Global diversity and phylogeny of *Fuscoporia* (Hymenochaetales, Basidiomycota)

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Abstract

The genus *Fuscoporia* is characterized by annual to perennial, resupinate to pileate basidiocarps, a dimitic hyphal system with generative hyphae bearing crystals, presence of hymenial setae in most species, and hyaline, thin-walled, smooth basidiospores. To explore the phylogenetic positions of *Fuscoporia* species, we performed a comprehensive study by using molecular data based on global specimens: a total of 105 specimens including 41 species of *Fuscoporia* were analyzed, ITS (95 with 46 new), nLSU (94 with 49 new), RPB2 (49 with 34 new) and TEF1 (73 with 52 new) sequences were used to reconstruct *Fuscoporia* phylogeny. According to our phylogenetic analyses inferred from the nLSU and ITS+nLSU+RPB2+TEF1 datasets, *Fuscoporia* comprises six distinct groups (*F. contigua* group, *F. fereea* group, *F. ferruginosa* group, *F. gilva* group, *F. torulosa* group and *F. viicola* group) and three ungrouped species (*F. acutimarginata*, *F. discipes* and *F. insolita*). Nine new species, *Fuscoporia australasica*, *F. australiana*, *F. bambusae*, *F. chinensis*, *F. eucalypti*, *F. karsteniana*, *F. plumertiae*, *F. shoreae* and *F. subchrysea*, are described. Two new combinations, *Fuscoporia bambusicola* and *F. roseocinerea*, are proposed. A key to 49 accepted species of *Fuscoporia* in worldwide is provided.

Key words – Nine new species – Hymenochaetales – Phylogeny – Taxonomy – Wood-rotting fungi

Introduction

*Fuscoporia* Murrill was introduced by Murrill (1907) with *F. ferruginosa* (Schrad.) Murrill selected as type species. The genus has been considered as a synonym of *Phellinus* Quël. *sensu lato* by many scientists for a long time (Overholt 1953, Lowe 1966, Ryvarden & Johansen 1980, Cunningham 1948, Larsen & Cobb-Poule 1990, Ryvarden & Gilbertson 1994). *Phellinus* is the largest genus in the family of Hymenochaetales and has a worldwide distribution in the world (Larsen & Cobb-Poule 1990). Many important forest pathogens, but also valuable medicinal fungi are currently included in *Phellinus sensu lato* (Dai et al. 2007, 2010, Wu et al. 2019). Fiasson & Niemelä (1984) defined *Fuscoporia* as a monophyletic genus which differs from *Phellinus sensu...
stricto by thin-walled basidiospores and encrusted generative hyphae at dissepiments. The genus was re-confirmed as an independent genus (Wagner & Fischer 2001, 2002), and this conclusion has been widely accepted by Niemelä et al. (2001), Groposo et al. (2007), Baltazar et al. (2009), Dai (2010), Baltazar & Gibertoni (2010), Raymundo et al. (2013a, b), Spirin et al. (2014), Pires et al. (2015), Chen & Yuan (2017), Chen et al. (2019) and Chen & Dai (2019). Fuscoporia is characterized by annual to perennial and resupinate to pileate basidiocarps, a dimitic hyphal system with encrusted generative hyphae at dissepiments and in trama, presence of hymenial setae, presence or absence of mycelial setae, and hyaline, thin-walled, smooth basidiospores (Fiasson & Niemelä 1984, Dai 2000, 2010). To date, thirty-eight species are accepted in the genus (Index Fungorum 2020, MycoBank 2020).

Recent studies demonstrated that some traditional species of Fuscoporia are species complexes. For example, Fuscoporia contigua (Pers.) G. Cunn. was defined as a species with variable shape of basidiospores (oblong ellipsoid or cylindric), but some Asian specimens were confirmed as different species based on morphological examinations and phylogenetic analyses. So, F. sinica Y.C. Dai, Q. Chen & J. Vlasák and F. monticola Y.C. Dai, Q. Chen & J. Vlasák were segregated from F. contigua (Chen et al. 2019). Similarly, F. ferrea (Pers.) G. Cunn. was considered as a single species occurring in temperate forests of North Hemisphere, but F. ramulicola Y.C. Dai & Q. Chen, F. subferrea Q. Chen & Y. Yuan and F. yunnanensis Y.C. Dai were derived from F. ferrea (Dai 2010, Chen & Yuan 2017). It is therefore likely that the diversity of Fuscoporia is underestimated.

In this study, we aimed to investigate the diversity and taxonomy of Fuscoporia based on samples from Asia, Europe, Oceania, and America. Nine new species are described and two new combinations are proposed. A phylogeny based on the combined ITS, nLSU, RPB2 and TEF1 DNA sequence data was analysed with a total of 105 specimens including 41 species of Fuscoporia. Six distinctive groups within the Fuscoporia are recovered, viz. F. contigua group, F. ferrea group, F. ferruginosa group, F. gilva group, F. torulosa group, and F. viticola group. A key to all 49 accepted species of Fuscoporia is provided.

Materials & Methods

Morphological studies

The studied specimens are deposited in the herbarium of the Institute of Microbiology, Beijing Forestry University (BJFC), Royal Botanic Gardens Victoria (MEL), and the private herbarium of Josef Vlasák (JV) which will be sent to National Museum Prague (PRM). Morphological descriptions are based on field notes and herbarium specimens. Microscopic analyses follow Song & Cui (2017). In the description: KOH = 5% potassium hydroxide, CB− = acyanophilous in Cotton Blue, IKI− = neither amyloid nor dextrinoid in Melzer’s reagent, the microscopical measurements and drawings were made from slide preparations stained with Cotton Blue, L = arithmetic average of all spore length, W = arithmetic average of all spore width, Q = L/W ratios, n = number of spores/measured from given number of specimens. Special color terms are cited from Anonymous (1969) and Petersen (1996).

DNA extraction, PCR and sequencing

Total genomic DNA was extracted from dried specimens by CTAB rapid plant genome extraction kit (Aidlab Biotechnologies Company, Limited, Beijing, China) according to the manufacturer’s instructions with some modifications (Chen et al. 2016). To generate PCR amplicons, the following primer pairs were used: ITS4 and ITS5 (White et al. 1990) for the internal transcribed spacer (ITS), and 983F and 1567R (Rehner & Buckley 2005) for a region of the translation elongation factor (TEF1), LR0R and LR7 (Vilgalys & Hester 1990) for the 28S gene region (nLSU) and bRPB2-6F and bRPB2-7.1R (Matheny 2005) for partial RNA polymerase II, second largest submit (RPB2). The PCR procedures followed Song & Cui (2017) and Zhu et al. (2019). PCR products were purified and sequenced at the Beijing Genomics Institute with the same
primers and the sequences were deposited in GenBank and listed in Table 1.

**Phylogenetic analyses**

In this study, 181 new sequences, viz. 46 ITS, 49 nLSU, 34 RPB2 and 52 TEF1, were generated (Table 1). To explore the phylogenetic position of *Fuscoporia* in Hymenochaetaeaceae, 90 sequences (not shown in Table 1 except for *Fuscoporia*) of representatives of 27 genera of Hymenochaetaeaceae were included in nLSU dataset (Fig. 1). The genus *Fuscoporia* was represented by 38 species and other genera were represented by a few known species (mainly the generic type). *Oxyporus populinus* (Schumach.) Donk and *Hyphodontia pallidula* (Bres.) J. Erikss. were used as outgroup taxa based on previous studies (Larsson et al. 2006, Zmitrovich & Malysheva 2014, Zhou et al. 2016, Chen et al. 2019).

To explore the phylogenetic relationships to species-level of *Fuscoporia*, 133 sequences in 30 species (shown in Table 1) in the ITS+nLSU+RPB2+TEF1 datasets (Fig. 2) were downloaded from GenBank based on Chen & Dai (2019) and Chen et al. (2019) and analysed. *Coniferiporia weirii* (Murrill) L.W. Zhou & Y.C. Dai and *Phellinidium fragrans* (M.J. Larsen & Lombard) Nuss were selected as outgroup for the ITS+nLSU+RPB2+TEF1 analysis, because they were shown to be sister groups of *Fuscoporia* based on the nLSU phylogenetic analysis (Fig. 1) and as outgroup in previous studies (Zhou et al. 2016, Chen et al. 2019). Sequences were aligned with BioEdit (Hall 1999) and the alignments generated in ClustalX were used to construct phylogenetic analyses (Thompson et al. 1997). GTR+I+G was the selected substitution model for each partition of the two alignments.

