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Article

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Updated systematics of *Trichaptum s.l.* (Hymenochaetales, Basidiomycota)

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Abstract

Trichaptum sensu lato is a widespread wood-decay fungal group important for the transfer of energy and recycling of nutrients in forest ecosystems. The taxonomy of *Trichaptum s.l.* was previously mostly based on morphology, and phylogenetic relationships among taxa of *Trichaptum s.l.* are poorly known. The systematics of *Trichaptum s.l.* was revised using morphology, and molecular study which analysed the combined datasets of ITS+nLSU+mt-SSU+nuc-SSU+TEF1 from 256 samples. Maximum Likelihood (ML) and Bayesian Inference (BI) were employed to perform phylogenetic analyses of these datasets. The traditional *Trichaptum s.l.* is polyphyletic. Two main clades, distantly related, are recognized and two new families, Hirschioporaceae and Trichaptaceae, are proposed to represent these two clades. All analyzed samples formed seven independent clades representing seven genera, among them five newly proposed. 38 independent lineages are nested in the seven genera, and 10 of them are described as new species. In addition, a total of 49 taxa are identified by phylogenetic analyses and morphological examination of 625 specimens from 19 countries, and 28 new combinations are proposed. To support our results, divergence time estimation and historical biogeography of *Trichaptum s.l.* are analyzed. Photos and illustrations for ten new species are presented, and a full description for each new species is given. This study recognizes 49 taxa in seven genera belonging to Hymenochaetales and provides a modern global treatment of *Trichaptum s.l.* Keys to families and genera are provided, and identification keys to accepted species worldwide are given.

Keywords – 38 new taxa – divergence time estimation – phylogeny – polypore – taxonomy

Introduction

The genus *Trichaptum* Murrill 1904 (Hymenochaetales Oberw.) contains mostly pileate polypores with annual to perennial basidiomata with a hispid to adpressed tomentose abhymenial surface, variable hymenophore (irpicoid, lamellate or poroid), with brownish to purplish hymenial surface, duplex context, mainly a dimitic hyphal system with clamped generative hyphae, predominately cylindrical basidiospores, and the presence of cystidia (Murrill 1904, Ryvarden & Johansen 1980, Gilbertson & Ryvarden 1987, Ryvarden 1991, Ryvarden & Gilbertson 1994, Núñez & Ryvarden 2001).

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Trichaptum sensu lato (*s.l.*) is a widespread important wood-decay fungal group being a pioneer in wood decomposition of forest ecosystems (Ryvarden & Gilbertson 1994, Wu et al. 2022). It causes a white rot of wood by breaking down lignin and destroying part of the cellulose. In addition, *Trichaptum s.l.* is of medical interest since its isolated compounds have shown anti-cancer, anti-virus, and anti-microbial activities, and industrial interest due to its ability to decolorize chemical dyes. (Dai et al. 2009a, Han et al. 2011, Esposito et al. 2011, Yang et al. 2014). In the latest study, it is reported that *T. abietinum* (Pers. ex J.F. Gmel.) Ryvarden and *T. biforme* (Fr.) Ryvarden caused significant changes in the morphology of whole rubber (Sato et al. 2022).

Most taxa of *Trichaptum s.l.* were included in *Trametes* Fr. until the genus was established based on *Trichaptum trichomallum* (Berk. & Mont.) Murrill (=*Trichaptum perrottetii* (Lév.) Ryvarden, Murrill 1904, Pilát 1936). Later, Donk (1933) established *Hirschioporus* Donk based on *Hirschioporus abietinus* (Pers. ex J.F. Gmel.) Donk, to include temperate species. In this context, *Trichaptum* contains tropical species with a distinct hispid to villose pileal surface, while *Hirschioporus* includes temperate boreal species with a more adpressed tomentum on the upper surface. Ryvarden & Johansen (1980) concluded that *Hirschioporus* was not essentially different from *Trichaptum*. Since then, it is generally acknowledged that *Trichaptum* is a cosmopolitan genus including species of *Hirschioporus*.

Trichaptum was considered a member of the Polyporales Gäum by many mycologists for a long time. However, an in-depth study of the microstructure of the genus by Traquiar and McKeen (1978) found the generative hyphae had distinct small clamps and imperforate dolipore septa, which indicated it was close to the Hymenochaetales, rather than the Polyporales. Later, imperforate dolipore septa were also found on the hyphae of *T. fumosoavellaneum* (Romell) Rajchenb. & Bianchin. The first molecular study on *Trichaptum* by Hibbet & Binder (2002) confirmed that the genus nested in the so called Hymenochaetoid clade close to *Hyphodontia* J. Erikss./*Schizopora* Velen.

Taxonomic and phylogenetic studies of *Trichaptum* have been carried out using the ITS sequence only and morphological characteristics (Dai et al. 2008, 2009b, 2012, Gibertoni et al. 2011, Zhou et al. 2016, Vlasák & Vlasák 2017, Kossmann et al. 2021). Recently, some mycologists mentioned that taxa of *Trichaptum s.l.* formed more than two lineages (Vlasák & Vlasák 2017, Kossmann et al. 2021). However, because of a limited number of species and samples, a multi-gene phylogeny based on a comprehensive dataset of *Trichaptum s.l.* had not been performed. Therefore, *Trichaptum s.l.* was still treated a member of Hymenochaetales as *incertae sedis*. So far, eight families are accepted in the Hymenochaetales, viz., Chaetoporellaceae, Coltriciaceae, Hymenochaetaceae, Hyphodontiaceae, Neoantrodiellaceae, Nigrofomitaceae, Oxyporaceae and Schizoporaceae. Kossmann et al. (2021) mentioned that *Trichaptum s.l.* may be a member of Nigrofomitaceae, but this was not supported by sufficient morphological evidence. So, the status of the genus at family level is not settled.

Hennig (1966) firstly proposed divergence times as a universal criterion for taxa ranking, and suggested that a taxonomic rank should reflect its geological age, and divergence time could be used as a universally standardized criterion in the systematics of all known organisms. With the advances of molecular techniques and analytical methods, the estimation of organism divergence times has now become feasible (Robinson & Robinson 2001, Drummond et al. 2006, 2012). Although molecular clock analysis has been used in biogeographic and phylogeographic studies (Hickerson et al. 2010, Zhao et al. 2013, Stefani et al. 2014), it has not been used in taxonomic ranking. Several recent reports have established divergence times for the fungi. For example, the Basidiomycota was estimated to have evolved during the Palaeozoic, around 500 million years (Mya) ago, and is a sister group to the Ascomycota being of similar age (Berbee & Taylor 2010, Oberwinkler 2012, Hibbett 2014). The Agaricomycetes diverged ca. 290 Mya (Floudas et al. 2012). The ages of some groups within the Agaricomycetes, such as the Boletales (Skrede et al. 2011, Wilson et al. 2012), Agaricales (Matheny et al. 2009, Ryberg & Matheny 2012), and brown-rot lineages (Garcia-Sandoval et al. 2011) have also been estimated, as were fungal epiphytes (Hongsanan et al. 2016). The first attempt at establishing a taxonomic system for the fungi based on divergence time was a reconstruction of a taxonomic system for *Agaricus* (Zhao et al. 2016). These authors produced a multigene phylogeny based on combined ITS, nLSU, TEF1, and RPB2 sequence data. Divergence times within the multigene phylogeny were calculated and used to standardize the ranking of taxa into subgenera and sections. Zhao et al. (2016) proposed that taxa above species level could be distinguished if the following criteria are met: (I) they must be monophyletic and statistically well-supported in the molecular dating analyses; (II) their respective stem ages should be roughly equivalent, and higher taxa stem ages must be older than lower-level taxa stem ages; and (III) they should be identifiable phenotypically. Based on those criteria some subgenera or sections were split or rejected, and new ones were discovered and named.

In cladistics, a lineage consists of a stem and a crown group. The stem group refers to those of origin, which may include not only the most recent common ancestor of all of its members and their descendants, but also extinct lineages. The crown group comprises the last common ancestor of a living clade, plus all of its descendants (Budd & Jensen 2000, Budd 2001). The concepts of stem and crown age refer to different points in time in the evolutionary history of a group of organisms. Because the crown age represents the point at which the group began to diversify and evolve into its current forms, it is always younger than the stem age. The stem age represents the entire history of the group, including the period of time before it became a recognizable entity, while the crown age represents only the part of that history that led to the living members of the group. (Stadler et al. 2014). Some researchers have determined that the length of the branch between the stem ancestor and the crown clade depends on factors such as the timescale, the net diversification rate, and the species richness of the clade (McPeek & Brown 2007, Stadler et al. 2014).

The taxonomic units at the same rank, especially higher ranks, should have roughly equivalent stem ages, and overlap between the ranges of different ranks should be minimized (Liu et al. 2017, Zhao et al. 2017, He et al. 2019). Moreover, excluding mass extinction events that are unknown for fungi, the crown group emerges just before the extinction of the stem group (Budd & Mann 2020), which indicates the higher the richness of existing species, the closer the crown age and stem age, and the crown age can better represent the formation time of the species. Conversely, if the number of existing species is less, the degree of discovery is less, and the gap between crown age and stem age is larger, the stem age can more accurately reflect the formation time of species.

In the current fungal systematics, the choice of crown or stem has always been controversial (Liu et al. 2017, Zhao et al. 2017, He et al. 2019, Wang et al. 2021). In our study, it is believed that stem age represents the earliest time of group emergence at the level of family, which is more convincing for the analysis of the evolutionary path of a species, while crown age represents the latest evolutionary time of a living species, which should also be considered when establishing new taxa. Therefore, we use stem age as the evolutionary time of taxa, and crown age also should be considered to support the establishment of new taxa.

Lücking (2019) argued that temporal banding should not be employed in an absolute manner, but rather as a tool complementing assessments of phenotypic disparity and differential diagnoses at given rank levels. We agree with this opinion, and believe that the determination of new taxa should be based on the combination of phylogeny, morphological characteristics and divergence time estimation.

Recently, molecular biogeographical studies have provided important insights into the histories of "species" range changes (Hosaka et al. 2008, Skrede et al. 2011, Zhao et al. 2016), and several studies have focused on fungal phylogeny, divergence time estimation, biogeographic distribution and geological events (Floudas et al. 2012, Cai et al. 2014, Chen et al. 2015, Song & Cui 2017, Wang et al. 2021, Zhao et al. 2022). However, such studies on *Trichaptum s.l.* have not yet been carried out.

So far, *Trichaptum* is a cosmopolitan genus with 32 accepted species (Ryvarden & Johansen 1980, Corner 1987, Gilbertson & Ryvarden 1987, Ryvarden & Gilbertson 1994, Núñez & Ryvarden 2001, Ryvarden & Iturriaga 2003, Ryvarden 2014) with ten species reported from China (Dai & Cui 2008). In this study, we aimed to investigate the diversity and taxonomy of *Trichaptum* *s.l.* based on 625 samples from around the world. Combined with the sequences of the type specimen or specimens from type localities in GenBank, a total of 256 samples in *Trichaptum s.l.* with available DNA sequences was involved in the phylogenetic analyses based on a combined sequence dataset of ITS+nLSU+mt-SSU+nuc-SSU+TEF1.

Materials & Methods

Morphological studies

625 samples of *Trichaptum s.l.* from East and South Asia, Europe, South, North and Central America, Africa and Australia were studied. These materials are preserved in the herbaria of Beijing Forestry University (BJFC), the Institute of Applied Ecology of the Chinese Academy of Sciences (IFP), the private herbarium of Josef Vlasák (JV), the National Museum Prague (PRM), the University of Oslo (O), the Estonian University of Life Sciences (TAA), the Southwest Forestry University of China (SWFC), the Connecticut Agricultural Experiment Station Valley Laboratory (NHES), the Seoul National University Fungus Collection (SFC), and the Royal Botanic Gardens Victoria (MEL). Macro-morphological descriptions are based on field notes and voucher herbarium specimens. Micro-morphological data were obtained from dried specimens and observed under a compound microscope following Dai (2010) and Li et al. (2014). Sections were studied at a magnification of up to 1000× using a Nikon E80i microscope and phase contrast illumination (Nikon, Tokyo, Japan). Line drawings were made with the aid of a drawing tube. Microscopic measurements and drawings were made from slides prepared from voucher tissues and stained with Cotton Blue and Melzer's reagent. The following abbreviations are used: KOH = 5% potassium hydroxide; CB = Cotton Blue; CB+ = cyanophilous in Cotton Blue; CB– = acyanophilous in Cotton Blue; IKI = Melzer's reagent; IKI– = neither amyloid nor dextrinoid in Melzer's reagent; L = mean basidiospore length (arithmetic average of basidiospores); W = mean basidiospore width (arithmetic average of basidiospores); Q = variation in the L/W ratios between specimens studied; n (a/b) = number of basidiospores (a) measured from the given number of specimens (b). In presenting basidiospore size variation, 5% of measurements were excluded from each end of the range and these values are given in parentheses. Special color terms follow Anonymous (1969) and Petersen (1996).

Figs 1–3 show some important types of pileal surfaces and hymenophores.

DNA Extraction and Sequencing

A Cetyltrimethyl Ammonium Bromide (CTAB) rapid plant genome extraction kit-DN14 (Aidlab Biotechnologies Co., Ltd, Beijing, China), AccuPrep Genomic DNA Extraction Kit (Bioneer, Daejeon, Korea), and FH plant DNA kit II (Demeter Biotech Co., Ltd., Beijing, China) were used to extract total genomic DNA from dried specimens and to perform the polymerase chain reaction (PCR) according to the manufacturer's instructions with some modifications. The Internal transcribed spacer (ITS) regions were amplified with primer pairs ITS5 (GGA AGT AAA AGT CGT AAC AAG G) and ITS4 (TCCTCC GCT TAT TGA TAT GC) (White et al. 1990). The nuclear large subunit rDNA (nLSU) regions were amplified with primer pairs LR0R (ACC CGC TGA ACT TAA GC) and LR7 (TAC TAC CAC CAA GAT CT) (Vilgalys & Hester 1990). The translation elongation factor 1 (TEF1) regions were amplified with primer pairs EF1-983F (GCY CCY GGH CAY CGT GAY TTY AT) and EF1-1567R (ACH GTR CCR ATA CCA CCR ATC TT) (Rehner & Buckley 2005). The mitochondrial small subunit rDNA (mt-SSU) regions were amplified with primer pairs MS1 (CAG CAG TCA AGA ATA TTA GTC AAT G) and MS2 (GCG GAT TAT CGA ATT AAA TAA C) (White et al. 1990). The nuclear small subunit rDNA (nuc-SSU) regions were amplified with primer pairs NS1 (GTA GTC ATA TGC TTG TCT C) and NS4 (CTT CCG TCA ATT CCT TTA AG) (White et al. 1990). The final PCR volume was 30 μL; each tube contained 1 μL of each primer, 1 μL extracted DNA, 12 μL ddH2O and 15 μL 2 × EasyTaq PCR Supermix (TransGen Biotech Co., Ltd., Beijing, China). PCRs were performed on S1000™ Thermal Cycler (Bio-Rad Laboratories, California, USA).

The PCR cycling schedule for ITS, TEF1 and mt-SSU included an initial denaturation at 95 °C for 3 min or 94 °C for 2 min, followed by 35 cycles at 94 °C for 40 s, 54 °C (mt-SSU), 54–58 °C (ITS) and 58 °C (TEF1) for 45 s and 72 °C for 1 min, and a final extension of 72 °C for 10 min. The PCR cycling schedule for nLSU and nuc-SSU included an initial denaturation at 94 °C for 1 min, followed by 35 cycles at 94 °C for 30 s, 50 °C (nLSU), 53 °C (nuc-SSU) for 1 min and 72 °C for 1.5 min, and a final extension of 72 °C for 10 min.

The PCR products were purified with a gel extraction and PCR purification combo kit (spin-column) in Beijing Genomics Institute, Beijing, P.R. China. The purified products were then sequenced on an ABI-3730-XL DNA analyzer (Applied Biosystems, Foster City, CA, USA) using the same primers as in the original PCR amplifications. The sequence quality was checked following Nilsson et al. (2012). All newly generated sequences were submitted to GenBank.

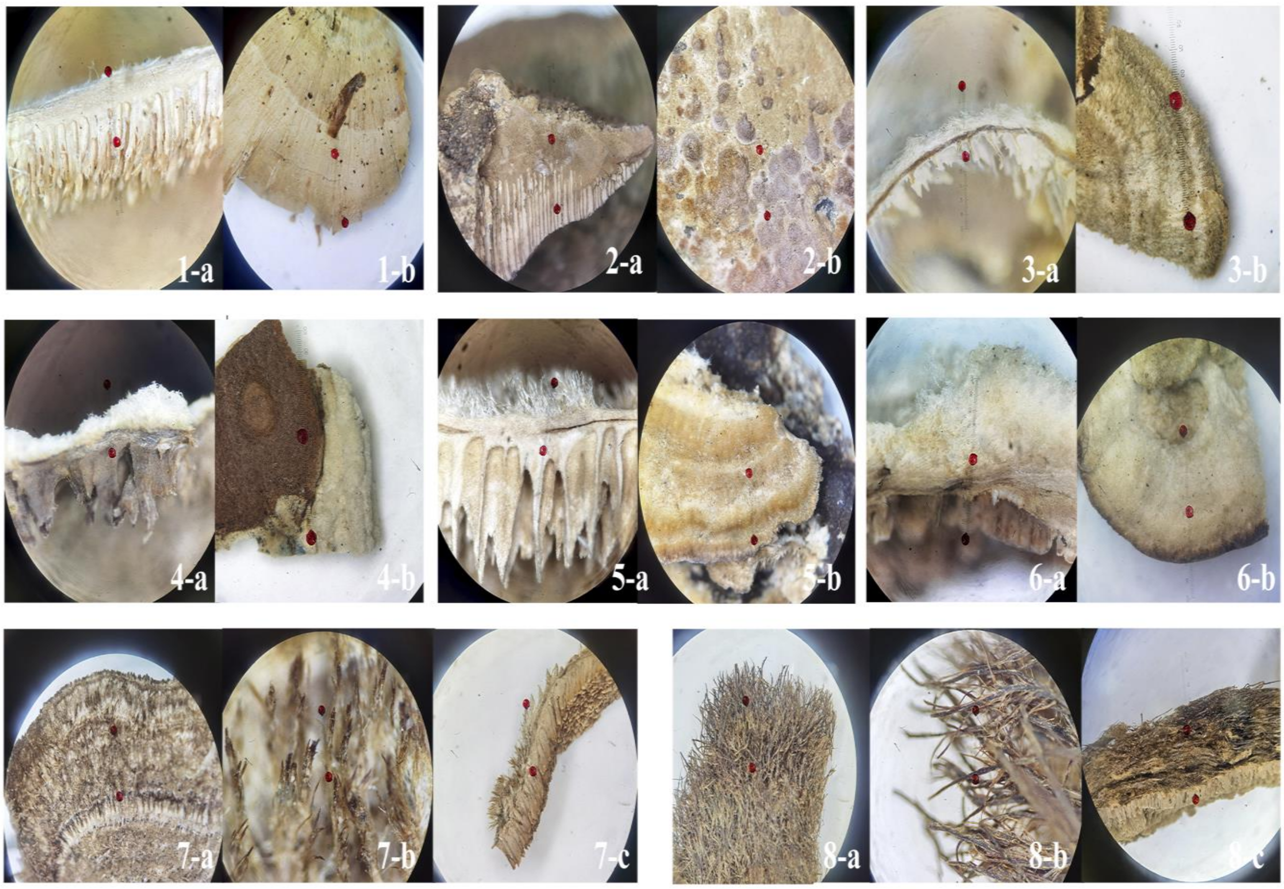

Figure 1 – Types of pileal surfaces (photos). 1 Smooth, section (1-a) and upper surface (1-b) of *Pallidohirschioporus brastagii*. 2 Warted, section (2-a) and upper surface (2-b) of *Perennihirschioporus perennis*. 3 Adpressed-velutinate, section (3-a) and upper surface (3-b) of *Hirschioporus chinensis*. 4 Velutinate, section (4-a) and upper surface (4-b) of *H. floridanus*. 5 Villose, section (5-a) and upper surface (5-b) of *Pallidohirschioporus versicolor*. 6 Pubescent, section (6-a) and upper surface (6-b) of *H. pubescens*. 7 Hispid, upper surface (7-a), hairs (7-b) and section (7-c) of *Trichaptum byssogenum*. 8 Strigose, upper surface (8-a), hairs (8-b) and section (8-c) of *T. perrottetii*. Scale bars: 1-b, 2-a–2-b, 3-b, 4-b, 5-b, 6-a–6-b, 7-a,7-c, 8-a,8-c = 5 mm, 1-a, 3-a, 4-a, 5-a, 7-b, 8-b = 1 mm. Red dots = bar.

