically, A. albipes is similar to A. auriporus, but, A. auriporus has a stipe coated at first with a pale lemon-coloured pruinosity, larger pleurocystidia measuring 38–70 × 9–16 μm, some hyphae in pileipellis slightly inflated, and it is distributed in North America (Smith & Thiers 1971). Phylogenetically, A. albipes is related to A. yunnanensis (Fig. 1). However, A. yunnanensis, originally described from Yunnan Province of southwestern China, has a pileus tinged with orange, a greyish yellow to blond stipe, wider basidiospores measuring 9–11 × 4–5.5 μm, and an ixotrichodermal pileipellis (Wu et al. 2016).
Fig. 2. Phylogram of Boletellus inferred from a multilocus (28S, tef1, and rpb2) data set using RAxML. Maximum likelihood bootstrap support values (≥ 70 %) and PP (≥ 0.95) are indicated above the branches. Notes: SE = southeastern, SW = southwestern; Chinese taxa/lineages are in color and newly generated sequences are in bold.


Known distribution: Southwestern China (Yunnan Province) (Wu et al. 2016).

Holotype: KUN-HKAS54467 (China, Yunnan Province).

Notes: Aureoboletus catenarius was originally described from Yunnan Province, southwestern China (Wu et al. 2016); illustrations and a full description of the species have been provided by Wu et al. (2016).
The subfamily Xerocomoideae (Boletaceae, Boletales) in China


Known distribution: Southern China (Hainan Province) (Zeng et al. 2015).

Holotype: KUN-HKAS59802 (China, Hainan Province).


Notes: Aureoboletus clavatus was originally described from Hainan Province, southern China (Zeng et al. 2015); illustrations and a full description of the species have been provided by Zeng et al. (2015).

Aureoboletus conicus N.K. Zeng, Xu Zhang & Zhi Q. Liang, sp. nov. MycoBank MB 846903. Figs 7D, E, 10.

Etymology: conicus (Lat.), refers to the conical squamules on pileus.

Diagnosis: Differs from other species of Aureoboletus by a small basidioma, an orangish brown, dry pileus densely covered with brown, small, conical squamules, a pale yellow hymenophore surface, and smaller basidiospores measuring 7–9 × 4–5.5 μm.
Fig. 3. Phylogram of *Hemileccinum* inferred from a three-locus (28S, ITS regions, and tef1) dataset using RAxML. Maximum likelihood bootstrap support values (≥ 70%) and PP (≥ 0.95) are indicated above the branches. Notes: SE = southeastern, SW = southwestern; Chinese taxa/lineages are in color and newly generated sequences are in bold.
The subfamily Xerocomoideae (Boletaceae, Boletales) in China

**Typus:** China. Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 550 m, 2 Jul. 2020, N.K. Zeng, Zeng4276 (holotype FHMU4730).

**Description:** Basidiomata small-sized. Pileus 2.6–3.3 cm diam, convex to nearly plane, surface dry, orangish brown (6C4), densely covered with brown, small, conical squamules; context whitish (1A1), unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores about 0.3 mm diam, angular, pale yellow (4A2), unchanging in colour when injured; tubes about 3 mm in length, white (1A1), unchanging in colour when injured. Stipe 3.5–6 × 1 cm, central, subcylindrical or subclavate; surface white, densely covered with pale orangish brown (6B2) squamules; context brownish white (6B2), unchanging in colour when injured. Odour indistinct.

**Basidia** 22–30 × 7–10 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, hyaline or yellowish in KOH; sterigmata 8–10 μm.

**Fig. 4. Phylogram of *Phylloporus* inferred from a three-locus (28S, ITS regions, and tef1) dataset using RAxML. Maximum likelihood bootstrap support values (≥ 70 %) and PP (≥ 0.95) are indicated above the branches. Notes: SE = southeastern, SW = southwestern; Chinese taxa/lineages are in color and newly generated sequences are in bold.**
3–4 μm in length. Basidiospores [20(11)/1] (6–)7–9(–9.5) × 4–5.5(–6) μm, Q = 1.17–1.7(–1.78), Qm = 1.51 ± 0.16, broadly ellipsoid to ellipsoid, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Cheilocystidia 25–30 × 8–9 μm, fusoid-ventricose or subclavate, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). Pleurocystidia 30–35 × 8–11 μm, fusoid-ventricose or subclavate, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). Hymenophoral trama bilateral, composed of hyphae 3–10 μm diam, thin- to slightly thick-walled (up to 1 μm), hyaline in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.
The subfamily Xerocomoideae (Boletaceae, Boletales) in China

Known distribution: Southern China (Hainan Province).

Notes: Aureoboletus conicus is morphologically similar to A. duplicatoporus and A. innixus. However, A. duplicatoporus, originally described from Yunnan Province of southwestern China, has a larger pileus (up to 9 cm diam) with a nearly glabrous surface, a bright yellow hymenophore with compound pores, longer basidiospores measuring 8.5–10.5 × 4–5.5 μm, and an ixotrichodermium-type pileipellis (see below). Aureoboletus innixus has a larger basidioma (pileus up to 7.5 cm diam), a pileal surface somewhat velvety, frequently cracked in age, a bright yellow hymenophore surface when young, longer and narrower basidiospores measuring 8–11 × 3–5 μm, and it is distributed in North America (Bessette et al. 2016). Phylogenetically, A. conicus is closely related to A. auriflammeus and A. miniatoaurantiacus (Fig. 1). However, A. auriflammeus, originally described from USA, has a tomentose or pulverulent pileus without conical squamules, a dark yellow to orange hymenophore, and longer and narrower basidiospores measuring 8–11 × 3–5 μm (García-Jiménez et al. 2019); A. miniatoaurantiacus, originally described from Guangdong Province of southern China (Zhang et al. 2019a), has a tomentose or pulverous, orangish yellow to orange pileus without conical squamules, and an orangish yellow to orange stipe (see below).


Description: Basidiomata small to medium-sized. Pileus 2–9 cm diam, subhemispherical when young, then convex to applanate; surface subtomentose, viscid, reddish brown when young, then brown; context white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores compound, 0.1–0.15 cm diam, angular to subround, bright yellow, unchanging in colour when injured; tubes about 0.5 cm in length, pale yellow, unchanging in colour when injured. Stipe 3–6.5 × 0.9–1.6 cm, central, subcylindrical, or subclavate; surface pale brownish red when young, then pastel reddish violet, viscid when wet; context white, sometimes tinged with reddish, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

Basidia 25–40 × 7.5–9 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, hyaline or yellowish in KOH; sterigmata 5–8.5 μm in length. Basidiospores [80/4/4] (7)–8.5–10.5 (–12) × 4–5.5 μm, Q = (1.4–)1.5–2.2 (–2.6), Qm = 1.89 ± 0.23, ellipsoid to cylindrical, slightly thick-walled (up to 1 μm), smooth, yellowish in KOH. Cheilocystidia 53–65 × 11–15 μm, fusoid-ventricose to clavate, thin- to thick-walled (up to 1.5 μm), yellowish white or hyaline in KOH. Pleurocystidia 35–68 × 10–20.5 μm, abundant, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). Hymenophoral trama bilateral, composed of hyphae 4–13 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Pileipellis an ixotrichoderm 500–800 μm thick, made up of hyphae 3–17 μm diam, occasionally branched, yellowish white or hyaline in KOH; terminal cells 22–50 × 8–16.5 μm, subclavate or

Fig. 5. Phylogram of Pulchroboletus inferred from a two-locus (28S and ITS) dataset using RAxML. Maximum likelihood bootstrap support values (≥ 70 %) and PP (≥ 0.95) are indicated above the branches. Notes: SE = southeastern, SW = southwestern; Chinese taxon/lineage is in color and newly generated sequences are in bold.


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subcylindrical, with obtuse apex. Pileal trama composed of hyphae 2–7 μm diam, thin- to slightly thick-walled (up to 1 μm), hyaline in KOH. Stipitipellis a trichoderm-like structure 400–700 μm thick, made up of hyphae 3–11 μm diam, thin-walled, hyaline in KOH; terminal cells 25–50 × 3.5–10 μm, broadly clavate, subcylindrical, or subfusiform, with obtuse apex. Stipe trama composed of parallel hyphae 3–15 μm wide, thin- to thick-walled (up to 1.5 μm), hyaline in KOH. Clamp connections absent in all tissues. Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Southern (Hainan Province) and southwestern China (Yunnan Province) (Wu et al. 2016).

Holotype: KUN-HKAS23687 (China, Yunnan Province).

Materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 520 m, 31 Jul. 2015, N.K. Zeng, Zeng2417 (FHMU3335); same location, 26 May 2017, N.K. Zeng, Zeng2979 (FHMU1940); same location, 27 May 2017, N.K. Zeng, Zeng3007 (FHMU1968); same location, 13 Aug. 2020, N.K. Zeng, Zeng4712 (FHMU4912).

Notes: Aureoboletus duplicatoporus was described from Yunnan Province, southwestern China by Zang (1992), and subsequently reported from Hainan Province, tropical China (Zeng & Jiang 2020). It was first classified in the genus Sinoboletus but was later transferred to Aureoboletus by Wu et al. (2016). The species is characterised by a small to medium-sized basidioma, a viscid, reddish brown to brown pileus, bright yellow, compound pores, a viscid, pale brownish red to pastel reddish violet stipe, and an ixotrichodermal pileipellis composed of mostly inflated hyphae. Aureoboletus erythraeus N.K. Zeng et al., Phytotaxa 472: 101. 2020. MycoBank MB 835947.

Known distribution: Southern China (Hainan Province) (Wang et al. 2020).
The subfamily Xerocomoideae (Boletaceae, Boletales) in China

**Xerocomus**

**Xerocomus parvus** KUN-HKAS105284 Jiangxi, eastern China

**Boletus** sp. 3543 China

Y. Li1109 (FHIMU2690) Zhejiang, eastern China

N.K. Zeng3280 (FHIMU2241) Fujian, southeastern China

Y. Li1166 (FHIMU6094) Zhejiang, eastern China

Xerocomus parvus KUN-HKAS2814 China

Xerocomus parvus XJSB1528 Jiangxi, eastern China

Xerocomus parvus XJSB1450 Jiangxi, eastern China

Xerocomus parvus XJSB1059 Jiangxi, eastern China

Xerocomus parvus KUN-HKAS0529 Yunnan, SW China, holotype

Xerocomus parvus KUN-HKAS53384 Yunnan, SW China

Xerocomus parvus LES15595 Vietnam

N.K. Zeng2510 (FHIMU1630) Hainan, southern China

N.K. Zeng4049 (FHIMU3344) Hainan, southern China

Xerocomus parvus JXSB1333 Jiangxi, eastern China

“Boletus” sp. EMF7 China

“Boletus” sp. EBM2 China

Xerocomus subsp. ZN127-445 Japan

Xerocomus sp. KUN-HKAS3387 China

**Holotype**: FHMU6121 Hainan, central China

Xerocomus sp. KUN-HKAS82384 Guangdong, southern China

N.K. Zeng4672 (FHIMU4967) Hainan, southern China

N.K. Zeng4678 (FHIMU4922) Hainan, southern China, holotype

N.K. Zeng4677 (FHIMU4925) Hainan, southern China

N.K. Zeng4664 (FHIMU4940) Hainan, southern China

N.K. Zeng3190 (FHIMU2515) Hainan, southern China

Xerocomus microupaei KUN-HKAS54752 Yunnan, SW China

Xerocomus microupaei JXSB2591 Jiangxi, eastern China

**Notes**: Aureoboletus erythraeus was originally described from Hainan Province, southern China (Wang et al. 2020); illustrations and a full description of the species have been provided by Wang et al. (2020).


**Known distribution**: Central China (Hunan Province) (Zhang et al. 2015a).  
**Holotype**: GDGM44441 (China, Hunan Province).

**Notes**: Aureoboletus formosus was originally described from Hunan Province, central China (Zhang et al. 2015a); illustrations and a full description of the species have been provided by Zhang et al. (2015a).


**Known distribution**: Central (Hunan Province) and eastern China (Anhui Province) (Zhang et al. 2019a).

**Holotype**: GDGM44477 (China, Hunan Province).

**Notes**: Aureoboletus glutinosus was originally described from Hunan Province, central China (Zhang et al. 2019a); illustrations and a full description of the species have been provided by Zhang et al. (2019a).


**Known distribution**: Southern China (Guangdong and Hainan Provinces) (Zhang et al. 2019a).  
**Holotype**: GDGM28490 (China, Guangdong Province).

**Notes**: Aureoboletus griseorufescens was originally described from Guangdong Province, southern China (Zhang et al. 2019a). Illustrations and a full description of the species have been provided by Zhang et al. (2019a).


**Known distribution**: Southern (Guangdong Province) and southeastern China (Fujian Province) (Zhang et al. 2022).  
**Holotype**: FHMU3797 (China, Guangdong Province).
Xue et al.

Notes: *Aureoboletus guangdongensis* was originally described from Guangdong Province, southern China (Zhang et al. 2022). Illustrations and a full description of the species have been provided by Zhang et al. (2022).


*Basionym:* *Boletus longicollis* Ces., Atti dell’Accademia di Scienze Fisiche e Matematiche Napoli 8: 4. 1879.


The subfamily Xerocomoideae (Boletaceae, Boletales) in China


Known distribution: Southern (Hainan and Guangdong Provinces), southeastern (Fujian Province), and eastern China (Zhejiang Province); Malaysia, Singapore, Japan, and Vietnam (Zeng et al. 2015, Pham & Morozova 2020).


**Notes:** *Aureoboletus longicollis* was first described from Malaysia, then reported from Singapore, Japan, China, and Vietnam (Cesati 1879, Corner 1972, Bi et al. 1997, Nagasawa 1997, Halling & Ortiz-Santana 2009, Horak 2011, Pham & Morozova 2020). It was first classified in the genus *Boletus* (Cesati 1879), but was later transferred to *Boletellus* for the basidiospores with longitudinal ridges (Pegler & Young 1981). One recent study indicated it is a member of *Aureoboletus* (Zeng et al. 2015). Illustrations and a full description of the species have been provided by Comer (1972) and Zeng et al. (2015). The species is common in subtropical and tropical China (Zeng et al. 2015).


**Known distribution:** Southern China (Hainan Province) (Zhang et al. 2022).

**Holotype:** FHMU4688 (China, Hainan Province).

**Material examined:** China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 550 m, 3 Jul. 2020, N.K. Zeng, Zeng4464 (FHMU4716).

**Notes:** *Aureoboletus microcarpus* was originally described from Hainan Province, southern China (Zhang et al. 2022). Illustrations and a full description of the species have been provided by Zhang et al. (2022).

**Basionym:** *Boletus miniatoaurantiacus* C.S. Bi & Loh, in Bi et al., Acta Bot. Yunnan. 4: 60. 1982.

**Synonym:** *Aureoboletus tomentosus* G. Wu & Zhu L. Yang, Fungal Diversity 81: 51. 2016.

**Description:** Basidiomata small to medium-sized. Pileus 2.6–8 cm diam, subhemispherical when young, then convex to applanate; surface tomentose or pulverous, slightly wrinkled, yellowish orange to orange; context white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular, 0.5–1 mm, yellowish, unchanging in colour when injured; tubes 0.5–1 cm in length, pale yellow, unchanging in colour when injured. Stipe 3–5.5 × 0.3–0.8 cm, central, subcylindrical or subclavate; surface orangish yellow to orange; context white, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

**Basidia** 32–40 × 10.5–13 μm, clavate, thin- to slightly thick-walled (up to 1.5 μm), yellowish white or hyaline in KOH. *Pleurocystidia* 50–60 × 10–15 μm, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). *Hymenophoral trama* bilateral, composed of hyphae 5–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. 

**Cheilocystidia** 42–56 × 10–15 μm, fusoid-ventricose to clavate, thin- to slightly thick-walled (up to 1.5 μm), yellowish white or hyaline in KOH. *Pleurocystidia* 50–60 × 10–15 μm, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). *Hymenophoral trama* bilateral, composed of hyphae 5–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. 

**Basidiomata** small to medium-sized. Pileus 2.6–8 cm diam, subhemispherical when young, then convex to applanate; surface tomentose or pulverous, slightly wrinkled, yellowish orange to orange; context white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular, 0.5–1 mm, yellowish, unchanging in colour when injured; tubes 0.5–1 cm in length, pale yellow, unchanging in colour when injured. Stipe 3–5.5 × 0.3–0.8 cm, central, subcylindrical or subclavate; surface orangish yellow to orange; context white, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

**Basidia** 32–40 × 10.5–13 μm, clavate, thin- to slightly thick-walled (up to 1 μm), yellowish white or hyaline in KOH. *Pleurocystidia* 50–60 × 10–15 μm, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). *Hymenophoral trama* bilateral, composed of hyphae 5–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. 

**Cheilocystidia** 42–56 × 10–15 μm, fusoid-ventricose to clavate, thin- to slightly thick-walled (up to 1.5 μm), yellowish white or hyaline in KOH. *Pleurocystidia* 50–60 × 10–15 μm, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). *Hymenophoral trama* bilateral, composed of hyphae 5–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. 

**Habitat:** Solitary or gregarious on the ground in forests dominated by fagaceous trees.

**Known distribution:** Eastern (Jiangxi Province), southeastern (Fujian Province), southern (Hainan and Guangdong Provinces), and southwestern China (Yunnan Province) (Wu et al. 2016, Zhang et al. 2019a).

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Xue et al. Holotype: GDGM4677 (China, Guangdong Province).


Notes: Aureoboletus miniatoaurantiacus was described from Guangdong Province, southern China by Bi et al. (1982). It was first classified in the genus Boletus, but was later transferred to Aureoboletus by Zhang et al. (2019a). The species is characterised by a small to medium-sized basidioma, a dry, yellowish orange to orange pileus with a tomentose or pulverous surface, a yellowish hymenophore surface, and a trichodermal pileipellis composed of mostly uninflated hyphae (up to 13 μm). It is common in tropical and subtropical regions of China (Wu et al. 2016, Zhang et al. 2019a).


Known distribution: Southwestern China (Yunnan Province) (Wu et al. 2016).

Holotype: KUN-HKAS74929 (China, Yunnan Province).

Notes: Aureoboletus nephrosporus was originally described from Yunnan Province, southwestern China (Wu et al. 2016), and subsequently also reported from India (Chakraborty et al. 2017). Illustrations and a full description of the species have been provided by Wu et al. (2016).


Etymology: ornatipes (Lat.), refers to the reticulated stipe.

Diagnosis: Differs from other species of Aureoboletus by a large basidioma, a reddish brown, dry pileal surface, a reticulated stipe, and a trichodermal pileipellis.


Description: Basidiomata large-sized. Pileus up to 10 cm diam, convex to planate; surface dry, reddish brown (8B3); context yellowish (6B2), unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular to subround,
yellow (6B2), unchanging in colour when injured; tubes about 3 cm in length, yellowish (5B3), unchanging in colour when injured. Stipe 9 × 2 cm, central, subcubillinear or subclavate; surface reticulate, reddish brown (8B3); context yellowish (6B2), unchanging in colour when injured. Basal mycelium white (1A1). Odour indistinct.

Basidiospores [20/1/1] 10–12.5(–13) × 4–5 μm, Q = 2.2–2.6(–3), Qm = 2.45 ± 0.26, cylindrical, slightly thick-walled (up to 1 μm), smooth, olive brown to yellowish brown in KOH. Cheilocystidia 46–57 × 8.5–11 μm, subfusciform, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Pleurocystidia 52–60 × 10–11 μm, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). Hymenophoral trama bilateral, composed of hyphae 5–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Pileipellis a trichoderm 300–500 μm thick, made up of hyphae 5–11 μm diam, yellowish to brownish yellow in KOH; terminal cells 30–95 × 6–9 μm, subclavate or subcubillinear, with obtuse apex. Pileal trama composed of hyphae 5–13 μm diam, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Stipe trama composed of parallel hyphae 5–13 μm wide, slightly thick-walled (up to 1 μm), yellowish in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Southern China (Hainan Province).

Notes: Morphologically, A. ornatipes is somewhat similar to North American A. mirabilis, A. projectellus, and A. russelli, which are also characterised by a reticulated stipe. However, A. mirabilis has a larger basidiomata (pileus up to 15 cm diam) and larger basidiospores measuring 18–22 × 7–9 μm (Singer 1945b, Thiels 1966); A. projectellus has a larger basidiomata (pileus up to 20 cm diam), larger basidiospores measuring 18–33 × 7.5–12 μm, and it is associated with pine trees (Bessette et al. 2016); A. russelli has a coarsely and deeply pocketed-reticulate stipe and longitudinally ridged basidiospores (Halling et al. 2015). Phylogenetically, A. ornatipes is closely related to A. clavatus. However, A. clavatus, originally described from Hainan Province of southern China, has a context changing yellowish olivaceous when injured, a stipe without reticula, broadly ellipsoid to ellipsoid basidiospores measuring 7–8 × 5.5–6 μm, and a pileipellis composed of a turf of clavate hyphae (Zeng et al. 2015).


Description: Basidiomata small to medium-sized. Pileus 3–6 cm diam, subhemispherical when young, then convex to planate; surface slightly viscid when wet, submentosentose, white, tinged with brownish; context white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular to subround, pale yellow (1A2), unchanging in colour when injured; tubes about 0.4 cm in length, pale yellow (1A2), unchanging in colour when injured. Stipe 2.5–8 × 0.8–1.1 cm, central, subcubillinear or subclavate; surface white, sometimes tinged with brownish (5B3); context white, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

Basidia 35–41 × 9.5–11 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-sспорed, hyaline or yellowish in KOH; sterigmata 3.5–5 μm in length. Basidiospores [60/3/3] (7–)7.5–9(–9.5) × 5–6(–6.5) μm, Q = (1.27–)1.33–1.7(–1.9), Qm = 1.51 ± 0.12, ellipsoid, slightly thick-walled (up to 1 μm), smooth, yellowish in KOH. Cheilocystidia abundant, 45–60 × 10–18 μm, clavate to subfusciform, thin- to slightly thick-walled (up to 1 μm), yellowish white or hyaline in KOH, surface covered with a layer (1–10 μm thick) pale yellow substance. Pleurocystidia 52–60 × 12–20 μm, fusoid or subfusciform, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm), surface covered with a layer (2–10 μm thick) pale yellow substance. Hymenophoral trama bilateral, composed of hyphae 4–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Pilei pelis a trichoderm 150–250 μm thick, made up of hyphae 5–10 μm diam, occasionally branched, pale yellow or hyaline in KOH; terminal cells 34–38 × 5–7 μm, subcubillinear, with obtuse apex. Stipe trama composed of hyphae 4–15 μm diam, slightly thick-walled (up to 1 μm), hyaline in KOH. Stipitellis a trichoderm-like structure 350–500 μm thick, made up of hyphae 4–13 μm diam, thin-walled, yellowish white or hyaline in KOH; terminal cells 30–40 × 3.5–4 μm, broadly clavate, subcubillinear, or subfusciform, with obtuse apex. Stipe trama composed of parallel hyphae 2–8 μm wide, slightly thick-walled (up to 1 μm), hyaline in KOH. Clamp connections absent in all tissues.

Habitat: Solitary or scattered on ground dominated by fagaceous trees.

Known distribution: Central (Hunan Province), eastern (Jiangxi Province), southern (Hainan Province), and southwestern China (Yunnan Province) (Zhang et al. 2019a). In the present study, it was also found to be distributed in Hainan and Yunnan Provinces of China. The species is characterised by a small to medium-sized basidiomata, a white pileus dry or slightly viscid when wet, a pale yellow hymenophore surface, wider basidiospores measuring 7.5–9 × 5–6 μm, and a trichoderm pileipellis composed of uninflated hyphae (up to 10 μm). According
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To our new specimens, a thick layer of pale yellow substance on cystidia was observed, while septa in cystidia were absent.


*Known distribution:* Southern (Hainan Province) and eastern China (Jiangxi Province) (Fang *et al.* 2019).

*Holotype:* KUN-HKAS105265 (China, Jiangxi Province).

*Material examined:* China, Hainan Province, Jianfengling of Hainan Tropical Rainforest National Park, elev. 850 m, 10 Aug. 2020, N.K. Zeng, Zeng4592 (FHMU4877).

Notes: *Aureoboletus rubellus* was originally described from Jiangxi Province, eastern China (Fang *et al.* 2019); illustrations and a full description of the species have been provided by Fang *et al.* (2019). The Hainan specimen cited above extends the range of distribution and is the first report from tropical China.


*Known distribution:* Southwestern China (Yunnan Province) (Zhang *et al.* 2022).

*Holotype:* FHMU6509 (China, Yunnan Province).

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Notes: *Aureoboletus rugosus* was originally described from Yunnan Province, southwestern China (Zhang et al. 2022). Illustrations and a full description of the species have been provided by Zhang et al. (2022).


*Synonyms:* Boletellus shichianus (Teng & L. Ling) Teng, Chung-kuo Ti Chen-chun, [Fungi of China]: 759. 1964.


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**Fig. 14.** Microscopic features of *Aureoboletus raphanaceus* (FMU2166). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. Scale bars = 10 μm. Drawings by X. Zhang.
Known distribution: Eastern (Zhejiang and Jiangxi Provinces) and southwestern China (Yunnan Province) (Wu et al. 2016).

Epitype: HKAS77183 (China, Yunnan Province).