Maximum parsimony (MP) analysis was used for the nLSU and the ITS+nLSU+RPB2+TEF1 datasets in PAUP* 4.0b10 (Swofford 2002). All characters were equally weighted and gaps treated as missing data. Trees were inferred using the heuristic search option with tree bisection reconnection (TBR) branch swapping and 1000 random sequence additions. The maxtrees parameter was set to 5000, branches of zero length were collapsed, and all parsimonious trees were saved. Clade robustness was assessed by a bootstrap analysis with 1000 replicates (Felsenstein 1985). Descriptive tree statistics such as tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated (Swofford 2002).

Maximum likelihood (ML) methods were also used for both datasets. Substitution models suitable for each partition, including ITS and nLSU, and introns and codons of the RPB2 and TEF1 gene, were determined using the Akaike information criterion implemented in MrModeltest 2.3 (Posada & Crandall 1998, Nylander 2004). RaxmlGUI 1.2 (Stamatakis 2006, Silvestro & Michalak 2012) was used for ML analysis. All parameters in the ML analysis used default settings. Statistical support values were obtained using nonparametric bootstraping with 1000 replicates. MP and ML methods were adopted to perform phylogenetic analysis of the two aligned datasets. The two phylogenetic methods produced a similar topology for each dataset, so, only the topology of the MP tree is presented along with statistical values of the MP/ML algorithm (simultaneous MP and ML not less than 50%) at the nodes. DNA alignments have been deposited at TreeBase (25546).

The nLSU dataset comprised 92 sequences and an alignment of 1435 positions, of which 1026 were constant, 93 parsimony-uninformative, and 316 parsimony-informative. Maximum Parsimony yielded four equally most parsimonious trees (TL = 1878, CI = 0.325, RI = 0.717, RC = 0.233, HI = 0.675). The four-gene dataset included sequences from 105 specimens representing 41 species of *Fuscoporia* and two species of related genera. This alignment contained 3686 sites: 900 positions from ITS, 1400 from nLSU, 821 from RPB2 and 566 from TEF1. In this alignment 2215 characters were constant, 180 variables but parsimony-uninformative, and 1291 parsimony-informative. MP analysis yielded four similar topologies (TL = 6400, CI = 0.434, RI = 0.837, RC = 0.363, HI = 0.566). Maximum Likelihood analysis resulted in a similar consensus tree as the MP analysis in two phylogenetic analyses, so MP trees are shown here (Figs 1–2) and all the other topologies are provided as supplemental materials.
Results

*Fuscoporia* is strongly supported (96/99) within the Hymenochaetaceae family by phylogenetic analysis inferred from the nLSU rDNA-based phylogeny (Fig. 1). The combined ITS, nLSU, RPB2, and TEF1 sequences (Fig. 2) including 41 species of *Fuscoporia* shows that nine new species formed nine independent lineages indicating that they are phylogenetically distinct from the species currently known in the genus. Two species, *Fuscoporia bambusicola* and *F. roseocinerea*, previously treated in *Phellinus* are nested in *Fuscoporia*. Six distinctive groups (highlighted in Fig. 2) are defined within *Fuscoporia*, viz. *F. contigua* group, *F. ferrea* group, *F. ferruginosa* group, *F. gilva* group, *F. torulos* group, and *F. viticola* group. Three species, *Fuscoporia acutimarginata*, *F. discipes* and *F. insolita*, are nested in three subclades (Fig. 2) without enough support, and they do not belong to any distinct group.

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* Newly generated sequences for this study. New species and new combinations are in bold.

**Taxonomy**

*Fuscoporia australasica* Q. Chen, F. Wu & Y.C. Dai, sp. nov.

- MycoBank number: MB 833958; Facesoffungi number: FoF 07995.
- Etymology – *Australasica* (Lat.): referring to the species found in Southern Asia.
- Holotype – China, Yunnan Province, Jingdong County, Ailaoshan Nature Reserve, on dead angiosperm tree, 24 Aug 2015, Y.C. Dai 15636 (BJFC 019740).
- Basidiocarps – Perennial, pileate, solitary to imbricate, without odor or taste when fresh, hard corky when dry. Pilei mostly dimidiate, rarely circular, projecting up to 6 cm long, 8 cm wide and 1.8 cm thick at the base. Pilear surface reddish brown, concentrically sulcate with zones, velutinate to glabrous; margin obtuse to slightly acute, yellowish brown, up to 5 mm wide. Pore surface honey-yellow to olivaceous buff, glancing, margin narrow, yellowish, up to 2 mm wide; pores circular, 6–8 per mm; dissepiments thin, entire, abundant hymenial setae in tube cavities (under anatomical lens). Context clay-buff, hard corky, about 1 mm thick. Tubes concolorous with pores, hard corky, up to 1.7 cm long.
- Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.
Figure 1 – Phylogenetic position of *Fusarium* within the Hymenochaetaceae inferred from the nLSU rDNA dataset. The topology is from one of the four MP trees. Statistical values (MP/ML) are indicated for each node that received bootstrap support from ML and MP ≥50%. Names of new species are in bold.
Figure 2 – Phylogeny of Fuscoporia species inferred from ITS+28S+RPB2+TEF1 dataset. The topology is one of the four MP trees. Statistical values (MP/ML) are indicated for each node that received bootstrap support from ML and MP ≥50%. Names of new species are in bold.
Context – Generative hyphae rare, hyaline, thin- to slightly thick-walled, unbranched, frequently simple septate, 2–2.5 μm in diam.; skeletal hyphae dominant, rust-brown, thick-walled with a medium to wide lumen, unbranched, occasionally septate, straight, regularly arranged, 3–3.5 μm in diam.

Tubes – Generative hyphae rare, mostly present at dissepiment edges and subhymenium, hyaline, thin-walled, frequently branched and simple septate, 1.5–2.5 μm in diam., some of them encrusted at dissepiment edges and in the hymenium; skeletal hyphae dominant, yellowish brown, thick-walled with a medium to wide lumen, frequently septate, more or less straight, subparallel along the tubes, 2.5–3.5 μm in diam. Hymenial setae subulate, occasionally hooked, mostly originating from trama hyphal, dark brown, thick-walled, 30–45 × 6–9 μm; fusoid cystidioles hyaline and thin-walled, 9.5–12 × 4–5.5 μm; basidia short clavate to barrel-shaped, with four sterigmata and a simple septum at the base, 9–11 × 5–6.5 μm; basidioles dominating the hymenium, in shape similar to basidia, but slightly smaller.

Spores – Basidiospores broadly ellipsoid to subglobose, hyaline, thin-walled, smooth, IKI–, CB–, some of them bearing a guttule, (3.8–)4–5 × (3.2–)3.3–4(–4.5) μm, L = 4.40 μm, W = 3.88 μm, Q = 1.12–1.15 (n = 90/3).


Note – Fuscoporia australasica grows on angiosperm wood in tropical Asia and is characterized by pileate basidiocarps, small pores (6–8 per mm), occasionally hooked hymenial setae and broadly ellipsoid to subglobose basidiospores, 4–5 × 3.2–4 μm. In our phylogeny, three specimens of Fuscoporia australasica form a lineage with strong support (100/100, Fig. 2). Fuscoporia australasica is closely related to F. eucalypti sp. nov. and F. wahlbergii (Fr.) T. Wagner & M. Fisch. (Figs 1–2). Morphologically, these species share the hooked hymenial setae and broadly ellipsoid to subglobose basidiospores; but basidiospores are wider in F. eucalypti than in F. australasica (4–4.5 μm vs. 3.3–4 μm) and F. wahlbergii has globose spores (3.5–4 μm, Reid 1975).

**Fuscoporia australiana** Q. Chen, F. Wu & Y.C. Dai, sp. nov. Figs 3c, 5

MycoBank number: MB 833960; Facesoffungi number: FoF 07996.

Etymology – Australiana (Lat.): referring to the species found in Australia.

Holotype – Australia, Sydney, Sydney Botanical Garden, on stump of Combretum, 20 May 2018, Y.C. Dai 18879 (BJFC 027347), isotype in MEL.

Basidiocarps – Usually annual, occasionally biennial, pileate, solitary to imbricate, sometimes effused-reflexed, without odor or taste and corky when fresh, becoming hard corky and light-weight when dry. Pilei mostly dimidiate to conchate, sometimes laterally fused, projecting up to 5 cm long, 10 cm wide and 1.5 cm thick at the base. Pilear surface olivaceous buff to clay-buff, indistinctly concentrically sulcate with zones, hispid to rugose; margin obtuse, honey-yellow. Pore surface grayish brown to olivaceous buff, slightly glancing; margin narrow, honey-yellow, paler than pore surface, up to 1 mm wide; pores more or less round, 7–9 per mm; dissepiments thin, entire to slightly lacerate, sometimes sinuous or irregular, abundant setae seen in tube cavities (under anatomical lens). Context honey-yellow to curry-yellow, hard corky, zonate, up to 0.5 cm thick. Tubes olivaceous buff, paler than pore surface, hard corky up to 1 cm long.