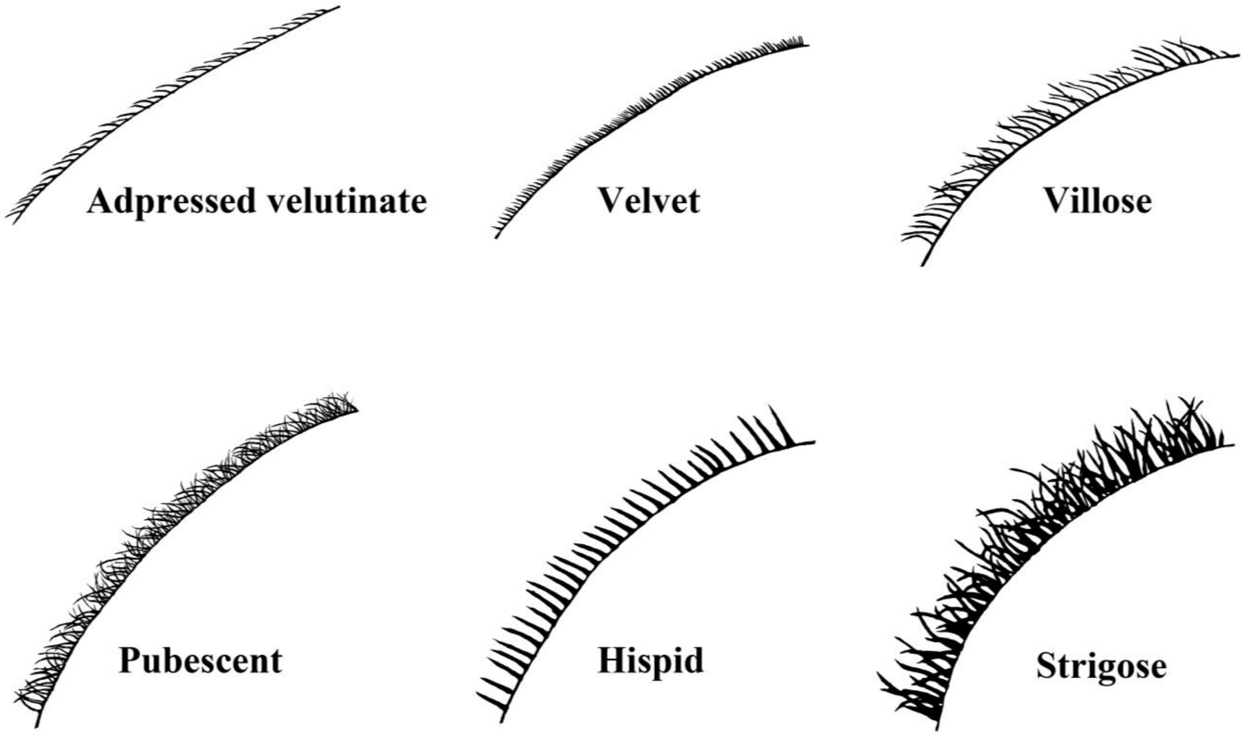

Figure 2 – Types of pileal surfaces (drawings).

Figure 3 – Types of hymenophores (photos). 1 Poroid, 1-a: *Hirschioporus abietinus*, 1-b: *H. montanus*. 2 Irpicoid, 2-a: "*H. fuscoviolaceus*", 2-b: *Pallidohirschioporus versicolor*. 3 Hydnoid, 3-a, b: "*H. fuscoviolaceus*". 4 Daedaleoid, 4-a, b: *Perennihirschioporus daedaleus*. 5 Sublamellate, 5-a: *H. acontextus*, 5-b: "*H. fuscoviolaceus*". 6 Lamellate, 6-a, b: *Pesudotrichaptum laricinum.* Scale bars: 3-a, b, 4-a, b = 5 mm, 6-a, b = 1 mm. Red dots = bar.

Phylogenetic analyses

The sequences used in this study were ITS, nLSU, mt-SSU, nuc-SSU and TEF1. The sequences used for each fragment are shown in Table 1. Additional sequences downloaded from GenBank (Table 1) were mostly from type specimens or specimens from the type locality, and most of these sequences have been used in previous published studies (Vlasák & Vlasák 2017, Kossmann et al. 2021, Wang et al. 2021). All sequences of these five gene segments were respectively aligned within MAFFT version (v.) 7 (Katoh & Standley 2013; http://maft.cbrc.jp/alignment/server/) and ClustalX v. 1.83 (Thompson et al. 1997), followed by manually proofreading in BioEdit v. 7.0.9 (Hall 1999). Alignments were spliced in Mesquite (Maddison & Maddison 2017) before phylogenetic analyses. The partition homogeneity test (PHT) (Farris et al. 1994) of the five-gene dataset was tested by PAUP v. 4.0b10 (Swofford 2002) under 1000 homogeneity replicates.

jModeltest v. 2.17 was used to determine the best-fit evolution model of the combined dataset (Darriba et al. 2012). Four unique partitions were established, GTR+I+G was selected substitution model for each partition. Maximum Likelihood (ML) and Bayesian Inference (BI) were employed to perform phylogenetic analyses of these datasets. The ML analyses were performed in RAxML v. 8.2.12 (Stamatakis 2014) for both datasets with the GTR+I+G model of site substitution, including estimation of Gamma-distributed rate heterogeneity and a proportion of invariant sites (Stamatakis 2006). Statistical support values (BS) were obtained using nonparametric bootstrapping with 1000 replicates (Hillis & Bull 1993).

The BI was calculated with MrBayes v. 3.2.6 (Ronquist et al. 2012) in two independent runs, each of which had four chains and started from random trees (Ronquist & Huelsenbeck 2003). Trees were sampled every 100 generations. The first 25% of sampled trees were discarded as burn-in, whereas other trees were used to construct a 50% majority consensus tree and for calculating Bayesian Posterior Probabilities (BPP).

The two methods produced nearly congruent topologies for each alignment. Therefore, only the topology generated from the ML analysis is presented along with the BS values and BPP, simultaneously at the nodes. Phylogenetic trees were visualized using FigTree v. 1.4.4 (Rambaut 2018). Branches that received bootstrap support for Maximum likelihood (BS) and Bayesian posterior probabilities (BPP), ≥ 75% for BS and 0.95 for BPP were considered as significantly supported. The final alignments and the retrieved topologies were deposited in TreeBASE (http://www.treebase.org), under accession ID: 30159.

Finally, four data matrices were compiled for different analyses.

Dataset I: The combined dataset of ITS, nLSU, mt-SSU, nuc-SSU and TEF1 regions was used to differentiate the species of studied specimens belonging to *Trichaptum s.l.* All vouchers belonging to *Trichaptum s.l.* are listed in Table 1 and samples of *Coltricia* were used as outgroups.

Dataset II: The combined dataset of ITS, nLSU, mt-SSU and TEF1 regions was used to explore the phylogenetic relationships of *Trichaptum s.l.* members and other main lineages within the Hymenochaetales. All vouchers and sequences of Hymenochaetales, Polyporales and Thelephorales are listed in Table 1 and a sample of *Lenzitopsis daii* L.W. Zhou & Kõljalg was included as an outgroup following Wang et al. (2021).

Dataset III: The combined dataset of ITS, nLSU and TEF1 regions was used to infer the divergence times of taxa within the Hymenochaetales. The vouchers and sequences of (described or undescribed) species available in the families of the Hymenochaetales and all main lineages in the Basidiomycota were included. *Neurospora crassa* (Ascomycota) was designated as an outgroup. Sequences of all specimens used for the divergence time estimation are listed in Tables 1–2.

Dataset IV: The combined dataset of ITS, nLSU and TEF1 regions was used to reconstruct historical biogeography and ancestral areas.

According to studies of phylogenetic and divergence time estimation, each taxon selects a sequence sample with a confirmed taxonomic position to represent the species within *Trichaptum s.l.*, and *Neoantrodiella gypsea* was designated as an outgroup. All samples included in the divergence time estimation analysis are listed in Table 2.

Table 1 Taxa used in phylogenetic analyses of *Trichaptum s.l.* and Hymenochaetales.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	nLSU	mt-SSU	TEF1	nuc-SSU
Cantharellales/ Hydnaceae	*Repetobasidium conicum*	KHL 12338	USA	DQ873647	DQ873647	–	–	–
Hymenochaetales/ Chaetoporellaceae	*Kneiffiella abieticola*	KHL 12498	Sweden	DQ873601	DQ873601	–	–	–
Hymenochaetales/ Chaetoporellaceae	*Kneiffiella barba-jovis*	KHL 11730	Sweden	DQ873609	DQ873610	–	–	–
Hymenochaetales/ Chaetoporellaceae	*Kneiffiella eucalypticola*	LWZ 20180509-11*	China	MT319410	MT319142	MT326421	–	–
Hymenochaetales/ Coltriciaceae	*Coltricia perennis*	Cui 10319	China	KU360687	KU360653	–	KY693935	–
Hymenochaetales/ Coltriciaceae	*Coltriciella dependens*	Dai 10944	China	KY693737	KY693757	–	–	–
Hymenochaetales/ Hymenochaetaceae	*Fomitiporia hartigii*	MUCL 53551	Estonia	JX093789	JX093833	–	JX093746	–
Hymenochaetales/ Hymenochaetaceae	*Fomitiporia hartigii*	Cui 9914	China	KY750527	MT319381	MT326559	–	–
Hymenochaetales/ Hymenochaetaceae	*Fomitiporia pseudopunctata*	AFTOL 688	–	AY854080	AY684157	–	AY885149	AY864870
Hymenochaetales/ Hymenochaetaceae	*Inonotus hispidus*	LWZ 20180703-1	China	MT332137	MT319383	MT326506	–	–
Hymenochaetales/ Hymenochaetaceae	*Onnia tomentosa*	Cui 10048	China	MT332141	MT319387	MT326561	–	–
Hymenochaetales/ Hymenochaetaceae	*Phellinus piceicola*	Cui 10440	China	JQ828908	MT319389	MT326563	–	–
Hymenochaetales/ Hymenochaetaceae	*Porodaedalea chinensis*	Cui 10252	China	KX673606	MH152358	–	KX852283	–
Hymenochaetales/ Hymenochaetaceae	*Porodaedalea pini*	FP-102122-T	USA	JX110036	JX110080	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	CBS 220.53	France	MH857166	MH868702	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	CBS 221.53	France	MH857167	MH868703	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Cui 2641	China	OQ449095	–	–	–	OQ449407
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Cui 2667	China	OQ449096	OQ449033	–	OQ831431	OQ449408
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Cui 6561	China	OQ449097	–	OQ517074	OQ831433	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Dai 12337	China	OL504712	OL477386	OQ517075	OQ831434	OQ449409
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Dai 23760	China	OQ449039	OQ449034	OQ517076	–	OQ449410
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Dai 23771	China	OQ449040	OQ449035	OQ517077	–	OQ449411
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Dai 23774	China	OQ449041	OQ449036	OQ517078	–	OQ449412
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Dai 23790	China	OQ449042	OQ449037	–	–	OQ449413

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	**nLSU**	**mt-SSU**	**TEF1**	**nuc-SSU**
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Dai 23792	China	OQ449043	OQ449038	OQ517079	–	OQ448998
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	Dai 1	Finland	OQ449044	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	FSU 2734	Germany	EU484271	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	JV 0907/ 9	Czech	MF381023	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus abietinus*	KUC 20130719-05	Republic of Korea	KJ668437	KJ668289	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	BFOTU23	Finland	AM901859	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Cui 17503	China	OQ449045	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Cui 9627	China	OQ449046	OQ449184	OQ517080	–	OQ448999
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 11338	China	OQ449047	–	OQ449110	OQ831435	OQ449000
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 18909	China	OQ449048	OQ449185	OQ449111	OQ831436	OQ449001
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 18952	China	OQ449049	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 19105	China	OQ449050	OQ449186	OQ449112	–	OQ449002
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 19307	China	OQ449051	–	–	OQ831437	OQ449003
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 20301	China	OQ449052	OQ449187	OQ449113	–	OQ449004
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 20942	China	OQ449053	OQ449188	OQ449114	–	OQ449005
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 22307	China	OQ449054	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 22963	China	OQ512027	OQ504477	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 22964	China	OQ449055	OQ449189	OQ449115	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23246	China	OQ449056	OQ449190	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23255	China	OQ449057	OQ449191	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23345	China	OQ449058	OQ449192	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23403	China	OQ449129	OQ449193	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23542	China	OQ449130	OQ449194	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23763	China	OQ449131	OQ449195	OQ449116	–	OQ449006
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23777	China	OQ449132	–	OQ449117	–	OQ449007
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 23956	China	OQ449133	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 24005	China	OQ449134	OQ449196	OQ449118	OQ831438	–
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 24212	China	OQ449135	OQ449197	OQ449119	–	OQ449008
Hymenochaetales/ Hirschioporaceae	*“Hirschioporus abietinus”*	Dai 24306	China	OQ449136	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus acontextus*	Cui 11451	China	OQ449137	–	–	–	OQ449009
Hymenochaetales/ Hirschioporaceae	*Hirschioporus acontextus*	Cui 11830	China	OQ449138	OQ449198	OQ449120	–	OQ449010
Hymenochaetales/ Hirschioporaceae	*Hirschioporus acontextus*	Cui 12067	China	OQ449139	–	OQ449121	OQ831432	OQ449011
Hymenochaetales/ Hirschioporaceae	*Hirschioporus acontextus*	Dai 19097	China	OQ449140	OQ449199	OQ449122	–	OQ449012
Hymenochaetales/ Hirschioporaceae	*Hirschioporus acontextus*	Dai 23793*	China	OQ449141	OQ449200	OQ449123	OQ831439	OQ449013

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	**nLSU**	**mt-SSU**	**TEF1**	**nuc-SSU**
Hymenochaetales/ Hirschioporaceae	*Hirschioporus acontextus*	KUC 20131001-03	Republic of Korea	KJ668436	KJ668288	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus beijingensis*	Dai 18907	China	OQ449142	OQ449201	OQ449124	OQ831440	OQ449014
Hymenochaetales/ Hirschioporaceae	*Hirschioporus beijingensis*	Dai 23704*	China	OQ449143	OQ449202	OQ449125	OQ831441	OQ449015
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Cui 17530	China	OQ449144	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Cui 18435	China	OQ449145	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Cui 2488	China	OQ449146	–	OQ449126	OQ831442	OQ449016
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 18550A	China	OQ449147	OQ449203	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 19107	China	OQ449148	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 19110	China	OQ449098	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 19111*	China	OQ449099	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 19115	China	OQ449100	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 20264	China	OQ449101	OQ449204	OQ449127	OQ831443	OQ449017
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 21116	China	OQ437348	OQ438001	OQ448978	OQ831444	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 23048	China	OQ437349	OQ438002	OQ448979	OQ831445	OQ438032
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 23291	China	OQ437350	OQ438003	OQ448980	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 6455	China	OQ437351	–	–	OQ831446	OQ438033
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Dai 6921	China	OQ437352	–	–	OQ831447	OQ438034
Hymenochaetales/ Hirschioporaceae	*Hirschioporus chinensis*	Y2618	China	OQ437353	–	OQ448981	OQ831448	OQ438035
Hymenochaetales/ Hirschioporaceae	*Hirschioporus floridanus*	Dolliner 640	USA	OQ437354	–	–	–	OQ438036
Hymenochaetales/ Hirschioporaceae	*Hirschioporus floridanus*	Dolliner 642*	USA	OQ437355	OQ438004	–	–	OQ438037
Hymenochaetales/ Hirschioporaceae	*Hirschioporus floridanus*	MC1	USA	MW795372	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 20987	Belarus	OQ437356	OQ438005	OQ448982	–	OQ438038
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 20988	Belarus	OQ437357	OQ438006	OQ448983	OQ831449	OQ438039
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 21008	Belarus	OQ437358	OQ438007	OQ448984	–	OQ438040
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 21011	Belarus	OQ437359	OQ438008	OQ448985	OQ831450	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 21021	Belarus	OQ437360	OQ438009	OQ448986	OQ831451	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	JV 1610/ 32	Czech	MF381026	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Cui 10439	China	OQ437361	OQ438010	OQ448987	OQ831452	OQ438041

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	**nLSU**	**mt-SSU**	**TEF1**	**nuc-SSU**
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Cui 11870	China	OQ437362	OQ438011	OQ448988	–	OQ438042
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Cui 8850	China	OQ437363	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Cui17609	China	OQ437364	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 10576	China	OQ437365	–	–	OQ831453	OQ438043
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 15431	China	OQ437366	–	–	OQ831454	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 21636	China	OQ437367	OQ438012	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 22771	China	OQ437368	OQ438013	–	–	OQ438044
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 6031	China	OQ437369	–	–	OQ831455	OQ438045
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	Dai 7196	China	OQ437370	–	–	OQ831456	OQ438046
Hymenochaetales/ Hirschioporaceae	*Hirschioporus fuscoviolaceus*	V. Haikonen 25849	Finland	MF319119	MF318985	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Cui 10733	China	OQ438012	OQ438014	OQ448989	OQ874780	OQ438047
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Cui 17067	China	OL470322	OL462836	OQ448990	OQ857931	OQ438048
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Dai 22979	China	OQ437372	OQ438015	OQ448991	OQ857932	OQ438049
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Dai 23134	China	OQ437373	–	OQ448992	OQ857933	OQ438050
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Dai 23143	China	OQ437374	OQ438016	OQ448993	OQ857934	OQ438051
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Dai 24196	China	–	–	OQ448994	OQ857935	OQ449149
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Dai 4189	China	OQ437375	OQ438017	OQ448995	OQ857936	OQ449150
Hymenochaetales/ Hirschioporaceae	*Hirschioporus montanus*	Dai 4204	China	OQ437376	OQ438018	OQ448996	OQ857937	OQ449151
Hymenochaetales/ Hirschioporaceae	*Hirschioporus pubescens*	Dai 17064*	China	OQ437377	OQ438019	OQ448997	–	OQ449152
Hymenochaetales/ Hirschioporaceae	*Hirschioporus pubescens*	Dai 19211	China	OQ437378	OQ438020	–	OQ857938	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus pubescens*	Dai 23710	China	OQ512026	OQ449059	OQ449169	OQ857930	OQ449153
Hymenochaetales/ Hirschioporaceae	*Hirschioporus pubescens*	KA17-0228	Republic of Korea	MN294864	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus* sp.	UBCF20347	Canada	KC581332	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus* sp.	UBCF28393	Canada	KP454016	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Cui 16849	China	OQ437379	OQ449060	OQ449170	OQ857939	OQ449154

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	nLSU	mt-SSU	TEF1	nuc-SSU
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Cui 16850	China	OQ437380	–	OQ449171	OQ857940	OQ449155
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Cui 18779	China	OQ437381	OQ449061	–	OQ857941	OQ449156
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Cui 19235	China	OQ437382	OQ449062	OQ449172	OQ857942	OQ449157
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 15944	China	OQ437383	OQ449063	OQ449173	OQ857943	OQ449158
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 19055	China	OQ437384	OQ449064	OQ449174	OQ857944	OQ449159
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 19057	China	OQ437385	OQ449065	OQ449175	OQ857945	OQ449160
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 19064	China	OQ437386	OQ449066	OQ449176	OQ857946	OQ449161
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 19067*	China	OQ448960	OQ449067	OQ449177	OQ857947	OQ449162
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 19076	China	OQ448961	OQ449068	OQ449178	OQ857948	OQ449163
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 19085	China	OQ448962	OQ449069	–	–	–
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	Dai 19086	China	OQ448963	OQ449070	OQ449179	OQ857949	OQ449164
Hymenochaetales/ Hirschioporaceae	*Hirschioporus tianschanicus*	KA16-1050	Kyrgyzstan	MK351689	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus bulbocystidiatus*	Ryvarden 42922*	Costa Rica	OQ448964	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus confertus*	JV 1407/ 75*	Costa Rica	MF380988	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus confertus*	JV 1504/ 101	Costa Rica	MF380992	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus confertus*	JV 1504/ 32	Costa Rica	MF380991	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus deviatus*	Ryvarden 46959*	Venezuela	OQ476081	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Cui 11327	China	OQ448965	OQ449071	OQ449180	OQ874781	OQ449165
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Cui 8350	China	OQ448966	–	–	OQ857950	OQ449166
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Cui 8353	China	OQ448967	–	–	–	–

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	nLSU	mt-SSU	TEF1	nuc-SSU
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Cui 8807	China	OQ448968	OQ449072	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Dai 12305	China	OQ448969	OQ449073	–	OQ857951	OQ449167
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Dai 18419	Vietnam	OQ448970	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Dai 19497	Sri Lanka	OQ448971	OQ449074	OQ449181	OQ857952	OQ449168
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Dai 19498	Sri Lanka	OQ448972	OQ449075	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Dai 19640	Sri Lanka	OQ476082	OQ504233	OQ512031	OQ857953	OQ512030
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	Dai 20642	China	OL470321	OL462835	OQ463070	OQ857954	OQ449103
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	He 20120724-11	China	OQ448973	OQ449076	OQ463071	OQ857955	OQ449104
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus durus*	He 20120726-2	China	OQ448974	OQ449077	OQ463072	OQ857956	OQ449105
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus fissilis*	TKC 145	Brazil	MK973088	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus fissilis*	TKC 99*	Brazil	MK973089	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus griseofuscus*	B3942	Brazil	OQ448975	OQ438022	–	OQ857957	OQ449106
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus griseofuscus*	JV 1808/ 103	French Guiana	OQ448976	OQ438023	OQ449182	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus griseofuscus*	JV 1808/ 27	French Guiana	OQ448977	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus griseofuscus*	JV 1909/ 6	French Guiana	OQ437343	OQ438024	–	OQ857958	OQ449107
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus sector*	AS 2707	Brazil	OQ437344	OQ438025	OQ449183	OQ857959	OQ449108
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus sector*	B3799	Brazil	OQ437345	OQ438026	–	OQ857960	OQ449109
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus sector*	Dolliner 897	USA	OQ437346	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus sector*	JV 1408/ 8-J	Costa Rica	OQ437347	OQ438027	–	OQ857961	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus sector*	JV 1504/ 61	Costa Rica	OQ453302	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus sector*	JV 1704/ 50	Costa Rica	OQ453303	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus sector*	JV 1808/ 108	French Guiana	OQ453304	OQ453531	OQ453509	–	OQ453485
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus* sp.	JV 0904/ 66-J	USA	MF381009	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus submurinus*	Dai 18392*	Vietnam	OQ453305	OQ453532	–	–	OQ453486
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus trimiticus*	B3471	Brazil	OQ453306	OQ453533	–	OQ857962	–
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus trimiticus*	B4105	Brazil	OQ453307	OQ453534	OQ453510	OQ857963	OQ453487
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus trimiticus*	B696*	Brazil	OQ453308	OQ453535	–	–	OQ453488

Table 1 Continued.