Material examined: China, Yunnan Province, Baoshan City, Baihualing, elev. 1950 m, 8 Jul. 2018, Y.G. Fan, Fan2743 (FHMU7612).

Notes: Aureoboletus shichianus was originally described from Zhejiang Province, eastern China (Teng 1932). It was first classified in the genus Boletus and then transferred to Boletellus and Austroboletus successively (Teng 1932, 1963, Horak 1980). One recent study indicated it is a member of Aureoboletus (Wu et al. 2016). Illustrations and a full description of the species have been provided by Wu et al. (2016).


Description: Basidiomata small to medium-sized. Pileus 3.7–6.4 cm diam, subhemispherical when young, then convex to applanate; surface viscid, submentosente, brownish violet when young, reddish brown to reddish violet when mature; context yellowish white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular to subround, pale yellow, unchanging in colour when injured; tubes 0.5–0.6 cm in length, pale yellow, unchanging in colour when injured. Stipe 8–10.5 × 1.3–1.5 cm, central, subcylindrical or subclavate; surface viscid when wet, pale brownish red when young, then pastel reddish violet, with distinct longitudinal streaks; context white to yellowish when wet, pale yellowish white, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

Basidia 22–25 × 10–11.5 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, hyaline or yellowish in KOH; sterigmata 3–4 μm in length. Basidiospores [60/3/2] (8.5–) 9.5–12 × (4–)4.5–5 μm, Q = (1.7–)1.9–2.75(--3), Qm = 2.34 ± 0.28, cylindrical, slightly thick-walled (up to 1 μm), smooth, yellowish brown in KOH. Cheilocystidia 32–44 × 9–15 μm, clavate to subfusiform, thin- to slightly thick-walled (up to 1 μm), yellowish white or hyaline in KOH. Pleurocystidia abundant, 42–54.5 × 11.5–17 μm, fusiform or subfusiform, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). Hymenophoral trama bilateral, composed of hyphae 4–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish white or hyaline in KOH. Pileipellis a trichoderm 300–500 μm thick, made up of hyphae 3–10 μm diam, occasionally branched, yellowish white or hyaline in KOH; terminal cells 25–43 × 5–9 μm, cystoid, subclavate or subcylindrical, with obtuse (sometimes acute) apex. Pileal trama composed of hyphae 3–11 μm diam, slightly thick-walled (up to 1 μm), hyaline in KOH. Stipitellis a trichoderm-like structure 300–600 μm thick, made up of hyphae 3–10 μm diam, thin-walled, yellowish white or hyaline in KOH; terminal cells 15–50 × 10–16 μm, broadly clavate, subcylindrical, or subfusiform, with obtuse apex. Stipe trama made up of parallel hyphae 4–6 μm wide, thin- to slightly thick-walled (up to 0.5 μm), hyaline in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Central (Hunan Province) and southern China (Guangdong and Hainan Provinces) (Zhang et al. 2019a).

Holotype: GDGM71932 (China, Guangdong Province).


Notes: Aureoboletus sinobadius was originally described from Guangdong Province, southern China (Zhang et al. 2019a). In the present study, it was also found to be distributed in Hainan Province, tropical China. The species is characterised by a small to medium-sized basidioma, a viscid, brownish violet, reddish brown to reddish violet pileus, a pale yellow hymenophore surface, and a trichodermal pellellis composed of uninflated hyphae (up to 10 μm). According to our new specimen, one of the diagnostic features, viz. the two shapes of basidiospores defined by Zhang et al. (2019a), was not observed.


Description: Basidiomata very small-sized. Pileus 1.2–2.5 cm diam, subhemispherical when young, then convex to applanate; slightly viscid when wet, submentosete, wrinkled, brownish yellow to brownish; context white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular to subround, yellow, unchanging in colour when injured; tubes about 0.2 cm in length, pale yellow, unchanging in colour when injured. Stipe 30 × 2 cm, central, subcylindrical or subclavate; surface pale brownish red, slightly viscid when wet; context white, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

Basidia 32–40 × 10.5–13 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, hyaline or yellowish in KOH; sterigmata 3.5–5 μm in length. Basidiospores [60/3/2] (9–)10–11.5–(12.5) × 4.5–5(–5.5) μm, Q = 1.8–1.81–2.3–2.4, Qm = 2.1 ± 0.15, elongate, slightly thick-walled (up to 1 μm), smooth, brownish yellow in KOH. Cheilocystidia 42–56 × 10–16 μm, fusoid-ventricose to clavate, thin- to thick-walled (up to 1.5 μm), yellowish white or hyaline in KOH. Pleurocystidia 50–60 × 10–15 μm, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). Hymenophoral trama bilateral, composed of hyphae 5–10 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Pileipellis a trichoderm 250–350 μm thick, composed of filamentous (sometimes slightly inflated) hyphae 5–13 μm diam, occasionally branched, yellowish white or hyaline in KOH; terminal cells 5–12 × 10–70 μm, subclavate or subcylindrical, with obtuse apex. Pileal trama composed of hyphae 2–7 μm diam, thin- to slightly thick-walled (up to 1 μm), hyaline in KOH. Stipitellis a trichoderm-like structure 150–250 μm thick, made up of hyphae 3–27 μm diam, thin-walled, hyaline in KOH; terminal cells 15–27 × 5–6 μm, broadly clavate, subcylindrical, or subfusiform, with obtuse apex. Stipe trama composed of parallel hyphae 5–10 μm wide, thin- to slightly thick-walled (up to 1 μm), hyaline in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Central (Hunan Province) and southern China (Guangdong and Hainan Provinces) (Zhang et al. 2019a).
Holotype: GDGM44759 (China, Guangdong Province).


Notes: Aureoboletus solus was originally described from Guangdong Province, southern China (Zhang et al. 2019a). In the present study, it was also distributed in Hainan and Hunan Provinces of China. The species is characterised by a very small-sized basidioma, a brownish yellow to brownish pileus slightly viscid when wet, a yellow hymenophore surface, and a trichodermal pileipellis composed of mostly uninflated hyphae (up to 13 μm).


Synonym: Aureoboletus marroninus T.H. Li & Ming Zhang, Mycoscience 56: 482. 2015.

Description: Basidiomata very small-sized. Pileus 1.4–3.5 cm diam, subhemispherical, convex to applanate; surface strongly viscid when young, then dry, distinctly wrinkled when young, then squamulose, brown, reddish brown to purplish brown, veil remnants usually present on the margin of the pileus when young; context white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores 0.2–0.5 mm diam, angular to subround, yellow, unchanging in colour when injured; tubes about 0.4 cm in length, pale yellow, unchanging in colour.

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Stipe 3–3.5 × 0.2–0.4 cm, central, subcylindrical or subclavate; surface strongly viscid when young, then dry, pale brownish red; context white, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

Basidia 21–34 × 8–10 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, yellowish in KOH; sterigmata 3.5–5 μm in length. Basidiospores [40/2/2] 9.5–10.5(–11) × 4–5(–5.5) μm, $Q = 1.8–2.22(–2.38)$, $Qm = 2.46 ± 0.29$, elongate, slightly thick-walled

A. tenuis the lineage of that our two new collections (FHMU2225 and FHMU7496) fall into same species-level lineage (Fig. 1). Interestingly, we also found conspecific status of A. tenuis are variable, which provides insights into the features of morphology (Fig. 8). These indicate the macromorphological


1296-1 (FHMU850, 7496); Yongan City, Tianbaoyan National Nature Town, Chengkou Village, elev. 350 m, 27 Jul. 2017, N.K. Zeng, Zeng1296, 124 Xue et al. A. tenuis holotype of 2022). Current molecular phylogenetic analyses also show that the distance between A. tenuis is significantly smaller than the value for the interspecific variation of A. marroninus.

This species is characterised by a very small-sized basidioma, a viscid, brown, reddish brown to purplish brown pileus distinctly wrinkled when young, then squamulose, a pileal margin usually made up of hyphae 3.5–5.5 μm diam, broadly clavate, subcylindrical, or sub fusiform, with obtuse or subacute apex. Stipe trama composed of parallel hyphae 3–15 μm wide, thin- to thick-walled (up to 1.5 μm), hyaline in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Southern (Guangxi and Guangdong Provinces) and southeastern China (Fujian Province) (Zhang et al. 2014, 2015b).

Holotype: GDGM42601 (China, Guangxi Province).


Notes: Aureoboletus tenuis was originally described from Guangxi Province, southern China (Zhang et al. 2014). In the present study, it was also found to be distributed in Fujian Province of China. This species is characterised by a very small-sized basidioma, a viscid, brown, reddish brown to purplish brown pileus distinctly wrinkled when young, then squamulose, a pileal margin usually with veil remnants, a yellow hymenophore surface, and an intricate ixotrichodermal pileipellis composed of mostly uniniliated hyphae (up to 12 μm). One previous study showed that the phylogenetic distance between A. tenuis and A. marroninus is significantly smaller than the value for the interspecific variation of Aureoboletus species, indicating A. tenuis and A. marroninus are conspecific (Zhang et al. 2022). Current molecular phylogenetic analyses also show that the holotype of A. tenuis and the holotype of A. marroninus were in the same species-level lineage (Fig. 1). Interestingly, we also found that our two new collections (FHMU2225 and FHMU7496) fall into the lineage of A. tenuis (Fig. 1), despite their different macroscopic morphology (Fig. 8). These indicate the macromorphological features of A. tenuis are variable, which provides insights into the conspecific status of A. tenuis and A. marroninus despite somewhat morphological differences between the two taxa.


Synonyms: Suillus thibetanus (Pat.) Kuntze; Revis. gen. pl. (Leipzig) 3(3): 536. 1898.


Known distribution: Southwestern China (Sichuan and Yunnan Provinces) (Wu et al. 2016, Gelardi 2017).

Holotype: Herb. Patouillard, FH 3711 (China, Sichuan Province).

Material examined: China, Yunnan Province, Kunming City, Kunming Botanical Garden, 23 Jul. 2011, elev. 1 950 m, N.K. Zeng, Zeng918 (FHMU561).

Notes: Aureoboletus thibetanus was originally described from Sichuan Province, southwestern China (Patouillard 1895). It was first classified in the genus Boletus (Patouillard 1895) and later transferred to Suillus and Pulveroboletus (Tai 1979, Singer 1986). Illustrations and a full description of the species have been provided by Yang et al. (2003) and Gelardi (2017).


Known distribution: Southern (Guangdong and Guangxi Provinces) and eastern China (Jiangxi Province) (Zhang et al. 2019a).

Holotype: GDGM44713 (China, Guangdong Province).

Notes: Aureoboletus velutipes was originally described from Guangdong Province, southern China (Zhang et al. 2019a); illustrations and a full description of the species have been provided by Zhang et al. (2019a).


Known distribution: Southern China (Guangdong and Hainan Provinces) (Li et al. 2016, Wang et al. 2020).

Holotype: KUN-HKAS77700 (China, Guangdong Province).

Materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 30 Jul. 2017, N.K. Zeng, Zeng3180-1 (FHMU7494); same location, 6 May 2018, N.K. Zeng, Zeng3345 (FHMU3146); same location, 3 Jul. 2020, S. Jiang, Jiang256, 259 (FHMU4776, 4784).

Notes: Aureoboletus venustus was originally described from Guangdong Province, southern China (Li et al. 2016), then it was also reported from Hainan Province, tropical China (Wang et al. 2020). Illustrations and a full description of the species have been provided by Li et al. (2016) and Wang et al. (2020).


Description: Basidiomata very small-sized. Pileus about 1.9 cm diam, subhemispherical; surface nearly glabrous, sometimes distinctly wrinkled, strongly viscid, brownish; context white, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores angular to subround, yellow, unchanging in colour when injured; tubes about 0.5 cm in length, pale yellow, unchanging in colour when injured. Stipe 4 × 0.3 cm, central, subcylindrical or subclavate; surface pale brown, strongly

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viscid; context white, unchanging in colour when injured. Basal mycelium white. Odour indistinct.

Basidia 27–35 × 10.5–12 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, yellowish in KOH; sterigmata 3–4 μm in length. Basidiospores [20/1/1] 12–15.5(–16) × 4–5.5(–6) μm, Q = 2.4–3.44(–3.56), Qm = 2.93 ± 0.29, cylindrical, slightly thick-walled (up to 1 μm), smooth, yellowish brown in KOH. Cheilocystidia 28–40 × 8–16 μm, subfusoid or clavate, thin- to thick-walled (up to 1.5 μm), yellowish white or hyaline in KOH. Pleurocystidia 38–50 × 10–16 μm, fusoid-ventricose, yellowish in KOH, thin- to slightly thick-walled (up to 1 μm). Hymenophoral trama bilateral, composed of hyphae 5–12 μm wide, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Pileipellis an ixotrichoderm 150–300 μm thick, made up of hyphae 3–12 μm diam, yellowish white or hyaline in KOH; terminal cells 26–50 × 3.5–9 μm, subclavate or subcylindrical, with obtuse apex. Pileal trama composed of hyphae 5–19 μm diam, thin- to slightly thick-walled (up to 1 μm), hyaline in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by *Pinus yunnanensis* and *Pin. armandii*.

Known distribution: Eastern (Jiangxi Province) and southwestern China (Yunnan Province) (Wu et al. 2016); Japan (Hongo 1974).

Material examined: China. Yunnan Province, Tengchong Prefecture-level City, near Dahe Reservoir, elev. 1 922 m, 29 Jul. 2015, S.D. Yang, Yang176 (FHMU5526).

Notes: *Aureoboletus viscidipes* was originally described from Japan (Hongo 1974), then also reported from Jiangxi Province, eastern China (Wu et al. 2016). In the present study, it was also found to be distributed in Yunnan Province, southwestern China. The species was first classified in the genus *Suillus* (Hongo 1974) and later transferred to *Aureoboletus* by Wu et al. (2016). It is characterised by a very small-sized basidioma, a viscid, wrinkled, yellow hymenophore surface, large basidiospores measuring 12–15.5 × 4–5.5 μm, and an ixotrichodermal pileipellis composed of mostly uninflated hyphae (up to 12 μm).

*Aureoboletus yunnanensis* G. Wu & Zhu L. Yang, Fungal Diversity 81: 44, 2016. MycoBank MB 818391. Fig 8L.

Known distribution: Southwestern (Yunnan Province) and southeastern China (Fujian Province) (Wu et al. 2016).

Holotype: KUN-HKAS57581 (China, Yunnan Province).


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**Fig. 18.** Microscopic features of *Aureoboletus viscidipes* (FHMU5526). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. Scale bars = 10 μm. Drawings by X. Zhang.
Notes: *Aureoboletus yunnanensis* was originally described from Yunnan Province, southwestern China (Wu et al. 2016); illustrations and a full description of the species have been provided by Wu et al. (2016). The Fujian specimen cited above extends the range of distribution.


**Key to accepted species of *Aureoboletus* in China**

1a. Stipe surface with reticulation .......................................................................................................................... *A. omatipes*  
1b. Stipe surface without reticulation .................................................................................................................. 2

2a. Pileal surface dry or slightly viscid when wet ........................................................................................................ 3  
2b. Pileal surface viscid ........................................................................................................................................... 16

3a. Basidiomata medium to larger (pileus ≥ 6 cm diam) .......................................................................................... 4  
3b. Basidiomata smaller (pileus < 6 cm diam) ........................................................................................................... 6

4a. Stipe surface white .................................................................................................................................................. *A. albipes*  
4b. Stipe surface greyish yellow, blond, brownish red to reddish brown ................................................................... 5

5a. Pileus 6–15 cm diam, brownish red to reddish brown, context yellowish white changing to yellowish olivaceous when injured, stipe surface brownish red to reddish brown, basidiospores 7–8 × 5.5–6 μm ................................................................*A. clavatus*  
5b. Pileus 6–10 cm diam, greyish orange to brownish orange, stipe surface greyish yellow to blond, context unchanging in colour when injured, basidiospores 9–11 × 4–5.5 μm ......................................................................................... *A. yunnanensis*

6a. Basidiospores with nodulose to verrucose ornamentations ...................................................................................... *A. shichianus*  
6b. Basidiospores smooth ............................................................................................................................................. 7

7a. Hymenophore surface bright yellow to vivid yellow, unchanging in colour when old .............................................. 8  
7b. Hymenophore surface pale yellow, light yellow, greenish yellow to olive brown ...................................................... 9

8a. Pileal surface greyish rose to brownish red, glabrous to slightly subtomentose, context pale yellow to light yellow unchanging in colour when injured, stipe surface dark orange to yellow ochre, with distinct longitudinal streaks and furfuraceous scales, basidiospores 8–10.5 × 5–6 μm ................................................................*A. nephrosporus*  
8b. Pileal surface reddish brown to greyish ruby, smooth to minutely velvety-subtomentose, context white to yellowish white changing to greyish red to greyish rose when injured, stipe surface concolorous with pileus, smooth, basidiospores 9–10.5 × 4.5–5 μm ................................................................................................. *A. griseorufescens*

9a. Pileal surface covered with a thin layer of white pruina when young .............................................................. *A. rubellus*  
9b. Pileal surface without white pruina ................................................................................................................... 10

10a. Pileal surface yellowish white to pinkish white ......................................................................................... *A. raphanaceus*  
10b. Pileal surface brownish orange, orangish brown, reddish brown, reddish violet, orangish yellow, reddish yellow, orange to reddish orange ........................................................................................................ 11

11a. Pileal surface yellowish orange to orange ........................................................................................................... *A. miniatoaurantiacus*  
11b. Pileal surface brown, reddish brown to reddish violet ...................................................................................... 12

12a. Pileal surface covered with conical squamules .................................................................................................. *A. conicus*  
12b. Pileal surface subtomentose, or covered with fibrillose to tomentose squamules ...................................................... 13

13a. Pileal context changing greyish red, greyish rose or pastel red when injured .................................................. *A. velutipes*  
13b. Pileal context unchanging in colour when injured ............................................................................................. 14

14a. Basidiospores wider (up to 6 μm) .................................................................................................................. *A. guangdongensis*  
14b. Basidiospores narrower (up to 5 μm) ............................................................................................................... 15
Besides five new species described in the present study, 12 species of Boletus, analyses also indicated that the genus in the broad sense is longitudinal wings, ridges, or striation. Recent molecular phylogenetic includes species with basidiospores furnished with more or less Singer's definition of the genus, advocating that the genus only includes species with smooth or variously ornamented species firstly described from USA with obvious longitudinal ridges, was originally erected to accommodate Boletellus Bol. ananas Boletellus 28b. Hyphae in pileipellis narrower (up to 9 μm diam) 25a. Basidiospores broadly ellipsoid, ellipsoid, elongate (15–21 × 5–6.5 μm), a distribution in temperate China 25b. Basidiospores subfusoid, cylindrical (2.0 ≤ Qm < 2.0) 24a. Pileal surface brownish red to deep red, greyish ruby to pink, basidiospore 15–16.5 × 4.5–5 μm, a distribution in subtropical China 24b. Pileal surface pale yellow, light yellow, light orange, greyish yellow, greyish orange, brownish orange to brownish red, basidiospore 15–21 × 5–6.5 μm, a distribution in temperate China 22b. Basidiospores 8.5–12.5 × 4–5.5 μm 22a. Basidiospores 12–15.5 × 4–5.5 μm 20a. Basidiospores wider (up to 6 μm) 20b. Basidiospores narrower (up to 5 μm) 19a. Pileus comparatively large (up to 3.5 cm) 19b. Pileus comparatively small (up to 2.5 cm) 18a. Pileal surface distinctly reticulate or coarsely rugose 18b. Pileal surface glabrous or slightly rugose 17a. Stipe with annulus, basidiospores with longitudinal ridges 17b. Stipe without annulus, basidiospores smooth 16b. Pileal margin without any membranous veil 16a. Pileal margin with a gelatinised membranous veil 15a. Basidiomata smaller (pileus 1.5–2.5 cm diam), pileipellis composed of hyphae 5–13 μm diam, basidiospores 10–11.5 × 4.5–5 μm A. solus A. catenarius 15b. Basidiomata larger (pileus 3.5–6 cm diam), pileipellis composed of hyphae 10–27 μm diam, basidiospores 7–9 × 3.5–5 μm A. longicollis A. viscidipes A. microcarpus A. glutinosus A. tenue A. formosus A. quercus-spinosae A. venustus A. duplicatoporus A. erythraeus


Boletellicus was originally erected to accommodate Bol. ananas, a species firstly described from USA with obvious longitudinal ridges, then Singer (1945a, 1986) further conceptualised the genus, which includes species with either smooth or variously ornamented basidiospores. However, Smith & Thiers (1971) disagreed with Singer's definition of the genus, advocating that the genus only includes species with basidiospores furnished with more or less longitudinal wings, ridges, or striation. Recent molecular phylogenetic analyses also indicated that the genus in the broad sense is polyphyletic, some species such as Bol. longicollis, Bol. mirabilis, Bol. projectellus, Bol. shichianus and Bol. viscosus are truly members of Aureoboletus (Halling et al. 2015, Zeng et al. 2015, Wu et al. 2016). Besides five new species described in the present study, 12 species were confirmed to be distributed in China (Wen 1985, Zang 1985, Wang & Liu 2002, Zeng & Yang 2011, Wu et al. 2016, Lin et al. 2022, Xu et al. 2022, Zhang & Wu 2022).


Description: Basidiomata medium-sized. Pileus about 6 cm diam, cup-shaped, margin uplifted; surface dry, densely covered with brown to dark brown, appressed scales; context about 1 cm thick in the center of the pileus, white, turning blue quickly when injured. Hymenophore poroid, depressed around apex of stipe; pores angular, about 0.5 mm diam, pale yellow, turning blue quickly when injured; tubes about 0.5 cm in length, pale yellow, turning blue quickly when injured. Stipe 5.5 × 0.8 cm long, central, subcylindrical, slightly enlarged at base, solid; surface dry, densely covered with appressed, reddish brown scales; context dull red.
but white near the apex, turning blue quickly when injured; annulus absent; basal mycelium white. Odour indistinct.

Basidia 28–45 × 10–14.5 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, colourless to yellowish brown in KOH; sterigmata 4–6 μm in length. Basidiospores [20/1/1] 9.5–11.5 × 5.5–6.5 μm, Q = 1.58–1.91, Qm = 1.71 ± 0.07, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with 5–8 longitudinal or oblique ridges visible in lateral view; ridges continuous or forked, shallowly and moderately spaced, projecting 0.5–1 μm, united at the apex, without cross-striations on the ridges observed under the light microscope. Hymenophoral trama boletoid, composed of hyphae 4–16 μm wide, colourless in KOH. Cheilocystidia 32–52 × 7–15 μm, abundant, subfusciform or fusiform, thin- to slightly thick-walled (up to 1 μm), colourless in KOH, no encrustations. Pleurocystidia 40–73 ×

7–16 µm, abundant, subfusiform or fusiform, thin- to slightly thick-walled (up to 1 µm), colourless in KOH, no encrustations. Pileipellis a trichoderm 156–200 µm thick, composed of interlaced, filamentous hyphae, 7–12 µm diam, thin-walled, yellowish to yellowish brown in KOH; terminal cells 20–85 × 8–15 µm, clavate to subcylindrical, with obtuse or acute apex. Pileus trama composed of interwoven hyphae 9–15 µm diam, subcylindrical, thin-walled, colourless in KOH. Stipitipellis a trichoderm-like structure about 150 µm thick, composed of slightly interlaced, filamentous hyphae, thin-walled, 5–7 µm diam, colourless to yellow in KOH; terminal cells 20–60 × 6–15 µm, clavate to subcylindrical. Stipe trama composed of longitudinally arranged, parallel hyphae 6–11 µm wide, cylindrical, thin-walled, colourless in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Southern China (Hainan Province).


Notes: Based on both morphological and molecular analyses, the new collection shows a close resemblance to *Bol. putuoensis*, with low genetic variation (Fig. 2) and overlapping morphological features. However, further research is needed to establish the exact taxonomic relationship between the two, requiring additional samples and DNA sequences. Therefore, for the time being, the new specimen found in tropical China is tentatively identified as *Bol. aff. putuoensis*.


**Description**: Basidiomata medium-sized. Pileus 5.5–7 cm diam, subhemispherical to convex, then planate, margin at first extending into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants; surface dry, red, usually fading to pale fawn in age, tomentose when young, then cracking into large, more or less erect scales; context 0.8–1 cm thick in the centre of pileus, white, turning blue strongly and quickly when injured. Hymenophore poroid, depressed around apex of stipe; pores 0.5–1 mm diam, angular, yellow, turning blue strongly and quickly when injured; tubes about 1 cm in length, yellowish, turning blue quickly when injured. Stipe 7–9 × 1–1.5 cm, central,
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subcylindrical, solid; surface dry, fibrous, concolourous with pileus; context white, turning blue strongly and quickly when injured; annulus absent; basal mycelium white. Odour indistinct.

Basidia 30–50 × 10–15 μm, clavate, thin-walled, 4-spored, light yellow to yellowish brown in KOH; sterigmata 4–6 μm in length.