Context – Generative hyphae rare, hyaline, thin-walled, occasionally branched, frequently simple septate, 2–3 μm in diam.; skeletal hyphae dominant, yellowish brown, thick-walled with a wide lumen, unbranched, aseptate, straight, regularly arranged, 3.5–5 μm in diam.
Tubes – Generative hyphae rare, mostly present at dissepiment edges and subhymenium, hyaline, thin-walled, frequently branched and septate, 1.5–2.5 μm in diam., some of them encrusted at dissepiment edges and in the hymenium; skeletal hyphae dominant, yellowish brown, thick-walled with a wide lumen, unbranched, aseptate, straight, subparallel along the tubes, 2.5–3.5 μm in diam. Setae frequent, mostly originating from tramal hyphae, ventricose to subulate, dark brown, thick-walled, 20–35 × 5–7 μm; fusoid cystidioles hyaline, thin-walled, sometimes bearing crystals, 15–22 × 3–4 μm; basidia short clavate to barrel-shaped, with four sterigmata and a simple septum at the base, 12–16 × 4–6 μm; basidioles dominating in hymenium, in shape similar to basidia, but slightly smaller.

Figure 3 – Basidiocarps of *Fuscoporia* species. a–b *Fuscoporia australasica* (paratype, Dai 15625). c *Fuscoporia australiana* (holotype, Dai 18879). d *Fuscoporia bambusae* (holotype, Dai 16599). e–f *Fuscoporia chinensis* (e paratype, Dai 17282, f paratype, Dai 17583). g *Fuscoporia eucalypti* (paratype, Dai 18642A). h *Fuscoporia karsteniana* (paratype, Dai 17925). Scale Bars = 10 mm.
Figure 4 – Microscopic structures of *Fuscoporia australasica* (holotype, Dai 15636). a Basidiospores. b Basidia and basidioles. c Cystidioles. d Hymenial setae. e Generative hyphae at dissepiment edge. f Hyphae from trama. g Hyphae from context.

Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

Spores – Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI−, CB−, usually bearing a small guttule, (3.8−)4−4.8−(5) × (2−)2.5−3−(3.5) μm, L = 4.28 μm, W = 2.73 μm, Q = 1.56−1.64 (n = 60/2).

Other materials examined (paratypes) – Australia, Melbourne, Dandenong Ranges Botanical
Garden, on fallen trunk of *Eucalyptus*, 12 May 2018, Y.C. Dai 18672 (BJFC 027141); Royal Botanic Gardens, on angiosperm stump, 8 May 2018, Y.C. Dai 18587A (BJFC 027056).

Note – *Fuscoporia australiana* was discovered in Australia, and the species is characterized by the annual to biennial, pileate basidiocarps with indistinctly concentrically sulcate, hispid to rugose pileal surface, small pores (7–9 per mm), ellipsoid basidiospores measuring 4–4.8 × 2.5–3 μm. *F. atlantica* Motato–Vásq., R.M. Pires & Gugliotta, *F. chinensis* sp. nov., *F. formosana* (T.T. Chang & W.N. Chou) T. Wagner & M. Fisch., *F. gilva* and *F. plumeriae* sp. nov. clustered together with *F. australiana* into a group with strong support (100/100, Figs 1–2). All these species share similar morphological characteristics as effused-reflexed to pileate basidiocarps with lacerate dissepiments and ellipsoid basidiospores. However, they formed six independent lineages in our phylogeny (Fig. 2). Morphologically, *F. atlantica* distinguishes itself from *F. australiana* by dark brown crust on pilear surface, hooked hymenial setae and wider basidiospores (3–3.5 μm vs. 2.5–3 μm, Pires et al. 2015). Both, *F. australiana* and *F. plumeriae* occur in Australia, but *F. plumeriae* has smaller basidiospores measuring 3–3.8 × 2.2–2.8 μm. *F. chinensis* differs from *F. australiana* by its septate hymenial setae and smaller basidiospores (3–4 × 2–2.5 μm vs. 4–4.8 × 2.5–3 μm). *F. gilva* is different from *F. australiana* by the presence of lacerate to dentate dissepiments, septate skeletal hyphae and shorter basidiospores (3.3–4.2 μm vs. 4–4.8 μm, Dai 2010). *F. formosana* is distinguished from *F. australiana* by larger pores (3–5 per mm) and smaller basidiospores measuring 3.5–4 × 1.5–2.5 μm (Chang & Chou 1998, Ryvarden 2005). Both *F. australiana* and *F. eucalipti* sp. nov. are from Australia and can grow on *Eucalyptus*, but the latter differs from the former by hooked setae and suggblobose basidiospores which are distinctly wider (4–4.5 μm in *F. eucalipti* vs. 2.5–3 μm in *F. australiana*). In addition, they are not phylogenetically related (Fig. 2).

*Fuscoporia bambusae* Q. Chen, F. Wu & Y.C. Dai, sp. nov.  
Figs 3d, 6

MycoBank number: MB 833963; Facesoffungi number: FoF 07997.

Etymology – *Bambusae* (Lat.): referring to the species growing on Bambusaceae.

Holotype – Thailand, Rai Empress, Dowager University Campus, on rotten bamboo, 21 Jul 2016, Y.C. Dai 16599 (BJFC 022710).

Basidiocarps – Annual, resupinate, inseparable, without odor or taste when fresh, corky and light-weight when dry, up to 15 cm long, 3 cm wide and less than 1 mm thick at centre. Pore surface grayish brown, more or less fawn, uncracked when dry, sterile margin curry-yellow, paler than pore surface, usually with abundant mycelial setae, up to 2 mm wide; pores more or less circular, sometimes sinuous or irregular, 5–7 per mm; dissepiments thin, entire to slightly lacerate, abundant hymenial setae seen in tube cavities (under anatomical lens). Subiculum fawn, corky, thin to almost lacking, up to 0.1 mm thick. Tubes honey-yellow, paler contrasting with subiculum, hard corky, up to 0.9 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

Subiculum – Generative hyphae very rare, hyaline, thin-walled, occasionally branched, frequently simple septate, 2.5–3.8 μm in diam.; skeletal hyphae dominant, rust-brown, thick-walled with a medium to wide lumen, unbranched, aseptate, flexuous, interwoven, 3–3.8 μm in diam.; mycelial setae frequent, dark reddish brown, thick-walled, septate, tapering to apex, present in the subiculum and in the rotten bamboo cavities, sometimes locally abundant, often in bundles, up to 240 μm long and 5–9 μm in the widest part.

Tubes – Generative hyphae rare, mostly present at dissepiment edges and subhymenium, hyaline, thin-walled, frequently branched and simple septate, 2–3.5 μm in diam, some of them encrusted at dissepiment edges and in hymenium; skeletal hyphae dominant, yellowish brown, thick-walled with a narrow to medium lumen, unbranched, aseptate, flexuous, interwoven, 2.8–4 μm in diam. Hymenial setae frequent, narrowly subulate, mostly originating from trama1 hyphae, dark brown, thick-walled, occasionally septate, 45–96 × 5–9 μm; fusoid cystidioles frequent, hyaline and thin-walled, 14–23 × 3–4.2 μm; basidia short clavate to barrel-shaped, with four
sterigmata and a simple septum at the base, occasionally bearing a medium size guttule, 12–16 × 4.5–7.2 μm; basidioles dominating in hymenium, barrel-shaped, smaller than basidia.

Spores – Basidiospores ellipsoid, hyaline, thin-walled, smooth, usually glued in tetrads, bearing a small guttule, IKI–, CB–, (4.2–)4.3–5.3(–5.8) × (2.7–)2.8–3.6(–3.8) μm, L = 4.87 μm, W = 3.24 μm, Q = 1.47–1.54 (n = 60/2).

Figure 5 – Microscopic structures of *Fuscoportia australiana* (holotype, Dai 18879). a Basidiospores. b Basidia and basidioles. c Cystidioles. d Hymenial setae. e Generative hyphae at dissepiment edge. f Hyphae from trama. g Hyphae from context.
Figure 6 – Microscopic structures of *Fuscoporia bambusae* (holotype, Dai 16599). a Basidiospores. b Basidia and basidioles. c Cystidioles. d Hymenial setae. e Mycelial setae. f Generative hyphae at dissepiment edge. g Hyphae from trama. h Hyphae from subiculum.