Order/ family	**Species**	**Voucher**	**Locality**	**GenBank Accession No.**				
				ITS	**nLSU**	**mt-SSU**	**TEF1**	**nuc-SSU**
Hymenochaetales/ Hirschioporaceae	*Nigrohirschioporus trimiticus*	RP 63	Brazil	KP859296	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Cui 10728	China	OQ453309	OQ453536	OQ453511	–	OQ453489
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Cui 7213	Japan	OQ453310	OQ453537	–	–	OQ453490
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	CZ 411	China	FJ755247	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 12746	USA	OQ453311	OQ453538	OQ453512	OQ874735	OQ453491
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 12748	China	OQ453312	–	OQ453513	OQ874736	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 14531	China	OQ453313	OQ453539	OQ453514	OQ874737	OQ453492
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 16018	China	OQ453314	OQ453540	OQ453515	OQ874738	OQ453493
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 16061	China	OQ453315	OQ453541	OQ453516	OQ874739	OQ453494
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 16076	China	OQ453316	OQ453542	OQ453517	OQ874740	OQ453495
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 19012	China	OQ453317	OQ453543	OQ453518	–	OQ453496
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 19095	China	OQ453318	OQ453544	OQ453519	OQ874741	OQ453497
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 19099	China	OQ453319	OQ453545	OQ453520	–	OQ453498
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 19104	China	OQ453320	OQ453546	OQ453521	OQ874742	OQ453499
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 19190	China	OQ453321	OQ453547	OQ453522	–	OQ453500
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 19466	China	OQ453223	OQ453548	OQ453523	OQ874743	OQ453501
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 20302	China	OQ453224	OQ453549	OQ453524	–	OQ453502
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 20913	Belarus	OQ453225	OQ453550	OQ453525	OQ874744	OQ453503

Table 1 Continued.

Order/ family	**Species**	**Voucher**	**Locality**	**GenBank Accession No.**				
				ITS	**nLSU**	**mt-SSU**	**TEF1**	**nuc-SSU**
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 20920	Belarus	OQ453226	OQ453282	OQ453526	OQ874745	OQ453504
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 20971	Belarus	OQ453227	OQ453283	OQ453527	–	OQ453505
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 21014	Belarus	OQ453228	OQ453284	OQ453528	OQ874746	OQ453506
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 22922	China	OQ453229	OQ453285	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	He 2146	USA	OQ453230	OQ453286	OQ453529	OQ874747	OQ453507
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Y844	China	OQ453231	–	OQ453530	OQ874748	OQ453508
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus biformis*	Dai 10598	China	OQ449102	OQ449205	OQ449128	–	OQ449018
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Cui 16753	China	OQ453232	OQ453287	OQ453266	–	OQ453244
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 12224	China	OQ453233	OQ453288	OQ453267	–	OQ453245
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 12227	China	OQ453234	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 12316	China	OQ453235	OQ453289	OQ453268	OQ874749	OQ453246
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 18804	Australia	OQ453236	OQ453290	OQ453269	–	OQ453247
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 18808	Australia	OQ453237	OQ453291	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 19417	China	OQ453238	OQ453292	OQ453270	–	OQ453248
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 19784	China	OQ453239	OQ453293	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 20459	China	OQ453240	OQ453294	OQ453271	–	OQ453249
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 20656	China	OQ453241	OQ453295	OQ453272	–	OQ453250
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 22686	China	OQ453242	–	–	–	–

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	nLSU	mt-SSU	TEF1	nuc-SSU
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 22918	China	OQ453243	OQ453296	OQ453273	OQ874750	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 22919	China	OQ453371	OQ453297	OQ453274	OQ874751	OQ453251
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 22921	China	OQ453372	OQ453298	OQ453275	OQ874752	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus brastagii*	Dai 23002	China	OQ453373	OQ453299	OQ453276	OQ874753	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus imbricatus*	Cui 5384	China	OQ453374	–	OQ453277	OQ874754	OQ453252
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Cui 6986	China	OQ453375	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Cui 7028	China	OQ453376	–	–	–	OQ453253
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Dai 14686	China	OQ453377	OQ453300	OQ453278	OQ874756	OQ453254
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Dai 19100	China	OQ453378	OQ453301	OQ453279	OQ874757	OQ453255
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Dai 19101	China	OQ453379	OQ474948	OQ453280	OQ874758	OQ453256
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Dai 19103	China	OQ453380	OQ474949	OQ453281	OQ874759	OQ453257
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Dai 5232	China	OQ453381	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus polycystidiatus*	Dai 5242	China	OQ453382	–	–	–	OQ453258
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus subchartaceus*	CCFC003932	USA	AF266679	–	AF408714	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus subchartaceus*	JV 0509/ 146	USA	MF381010	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	CLZhao 3914	China	MH114919	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	CLZhao 6185	China	MK404522	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Cui 16974	China	OQ453383	OQ474950	OQ534100	–	OQ453259

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	nLSU	mt-SSU	TEF1	nuc-SSU
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Cui 18121	China	OQ453384	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Cui 19701	China	OQ504334	OQ504324	OQ512029	OQ874760	OQ504328
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Dai 19327	China	OQ453385	–	OQ534101	OQ874761	OQ453260
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Dai 19331*	China	OQ453386	OQ474951	–	OQ874762	OQ453261
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Dai 19332	China	OQ453387	OQ474952	OQ534102	OQ874763	OQ453262
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Dai 19366	China	OQ453388	–	OQ534103	OQ874764	OQ453263
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Dai 22844	China	OQ453389	OQ474953	OQ534104	OQ874765	OQ453264
Hymenochaetales/ Hirschioporaceae	*Pallidohirschioporus versicolor*	Dai 22867	China	OQ453390	OQ474954	OQ534105	OQ874766	OQ453265
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus agricola*	JV 1407/ 97	Costa Rica	MF380993	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus agricola*	JV 1504/ 75-J*	Costa Rica	MF380995	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus daedaleus*	Cui 18235	Malaysia	OQ474938	–	OQ534106	OQ874767	OQ450175
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus daedaleus*	Dai 21143*	Malaysia	OQ474939	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus fumosoavellaneus*	JV 1607/ 79-J	Costa Rica	MF381021	–	–	–	–
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus fumosoavellaneus*	JV 2203/ 80	Costa Rica	OQ474940	OQ474955	OQ512028	OQ874768	OQ450176
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus perennis*	Dai 19295	China	OQ474941	OQ474956	–	OQ874779	–
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus variabilis*	B856	Brazil	OQ474942	OQ474957	–	OQ874769	OQ450177
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus variabilis*	Ryvarden 37787	Venezuela	OQ474943	OQ474958	–	–	–
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus variabilis*	JV 1707/ 40-J	Mexico	OQ504335	OQ504325	OQ883911	OQ874770	–

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	**nLSU**	**mt-SSU**	**TEF1**	**nuc-SSU**
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus variabilis*	JV 1909/ 4-J	French Guiana	OQ504336	OQ504326	–	–	OQ450178
Hymenochaetales/ Hirschioporaceae	*Perennihirschioporus variabilis*	Ryvarden 35177*	Venezuela	OQ504337	–	–	–	–
Hymenochaetales/ Hyphodontiaceae	*Hyphodontia alutaria*	KHL 11889	Sweden	DQ873603	–	–	–	–
Hymenochaetales/ Hyphodontiaceae	*Hyphodontia densispora*	LWZ 20170908-5*	China	MT319426	MT319160	MT326431	–	–
Hymenochaetales/ Incertae sedis	*Basidioradulum radula*	AFTOL-ID 451	USA	DQ234537	AY700184	–	–	–
Hymenochaetales/ Incertae sedis	*Blasiphalia pseudogrisella*	Lutzoni 930728-3	–	U66437	U66437	–	–	–
Hymenochaetales/ Incertae sedis	*Fibricium rude*	CBS 339.66	France	MH858815	MH870454	–	–	–
Hymenochaetales/ Incertae sedis	*Gyroflexus brevibasidiatus*	Lutzoni 930826-1	–	U66441	U66441	–	–	–
Hymenochaetales/ Incertae sedis	*Hastodontia halonata*	HHB-17058	Mexico	MK575207	MK598738	–	–	–
Hymenochaetales/ Incertae sedis	*Hastodontia hastata*	KHL 14646	Norway	MH638232	MH638232	–	–	–
Hymenochaetales/ Incertae sedis	*Leifia brevispora*	LWZ 20170820-46	China	MK343469	MT319400	–	–	–
Hymenochaetales/ Incertae sedis	*Loreleia marchantiae*	Lutzoni 930826-1	USA	U66432	U66432	–	–	–
Hymenochaetales/ Incertae sedis	*Odonticium romellii*	1514b	Norway	DQ873639	DQ873639	–	–	–
Hymenochaetales/ Incertae sedis	*Podocarpioporus podocarpi*	Dai 12015	China	OQ449081	–	–	–	OQ449397
Hymenochaetales/ Incertae sedis	*Podocarpioporus podocarpi*	Dai 21986	China	OQ449082	OQ449023	OQ517064	OQ785648	OQ449398
Hymenochaetales/ Incertae sedis	*Pseudotrichaptum laricinum*	ANT242-QFB28749	Canada	MN992532	–	–	–	–
Hymenochaetales/ Incertae sedis	*Pseudotrichaptum laricinum*	Dai 19455	China	–	OQ449019	–	–	OQ449394
Hymenochaetales/ Incertae sedis	*Pseudotrichaptum laricinum*	Dai 19457	China	OQ449078	OQ449020	OQ517061	–	OQ449395
Hymenochaetales/ Incertae sedis	*Pseudotrichaptum laricinum*	Dai 23782	China	OQ449079	OQ449021	OQ517062	–	OQ449396
Hymenochaetales/ Incertae sedis	*Pseudotrichaptum laricinum*	RLG-4665	USA	U63471	–	–	–	–
Hymenochaetales/ Incertae sedis	*Pseudotrichaptum laricinum*	RLG-6936	USA	U63477	–	–	–	–
Hymenochaetales/ Incertae sedis	*Pseudotrichaptum laricinum*	YY 99	China	OQ449080	OQ449022	OQ517063	–	–
Hymenochaetales/ Incertae sedis	*Sidera lunata*	JS 15063	Norway	DQ873593	DQ873593	–	–	–
Hymenochaetales/ Incertae sedis	*Skvortzovia furfuraceum*	KHL 11738	Finland	DQ873648	DQ873648	–	–	–
Hymenochaetales/ Incertae sedis	*Skvortzovia furfurella*	KHL 10180	Puerto Rico	DQ873649	DQ873649	–	–	–
Hymenochaetales/ Incertae sedis	*Sphaerobasidium minutum*	KHL 11714	Finland	DQ873652	DQ873653	–	–	–
Hymenochaetales/ Incertae sedis	*Tubulicrinis globisporus*	KHL 12133	Sweden	DQ873655	DQ873655	–	–	–
Hymenochaetales/ Incertae sedis	*Tubulicrinis hirtellus*	KHL 11717	Finland	DQ873657	DQ873657	–	–	–

Table 1 Continued.

Order/ family	Species	Voucher	Locality	GenBank Accession No.				
				ITS	nLSU	mt-SSU	TEF1	nuc-SSU
Hymenochaetales/ Oxyporaceae	*Bridgeoporus sinensis*	Cui 10013	China	KY131832	KY131891	–	–	–
Hymenochaetales/ Oxyporaceae	*Leucophellinus hobsonii*	Cui 6468	China	KT203288	KT203309	KT203330	–	–
Hymenochaetales/ Oxyporaceae	*Leucophellinus irpicoides*	Yuan 2690	China	KT203289	KT203310	KT203331	–	–
Hymenochaetales/ Oxyporaceae	*Rigidoporus corticola*	Dai 12632	Finland	KF111018	KF111020	KT203334	–	–
Hymenochaetales/ Oxyporaceae	*Rigidoporus ginkgonis*	Cui 5555	China	KT203295	KT203316	KT203336	–	–
Hymenochaetales/ Rickenellaceae	*Cotylidia* sp.	AFTOL-ID 700	–	AY854079	AY629317	–	–	–
Hymenochaetales/ Rickenellaceae	*Peniophorella* sp.	KHL 13164	Estonia	DQ873597	DQ873597	–	–	–
Hymenochaetales/ Rickenellaceae	*Contumyces rosellus*	Redhead 7501	–	U66452	U66452	–	–	–
Hymenochaetales/ Rickenellaceae	*Atheloderma mirabile*	TAA 169235	Estonia	DQ873592	DQ873592	–	–	–
Hymenochaetales/ Rickenellaceae	*Globulicium hiemale*	Hjm 19007	Sweden	DQ873595	DQ873595	–	–	–
Hymenochaetales/ Rickenellaceae	*Rickenella fibula*	AFTOL-ID 486	–	DQ241782	AY700195	–	–	–
Hymenochaetales/ Rickenellaceae	*Rickenella mellea*	Lamoure 74	USA	U66438	U66438	–	–	–
Hymenochaetales/ Schizoporaceae	*Fasciodontia brasiliensis*	MSK-F 7245a	Brazil	MK575201	MK598734	–	–	–
Hymenochaetales/ Schizoporaceae	*Fasciodontia bugellensis*	MSK-F 5548	Belarus	MK575204	MK598736	–	–	–
Hymenochaetales/ Schizoporaceae	*Lyomyces crustosus*	LWZ 20170815-23	China	MT319465	MT319201	MT326446	MT326400	–
Hymenochaetales/ Schizoporaceae	*Lyomyces leptocystidiatus*	LWZ 20170814-14*	China	MT319429	MT319163	MT326512	MT326395	–
Hymenochaetales/ Schizoporaceae	*Lyomyces microfasciculatus*	LWZ 20170820-18	China	MT319451	MT319185	MT326441	MT326387	–
Hymenochaetales/ Schizoporaceae	*Xylodon flaviporus*	LWZ 20150708-1	China	MT319553	MT319277	MT326473	MT326405	–
Hymenochaetales/ Schizoporaceae	*Xylodon heterocystidiatus*	LWZ 20171015-33	China	MT319518	MT319264	MT326466	MT326382	–
Hymenochaetales/ Schizoporaceae	*Xylodon kunmingensis*	LWZ 20170820-41	China	MT319512	MT319259	MT326462	MT326399	–
Hymenochaetales/ Schizoporaceae	*Xylodon nesporii*	LWZ 20171016-12	Vietnam	MT319493	MT319235	MT326455	MT326384	–
Hymenochaetales/ Neoantrodiellaceae	*Neoantrodiella gypsea*	Cui 10372	China	KT203290	MT319396	MT326567	–	–
Hymenochaetales/ Neoantrodiellaceae	*Neoantrodiella gypsea*	Yuan 5589	China	KT203292	KT203313	–	–	–
Hymenochaetales/ Neoantrodiellaceae	*Neoantrodiella thujae*	Dai 5065	China	KT203293	MT319397	MT326568	–	–

Table 1 Continued.

Order/ family	**Species**	**Voucher**	**Locality**	**GenBank Accession No.**				
				ITS	**nLSU**	**mt-SSU**	**TEF1**	**nuc-SSU**
Hymenochaetales/ Nigrofomitaceae	*Nigrofomes melanoporus*	JV 1704/ 39	Costa Rica	MF629835	MF629831	–	–	–
Hymenochaetales/ Nigrofomitaceae	*Nigrofomes melanoporus*	JV 1607/ 82	Costa Rica	MF381027	–	–	–	–
Hymenochaetales/ Nigrofomitaceae	*Nigrofomes sinomelanoporus*	Cui 5277	China	MF629836	MT319398	–	–	–
Hymenochaetales/ Nigrofomitaceae	*Nigrofomes sinomelanoporus*	Dai 16286*	China	MF629839	–	–	–	–
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	Dai 10753	China	OQ449083	OQ449024	OQ517065	–	OQ449399
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	Dai 11543	China	OQ449084	OQ449025	OQ517066	–	OQ449400
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	Dai 15555	China	OQ449085	OQ449026	OQ517067	OQ874771	OQ449401
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	Dai 16758	Thailand	OQ449086	OQ449027	OQ517068	OQ874772	OQ449402
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	Dai 18850	Australia	OQ449087	–	OQ517069	OQ874773	–
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	Dai 18851	Australia	OQ449088	–	OQ517070	–	OQ449403
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	Dai 22342	China	OQ449089	OQ449028	–	–	–
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	E7361	Indonesia	AJ536654	–	–	–	–
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	JV 0411/ 9	Thailand	MF381016	–	–	–	–
Hymenochaetales/ Trichaptaceae	*Trichaptum byssogenum*	JV 1112/ 5-J	Puerto Rico	OQ449090	OQ449029	OQ517071	OQ874774	–
Hymenochaetales/ Trichaptaceae	*Trichaptum perrottetii*	JV 1808/ 101	French Guiana	OQ449091	OQ449030	OQ517072	OQ874775	OQ449404
Hymenochaetales/ Trichaptaceae	*Trichaptum perrottetii*	JV 1908/ 45	French Guiana	OQ449092	OQ449031	–	OQ874776	OQ449405
Hymenochaetales/ Trichaptaceae	*Trichaptum perrottetii*	B2626	Brazil	OQ449093	OQ449032	–	OQ874777	OQ449406
Hymenochaetales/ Trichaptaceae	*Trichaptum perrottetii*	JV 1808/ 53-J	French Guiana	OQ449094	–	–	–	–
Hymenochaetales/ Trichaptaceae	*Trichaptum resacarium*	JV 1109/ 56	USA	MF381020	–	–	–	–
Hymenochaetales/ Trichaptaceae	*Trichaptum resacarium*	JV 1109/ 57*	USA	MF381018	–	–	–	–
Hymenochaetales/ Trichaptaceae	*Trichaptum strigosum*	JV 1012/ 2-J	USA	MF381011	–	OQ517073	OQ874778	–
Polyporales/ Polyporaceae	*Donkioporiella mellea*	LWZ 20140622-12	China	KX258957	KX258955	–	–	–
Polyporales/ Polyporaceae	*Melanoporia nigra*	FP 90875	USA	KC585356	KC585185	–	–	–
Polyporales/ Polyporaceae	*Melanoporia nigra*	JV 1410/ 10-J	USA	KT156694	–	–	–	–
Polyporales/ Polyporaceae	*Trametes versicolor*	ZRL20151477	China	LT716079	KY418903	–	KY419091	–
Thelephorales/ Thelephoraceae	*Lenzitopsis daii*	Yuan 2959*	China	JN169799	JN169795	–	–	–