Basidiospores [140/7/7] 15–21 × 7–10 μm, Q = 1.85–2.47, Qm = 2.11 ± 0.17, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with longitudinal or oblique ridges, 5–8 ridges visible in lateral view; ridges continuous or forked, united at the apex, projecting 1–2 μm, with cross-striations on the ridges observed under the light microscope. Hymenophoral trama boletoid, composed of hyphae 5–13 μm wide, colourless to yellowish in KOH. Cheilocystidia 28–65 × 11–17 μm, abundant, subfusiform or fusiform, thin-walled, colourless to yellowish brown in KOH, no encrustations. Pleurocystidia 38–65 × 11–17 μm, abundant, subfusiform or fusiform, thin- to slightly thick-walled (up to 1 μm), colourless in KOH, no encrustations. Pileipellis a trichoderm about 220 μm thick, composed of slightly interlaced, filamentous hyphae, 6–10 μm diam, thin-walled, light yellow in

Xue et al. 2022, KOH; terminal cells 22–80 × 5.5–11 μm, clavate to subcylindrical, with obtuse apex. *Pileus trama* composed of interlaced hyphae 7–11 μm diam, subcylindrical, thin-walled, colourless in KOH. *Stipitipellis* a trichoderm-like structure about 140 μm thick, composed of erect, slightly interlaced, filamentous hyphae, thin-walled, 5.5–8 μm diam, colourless to light yellow in KOH; terminal cells 20–67 × 5–8 μm, clavate to subcylindrical. *Stipe trama* composed of longitudinally arranged, parallel hyphae 5–13 μm wide, cylindrical, thin- to slightly thick-walled (up to 0.5 μm), yellowish in KOH. *Clamp connections* absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Southern (Hainan Province), central (Hunan Province), and southwestern China (Yunnan Province); Japan (Sato & Hattori 2015).

Holotype: TNS F-61568 (Japan, Kyushu).

Materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 600 m, 5 Jun. 2017, N.K. Zeng, Zeng3085 (FHMU2046); Limushan of Hainan Tropical Rainforest National Park, elev. 650 m, 26 Jul. 2017, N.K. Zeng, Zeng3112 (FHMU2073); Yunnan Province, Jinghong City, Dadugang Town, 29 Jun. 2014, K. Zhao, Zhao451 (KUN-HKAS89114); Gongleng Town, near Yangdian River, 1 Jul. 2015, K. Zhao, Zhao806 (KUN-HKAS92436); Wenshan City, Maguan County, Qiaotou Town, Dawanzi Village, elev. 1 206 m, 27 Jul. 2016, G. Wu, Wu1642 (KUN-HKAS99761); Wenshan City, Maguan County, Qiaotou Town, Xiaoxinzhai Village, elev. 1 206 m, 27 Jul. 2016, G. Wu, Wu1648 (KUN-HKAS99767); Wenshan City, Malipo County, Mali Town, Nanyatian Village, elev. 1 175 m, 30 Jul. 2016, G. Wu, Wu1674 (KUN-HKAS99793); Hunan Province, Yizhang County, Mangshan National Nature Reserve, 30 Jul. 2019, N.K. Zeng, Zeng4186 (FHMU3305).

Notes: Boletellus areolatus was first described from Japan (Sato & Hattori 2015). In the present study, it was also found to be distributed in Hainan, Yunnan, and Hunan Provinces of China. The species was redescribed according to Chinese specimens, which is characterised by a red pileus covered with large, more or less erect scales, a white context, hymenophore and context turning blue when injured, and large, distinctly striate basidiospores with cross-striations on ridges, and a pileipellis composed of filamentous hyphae. Sato & Hattori (2015) pointed out that the pallid or pale cream colour at the upper half of the stipe is an important diagnostic feature; however, according to our examinations based on the new collections from China, the upper half of the stipe is yellow when young, then red when mature, and fading to pallid or pale cream when old. Moreover, cross-striations on the ridges of basidiospores were observed in the present study, whereas the feature was neglected in the protologue (Sato & Hattori 2015).


Description: Basidiomata small-sized. Pileus 2.5–3.5 cm diam, subhemispherical to convex margin decurved; surface dry, tomentose, brown; context about 0.6 cm thick in the centre of the pileus, yellowish, turning blue quickly when injured. Hymenophore poroid, depressed around apex of stipe; pores angular, 0.5 mm diam, yellow, turning blue quickly, then brown slowly when injured; tubes about 0.4 cm in length, pale yellow, turning blue quickly when injured. Stipe 5–6 × 0.5–0.8 cm, central, subcylindrical, solid;
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surface dry, tomentose, reddish brown to brown, but yellow near
the apex; context yellowish brown to reddish brown, but yellowish
white near the apex, turning blue when injured; annulus absent;
basal mycelium white. 

Odour indistinct.

Basidia 20–34.5 × 7–11 \( \mu \text{m} \), clavate, thin- to slightly thick-
walled (up to 0.5 \( \mu \text{m} \)), 4-spored, colourless to yellowish in KOH;
sterigmata 3–4 \( \mu \text{m} \) in length.

Basidiospores [100/5/2] \((9–)10–12.5(–13) \times 4–5 \mu \text{m}, Q = (1.9–)2.1–2.78(–3), Qm = 2.45 ± 0.20, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with
shallowly longitudinal or oblique ridges, 5–8 ridges visible in lateral
view, ridges continuous or forked, projecting 0.5 \( \mu \text{m} \), united at the
apex, without cross-striations on the ridges observed under the light
microscope.

Hymenophoral trama boletoid, composed of hyphae
4–11 \( \mu \text{m} \) wide, colourless to yellowish in KOH.

Cheilocystidia 30–41 × 8–10 \( \mu \text{m} \), subfusiform or fusiform, thin-walled, colourless
to yellowish brown in KOH, no encrustations. Pleurocystidia 35–
56 × 9–12 \( \mu \text{m} \), subfusiform or fusiform, thin-walled, colourless
to yellowish in KOH, no encrustations. Pileipellis a trichoderm
about 250 \( \mu \text{m} \) thick, composed of more or less vertically arranged
hyphae, 5–12 \( \mu \text{m} \) diam, thin- to slightly thick-walled (up to 0.5 \( \mu \text{m} \)),
colourless to yellowish in KOH; terminal cells 22–96 × 6–10 \( \mu \text{m} \),
clave to subcylindrical, with obtuse apex. Pileus trama composed
of interlaced hyphae 5–15 \( \mu \text{m} \) wide, cylindrical, thin-walled, yellowish in
KOH. Clamp connections absent in all tissues.

Habitat: Gregarious on the ground in forests dominated by
Pinus massoniana or fagaceous trees.

Known distribution: Southeastern (Fujian Province) and southern
China (Guangdong and Hainan Provinces) (Lin et al. 2022).

Holotype: GDGM87996 (China, Guangdong Province).

Materials examined: China. Fujian Province, Zhangping City, Xinqiao
Town, Chengkou Village, elev. 350 m, 2 Sep. 2009, N.K. Zeng, Zeng665
(FHMU425); Zhangping City, Fuzhige Park, 24 Jul. 2013, N.K. Zeng,
Zeng1271, 1271-1 (FHMU3249, 3250); Sanming City, Geshikao National
Forest Park, elev. 420 m, 26 Aug. 2007, Y.C. Li, Li1030 (KUN-HKAS53375);
Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park,
elev. 650 m, 9 Sep. 2016, N.K. Zeng, Zeng2913 (FHMU1885).

Notes: Boletellus brunoflavus was originally described from
Guangdong Province of southern China (Lin et al. 2022). In the
present study, it was also found to be distributed in Hainan and
Fujian Provinces of China. The species is characterised by a small-sized basidioma, a brown pileus, hymenophore and context turning blue when injured, small, faintly striate basidiospores without crossstriations on ridges, and a pileipellis composed of vertically arranged mostly filamentous hyphae. In the protolog of *Bol. brunoflavus*, the size of basidiospores was described as “6.4–8.2 × 2.3–3.3 µm”. According to our specimens, a larger size of basidiospores was observed.


**Synonym:** *Suillus emodensis* (Berk.) Kuntze, Revisio generum plantarum 3 (3): 535. 1898.

**Description:** Basidiomata small to medium-sized. *Pileus* 3.5–6.5 cm diam, subhemispherical to convex, then planate, margin at first extending into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants; surface dry, reddish brown, purplish red to red, usually fading to pale fawn in age, tomentose when young, then cracking into large, appressed scales; context 0.7–1 cm thick in the centre of the pileus, pale yellow to yellow, turning blue quickly and strongly when injured. *Hymenophore* poroid, depressed around apex of stipe, pores 0.5–2 mm diam, angular, pale yellow to yellow, turning blue strongly and quickly when injured; tubes 0.6–1.3 cm in length, yellowish, turning blue quickly when injured. *Stipe* 4.5–6 × 0.5–2 cm, central, subcylindrical, sometimes slightly enlarged at base, solid, flexuous; surface dry, fibrous, concolourous with pileus; context pale yellow to yellow, turning blue strongly and quickly when injured; annulus absent; basal mycelium white. *Odour* indistinct.

*Basidia* 28–48 × 12–23 µm, clavate, thin- to slightly thick-walled (up to 0.5 µm), 4-spored, colourless to yellowish brown in KOH; sterigmata 3–6 µm in length. *Basidiospores* [600/30/14] 18.5–21.5 × 7.5–9(–9.5) µm, Q = (2.1–)2.5–2.53(–2.67), Qm = 2.31 ± 0.01, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with longitudinal or oblique ridges, 5–8 ridges visible in lateral view; ridges continuous or forked, united at the apex, projecting 1–1.5 µm, with cross-striations on the ridges observed under the light microscope. *Hymenophoral trama* boletoid, composed of hyphae 4–18 µm wide, colourless to yellowish in KOH. *Cheilocystidia* 27–53 × 10–18 µm, abundant, subfusiform or fusiform, thin-walled, yellowish to yellowish brown in KOH, no encrustations. *Pleurocystidia* 39–80 × 11–18 µm, abundant, subfusiform or fusiform, thin- to slightly thick-walled (up to 1 µm), colourless to yellowish in KOH, no encrustations. *Pileipellis* a trichoderm about 195 µm thick, composed of slightly interlaced, filamentosus hyphae, 7–11 µm diam, thin- to slightly thick-walled (up to 1 µm), yellowish to yellowish brown in KOH; terminal cells 21–65 × 5–12 µm, clavate to subcylindrical, with obtuse apex. *Pileus trama* composed of interlaced hyphae 5.5–15 µm diam, subcylindrical, thin-walled,
colourless to yellowish in KOH. Stipitellis a trichoderm-like structure about 100 μm thick, composed of thin-walled, emergent hyphae with subclavate to subcylindrical terminal cells (26–62 × 5–7.5 μm), colourless to yellowish in KOH. Stipe trama composed of longitudinally arranged, parallel hyphae 5–15 μm wide, cylindrical, thin- to slightly thick-walled (up to 0.5 μm), yellowish to yellow in KOH. Clamp connections absent in all tissues.

Habitat: Solitary or gregarious on the ground, tree stumps or rotten wood in forests dominated by fagaceous trees.

Known distribution: Southern (Guangdong and Hainan Provinces), southeastern (Fujian Province), southwestern (Yunnan Province), and central China (Hunan Province) (Zeng & Yang 2011); Japan (Sato & Hattori 2015); India (Berkeley 1851).

Holotype: K(M), Hooker 100 (India, West Bengal).


Notes: Boletellus emodensis was first described from northeastern India (Pegler & Young 1981), then subsequently reported from southeast Asia, east Asia, and Australia (Zeng & Yang 2011, Halling et al. 2015), which is characterised by its pileus covered with large, appressed, reddish brown, purplish red to red scales, a yellow context, hymenophore and context turning blue strongly and rapidly when injured, large distinctly striate basidiospores with cross-striations on ridges, and a pileipellis composed of filamentous hyphae.

Currently available data suggest that there are no significant morphological differences between Bol. emodensis and Japanese Bol. aurocontextus (Zeng & Yang 2011, Halling et al. 2015, Sato & Hattori 2015). Moreover, our molecular phylogenetic
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analyses indicated that the collections of *Bol. emodensis* from China, the holotype of *Bol. aurocontextus*, and one specimen from northeastern India (type locality of *Bol. emodensis*) labeled as *Boletellus* sp. (Bol-10) form an independent species-level lineage with high statistical support (Fig. 2), which not only further demonstrated the Chinese specimens are true *Bol. emodensis*, but also provided molecular evidence that *Bol. aurocontextus* is a synonym of *Bol. emodensis*.


**Etymology:** *erythrolepis* (Lat.), refers to the red scales on the stipe.

**Diagnosis:** Differs from other species of *Boletellus* by a very small basidioma, an olive brown, brownish red to red pileus, a hymenophore surface turning blue, then reddish when injured, a stipe with red scabers, faintly striate basidiospores without cross-striations on ridges, and a pileipellis composed of chains of subglobose, pyriform to broadly subcylindrical cells.

**Typus:** China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 750 m, 5 Jun. 2017, S. Jiang, Jiang78 (holotype FHMU3255).

**Additional materials examined:** China, Fujian Province, Zhangping County, Xinqiao Town, Chengkou Village, elev. 350 m, 3 Aug. 2013, N.K. Zeng, Zeng1362 (FHMU913); Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 750 m, 5 Jun. 2017, S. Jiang, Jiang78-1, 78-2, 78-3 (FHMU3312, 3313, 3314).
Description: Basidiomata very small-sized. Pileus 1.3–2.2 cm diam, subhemispherical to convex, margin decurved; surface dry, olive brown (6C2), brownish red (10C6) to red (9B6), tomentose; context 0.2–0.3 cm thick in the centre of pileus, white (2A1), turning blue (19C6) quickly when injured. Hymenophore poroid, depressed around apex of stipe; pores about 0.5 mm diam, angular, yellow.
Boletellus fanjingensis


Notes: Boletellus fanjingensis is morphologically similar to Bol. erythrolepis, originally described from Guizhou Province of southwestern China (Wen 1985), is a poorly known species. In the present study, the holotype of the species was re-examined, which is characterised by a small, tomentose, brown to reddish brown pileus, hymenophore and context turning blue, then reddish when injured, distinctly striate basidiospores without cross-striaions on ridges, and a pileipellis composed of filamentous hyphae. Boletellus fanjingensis is morphologically similar to Bol. brunoflavus, Bol. chrysenteroides, Bol. fujianensis, Bol. nordestinus, Bol. pseudochrysenteroides, Bol. putuoensis, Bol. shoreae, Bol. sinapipes, and Bol. wenshanensis. However, Bol. brunoflavus has smaller basidiospores measuring 10–12.5 × 4–5 μm with faint ridges (see above); Bol. chrysenteroides has slightly narrower basidiospores measuring 12–16 × 4.6–7.5 μm, a pileipellis with cylindrical terminal cells and inflated sub-terminal elements (12–20 μm broad and 15–30 μm long), and a distribution in North America (Smith & Thiers 1971); Bol. fujianensis has larger basidiospores measuring 19–23.5 × 10.5–12 μm with cross-striaisons on ridges observed under the light microscope (see below); Bol. nordestinus has non-cyanescent hymenophore and context, shorter basidiospores measuring 8–10 × 6–7 μm, a pileipellis composed of inflated hyphae, and a distribution in South America (Magnag et al. 2019); Bol. pseudochrysenteroides has a dark rose red pileus, smaller basidiospores measuring 11–14 × 5.5–7 μm, and a distribution in North America (Smith & Thiers 1971); Bol. putuoensis has shorter basidiospores measuring 9–12 × 6–7.5 μm, and a pileipellis composed of inflated hyphae (Xu et al. 2022); Bol. shoreae has shorter basidiospores measuring 8–11 × 5.3–7.6 μm, and it is associated with trees of Dipterocarpaceae (Panthar et al. 2018); Bol. sinapipes has a mustard brown-coloured tomentum at the base of the stipe, and a distribution in South America (Halling et al. 2015); Bol. wenshanensis has a pileus without reddish tinge, and the hymenophore and context turning blue (not changing reddish further) when injured (Zhang & Wu 2022).

Macroscopic descriptions are from the protologue (Wen 1985); microscopic descriptions are from our examinations.

Description: "Pileus 4.5 cm latus, applanatus, subviscosus, flavor-badius, squamis velutinis brunneis, sine velo, hyphis cuticulis intertextis, cellulis extremis inflatis, 5.2–8.4 μm crassis, KOH flavescentibus vel brunneis per microscopium, sine fibula, carneluteola, immutabili in vulnore. Tubuli flavi, adnexi. Pori angulares, 1–2 in uno mm. Hymenia flavo-brunnea in solutionem KOH. Stipes 4.5 cm longus, 0.5 cm crassus."


Macroscopic descriptions are from the protologue (Wen 1985); microscopic descriptions are from our examinations.

Description: "Pileus 4.5 cm latus, applanatus, subviscosus, flavor-badius, squamis velutinis brunneis, sine velo, hyphis cuticulis intertextis, cellulis extremis inflatis, 5.2–8.4 μm crassis, KOH flavescentibus vel brunneis per microscopium, sine fibula, carneluteola, immutabili in vulnore. Tubuli flavi, adnexi. Pori angulares, 1–2 in uno mm. Hymenia flavo-brunnea in solutionem KOH. Stipes 4.5 cm longus, 0.5 cm crassus."
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Continuous or forked, projecting 1–1.5 µm, with cross-striations on the ridges observed under the light microscope. *Hymenophoral trama* boletoid, composed of hyphae 6–12 µm wide, colourless to yellow in KOH. *Cystidia* 52–78 × 13–21 µm, subfusiform or ventricose, thin-walled, yellow in KOH, no encrustations. *Pileipellis* a trichoderm composed of more or less vertically arranged, filamentous hyphae, 5–9 µm diam, thin-walled, yellow in KOH; terminal cells 30–70 × 5–10 µm, clavate to subcylindrical, with ocute apex. *Pileus trama* composed of interlaced hyphae 5–16 µm diam, thin-walled, yellowish to yellow in KOH.

**Habitat:** Solitary on the base of stumpage of *Pinus massoniana*.

**Known distribution:** Southeastern China (Fujian Province).

**Material examined:** China. Fujian Province, Sanming City, Yangshan, 11 Jul. 1974, X.L. Mao, Q.M. Ma & C.R. Jiang, Jiang187 (holotype HMAS45913).

**Notes:** *Boletellus fujianensis*, firstly described from Fujian Province of southeastern China (Wen 1985), is also a poorly known species. In the present study, the holotype of the species was re-examined, which is characterised by a small pileus covered with brown scales, hymenophore and context unchanging in colour when injured, large distinctly striate basidiospores with cross-striations on ridges, and a pileipellis composed of filamentous hyphae with acute apex of terminal cells. *Boletellus fujianensis* is morphologically similar to *Bo. brunoflavus*, *Bo. chrysenteroides*, *Bo. nordestinus*, *Bo. pseudochrysenteroides*, *Bo. putuoensis*, *Bo. shoreae*, *Bo. sinapipes*, and *Bo. wenshanensis*. However, all of them have smaller basidiospores measuring 10–12.5 × 4–5 µm, 12–16 × 4.6–7.5 µm, 8–10 × 6–7 µm, 11–14 × 5.5–7 µm, 9–12 × 6–7.5 µm, 8–11 × 5.3–7.6 µm, 11.9–15.4 × 5.6–7 µm, and 12–15.5 × 6–8 µm, respectively (Smith & Thiers 1971, Halling et al. 2015, Parihar et al. 2018, Magnago et al. 2019, Lin et al. 2022, Xu et al. 2022, Zhang & Wu 2022). Moreover, *Bo. chrysenteroides* has a pileipellis with cystidioid terminal cells and inflated sub-terminal elements (12–20 µm broad and 15–30 µm long), and a distribution in North America (Smith & Thiers 1971); *Bo. nordestinus* has a pileipellis composed of inflated hyphae, and a distribution in South America (Magnago et al. 2019); *Bo. pseudochrysenteroides* has a dark rose red pileus, and a distribution in North America (Smith & Thiers 1971); *Bo. putuoensis* has a pileipellis composed of inflated hyphae (Xu et al. 2022); *Bo. sinapipes* has a mustard brown-coloured tomentum at the base of the stipe, basidiospores without cross-striations on ridges, and a distribution in Australia (Halling et al. 2015).

**Fig. 32.** Microscopic features of *Boletellus fanjingensis* (holotype HMAS45914). A. Basidia. B. Basidiospores. C. Cystidia. D. Pileipellis. Scale bars = 10 µm. Drawings by R. Xue.

Description: Basidiomata small, middle to large-sized. Pileus 3.5–12 cm diam, subhemispherical to convex, then applanate, margin decurved; surface dry, tomentose, pinkish to pink; context 1–2.5 cm thick in the centre of the pileus, yellowish white to yellowish, turning blue quickly when injured. Hymenophore poroid, nearly adnate to slightly decurrent; pores 0.25–2 mm diam, angular to round, yellowish to yellow, turning blue quickly when injured; tubes 0.2–0.9 cm in length, yellowish to yellow, turning blue quickly when injured. Stipe 5–14 × 0.9–2.5 cm, central, subcylindrical, solid; surface dry, sometimes covered with reticulations, concolourous with pileus, but yellow near the apex; context pale yellow, turning blue quickly when injured; annulus absent; basal mycelium white. Odour indistinct.

Basidia 30–40 × 10–12 μm, clavate, thin-walled, 4-spored, colourless to yellow in KOH; sterigmata 3–5 μm in length. Basidiospores [560/28/9] (10.5–)11–11.5(–12) × 4.5–5.5(–6) μm, Q = (1.83–)1.91–2.63, Qm = 2.21 ± 0.01, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with faintly longitudinal ridges, united at the apex, 10–12 ridges visible in lateral view. Hymenophoral trama boletoid, composed of hyphae 5–15 μm wide, colourless to yellowish in KOH. Cheilocystidia 28–50 × 6–8.5 μm, abundant, subfusiform or fusiform, thin-walled, colourless in KOH, no encrustations. Pleurocystidia 37–60 × 7–10 μm, abundant, subfusiform or fusiform, thin-walled, colourless to yellowish in KOH, no encrustations. Pileipellis a trichoderm about 200 μm thick, composed of slightly interfaced, filamentous hyphae, 5–8 μm diam, thin-walled, yellow to yellowish brown in KOH; terminal cells 32–75 × 5.5–8 μm, clavate to subcylindrical, with obtuse apex. Pileus trama composed of interfaced hyphae 4–12 μm diam, colourless in KOH. Stipitipellis a trichoderm-like structure about 100 μm thick, composed of thin-walled emergent hyphae with subclavate to subcylindrical terminal cells (25–43 × 5–11 μm), yellowish to yellowish brown in KOH. Stipe trama composed of longitudinally arranged, parallel hyphae 5–16 μm wide, cylindrical, thin- to slightly thick-walled (up to 0.5 μm), colourless to yellowish in KOH. Clamp connections absent in all tissues.

Fig. 33. Microscopic features of Boletellus fujianensis (holotype HMAS45913). A. Basidia. B. Basidiospores. C. Cystidia. D. Pileipellis. Scale bars = 10 μm. Drawings by R. Xue.
**Habitat:** Gregarious on the ground in forests dominated by fagaceous trees.

**Known distribution:** Southern (Guangdong and Hainan Provinces), southeastern (Fujian Province), and southwestern China (Yunnan Province) (Wu et al. 2016).

**Holotype:** KUN-HKAS77623 (China, Guangdong Province).

**Materials examined:** **China,** Guangdong Province, Danxia National Nature Reserve, 27 Jul. 2019, N.K. Zeng, Zeng4134, 4135, 4137 (FHMU3320, 3321, 3322); Fujian Province, Zhangzhou City, Xinxiao Town, Chengkou Village, elev. 360 m, N.K. Zeng, Zeng649 (FHMU412); same location, 30 Jul. 2013, N.K. Zeng, Zeng1333 (FHMU386); same location, 7 Aug. 2013, N.K. Zeng, Zeng1388, 1393 (FHMU396, 940); same location, 14 Aug. 2014, N.K. Zeng, Zeng1624 (FHMU1088); same location, 21 Aug. 2017, N.K. Zeng, Zeng3298 (FHMU2259); same location, 22 Aug. 2017, N.K. Zeng, Zeng3308 (FHMU2269); Hainan Province, Yingseling of Hainan Tropical Rainforest National Park, 1 Aug. 2015, N.K. Zeng, Zeng2470 (FHMU1956); same location, 17 May 2019, Y.Q. Fu, Fu91, 99 (FHMU3316, 3317); same location, elev. 650 m, 4 Jun. 2017, N.K. Zeng, Zeng3067 (FHMU2028); same location, 30 Jul. 2017, N.K. Zeng, Zeng3188 (FHMU2149); same location, 24 Apr. 2019, R. R. Xue and N.K. Zeng, Zeng3652 (FHMU2852); Xishuangbanna Dai Autonomous Prefecture, Mengla County, elev. 1 039 m, 6 Jul. 2014, L.H. Han, Han381 (KUN-HKAS84677).

**Notes:** *Boletellus indistinctus* was originally described from Guangdong Province of southern China, and also reported to distribute in Fujian Province of southeastern China (Wu et al. 2016), then it was confirmed to distribute in Hainan Province, tropical China (Zeng & Jiang 2020). In the present study, it was also found to be distributed in Yunnan Province of southwestern China. The species is characterised by its rose-red pileal surface, cyanescent hymenophore and context, faintly longitudinally striate basidiospores, and a pileipellis composed of filamentous hyphae.


**Basionym:** *Boletus puniceus* W.F. Chiu, Mycotaxona 40: 217. 1948.


**Known distribution:** Southwestern (Yunnan Province) and southern China (Guangdong Province) (Chiu 1948, Wang & Liu 2002, Wu et al. 2016).