Other materials examined (paratypes) – Thailand, Rai Empress, Dowager University Campus, on rotten bamboo, 21 Jul 2016, Y.C. Dai 16607 (BJFC 022718); on dead bamboo, 21 Jul 2016, Y.C. Dai 16615 (BJFC 022725).
**Fuscoporia bambusae** is a tropical species growing on bamboo, differs from other species in *Fuscoporia* by its septate hymenial setae and mycelial setae. Three species of *Fuscoporia* grow on bamboo, *F. bambusae*, *F. bambusicola*, and *F. subchrysea*, they share resupinate basidiocarps and presence of mycelial setae; but *F. bambusicola* can be easily distinguished from *F. bambusae* by its larger pores (3–5 per mm, Zhou & Jia 2010); *F. subchrysea* is closely related phylogenetically to *F. bambusae* (Figs 1–2), but differs by its smaller pores (8–9 per mm) and shorter basidiospores (3.8–4.4μm long).

**Fuscoporia chinensis** Q. Chen, F. Wu & Y.C. Dai, sp. nov.  
Figs 3e, f, 7

**MycoBank number:** MB 833956; **Facesoffungi number:** FoF 07998.

**Etymology** – **Chinensis** (Lat.): referring to the species found in China.

**Holotype** – China, Yunnan Province, Binchuan County, Jizushan Park, on fallen angiosperm branch, 30 Aug 2015, Y.C. Dai 15713 (BJFC 019817).

Basidiocarps – Annual, effused-reflexed to pileate, broadly attached, imbricate, without odor or taste and corky when fresh. Pilei dimidiate or conchate, often laterally fused, projecting up to 2 cm long, 5 cm wide and 5 mm thick at the base. Pilear surface yellowish brown to dark reddish, indistinctly concentrically sulcate, velutinate to rugose with age; margin obtuse, yellowish brown. Pore surface grayish brown to dark reddish brown, glancing; margin distinct, yellowish, paler than pore surface, up to 2 mm wide; pores circular to angular, 7–8 per mm; dissepiments thin, slightly lacerate, abundant setae seen in tube cavities (under anatomical lens). Context yellowish brown, corky, up to 2 mm thick. Tubes yellowish brown, paler than context, corky, up to 3 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

**Context** – Generative hyphae rare, hyaline, thin-walled, occasionally branched and simple septate, 2.5–4 μm in diam.; skeletal hyphae dominant, yellowish brown, thick-walled with a wide lumen, unbranched, aseptate, interwoven, 3.5–5 μm in diam.

**Tubes** – Generative hyphae common, hyaline, thin-walled, frequently simple septate, occasionally branched, 2–4 μm in diam., some of them encrusted at dissepiment edges; skeletal hyphae dominant, yellowish brown, thick-walled with a wide lumen, unbranched, aseptate, straight, subparallel along the tubes, 3–4.5 μm in diam. Hymenial setae mostly originating from tramal hyphae, subulate, frequently septate, dark brown, thick-walled, 20–40 × 4–8 μm; fusoid cystidioles frequent, hyaline, thin-walled, sometimes covered with crystals, 14–20 × 4–6 μm; basidia short clavate to barrel-shaped, with four sterigmata and a simple septum at the base, 10–14 × 4–6 μm; basidioles in shape similar to basidia, but slightly smaller.

**Spores** – Basidiospores ellipsoid, hyaline, thin-walled, smooth, sometimes bearing a small guttule, IKI–, CB–, (2.9–)3–4(–4.3) × (1.8–)2–2.5(–2.8) μm, L = 3.55 μm, W = 2.26 μm, Q = 1.42–1.65 (n = 90/3).

**Other materials examined** (paratypes) – China, Hainan Province, Lingshui County, Diao.luoshan Forest Park, on fallen angiosperm branch, 13 Nov 2015, Y.C. Dai 16096 (BJFC 020189); Y.C. Dai 16119 (BJFC 020212); Heilongjiang Province, Heihe, Shengshan Nature Reserve, on fallen trunk of *Quercus*, 25 Aug 2014, Y.C. Dai 14246 (BJFC 017737); Hubei Province, Xiangfan, Xiangyang District, on fallen trunk of *Castanea*, 17 Oct 2016, Y.C. Dai 17282 (BJFC 023381); Wufeng County, Chaibuxi Park, on dead angiosperm tree, 14 Aug 2017, Y.C. Dai 17926 (BJFC 025455), Y.C. Dai 17936 (BJFC 025465), on dead tree of *Prunus*, 14 Aug 2017, Y.C. Dai 17913 (BJFC 025442); Houhe Nature Reserve, on angiosperm branch, 16 Aug 2017, Y.C. Dai 17960 (BJFC 025489); Y.C. Dai 17961 (BJFC 025490); Shanxi Province, Pingli County, Hualongshan Nature Reserve, on dead angiosperm tree, 14 Sept 2013, B.K. Cui 11209 (BJFC 015324); Sichuan Province, Qiong.lai County, Tiantaishan Forest Park, on dead angiosperm tree, 23 Oct 2012, B.K. Cui 10872 (BJFC 013794); Yunnan Province, Baoshan, Longyang District, Baihualing, on stump of angiosperm tree, 30 Nov 2015, Y.C. Dai 16386 (BJFC 020474); Nanhua County, Dazhongshan Nature Reserve, on dead angiosperm tree, 14 Jul 2013, B.K. Cui 11117 (BJFC 015232); Xinpeng County, Shimenxia Park, on stump of *Alnus*, 16 Jun 2017, Y.C. Dai 17583
Figure 7 – Microscopic structures of *Fuscoporia chinensis* (holotype, Dai 15713). a Basidiospores. b Basidia and basidioles. c Cystidioles. d Hymenial setae. e Generative hyphae at dissepiment edge. f Hyphae from trama. g Hyphae from context.

Note – *Fuscoporia chinensis* is a common species in China. Morphologically, it is characterized by annual, effused-reflexed to pileate basidiocarps with indistinctly concentrically
sulcate, velutinate to radially rugose pilear surface, small pores (7–8 per mm), septate hymenial setae, and small, ellipsoid basidiospores measuring 3–4 × 2–2.5 μm. Almost all specimens of **F. chinensis** were previously identified as **F. gilva** (Dai 1999, 2010, Chen & Dai 2019, Chen et al. 2019), and now they are confirmed as different species and segregated from **F. gilva**, which has septate skeletal hyphae and larger basidiospores (4–5 × 3–3.5 μm, Gilbertson 1979). **Fuscoporia chinensis** is closely related to **F. plumeriae** sp. nov. and **F. formosana**, but **F. plumeriae** has smaller pores (8–10 per mm), aseptate hymenial setae, septate skeletal hyphae; **F. formosana** is distinguished from **F. chinensis** by larger pores (3–5 per mm, Chang & Chou 1998).

**Fuscoporia eucalyti** Q. Chen, F. Wu & Y.C. Dai, sp. nov.

- MycoBank number: MB 833959; Facesoffungi number: FoF 07999.
- Etymology – *Eucalypti* (Lat.): referring to the species growing on *Eucalyptus*.
- Basidiocarps – Perennial, effused-reflexed to pileate, laterally fused, solitary to imbricate, without odor or taste and corky when fresh, light-weight and hard corky when dry. Pilei mostly dimidiate, projecting up to 5 cm long, 8 cm wide and 3 cm thick at the base. Pilear surface blackish brown to black, concentrically sulcate with zones, velutinate to glabrous; margin yellowish brown, distinctly paler than the pilear surface, obtuse. Pore surface grayish brown to brown, more or less glancing, uncracked when dry, margin narrow, yellowish, up to 3 mm wide; pores more or less circular, 6–8 per mm; disseminations thin, entire, abundant hymenial setae in tube cavities (under anatomical lens). Context clay-buff, corky, about 2 mm thick. Tubes grayish brown to clay-buff, hard corky, up to 2.8 cm long, tube layers distinct.

- Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

- Context – Generative hyphae rare, hyaline, thin- to slightly thick-walled, frequently branched and simple septate, 2–3 μm in diam.; skeletal hyphae dominant, rust-brown, thick-walled with a narrow lumen, unbranched, moderately septate, straight, regularly arranged, 2.5–3 μm in diam.

- Tubes – Generative hyphae rare, most present at disseminipetum edges and subhymenium, hyaline, thin-walled, frequently branched and simple septate, 2–2.5 μm in diam, some of them encrusted at disseminipetal edges and in hymenium; skeletal hyphae dominant, yellowish brown, thick-walled with a narrow lumen, septate, more or less straight, subparallel along the tubes, 2–3 μm in diam. Hymenial setae occasionally present, subulate, occasionally hooked, mostly originating from tramal hyphae, dark brown, thick-walled, 25–45 × 5–8 μm; fusoid cystidioles hyaline and thin-walled, 18–28 × 3–6 μm; basidia short clavate to barrel-shaped, with four sterigmata and a simple septum at the base, usually bearing a medium size guttule, 14–18 × 5.5–8 μm; basidioles dominating in hymenium, barrel-shaped, smaller than basidia.