*: Type sequence

Table 2 Species used in molecular clock analysis besides those indicated in *Trichaptum s.l.*

Order/family	**Species**	**Voucher**	**ITS**	**nLSU**	**TEF1**
Agaricales/ Agaricaceae	*Lepiota cristata*	ZRL20151133	LT716026	KY418841	KY419048
Agaricales/ Strophariaceae	*Gymnopilus picreus*	ZRL2015011	LT716066	KY418882	KY419077
Amylocorticiales/ Amylocorticiaceae	*Anomoloma flavissimum*	Cui 12188	KT954956	KT954970	–
Amylocorticiales/ Amylocorticiaceae	*Amylocorticium cebennense*	HHB 2808	GU187505	GU187561	GU187675
Atheliales/ Atheliaceae	*Athelia arachnoidea*	CBS 418.72	GU187504	GU187557	GU187672
Atheliales/ Atheliaceae	*Leptosporomyces raunkiaeri*	HHB 7628	GU187528	GU187588	GU187719
Auriculariales/ Auriculariaceae	*Auricularia heimuer*	Xiaoheimao	LT716074	KY418890	KY419083
Boletales/ Gomphidiaceae	*Gomphidius roseus*	MB 95-038	DQ534570	DQ534669	GU187702
Boletales/ Suillaceae	*Suillus pictus*	AFTOL 717	AY854069	AY684154	AY883429
Cantharellales/ Clavulinaceae	*Multiclavula mucida*	AFTOL 1130	DQ521417	AY885163	–
Cantharellales/ Hydnaceae	*Hydnum repandum*	BB 07.341	–	KF294643	JX192980
Corticiales/ Corticiaceae	*Corticium roseum*	MG43	GU590877	AY463401	–
Corticiales/ Punctulariaceae	*Punctulariopsis subglobispora*	Hallenberg 12761 (GB)	HM046917	HM046932	–
Corticiales/ Vuilleminiaceae	*Cytidia salicina*	He 4908	MW507083	MW507025	–
Corticiales/ Vuilleminiaceae	*Vuilleminia comedens*	Hallenberg 12314 (GB)	HM046898	AY586725	–
Dacrymycetales/ Dacrymycetaceae	*Calocera cornea*	AFTOL 438	AY789083	AY701526	AY881019
Geastrales/ Geastraceae	*Pyrenogaster pityophilus*	OSC 59743	–	DQ218519	DQ219232
Geastrales/ Geastraceae	*Geastrum recolligens*	OSC 41996	–	DQ218486	DQ219230
Gloeophyllales/ Gloeophyllaceae	*Gloeophyllum sepiarium*	Wilcox-3BB	HM536091	HM536061	HM536110
Gloeophyllales/ Gloeophyllaceae	*Gloeophyllum striatum*	ARIZAN 027866	HM536092	HM536063	HM536111
Gomphales/ Gomphaceae	*Ramaria rubella*	AFTOL 724	AY854078	AY645057	AY883435
Gomphales/ Gomphaceae	*Gautieria otthii*	AFTOL 466	–	AF393058	AY883434
Hymenochaetales /Incertae sedis	*Fibricium rude*	CBS 339.66	MH858815	MH870454	–
Hymenochaetales /Incertae sedis	*Basidioradulum radula*	AFTOL-ID 451	DQ234537	AY700184	–
Hymenochaetales/ Chaetoporellaceae	*Kneiffiella abieticola*	KHL 12498	DQ873601	DQ873601	–

Table 2 Continued.

Order/family	**Species**	**Voucher**	**ITS**	**nLSU**	**TEF1**
Hymenochaetales/ Chaetoporellaceae	*Kneiffiella barba-jovis*	KHL 11730	DQ873609	DQ873610	–
Hymenochaetales/ Chaetoporellaceae	*Kneiffiella eucalypticola*	LWZ 20180509-11	MT319410	MT319142	–
Hymenochaetales/ Chaetoporellaceae	*Kneiffiella subalutacea*	LWZ 20170816-9	MT319407	MT319139	–
Hymenochaetales/ Coltriciaceae	*Coltricia perennis*	Cui 10319	KU360687	KU360653	KY693935
Hymenochaetales/ Coltriciaceae	*Coltricia dependens*	Dai 10944	KY693737	KY693757	–
Hymenochaetales/ Hymenochaetaceae	*Hymenochaete rubiginosa*	He 104	JQ716407	JQ279667	–
Hymenochaetales/ Hymenochaetaceae	*Fomitiporia mediterranea*	AFTOL 688	AY854080	AY684157	AY885149
Hymenochaetales/ Hymenochaetaceae	*Fomitiporia hartigii*	MUCL 53551	JX093789	JX093833	JX093746
Hymenochaetales/ Hymenochaetaceae	*Porodaedalea chinensis*	Cui 10252	KX673606	MH152358	MG585301
Hymenochaetales/ Hyphodontiaceae	*Hyphodontia densispora*	LWZ 20170908-5	MT319426	MT319160	–
Hymenochaetales/ Hyphodontiaceae	*Hyphodontia* sp.	LWZ 20170814-15	MT319417	MT319148	–
Hymenochaetales/ Neoantrodiellaceae	*Neoantrodiella gypsea*	Cui 10372	KT203290	MT319396	–
Hymenochaetales/ Neoantrodiellaceae	*Neoantrodiella thujae*	Dai 5065	KT203293	MT319397	–
Hymenochaetales/ Nigrofomitaceae	*Nigrofomes melanoporus*	JV 1704/39	MF629835	MF629831	–
Hymenochaetales/ Nigrofomitaceae	*Nigrofomes sinomelanoporus*	Cui 5277	MF629836	MT319398	–
Hymenochaetales/ Oxyporaceae	*Rigidoporus corticola*	ZRL20151459	LT716075	KY418899	KY419087
Hymenochaetales/ Oxyporaceae	*Rigidoporus ginkgonis*	Cui 5555	KT203295	KT203316	–
Hymenochaetales/ Oxyporaceae	*Bridgeoporus sinensis*	Cui 10013	KY131832	KY131891	–
Hymenochaetales/ Oxyporaceae	*Leucophellinus hobsonii*	Cui 6468	KT203288	KT203309	–
Hymenochaetales/ Schizoporaceae	*Fasciodontia brasiliensis*	MSK-F 7245a	MK575201	MK598734	–
Hymenochaetales/ Schizoporaceae	*Fasciodontia bugellensis*	MSK-F 5548	MK575204	MK598736	–
Hymenochaetales/ Schizoporaceae	*Lyomyces crustosus*	LWZ 20170815-23	MT319465	MT319201	MT326400
Hymenochaetales/ Schizoporaceae	*Lyomyces leptocystidiatus*	LWZ 20170814-14	MT319429	MT319163	MT326395
Hymenochaetales/ Schizoporaceae	*Lyomyces microfasciculatus*	LWZ 20170820-18	MT319451	MT319185	MT326387
Hymenochaetales/ Schizoporaceae	*Lyomyces sambuci*	LWZ 20180905-2	MT319438	MT319172	MT326389

Table 2 Continued.

Order/family	Species	Voucher	ITS	nLSU	TEF1
Hymenochaetales/ Schizoporaceae	*Xylodon flaviporus*	LWZ 20150708-1	MT319553	MT319277	MT326405
Hymenochaetales/ Schizoporaceae	*Xylodon heterocystidiatus*	LWZ 20171015-33	MT319518	MT319264	MT326382
Hymenochaetales/ Schizoporaceae	*Xylodon kunmingensis*	LWZ 20170820-41	MT319512	MT319259	MT326399
Hymenochaetales/ Schizoporaceae	*Xylodon nesporii*	LWZ 20171016-12	MT319493	MT319235	MT326384
Hymenochaetales/ Schizoporaceae	*Xylodon niemelaei*	LWZ 20171015-12	MT319625	MT319361	MT326407
Hysterangiales/ Hysterangiaceae	*Aroramyces gelatinosporus*	H4010	–	DQ218524	DQ219118
Hysterangiales/ Mesophelliaceae	*Chondrogaster pachysporus*	OSC 49298	–	DQ218538	DQ219136
Jaapiales/ Jaapiaceae	*Jaapia argillacea*	CBS 252.74	NR_119766	GU187581	GU187711
Phallales/ Phallaceae	*Dictyophora duplicata*	OSC 38819	–	DQ218481	DQ219265
Phallales/ Phallaceae	*Phallus costatus*	MB 02040	–	DQ218513	DQ219279
Polyporales/ Meripilaceae	*Grifola frondosa*	AFTOL 701	AY854084	AY629318	AY885153
Polyporales/ Polyporaceae	*Trametes versicolor*	ZRL20151477	LT716079	KY418903	KY419091
Russulales/ Bondarzewiaceae	*Bondarzewia montana*	AFTOL 452	DQ200923	DQ234539	DQ059044
Sebacinales/ Sebacinaceae	*Craterocolla cerasi*	TUB 020203	KF061265	KF061265	–
Sordariales/ Sordariaceae	*Neurospora crassa*	OR74A	HQ271348	AF286411	XM959775
Thelephorales/ Bankeraceae	*Boletopsis leucomelaena*	AFTOL 1527	DQ484064	DQ154112	GU187763
Thelephorales/ Thelephoraceae	*Thelephora ganbajun*	ZRL20151295	LT716082	KY418908	KY419093
Trechisporales/ Hydnodontaceae	*Brevicellicium olivascens*	KHL 8571	HE963792	HE963793	–
Trechisporales/ Hydnodontaceae	*Trechispora alnicola*	AFTOL 665	DQ411529	AY635768	DQ059052
Tremellales/ Tremellaceae	*Cryptococcus humicola*	AFTOL 1552	DQ645516	DQ645514	DQ645519
Tremellales/ Tremellaceae	*Dacryopinax spathularia*	AFTOL 454	AY854070	AY701525	AY881020
Ustilaginales/ Ustilaginaceae	*Ustilago maydis*	AFTOL 505	AY854090	AF453938	AY885160

Divergence time estimation

In this study, a dataset with 108 specimens (Table 2) was used to infer the divergence times of taxa within the Hymenochaetales based on Dataset III. Divergence times were estimated using BEAST v. 2.6.5 (Bouckaert et al. 2014). An XML (Extensible Markup Language) file was generated with BEAUti v. 2. The rates of evolutionary changes at nuclear acids were estimated using ModelTest v. 3.7 with the GTR substitution model (Posada & Crandall 1998). Divergence times and corresponding CIs were conducted with a log-normal relaxed molecular clock and the Yule speciation prior.

Four fossil time points were selected, 90 Mya representing the minimum age of the Agaricales by *Archaeomarasmius leggetti*, a fossil agaricoid species preserved in Dominican amber (Hibbett et al. 1995, 1997); 125 Mya representing the minimum age of the Hymenochaetaceae by *Quatsinoporites cranhamii*, a fossil poroid species collected from Apple Bay on Vancouver Island (Smith et al. 2004, Berbee & Taylor 2010); 400 Mya representing the divergence time between the Ascomycota and the Basidiomycota by *Paleopyrenomycites devonicus*, a fossil fungus found in Great Britain (Taylor et al. 1999, 2005); and 290 Mya representing the mean age of the Agaricomycetes by the analyses of genome data (Floudas et al. 2012). According to these time points, the offset age with a gamma distribution prior (scale = 20, shape = 1) for the Agaricales was set as 90 Mya, for the Hymenochaetaceae as 125 Mya, and for the Basidiomycota as 400 Mya, while the mean age with a normal distribution prior (SD = 1) for the Agaricomycetes was set as 290 Mya following Wang et al. (2021).

Four independent Markov chain Monte Carlo (MCMC) chains of 100 million generations were conducted and saving trees every 5000th generation. The resulting log file was inspected with Tracer v. 1.5 (http://tree.bio.ed.ac.uk/software/tracer/) to confirm that the estimated effective sample size (ESS) ≥ 200. Consequently, a Maximum Clade Credibility (MCC) tree was summarized with FigTree v. 1.4.4 (Rambaut 2018) to estimate the 95% credible node intervals referred to as Highest Posterior Densities (HPD), discarding 10% of states as burn-in and setting a posterior probability limit of 0.80.

Inferring historical biogeography

A consensus tree for the alignment of dataset IV was generated by BI algorithm with 50 million generations and the first 10% of the sampled trees every 1000th generation as burn-in using BEAST v. 2.6.5 (Bouckaert et al. 2014) and then used for ancestral state reconstruction. The resulting log file was checked for chain convergence using v. 1.5. The evolution of geographic distributions of species and evolution of basidiomata trait were evaluated using Reconstruct Ancestral State in Phylogenies v. 4.2 (RASP) under the Statistical Dispersal Extinction Cladogenesis (S-DEC) model and Bayesian Binary MCMC model (Yu et al. 2015, 2020). Refer to previous biogeography studies (Chen et al. 2015, Peel et al. 2007, Song & Cui 2017, Wang et al. 2021, Zhao et al. 2022), the geographic distributions for *Trichaptum s.l.* were identified in four areas: (A) temperate zones, (B) subtropical zones, (C) tropical zones, (D) mountain zones.

As a main morphological trait of basidiomata, the shapes of basidiomata were identified as five types: (A) pileate, (B) pileate to effused-reflexed, (C) effused-reflexed, (D) effused-reflexed to resupinate, (E) resupinate. Each sample was coded on the basis of its collection locality, the field notes and references.

Results

Phylogenetic analyses

In the combined dataset of ITS, nLSU, mt-SSU, nuc-SSU and TEF1 regions (Dataset I), a total of 256 specimens including 49 species of *Trichaptum s.l.* and eight other specimens (not *Trichaptum s.l*) were selected for phylogenetic analyses (Table 1, Fig. 4). The aligned dataset had a length of 5765 characters including gaps (1621 characters for ITS, 1385 characters for nLSU, 1049 characters for mt-SSU, 1104 characters for nuc-SSU, 606 characters for TEF1). The best-fitting substitution model for Dataset I evaluated and applied in the Bayesian analysis was GTR + I + G. The ML search stopped after 1000 BS replicates. In the Bayesian analyses, after 8 million generations with an average standard deviation of split frequencies of 0.007689. ML and BI algorithms generated similar topologies in the main lineages with minor differences in statistical supports. Therefore, only the ML tree is presented with the BS (≥ 50%) and BPP (≥ 0.90%) at the nodes (Fig. 4).

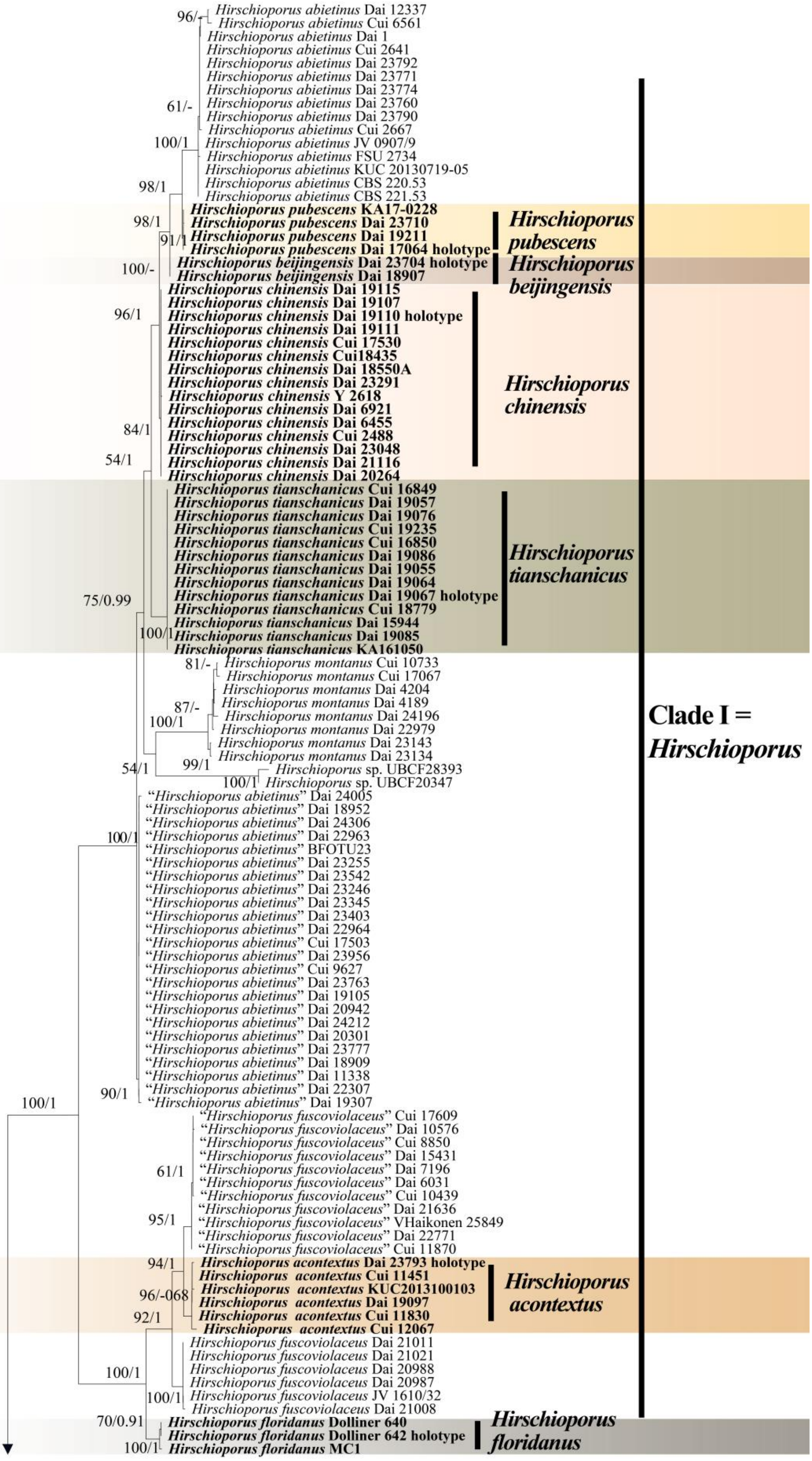

Figure 4 – Maximum Likelihood tree illustrating the phylogeny of *Trichaptum s.l.* and its related genera within the Hymenochaetales based on the combined sequences dataset of ITS + nLSU + mt-

SSU + nuc-SSU + TEF1. Branches are labeled with a Maximum Likelihood bootstrap value higher than 50% and Bayesian Posterior Probabilities more than 0.90, respectively. New species are in bold.

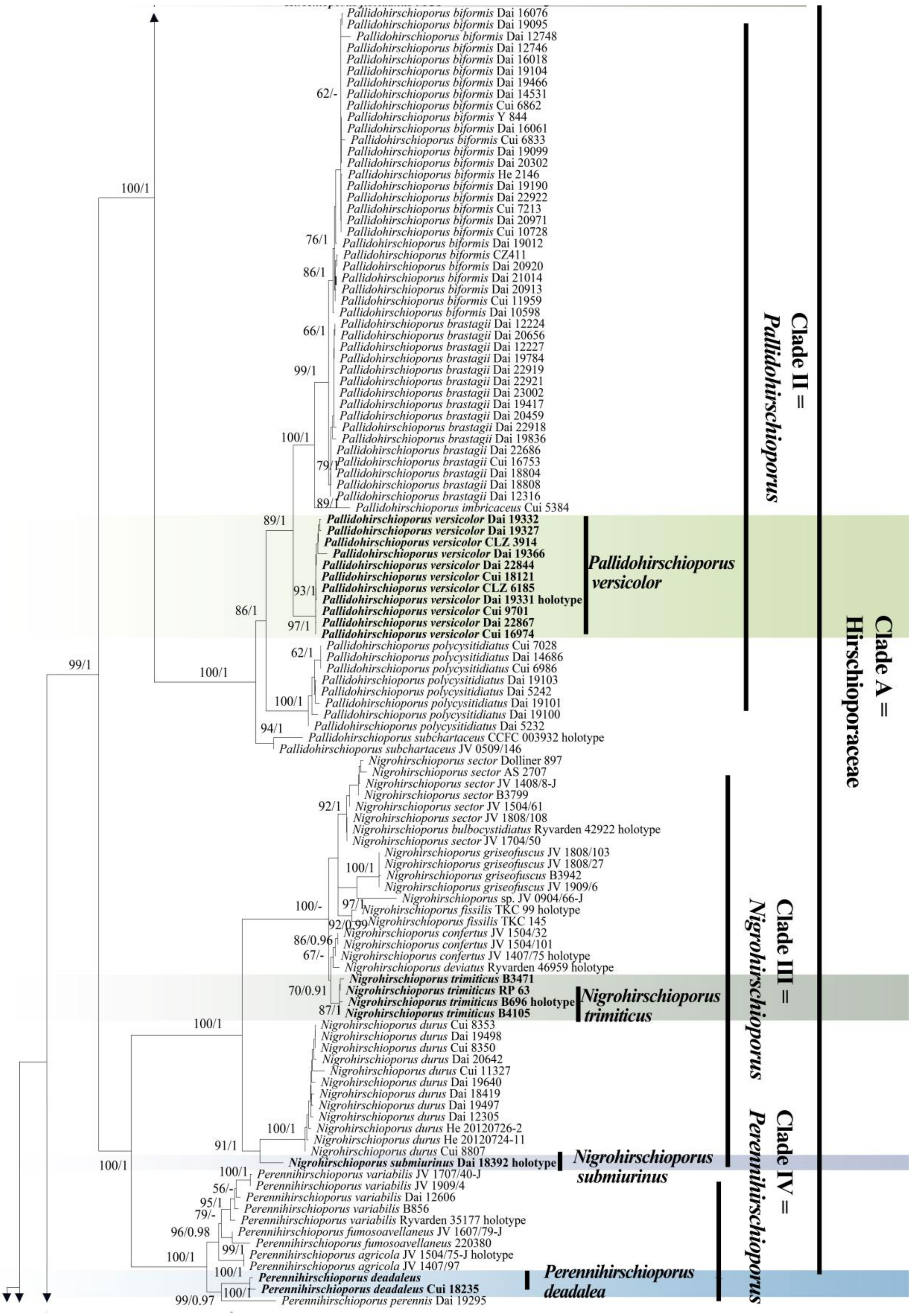

Figure 4 – Continued.