**Holotype:** KUN-HKAS37152 (China, Yunnan Province).

**Notes:** *Boletellus puniceus* was originally described from Yunnan Province, southwestern China by Chiu (1948). It was first classified in the genus *Boletus* and later transferred to *Xerocomus* (Tai 1979). One recent study indicated it is a member of *Boletellus* (Wang & Liu 2002). Judging from morphological features and geographical distributions provided by Wu et al. (2016), two collections labelled as *Bo. obscureoccineus* from subtropical China including Yunnan Province, were represent true *Bo. puniceus*. *Boletellus obscureoccineus*, originally described from Indonesia, was not confirmed to be distributed in China.


**Description:** *Basidiomata* small-sized. *Pileus* 1.7–4.8 cm diam, subhemispherical to convex when young, then planate, margin decurved; surface dry, tomentose, brown to dark brown; context 0.2–0.5 cm thick in the centre of the pileus, yellow, turning blue quickly when injured. *Hymenophore* poroid, depressed around apex of stipe; pores angular, 0.3–0.8 mm diam, pale yellow to yellow, turning blue quickly when injured; tubes 0.3–0.6 cm in length, pale yellow to yellow, turning blue quickly then blackening when injured. *Stipe* 3.5–5.5 × 0.5–4 cm, central, subcylindrical, solid, sometimes slightly enlarged at base; surface dry, covered with brown to dark brown scabers; context pale yellow, but light brown at base, unchanging in colour when injured; annulus absent; basal mycelium white. Odour indistinct.

*Basidia* 24–50 × 13–19 μm, clavate, thin-walled, 4-spored, colourless to yellow in KOH; sterigmata 3.5–5.5 μm in length. *Basidiospores* [80/4/4] (8.5–)9–12(–15) × 6–7.5 μm, Q = (1.27–) 1.29–1.92(–2.08), Qm = 1.51 ± 0.17, yellowish to yellowish brown in KOH, subglobose to ellipsoid, with 5–8 longitudinal or oblique ridges visible in lateral view, ridges continuous or forked, rarely not continuous, projecting 0.8–1 μm, united at the apex, lacking cross-striations observed under the light microscope. *Hymenophoral trama* boletoid, composed of hyphae 5–13 μm wide, colourless in KOH. *Cheilocystidia* 38–64 × 10–18 μm, abundant, sub fusiform or fusiform, thin-walled, colourless to yellow in KOH, no encrustations. *Pleurocystidia* 54–90 × 11–17.5 μm, abundant, fusiform, sub fusiform or ventricose, thin-walled, colourless to yellow in KOH, no encrustations. *Pileipellis* a trichoderm about 150 μm thick, composed of more or less vertically arranged hyphae, expanded to 20 μm in width, thin-walled, colourless to yellowish in KOH; terminal cells 32–75 × 10–17 μm, clavate to subcylindrical, with acute apex. *Pileus trama* composed of interlaced hyphae 4–18 μm diam, subcylindrical, thin-walled, yellowish in KOH. *Stipitpellis* a trichoderm-like structure about 60 μm thick, composed of colourless to yellow in KOH, thin-walled emergent hyphae with subclavate, sub fusiform or subcylindrical terminal cells (21–38 × 8–14 μm), and with clavate, 4-spored basidia. *Stipe trama* composed of longitudinally arranged, parallel hyphae 5–15 μm diam, cylindrical, thin-walled, light yellow in KOH. *Clamp connections* absent in all tissues.

**Habitat:** Solitary on the ground in forests dominated by fagaceous trees.

**Known distribution:** Southern (Guangdong and Hainan Provinces) and eastern China (Zhejiang Province) (Xu et al. 2012).

**Holotype:** FHMU6907 (China, Zhejiang Province).


**Notes:** *Boletellus putuoensis* was originally described from Zhejiang Province of eastern China, and also reported to be distributed in Guangdong Province of southern China (Xu et al. 2022). In the present study, it was also distributed in Hainan Province, tropical China. The species is characterised by a very small to small-sized basidioma, a brown to dark brown pileus, a sipe covered with brown to dark brown scabers, cyanescent hymenophore and context, small basidiospores without cross-striations on ridges, and a pileipellis composed of inflated hyphae. According to our new
specimens, the yellow pileal context was observed, while it was described as “white” in the protologue.


*Etymology:* *rubidus* (*Lat.*), refers to the dark red pileus.

*Diagnosis:* Differs from other species of *Boletellus* by a pileus densely covered with pink, brownish red, red to dark red, hairy, appressed squamules, a white context, small, distinctly striate basidiospores with cross-striations on ridges, and a pileipellis composed of filamentous hyphae with terminal cells sometimes expanded to 19 μm wide.


*Additional materials examined:* **China,** Yunnan Province, Yongping County, roadside of 320 National Road, 30 Jul. 2009, Q. Cai, Cai46 (KUN-HKAS58713); Baoshan City, Baihualing, elev. 1 950 m, 9 Jul. 2018, Y.G. Fan, Fan2795 (FHMU3267).
**The subfamily Xerocomoideae (Boletaceae, Boletales) in China**

**Description:** Basidiomata medium to large-sized. Pileus 5–9 cm diam, subhemispherical to convex, then planarate, margin at first extending into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants; surface dry, densely covered with pink (7A4), brownish red (10C6), red (10A8) to dark red (11E8), hairy, appendiculate squamules; context about 0.8 cm thick in the centre of the pileus, white (1A1), turning blue (19C6) quickly when injured. Hymenophore poroid, depressed around apex of stipe, pores 0.5–2 mm diam, angular, yellow (4A5), turning blue (19C6) quickly when injured; tubes about 1.7 cm in length, yellow (4A5), turning blue (19C6) quickly when injured. Stipe 11–13 × 1–1.5 cm, central, subcylindrical, solid, flexuous; surface dry, fibrous, light pink (7A2) to pink (7A4), with longitudinal ridges; context white (1A1), turning blue (19C6) quickly when injured; annulus absent; basal mycelium white (1A1). Odour indistinct.

Basidia 31–48 × 13–17 μm, clavate, thin-walled, 4-spored, colourless to yellowish in KOH; sterigmata 3–5 μm in length. Basidiospores [20/2/2] 15–19.5 × 7–9 μm, Q = 1.94–2.44, Qm = 2.11 ± 0.12, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with longitudinal or oblique ridges, 5–8 ridges visible in

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**Fig. 35.** Microscopic features of *Boletellus putuoensis* (FHMU3261). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitipellis. Scale bars = 10 μm. Drawings by R. Xue.
lateral view; ridges continuous or forked, projecting 0.5–1 μm, with cross-stria tions on the ridges observed under the light microscope. **Hymenophoral trama** boletoid, composed of hyphae 5–15 μm wide, colourless in KOH. **Cheliocephalys** 28–41 × 8–11 μm, abundant, subfuscispor, fusiform or ventricose thin-walled, colourless in KOH, no encrustations. **Pleurocystidia** 47–65 × 11–17 μm, abundant, subfuscispor or fusiform, thin-walled, colourless, occasionally yellowish brown in KOH, no encrustations. Pileipellis a trichoderm about 190 μm thick, composed of interlaced hyphae, 6–13 μm diam, thin- to slightly thick-walled (up to 0.5 μm), colourless in KOH; terminal cells 34–65 × 8–13 μm, sometimes expanded to 19 μm wide, clavate to subcylindrical, with obtuse apex. **Pileus trama** composed of interlaced hyphae 5–15 μm diam, thin-walled, yellowish in KOH. **Stipitipellis** a trichoderm-like structure about 150 μm thick, composed of erect, slightly interlaced, filamentous hyphae, thin-walled, 4–9 μm diam, colourless in KOH; terminal cells 38–80 × 5–11 μm, clavate to subcylindrical. **Stipe trama** composed of longitudinally arranged, parallel hyphae 4–18 μm wide, cylindrical, thin-walled, light yellow in KOH. **Clamp connections** absent in all tissues.

**Habitat:** Solitary on the ground in mixed forests dominated by *Pinus yunnanensis*, *Pin. kesiya*, *Pin. armandii*, and fagaceous trees.

**Known distribution:** Southwestern China (Yunnan Province).

**Notes:** Morphologically, *Bot. rubidus* is similar to *Bot. ananiceps*, *Bot. emodensis*, *Bot. deceptivus*, *Bot. dissiliens*, *Bot. squamosus*, and *Bot. yunnanensis*. However, *Bot. ananiceps* has a pileus coloured with pink to pale red below the squamae, a yellow context, a stipe context changing brownish orange or pinkish brown when injured, basidiospores without cross-stria tions on the ridges, and a distribution in Australia (Singer 1955, Halling & Fechner 2011, Halling et al. 2015); *Bot. emodensis* has a yellow context, and longer basidiospores measuring 18.5–21.5 × 7.5–9 μm with ridges projecting 1–1.5 μm (see above); *Bot. deceptivus* has a yellow context, smaller basidiospores measuring 15.4–17.5 × 7–7.7 μm, hyphae in pileipellis wider (up to 17.5 μm), and a distribution in Australia associ ating with Myrtaceae, Allocasuarina (Halling et al. 2015); *Bot. dissiliens*, originally described from Singapore, has an absence of red pigmenta tion in pileus, a yellow pileal context, and it is associated with trees of Pinaceae (see below); *Bot. yunnanensis* has larger basidiospores measuring 18.5–22.5 × 9.5–11 μm with ridges projecting 1–1.5 μm (see below).

Phylogenetically, *Bot. rubidus* is closely related to *Bot. ananiceps* and *Bot. areolatus* (Fig. 2). However, the pileus of *Bot. ananiceps* is pink or red, then fades to pale fuscous tan, the stipe is never red, and a distribution in North/Central America (Smith & Thiers 1971, Zeng & Yang 2011, Halling et al. 2015). *Bot. deceptivus* has a pileus covered with more or less erect scales, basidiospores with ridges projecting 1–2 μm, and hyphae in pileipellis narrower (up to 8 μm) (see above).


**Etymology:** *sinochrysenteroides* (Lat.), meaning the new species is similar to *Bot. chrysenteroides* in morphology, but currently found from China.

**Diagnosis:** Differs from other species of *Boletellus* by a small, brown pileus, the hymenophore and context turning blue when injured, distinctly striate basidiospores with cross-stria tions on ridges, and a pileipellis with clavate terminal cells having acute apex and slightly inflated sub-terminal elements (up to 16 μm).

**Typus:** China, Jiangxi Province, Jiujiang City, Lushan Botanical Garden, elev. 50 m, K. Zhao, Zhao998 (holotype FHMU3264).

**Additional material examined:** China. Zhejiang Province: Hangzhou City, Tianmushan National Natural Reserve, elev. 700 m, K. Zhao, Zhao925 (FHMU3265).

**Description:** **Basidiomata** small-sized. **Pileus** 3.5–4 cm diam, subhemispherical to convex, then planate, margin decurved; surface dry, brown (6D6) to dark brown (7F8), tomentose when young, sometimes cracking into appressed squamales; context 0.2–0.5 cm thick in the centre of pileus, yellow (4A5), turning blue (19C6) when injured. **Hymenophoral poroid**, depressed around apex of stipe; pores about 0.5 mm diam, angular, yellow (4A5), turning blue (19C6) when injured. Stipe 3–7 × 0.3–0.6 cm, central, subcylindrical, solid, flexuous; surface dry, concolourous with pileus, tomentose when young, then cracking into scabers; context yellow (4A5), turning blue (19C6) when injured; annulus absent; basal mycelium white (1A1). *Odour* indistinct.

**Basidia** 28–37 × 11.5–15 μm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 4–5 μm in length. **Basidiospores** [40/2/2] (11–)15.5–16 × 6.5–8 μm, Q = (1.56–)1.57–2.07–2.13, Qm = 1.80 ± 0.13, yellowish to yellowish brown in KOH, ellipsoid to subfusciform, with longitudinal or oblique ridges, 6–10 ridges visible in lateral view; ridges continuous, projecting about 1 μm, with cross-stria tions on ridges. **Hymenophoral trama** boletoid, composed of hyphae 6–12 μm wide, thin- to slightly thick-walled (up to 0.5 μm), yellowish in KOH. **Cheliocephalys** 23–42 × 8.5–13.5 μm, not abundant, subfuscispor or fusiform, thin-walled, colourless in KOH, no encrustations. **Pleurocystidia** 37–60 × 10–16.5 μm, not abundant, subfuscispor or fusiform, thin-walled, colourless in KOH, no encrustations. **Pileipellis** a trichoderm about 160 μm thick, composed of more or less vertically aligned hyphae, up to 16 μm in width, thin-walled, yellow in KOH; terminal cells 25–60 × 6–11 μm, clavate to subcylindrical, with obtuse apex. **Pileus trama** composed of hyphae 5–15 μm diam, interwoven, subcylindrical, thin-walled, yellowish in KOH. **Stipitipellis** a trichoderm-like structure about 250 μm thick, composed of thin-walled, emergent hyphae, with subclavate, subfuscispor or subcylindrical terminal cells (15–50 × 4–14 μm), yellowish to yellow in KOH. **Stipe trama** composed of longitudinally arranged, parallel hyphae 6–15 μm diam, cylindrical, thin-walled, light yellow in KOH. **Clamp connections** absent in all tissues.

**Habitat:** Solitary or gregarious on the ground in forests dominated by fagaceous trees.

**Known distribution:** Eastern China (Jiangxi and Zhejiang Provinces).

**Notes:** Although the genetic variation is low between Chinese collections and North American *Bot. chrysenteroides* (Fig. 2), the new species “*Bot. chrysenteroides*” was proposed due to the geographical isolation and morphological differences between Chinese specimens and *Bot. chrysenteroides*, which is characterised by narrower basidiospores measuring 12–16 × 4.6–7.5 μm, and a pileipellis with cystidiotial terminal cells and
inflated sub-terminal elements (12–20 μm broad and 15–30 μm long) (Smith & Thiers 1971). *Boletellus sinochrysenteroides* is also morphologically similar to *Bo. pseudochrysenteroides*, however, the latter has a dark rose red pileus, dull yellow basal mycelium, smaller basidiospores measuring 11–14 × 5.5–7 μm, and a distribution in North America (Smith & Thiers 1971). Moreover, the brown pileus of *Bol. sinochrysenteroides* is reminiscent of *Bol. brunoflavus*, *Bol. fanjingensis*, *Bol. fujianensis*, *Bol. nordestinus*, *Bol. putuoensis*, *Bol. shoreae*, *Bol. sinapipes*, and *Bol. wenshanensis*. However, *Bol. brunoflavus* has smaller basidiospores measuring 10–12.5 × 4–5 μm with faint ridges, lacking cross-striations on ridges, and hyphae in pileipellis narrower (up to 12

**Fig. 36.** Microscopic features of *Boletellus rubidus* (holotype KUN-HKAS83069). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitipellis. Scale bars = 10 μm. Drawings by R. Xue.
\[ \mu \text{m} \] (see above); *Bol. fanjingensis* has a pileus tinged with reddish, hymenophore and context turning blue, then reddish when injured, basidiospores lacking cross-striations on ridges, and hyphae in pileipellis narrower (up to 7 \( \mu \text{m} \)) (see above); *Bol. fujianensis* has larger basidiospores measuring 19–23.5 × 10.5–12 \( \mu \text{m} \), and hyphae in pileipellis narrower (up to 9 \( \mu \text{m} \)) (see above); *Bol. nordestinus* has non-cyanescent hymenophore and context, smaller basidiospores measuring 8–12 × 6–7.5 \( \mu \text{m} \) (Magnago et al. 2019); *Bol. putouensis* has smaller basidiospores measuring 9–12 × 6–7 \( \mu \text{m} \) without cross-striations on ridges (see above); *Bol. shoreae* has smaller basidiospores measuring 8–11 × 5.3–7.6 \( \mu \text{m} \), and it is associated with trees of *Dipterocarpaceae* (Parihar et al. 2018), *Bol. sinapipes* has a mustard brown-coloured tomentum at the base of the stipe, basidiospores without cross-striations on ridges, and a distribution in Australia (Halling et al. 2015); *Bol. wenshanensis* has a stipe covered with golden yellow, orange to brownish yellow punctate squamules, and a pileipellis composed of filamentous hyphae (Zhang & Wu 2022).


Description: Basidiomata medium-sized. Pileus 5–7 cm diam, subhemispherical to convex, then planar, margin at first extended into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants; surface dry, densely covered with brown to brownish pink, hairy, large, appressed squamules; context about 0.7 cm thick in the centre of the pileus, yellow, turning blue strongly and quickly when injured. Hymenophore poroid, depressed around apex of stipe, pores 0.5–1 mm diam, angular, yellow, turning blue strongly and quickly when injured; tubes about 1.5 cm in length, yellowish, turning blue strongly and quickly when injured. Stipe 5.8–8 × 0.8–1 cm, central, subcylindrical, solid, flexuous; surface dry, fibrous, concolourous with pileus; context yellow, turning blue strongly and quickly when injured; annulus absent; basal mycelium white. Odour indistinct.

Basidia 34–43 × 13–18 \( \mu \text{m} \), clavate, thin-walled, 4-spored, colourless to yellowish in KOH; sterigmata 5–7 \( \mu \text{m} \) in length. Basidiospores [40/2] (16.5–)17–21(–22) × 9–11 \( \mu \text{m} \), \( Q = (1.55–)1.71–2.11(–2.17) \), Qm = 1.92 ± 0.13, yellowish to brownish yellow in KOH, ellipsoid to subfusiform, with 6–9 longitudinal or oblique ridges visible in lateral view; ridges continuous or forked, rarely not continuous, projecting 1–1.5 \( \mu \text{m} \), with cross-striations on the ridges observed under the light microscope. Hymenophoral trama boletoid, composed of hyphae 5–15 \( \mu \text{m} \) wide, yellowish in KOH. Cheilocystidia 41–65 × 10–16 \( \mu \text{m} \), abundant, subtuspid or fusiform, thin-walled, colourless to yellow in KOH, no encrustations. Pleurocystidia 54–80 × 10–17 \( \mu \text{m} \), abundant, subtuspid or fusiform, thin-walled, colourless to yellow in KOH, no encrustations. Pileipellis a trichoderm about 300 \( \mu \text{m} \) thick, composed of interlaced, occasionally branched filamentous hyphae 6–10 \( \mu \text{m} \) diam, thin-walled, yellow in KOH; terminal cells 25–70 × 6–14 \( \mu \text{m} \), clavate to subcylindrical with obtuse apex. Pileus trama composed of hyphae 9–18 \( \mu \text{m} \) diam, interfaced, subcylindrical, thin-walled, colourless in KOH. Stipitipellis a trichoderm-like structure about 150 \( \mu \text{m} \) thick, composed of yellowish in KOH, thin-walled filamentous hyphae, with subclavate or subcylindrical terminal cells (21–72 × 5–9 \( \mu \text{m} \)), and with clavate, 4-spored basidia. Stipe trama composed of longitudinally arranged, parallel hyphae 4–9 \( \mu \text{m} \) diam, cylindrical, thin-walled, colourless in KOH. Clamp connections absent in all tissues.

**Habitat:** Gregarious on the ground in forests dominated by *Pinus larieti* or *Pin. yunnanensis*.

**Known distribution:** Southern (Hainan Province) and southwestern China (Yunnan Province); Thailand (Fig. 2).

Materials examined. **China,** Hainan Province, Bawangling of Hainan Tropical Rainforest National Park, 23 May 2019, N.K. Zeng, Zeng4051 (FHMUS266); Yunnan Province, Nuijiang of the Lisu Autonomous Prefecture, Zhiliu Village (previously called “Bijiang County”), Gaoligongshan National Nature Reserve, elev. 2 612 m, 27 Jul. 1978, M. Zang, Zang4012 (KUN-HKAS4112); Baoshan City, on the way from Baoshan to Chanying, Woaioji Village, elev. 1 780 m, 24 Jul. 2009, Y.C. Li, Li1789 (KUN-HKAS5936).

**Notes:** *Boletellus squamosus* was first described from Yunnan Province of southwestern China in 1985; however, the information on the morphological structures of the species was scanty (Zang 1985). New collections and the holotype of the species were examined carefully in the present study, the characteristics of the taxon were updated. It is well characterised by a pileus densely covered with brown to brownish pink, hairy, large, appressed squamules, a yellow context in both pileus and stipe that is strongly and rapidly cyanescent in both when injured, large, longitudinally striate basidiospores with fine cross-striations on ridges, a pileipellis composed of filamentous hyphae, and it is associated with pine trees. *Boletellus squamosus* is easily confused with *Bol. areolatus* and *Bol. yunnanensis* in China. However, both *Bol. areolatus* and *Bol. yunnanensis* are associated with fageceous trees (see above). Moreover, *Bol. areolatus* has a red pileus and a white context; *Bol. yunnanensis* has a pileipellis composed of slightly inflated hyphae (see above).

**Boletellus squamosus** is also morphologically similar to *Bol. ananas*, *Bol. ananiceps*, *Bol. deceptivus*, and *Bol. dissiliens*. However, *Bol. ananas* has a pileus pink or red, then fades to pale fuscous tan, a stipe never red, narrower basidiospores measuring 16–20 × 7.5–9.5 \( \mu \text{m} \), and a distribution in North/Central America (Smith & Thiers 1971, Zeng & Yang 2011, Halling et al. 2015); *Bol. ananiceps* has a pileus coloured with pink to pale red below the squamae, a stipe context changing brownish orange or pinkish brown when injured, basidiospores without cross-striations on ridges, and a distribution in Australia (Singer 1955, Halling & Fechner 2011, Halling et al. 2015); *Bol. deceptivus* has a smaller basidiospores measuring 15.4–17.5 × 7–7.7 \( \mu \text{m} \), hyphae in pileipellis wider (up to 17.5 \( \mu \text{m} \)), and a distribution in Australia associating with *Myrtaceae*, *Allocasuarina* (Halling et al. 2015); *Bol. dissiliens*, originally described from Singapore, has smaller basidiospores measuring 14–16 × 5.5–7 \( \mu \text{m} \) (Corner 1972, Halling et al. 2015).

Phylogenetically, *Bol. squamosus* is closely related to *Bol. emodensis* (Fig. 2). However, the latter has a reddish brown, purplish red to red pileus, and narrower basidiospores measuring 18.5–21.5 × 7.5–9 \( \mu \text{m} \) (see above).


**Etymology:** subglobosus (Lat.), refers to the subglobose hyphae in pileipellis.

**Diagnosis:** Differs from other species of *Boletellus* by a small to medium-sized basidioma, a pileus with reddish to dark red scales, broad pores, hymenophore and context unchanging in colour.
The subfamily Xerocomoideae (Boletaceae, Boletales) in China

when injured, shallowly longitudinal striate basidiospores without cross-striations on ridges, and a pileipellis composed of chains of subglobose, globose to subcylindrical cells.

**Typus:** China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 750 m, 27 Jul. 2017, S. Jiang, Jiang100 (holotype FHMU3256).

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**Fig. 37.** Microscopic features of *Boletellus sinochrysenteroides* (holotype FHMU3264). A. Basidia and pleurocystidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitpellis. Scale bars = 10 μm. Drawings by R. Xue.

Description: Basidiomata small to medium-sized. Pileus 1.8–7 cm diam, subhemispherical to planate, margin decurved; surface dry, densely covered with reddish (10A8) to dark red (11E8) scales; context 0.1–0.2 cm thick in the centre of the pileus, yellow (4A5), unchanging in colour when injured. Hymenophore poroid,
The subfamily Xerocomoideae (Boletaceae, Boletales) in China

Depressed around apex of stipe; pores angular, 0.1–0.2 cm diam, yellow (4A5), unchanging in colour when injured; tubes 0.4–0.5 cm in length, pale yellow (2B7), unchanging in colour when injured. Stipe 2.5–2.8 × 0.2–0.4 cm, central, subcylindrical, solid; surface dry, densely covered with pink (7A3) to red (10A8) scales; context yellow (4A5), unchanging in colour when injured; annulus absent; basal mycelium white (1A1). Odour indistinct.

Basidia 28–50 × 10–15 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, yellowish to yellowish brown in KOH; sterigmata 4–6 × (6–)6.5–8(–8.5) μm, Q = (2–)2.2–2.85(–3.17), Qm = 2.49 ± 0.24, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with shallowly longitudinal ridges, 10–15 ridges visible in lateral view; ridges continuous or forked, united at the apex. Hymenophoral trama boletoid, composed of hyphae 4–12 μm wide, colourless to light yellow in KOH. Cheilocystidia 27–54 × 8–13 μm, abundant, subclavate or subfusiform, thin-walled, colourless to yellowish in KOH, no encrustations. Pleurocystidia 39–81 × 8–13 μm, abundant, subclavate, subfusiform or fusiform, thin- to slightly thick-walled (up to 1 μm), colourless to yellowish in KOH, no encrustations. Pileipellis a trichoderm about 197 μm thick, composed of chains of subglobose, pyriform to to broadly subcylindrical cells up to 20 μm in width arising from filamentous hyphae, thin- to slightly thick-walled (up to 1 μm), yellow to yellowish brown in KOH; terminal cells 25–62 × 9–17 μm, subglobose, pyriform to subcylindrical, with obtuse apex. Pileus trama composed of hyphae 7–11 μm diam, thin- to slightly thick-walled (up to 1 μm), yellowish in KOH. Stipitipellis a trichoderm-like structure about 150 μm thick, composed of yellow to yellowish brown in KOH, thin-walled emergent hyphae with subclavate, subfusiform or subcylindrical terminal cells (22–49 × 6.5–14 μm), and with clavate, 4-spored basidia. Stipe trama composed of longitudinally arranged, parallel hyphae 3–13 μm diam, cylindrical, thin-walled, colourless in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests of dominated by fagaceous trees.