- Spores – Basidiospores subglobose, hyaline, thin-walled, smooth, usually bearing a small guttule, IKI−, CB−, (4–)4.3–5.5(–5.8) × (3.5–)4–4.5(–4.6) μm, L = 4.80 μm, W = 4.16 μm, Q = 1.16–1.22 (n = 90/3).
- Other materials examined (paratypes) – Australia, Tasmania, Arve River, Streamside Nature Reserve, on stump of *Eucalyptus*, 15 May 2018, Y.C. Dai 18783 (BJFC 027251); on base of living *Eucalyptus*, 15 May 2018, Y.C. Dai 18791 (BJFC 027259), Y.C. Dai 18792 (BJFC 027260); Victoria, Yarra Ranges National Park, on base of living *Eucalyptus*, 10 May 2018, Y.C. Dai 18626A (BJFC 027095), Y.C. Dai 18634A (BJFC 027103); on dead tree of *Eucalyptus*, 10 May 2018, Y.C. Dai 18642A (BJFC 027111).
- Note – **Fuscoporia eucalyti** grows on *Eucalyptus* sp. in South Australia. The species is characterized by fuscos to black brown pilear surface, occasionally hooked hymenial setae and subglobose basidiospores, 4.3–5.5 × 4–4.5 μm. *F. eucalyti* is similar to *F. atlantica* by effused-reflexed to pileate basidiocarps, small pores (7–9 per mm) and hooked hymenial setae, but *F. atlantica* has ellipsoid basidiospores (4–4.5 × 3–3.5 μm, Q = 1.5, Pires et al. 2015), and the two species are not closely related phylogenetically (Figs 1–2). **Fuscoporia eucalyti** is closely related...
phylogenetically to *F. wahlbergii* and *F. australasica* (Figs 1–2). However, the latter two species have narrower basidiospores (3.3–4 μm and 3.3–4.2 μm, respectively, Dai 2010). In addition, a comparison of nucleotide differences in ITS region shows that *F. eucalypti* differs respectively from *F. australasica* and *F. wahlbergii* by 2.5 and 2%, and at least 1.5% nucleotide differences in the ITS regions was proposed as indicative of a new species (Jeewon & Hyde 2016).
**Figure 8** – Microscopic structures of *Fuscoporia eucalypti* (holotype, Dai 18792). a Basidiospores. b Basidia and basidioles. c Cystidioles. d Hymenial setae. e Generative hyphae at dissepiment edge. f Hyphae from trama. g Hyphae from context.

*Fuscoporia karsteniana* Q. Chen, F. Wu & Y.C. Dai, sp. nov.  
MycoBank number: MB 833962; Facesoffungi number: FoF 08000.

Etymology – *Karsteniana* (Lat.): in honor of the Finnish mycologist Petter Adolf Karsten.


Basidiocarps – Perennials, resupinate, inseparable, without odor or taste and soft corty when fresh. Corky and light-weight when dry, up to 16 cm long, 5 cm wide and 7 mm thick at centre. Pore surface rusty brown, more or less fawn, occasionally cracked when dry, sterile margin narrow or almost lacking, up to 1 mm wide, honey-yellow, distinctly paler than pore surface, usually with mycelial setae; pores more or less circular, 5–7 per mm; dissepiments thin, entire, abundant in hymenial setae seen in tube cavities (under anatomical lens). Subiculum cinnamon to reddish brown, corty, very thin, less 0.3 mm thick. Tubes grayish brown, paler contrasting with subiculum, hard corty, up to 6.7 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

Subiculum – Generative hyphae rare, hyaline, thin-walled, occasionally branched, frequently simple septate, 2–2.5 μm in diam.; skeletal hyphae dominant, rust-brown, thick-walled with a narrow to medium lumen, unbranched, asceptate, more or less straight, interwoven, 2.5–3 μm in diam.; mycelial setae frequent, dark reddish brown, thick-walled, tapering to apex, occasionally septate, present in the subiculum, sometimes locally abundant, often in bundles, up to 265 μm long and 5–9 μm in the widest part.

Tubes – Generative hyphae rare, mostly present at dissepiment edges and subhymenium, hyaline, thin-walled, frequently branched and simple septate, 1.5–2.2 μm in diam., some of them encrusted at dissepiment edges and in hymenium; skeletal hyphae dominant, yellowish brown, thick-walled with a narrow to medium lumen, unbranched, asceptate, more or less straight, subparallel along the tubes, 2.3–2.8 μm in diam. Hymenial setae frequent, narrowly subulate, mostly originating from trunal hyphae, dark brown, thick-walled, 34–45 × 5–7.5 μm; basidia barrel-shaped, with four sterigmata and a simple septum at the base, occasionally bearing a small guttule, 14–16 × 4–6 μm; basidioles dominating in hymenium, in shape similar to basidia, but slightly smaller.

Spores – Basidiospores ellipsoid, hyaline, thin-walled, smooth, usually glued in tetrads, bearing a small guttule, IKI–, CB–, 4.5–5.6(–5.8) × (2.8–)3–3.8(–3.9) μm, L = 5.05 μm, W = 3.37 μm, Q = 1.50–1.65 (n = 60/2).

Other materials examined (paratypes) – China, Guizhou Province, Libo County, Maolan Nature Reserve, on fallen trunk of *Prunus*, 15 Jun 2016, Y.C. Dai 16552 (BJFC 022664); Hubei Province, Yichang, Wufeng County, Chaibuxi Park, on dead angiosperm tree, 15 Aug 2017, Y.C. Dai 17925 (BJFC 025454); Shennongjia Park, on fallen angiosperm trunk, 16 Oct 2016, Y.C. Dai 17229 (BJFC 023327); Yunnan Province, Binhuan County, Jizushan Nature Reserve, on fallen trunk of *Quercus*, 30 Aug 2015, Y.C. Dai 15717 (BJFC 019821); Yuxi, Xinping County, Mopanshan Forest Park, on dead tree of *Schima*, 15 Jun 2017, Y.C. Dai 17618 (BJFC 025150); on dead angiosperm tree, 15 Jun 2017, Y.C. Dai 17629 (BJFC 025161).

Note – *Fuscoporia karsteniana* is widely distributed in China and characterized by perennial basidiocarps, septate mycelial setae, absence of cystidioles, and ellipsoid basidiospores measuring 4.5–5.6 × 3–3.8 μm. The new species is closely related to *F. ferruginosa sensu stricto* in our phylogenies (Figs 1–2), but *F. ferruginosoides sensu stricto* has mostly annual and nodulous basidiocarps, very thick dissepiments (> pore diam.), presence of cystidioles, asceptate mycelial setae; while *F. karsteniana* has perennial, resupinate and even basidiocarps, thin dissepiments (< pore diam.), absence of cystidioles, some septate mycelial setae. *Fuscoporia chinensis* is another common species in China, it differs from *F. karsteniana* by effused-reflexed to pileate basidiocarps.
and absence of mycelial setae.

Figure 9 – Microscopic structures of *Fuscoporia karsteniana* (holotype, Dai 11403). 
a Basidiospores. b Basidia and basidioles. c Hymenial setae. d Mycelial setae. e Generative hyphae at dissepiment edge. f Hyphae from trama. g Hyphae from subiculum.

**Fuscoporia plumeriae** Q. Chen, F. Wu & Y.C. Dai, sp. nov.  
MycoBank number: MB 833957; Facesoffungi number: FoF 08001.  
Etymology – *Plumeriae* (Lat.): referring to the species growing on *Plumeria*.
Holotype – Australia, Queensland, Cairns, Crater Lake National Park, on dead tree of *Plumeria*, 18 May 2018, Y.C. Dai 18858 (BJFC 027326, isotype in MEL).

Basidiocarps – Annual, pileate, solitary, corky and without taste or odor when fresh, becoming hard corky and light-weight when dry. Pilei mostly dimidiate to conchate, projecting up to 7 cm long, 13 cm wide and 3.5 cm thick at the base. Pilear surface grayish brown to olivaceous buff, indistinctly concentrically zonate, nodulose; margin obtuse, honey-yellow. Pore surface fuscous, slightly glancing; margin narrow, honey-yellow, paler than pore surface, up to 1 mm; pores circular, 8–10 per mm; dissepiments thin, entire to slightly lacerate; abundant setae seen in tube cavities (under anatomical lens). Context honey-yellow, corky, zonate, up to 3 cm thick. Tubes grayish brown, paler than pore surface, hard corky up to 0.5 cm long.

Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

Context – Generative hyphae frequent, hyaline, thin- to slightly thick-walled, occasionally branched, frequently simple septate, 2–3 μm in diam.; skeletal hyphae dominant, yellowish brown, thick-walled with a wide lumen, unbranched, occasionally septate, straight, regularly arranged, 3–5 μm in diam.

Tubes – Generative hyphae frequent, mostly present at dissepiment edges and subhymenium, hyaline, thin-walled, frequently branched and septate, 2–3 μm in diam, some of them encrusted at dissepiment edges and in hymenium; skeletal hyphae dominant, yellowish brown, thick-walled with a wide lumen, unbranched, occasionally septate, straight, parallel along the tubes, 3–4 μm in diam. Hymenial setae frequent, mostly originating from tramal hyphae, ventricose to subulate, dark brown, thick-walled, 15–25 × 5–6 μm; fusoid cystidioles hyaline, thin-walled, sometimes covered by crystals, 12–18 × 2–3 μm; basidia short clavate to barrel-shaped, with four sterigmata and a simple septum at the base, 12–17 × 5–6.5 μm; basidioles dominating in hymenium, barrel-shaped to capitate, smaller than basidia.

Spores – Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI−, CB−, 3–3.8(−4) × (2–)2.2—2.8(−3) μm, L = 3.54 μm, W = 2.54 μm, Q = 1.31–1.40 (n = 60/2).

Other materials examined (paratypes) – Australia, Queensland, Cairns, Crater Lake National Park, on fallen trunk of *Plumeria*, 17 May 2018, Y.C. Dai 18820 (BJFC 027288); Mt. Whitfield Conservation Park, on dead tree of *Plumeria*, 18 May 2018, Y.C. Dai 18861 (BJFC 027329), Singapore, Bukit Timah Nature Reserve, on fallen angiosperm trunk, 18 Jul 2017, Y.C. Dai 17814 (BJFC 025346).

Note – *Fuscoporia plumeriae* is characterized by annual and pileate basidiocarps with nodulose pilear surface, small pores (8–10 per mm), short hymenial setae (< 25 μm long), septate skeletal hyphae, small and ellipsoid basidiospores measuring 3–3.8 × 2.2–2.8 μm, and distributed in northern Australia and Singapore. It is a unique species in the genus that its context is thicker than the tubes. Macromorphologically *F. plumeriae* resembles *F. gilva* and *F. australiana*, but *F. gilva* has larger pores (6–8 per mm) and larger basidiospores (4–5 × 3–3.5 μm, Gilbertson 1979, Ryvarden & Johansen 1980). On the other hand, *F. australiana* has acute margin, aseptate skeletal hyphae and longer basidiospores (4–4.8 μm).

*Fuscoporia shoreae* Q. Chen, F. Wu & Y.C. Dai, sp. nov.

Figs 10c, d, 12

Mycobank number: MB 833969; Facesoffungi number: FoF 08002.

Etymology – *Shorea* (Lat.): referring to the species growing on *Shorea* sp.


Basidiocarps – Annual, pileate, solitary, corky and without odor or taste when fresh, hard corky when dry. Pilei mostly dimidiate, projecting up to 6 cm long, 9 cm wide and 1 cm thick at the base. Pilear surface grayish brown, concentrically sulcate with zones; margin obtuse, yellowish brown, distinctly paler than pilear surface. Pore surface curry-yellow to olivaceous buff, sterile margin distinct, yellowish, up to 3 mm wide; pores circular, 9–10 per mm; dissepiments thick, entire. Context curry-yellow, corky, about 0.8 cm thick. Tubes olivaceous buff, hard corky, up to

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0.2 cm long.

Hyphal structure – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

Context – Generative hyphae rare, hyaline, thin-walled, frequently branched and simple septate, 1.5–2 μm in diam.; skeletal hyphae dominant, rust-brown, thick-walled with a narrow lumen, unbranched, frequently septate, flexuous, interwoven, 2.5–3 μm in diam.

Figure 10 – Basidiocarps of Fuscoporia species. a–b Fuscoporia plumeriae (holotype, Dai 18858). c–d Fuscoporia shoreae (c holotype, Dai 17818, d paratype, Dai 17800). e Fuscoporia subchrysea (holotype, Dai 16201). f Fuscoporia bambusicola (holotype, Cui 8692). g Fuscoporia roseocinerea (holotype, JV 1407/85). Scale Bars = 10 mm.
Figure 11 – Microscopic structures of *Fuscoporia plumeriae* (holotype, Dai 18858). a Basidiospores. b Basidia and basidioles. c Cystidioles. d Hymenial setae. e Generative hyphae at dissepiment edge. f Hyphae from trama. g Hyphae from context.

Tubes – Generative hyphae frequent, mostly present at dissepiment edges and subhymenium, hyaline, thin-walled, frequently branched and simple septate, 1.5–2 μm in diam.; skeletal hyphae dominant, yellowish brown, thick-walled with a narrow lumen, frequently septate, more or less straight, subparallel along the tubes, 2–2.5 μm in diam. Hymenial setae absent; fusoid cystidioles
hyaline and thin-walled, 16–22 × 3.5–5.5 μm; basidia barrel-shaped to capitate, with four sterigmata and a simple septum at the base, 12–15 × 4.5–6 μm; basidioles dominating in hymenium, in shape similar to basidia, almost the same size of basidia.

**Figure 12** – Microscopic structures of *Fuscoporia shoreae* (holotype, Dai 17818). a. Basidiospores. b. Basidia and basidioles. c. Cystidioles. d. Hyphae from trama. e. Hyphae from context.

Spores – Basidiospores broadly ellipsoid, hyaline, thin-walled, smooth, bearing a medium guttule, IKI–, CB–, (3.5–)3.8–4.8(–5) × (2.6–)3–3.8 (–4) μm, L = 4.18 μm, W = 3.34 μm, Q = 1.24–1.30 (n = 60/2).

Note – Three specimens of *Fuscoporia shoreae* from Singapore are clustered into a lineage with high support (100/100 in Fig. 2). The species is phylogenetically nested in *Fuscoporia*, although morphologically it doesn’t present hymenial setae and encrustations on generative hyphae. In fact, *F. longisetulosa* (Bondartseva & S. Herrera) Bondartseva & S. Herrera and *F. discipes* (Berk.) Y.C. Dai & Ghob.-Nejh. neither present hymenial setae, *F. discipes* differs from *F. shoreae* by its larger pores (6–8 per mm, Ryvarden & Johansen 1980, Dai 2010) and usually laterally stipitate; *F. longisetulosa* differs from *F. shoreae* by presence of mycelial setae (Ryvarden 2004). It seems that the hymenial setae are not an important character for diagnosis of *Fuscoporia* although most species in the genus have hymenial setae, and the hyaline, thin-walled basidiospores are the basic character for definition of the genus.

*Fuscoporia subchrysea* Q. Chen, F. Wu & Y.C. Dai, sp. nov.  
(Figs 10e, 13)

**Mycobank number:** MB 833961; Facesoffungi number: FoF 07992.

**Etymology** – *Subchrysea* (Lat.): referring to the species similar to *Fuscoporia chrysea*.

**Holotype** – China, Hainan Province, Wuzhishan County, Wuzhishan Nature Reserve, on dead bamboo, 15 Nov 2015, Y.C. Dai 16201 (BJFC 020287).

**Basidiocarps** – Annual, resupinate, inseparable, soft corky and without odor or taste when fresh, becoming corky and light-weight upon drying, up to 18 cm long, 4 cm wide and 1 mm thick at centre. Pore surface fuscous to honey-yellow or fawn, occasionally cracked when dry; sterile margin cinnamon-buff, distinctly paler than pore surface, usually with abundant mycelial setae, up to 1 mm wide; pores more or less circular, 8–9 per mm; disseipements thin, entire, abundant hymenial setae seen in tube cavities (under anatomical lens). Subiculum reddish brown, corky, very thin, up to 0.2 mm thick. Tubes grayish brown, paler than subiculum, hard corky, up to 0.8 mm long.

**Hyphal structure** – Hyphal system dimitic; generative hyphae simple septate; tissue darkening but otherwise unchanged in KOH.

**Subiculum** – Generative hyphae rare, hyaline, thin-walled, occasionally branched, frequently simple septate, 2–3.5 μm in diam.; skeletal hyphae dominant, rust-brown, thick-walled with a wide lumen, unbranched, occasionally septate, flexuous, interwoven, 3.5–4 μm in diam.; mycelial setae frequent, dark reddish brown, thick-walled, tapering to apex, present in the subiculum and in the rotten wood cavities, sometimes locally abundant, often in bundles, up to 130 μm long and 6–9 μm in the widest part.