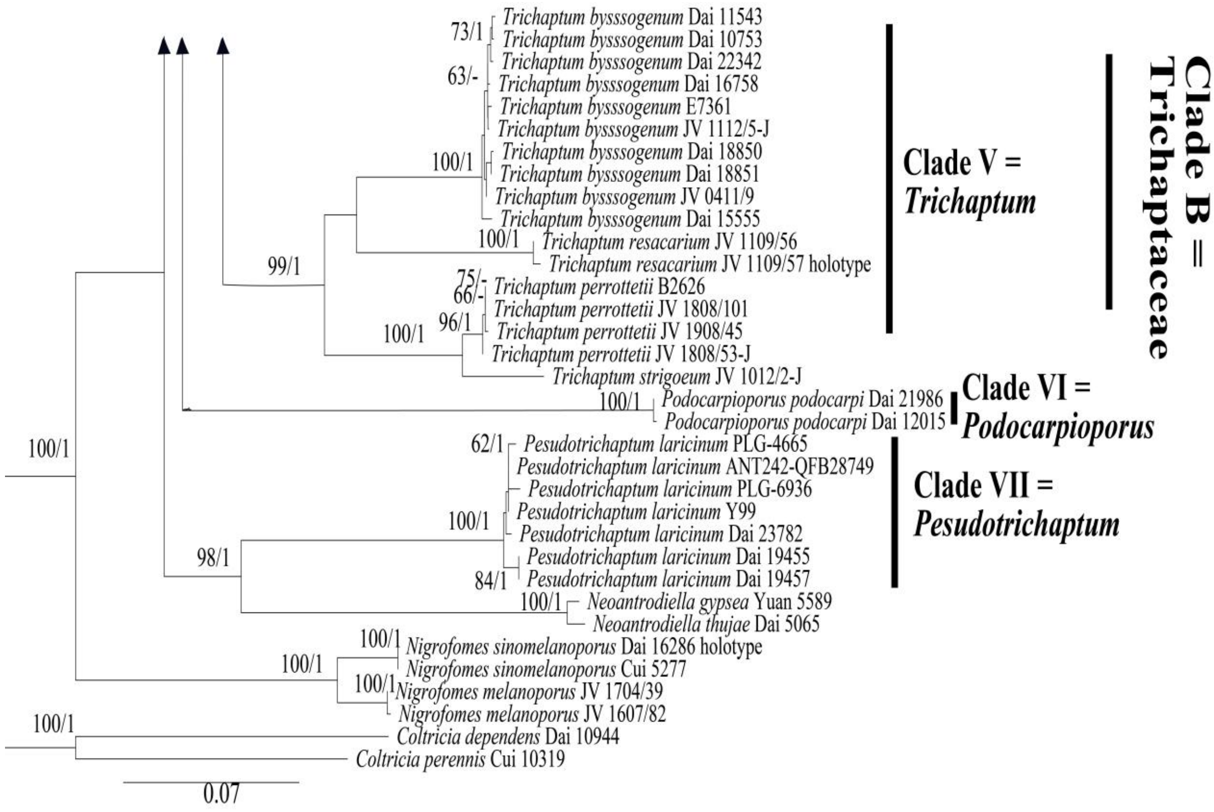

Figure 4 – Continued.

The combined dataset of ITS, nLSU, mt-SSU and TEF1 regions (Dataset II) comprised 264 specimens of 46 genera within the Hymenochaetales and three additional genera from the Polyporales and Thelephorales (Table 2, Fig. 5). The aligned dataset had a length of 5424 characters including gaps (1921 characters for ITS, 1417 characters for nLSU, 1020 characters for mt-SSU, 1066 characters for TEF1) with GTR+I+G as the best-fit evolutionary model. The ML search stopped after 1000 BS replicates. In BI, all chains converged after 12 million generations with an average standard deviation of split frequencies of 0.004183. The combined dataset (Table 2, Fig. 6) with 147 specimens of 97 taxa of 46 genera within the Hymenochaetales, Polyporales and Thelephorales were selected from Dataset II and branches were collapsed by genus. The aligned dataset had a length of 5424 characters including gaps with GTR+I+G as the best-fit evolutionary model. The ML search stopped after 1000 BS replicates. In BI, all chains converged after 8 million generations with an average standard deviation of split frequencies of 0.009195. ML and BI algorithms generated similar topologies in main lineages with minor differences in statistical supports. Therefore, only the ML tree is presented with the BS (≥ 50%) and BPP (≥ 0.90) at the nodes (Figs 5–6).

In general, the combined dataset of ITS + nLSU + mt-SSU + nuc-SSU + TEF1 phylogeny (Fig. 4) delimited species well. At the generic rank, samples of *Trichaptum s.l.* nested into seven clades with robust support (BS > 90%, BPP = 1). Among the seven clades, Clades I–IV are clustered together with a strong support (BS > 90%, BPP = 1), Clades V–VII are distantly related to Clades I–IV. In addition, Clades V–VII are distantly related to each other. The samples of the type species of *Trichaptum* nested in Clade V. Samples of *Trichaptum s.l.* formed 38 independent lineages including 14 new lineages.

The phylogeny generated by our dataset strongly supports the Hymenochaetales as an independent order (BS = 98%, BPP = 1, Fig. 5). At the family level, Clade A (Hirschioporaceae), Clade B (Trichaptaceae) and eight other families, viz., Chaetoporellaceae, Coltriciaceae, Hymenochaetaceae, Hyphodontiaceae, Neoantrodiellaceae, Nigrofomitaceae, Oxyporaceae and Schizoporaceae are well supported as monophyletic clades within the Hymenochaetales.

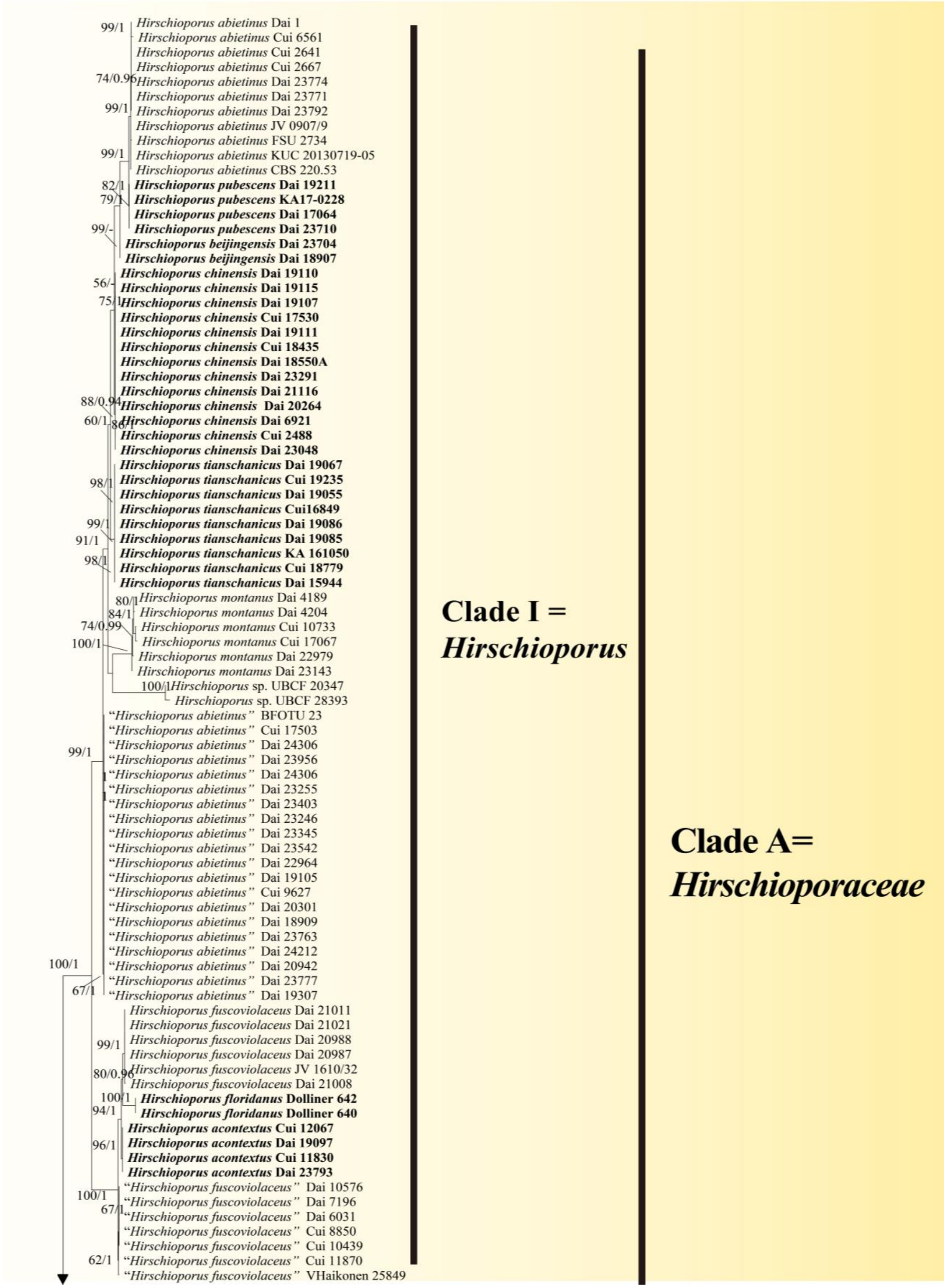

Figure 5 – Maximum Likelihood tree illustrating the phylogenetic relationships of the Hymenochaetales based on the combined dataset of ITS + nLSU + mtSSU + TEF1 sequences. Branches are labeled with Maximum Likelihood bootstrap ≥ 50% and Bayesian Posterior Probabilities ≥ 0.90, respectively. New species are in bold.

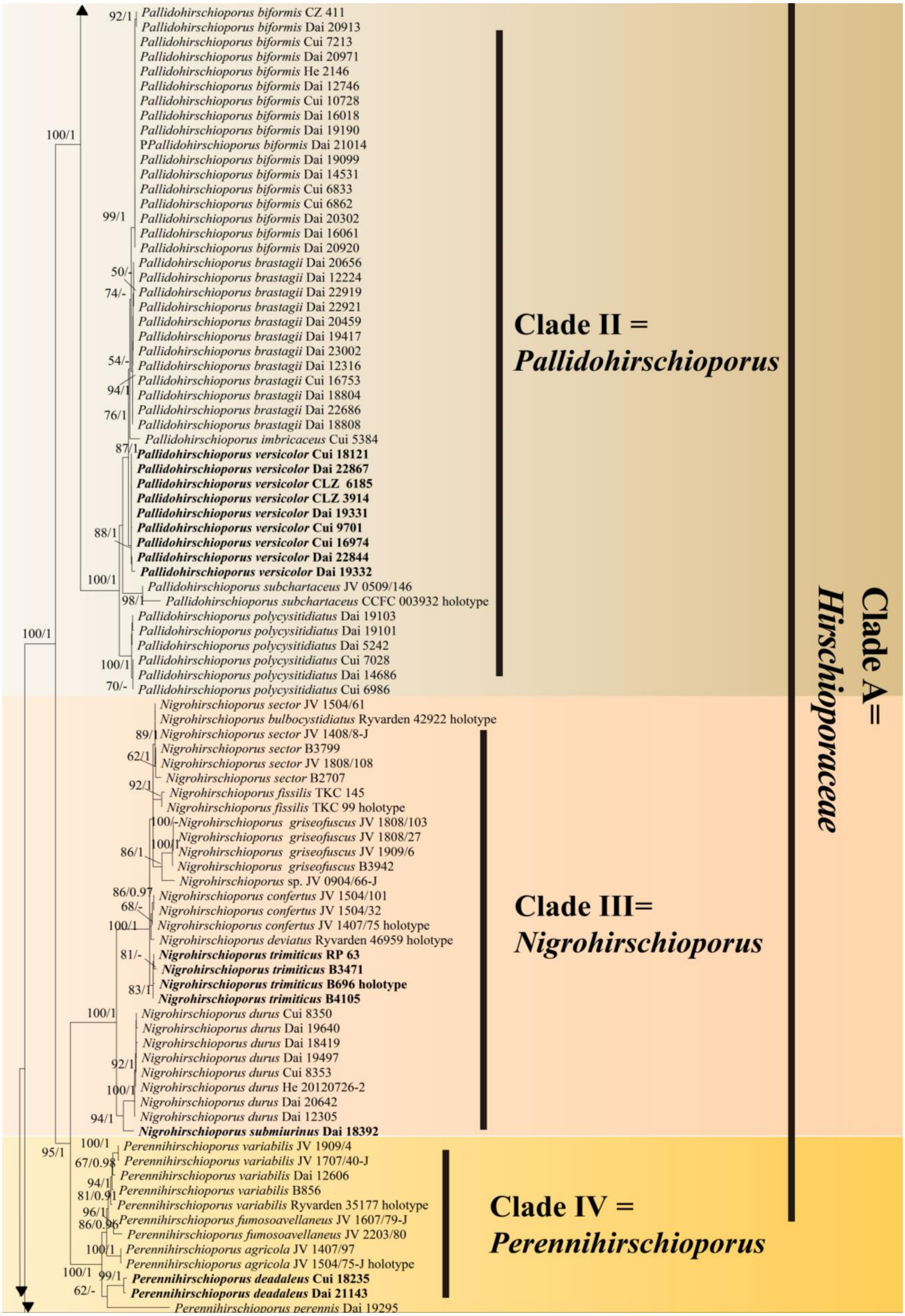

Figure 5 – Continued.

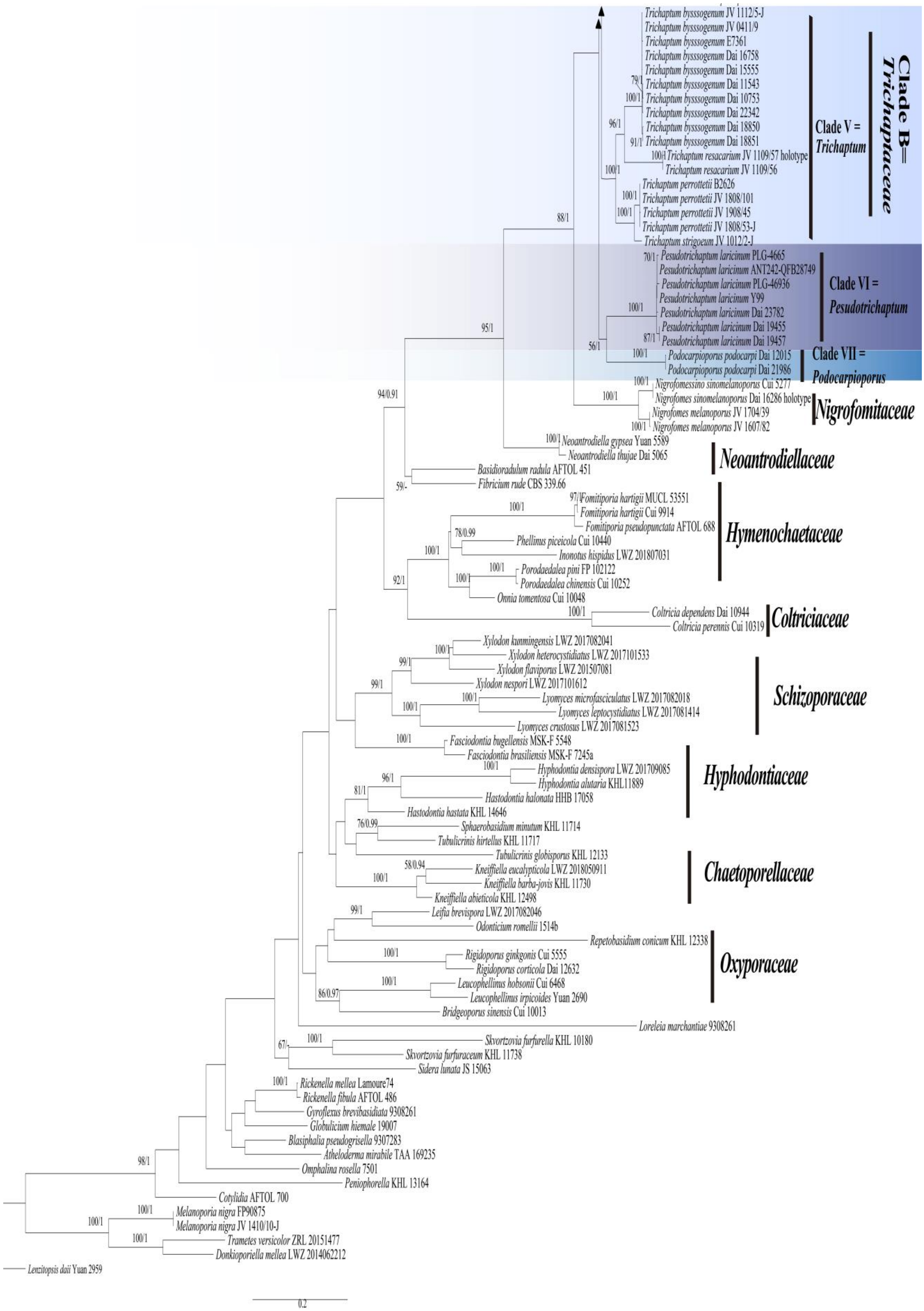

Figure 5 – Continued.