Known distribution: Southern China (Hainan Province).

Notes: In China, Bol. subglobosus was misidentified as Bol. obscurecoccineus, however, the Indonesian species has a tomentose pileus, wider basidiospores measuring 16–20.5 × 7.5–8.5 μm, and a pileipellis without subglobose or globose cells (Zeng

& Yang 2011). Based on morphological features and geographical distributions provided by Wu et al. (2016), two collections labeled as Bol. obscurecoccineus from subtropical China including Yunnan Province were actually Bol. punicus. *Boletellus subglobosus* is highly similar to Bol. punicus. However, Bol. punicus has a slender basidioma, a pileipellis composed of chains of subcylindrical, few subglobule to globose cells, and a distribution in subtropical China (Wang & Liu 2002, Wu et al. 2016). Phylogenetically, Bol. subglobosus is also somewhat distant from Bol. punicus (Fig. 2).


Macroscopic descriptions are from the protologue (Zang 1985); microscopic descriptions are from our examinations.

**Description:** "Pileus 4–6 cm latus, convexus demum leviter complanatus, siccus, submentosus, hirsutus vel squamulosus, rimosareolatus vel cuticulatus, purpureus vel violaceus. Cortextus 0.5–1.6 cm crassus, albus laeae luteus, immutabilis. Tubuli 3–5 mm longi, adnexi vel sinuato-adnexi. Stipes 5–8 cm longus, 5–10 mm crassus, bulbosus basim versus incrassatus, laevigatus et striatus, non-recluentus, apice purpureus, basim versus purpureo-brunneus."

Basidia 32–45 × 13–18 μm, clavate, thin-walled, 4-spored, yellow in KOH; sterigmata 3–6 μm in length. Basidiospores [20/1/1] 20–24 × 10–11 μm, Q = 1.9–2.4, Qm = 2.05 ± 0.12, ellipsoid, with 5–8 continuous longitudinal or forked ridges, projecting 0.8–1.8 μm, with cross-striations on the ridges observed under the light microscope, light yellow to yellowish brown in KOH. **Hymenophoral trama** boletoid, composed of hyphae 5–10 μm wide, light yellow to yellow in KOH. Chelo- and pleurocystidia 28–50 × 9–15 μm, with cross-striations on the ridges visible in lateral view; ridges continuous or forked, projecting 0.8–1.8 μm, with cross-striations on the ridges observed under the light microscope, united at the apex. **Pileipellis** composed of erect, slightly interwoven, filamentous hyphae, 5–13 μm diam, thin- to slightly thick-walled (up to 0.5 μm), light yellow to yellowish brown in KOH; terminal cells 15–42 × 8–15 μm, subcylindrical to subclavate. Pileus trama composed of interwoven hyphae 4–15 μm diam, light yellow to yellow in KOH.

**Habitat:** Solitary on the ground in forests dominated by broad-leaved forests.

**Known distribution:** Southeastern China (Fujian Province).

**Material examined:** China, Fujian Province, Nanjing County, 1 Jul. 1975, H.C. Tan, Tan2360 (holotype KUN-HKAS10249).

**Notes:** *Boletellus violaceus*, first described from Fujian Province of southeastern China, is a poorly known species (Zang 1985). In the present study, the holotype of the species was re-examined, characterised by purple pileus and stipe, non-cyanescent hymenophore and context, large, longitudinally ridged basidiospores with fine cross-striations on ridges, a pileipellis composed of filamentous to slightly inflated hyphae. *Boletellus violaceus* is similar to Bol. fujianensis and Bol. nordestinus with non-cyanescent hymenophore and context. However, Bol. fujianensis has a pileus covered with brown scales, and hyphae in pileipellis narrower (up to 9 μm) (see above); Bol. nordestinus has a brown pileus, shorter basidiospores measuring 8–10 × 6–7 μm, and a distribution in South America (Magnago et al. 2019).


**Known distribution:** Southwestern China (Yunnan Province) (Zhang & Wu 2022).

**Holotype:** KUN-HKAS122938 (China, Yunnan Province).

**Notes:** *Boletellus wenshanensis* was originally described from Yunnan Province, southwestern China (Zhang & Wu 2022). Illustrations and a full description of the species have been provided by Zhang & Wu (2022).


Macroscopic descriptions are from the protologue (Zhang 1985); microscopic descriptions are from our examinations.

**Description:** "Pileus 8–12 cm latus, planus, siccus, submentosus demus cuticulatus, subcervinus vel fuscus. Marginine appendiculato. Contextus 1–3 cm crassus, fuscus, spongioso-cavus vel vermiculocavus, brunneus, haud cyanescentibus. Tubuli 1–2 cm longi, liberati, glandaceus et umbrinus. Pori elliptico-angulares vel irregularis, 4–5 per cm. Stipes 7–9 cm longus, 1–2 cm crassus, laete cylindricus et basim versus attenuatus, laevigatus, subcervinus."

Basidia 38–51 × 11–17 μm, clavate, thin-walled, 4-spored, yellowish in KOH; sterigmata 4–7 μm in length. Basidiospores [20/1/1] 18.5–22.5 × 9.5–11 μm, Q = 1.81–2.21, Qm = 1.99 ± 0.11, yellowish to yellowish brown in KOH, ellipsoid to subsufiform, with 5–8 longitudinal or oblique ridges visible in lateral view; ridges continuous or forked, projecting 1–1.5 μm, with cross-striations on the ridges observed under the light microscope, united at the apex. **Hymenophoral trama** boletoid, composed of hyphae 7–15 μm wide, yellow in KOH. **Cystidia** 39–78 × 10–20 μm, subfusiform or subfusciform, thin-walled, yellowish in KOH, no encrustations. **Pileipellis** a thinchdom composed of more or less vertically arranged hyphae, 7–16 μm diam, thin- to slightly thick-walled (up to 0.5 μm), yellow in KOH; terminal cells 15–62 × 8–15 μm, subglobose, subcylindrical to subclavate, with obtuse apex. **Pileus trama** composed of interfaced hyphae 9–17 μm diam, yellowish to yellow in KOH.

**Habitat:** Solitary on the ground in forests dominated by fagaceous trees.

**Known distribution:** Southwestern China (Yunnan Province).

**Material examined:** China, Yunnan Province, Mang City (previously called “Luxi County”), Santai Mountain, elev. 1 370 m, 1 Jul. 1977, X.J. Li, Li41 (holotype KUN-HKAS2871).

**Notes:** *Boletellus yunnanensis*, first described from Yunnan Province of southwestern China, is a poorly known species (Zang 1985). In the present study, the holotype of the species was re-examined, characterised by a large pileus, a context turning blue when injured, longitudinally ridged basidiospores with fine cross-striations on ridges, a pileipellis composed of slightly inflated hyphae, and it is associated with fagaceous trees.

In China, Bol. yunnanensis is easily confused with Bol. areolatus, Bol. emodensis, Bol. rubidus, and Bol. squamosus. However, both Bol. areolatus and Bol. emodensis have narrower hyphae.
in pileipellis (see above). Moreover, *Bol. areolatus* has smaller basidiospores measuring 15–21 × 7–10 μm; *Bol. emodensis* has narrower basidiospores measuring 18.5–21.5 × 7.5–9 (see above). The morphological differences of *Bol. yunnanensis*, *Bol. rubidus*, and *Bol. squamosus* have been discussed under *Bol. rubidus* and *Bol. squamosus*, respectively (see above).

*Boletellus yunnanensis* is also morphologically similar to *Bol. ananas*, *Bol. ananiceps*, *Bol. deceptivus*, and *Bol. dissiliens*. However, *Bol. ananas*, originally described from North America, has a pileus pink or red, then pale fuscous tan, with coarse squama, smaller basidiospores measuring 16–20 × 7.5–9.5 μm, and a stipe without red pigmentation (Smith & Thiers 1971, Zeng & Yang 2011); *Bol. ananiceps*, originally described from Australia, has basidiospores without cross-striations on ridges (Halling et al. 2015). Australian *Bol. deceptivus* has smaller basidiospores measuring 15.4–17.5 × 7–7.7 μm (Halling et al. 2015); Singaporean *Bol. dissiliens* has an absence of red pigmentation in pileus, and smaller basidiospores measuring 14–16 × 5.5–7 μm (Corner 1972, Halling et al. 2015).

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**Etymology:** *zenghuoxingii* (Lat.) is named after N.K. Zeng’s father Huo-Xing Zeng, who was not only an expert in cultivating *Lentinula edodes* and *Auricularia cornea*, but also encouraged N.K. Zeng’s interest in the taxonomy of fungi.

**Diagnosis:** Differs from other species of *Boletellus* by a medium-sized basidioma, a pileus with erect, cone shape scales, a stipe with pallid or pale cream colour at lower part, and relatively large basidiospores with cross-striations on the ridges, and a pileipellis composed of slightly inflated hyphae.

**Typus:** China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 750 m, 4 Aug. 2015, N.K. Zeng, Zeng2553 (holotype FHMU3251).

**Additional material examined:** China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 25 May 2017, N.K. Zeng, Zeng3018 (FHMU1979).

**Description:** Basidiomata medium-sized. Pileus 5–7 cm diam, subhemispherical to convex, margin at first extending into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants; surface dry, covered with deep red (11C8), greyish red (11B6), pinkish red (7A3) to brownish red (10C6), more or less erect, cone shape scales; context about 0.7 cm thick in the centre of the pileus, yellow (4A5), turning blue (19C6) quickly when injured. Hymenophore poroid, depressed around apex of stipe; pores angular, yellow (4A5), turning blue (19C6) quickly when injured; tubes about 1.2 cm in length, yellowish (1A4), turning blue (19C6) quickly when injured. Stipe 5–8.5 × 0.8–1 cm, central, subcylindrical, solid; surface dry, purplish red (14C8) to brown (6E8), with longitudinal ridges; context pale yellow (2B7), unchanging in colour when injured; annulus absent; basal mycelium white (1A1). Odour indistinct.

**Basidia** 30–59 × 11–16 μm, clavate, thin-walled, 4-spored, colourless to yellowish brown in KOH; sterigmata 4–6 μm in length. Basidiospores [40/2/2] (17.5–)18–22 × (7.5–)8–9.5(–10) μm, Q = 2–2.4(–2.73), Qm = 2.3 ± 0.17, yellowish to yellowish brown in KOH, ellipsoid to subfusiform, with longitudinal or oblique ridges, united at the apex, 7–12 ridges visible in lateral view; ridges continuous or forked, projecting 1–2 μm, with cross-striations on the ridges observed under the light microscope. Hymenophoral trama boletoid, composed of hyphae 4–16 μm wide, yellowish in KOH. Cheilocystidia 40–61 × 13–19.5 μm, not abundant, subfusiform.
or fusiform, thin-walled, yellowish in KOH, no encrustations. Pleurocystidia 83–103 × 11–17 μm, not abundant, subfusiform or fusiform, thin- to slightly thick-walled (up to 0.5 μm), colourless in KOH, no encrustations. Pileipellis a trichoderm about 300 μm thick, composed of slightly interlaced hyphae, 7–12 μm diam, thin-walled, yellowish brown in KOH; terminal cells 22.5–42 × 6–13 μm, clavate to subcylindrical, with obtuse apex. Pileus trama composed of interlaced hyphae 6–9 μm diam, thin- to slightly thick-walled (up to 0.5 μm), yellowish in KOH. Stipitipellis a trichoderm-like structure about 170 μm thick, composed of more or less vertically arranged hyphae, thin-walled, 6–10 μm diam, yellowish brown in KOH; terminal cells 32–53 × 7–11 μm, clavate to subcylindrical, with obtuse apex. Stipe trama composed of longitudinally arranged, parallel hyphae 5–15 μm wide, cylindrical, thin-walled, light yellow in KOH. Clamp connections absent in all tissues.

Habitat: Solitary on the ground in forests dominated by fagaceous trees.

Known distribution: Southern China (Hainan Province).

Notes: Boletellus zenghuoxingii is easily confused with Bol. areolatus, Bol. dissiliens, Bol. emodensis, Bol. rubidus, Bol. squamosus, and Bol. yunnanensis in Asia. However, Bol. areolatus has a white context, shorter pleurocystida, and a pileipellis composed of filamentous hyphae (see above); Bol. dissiliens has an absence of red pigmentation in pileus, and smaller basidiospores measuring 14–16 × 5.5–7 μm (Corner 1972, Halling et al. 2015); Bol. emodensis has a pileus with large, appressed scales, shorter pleurocystida, and a pileipellis composed of filamentous hyphae; Bol. rubidus has a pileus with hairy, appressed squamules, shorter basidiospores measuring 15–19.5 × 7–9 μm, and a pileipellis composed of filamentous hyphae; Bol. squamosus has a pileus with large, appressed scales, wider basidiospores measuring 17–21 × 9–11 μm, shorter pleurocystida, a pileipellis composed of filamentous hyphae, and it is associated with pine trees; Bol. yunnanensis has wider...
basidiospores measuring 18.5–22.5 × 9.5–11 μm, and shorter cystida (see above). Moreover, Bol. zenghuoxingii is also morphologically similar to some other out-Asian species, such as Bol. ananas, Bol. ananceps, and Bol. deceptivus. However, Bol. ananas has a pileus pink or red, then pale fuscous tan, and a stipe without red pigmentation (Smith & Thiers 1971, Zeng & Yang 2011); Bol. ananceps has basidiospores without cross-striations on ridges (Halling et al. 2015); Bol. deceptivus has smaller basidiospores measuring 15.4–17.5 × 7–7.7 μm, shorter cheilocystidia measuring 30–40 μm, and a distribution in Australia (Halling et al. 2015). Phylogenetically, species closely related to Bol. zenghuoxingii was not detected from our current data (Fig. 2).

**Key to accepted species of Boletellus in China**

1a. Margin of pileus at first extended into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants


1b. Margin of pileus without a false veil or false veil remnants


2a. Pileus covered with erect, conical scales


2b. Pileus covered with appressed scales


3a. A pileipellis composed of somewhat inflated hyphae


3b. A pileipellis composed of mostly filamentous hyphae


5a. Basidiospores narrower measuring 18.5–21.5 × 9.5–11 μm, and shorter


5b. Basidiospores measuring 19–23.5 × 10.5–12 μm, and hyphae in pileipellis narrower (up to 9 μm)


7a. Pileal surface purple, pinkish, pink, reddish, greyish red, red to dark red


7b. Pileal surface brown


8a. Pileal surface purple, basidiospores with distinct ridges observed under the light microscope


8b. Pileal surface pinkish, pink, reddish, greyish red, red to dark red, basidiospores nearly smooth or with faintly ridges observed under the light microscope


9a. Pileal surface pinkish to pink, basidiospores nearly smooth observed under the light microscope


9b. Pileal surface reddish, greyish red, red to dark red, basidiospores with faint ridges observed under the light microscope


10a. Hymenophore and context turning blue when injured


10b. Hymenophore and context unchanging in colour when injured


11a. Basidioma comparatively robust, a pileipellis composed of chains of subglobose to globose, few subcylindrical cells, and a distribution in tropical China


11b. Basidioma comparatively slender, a pileipellis composed of chains of subcylindrical, few subglobose to globose cells, and a distribution in subtropical China


12a. Basidiospores with faint ridges observed under the light microscope


12b. Basidiospores with distinct ridges observed under the light microscope


13a. Basidiospores with fine cross-striations on the ridges observed under the light microscope


13b. Basidiospores without fine cross-striations on the ridges observed under the light microscope


14a. Basidiospores larger measuring 19–23.5 × 10.5–12 μm, and hyphae in pileipellis narrower (up to 9 μm)


14b. Basidiospores smaller measuring 11.5–15.5 × 6.5–8 μm, and hyphae in pileipellis wider (up to 16 μm)


15a. Basidiospores longer (up to 15.5 μm)


15b. Basidiospores shorter (up to 12 μm)


16a. Margin of pileus at first extended into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants


16b. Margin of pileus without a false veil or false veil remnants


17a. Margin of pileus at first extended into a false veil and covering the pores, then splitting radially, appendiculate with false veil remnants


17b. Margin of pileus without a false veil or false veil remnants


18a. Pileus covered with erect, conical scales


18b. Pileus covered with appressed scales


19a. Pileus covered with somewhat inflated hyphae


19b. Pileus covered with mostly filamentous hyphae


20a. Context white


20b. Context yellow


21a. Basidiospores ridges projecting 0.5–1 μm, terminal cells of hyphae in pileipellis 34–65 × 8–13 μm, sometimes expanded to 19 μm wide


21b. Basidiospores ridges projecting 1–2 μm, terminal cells of hyphae in pileipellis 22–80 × 5.5–11 μm


22a. Basidiospores measuring 11.5–15.5 × 6.5–8 μm, and hyphae in pileipellis wider (up to 16 μm)


22b. Basidiospores measuring 19–23.5 × 10.5–12 μm, and hyphae in pileipellis narrower (up to 9 μm)


23a. A pileipellis composed of somewhat inflated hyphae


23b. A pileipellis composed of mostly filamentous hyphae


24a. Basidiospores without fine cross-striations on the ridges observed under the light microscope


24b. Basidiospores with fine cross-striations on the ridges observed under the light microscope


25a. Basidiospores measuring 15.4–17.5 × 7–7.7 μm, shorter cheilocystidia measuring 30–40 μm, and a distribution in Australia (Halling et al. 2015). Phylogenetically, species closely related to Bol. zenghuoxingii was not detected from our current data (Fig. 2).
16a. Hymenophore and context turning blue, then reddish when injured ......................................................... *Bol. fanjingensis*

16b. Hymenophore and context turning blue when injured ....................................................................................... *Bol. wenshanensis*

17a. Basidiospores narrower measuring 9.5–11.5 × 5.5–6.5 μm, and a pileipellis composed of filamentous hyphae ... *Bol. aff. putuoensis*

17b. Basidiospores wider measuring 9–12 × 6–7.5 μm, and a pileipellis composed of inflated hyphae ....................... *Bol. putuoensis*

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**Fig. 43.** Microscopic features of *Boletellus zenghuoxingii* (holotype FHMU3251). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitpellis. Scale bars = 10 μm. Drawings by R. Xue.

Heimioporus, typified by *H. retisporus*, was erected by Horak (2004) to replace an invalid name, viz., *Heimiella* (Boedijn 1951). It is mainly characterised by a distinctly pitted or alveolate-reticulate to reticulate basidiospore covered by a coarse, net-like ornament (Boedijn 1951, Horak 2004, Halling & Fechner 2011, Wu et al. 2016). Until now, four species have been confirmed to be distributed in China (Zeng et al. 2018b, Wu et al. 2022).


Known distribution: Southern (Hainan Province) and central China (Hunan Province) (Zeng et al. 2018).

Holotype: FHMU273 (China, Hainan Province).

Notes: *Heimioporus conicus* was originally described from Hainan Province, southern China (Zeng et al. 2018). Illustrations and a full description of the species have been provided by Zeng et al. (2018).


Known distribution: Southwestern China (Yunnan Province) (Zeng et al. 2018).

Holotype: FHMU5806 (China, Yunnan Province).

Notes: *Heimioporus gaojiaocong* was originally described from Yunnan Province, southwestern China (Zeng et al. 2018); illustrations and a full description of the species have been provided by Zeng et al. (2018). In China, *Hei. gaojiaocong* was misidentified as *Hei. retisporus* or *Hei. subretisporus* (Wu et al. 2016, Zeng et al. 2018).


**Key to accepted species of Heimioporus in China**

1a. Stipe surface with reticulations .......................................................... 2
1b. Stipe surface without reticulations .................................................... *H. conicus*

2a. Reticulations on the stipe surface overlaid by yellow squamules .................................................. *H. gaojiaocong*
2b. Reticulations on the stipe surface overlaid by red squamules .................................................. 3

3a. Basidiospores narrower measuring 11−14 × 7−8 μm, surface completely reticulate, globose to oblong terminal cells in pileipellis .................................................. *H. japonicus*
3b. Basidiospores wider measuring 11.5−13.5 × 8−9.5 μm, surface incompletely reticulate to reticulate-alveolate, cylindrical to narrowly clavate-subcapitate terminal cells in pileipellis .................................................. *H. sinensis*

**Heimileccinum** Šutara, Czech Mycol. 60: 52. 2008.

*Heimileccinum*, typified by *H. impollitum*, is mainly characterised by a lateral stipe stratum of the leccinoid type, and irregularly warty basidiospores under SEM (Šutara 2008, Wu et al. 2014, 2016, Li et al. 2021). Besides one new species described in the present study, six species have been confirmed to be distributed in China (Wu et al. 2016, Li et al. 2021).


Known distribution: Southwestern China (Yunnan Province) (Li et al. 2021).

Holotype: KUN-HKAS81120 (China, Yunnan Province).
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Notes: *Hemileccinum albidum* was originally described from Yunnan Province, southwestern China (Li et al. 2021). Illustrations and a full description of the species have been provided by Li et al. (2021).


**Known distribution:** Southwestern China (Yunnan Province) (Li et al. 2021).

**Holotype:** KUN-HKAS89150 (China, Yunnan Province).

Notes: *Hemileccinum brevisporum* was originally described from Yunnan Province, southwestern China (Li et al. 2021). Illustrations and a full description of the species have been provided by Li et al. (2021).


**Description:** Basidiomata small to medium-sized. Pileus 3.7–5.7 cm diam, subhemispherical when young, then convex to applanate, margin decurved; surface dry, subtomentose, yellowish brown to reddish brown; context 0.3–0.9 cm thick in the centre of the pileus, yellowish white to yellowish, unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores subround, 0.3–0.5 mm diam, yellow, unchanging in colour when injured; tubes 0.4–0.6 cm in length, yellowish, unchanging in colour when injured. Stipe 4.5–8.5 × 0.4–1 cm, central, subcylindric; surface reddish brown to dark reddish brown, but light yellow at the apex, densely covered with small, white scales; context upper part pale yellow, lower part reddish brown, unchanging in colour when injured; basal mycelium white. **Odour** indistinct.
We also noted that the stipe surface was described as "yellowish reddish brown pileus, hymenophore and context unchanging in to medium-sized basidioma, a subtomentose, yellowish brown to Fujian Provinces of China. The species is characterised by a small present study, it was also found to be distributed in Hainan and et al. 2021). In the Yunnan Province, southwestern China (Li

Notes

Hemileccinum ferrugineipes: KUN-HKAS115554 (China, Yunnan Province). Holotype: KUN-HKAS115554 (China, Yunnan Province).

Materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 26 May 2017, N.K. Zeng, Zeng2578 (FHMU1939); Fujian Province, Zhangping City, Xinqiao Town, Chengkou Village, elev. 350 m, 1 Aug 2013, N.K. Zeng, Zeng1342 (FHMU894); same location, 22 Aug 2017, N.K. Zeng, Zeng2978. pleurocystidia microsclereid, 320–600 × 11–15 μm, 2–4 spored, yellow-brown in KOH, 4–8 μm thick, with thin-walled, 5–12 μm wide hyphae. Stipes and hymenophoral tissue yellowish brown in KOH, thin-walled, 5–12 μm wide hyphae, 3–12 μm thick, composed of thin-walled, 3–9 μm wide, yellowish brown in KOH, emergent hyphae with subfusiform or clavate terminal cells (24–47 × 5–11 μm). Stipe trama composed of cylindrical, yellow in KOH, thin-walled hyphae, 3–12 μm wide. Clamp connections absent in all tissues.

Habitat: Scattered on the ground in forests dominated by fagaceous trees.

Known distribution: Southern (Hainan Province), southeastern (Fujian Province), and southwestern China (Yunnan Province) (Li et al. 2021).

Holotype: K 171145 (Singapore).


Notes: Hemileccinum ferrugineipes was originally described from Yunnan Province, southwestern China (Li et al. 2021). In the present study, it was also found to be distributed in Hainan and Fujian Provinces of China. The species is characterised by a small to medium-sized basidioma, a subtomentose, yellowish brown to reddish brown pileus, hymenophore and context unchanging in colour when injured, and a stipe densely covered with white scales. We also noted that the stipe surface was described as "yellowish to yellow at upper part, lower part pale red-brown of stipe pileus; covered with longitudinal striations and densely dotted scales" by Li et al. (2021), which is somewhat different from our new specimens.


Known distribution: Southern China (Hainan Province); Singapore, Malaysia (Corner 1972, Zeng et al. 2012, Wu et al. 2016).

Holotype: K 171145 (Singapore).


Notes: Hemileccinum indecorum was originally described from Singapore (Corner 1972); illustrations and a full description of the species have been provided by Corner (1972) and Zeng et al. (2012). The phylogenetic position of the species was ambiguous in the past (Zeng et al. 2012). Recently, the species was transferred to Hemileccinum according to the results of phylogenetic analyses (Wu et al. 2016).


Known distribution: Southwestern China (Yunnan Province) (Li et al. 2021).
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**Holotype**: KUN-HKAS115553 (China, Yunnan Province).