**Tubes** – Generative hyphae frequent, mostly present at disseipiment edges and subhymenium, hyaline, thin-walled, occasionally branched and frequently simple septate, 1.5–3 μm in diam, some of them encrusted at disseipiment edges and in hymenium; skeletal hyphae dominant, yellowish brown, thick-walled with a medium or wide lumen, unbranched, aseptate, more or less straight, subparallel along the tubes, 3–4 μm in diam. Hymenial setae frequent, narrowly subulate, mostly originating from trama111, dark brown, thick-walled, 40–68 × 5–8 μm; basidia barrel-shaped, with four sterigmata and a simple septum at the base, 11–13 × 5–7.5 μm; basidioles dominating in hymenium, capitate, but shorter than basidia.

**Spores** – Basidiospores ellipsoid, hyaline, thin-walled, smooth, usually glued in tetrads, sometimes bearing a small guttule, IKI–, CB–, 3.8–4.4(–4.7) × 2.6–3.2(–3.4) μm, L = 4.07 μm, W = 3 μm, Q = 1.31–1.42 (n = 60/2).

**Other material examined** (paratype) – China, Hainan Province, Baoting County, Qixianling Forest Park, on fallen angiosperm trunk, 8 Jun 2017, Y.C. Dai 17656 (BJFC 025188).

**Note** – *Fuscoporia subchrysea* is characterized by small pores (8–9 per mm), septate skeletal hyphae, long hymenial setae (> 40 μm), presence of mycelial setae and absence of cystidioles. The species may be confused with *F. chrysea* (Lév.) Baltazar & Gibertoni by the similar resupinate basidiocarps, small pores (9–10 per mm in *F. chrysea*) and broadly ellipsoid basidiospores. However, *F. chrysea* has perennial basidiocarps with bright golden yellow pore surface and absence
of mycelial setae (Ryvarden & Johansen 1980, Ryvarden 2004, Dai 2010). In addition, *F. subchrysea* and *F. chrysea* are genetically very distant species (Fig. 2). *Fuscoporia bambusae* and *F. subchrysea* are found in tropical Asia, and both species can grow on bamboo. However, pores are bigger in *F. bambusae* than in *F. subchrysea* (5–7 per mm vs. 8–9 per mm), and spores are longer in *F. bambusae* than in *F. subchrysea* (4.3–5.3 μm vs. 3.8–4.4 μm).

![Figure 13](image)

**Figure 13** – Microscopic structures of *Fuscoporia subchrysea* (holotype, Dai 16201). 

a Basidiospores. b Basidia and basidioles. c Hymenial setae. d Generative hyphae at dissepiment edge. e Mycelial setae. f Hyphae from trama. g Hyphae from subiculum.

Figs 10f, 14

MycoBank number: MB 833968; Facesoffungi number: FoF 07993.
Material examined – China, Hainan Province, Changjiang County, Bawangling Nature Reserve, on dead bamboo, 8 Jul 2009, B.K. Cui 8692 (BJFC 007632, holotype).

Note – Fuscoporia bambusicola was originally described as Phellinus bambusicola from southern China based on morphology (Zhou & Jia 2010). Its holotype was studied and DNA was extracted. Our phylogenetic analysis indicated that F. bambusicola nested in Fuscoporia. It is therefore the above combination is proposed. Fuscoporia bambusicola is closely related to F. latispora Y.C. Dai, Q. Chen & J. Vlasák (Figs 1–2), but F. latispora has mycelial setae often in sterile margin which lead the sterile margin darker than pores surface, longer hymenial setae (55–72 \( \mu \)m), and a distribution in Central America (Chen et al. 2019); while F. bambusicola has mycelial setae in subiculum rather than at sterile margin, shorter hymenial setae (32–54 \( \mu \)m), and occurs in tropical China (Zhou & Jia 2010). Fuscoporia monticola also occurs in southern China, it resembles F. bambusicola by similar basidiocarps and presence of mycelial setae, but it has larger pores (2–3 per mm vs. 3–5 per mm in F. bambusicola) and oblong ellipsoid basidiospores (4.4–6.3 × 3.2–3.3 \( \mu \)m vs. 4.2–5 × 3.1–4 \( \mu \)m in F. bambusicola, Chen et al. 2019, Zhou & Jia 2010). Fuscoporia bambusae grows also on bamboo, but it differs from F. bambusicola by smaller pores (5–7 per mm, 3–5 per mm in F. bambusicola). In addition, both species are phylogenetically distant (Figs 1–2).

Fuscoporia roseocinerea (Murrill) Q. Chen, F. Wu & Y.C. Dai, comb. nov.  

Figs 10g, 15

MycoBank number: MB 833970; Facesoffungi number: FoF 07994.

Materials examined – Costa Rica, Guanacaste Province, Lomas de Barbudal Biological Reserve, on hardwood, Jul 2014, J. Vlasák, JV 1407/84 (duplicate in BJFC 020687), JV 1407/85 (duplicate in BJFC 020686); Parque Nacional Santa Rosa, on hardwood, Aug 2014, J. Vlasák, JV 1408/31 (duplicate in BJFC 020688). USA, Texas, Brownsville, Resaca de la Palma State Park, on Acacia farnesiana, Sep 2011, J. Vlasák, JV 1109/78-J (duplicate in BJFC 020653).

Note – Fuscoporia roseocinerea was originally described as Pyropolyporus roseocinereus from Costa Rica and Cuba (Murrill 1908) and combined as Phellinus roseocinereus for a long time (Reid 1976). Three specimens from USA and Costa Rica were studied, which presented a dimitic hyphal system with encrustations on generative hyphae and broadly ellipsoid, hyaline, thin-walled basidiospores (4–5 × 3–3.6 \( \mu \)m, \( Q = 1.30–1.35 \)). These data are more or less close to the descriptions by Murrill (1908) and Reid (1976). In addition, these three samples nested in Fuscoporia and clustered into a lineage with high support (100/100 in Fig. 2), so Fuscoporia roseocinerea is proposed.

Following Murrill (1908), Fuscoporia roseocinerea is characterized by perennial, effused-reflexed basidiocarps, encrusted pilear surface with concentrically sulcate, acute margin, round pores, 5–6 per mm, entire dissemineta, globose to ovoid, smooth, hyaline basidiospores, 5–6 × 3–4 \( \mu \)m. However, Lowe (1957) mentioned the species has pores as 6–10 per mm, and spores as broadly oval, 3.5–4 × 2–3 \( \mu \)m (Larsen & Cobb-Poule 1990). So, there are very different morphologies on this species. We did not study its type, and further study in needed to confirm its morphology.

Fuscoporia roseocinerea is similar to F. callimorpha (Lév.) Groposo, Log.-Leite & Góes-Neto but the latter has smaller pores (7–10 per mm) and oblong ellipsoid basidiospores (3.5–4.5 × 2–3 \( \mu \)m, Lowe 1957, Ryvarden & Johansen 1980, Raymundo et al. 2013a). Fuscoporia chrysea (type locality in Colombia) is closely related to F. roseocinerea (Figs 1–2), but the former species has smaller basidiospores (3–4 × 2–2.5 \( \mu \)m, Ryvarden 2004).
Figure 14 – Microscopic structures of *Fuscoporia bambusicola* (holotype, Cui 8692). 
a Basidiospores. 
b Basidia and basidioles. 
c Cystidioles. 
d Hymenial setae. 
e Mycelial setae. 
f Generative hyphae at dissepiment edge. 
g Hyphae from trama. 
h Hyphae from subiculum.
Figure 15 – Microscopic structures of *Fuscoporia roseocinerea* (JV 1407/84). a Basidiospores. b Basidia and basidioles. c Hymenial setae. d Generative hyphae at dissepiment edge. e Hyphae from trama. f Hyphae from context.