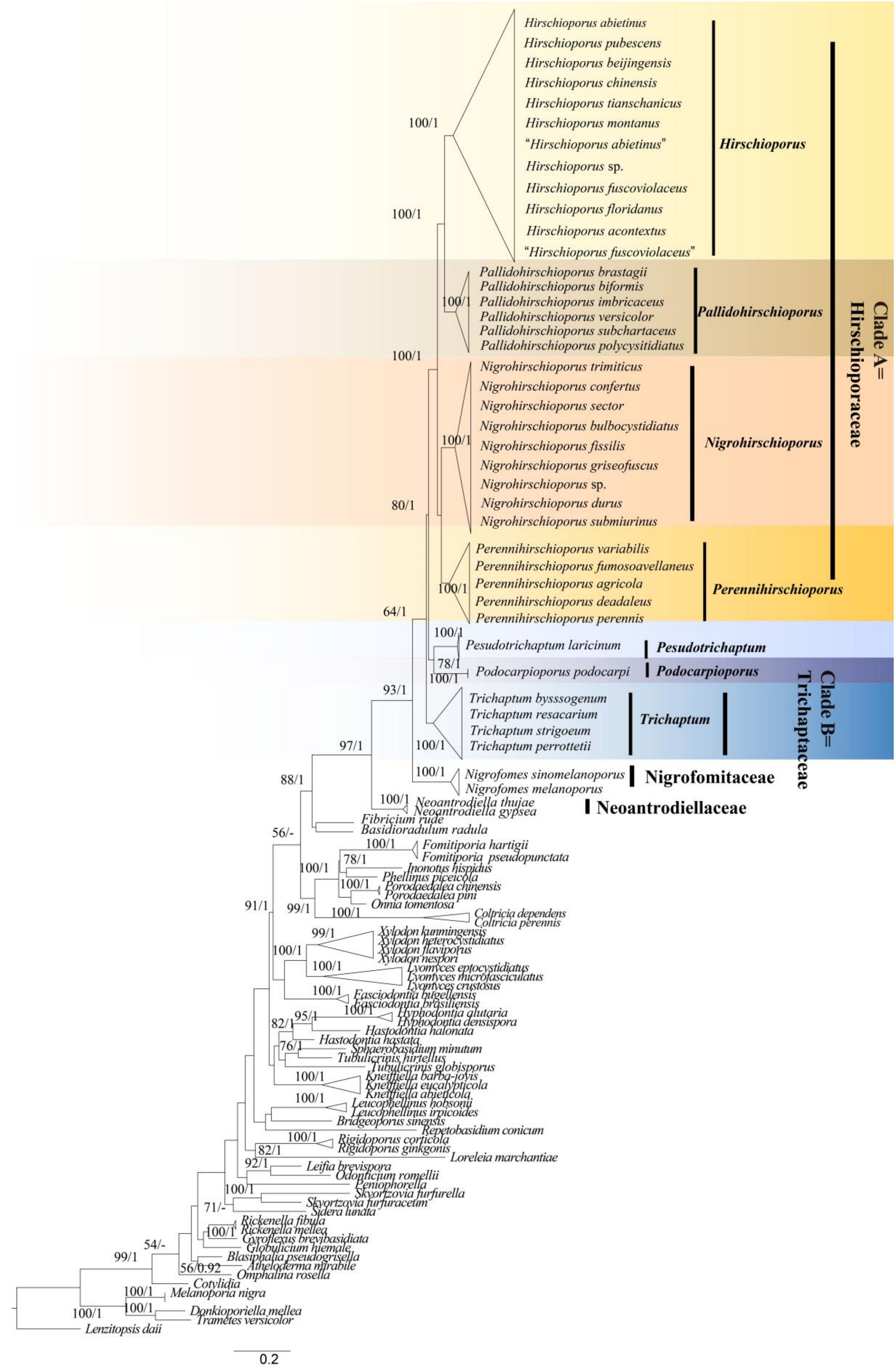

Figure 6 – Maximum Likelihood tree illustrating the phylogenetic relationships of genera of Hymenochaetales based on the combined dataset of ITS + nLSU + mtSSU + TEF1 sequences.

Branches are labeled with Maximum Likelihood bootstrap ≥ 50% and Bayesian Posterior Probabilities ≥ 0.90, respectively. Branches were collapsed by genus.

According to our phylogenies (Figs 5–6), the seven clades (Clades I–VII) are recognized as *Hirschioporus, Nigrohirschioporus, Pallidohirschioporus, Perennihirschioporus, Podocarpioporus, Pseudotrichaptum* and *Trichaptum* with robust support. Clades I–IV clustered together and formed a strongly supported upper clade as Clade A (BS = 100%, BPP = 1, Figs 4–6) which is recognized as the family Hirschioporaceae. Similarly, Clade V is recognized as the family Trichaptaceae with robust support (BS = 100%, BPP = 1). Clades VI and VII are respectively recognized as *Podocarpioporus* and *Pseudotrichaptum* with strong support (BS = 100%, BPP = 1) in the Hymenochaetales, but do not belong to any existing families. In both phylogenies of *Trichaptum s.l.* and the Hymenochaetales (Figs 4–5), the 14 new species-level lineages are recognized.

In our phylogenetic analysis (Fig. 4), samples that used to be recognized as *Hirschioporus abietinus* (*Trichaptum abietinum*) formed eight lineages with their own morphological and molecular peculiarities. So, we treat them as the *H. abietinus* complex including *H. abietinus*, *"H. abietinus", H. beijingensis, H. chinensis, H. pubescens, H. montanus, H. tianschanicus* and *Hirschioporus* sp. All these eight taxa have poroid hymenophore, *abietinum*-liked basidiomata and grow only on gymnosperm wood.

Taking morphological characters and the phylogenies from the datasets (Dataset I–IV) into consideration, the systematics of *Trichaptum s.l.* is revised. Two new families and five new genera are proposed, and ten new species are described. Identification keys to genera and species are provided. In addition, the taxonomic status of the additional 35 taxa is discussed.

Taxonomy

Key to families of *Trichaptum s.l.*

1. Upper surface glabrous to adpressed tomentose mixed with glabrous zones; cystidia mostly fusoid or clavate to capitated, distribution from boreal to tropics ...……………....Hirschioporaceae

1. Upper surface strongly strigose to hispid; cystidia mostly subulate to ventricose; distribution mostly in tropics ……………………………………………………………………Trichaptaceae

Hirschioporaceae Y.C. Dai, Yuan Yuan & Meng Zhou, fam. nov.

MycoBank number: MB 849208; Facesoffungi number: FoF 14469

Type genus – *Hirschioporus* Donk , Rev. Niederl. Homob. Aphyll. 2: 168 (1933).

Habitat – Grows on angiosperm and gymnosperm wood, including dead trees, fallen trunks and rotten wood, causes a white rot.

Basidiomata annual to perennial, resupinate, effused-reflexed or distinctly pileate, pileal surface smooth to pubescent, soft corky to hard corky or woody hard; hymenophore poroid to irpicoid or daedaleoid to lamellate, context distinctly duplex or homogeneous. Hyphal system dimitic, generative hyphae with clamp connections; fusoid or clavate to capitated cystidia present, usually apically encrusted; basidiospores cylindrical to allantoid or ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–.

Notes – The family Hirschioporaceae (Bondartsev & Singer) R.T. Moore was proposed (Sneh et al. 1996), but is invalid, because its full and direct reference to the basionym is omitted, and it was published as 'comb. nov. (Type, Hirschioporae Bondarzew & Singer 1941)'. So, we propose the above new family. Morphologically, species in Hirschioporaceae differ from those in Trichaptaceae by glabrous to adpressed tomentose upper surface, mostly fusoid or clavate to capitated cystidia and have a distribution from boreal to tropics. In our phylogenies (Figs 5–6) taxa of Hirschioporaceae nested in Clade A with robust support, and four genera, viz., *Hirschioporus, Nigrohirschioporus, Pallidohirschioporus* and *Perennihirschioporus,* are included in the family.

Key to genera of Hirschioporaceae

1. Basidiomata annual to perennial, pileal surface brownish-colored; distribution in tropical to subtropical zones ………………………………………………………………………………………2

1. Basidiomata annual, pileal surface white or cream to ochraceous; widely distribution in temperate to tropical zones …………………………………………………………………………..3

2. Basidiomata perennial, pileate, rarely effused; hymenophore poroid to irpicoid or daedaleoid to lamellate, pores 0.5–3 per mm ……………………………………………...*Perennihirschioporus*

2. Basidiomata annual to perennial, resupinate to effused-reflexed or pileate; hymenophore poroid to irpicoid or hydnoid, pores 3–16 per mm or teeth 1–3 per mm ………………..*Nigrohirschioporus*

3. Growth on angiosperm wood ……………………………………………..*Pallidohirschioporus*

3. Growth on gymnosperm wood ……………………………………………………..*Hirschioporus*

Hirschioporus Donk 1933

Type species – *Hirschioporus abietinus* (Pers. ex J.F. Gmel.) Donk.

Description – Basidiomata annual, resupinate, effused-reflexed or pileate, pilei imbricate, often laterally fused; pileal surface gray or dirty white to buff, pubescent to finely adpressed velutinate; hymenophore poroid to irpicoid or hydnoid, mostly light to dark purple when actively growing; context distinctly duplex with the hairy upper layer and a dense fibrous lower layer or with gelatinous zone between the two layers. Hyphal system dimitic; generative hyphae with clamp connections; cystidia thick-walled, smooth or apically encrusted; cystidioles present or not; basidiospores cylindrical, slightly bent to allantoid, smooth, hyaline, thin-walled, IKI–, CB–. Grows on conifers, causes a white rot and occurs in temperate to subtropical areas.

Notes – *Hirschioporus* was established by Donk (Donk 1933) and typified by *H. abietinus* as a genus distributed in temperate regions. The genus used to be considered a synonym of *Trichaptum* which has a strongly strigose to hispid pileal surface and a distribution in the tropics to subtropics. With further study, the genus was confirmed as an independent clade and accommodates many species from the temperate-boreal to subtropical zones. Species in the genus have small basidiomata and adpressed tomentum, grow on gymnosperms, while species of *Trichaptum* usually grow on angiosperms.

Six new species, *Hirschioporus acontextus, H. beijingensis, H. chinensis, H. floridanus, H. pubescens,* and *H. tianschanicus,* are described in the present paper. In addition, another six taxa, *H. abietinus, H. fuscoviolaceus, H. montanus*, "*H. abietinus*", "*H. fuscoviolaceus*", *Hirschioporus* sp., are recognized. Furthermore, "*H. abietinus*", *H. beijingensis, H. chinensis, H. montanus, H. pubescens, H. tianschanicus*, *H. abietinus* and *Hirschioporus* sp. belong to the *H. abietinus* complex.

Key to species of *Hirschioporus*

1. Hymenophore irpicoid to hydnoid or sublamellate ……………………………………………2

1. Hymenophore poroid to irpicoid ……………………………………………………………4

2. Context distinct, about 1 mm thick, both the lower context layer and the tubes having same color and texture …………………………………………………………………*H. fuscoviolaceus*

2. Context extremely thin, the lower layer almost absent ………………………………………...3

3. Hymenophore irpicoid to hydnoid; spores 4.3–6.5 × 2–3 µm; distributed in northeast Asia ……………………………………………………………………………"*H. fuscoviolaceus*"

3. Hymenophore hydnoid to sublamellate; spores 5.3–6.7 × 2.2–2.8 µm; distributed in temperate to subtropical zones of Eurasia ……………………………………………………...*H. acontextus*

4. Basidiomata resupinate to effused-reflexed, rarely pileate ……………………………………5

4. Basidiomata effused-reflexed to pileate ……………………………………………………..7

5. Pores angular to irpicoid, 2–4 per mm ………………………………………..*H. beijingensis*

5. Pores angular, lacerated with age, 4–6 per mm ………………………………………..…6

6. Spores 6–8.5 × 2.5–3 µm, Q = 2.39–2.70; distributed in the Tianshan Mountains ……………………………………………………………………………*H. tianschanicus*

6. Spores 5.2–7.3 × 2.5–3.2 µm, Q = 1.93–2.41; distributed in temperate Eurasia …..H. “*abietinus*”
7. Context up to 15 mm thick; pileal surface densely tomentose …………………………………...8
7. Context < 1 mm thick; pileal surface loosely adpressed velutinate or velutinate ………………...9
8. Pores 2–4 per mm; spores 5.8–7.6 × 3–4 µm ………………………………………..*H. pubescens*
8. Pores 4–6 per mm; spores 5.2–7.1 × 1.9–2.3 µm ……………………………………*H. montanus*
9. Pores 2–4 per mm; hyphal pegs absent ………………………………………………*H. chinensis*
9. Pores 4–6 per mm; hyphal pegs present ………………………………………………*H. abietinus*

The *Hirschioporus abietinus* complex

Hirschioporus abietinus (Pers. ex J.F. Gmel.) Donk, Mededelingen van het botanisch Museum en Herbarium van de Rijksuniversiteit Utrecht 9: 168 (1933)

≡ *Boletus abietinus* Pers. ex J.F. Gmel., Syst. Nat., Edn 13 2(2): 1437 (1792).

≡ *Trichaptum abietinum* (Pers. ex J.F. Gmel.) Ryvarden, Norwegian Journal of Botany 19: 237 (1972).

Type locality – GERMANY.

Description – Basidiomata annual, effused-reflexed to pileate; pilei small, imbricate, usually laterally fused. Pileal surface cream to gray, concentrically indistinctly sulcate or azonate, pubescent or velutinate when juvenile, then becoming sparse to adpressed velutinate; margin concolorous with pileal surface, more purple when juvenile. Hymenophore poroid, bright purplish, fading to ochraceous with age; pores angular, 4–6 per mm; dissepiments entire when juvenile, strongly lacerated with age. Context duplex, usually less than 1 mm thick, the upper layer whitish, floccose, soft, the lower layer white, firm to tough-fibrous. Tubes concolorous with pores, separated from the context by a thin gelatinous layer. Cystidia fusoid, thick-walled, abundant, usually apically encrusted, embedded or projecting from the hymenium up to 15 µm, 4–7 µm wide. Hyphal pegs present. Basidiospores cylindric, slightly curved, hyaline, IKI–, CB–, (5–)5.2–7.4(–7.8) × (2–)2.3–3 µm, L = 6.35µm, W = 2.68 µm, Q = 2.22–2.67 (n = 150/5).

Distribution and ecology – *Hirschioporus abietinus* is a widespread species, distributed throughout the coniferous forest regions of the Northern Hemisphere. It occurs mostly in temperate zones, but can also be found in warm temperate and subtropical zones. The species is a saprophytic fungus, and prefers to grow on *Picea*, but also occurs on *Abies*, *Larix*, *Pinus* and *Taxus*. The substrates are dead and standing trees, fallen trunks, branches and twigs, and stumps (Ryvarden & Gilbertson 1994, Gilbertson & Ryvarden 1987). As a pioneer on recently fallen logs, the species can occupy whole logs with hundreds of basidiomata intergrading from completely resupinate to pileate (Ryvarden & Gilbertson 1994).

Biological activities – Antitumor, antioxidant, enzymatic, antimicrobial, immunomodulatory, anti-proliferative (Choi et al. 1999, Breuil 2008, Dai et al. 2009a, Lee et al. 2013, Tetianec et al. 2014, Mbayo et al. 2015, Barad et al. 2016, Balaes et al. 2017, Gevorgyan et al. 2017, Mali et al. 2017, Smith et al. 2017, Tamrakar et al. 2017, Adhikari et al. 2019).

Notes – *Hirschioporus abietinus* is the type species of *Hirschioporus*, and several taxa used to be recognized as this species. It is distinguished by annual, effused-reflexed to pileate basidiomata, an entirely poroid hymenophore a bright purplish color in youth fading to ochraceous with age, small pores, 4–6 per mm, the presence of hyphal pegs and narrow basidiospores, 2.3–3 µm in width and Q = 2.22–2.67.

Specimens examined – CHINA. Fujian, Wuyishan, on branch of *Pinus*, 18.X.2005, *Dai 7201* (BJFC002673). Hainan, Changjiang, Bawangling Nat. Res., 10.V.2009, on fallen trunk of *Pinus*, *Cui 6524* (BJFC004377); on branch of *Pinus*, *Cui 6561* (BJFC004414). Jilin, Antu, Changbaishan Nat. Res., Huangsongpu, on dead tree of *Larix*, 24.VII.2022, *Dai 23760* (BJFC039004); on fallen trunk of *Picea*, 24.VII.2022, *Dai 23771* (BJFC039015), *Dai 23790* (BJFC039034); on fallen branch of *Picea*, 24.VII.2022, *Dai 23774* (BJFC039018); on fallen trunk of *Abies*, 24.VII.2022, *Dai 23792* (BJFC039036). Shanxi, Qinshui, Lishan Nat. Res., on *Pinus*, 19.X.2004, *Yuan 1052*

(BJFC002672). Yunnan, Jinghong, Dadugang, on branch of *Pinus*, 8.VI.2011, *Dai 12337* (BJFC010617). Zhejiang, Linan, Tianmushan Nat. Res., on dead tree of *Cedrus*, 17.X.2004, *Dai 6455* (BJFC002675); on branch of *Pinus*, 10.X.2005, *Cui 2641* (BJFC002671); 11.X.2005, *Cui 2667* (BJFC002681). FINLAND. 28.VII.1992, on fallen trunk of *Picea abies, Dai 1* (BJFC002689).

"*Hirschioporus abietinus*" Fig. 7

Description – Basidiomata annual, usually resupinate to effused-reflexed, occasionally pileate, imbricate with elongated pilei, sometimes laterally fused; soft corky when fresh, hard corky when dry; pilei projecting up to 1 cm, 1.5 cm wide and 2.5 mm thick at base, the resupinate part up to 10 cm long and 5 cm wide. Pileal surface white to cream when fresh, cream when dry, concentrically sulcate with narrow zones, pubescent when juvenile, becoming loosely adpressed velutinate with age; margin concolorous with pileal surface, acute, entire. Hymenophore poroid, darkish, fawn to grayish violet when fresh, becoming milky coffee to snuff brown or grayish brown upon drying; pores angular, 4–6 per mm; dissepiments thin, entire when young, becoming strongly lacerated with age. Sterile margin distinct, lighter than pores, light purple to cream. Context duplex, up to 1 mm thick, the upper layer white, loosely adpressed velutinate, soft, up to 0.5 mm thick, the lower layer firm, tough-fibrous and concolorous with tubes. Tubes pale grayish brown, up to 1.5 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia of two types: hymenial cystidia fusoid to subulate, thin- to moderately thick-walled, apically encrusted, 25–32 × 5–6.5 µm; skeletocystidia capitate to clavate, thick-walled to almost solid, 18–22 × 5.5–9 µm, apex obtuse with a large mass of crystals. Hyphal pegs present. Basidiospores cylindric, slightly curved, hyaline, thin-walled, smooth, IKI–, CB–, 5.2–7.3(–7.5) × (2.3–)2.5–3.2(–3.5) µm, L = 6.52 µm, W = 2.92 µm, Q = 1.93–2.41 (n = 180/6).

Distribution and ecology – "*Hirschioporus abietinus*" is widely distributed in temperate Eurasia and is a common species in temperate and high-altitude areas of subtropical China. The taxon grows on several genera of Pinaceae, such as *Abies, Larix, Picea* and *Pinus.*

Notes – "*Hirschioporus abietinus*" is characterized by resupinate to effused-reflexed basidiomata, small angular pores, 4–6 per mm, and cylindric basidiospores, 5.2–7.3 ×2.5–3.2 µm. Phylogenetically, samples of "*H. Abietinus*" nested in the *H. abietinus* complex with low support because of their relatively short ITS sequences and mostly belonging to conservative regions. But all studied samples clustered together stably as an independent lineage. Therefore, we treat them as an independent taxon. However, many taxa described from Europe were treated as synonyms of *H. abietinus*, and according to our phylogenetic analyses, a sequence (BFOTU23) from Finland nested within "*H. Abietinus*". We did not study the types of these synonyms, and "*H. Abietinus*" may represent one of these synonyms. The morphological characteristics of this taxon and other species in the *H. abietinus* complex are listed in Table 3.