**Notes**: *Hemileccinum parvum* was originally described from Yunnan Province, southwestern China (Li et al. 2021); illustrations and a full description of the species have been provided by Li et al. (2021).


**Description**: Basidiomata medium-sized. Pileus 5–5.4 cm diam, subhemispherical when young, then convex to applanate, margin uneven; surface dry, rugose, pale brown to brown; context about 1 cm thick in the centre of the pileus, yellowish, unchanging in colour when injured. Hymenophore poroid, slightly depressed around apex of stipe; pores angular, about 0.1 mm diam, yellow, unchanging in colour when injured; tubes about 0.8 cm in length, yellowish, unchanging in colour when injured. Stipe 5.2–7.4 × 0.8–1 cm, central, solid, subcylindric; surface white, densely covered with...
minute, pale brown scales; context yellowish white, unchanging in colour when injured; basal mycelium white. Odour indistinct.

_Basidia_ 24–26 × 9–11 μm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 3–5 μm long. _Basidiospores_ [40/2/1] 10–11.5 × 4–5 μm, Q = 2.20–2.75, Qm = 2.43 ± 0.21, sub fusiform, slightly thick-walled (up to 0.7 μm), yellowish brown in KOH, smooth under light microscopy, but with tiny warts on the surface under SEM. _Hymenophoral trama_ composed of thin-walled hyphae, 4–9.5 μm wide, yellowish in KOH. _Cheilocystidia_ 19–39 × 5–10 μm, sub fusiform or fusiform, thin-walled, colourless to yellowish in KOH. _Pileipellis_ a hypophyllum 110–160 μm thick, composed of chains of subglobose to pyriform cells up to 29 μm in width, thin-walled, pale yellow to yellow in KOH; terminal cell 6–29 × 3–9 μm, clavate or subcylindrical. _Pileal trama_ made up of hyphae 5–20 μm diam, thin-walled, hyaline to yellowish in KOH. _Stipitellipellis_ a trichoderm-like structure 50–90 μm thick, composed of thin-walled, 2–6 μm wide, colourless in KOH, emergent hyphae with clavate terminal cells (15–32 × 6–12 μm). _Stipe trama_ composed of cylindrical, yellowish in KOH, thin-walled, hyphae 5–10 μm wide. _Clamp connections_ absent in all tissues.

_Habitat_: Scattered on the ground in forests dominated by fagaceous trees.

KNOWN DISTRIBUTION: Southern China (Hainan Province) and southwestern China (Yunnan Province) (Wu et al. 2016).

_Holotype_: KUN-HKAS84355 (China, Yunnan Province).


_Notes_: _Hemileccinum rugosum_ was originally described from Yunnan Province, southwestern China (Wu et al. 2016). In the present study, it was also found to be distributed in Hainan Province, tropical China. The species is characterised by a medium-sized basidioma, a rugose, pale brown to brown pileus, hymenophore and context unchanging in colour when injured, and a stipe densely covered with minute, pale brown scales. We also noted that the pileal surface was described as “light orange to reddish orange” by Wu et al. (2016) whereas our new collection is pale brown to brown (5E5); context 0.3–0.5 cm thick in the centre of the pileus, yellowish white (1A2), unchanging in colour when injured. _Hymenophore_ poroid, slightly depressed around apex of stipe; pores angular, 0.3–1 mm diam, yellow (1A4), unchanging in colour when injured; tubes about 0.3 cm in length, pale yellow, unchanging in colour when injured. _Stipe_ 6.5–8 × 0.7–1 cm, central, subcylindrical; surface white, covered with yellow (2A4) to brown (5D3) squamules; context yellow (2A3), sometimes tinged with brown (5D2), unchanging in colour when injured; basal mycelium white (1A1). _Odour_ indistinct.

_Basidia_ 30–38 × 9–11 μm, clavate, thin- to slightly thick-walled (up to 1 μm), 4-spored, colourless to pale yellow in KOH; sterigmata 2–4 μm long. _Basidiospores_ [60/3/3] 10–11 (–11.5) × 4–5 μm, Q = 2.10–2.75 (–3.14), Qm = 2.46 ± 0.28, fusoid, slightly thick-walled (up to 1 μm), yellowish brown in KOH, smooth under light microscopy, but with tiny warts on the surface under SEM. _Hymenophoral trama_ composed of thin-walled hyphae, 5–10 μm wide, yellowish in KOH. _Cheilocystidia_ 26–53 × 8–15 μm, sub fusiform or fusiform, thin-walled, colourless in KOH. _Pileipellis_ 35–52 × 9–12 μm, sub fusiform or fusiform, thin-walled, colourless in KOH. _Pileipellis_ a hypophyllum 150–460 μm thick, composed of chains of subglobose to pyriform cells up to 17 μm in width, thin- to slightly thick-walled (up to 1 μm), lemon yellow in KOH; terminal cell 4–17 × 3.5–14 μm, sub spherical, spherical, clavate, or sub fusiform, with obt use, occasionally acute apex. _Pileal trama_ made up of hyphae 4–15.5 μm diam, thin- to slightly thick-walled (up to 1 μm), hyaline to yellowish in KOH. _Stipitellipellis_ a trichoderm-like structure 98–145 μm thick, composed of thin- to slightly thick-walled (up to 1 μm), 5–12 μm wide, colourless to yellow in KOH, emergent hyphae with sub fusiform, subcylindrical or clavate terminal cells (17–38 × 6–11 μm). _Stipe trama_ composed of cylindrical, hyaline to yellowish in KOH, slightly thick-walled (up to 0.5 μm) hyphae 4–13 μm wide. _Clamp connections_ absent in all tissues.

_Habitat_: Scattered in the forests dominated by fagaceous trees.

KNOWN DISTRIBUTION: Southern (Hainan Province) and southwestern China (Yunnan Province).

_Notes_: Morphologically, _H. squamipes_ is similar to _H. albidum_, _H. brevisporum_, and _H. parvum_, three taxa originally described from Yunnan Province, southwestern China (Li et al. 2021). However, _H. albidum_ has a whitish, nearly smooth stipe with only small, granular scales at the base, and larger basidiospores measuring 10–12.5 × 4.0–5.5 μm (Li et al. 2021); _H. brevisporum_ has a pileus tinged with reddish, a long stipe (13–15 × 2.0–2.3 cm), and small basidia measuring 18.5–27 × 8–11 μm (Li et al. 2021); _H. parvum_ has a smaller basidioma (pileus only up to 3.6 cm diam), a pileal context turning blue when injured, a pale yellow stipe, and longer basidiospores measuring 12–14 × 4.5–5 μm (Li et al. 2021).

_Hemileccinum squamipes_ is also morphologically similar to North American _H. floridanum_, _H. hortonii_, and _H. subglabripes_. However, _H. floridanum_ has a larger basidioma (pileus up to 12.5 cm diam), a pileal surface usually tinged with reddish, and larger basidiospores measuring 13–16 × 4.5–6 μm (Farid et al. 2021);
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**H. hortonii** has a larger basidioma (pileus up to 12 cm diam), a pileal surface uneven to corrugated or alveolate, usually tinged with reddish, and longer but narrower basidiospores measuring 12–15 × 3.5–4.5 μm (Smith & Thiers 1971, Kuo & Ortiz-Santana 2020);

**H. subglabripes** has a stipe yellow at first, then slowly developing red colours from the base upwards, and longer basidiospores measuring 11–14 × 3–5 μm (Smith & Thiers 1971, Halling et al. 2020).

![Fig. 47. Microscopic features of Hemileccinum rugosum (FHMU2966). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitipellis. Scale bars = 10 μm. Drawings by Z. Li.]

**Key to accepted species of Hemileccinum in China**

1a. Pileal surface with conical, subconical to irregularly shaped squamules, a presence of a zone on the stipe ................. **H. indecorum**

1b. Pileal surface slightly submentose, rugose to wrinkled, an absence of a zone on the stipe .................................................. 2
2a. Pileus smaller (up to 4 cm in diam), pileal context turning pale blue very slowly when injured at some spots .................. H. parvum
2b. Pileus larger (> 4 cm in diam), pileal context unchanged in colour when injured ......................................................... 3

3a. Stipe surface whitish or whitish brown .......................................................... 4
3b. Stipe surface yellowish to yellow at upper part, pale yellowish brown to reddish brown at lower part ................................. 5

4a. Pileal surface distinctively rugose when mature ............................................. H. rugosum
4b. Pileal surface smooth when mature ................................................................ H. albidum

5a. Pileal surface pale brown to brown, without reddish tinge ................................. 3
5b. Pileal surface yellowish brown tinged with reddish ........................................ 6

6a. Stipe surface cream to yellowish at upper part, pale yellowish brown to yellowish brown at lower part, covered with yellowish brown scales .................................................. H. brevisporum
6b. Stipe surface reddish brown to dark reddish brown, but light yellow at the apex, densely covered with white scales ... H. ferrugineipes


*Hourangia*, typified by *Hou. cheoi*, is characterised by a context of the stipe turning bluish firstly, then reddish to brownish red, and finally brownish to blackish when injured, a thick hymenophore being 3–5 (~7) times that of the pileal context, and the basidiospore surface with bacillate ornamentation (Zhu et al. 2015). Until now, four species have been confirmed to distribute in China (Zhu et al. 2015, Gelardi et al. 2017, Wang et al. 2020).


*Boletus punctilifer* W.F. Chiu, Mycologia 40: 216. 1948.


*Known distribution*: Southwestern China (Yunnan Province) (Chiu 1948, Zhu et al. 2015, Gelardi et al. 2017).

*Epitype*: KUN-HKAS52269 (China, Yunnan Province).

*Material examined*: China, Yunnan Province, Jingdong County, elev. 2 500 m, 20 Jul. 2006, Z.L. Yang, Yang4683 (KUN-HKAS50480)

*Notes*: *Hourangia cheoi* was originally described from Yunnan Province, southwestern China (Chiu 1948). It was placed in the genus *Boletus* firstly (Chiu 1948), and later transferred to *Xerocomus* (Tai 1979). One recent study indicated it is a member of *Hourangia* (Zhu et al. 2015). Illustrations and a full description of the species have been provided by Zhu et al. (2015) and Gelardi et al. (2017).


*Known distribution*: Southeastern China (Fujian Province) (Wang et al. 2020).

*Holotype*: FHMU855 (China, Fujian Province).

*Notes*: *Hourangia densisquamata* was originally described from Fujian Province, southeastern China (Wang et al. 2020). Illustrations and a full description of the species have been provided by Wang et al. (2020).


*Known distribution*: Southern (Hainan Province) and southeastern China (Fujian Province) (Wang et al. 2020).

*Holotype*: FHMU2979 (China, Hainan Province).

*Notes*: *Hourangia dilatata* was originally described from Hainan Province, southern China (Wang et al. 2020); illustrations and a full description of the species have been provided by Wang et al. (2020). In China, *Hou. dilatata* was misidentified as *Hou. microcarpa* (Zhu et al. 2015, Wang et al. 2020).


*Known distribution*: Southwestern (Sichuan and Yunnan Provinces), central (Hunan Province), southeastern (Fujian Province), and southern China (Guangxi and Hainan Provinces) (Zhu et al. 2015, Wang et al. 2020).

*Epitype*: KUN-HKAS76657 (China, Guizhou Province).


*Notes*: *Hourangia nigropunctata* was originally described from Sichuan Province, southwestern China (Chiu 1948). It was placed in the genus *Boletus* firstly (Chiu 1948), and later transferred to *Xerocomus* (Tai 1979). One recent study indicated it is a member of *Hourangia* (Zhu et al. 2015). Illustrations and a full description of the species have been provided by Zhu et al. (2015) and Wang et al. (2020). The species is common in subtropical and tropical China (Zhu et al. 2015, Wang et al. 2020).
Key to accepted species of *Hourangia* in China

1a. Basidiospores longer (up to 12.5 μm), pileal context changing to blue quickly and distinctly when injured ........................................... *H. cheoi*
1b. Basidiospores shorter (up to 11 μm), pileal context changing slightly to blue or unchanging in colour when injured .............................. 2

2a. Basidiomata smaller (≤ 2.5 cm) ............................................................................................................................................................... *H. dilatata*
2b. Basidiomata larger (> 2.5 cm) ............................................................................................................................................................... 3

3a. Basidiospores smaller (7–9.5 × 3.5–4.5 μm, Qm = 1.98 ± 0.20), pileal context changing to blue slightly, then to reddish when injured, stipe surface without a layer of white pruina ................................................................................................................ *H. nigropunctata*
3b. Basidiospores larger (9–11 × 4–5 μm, Qm = 2.36 ± 0.20), pileal context unchanging in colour or changing slightly to blue when injured, stipe surface covered with a layer of white pruina .............................................................................................................. *H. densisquamata*


**Known distribution:** Central (Hunan Province) and southern China (Guangdong and Hainan Provinces) (Wu et al. 2021).

**Holotype:** FHMU3276 (China, Hunan Province).

**Materials examined:** China. Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 14 Aug. 2020, N.K. Zeng, Zeng4783, 4784, 4787 (FHMU5428, 5408, 5450).

**Notes:** *Phylloporus alboinfuscatus* was originally described from Hunan Province, central China (Wu et al. 2021); illustrations and a full description of the species have been provided by Wu et al.

![Fig. 49. Basidiomata of Phylloporus species. A, B. *P. hainanensis* (holotype FHMU1718). C, D. *P. pusillus* (FHMU5010). Photos by N.K. Zeng.](image-url)
The subfamily Xerocomoideae (Boletaceae, Boletales) in China (2021). The Hainan specimens cited above extends the range of distribution and is the first report from tropical China.


**Known distribution:** Southwestern (Yunnan Province) and southern China (Guangdong and Hainan Provinces); Singapore, Malaysia, New Guinea, Korea, Japan, Philippines, and India (Massee 1914, Corner 1970, Zeng et al. 2013, Acharya et al. 2017).

**Materials examined:** China, Hainan Province, Wuzhishan of Hainan Tropical Rainforest National Park, elev. 650 m, 12 Aug. 2020, N.K. Zeng, Zeng4625, 4629, 4655 (FHMU4994, 4978, 4995).

**Notes:** *Phylloporus bellus* was originally described from Singapore (Massee 1914, Corner 1970), then reported from Malaysia, New Guinea, Korea, Japan, China, Philippines, and India (Massee 1914, Corner 1970, Bi et al. 1997, Zeng et al. 2013, Acharya et al. 2017). Illustrations and a full description of the species have been provided by Corner (1970) and Zeng et al. (2013).


**Holotype:** KUN-HKAS56903 (China, Yunnan Province).

**Known distribution:** Southern China (Hainan Province); Korea, Pakistan (Zeng et al. 2013, Lee et al. 2014, Naseer et al. 2017).

**Materials examined:** China, Hainan Province, Wuzhishan City, campus of Qiongzhou College, elev. 350 m, 30 Jul. 2010, N.K. Zeng, Zeng761 (FHMU459).

**Notes:** *Phylloporus bogoriensis* was originally described from Southeast Asia (Höhnel 1914, Corner 1970); illustrations and a full description of the species have been provided by Corner (1970) and Wu et al. (2021).


**Known distribution:** Southwestern China (Yunnan Province); Korea, Pakistan (Zeng et al. 2013, Lee et al. 2014, Naseer et al. 2017).

**Materials examined:** China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 14 Aug. 2020, N.K. Zeng, Zeng4788, 4789 (FHMU5400, 5413).

**Notes:** *Phylloporus brunneiceps* was originally described from Yunnan Province, southwestern China (Zeng et al. 2013), then reported from Korea and Pakistan (Lee et al. 2014, Naseer et al. 2017). Illustrations and a full description of the species have been provided by Zeng et al. (2013).


**Known distribution:** Southern China (Hainan Province); Thailand (Neves et al. 2012, Wu et al. 2021).

**Holotype:** MFLU 08-1118 (Thailand, Chiang Mai Province).

**Materials examined:** China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 14 Aug. 2020, N.K. Zeng, Zeng4788, 4789 (FHMU5400, 5413).

**Notes:** *Phylloporus castanopsidis* was originally described from Thailand (Neves et al. 2012), and subsequently also reported from China (Wu et al. 2021). Illustrations and a full description of the species have been provided by Neves et al. (2012).
species have been provided by Neves et al. (2012) and Wu et al. (2021).


Known distribution: Central (Hunan Province) and southern China (Hainan Province) (Wu et al. 2021).

Holotype: FHMU3277 (China, Hunan Province).

Materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 2 Jul. 2020, N.K. Zeng, Zeng4263, 4304 (FHMU4746, 4556); same location, 15 Aug. 2020, N.K. Zeng, Zeng4810, 4815, 4817 (FHMU5035, 5025, 4988).

Notes: *Phylloporus grossus* was originally described from central China (Hunan Province). Illustrations and a full description of the species have been provided by Wu et al. (2021).


Etymology: hainanensis (Lat.), refers to Hainan Province, China, holotype locality.

Diagnosis: Differs from other species of *Phylloporus* by a pileus covered with pale brown to brown squamules, a white pileal context unchanging in colour when injured, a stipe covered with minute, reddish brown squamules, thin-walled cystidia, and a pileipellis composed of filamentous hyphae.


Additional materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 2 Jul. 2020, N.K. Zeng, Zeng4272 (FHMU4723); Bawangling of Hainan Tropical Rainforest National Park, elev. 550 m, 3 Sep. 2020, N.K. Zeng, Zeng4984 (FHMU5550).

Description: Basidiomata very small to small-sized. *Pileus* 1.3–4.6 cm diam, convex to applanate; margin usually uplifted; surface dry, tomentose, then squamulose, pale brown (5B2) to brown (5B4); context about 0.5 cm thick in the centre of the pileus, white (1A6), changing bluish when injured, then reddish when injured, a stipe tinged with orangish brown, a stipe tinged with orangish brown, and a pileipellis composed of inflated hyphae. Clamp connections absent in all tissues.

Habitat: Solitary or gregarious on the ground in forests dominated by fagaceous trees.

Known distribution: Southern China (Hainan Province).

Notes: Morphologically, *P. hainanensis* is similar to Chinese *P. bruneiceps* and *P. maculatus*. However, *P. bruneiceps* has a yellow to yellowish brown stipe with yellowish basal mycelia (Zeng et al. 2013); *P. maculatus* has a yellow to brownish yellow stipe, and hyphae in pileipellis wider (up to 25 μm) (Zeng et al. 2013). *Phylloporus hainanensis* is also morphologically similar to *P. phaeoxanthus* var. *simplex*, however, the latter has a larger basidioma (pileus up to 6.5 cm), lamellae unchanging in colour when injured, and it is distributed in Costa Rica (Neves & Halling 2010). Phylogenetically, *P. hainanensis* is closely related to *P. rubeolus*, *P. pelletieri* and *P. subbacillisporus* (Fig. 4). However, *P. rubeolus* has a larger, reddish brown pileus (2.4–7 cm), and a pileipellis composed of inflated hyphae (up to 25 μm) with longer and wider terminal cells (25–60 × 7–11 μm) (Zeng et al. 2013); *P. pelletieri*, originally described from Europe (Ladurner & Simonini 2003), has a pileus tinged with red, a yellowish pileal context, and slightly longer basidiomes measuring 10–15 × 3.5–5 μm (Taylor et al. 2002); *P. subbacillisporus* has a pileal context turning blue, then reddish when injured, a stipe tinged with orangish brown, and narrower basidiomes measuring 8.8–13.1 × 2.9–3.9 μm (Chuankid et al. 2019).


Known distribution: Southwestern China (Yunnan Province) (Wu et al. 2021).

Holotype: KUN-HKAS54647 (China, Yunnan Province).

Notes: *Phylloporus imbricatus* was originally described from Yunnan Province, southwestern China (Wu et al. 2021); illustrations and a full description of the species have been provided by Zeng et al. (2013).


Known distribution: Southwestern (Yunnan Province), southeastern (Fujian Province), central (Hunan Province), and southern China (Hainan Province); Thailand, Vietnam (Zeng & Zeng 1978, Lee et al. 2020, Zeng et al. 2011, Wu et al. 2021, Neves et al. 2012).

Holotype: KUN-HKAS40150 (China, Yunnan Province).

Material examined: China, Yunnan Province, Nanhua County, Zixi Town, near Dafengyakou Bridge, elev. 2 013 m, 5 Aug. 2020, W.H. Zhang, Zhang367 (FHMU6088).

Notes: Phylloporus luxiensis was originally described from Yunnan Province, southwestern China (Zeng & Zeng 1978); illustrations and a full description of the species have been provided by Zeng et al. (2011) and Wu et al. (2021). The species was called “Qiaomianbabajun” in Yunnan Province of southwestern China, which sold in the market for edibility. Our molecular data further confirmed that P. dimorphus, originally described from Thailand (Neves et al. 2012), is a synonym of P. luxiensis (Fig. 4), which was also noted by Wu et al. (2021).


Known distribution: Southwestern China (Yunnan Province); India (Zeng et al. 2013, Dyutiparna et al. 2018).

Holotype: KUN-HKAS56683 (China, Yunnan Province).

Notes: Phylloporus maculatus was originally described from Yunnan Province, southwestern China (Zeng et al. 2013), then reported from India (Dyutiparna et al. 2018). Illustrations and a full description of the species have been provided by Zeng et al. (2013).


Known distribution: Southern (Hainan and Guangxi Provinces) and southwestern China (Yunnan Province) (Wu et al. 2021).

Holotype: FHMU1678 (China, Hainan Province).

Notes: Phylloporus microsquamus was originally described from Hainan Province, southern China (Wu et al. 2021). Illustrations and a full description of the species have been provided by Wu et al. (2021).


Known distribution: Southwestern China (Yunnan Province) (Wu et al. 2021).

Holotype: FHMU3271 (China, Yunnan Province).

Notes: Phylloporus nigrisquamus was originally described from Yunnan Province, southwestern China. Illustrations and a full description of the species have been provided by Wu et al. (2021).


Known distribution: Southwestern China (Yunnan Province) (Wu et al. 2021).

Holotype: FHMU3268 (China, Yunnan Province).

Notes: Phylloporus nigrobrunneus was originally described from Yunnan Province, southwestern China (Wu et al. 2021). Illustrations and a full description of the species have been provided by Wu et al. (2021).


Known distribution: Southwestern China (Yunnan Province); Vietnam (Zeng et al. 2013, Pham & Morozova 2020).

Holotype: KUN-HKAS54540 (China, Yunnan Province).

Notes: Phylloporus pachycystidatus was originally described from Yunnan Province, southwestern China (Zeng et al. 2013), then reported from Vietnam (Pham & Morozova 2020). Illustrations and a full description of the species have been provided by Zeng et al. (2013).


Known distribution: Southern (Hainan Province), southeastern (Fujian Province), and southwestern China (Yunnan Province); Singapore (Bi et al. 1997, Zeng et al. 2013, Zeng & Jiang 2020).

Material examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 800 m, 4 Jul. 2020, N.K. Zeng, Zeng4477 (FHMU3340).

Notes: Phylloporus parvisporus was originally described from Singapore (Corner et al. 1971), then reported from China (Bi et al. 1997, Zeng et al. 2013). Illustrations and a full description of the species have been provided by Corner et al. (1971) and Zeng et al. (2013).


Known distribution: Eastern (Anhui Province) and southwestern China (Yunnan Province) (Zhao et al. 2018).

Holotype: KUN-HKAS101929 (China, Anhui Province).

Notes: Phylloporus pruinatus was originally described from Anhui Province, eastern China (Zhao et al. 2018). Illustrations and a full description of the species have been provided by Zhao et al. (2018).


Description: Basidiomata very small-sized. Pileus 1.5–1.9 cm diam, convex to applanate, centre slightly depressed; margin decurred; surface dry, tomentose, pale brown, brown to dark brown, usually covered with a thin layer of white pruina; context 0.1–0.3 cm thick in the centre of the pileus, yellowish, unchanging in colour when injured. Hymenophore lamellate, decurrent. Lamellae up to 0.2 cm
broad, subdistant, commonly anastomosing, yellow, unchanging in colour when injured; lamellae common, attenuate, concolour with lamellae. Stipe 1.6–2.2 × 0.3–0.4 cm, central, subcylindrical; surface dry, densely covered with minute, pale brown squamules; context yellowish, unchanging in colour when injured; annulus absent. Basal mycelium white. Odour not distinct.

Basidia 34–41 × 8.5–10.5 μm, clavate, thin-walled, 4-spored, yellowish in KOH; sterigmata 3–5 μm in length. Basidiospores [40/212] 8.5–11–(11.5) × 4.5–5.5–(6.5) μm, Q = (1.62–)1.90–2.44, Qm = 2.06 ± 0.18, elongate to cylindrical, slightly thick-walled (up to 0.5 μm), olive brown to yellowish brown in KOH, smooth under the light microscope, but with bacillate ornamentation under SEM. Hymenophoral trama phylloporoid, composed of slightly thick-walled (up to 1 μm) hyphae, 5–17 μm wide, colourless in KOH. Cheilocystidia 50–74 × 10.5–16 μm, abundant, subfusiform or fusiform, colourless or yellowish in KOH, no encrustations. Pleurocystidia 54–87 × 10–14 μm, abundant, fusiform or subfusiform, colourless in KOH, no encrustations. Pleipeilis a trichoderm 60–100 μm thick, composed of slightly interwoven, yellow in KOH, 6–15 μm wide, thin- to slightly thick-walled (up to 0.5 μm) hyphae; terminal cells 29–62 × 9–15 μm, clavate, subcylindrical or fusiform, with obtuse apex. Pleilea trama composed of 6–16 μm wide, yellow in KOH, slightly thick-walled (up to 0.5 μm) hyphae. Stipitipellis a trichoderm-like structure 55–125 μm thick, composed of thin- to slightly thick-walled (up to 0.5 μm) hyphae 5–15 μm wide, yellowish brown in KOH; terminal cells 33–70 × 8.5–15 μm, clavate, subcylindrical or fusiform, with obtuse apex. Stipe trama composed of longitudinally arranged hyphae 5–19 μm wide, cylindrical, thin- to slightly thick-walled (up to 0.5 μm), yellowish in KOH. Clamp connections absent in all tissues.