A key to species of *Fuscoporia* in worldwide

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    *F. ramulicola* Y.C. Dai & Q. Chen
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16. Basidiospores ellipsoid, 4.3–5.3 × 2.8–3.6 μm, Q = 1.47–1.54. Type locality Thailand............
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    *F. bambusae* Q. Chen et al.
17. Hymenial setae absent. Type locality Cuba ..................................
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    *F. longisetulosa* (Bondartseva & S. Herrera) Bondartseva & S. Herrera
18. Hymenial setae present .............................................................19
18. Cystidioles present and basidiospores cylindric to subcylindric .............................................19
19. Skeletal hyphae septate. Type locality Russia..................................20
    *F. insolita* Spirin et al.
19. Skeletal hyphae aseptate.............................................................20
20. Basidiospores cylindric, 6–7.8 × 2–2.5 μm, Q = 2.84–3.38. Type locality France.................
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    *F. ferrea* (Pers.) G. Cunn
20. Basidiospores cylindric to subcylindrical, 4.2–5.2 × 2.8–3.5 μm. Type locality USA...............21
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    *F. punctatiformis* (Murrill) Zmitr. et al.
21. Basidiospores oblong-ellipsoid. Type locality Costa Rica...............22
    *F. costaricana* Y.C. Dai et al.
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22. Cystidioles present; basidiospores 4.1–5.2 × 2.8–3.2 μm, Q = 1.55–1.61. Type locality Germany ................. F. ferruginosa (Schrad.) Murrill
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24. Basidiospores cylindric, 4.2–6.2 × 2–2.6 μm. Type locality China. ........................................ F. altocedronensis (Murrill) Bondartseva & S. Herrera
24. Basidiospores globose, 4–4.5 × 3–4 μm. Type locality Cuba. ........................................ F. acutimarginata Y.C. Dai & Q. Chen
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52. Hymenial setae absent, basidiospores cylindric, 4.5–5.5 × 2–3 μm, Q = 1.63. Type locality Sri Lanka ........................................................................................................ F. discipes (Berk.) Y.C. Dai & Ghob.-Nejh.
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Discussion

In this study 315 sequences of ITS, nLSU, RPB2 and TEF1 were analyzed, of them 181 sequences, viz. 46 ITS, 49 nLSU, 34 RPB2 and 52 TEF1 are newly generated. Phylogenetic analyses from 105 specimens including 41 species of Fuscoporia were studied; 226 specimens were morphologically examined. Based on laboratory examinations and phylogenetic analyses, nine new species are described and two new combinations are proposed. To date, 49 Fuscoporia species are accepted, but eight species, Fuscoporia altocedrenensis (Murrill) Bondartseva & S. Herrera, F. bifurcata Baltaza et al., F. contiguiformis (Pilát) Raymundo et al., F. flavomarginata (Murrill) Groposo et al., F. longisetulosa, F. mesophila Raymundo et al., F. nicaraguensis Murrill and F. xerophila Raymundo et al., were studied only by literature due to lack of voucher specimens and DNA sequences data. So, their phylogenetic relationships with other species remain uncertain. Our newly described species can be distinguished from these eight species in morphology. An identification key to 49 accepted species in the genus is provided.

Previously Fuscoporia was defined by a dimictic hyphal system, generative hyphae encrusted with crystals in the disseipment edge and tube trama, the hymenial setae mostly originating from tramas hyphae and hyaline, thin-walled, smooth basidiospores (Fiasson & Niemelä 1984, Dai 2010, Chen et al. 2019). However, there are some exceptions like F. shoreae, F. longisetulosa and F. discipes without hymenial setae. Hence, we re-define the genus as basidioarps annual to perennial, resupinate to pileate, hyphal system dimictic, generative hyphae encrusted (at least at disseipments) in most species, hymenial setae usually present, mycelial setae present in some species, and basidiospores hyaline, thin-walled, smooth.

Six groups, Fuscoporia contigua group, F. ferrea group, F. ferruginosa group, F. gilva group, F. torulosa group, and F. viticola group are recognized with strong support in our phylogenies (Figs 1–2). The Fuscoporia ferrea group includes F. ferrea, F. punctatiformis (Murrill) Zmitr. et al., F. ramulicola, F. subferrea and F. yunnanensis. These species are characterized by resupinate
basidiocarps, aseptate skeletal hyphae, absence of mycelial setae, presence of hymenial setae and cystidioles, and cylindrical basidiospores (Dai 2010, Chen & Dai 2019).


The Fuscoporia ferruginosa group includes F. ferruginosa, F. karsteniana, F. bambusae and F. subchrysea. These species are characterized by resupinate basidiocarps, relatively small pores, entire dissepiments, straight hymenial setae, presence of mycelial setae and ellipsoid basidiospores. In our phylogeny (Fig. 2), samples of F. ferruginosa nested in two independent lineages, one lineage represented by American and Chinese samples, another by European samples. Because the type locality of F. ferruginosa is Germany, it means that the European samples represent the real F. ferruginosa, and the American and Chinese samples may be new species. The European specimens can be segregated from American and Chinese ones by perennial basidiocarps (annual in the latter) and smaller pores (6–8 per mm in the former and 5–6 per mm in the latter). Because some synonyms of F. ferruginosa were described from North America, for the time being we treat all these samples as F. ferruginosa.

The Fuscoporia gilva group including F. atlantica, F. australiana, F. chinensis, F. formosana, F. gilva, F. plumeriae, and F. setifera. These species are characterized by effused-reflexed to pileate basidiocarps, indistinctly concentrically sulcate with zones, hispid to rugose or nodulose pileal surface, lacerate dissepiments, presence of cystidioles and ellipsoid to cylindrical basidiospores. Fuscoporia gilva was originally described as Boletus gilvus Schwein. from USA (Schweinitz 1822), and it is a common fungus on hardwoods in southwest America (Gilbertson 1979). Abundant specimens of F. gilva sensu lato were collected from China, but most of them are in fact F. chinensis, which differ from F. gilva by the aseptate skeletal hyphae and smaller basidiospores (3–4 × 2–2.5 μm vs. 4–5 × 3–3.5 μm, Gilbertson 1979). Several synonyms of F. gilva were described from Argentina, France, North America and New Zealand. We have studied these taxa following the literature (Polyporus balansae Spec., Specgazzini 1884, Placodes fucatus Quél., Quélet 1887, Polyporus calciscens Berk., Berkeley 1839, Polyporus gilvorigidus Lloyd, Lloyd 1925) and our newly described species F. chinensis is different from these taxa.

The Fuscoporia torulosa group includes F. callimorpha, F. torulosa (Pers.) T. Wagner & M. Fisch., F. rhabbararina (Berk.) Groposo et al. and F. senex (Nees & Mont.) Ghob.-Nehj., F. wahlbergii, F. australasica, F. eucalypti, F. roseocinerea, F. chrysea and F. shoreae. Species in this group are characterized by the resupinate, effused-reflexed to pileate basidiocarps, small pores (5–10 per mm), entire dissepiments, septate skeletal hyphae, straight or hooked hymenial setae, lacking mycelial setae, presence of cystidioles, broadly ellipsoid to subglobose basidiospores. Fuscoporia senex is very close to F. rhabbararina in phylogeny (Fig. 2), but F. rhabbararina has a distinctive black crust at upper surface, smaller basidiospores and skeletal hyphae swelling in KOH (Singer 1959, Bakshi et al. 1970, Ryvarden & Johansen 1980, Corner 1991, Groposo et al. 2007). Specimens from different localities of these two species should be compared and phylogenetically analyzed in the future. Fuscoporia callimorpha present a pantropical distribution (Ryvarden & Johansen 1980, Lowe 1957, Loguercio-Leite & Wright 1995, Groposo et al. 2007, Raymundo et al. 2013a), and it is easily separated from other species in the group by smaller basidiospores (3.5–4.5 × 2.4–3 μm, Ryvarden & Johansen 1980). Fuscoporia wahlbergii was reported to have a wide distribution among pantropical zones (Ryvarden & Johansen 1980, Ryvarden & Gilbertson 1994, Loguercio-Leite & Wright 1995, Wagner & Fischer 2001), despite the species was originally described from South Africa. No sequences of F. wahlbergii from the type locality are available and we presume that the species has a wide distribution in Europe, USA, Australia and Asia, so specimens from these areas are treated as F. wahlbergii in our study. The Chinese samples previously treated as F. wahlbergii in Dai (2010) are in fact different from the type description of F.
walbergii, because the spores from the type of F. wahlbergii are globose, 3.5–4 μm in diam. (Reid 1975), and now Chinese specimens were described as F. australasica. Fuscosporia atlantica from Brazil also has hooked hymenial setae and ellipsoid basidiospores, but the species clustered into F. gilva group (Pires et al. 2015).

The Fuscosporia viticola group includes F. palomari Vlasák & Ryvarden and F. viticola (Schwein.) Murrill. The two species are characterized by resupinate to effused-reflexed basidiocarps, moderately large pores (< 7 per mm), absence of mycelial setae, narrowly subulate and long hymenial setae (> 40 μm long), cylindric and long basidiospores (> 7 μm long). This small group is distinguished from other groups by the longer hymenial setae and larger basidiospores (Vlasák et al. 2012).

Fuscosporia acutimarginata, F. discipes, F. insolita Spirin, Vlasák & Niemelä are nested in three subclades (Fig. 2), but without enough support. They certainly do not belong to a group, and are different from the above mentioned six groups. For the time being we do not treat them in any groups.

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