Specimens examined – BELARUS. Mahilyowskaya, Svislach-Byarezina Projecting Nat. Park, on fallen trunk of *Picea*, 14.X.2019, *Dai 20921* (BJFC032580); on fallen trunk of *Pinus*, 14.X.2019, *Dai 20942* (BJFC032601). CHINA. Beijing, Mentougou, Xiaolongmen Forest Farm, on fallen trunk of *Pinus tabulaeformis*, 4.VIII.2018, *Dai 18909* (BJFC027378). Guangxi, Guiping, Xishan Forest Park, on fallen trunk of *Pinus massoniana*, 25.XII.2020, *Dai 22156* (BJFC036048). Guizhou, Jiangkou, Fanjingshan Nat. Res., on fallen trunk of *Pinus massoniana*, 12.VII.2022, *Dai 24306* (BJFC039548). Henan, Baotianman Nat. Res., on fallen trunk of *Pinus tabulaeformis*, 23.IX.2009, *Dai 11338* (BJFC007484). Jilin, Antu, Changbaishan Nat. Res., on dead tree of *Picea*, 18.IX.2018, *Dai 19105* (BJFC027575); Huangsongpu Forest Farm, on dead tree of *Picea*, 18.IX.2018, *Dai 19093* (BJFC027563); on fallen trunk of *Larix*, 18.IX.2018, *Dai 19094* (BJFC027564); 24.VII.2022, *Dai 23763* (BJFC039007). Shandong, Mengyin, on fallen trunk of *Pinus*, 28.VII.2007, *Cui 5030* (BJFC003071); Tai'an, Mount Tai, on fallen trunk of *Pinus tabulaeformis*, 13.X.2003, *Dai 5309* (BJFC002677). Sichuan, Aba, Mao, on dead tree of *Picea*, 2020, *TA 1088-20*; Litang, on fallen branch of *Picea*, 9.VIII.2019, *Cui 17357* (BJFC034216); Ninglang, Luguhu Nat. Res., on stump of *Pinus yunnanensis*, 9.IX.2021, *Dai 23011*

(BJFC037584); Xichang, Yiwanshui, on stump of *Pinus yunnanensis*, 16.IX.2019, *Cui 17829* (BJFC034688); Yajiang, Kangba, on stump of *Abies*, 7.IX.2020, *Cui 18368* (BJFC035224); Yanyuan, on stump of *Pinus yunnanensis*, 15.VIII.2019, *Cui 17535* (BJFC034394). Shaanxi, Foping, Foping Nat. Res., on fallen trunk of *Picea*, 7.VIII.2019, *Dai 20296* (BJFC031964), *Dai 20297* (BJFC031965); on dead tree of *Pinus armandii*, *Dai 20301* (BJFC031969). Shanxi, Lingchuan, Xiya Valley, on stump of *Pinus tabulaeformis*, 26.VIII.2016, *Dai 17064* (BJFC023170). Tibet, Bome, Yigong Tea plantation, on branch of *Pinus armandii*, 24.X.2021, *Dai 23403* (BJFC037975); on dead tree of *Abies*, *Dai 23555* (BJFC038127); on fallen trunk of *Larix*, 26.X.2021, *Dai 23542* (BJFC038114); Dayak, Nianla Mts., on fallen trunk of *Picea*, 23.IX.2010, *Cui 9627* (BJFC008564); Nyingchi, Sejila Mts., on dead branch of *Abies*, 23.X.2021, *Dai 23325* (BJFC037896); on fallen trunk of *Abies*, 23.X.2021, *Dai 23345* (BJFC037916); Nanyigou, on fallen trunk of *Picea*, 22.X.2021, *Dai 23246* (BJFC037817); *Dai 23255* (BJFC037826); Zogong, Dongda Mt., on stump of *Abies*, 9.IX.2020, *Cui 18395* (BJFC035256). Yunnan, Binchuan, Jizu Mt., on fallen trunk of *Pinus yunnanensis*, 6.IX.2018, *Dai 19307* (BJFC027776), 1.IX.2021, *Dai 22705* (BJFC037278); *Dai 22706* (BJFC037279); Deqin, Baimaxueshan Nat. Res., on stump of *Picea*, 5.IX.2021, *Dai 22814* (BJFC037387), *Dai 22830* (BJFC037403); on fallen trunk of *Picea*, 5.IX.2021, *Dai 22815* (BJFC037388), *Dai 22836* (BJFC037409); on fallen branch of *Pinus armandii*, 5.IX.2021, *Dai 22877* (BJFC037450); Jianchuan, Huacong Mts., on fallen trunk of *Pinus*, 10.IX.2021, *Dai 23045* (BJFC037619); Lanping, Xinshengqiao Forest Park, on fallen branch of *Pinus*, 2.IX.2021, *Dai 22740* (BJFC037313); Luoguqing Nat. Res., on fallen branch of *Pinus armandii*, 2.IX.2021, *Dai 22750* (BJFC037323); Shangri-La, Patatson Nat. Park, on fallen branch of *Larix*, 6.IX.2021, *Dai 22933* (BJFC037506), *Dai 22930* (BJFC037503), *Dai 22941* (BJFC037514); on fallen branch of *Abies*, 7.IX.2021, *Dai 22957* (BJFC037530); *Dai 22963* (BJFC037536); on fallen trunk of *Abies*, 7.IX.2021, *Dai 22962* (BJFC037535), *Dai 22964* (BJFC037537), *Dai 22978* (BJFC037551), *Dai 22980* (BJFC037553), *Dai 22990* (BJFC037563); Yulong, Laojun Mts., on fallen trunk of *Abies*, 1.IX.2015, *Dai 15760* (BJFC019864); Zhanyi, Zhujiangyuan Forest Park, on fallen branch of *Pinus*, 11.VI.2011, *Dai 12421* (BJFC010701). Zhejiang, Pingyang, Nanyandangshan Forest Park, on dead tree of *Pinus*, 3.VI.2021, Dai 22307 (BJFC036895).

Hirschioporus beijingensis Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 8

MycoBank number: MB 849217; Facesoffungi number: FoF 14431

Type – CHINA. Beijing, Mentougou, on dead branch of living *Pinus tabuliformis*, 3.VII.2022, *Dai 23704* (Holotype BJFC038949).

Etymology – *Beijingensis* (Lat.): refers to the species being found in Beijing, northern China.

Basidiomata – Annual, mostly resupinate to effused-reflexed, imbricate with elongated pilei, sometimes laterally fused; corky when fresh, becoming brittle upon drying. Pilei projecting up to 1 cm, 1.5 cm wide and 2 mm thick at base, the resupinate part up to 6 cm long and 3 cm wide. Pileal surface buff to olivaceous buff when fresh and dry, concentrically indistinctly sulcate or azonate, loosely adpressed velutinate; margin concolorous with pileal surface, tomentose, thin, acute, entire. Hymenophore poroid to irpicoid**,** light purple when juvenile and fresh, becoming vinaceous brown and grayish brown when dry. Sterile margin distinct, white when fresh, cream to pale buff when dry; pores angular when juvenile, becoming irpicoid with age, 2–4 per mm; dissepiments thin, deeply lacerated to dentate with age. Context duplex, thin, up to 0.5 mm thick, the upper layer cream to buff, spongy, velutinate, the lower layer firm, tough-fibrous, concolorous with tubes. Tubes vinaceous brown, up to 1.5 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae distinctly thick-walled, IKI–, CB+; tissues unchanged in KOH.

Context – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–3 µm in diam.; skeletal hyphae thick-walled with a narrow lumen, unbranched, interwoven, 2.5–3.5 µm in diam.

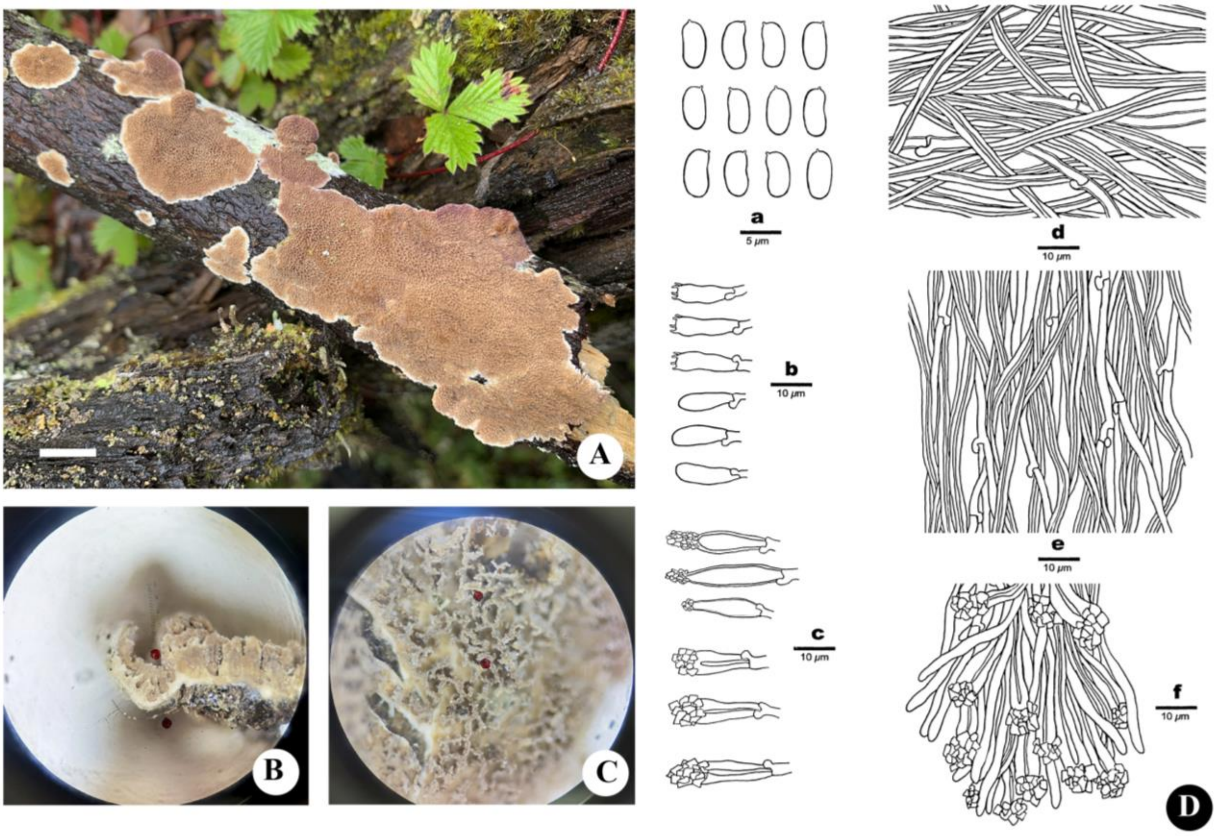

Figure 7 – A Basidiomata of “*Hirschioporus abietinus*” (*Dai 23255*). B Longitudinal section. C Hymenophore. D Microscopic structures of “*H. abietinus*” (*Dai 23255*). a Basidiospores. b Basidia and basidioles. c Cystidia. d Hyphae from context. e Hyphae from trama. f Hyphae at dissepiment edge. Scale bars: A = 1 cm, B = 5 mm, C = 1 mm.

Tubes – Generative hyphae hyaline, slightly thick-walled, often branched, 2.5–3.5 µm in diam.; skeletal hyphae thick-walled, unbranched, loosely interwoven to subparallel along tubes, 3–5 µm in diam.; hyphae at dissepiment edges smooth.

Hymenium – Cystidia clavate, thick-walled, abundant, usually apically encrusted, 20–30 × 4.5–8 µm and projecting from hymenium up to 15 µm, with a basal clamp connection; hyphal pegs present; basidia clavate with four sterigmata and a basal clamp connection, 16–25 × 5–6 µm; basidioles similar to basidia in shape, but slightly smaller.

Spores – Basidiospores oblong-ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, 5–7(–7.5) × (2.7–)3–3.5 µm, L = 5.67 µm, W = 3.11 µm, Q = 1.82–2.00 (n = 120/4).

Type of rot – White rot.

Distribution and ecology – *Hirschioporus beijingensis* is known from Beijing, and grows on branches of *Pinus tabuliformis*.

Notes – Morphologically, *Hirschioporus beijingensis* is characterized by annual, resupinate to effused-reflexed basidiomata with distinct thin context, large pores, 2–4 per mm, the presence of hyphal pegs, clavate cystidia, oblong-ellipsoid basidiospores, 5–7 ×3–3.5 µm, and growth on branches of *Pinus tabuliformis*.

Phylogenetically, two samples of *Hirschioporus beijingensis* formed a distinct lineage with strong support (99% ML, 1.00 BPPs), which nested in the *H. abietinus* complex and is cloesly related to *H. abietinus*, *H. chinensis* and *H. pubescens.*

Hirschioporus beijingensis shares similar lacerated pores with *H. chinensis* and *H. pubescens*. However, there are more than 20 base pair differences among the ITS sequences of *H. beijingensis*, *H. chinensis* and *H. pubescens* which accounts for >2% of the nucleotides. In addition, *H. chinensis* differs from *H. beijingensis* by the absence of hyphal pegs and narrower cystidia (3–5 µm vs. 4.5–8 µm); *H. pubescens* is distinguished from *H. beijingensis* by usually pileate basidiomata, distinct thick context and white pubescent upper surface. In the field, it is difficult to distinguish *H. beijingensis* from *H. abietinus* and "*H. abietinus*", but the latter two taxa have smaller pores (3–6 per mm vs. 2–4 per mm) and slightly narrower spores (Q = 2.22–2.67 and Q = 1.93–2.41 vs. Q = 1.82–2). Meanwhile, the nucleotide difference between *H. beijingensis* and *H. abietinus* is more than 3% in the ITS regions, and there are 17 base pair differences between the ITS sequences of *H. beijingensis* and "*H. abietinus*", which accounts for >1.5% of the nucleotides.

Additional specimens examined – CHINA. Beijing, Mentougou, Xiaolongmen Forest Farm, on fallen branch of *Pinus tabuliformis*, 4.VIII.2018, *Dai 18907* (BJFC027376); on dead branch of living *Pinus tabuliformis*, 3.VII.2022, *Dai 23703* (BJFC038948), *Dai 23705* (BJFC038950).

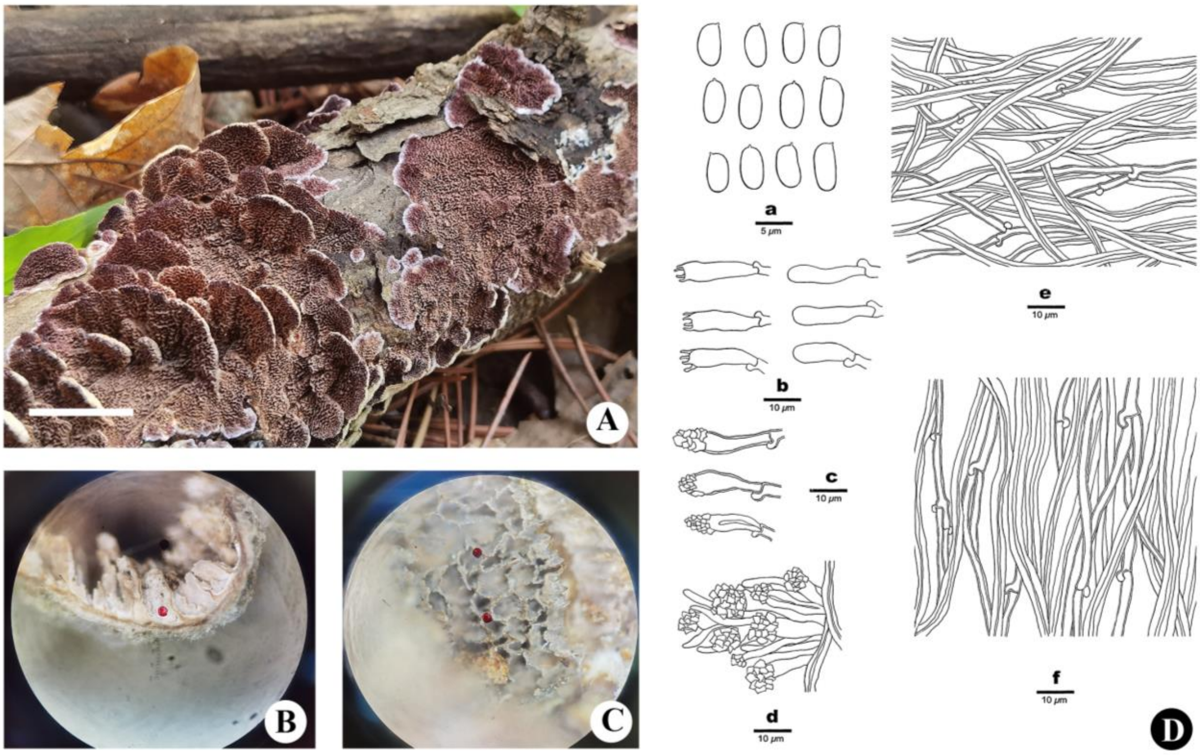

Figure 8 – A Basidiomata of *Hirschioporus beijingensis* (*Dai 23704*). B Longitudinal section. C Hymenophore. D Microscopic structures of *H. beijingensis* (*Dai 23704*). a Basidiospores. b Basidia and basidioles. c Cystidia. d A hyphal peg. e Hyphae from context. f Hyphae from trama. Scale bars: A = 1 cm, B = 5 mm, C = 1 mm.

Hirschioporus chinensis Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 9

MycoBank number: MB 849218; Facesoffungi number: FoF 14432

Type – CHINA. Yunnan, Chuxiong, Zixishan Forest Park, on fallen trunk of *Pinus*, 19.IX.2018, *Dai 19111* (Holotype BJFC027580).

Etymology – *Chinensis* (Lat.): refers to the species having a distribution in China.

Basidiomata – Annual, usually effused-reflexed sometimes pileate, soft corky when fresh, hard corky when dry. Pilei imbricate, often laterally fused, projecting up to 1 cm, 1.5 cm wide and 2 mm thick at base. Pileal surface white to grayish cream when fresh, cream when dry, concentrically indistinctly sulcate or azonate, loosely velutinate, margin concolorous with pores, more purple when juvenile, acute, entire. Hymenophore poroid, pale purple to clay pink when fresh, pinkish buff to clay buff when dry; pores angular when juvenile, becoming irpicoid with age, 2–4 per mm; dissepiments thin, entire, becoming strongly lacerated with age. Sterile margin paler than pores, pale purple to white. Context duplex, up to 1 mm thick, the upper layer white to cream, velutinate, soft, up to 0.5 mm thick, the lower layer tough-fibrous and concolorous with tubes. Tubes clay buff, sometimes separated from the context by a thin gelatinous layer, up to 1 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae distinctly thick-walled, IKI–, CB+; tissues unchanged in KOH.

Context – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–3 µm in diam.; skeletal hyphae thick-walled with a narrow lumen to subsolid, unbranched, interwoven, 3–4 µm in diam.

Tubes – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–2.5 µm in diam.; skeletal hyphae thick-walled with a narrow lumen to subsolid, unbranched, parallel along tubes, 3–6 µm in diam.; hyphae at dissepiment edges smooth, slightly swollen at tips.

Hymenium – Cystidia subulate, hyaline, abundant, thin- to moderately thick-walled, usually apically encrusted, 17–25 × 3–5 µm, projecting from hymenium up to 10 µm, with a basal clamp connection; hyphal pegs absent; basidia pyriform with four sterigmata and a basal clamp connection, 17–22 × 4–5 µm; basidioles similar to basidia in shape, but slightly smaller.

Spores – Basidiospores cylindric to allantoid, hyaline, thin-walled, smooth, IKI–, CB–, 6–7.4(–8) × (2.9–)3–3.7(–4) µm, L = 6.45 µm, W = 3.29 µm, Q = 1.84–2.10 (n = 90/3).

Type of rot – White rot.

Distribution and ecology – *Hirschioporus chinensis* has a distribution from the warm temperate zone to the subtropical zone of China, and grows mostly on *Pinus.*

Notes – *Hirschioporus chinensis* is a common species in China. Almost all specimens of the species were previously identified as *H. abietinus.* Now, these samples are confirmed to represent an independent species, segregated from *H. abietinus*, and nested within the *H. abietinus* complex.

Phylogenetically, *Hirschioporus chinensis* is closely related to *H. abietinus*, *H. beijingensis* and *H. pubescens.* However, more than 30 base pair differences are identified between the sequences of *H. chinensis* and *H. abietinus*, which accounts for >3 % of the nucleotides in the ITS regions. Morphologically, *H. abietinus* differs from *H. chinensis* by a distinct dark-colored pore surface, the presence of hyphal pegs and narrower basidiospores (5.2–7.4 ×2.3–3 µm vs. 6–7.4 × 3–3.7 µm).