Habitat: Solitary to gregarious on the ground in forests dominated by fagaceous trees.

Known distribution: Southwestern (Yunnan Province) and southern China (Hainan Province); Thailand (Chuankid et al. 2019).

Holotype: CMUB, Raspé, OR1310 (Thailand, Chiang Mai Province).

Materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 2 Jul. 2020, N.K. Zeng, Zeng4287, 4304 (FHMU4746, 4556); same location, 4 Sep. 2020, N.K. Zeng, Zeng4993, 5009 (FHMU4800, 4791); Wanning City, Shimei Bay, elev. 5 m, 28 August 2020, N.K. Zeng, Zeng4828, 4833, 4834, 4836 (FHMU5377, 5378); same location, 15 Aug. 2020, N.K. Zeng, Zeng4810, 4815, 4817 (FHMU5035, 5025, 4986).

Notes: Phylloporus rubiginosus was originally described from Thailand (Neves et al. 2012), and subsequently reported from China and Vietnam (Ye et al. 2014, Zhang et al. 2019b). Illustrations and a full description of the species have been provided by Neves et al. (2012) and Zhang et al. (2019b).


Known distribution: Southwestern China (Yunnan Province) (Zeng et al. 2013).

Holotype: KUN-HKAS54559 (China, Yunnan Province).

Notes: Phylloporus rubrosquamosus was originally described from Yunnan Province, southwestern China (Zeng et al. 2013). Illustrations and a full description of the species have been provided by Zeng et al. (2013).


Known distribution: Southern China (Hainan Province); Singapore (Corner et al. 1971, Zeng et al. 2013).


Notes: Phylloporus rufescens was originally described from Singapore (Corner et al. 1971), then reported from China (Zeng et al. 2013). Illustrations and a full description of the species have been provided by Corner et al. (1971) and Zeng et al. (2013).


Known distribution: Southwestern (Yunnan Province), eastern China (Anhui Province); Thailand (Chuankid et al. 2019, Wu et al. 2021).

Holotype: HMAS279879 (China, Yunnan Province).
Material examined: China, Anhui Province, Jinzhai County, Roadside from Mazongling Tree Farm to Tiantan Village, elev. 955 m, 23 Jul. 2017, Y.J. Hao, Hao1553 (FHMU3293).

Notes: Phylloporus subbacilliporus was originally described from Yunnan Province, southwestern China (Chuankid et al. 2019). In the present study, it was also found to be distributed in Anhui Provinces of eastern China. Illustrations and a full description of the species have been provided by Chuankid et al. (2019).


Known distribution: Southern (Hainan and Guangdong Provinces) and central China (Hunan Province); Thailand (Chuankid et al. 2019, Wu et al. 2021).

Holotype: MFLU 16–2229 (Thailand, Chiang Mai Province).

Material examined: China, Hainan Province, Jianfengling of Hainan Tropical Rainforest National Park, elev. 850 m, 10 Aug. 2020, N.K. Zeng, Zeng4588 (FHMU4891).

Notes: Phylloporus subrubeolus was originally described from Thailand (Chuankid et al. 2019), and subsequently reported from China (Wu et al. 2021). Illustrations and a full description of the species have been provided by Chuankid et al. (2019) and Wu et al. (2021).

### Key to the accepted Phylloporus species from China

1. Pileal surface brown, dark brown or olivaceous, without reddish tinge when mature .......................................................... 2
2. Pileal surface reddish to reddish brown .......................................................... 14

2a. Pileal surface tinged with olivaceous, context pale brownish fuliginous ............................................... *P. parvisporus*
2b. Pileal surface brown, dark brown, context cream-coloured, yellowish or yellowish white .......................................................... 3

3a. Hymenophore unchanging in colour when injured .......................................................... 4
3b. Hymenophore turning blue when injured .......................................................... 8

4a. Cystidia moderately thick-walled (up to 2 μm) ......................................................... *P. grossus*
4b. Cystidia thin- to slightly thick-walled (up to 1 μm) ......................................................... 5

5a. Pileal surface covered with a thin layer of white pruina ..................................................... *P. pusillus*
5b. Pileal surface without a pruina .......................................................... 6

6a. Pileal surface covered with squamules, cystidia longer (up to 175 μm) ............................................... *P. nigrisquamus*
6b. Pileal surface subtomentose, cystidia shorter (up to 93 μm) ......................................................... 7

7a. Basidioma comparatively small (pileus 1.5–2 cm diam), basidiospores narrower (up to 4.5 μm), hyphae in pileipellis 9–18 μm wide ........................................................................... *P. nigrobrunneus*
7b. Basidioma comparatively large (pileus up to 9.5 cm diam), basidiospores wider (up to 5.5 μm), hyphae in pileipellis 5–9 μm wide ........................................................................... *P. luxiensis*

8a. Context changing bluish or reddish when injured .......................................................... 9
8b. Context unchanging in colour when injured .......................................................... 11

9a. Context changing reddish quickly, then blackening when injured ............................................. *P. bogoriensis*
9b. Context changing bluish when injured .......................................................... 10

10a. Pileal context about 0.5 cm in thickness, basidiospores 10–14.5 × 4–5.5 μm, pleurocystidia 89–115 × 14–17 μm .... *P. castanopsis*
10b. Pileal context about 0.2 cm in thickness, basidiospores 10–12 × 4–5 μm, pleurocystidia 56–89 × 10–20 μm ............ *P. tenuissimus*
11a. Pleurocystidia moderately thick-walled (1–2 μm), basidiospores wider (up to 5.5 μm) .......................................................... P. alboinfuscatus
11b. Pleurocystidia thin- to slightly thick-walled (up to 1 μm), basidiospores narrower (up to 4.5 μm) .................................................. 12

12a. Hyphae in pileipellis wider (up to 25 μm) ...................................................................................... P. maculatus
12b. Hyphae in pileipellis narrower (up to 11 μm) .................................................................................. 13

13a. Stipe surface densely covered with reddish-brown squamules ......................................................... P. hainanensis
13b. Stipe surface tomentose, yellow to yellowish-brown ......................................................... P. brunneiceps

14a. Cystidia thick-walled (> 1 μm) ........................................................................................................ 15
14b. Cystidia thin- to slightly thick-walled (< 1 μm) .............................................................................. 16

15a. Pileal surface yellowish-brown to reddish-brown, context unchanging in colour but hymenophore turning bluish when injured .......................................................... P. pachycystidatus
15b. Pileal surface brownish red to reddish, hymenophore and context turning bluish-olivaceous, then turning red and finally blackening when injured ........................................... P. rubiginosus

16a. Lamellae crowded, blue-red-black colour change of context ......................................................... P. rufescens
16b. Lamellae subdistant, context turning bluish or unchanging in colour when injured .......................... 17

17a. Hyphae uninflected in the pileipellis .................................................................................................. 18
17b. Hyphae more or less inflated in the pileipellis .................................................................................. 19

18a. Basidiospores longer (11–12.5 × 4.5–5 μm) ................................................................................. P. rubrosquamosus
18b. Basidiospores shorter (8–11 × 4–5.5 μm) ....................................................................................... P. microsquamus

19a. Basidiospores narrower (< 4 μm) .................................................................................................. 20
19b. Basidiospores wider (≥ 4 μm) ...................................................................................................... 21

20a. Basidiospores shorter (< 8 μm) ....................................................................................................... 21
20b. Basidiospores longer (≥ 8 μm) ...................................................................................................... 22

21a. Basidiomata smaller (pileus 2–3 cm diam), pileus with a thin, white pruina ........................................ P. pruinatus
21b. Basidiomata larger (pileus up to 11 cm diam), pileus without a pruina ............................................. P. imbricatus

22a. Distributed in temperate China, associated with trees of Abies and/or Picea ........................................ P. imbricatus
22b. Distributed in subtropical-tropical China, associated with trees of Fagaceae ................................. P. imbricatus

23a. Terminal cells of pileipellis with acute apex ................................................................................... P. rubeolus
23b. Terminal cells of pileipellis with obtuse apex ................................................................................ P. rubeolus

24a. Basidiospores wider (up to 5 μm) .................................................................................................. P. bellus
24b. Basidiospores narrower (up to 4.5 μm) ......................................................................................... P. yunnanensis


Pulchroboletus, typified by P. roseoalbidus, is characterised by its pale pink, cream pinkish to whitish pink or rarely blood red pileus, smooth to densely punctuate, or rarely coarse reticulate stipe, sometimes with pseudo-anulus at the upper or middle part, and pinkish purple context of the pileus (Gelardi et al. 2014). The genus was reported from Europe and North America in previous studies (Gelardi et al. 2014, Farid et al. 2017, Crous et al. 2019). The discovery of new species of Pulchroboletus in China in the present study indicates that the genus has a much wider geographical distribution range.


Etymology: erubescens (Lat.), refers to the pink pileus.

Diagnosis: Differs from other species of Pulchroboletus by a pink pileus, a yellowish white stipe densely covered with pink squamules, and small basidiospores.

Typus: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 2 Jul. 2020, N.K. Zeng, Zeng4274 (holotype FHMU4543).

Additional materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rainforest National Park, elev. 650 m, 2 Jul. 2020, N.K. Zeng, Zeng4302 (FHMU4710); same location, elev. 550 m, 4 Jun. 2017, S. Jiang, Jian52 (FHMU7592).

Description: Basidiomata large-sized. Pileus 10.5–11 cm diam, convex to applanate, margin uneven; surface dry, subtomentose, wrinkle, pink (7A2); context 1–2 cm thickness in the centre of the pileus, yellowish (1A2), unchanging in colour when injured. Hymenophore poroid, slightly depressed around apex of stipe; pores angular, about 0.3 mm diam, yellow (1A3), changing blue.
The subfamily Xerocomoideae (Boletaceae, Boletales) in China

when injured; tubes 0.6–0.8 cm in length, yellowish, changing blue when injured. Stipe 7.5–8 × 1–2.2 cm, central, solid, subcylindric; surface yellowish white, densely covered with pink (7A2) squamules; context yellowish (1A2), unchanging in colour when injured; basal mycelium white (2A1). Odour indistinct.

Basidia 20–38 × 9–11 μm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 3–5 μm long.

Basidiospores 9–11.5 × 4–5.5 μm, Q = 1.80–2.50, Qm = 2.12 ± 0.16, subfusiform, slightly thick-walled (up to 1 μm), yellowish brown in KOH, smooth.

Hymenophoral trama composed of thin- to slightly thick-walled (up to 1 μm) hyphae, 5–8 μm wide, colourless in KOH.

Cheilocystidia 35–40 × 7–11 μm, subfusiform or fusiform, thin- to slightly thick-walled (up to 1 μm), colourless in KOH.

Pleurocystidia 43–60 × 6–11 μm, clavate, subfusiform or fusiform, thin- to slightly thick-walled (up to 1 μm), colourless in KOH.

Pileipellis a trichoderm 113–137 μm thick, composed of hyphae thin- to slightly thick-walled (up to 1 μm), colourless in KOH, 4–13 μm in width; terminal cell 20–40 × 4–7 μm, clavate or subcylindrical, with obtuse apex.

Pileal trama made up of hyphae 5–13 μm diam, thin-walled, dark yellowish brown in KOH. Stipitipellis a trichoderm-like structure 50–180 μm thick, composed of thin- to slightly thick-walled (up to 1 μm), 7–16 μm wide, colourless in KOH, emergent hyphae with clavate, subfusiform or subcylindrical terminal cells (20–49 × 4–10 μm). Stipe trama composed of cylindrical, brownish yellow in KOH, thin- to slightly thick-walled (up to 0.6 μm) hyphae 3–12 μm wide. Clamp connections absent in all tissues.

Habitat: Scattered on the ground in forests dominated by fagaceous trees.

Known distribution: Southern China (Hainan Province).

Notes: Morphologically, Pul. erubescens is similar to Pul. roseoalbidus, Pul. rubricitrinus, and Pul. sclerotiorum. However, Pul. roseoalbidus has a stipe with a prominent but narrow granular pseudo-annular zone, larger basidiospores measuring 13.5–16 × 6.5–7.5 μm, and it is distributed in Europe (Gelardi et al. 2014); Pul. rubricitrinus has a larger basidioma (pileus up to 16 cm diam), a pink, testaceous, blood red pileus, larger basidiospores measuring 13.8–15.9 × 4.6–5.8 μm, and it is distributed in North America (Farid et al. 2017); Pul. sclerotiorum has a rose red to purple red pileus, a stipe covered with reddish brown spots, large basidiospores measuring 12–18 × 4–6 μm, and it is distributed in North America (Crous et al. 2019). Phylogenetically, species closely related to Pul. erubescens was not detected from our current data (Fig. 5).

Xerocomus Quél. Fl. Vosges, Champ.: 477. 1887.

Xerocomus, typified by X. subtomentosus, is characterised by tomentose and succulent pileus, normal long tubes with relatively large pores (1–3 mm diam), context becoming bluish to blue when injured, trichodermium pileipellis, and bacillately warted, sometimes smooth basidiospores under SEM (Cokers et al. 1974, Wu et al. 2016). Besides two new species described in the present study, eight species have been confirmed to distribute in China (Wu et al. 2016).
Fig. 55. Microscopic features of *Pulchroboletus erubescens* (holotype FHMU4543). **A.** Basidia. **B.** Basidiospores. **C.** Cheilocystidia. **D.** Pleurocystidia. **E.** Pileipellis. **F.** Stipitipellis. Scale bars = 10 μm. Drawings by Y.Y. Yang.
The subfamily Xerocomoideae (Boletaceae, Boletales) in China


**Etymology:** *albotomentosus* (Lat.), refers to the white villous mycelia at the stipe base.

**Diagnosis:** Differs from other species of *Xerocomus* by a stipe covered with minute, yellowish brown to pale yellowish brown squamules, a stipe base with obvious white villous mycelia, and a context unchanging in colour when injured.

**Typus:** China, Hainan Province, Jianfengling of Hainan Tropical Rainforest National Park, elev. 850 m, 10 Aug. 2020, N.K. Zeng, Zeng3395 (holotype FHMU2974).

**Additional materials examined:** China, Fujian Province, Yongan City, Tianbaoyuan National Natural Reserve, elev. 350 m, 17 Aug. 2017, N.K. Zeng, Zeng3271 (FHMU2232); Yunnan Province, Jinping County, Fenshuiling National Nature Reserve, elev. 1 800 m, 13 Jul. 2018, N.K. Zeng, Zeng3611 (FHMU2825); Guangdong Province, Renhua County, Danxiashan National Natural Reserve, elev. 360 m, 5 Jun. 2019, N.K. Zeng, Zeng4104 (FHMU3794).

**Description:** Basidiomata small to medium-sized. Pileus 3–6 cm diam, convex to applanate, slightly depressed in the centre when old, margin decurved; surface dry or sometimes slightly sticky, tomentose, yellowish brown (2B5), brown (2B8) to dark brown (7D5); context 0.3–1.1 cm thick in the centre of the pileus, white (7A2), unchanging in colour when injured. Hymenophore poroid, depressed around apex of stipe; pores compound, angular, 0.5–1 mm diam, yellow (2A7), turning bluish when injured; tubes 0.5–0.9 cm in length, yellowish (2A5), slowly turning bluish in colour when injured. Stipe 3–5.8 × 0.5–0.6 cm, central, subcylindric; surface dry, densely covered with minute, pale yellowish brown squamules; context white (7A1), unchanging in colour when injured; annulus absent; basal mycelium white (1A1). Odour indistinct.

Fig. 57. Basidiomata of Xerocomus species. A–C. X. subparvus (A. FHMU1630; B. FHMU2241; C. FHMU3344). D–F. X. yunnanensis (D. FHMU3071; E, F. FHMU3059). Photos by N.K. Zeng.

Fig. 58. Basidiospores of Xerocomus species from herbarium materials under SEM. A, B. X. albotomentosus (FHMU2825). C, D. X. fuscatus (holotype FHMU4922). Photos by C. Xu.

Basidia 22–34 × 10–12 μm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 2–4 μm long. Basidiospores [100/5/4] 8–12(–13) × 4–5.5(–6) μm, Q = (1.5–)1.6–2.7(–3), Qm = 2.12 ± 0.31, subfusiform, slightly thick-walled (up to 0.5 μm), yellowish brown in KOH, smooth. Hymenophoral trama composed of thin- to slightly thick-walled (up to 0.5 μm) hyphae, 6–14 μm wide, colourless in KOH. Cheilocystidia 13–50 × 6–13 μm, subfusiform or fusiform, thin-walled, colourless in KOH. Pleurocystidia 40–63 ×
11–18 µm, subfasiform or fusiform, thin-walled, colourless in KOH. Pileipellis a trichoderm 200–300 µm thick, composed of hyphae thin- to slightly thick-walled (up to 1 µm), colourless to light yellow in KOH, 4–19 µm in width; terminal cell 20–77 × 4–11.5 µm, clavate, subcylindrical or subfusiform, with obtuse apex. Pileal trama made up of hyphae 3–21 µm diam, slightly thick-walled (up to 1 µm), light yellow in KOH. Stipitipellis a trichoderm-like structure 60–100 µm thick, composed of thin- to slightly thick-walled (up to 1 µm), 4–13 µm wide, light yellow in KOH, emergent hyphae with subfusiform, subcylindrical or clavate terminal cells (16–36 × 4–13 µm). Stipe trama composed of cylindrical, light yellow in KOH, slightly thick-walled (up to 1 µm), parallel hyphae 4–17 µm wide. Clamp connections absent in all tissues.

Habitat: Solitary or caespitose on the ground in forests dominated by fagaceous trees.

Known distribution: Southwestern (Yunnan Province), southeastern (Fujian Province), and southern China (Hainan Province).

Notes: In one previous study, X. albotomentosus was misidentified as X. nigromaculatus (Thongkantha et al. 2021), originally described from Japan (Hongo 1966). However, X. nigromaculatus is easily recognised by the blackish staining of pileus and stipe, the context becoming first bluish then reddish, and smaller basidiospores measuring 6–9 × 3–5 µm (Hongo 1966). Xerocomus albotomentosus is also morphologically similar to X. illudens, X. subtomentosus, and X. tenax. However, X. illudens, originally described from North America, has a pileus tinged with pinkish, a stipe usually marked by coarse ridges and anastomosing lines, longer but narrower basidiospores measuring 10–14 × 4–5 µm, and hyphae in pileipellis uninflected (up to 10 µm) (Singer 1945c, Smith & Thiers 1971); X. subtomentosus has a larger basidioma (pileus up to 15 cm diam), larger basidiospores measuring 9.8–14.8 × 3.9–6 µm, and it is distributed in temperate region (Hills 2008); X. tenax has a larger basidioma (pileus up to 10 cm diam), a conspicuously reticulate stipe, hyphae in pileipellis uninflected (up to 10 µm), and it is distributed in North America (Smith & Thiers 1971, Halling et al. 2015). Phylogenetically, X. albotomentosus is closely related to X. fraternus (Fig. 6), however, the latter has a stipe with fine longitudinal striations, stipe context turning pale red brown when injured, and narrower hyphae in pileipellis (up to 14 µm) (Wu et al. 2016).


Known distribution: Southwestern China (Yunnan Province) (Wu et al. 2016).

Holotype: KUN-HKAS55328 (China, Yunnan Province).

Notes: Xerocomus fraternus was originally described from Yunnan Province, southwestern China (Wu et al. 2016). Illustrations and a full description of the species have been provided by Wu et al. (2016).


Known distribution: Southwestern China (Yunnan Province) (Wu et al. 2016).

Notes: Xerocomus fulvipes was originally described from Yunnan Province, southwestern China (Wu et al. 2016); illustrations and a full description of the species have been provided by Wu et al. (2016).

Holotype: KUN-HKAS68246 (China, Yunnan Province).

Notes: Xerocomus fulvipes was originally described from Yunnan Province, southwestern China (Wu et al. 2016); illustrations and a full description of the species have been provided by Wu et al. (2016).


Etymology: fuscatus (Lat.), refers to the dark brown pileus.

Diagnosis: Differs from other species of Xerocomus by a small to medium-sized basidioma, a yellowish brown, brown to dark brown pileus, and smooth basidiospores without bacillate surface ornamentation under SEM.


Additional materials examined: China, Hainan Province, Yinggeling of Hainan Tropical Rain Forest National Park, elev. 650 m, 30 Jul. 2017, N.K. Zeng, Zeng3190 (FHMU2151); same location, 13 Aug. 2020, N.K. Zeng, Zeng4664, 4672, 4677 (FHMU4940, 4967, 4925).

Description: Basidiomata small to medium-sized. Pileus 3–6.5 cm diam, convex to planate, margin decurved, usually uplifted when old; surface dry, submentose, yellowish brown (4B4), yellow (4B5) to dark brown (6D6); context 0.2–1.2 cm thick in the centre of the pileus, white (2A1) to yellowish white (2A3), turning bluish when injured. Hymenophore poroid, slightly depressed around apex of stipe; pores angular to subround, 0.5–1 mm diam, yellow (3A6), turning bluish when injured; tubes 0.15–0.3 cm in length, yellowish (2A6), turning bluish when injured. Stipe 2.7–5.5 × 0.25–1 cm, central, subcylindric; surface dry, densely covered with minute, yellowish brown (5C5) to reddish brown (6D7) squamules; context white (2A1) to yellowish white (2A3), turning bluish when injured; annulus absent; basal mycelium white (2A1). Odour indistinct.

Basidia 27–34 × 9–11 µm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 3–6 µm long. Basidiospores [120/6/5] 9–11(–12) × 4–5 µm, Q = (1.8–)2.2–2.8(–3.0), Qm = 2.47 ± 0.21, subfusiform, slightly thick-walled (up to 0.5 µm), yellowish brown in KOH, smooth under both light microscopy and SEM. Hymenophoral trama composed of thin- to slightly thick-walled (up to 0.5 µm) hyphae, 5–15 µm wide, colourless in KOH. Cheilocystidia 16–53 × 5–14 µm, subfusiform or fusiform, thin-walled, colourless in KOH. Pleurocystidia 31–57 × 10–14 µm, subfusiform or fusiform, thin-walled, colourless in KOH. Pileipellis a trichoderm 200–300 µm thick, composed of hyphae thin- to slightly thick-walled (up to 1 µm), light yellow in KOH, 4–18 µm in width; terminal cell 17–52 × 6–16 µm, clavate, subcylindrical or subfusiform, with obtuse apex. Pileal trama made up of hyphae 4–20 µm diam, slightly thick-walled (up to 1 µm), colourless in KOH. Stipitipellis a trichoderm-like structure 60–100 µm thick, composed of thin- to slightly thick-walled (up to 1 µm), 4–9 µm wide, light yellow in KOH, emergent hyphae with subfusiform, subcylindrical or clavate terminal cells (11–32 × 5–9 µm). Stipe trama composed of cylindrical, light yellow in KOH, slightly thick-walled (up to 1 µm), parallel hyphae 3–19 µm wide. Clamp connections absent in all tissues.

Habitat: Solitary to scattered on the ground in forests dominated by fagaceous trees.
Known distribution: Southern China (Hainan Province).

Notes: In China, *X. fuscatus* was misidentified as *X. microcarpoides*, originally described from Malaysia (Corner 1972), however, *X. microcarpoides* has a very small basidioma and larger basidiospores measuring 10–17 × 4.5–5.7 μm (Corner 1972). *Xerocomus fuscatus* is also morphologically similar to *X. illudens*, *X. subtomentosus*, and *X. tenax*. However, *X. illudens* has a pileus tinged with pinkish, a stipe usually marked by coarse ridges and anastomosing lines, longer basidiospores measuring 10–14 × 4–5 μm, hyphae in pileipellis uninflated (up to 10 μm), and it is distributed in North America (Singer 1945c, Smith & Thiers 1971); *X. subtomentosus* has a larger basidioma (pileus up to 15 cm diam), larger basidiospores measuring 9.8–14.8 × 3.9–6 μm, and it is distributed in temperate region (Hills 2008); *X. tenax*, originally described from North America, has a larger basidioma (pileus up...
to 10 cm diam), a conspicuously reticulate stipe, and hyphae in pileipellis uninflated (up to 10 μm) (Smith & Thiers 1971, Halling et al. 2015). Phylogenetically, X. fuscatus is closely related to X. subparvus (Fig. 6), however, the latter has a pale yellowish brown to yellow stipe with fine longitudinal striations, narrower basidiospores (9–10.5 × 3.5–4 μm) with bacillate ornamentation under SEM (Wu et al. 2016).


*Known distribution*: Northwestern (Gansu Province) and southwestern China (Sichuan and Yunnan Provinces) (Zang & Yuan 1999, Wu et al. 2016).

*Holotype*: KUN-HKAS30540 (China, Gansu Province).

*Notes*: *Xerocomus piceicola* was originally described from Gansu Province, northwestern China (Zang & Yuan 1999); illustrations and a full description of the species have been provided by Wu et al. (2016).


*Holotype*: GDGM27443 (China, Guangdong Province).

*Material examined*: China, Guangdong Province, Fengkai County, Heishiding Mountain, 2 Jun. 2013, elev. 800 m, K. Zhao, Zhao258 (KUN-HKAS80683).

*Notes*: *Xerocomus puniceiporus* was originally described from Guangdong Province, southern China (Zhang *et al.* 2012); illustrations and a full description of the species have been provided by Zhang *et al.* (2012) and Wu *et al.* (2016).

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![Fig. 60. Microscopic features of *Xerocomus fuscatus* (holotype FHMU4922).](image)


Description: Basidiomata small, medium to large-sized. Pileus 3.2–7.3 cm diam, convex to aplanate, margin decurved; surface dry, submentose, light greyish brown, greyish brown to light yellowish brown; context 0.6–0.7 cm thick in the centre of the pileus, yellowish white to light yellow, turning bluish slowly or indistinctly when injured. Hymenophore poroid, slightly decurrent around apex of stipe; pores angular, about 0.5 mm diam, yellow, turning blue distinctly when injured; tubes 0.3–0.7 cm in length, light yellow, turning bluish when injured. Stipe 2.8 × 0.5 cm, central, subcylindric; surface dry, yellowish brown to reddish brown; context white, turning bluish when injured; annulus absent; basal mycelium white. Odour indistinct.

Basidia 20–28 × 7–10 μm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 3–6 μm long. Basidiospores [60/3/3] 9–12(−14) × 4–5 μm, Q = (1.8)−2.0–2.8(−2.8). Qm = 2.37 ± 0.22, subfusiform, slightly thick-walled (up to 0.5 μm), yellowish brown in KOH, smooth in light microscopy, with bacillate ornamentation under SEM. Hymenophoral trama composed of thin- to slightly thick-walled (up to 0.5 μm) hyphae, 4–14 μm wide, colourless in KOH. Cheilocystidia 36–77 × 9–20 μm, subfusiform or fusiform, thin-walled, colourless in KOH. Pleurocystidia 65–90 × 10–17 μm, subfusiform or fusiform, thin-walled, colourless in KOH. Pileipellis a trichoderm 240–300 μm thick, composed of hyphal thin- to slightly thick-walled (up to 0.5 μm), colourless in KOH, 7–17 μm in width; terminal cell 28–63 × 9–17 μm, clavate, subcylindrical or subfusiform, with obtuse apex. Pileal trama made up of hyphae 5–16 μm diam, slightly thick-walled (up to 0.5 μm), colourless in KOH. Stipitipellis a trichoderm-like structure 60–100 μm thick, composed of thin- to slightly thick-walled (up to 0.8 μm), 4–14 μm wide, colourless to light yellow in KOH, emergent hyphae with subfusiform, subcylindrical or clavate terminal cells (12–39 × 7–11 μm). Stipe trama composed of cylindrical, colourless to light yellow in KOH, slightly thick-walled (up to 0.9 μm), parallel hyphae 4–18 μm wide. Clamp connections absent in all tissues.

Habitat: Scattered on the ground in mixed forests dominated by fagaceous trees (Quercus spp.) and Pinus yunnanensis.

Known distribution: Southwestern China (Yunnan Province).

Holotype: HMAS03872 (China, Yunnan Province).

Materials examined: China, Yunnan Province, Jianchuan County, Shibaoshan Scenic Spot, elev. 2 504 m, 12 Sep. 2019, H.Y. Huang, Huang490 (FHMU6029); same location, elev. 2 528 m, 14 Sep. 2019, H.Y. Huang, Huang529 (FHMU6011).

Notes: Xerocomus rugosellus was described from Yunnan Province, southwestern China (Chiu 1948). It was placed in the genus Boletus firstly (Chiu 1948), then transferred to Xerocomus (Tai 1979). The amended descriptions of the species were provided by Wu et al. (2016) and us. The species is characterised by a small, medium to large-sized basidioma, a yellow hymenophore, and large basidiospores measuring 12–14.5 × 4–6 μm, with bacillate ornamentation under SEM. We also noted that the young pileal surface was described as “rugose” (Wu et al. 2016) whereas this was not observed in our new collections.


Description: Basidiomata small to medium-sized. Pileus 3.2–6 cm diam, convex to aplanate, margin decurved, sometimes uplifted; surface dry, submentose, yellowish brown, yellowish white, brownish yellow when injured. Clamp connections yellow in KOH, slightly thick-walled (up to 0.9 μm), brownish white, turning bluish when injured. Hymenophore poroid, slightly decurrent around apex of stipe; pores angular, about 0.5 mm diam, yellow, turning blue distinctly when injured; tubes 0.3–0.7 cm in length, light yellow, turning bluish when injured. Stipe 2.8 × 0.5 cm, central, subcylindric; surface dry, yellowish brown to reddish brown; context white, turning bluish when injured; annulus absent; basal mycelium white. Odour indistinct.

Basidia 20–28 × 7–10 μm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 3–6 μm long. Basidiospores [60/3/3] 9–12(−14) × 4–5 μm, Q = (1.8)−2.0–2.8(−2.8). Qm = 2.37 ± 0.22, subfusiform, slightly thick-walled (up to 0.5 μm), yellowish brown in KOH, smooth in light microscopy, with bacillate ornamentation under SEM. Hymenophoral trama composed of thin- to slightly thick-walled (up to 0.5 μm) hyphae, 4–13 μm wide, colourless in KOH. Cheilocystidia 18–62 × 6–17 μm, subfusiform or fusiform, thin-walled, colourless to light yellow in KOH. Pleurocystidia 18–62 × 10–19 μm, subfusiform or fusiform, thin-walled, colourless to light yellow in KOH. Pileipellis a trichoderm 100–160 μm thick, composed of hyphal thin- to slightly thick-walled (up to 1 μm), colourless to light yellow in KOH, 6–16 μm in width; terminal cell 23–105 × 11–21 μm, clavate, subcylindrical or subfusiform, with obtuse apex. Pileal trama made up of hyphae 4–20 μm diam, slightly thick-walled (up to 0.8 μm), colourless in KOH. Stipitipellis a trichoderm-like structure 60–100 μm thick, composed of thin- to slightly thick-walled (up to 1 μm), 3–10 μm wide, light yellow in KOH, emergent hyphae with subfusiform, subcylindrical or clavate terminal cells (17–30 × 3–10 μm). Stipe trama composed of cylindrical, light yellow in KOH, slightly thick-walled (up to 1 μm), parallel hyphae 3–17 μm wide. Clamp connections absent in all tissues.

Habitat: Scattered on the ground in forests dominated by fagaceous trees.

Known distribution: Central (Hunan Province), southeastern (Fujian Province), eastern (Zhejiang Province), and southern China (Hainan Province) (Wu et al. 2016).

Holotype: KUN-HKAS50295 (China, Yunnan Province).

Materials examined: China, Hainan Province, Yinggeling, Hainan Tropical Rain Forest National Park, elev. 850 m, 17 Aug. 2015, N.K. Zeng, Xang818 (FHMU6241); same location, elev. 700 m, 15 Dec. 2015, N.K. Zeng, Xang819 (FHMU6242); same location, elev. 700 m, 7 Aug. 2015, N.K. Zeng, Xang820 (FHMU6243); Hainan Province, Zhanjiang National Nature Reserve, 12 Aug. 2020, Z.H. Chen, IMG4569 (FHMU6120); Zhoushan City, elev. 35 m, Y. Li, Li3109, 3166 (FHMU6901, 6904).

Notes: Xerocomus subparvus was originally described from Yunnan Province, southwestern China (Wu et al. 2016). Besides Yunnan, Fujian, and Guangdong Provinces of China (Wu et al. 2016), it was also reported from tropical China (Hainan Province) and Vietnam (Pham & Morozova 2020, Zeng & Jiang 2020). In the present study, it was found to distributed in Hunan and Zhejiang Provinces of China. The species is characterised by a small, medium-sized basidioma, a yellow hymenophore, a yellow brown
The subfamily *Xerocomoideae* (*Boletaceae, Boletales*) in China

to reddish brown stipe, a context turning bluish when injured, and smaller basidiospores measuring 9–12 × 4–5 μm, with bacillate ornamentation under SEM.


*Known distribution:* Southwestern China (Yunnan Province) (Wu et al. 2016).

*Holotype:* KUN-HKAS68135 (China, Yunnan Province).

*Notes:* *Xerocomus velutinus* was originally described from Yunnan Province, southwestern China (Wu et al. 2016). Illustrations and a full description of the species have been provided by Wu et al. (2016).


*Description:* Basidiomata very small-sized. *Pileus* 1.5–2 cm diam, convex to applanate, margin decurved; surface dry, tomentose, yellowish brown to reddish brown; context about 0.2 cm thick in the centre of the pileus, white, unchanging in colour when injured. *Hymenophore* poroid, slightly decurrent around apex of stipe; pores subround to round, 0.3–0.5 mm diam, yellow, turning bluish when injured; tubes 0.2–0.4 cm in length, yellow, turning bluish when injured. *Stipe* 3.5–4 × 0.4–0.6 cm, central, subcylindric; surface dry, yellowish white to yellow; context light yellow, unchanging in colour when injured; annulus absent; basal mycelium white. *Odour* indistinct.

*Basidia* 27–35 × 11–13 μm, clavate, thin-walled, 4-spored, colourless in KOH; sterigmata 2–5 μm long. *Basidiospores* [40/2/2] 9–12 × 4–5(–5.5) μm, *Q* = 2.0–2.8(–2.9), *Qm* = 2.33 ± 0.20, subfusiform, slightly thick-walled (up to 0.5 μm), yellowish brown in KOH, smooth under light microscopy, with bacillate surface ornamentation under SEM. *Hymenophoral trama* composed of thin- to slightly thick-walled (up to 0.5 μm) hyphae, 4–15 μm wide, colourless in KOH. *Cheilocystidia* 22–65 × 7–18 μm, subfusiform or fusiform, thin-walled, colourless in KOH. *Pleurocystidia* 32–62 ×

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**Fig. 62.** Microscopic features of *Xerocomus subparvus* (FHMU2241). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitipellis. Scale bars = 10 μm. Drawings by H.J. Xie.
10–19 μm, subfusiform or fusiform, thin-walled, colourless in KOH. *Pileipellis* a trichoderm 120–230 μm thick, composed of hyphae thin- to slightly thick-walled (up to 1 μm), yellow to brownish yellow in KOH, 4–12 μm in width; terminal cell 12–31 × 4–12 μm, clavate, subcylinrdrical or subfusciform, with obtuse apex. *Pileal trama* made up of hyphae 3–16 μm diam, slightly thick-walled (up to 0.8 μm), colourless in KOH. *Stipitipellis* a trichoderm-like structure 80–100 μm thick, composed of thin- to slightly thick-walled (up to 1 μm), 3–9 μm wide, light yellow in KOH, emergent hyphae with subfusciform, subcylinrdical or clavate terminal cells (12–24 × 4–9 μm). *Stipe trama* composed of cylindrical, light yellow in KOH, slightly thick-walled (up to 1 μm), parallel hyphae 3–15 μm wide. *Clamp connections* absent in all tissues.

**Habitat:** Solitary on the ground in forests dominated by fagaceous trees.

**Key to accepted species of Xerocomus in China**

1. Hymenophoral surface vivid red, red to dark red, brownish red; tubes yellow .................................................. X. puniceiporus
2. Both hymenophoral surface and tubes yellow ............................................................... ............................. 2
3. Basidiospores comparatively large measuring 9–11 × 4–5 μm, distribution in subtropical or tropical forests dominated by fagaceous trees .......................................................... X. fusatus
4. Basidiospores comparatively large (up to 14.5 μm in length) .................................................. X. piceicola
5. Basidiospores comparatively small (pileus > 5 cm diam) .......................................................... X. rugosellus
6. Basidiospores comparatively small (pileus ≤ 5 cm diam) .......................................................... X. velutinus
7. Stipe surface yellowish white to yellow .......................................................... X. yunnanensis
8. Context unchanging in colour when injured .......................................................... X. albotomentosus
9. Stipe surface pale yellowish brown to pale brown, and an absence of reddish .................................................. X. fraternus
10. Stipe surface reddish brown .......................................................... X. fulvipes

**DISCUSSION**

High species diversity of the subfamily *Xerocomoideae* in China was revealed in this study, and 103 species-level lineages (37 of *Aureoboletus*, 15 of *Boletellus*, seven of *Hemileccinum*, 31 of *Phylloporus*, one of *Pulchrboletus*, and 12 of *Xerocomus*) of the subfamily were identified (Figs 1–6). Based on morphological studies of new collections and re-examinations holotypes of some species, combined with previous studies, 13 new species (three of *Aureoboletus*, five of *Boletellus*, one of *Hemileccinum*, one of *Phylloporus*, one of *Pulchrboletus*, and two of *Xerocomus*) of *Xerocomoideae* were described, and 84 previous species (26 of *Aureoboletus*, 12 of *Boletellus*, four of *Heimioporus*, six of *Hemileccinum*, four of *Hourangia*, 24 of *Phylloporus*, and eight of *Xerocomus*) were confirmed to be distributed in China (Table 2). Among the 97 accepted species of *Xerocomoideae*, only two species, viz. *A. quercus-spinosa* and *X. piceicola* grow in temperate areas (Wu et al. 2016, Zhang et al. 2017), one species, viz. *A. zangii* occurs in temperate and subtropical regions (Shi & Liu 2013, Wu et al. 2016); the other 94 species are distributed in tropical and subtropical regions. The geographical distribution pattern indicated that the subtropical-tropical region of China is the current species diversity centre of *Xerocomoideae*.

*Aureoboletus mirabilis*, originally described from North America (Murrill 1912), was also reported to be distributed in China (Wu et al. 2016). However, our molecular data indicated that one Chinese collection identified as *A. mirabilis* is genetically distinct from North...
American *A. mirabilis* (Fig. 1). The occurrence of *A. mirabilis* in China should be further defined in the future.

Our molecular data indicated that the collections named “Bol. emodensis” were present in four parts of the tree (Fig. 2). According to our careful examinations, lineage 1 including collections from northeastern India, China, and Japan corresponds to true *Bol. emodensis*, and that *Bol. aurocontextus* is probably a synonym of *Bol. emodensis*. Other collections identified as “Bol. emodensis” from Australia, Thailand, and Japan, respectively (Fig. 2), should be further studied. Besides several species of *Boletellus* defined based on morphological and molecular phylogenetic evidence (see above), there are many other species originally described from China, viz. *Bol. fanjingensis*, *Bol. fujianensis*, *Bol. radiates*, *Bol. serpentipileus*, *Bol. taiwanensis*, *Bol. violaceus*, and *Bol. yunnanensis* (Table 2), which have no molecular data from the type specimens. To re-evaluate these taxa, more collections from a wide area (including the type locality), and more DNA sequence data should be obtained before elucidating their true taxonomic relationship to other *Boletellus* species. *Boletellus elatus*, a species reported to be distributed in China (Li & Song 2003), still needs further information to assess the phylogenetic position for the species may probably represent a new genus according to one previous molecular phylogenetic analysis (Halling *et al.* 2015).

Besides several species of *Xerocomus* defined based on morphological and molecular phylogenetic evidence (see above), there are several other species originally described from China, viz. *Xerocomus yunnanensis* (FHMU3059). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitipellis. Scale bars = 10 μm. Drawings by H.J. Xie.

**Fig. 63.** Microscopic features of *Xerocomus yunnanensis* (FHMU3059). A. Basidia. B. Basidiospores. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitipellis. Scale bars = 10 μm. Drawings by H.J. Xie.
Table 2. List of described, reported and controversial Xerocomoideae species in China.

<table>
<thead>
<tr>
<th>Species</th>
<th>Type locality</th>
<th>Treatment</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aureoboletus albipes</em></td>
<td>Fujian, SE China</td>
<td>Accepted</td>
<td>This study</td>
</tr>
<tr>
<td><em>A. betula</em></td>
<td>North America</td>
<td>Confirmed as absent from China</td>
<td>Schweinitz (1822), Li &amp; Song (2003)</td>
</tr>
<tr>
<td><em>A. catarinus</em></td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Wu et al. (2016)</td>
</tr>
<tr>
<td><em>A. clavatus</em></td>
<td>Hainan, southern China</td>
<td>Accepted</td>
<td>Zeng et al. (2015)</td>
</tr>
<tr>
<td><em>A. conicus</em></td>
<td>Hainan, southern China</td>
<td>Accepted</td>
<td>This study</td>
</tr>
<tr>
<td><em>A. duplicatoreus</em></td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Zang (1992)</td>
</tr>
<tr>
<td><em>A. erythraeus</em></td>
<td>Hainan, southern China</td>
<td>Accepted</td>
<td>Wang et al. (2020)</td>
</tr>
<tr>
<td><em>A. formosus</em></td>
<td>Hunan, central China</td>
<td>Accepted</td>
<td>Zhang et al. (2015a)</td>
</tr>
<tr>
<td><em>A. glutinosus</em></td>
<td>Hunan, central China</td>
<td>Accepted</td>
<td>Zhang et al. (2019a)</td>
</tr>
<tr>
<td><em>A. griseorufescens</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Zhang et al. (2019a)</td>
</tr>
<tr>
<td><em>A. guangdongensis</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Zhang et al. (2022)</td>
</tr>
<tr>
<td><em>A. longicollis</em></td>
<td>Malaysia</td>
<td>Accepted</td>
<td>Cesati (1879), Zhang et al. (2019a)</td>
</tr>
<tr>
<td><em>A. marroninus</em></td>
<td>Guangdong, southern China</td>
<td>A synonym of <em>A. tenuis</em></td>
<td>Zhang et al. (2015)</td>
</tr>
<tr>
<td><em>A. microcarpus</em></td>
<td>Hainan, southern China</td>
<td>Accepted</td>
<td>Zhang et al. (2022)</td>
</tr>
<tr>
<td><em>A. miniatoaurantiacus</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Bi et al. (1982)</td>
</tr>
<tr>
<td><em>A. mirabilis</em></td>
<td>North America</td>
<td>Confirmed as absent from China</td>
<td>Murrill (1912), Wu et al. (2014)</td>
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<td><em>A. nephrosporus</em></td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Wu et al. (2016)</td>
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<tr>
<td><em>A. ornatipes</em></td>
<td>Hainan, southern China</td>
<td>Accepted</td>
<td>This study</td>
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<tr>
<td><em>A. quercus-spinosae</em></td>
<td>Tibet, SW China</td>
<td>Accepted</td>
<td>Zhang et al. (2017)</td>
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<td><em>A. raphanaceus</em></td>
<td>Jiangxi, eastern China</td>
<td>Accepted</td>
<td>Zhang et al. (2019a)</td>
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<td><em>A. reticuloceps</em></td>
<td>Sichuan, SW China</td>
<td>Transferred to <em>Boletus</em></td>
<td>Zang et al. (1993), Wang et al. (2005)</td>
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<td><em>A. rubellus</em></td>
<td>Jiangxi, eastern China</td>
<td>Accepted</td>
<td>Fang et al. (2019)</td>
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<td><em>A. rugosus</em></td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Zhang et al. (2022)</td>
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<tr>
<td><em>A. russellii</em></td>
<td>North America</td>
<td>Confirmed as absent from China</td>
<td>Frost (1874), Li &amp; Song (2003)</td>
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<tr>
<td><em>A. shichianus</em></td>
<td>Zhejiang, eastern China</td>
<td>Accepted</td>
<td>Teng (1932), Wu et al. (2016)</td>
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<td><em>A. sinobadius</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Zhang et al. (2019a)</td>
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<tr>
<td><em>A. solus</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Zhang et al. (2019a)</td>
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<td><em>A. tenuis</em></td>
<td>Guangxi, southern China</td>
<td>Accepted</td>
<td>Zhang et al. (2014)</td>
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<td><em>A. thibetanus</em></td>
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<td>Patouillard (1895), Yang et al. (2003)</td>
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<tr>
<td><em>A. tomentosus</em></td>
<td>Guangdong, southern China</td>
<td>A synonym of <em>A. miniatoaurantiacus</em></td>
<td>Wu et al. (2016)</td>
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<tr>
<td><em>A. velutipes</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Zhang et al. (2019a)</td>
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<td><em>A. venustus</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Li et al. (2016)</td>
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<tr>
<td><em>A. viscidipes</em></td>
<td>Japan</td>
<td>Accepted</td>
<td>Hongo (1974), Wu et al. (2016)</td>
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<tr>
<td><em>A. viscosus</em></td>
<td>Guangdong, southern China</td>
<td>Probably a synonym of <em>A. longicollis</em></td>
<td>Bi et al. (1982)</td>
</tr>
<tr>
<td><em>A. yunnanensis</em></td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Wu et al. (2016)</td>
</tr>
<tr>
<td><em>A. zangii</em></td>
<td>Shaanxi, NW China</td>
<td>Accepted</td>
<td>Shi &amp; Liu (2013)</td>
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<tr>
<td><em>Boletellus aff. putuoensis</em></td>
<td>Hainan, southern China</td>
<td>Accepted</td>
<td>This study</td>
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<tr>
<td><em>Bol. ananas</em></td>
<td>North America</td>
<td>Confirmed as absent from China</td>
<td>Curtis (1848), Li &amp; Song (2003)</td>
</tr>
<tr>
<td><em>Bol. ananiceps</em></td>
<td>Australia</td>
<td>Confirmed as absent from China</td>
<td>Berkeley (1873), Li &amp; Song (2003)</td>
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<tr>
<td><em>Bol. areolatus</em></td>
<td>Japan</td>
<td>Accepted</td>
<td>Sato &amp; Hattori (2015)</td>
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<td><em>Bol. aurocontextus</em></td>
<td>Japan</td>
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<td>Sato &amp; Hattori (2015)</td>
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<td><em>Bol. badovinicus</em></td>
<td>Papua New Guinea</td>
<td>Confirmed as absent from China</td>
<td>Horak (1977), Wen (1985)</td>
</tr>
<tr>
<td><em>Bol. brunoflavus</em></td>
<td>Guangdong, southern China</td>
<td>Accepted</td>
<td>Lin et al. (2022)</td>
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<tr>
<td><em>Bol. betula</em></td>
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<td>X. subpaludosus</td>
<td>Yunnan, SW China</td>
<td>Transferred to <em>Hortiboletus</em></td>
<td>Chiu (1948), Wu et al. (2016)</td>
</tr>
<tr>
<td>X. subparvus</td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Wu et al. (2016)</td>
</tr>
<tr>
<td>X. subtomentosus</td>
<td>Europe</td>
<td>Confirmed as absent from China</td>
<td>Linnaeus (1753), Li &amp; Song (2003)</td>
</tr>
<tr>
<td>X. sylvestris</td>
<td>Sri Lanka</td>
<td>Confirmed as absent from China</td>
<td>Petch (1922), Li &amp; Song (2003)</td>
</tr>
<tr>
<td>X. tengii</td>
<td>Fujian, SE China</td>
<td>Re-evaluated</td>
<td>Zang et al. (2002)</td>
</tr>
<tr>
<td>X. velutinus</td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Wu et al. (2016)</td>
</tr>
<tr>
<td>X. versicolor</td>
<td>Europe</td>
<td>A synonym of <em>Hortiboletus rubellus</em></td>
<td>Rostkovius (1844), Li &amp; Song (2003)</td>
</tr>
<tr>
<td>X. yunnanensis</td>
<td>Yunnan, SW China</td>
<td>Accepted</td>
<td>Chiu (1948)</td>
</tr>
</tbody>
</table>

Note: NW = northwestern, SE = southeastern, SW = southwestern.
X. anthracinus, X. atraecolopsis, X. bambusicola, X. davidicola, X. heterocystides, X. magniporus, X. minicystidius, X. parvus, X. piceicola, X. pseudostrobilomyces, X. subdaedaleus, and X. tennii (Table 2), which have no molecular data from type specimens. In order to re-evaluate these taxa, more collections from a wide area (including the type locality), and more DNA sequence data should be obtained before elucidating their true taxonomic relationships to other Xerocomus species.

Biogeographic connections between China and North America/Europe have been discussed in boletes (Mueller et al. 2001, Li et al. 2009, 2014, Feng et al. 2012, Zeng et al. 2013, 2016). So far, no disjunct populations of the same putative species of Xerocomioideae have been found between China and North America/Europe. The similarities in Xerocomioideae species between subtropical-tropical China and Southeast Asia/South Asia suggest a close biogeographic connection between these regions, as they share some common taxa, i.e., A. longicollis, Bol. emodensis, H. indecorum, P. bellus, P. bogoriensis, P. castanospidis, P. parvisporus, P. pulissus, P. rubiginosus, P. rufescens, and P. subrubreolus. Similar affinities have been observed for other fungi as well (Zeng & Jiang 2020). In addition, we also noted that China and Japan share several common species, such as A. viscidipes, Bol. areolatus, and Hei. japonicus.

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DECLARATION ON CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Supplementary Material: https://studiesinmycology.org/

Table S1. Taxa, vouchers, locations, and GenBank accession numbers of published/unpublished (except for newly generated) sequences used in this study.