In addition, the nucleotide differences in the ITS regions among *Hirschioporus chinensis, H. beijingensis* and *H. pubescens* are more than 2%. Morphologically, *H. pubescens* and *H. beijingensis* share the same pore size and the presence of hyphal pegs, which are readily distinguished from *H. chinensis. H. chinensis* sharing similar pore size (4–6 per mm) with "*H. abietinus*", *H. montanus* and *H. tianschanicus*. However, "*H. abietinus*" differs from *H. chinensis* by a darker pore surface, the presence of hyphal pegs and wide fusoid cystidia. Meanwhile, *H. montanus* and *H. tianschanicus* are different from *H. chinensis* by narrower basidiospores (5.2–7.1× 1.9–2.3 µm, 6–8.5× 2.5–3 µm, Q > 2.3 vs. 6–7.4 × 3–3.7 µm, Q = 1.84–2.10)

Additional specimens examined – CHINA. Anhui, Huangshan, on dead tree of *Pinus massoniana*, 10.X.2004, *Dai 6047* (BJFC002688); 22.X.2010, *Dai 11926* (BJFC009027). Fujian, Wuyishan Nat. Res., on dead tree of *Pinus massoniana*, 18.X.2005, *Dai 7205* (BJFC002674). Guangdong, Nanling Nat. Res., on dead tree of *Pinus massoniana*, 15.V.2009, *Dai 10947* (BJFC005190); on fallen trunk of *Pinus massoniana*, 16.V.2009, *Dai 10968* (BJFC005212), *Dai 10971* (BJFC005215); on dead tree of *Pinus massoniana*, 16.IX.2009, *Cui 7573* (BJFC006061); Shixing, Chebaling Nat. Res., on dead tree of *Pinus massoniana*, 12.IX.2009, *Cui 7340* (BJFC005827), *Cui 7346* (BJFC005833); 26.VI.2010, *Cui 8835* (BJFC007775), *Cui 8867* (BJFC007807); Zhaoqing, Dinghushan Nat. Res., on fallen trunk of *Pinus massoniana*, 28.IV.2018, *Dai 18550A* (BJFC027018); on dead tree of *Pinus massoniana*, 29.VI.2010, *Cui 8914* (BJFC007854).Guangxi, Nanning, Qingxiushan Nat. Res., on dead tree of *Pinus massoniana*, 13.VIII.2005, *Dai 6921* (BJFC002678). Hainan, Bawangling Nat. Res., on dead tree of *Pinus*, 3.IX.2006, *Dai 7903* (BJFC002676). Hubei, Shiyan, Wudangshan Nat. Res., on fallen trunk of *Pinus massoniana*, 6.VIII.2019, *Dai 20264* (BJFC031932). Hunan, Yongzhou, Xiaoxiang Park, on stump of *Pinus massoniana*, 3.XI.2019, *Dai 21116* (BJFC032776); Shaoyang, Dongta Park, on dead tree of *Pinus massoniana*, 16.X.2018, Dai *19216* (BJFC027683); Yizhang, Mangshan Nat. Res., on bark of *Pinus massoniana*, 27.VII.2016, *Dai 16832* (BJFC022938). Jiangsu, Nanjing, Zijin Mt., on dead tree of *Pinus massoniana*, 10.X.2003, *Dai 5228* (BJFC002684); on dead tree of *Cedrus*, 13.X.2004, *Wei 2369* (BJFC002687). Jiangxi, Fenyi, Dagang Mt., on dead tree of *Pinus massoniana*, 17.IX.2008, *Dai 10396* (BJFC004645). Shaanxi, Zhouzhi, on dead tree of *Pinus*, 23.X.2006, *Yuan 2618* (BJFC002686). Yunnan, Chuxiong, Zixishan Forest Park, on fallen trunk of *Pinus yunnanensis*, 19.IX.2018, *Dai 19107* (BJFC027576), *Dai 19110* (BJFC027579), *Dai 19111* (BJFC027580); on fallen trunk of *Pinus yunnanensis*, 20.IX.2018, *Dai 19115* (BJFC027584); Jianchuan, on fallen trunk of *Pinus yunnanensis*, 10.IX.2021, *Dai 23048* (BJFC037623); Kunming, Qiongzhu Temple Park, on fallen trunk of *Pinus yunnanensis*, 3.IX.2018, *Dai 19247* (BJFC027714); Tengchong, Shuanghe Village, on dead tree of *Pinus*, 5.VIII.2014, *Dai 13837* (BJFC017567); Laifengshan Forest Park, on fallen trunk of *Pinus yunnanensis*, 25.IX.2018, *Dai 19149* (BJFC027618), *Dai 19150* (BJFC027619); Yuxi, Xinping, on fallen trunk of *Pinus*, 15.VI.2017, *Dai* 17615 (BJFC025147). Zhejiang, Linan, Tianmushan Nat. Res., on dead tree of *Pinus massoniana*, 14.X.2004, *Dai 6252* (BJFC002685). Tibet, Nyingchi, Nanyigou, on fallen trunk of *Picea*, 22.X.2021, *Dai* 23291 (BJFC037862).

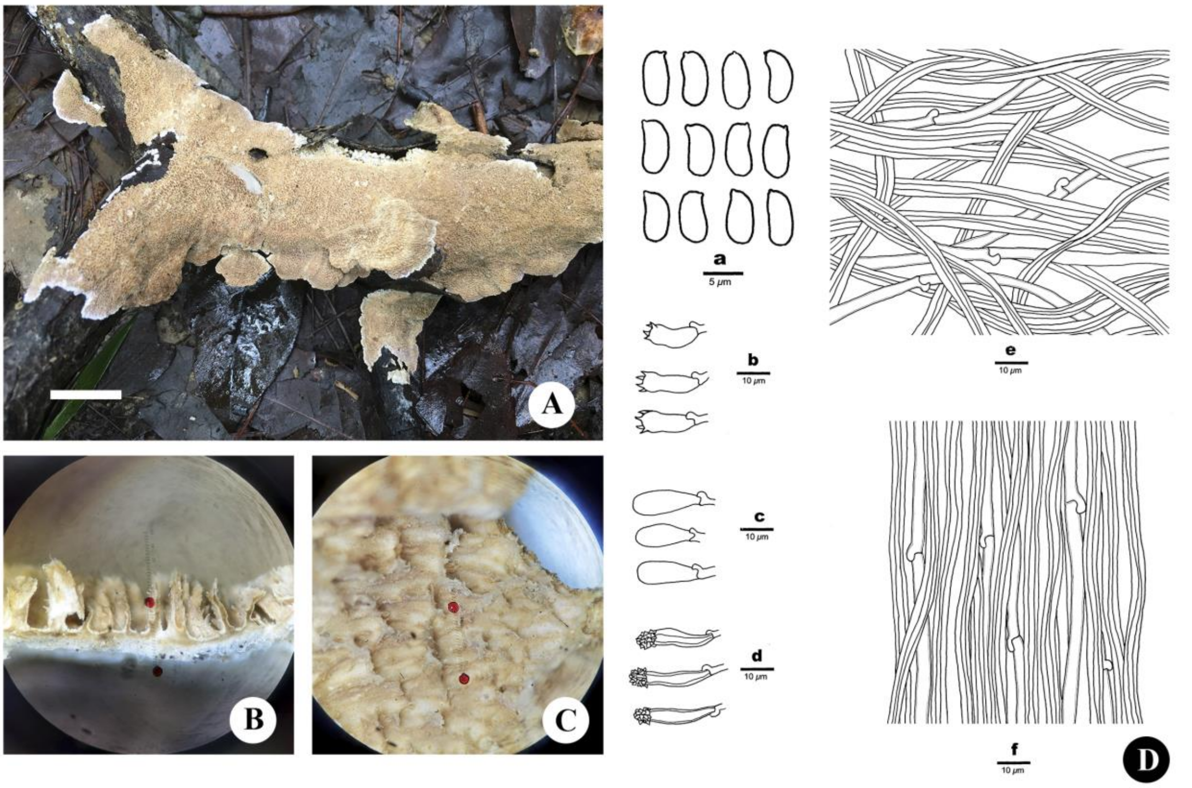

Figure 9 – A Basidiomata of *Hirschioporus chinensis* (*Dai 19111*). B Longitudinal section. C Hymenophore. D Microscopic structures of *H. chinensis* (*Dai 19111*). a Basidiospores. b Basidia. c basidioles. d Cystidia. e Hyphae from context. f Hyphae from trama. Scale bars: A = 1 cm, B–C = 1 mm.

Hirschioporus montanus (T. Hatt.) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849219; Facesoffungi number: FoF 14433

Basionym – *Trichaptum montanum* T. Hatt., in Hattori, Adhikari, Suda & Doi, Bull. natn. Sci. Mus., Tokyo, B 28(2): 35 (2002).

Type locality – NEPAL.

Description – Basidiomata annual, usually pileate, sometimes effused-reflexed; pilei partly dimidiate to broadly attached, imbricate, coriaceous when fresh, hard corky and flexible when dry.

Pileal surface white when fresh, cream to pale buff with age, concentrically sulcate with narrow zones, with densely fibrous tomentum. Hymenophore poroid, violet to vinaceous brown when fresh, dark brown to fuscous when dry; pores regular and angular, 4–6 per mm; dissepiments entire when juvenile, slightly lacerated with age. Context duplex, up to 17 mm thick, the upper layer white when fresh, cream to pale buff or ochraceous when dry, floccose, soft, the lower layer darker, firm, fibrous; a thin gelatinous layer present between the two layers. Tubes concolorous with pores. Hyphal system dimitic. Cystidia narrowly subulate to clavate, slightly to distinctly thick-walled, abundant, embedded or slightly projecting from hymenium, with a small apical crown of crystals, 21–26 × 3.5–6 µm. Hyphal pegs absent. Basidiospores cylindric, smooth, IKI–, CB–, 5.2–7.1(–7.3) × 1.9–2.3(2.6) µm, L = 6.34 µm, W = 2.08 µm, Q = 2.83–3.04 (n = 90/3).

Distribution and ecology – *Hirschioporus montanus* is widely distributed in the Himalayan region included Nepal and western Sichuan, northern Yunnan and southern Gansu. The species grows almost exclusively on *Abies* at a high altitude.

Notes – *Hirschioporus montanus* is easy to recognize in the field and distinctly differs from other species of the *H. abietinus* complex due to its pileal surface with a dense fibrous tomentum up to 17 mm thick, small pores, 4–6 per mm, narrow basidiospores (Q > 2.8) and distribution in the mountainous areas. Interestingly, the ITS sequence of *H. montanus* has a specific fragment in the ITS 1, up to 800 bp in length, clearly distinguishing it from other species in the complex.

Specimens examined – CHINA. Gansu, Zhuoni, Binghe Nat. Res., on dead branch of *Abies*, 19.VIII.2022, *Dai 24196* (BJFC039438). Sichuan, Aba, Jiuzhaigou Nat. Res., on fallen trunk of *Abies*, 14.X.2021, *Dai 4189* (BJFC002708), *Dai 4204* (BJFC013434); Luding, Hailuogou Forest Park, on dead tree of *Abies*, 8.X.2021, *Dai 23134* (BJFC037705), *Dai 23143* (BJFC037714); Xiaojin, Jiajin Mt., on fallen trunk of *Abies*, 17.X.2012, *Cui 10733* (BJFC013655); Yajiang, Gexigou Nat. Res., on fallen trunk of *Abies*, 7.IX. 2020. *Cui 18351* (BJFC035210). Yunnan, Xianggelila, Potatso Nat. Park, on fallen trunk of *Abies*, 7.IX.2021, *Dai 22979* (BJFC037552); Yulongxueshan Nat. Res., on living tree of *Abies*, 16.IX.2018, *Cui 17067* (BJFC030366).

Hirschioporus pubescens Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 10

MycoBank number: MB 849253; Facesoffungi number: FoF 14434

Type – CHINA. Shanxi, Lingchuan, on stump of *Pinus*, 26.VIII.2016, *Dai 17064* (Holotype BJFC023170).

Etymology – *Pubescens* (Lat.): refers to the species having silky hairs on the upper surface.

Basidiomata – Annual, pileate to effused-reflexed, imbricate with elongated pilei, sometimes laterally fused; soft corky when fresh, hard corky when dry. Pilei projecting up to 1.5 cm, 2.5 cm wide and 3.5 mm thick at base. Pileal surface white when fresh and dry, concentrically sulcate with narrow zones, with dense silky hairs; margin vinaceous brown, acute, entire. Hymenophore poroid, vinaceous brown when fresh, becoming dark vinaceous purple to grayish brown or light gray with age or when dry; pores angular to almost irpicoid, 2–4 per mm; dissepiments thin, entire when juvenile, becoming strongly lacerated with age. Sterile margin darker than pores, vinaceous purple. Context duplex, up to 2 mm thick, white to cream, the upper layer pubescent, soft, up to 1.5 mm thick, the lower layer firm, tough-fibrous and pale ochraceous. Tubes grayish brown, sometimes separated from the context by a thin gelatinous layer, up to 1.5 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae dominant, distinctly thick-walled to subsolid, IKI–, CB+; tissues unchanged in KOH.

Context – Generative hyphae hyaline, slightly thick-walled, occasionally branched, 2–3 µm in diam.; skeletal hyphae thick-walled with a narrow lumen to subsolid, unbranched, loosely interwoven, 4–7 µm in diam.

Tubes – Generative hyphae hyaline, slightly thick-walled, usually branched, 2.5–3 µm in diam.; skeletal hyphae thick-walled with a wide lumen, unbranched, loosely interwoven to subparallel along tubes, 2.5–4 µm in diam.; hyphae at dissepiment edges smooth, slightly swollen at tips; encrusted cystidia present at dissepiment edges.

Hymenium – Cystidia hyaline, thin- to moderately thick-walled, abundant, fusoid to subulate, usually apically encrusted, 20–35 × 3.5–5 µm, projecting from hymenium up to 17 µm, with a basal clamp connection; hyphal pegs present, with capitate, encrusted thick-walled cystidia, 22–30 × 4.5–9 µm; basidia more or less clavate with four sterigmata and a basal clamp connection, 22–27 × 5–6 µm; basidioles similar to basidia in shape, but slightly smaller.

Spores – Basidiospores cylindric, slightly curved, hyaline, thin-walled, smooth, IKI–, CB–, (5.5–)5.8–7.6(–8) × (2.9–)3–4 µm, L = 6.60 µm, W = 3.4 µm, Q = 1.88–2 (n = 60/2).

Type of rot – White rot.

Distribution and ecology – *Hirschioporus pubescens* seems to be a rare species in temperate areas of China and Republic of Korea. It grows on dead trees and charred wood of *Pinus* in a dry environment.

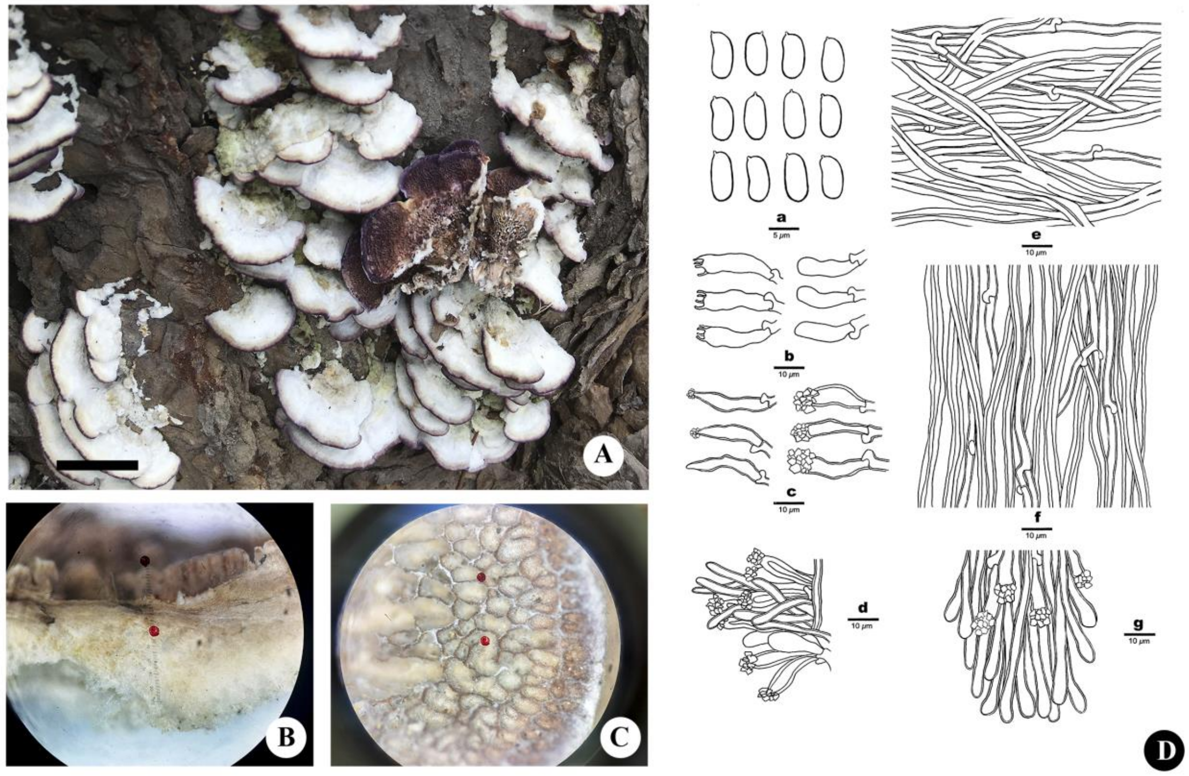

Figure 10 – A Basidiomata of *Hirschioporus pubescens* (*Dai 17064*). B Longitudinal section. C Hymenophore. D Microscopic structures of *H. pubescens* (*Dai 17064*). a Basidiospores. b Basidia and basidioles. c Cystidia. d Hyphal peg. e Hyphae from context. f Hyphae from trama. g Hyphae at dissepiment edge. Scale bars: A = 1 cm, B–C = 1 mm.

Notes – *Hirschioporus pubescens* is characterized by annual, pileate to effused-reflexed, imbricate basidiomata, duplex context with a white pubescent upper surface and a compacted lower layer, large pores, 2–4 per mm, the presence of hyphal pegs, cylindric basidiospores, 5.8–7.6 × 3–4 µm, and growth on *Pinus* in temperate areas.

Phylogenetically, *Hirschioporus pubescens* is closely related to *H. abietinus, H. beijingensis* and *H. chinensis* (Fig. 4); these four species nested in the *H. abietinus* complex. 13 base pair differences in the ITS regions were identified between *H. abietinus* and *H. pubescens*. Morphologically, *H. abietinus* is readily distinguished from *H. pubescens* by smaller pores (4–6 vs. 2–4 per mm), and narrower basidiospores (< 3.2 µm vs. > 3 µm in width).

The nucleotide difference between *H. beijingensis* and *H. pubescens* is 25 base pairs which accounts for > 2% of the nucleotides in the ITS regions. Morphologically, *H. beijingensis* differs from *H. pubescens* by a distinctly thin context and light purple pore surface. *H. chinensis* is distinguished from *H. pubescens* by its smaller pores (3–6 per mm vs. 2–4 per mm), and absence of hyphal pegs.

Additional specimens examined – CHINA. Beijing, Pinggu, on fallen trunk of *Pinus tabuliformis*, 4.VII.2022, *Dai 23710* (BJFC038955), *Dai 23711* (BJFC038956), *Dai 23713* (BJFC038958). Hunan, Loudi, Zhushan Park, on dead tree of *Pinus massoniana*, 16.X.2018, *Dai 19211* (BJFC027678). Liaoning, Beizhen, Yiwulvshan Nat. Res., on charred wood of *Pinus tabuliformis*, 13.X.2020, *Dai 21898* (BJFC035797).

Hirschioporus tianschanicus Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 11

MycoBank number: MB 849272; Facesoffungi number: FoF 14435

Type – CHINA. Xinjiang, Fukang, Tianchi Nat. Res., on fallen trunk of *Larix*, 12.IX.2018, *Dai 19067* (Holotype BJFC027537).

Etymology – *Tianschanicus* (Lat.): refers to the species having a distribution in the Tianshan Mountains, Central Asia.

Basidiomata – Annual, usually resupinate to effused-reflexed, rarely pileate; corky when fresh, becoming brittle upon drying. Pilei sometimes laterally fused, projecting up to 1 cm, 1.5 cm wide and 4 mm thick at base, the resupinate part up to 6 cm long and 3 cm wide. Pileal surface white to cream when fresh, cream when dry, concentrically sulcate with narrow zones, adpressed velutinate; margin concolorous with pileal surface, acute, entire. Hymenophore poroid, light purple when juvenile and fresh, becoming grayish brown to vinaceous brown when dry; pores angular, 4–6 per mm; dissepiments thin, entire, slightly lacerated with age. Sterile margin more grayish than pores. Context duplex, up to 0.5 mm thick, the upper layer cream, slightly spongy, velutinate, the lower layer firm, tough-fibrous, darker than tubes. Tubes grayish brown, up to 3.5 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae distinctly thick-walled, IKI–, CB+; tissues unchanged in KOH.

Context – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–2.5 µm in diam.; skeletal hyphae thick-walled, unbranched, regularly arranged, 3–5 µm in diam.

Tubes – Generative hyphae hyaline, slightly thick-walled, occasionally branched, 2–3 µm in diam.; skeletal hyphae thick-walled, unbranched, loosely interwoven to subparallel along tubes, 2.5–4 µm in diam.; hyphae at dissepiment edges usually encrusted with small purple crystals.

Hymenium – Cystidia clavate, thick-walled, abundant, usually apically encrusted, 17–27 × 4–8 µm, projecting from hymenium up to 10 µm, with a basal clamp connection; cystidioles present, fusoid, thin-walled, smooth, 14–25 × 4–4.5 µm; hyphal pegs absent; basidia more or less clavate, with four sterigmata and a basal clamp connection, 18–28 × 5–6 µm; basidioles clavate to pyriform, distinctly smaller than basidia.

Spores – Basidiospores cylindric to allantoid, hyaline, thin-walled, smooth, IKI–, CB–, 6–8.5(–8.9) × (2.4–)2.5–3(–3.1) µm, L = 7.05 µm, W = 2.74 µm, Q = 2.39–2.70 (n = 120/4).

Type of rot – White rot.

Distribution and ecology – *Hirschioporus tianschanicus* has a distribution in the Tianshan Mountains, Central Asia. In our study, the phylogeny inferred from the multi-gene phylogeny dataset (Fig. 4) shows the Chinese samples and one specimen (KA16-1050, ITS: MK351689) from Kyrgyzstan formed a distinct lineage. All these samples were collected from the Tianshan Mountains, Central Asia, and it appears that the species is endemic to the Tianshan Mountains. *H. tianschanicus* grows on recently fallen trunks of *Larix* and *Picea*, indicating it is a pioneer decayer in the coniferous forests of the Tianshan Mountains.

Notes – *Hirschioporus tianschanicus* is characterized by annual, resupinate to effused-reflexed basidiomata, large pores, 2–4 per mm, the presence of cystidioles, cylindric to allantoid basidiospores, 6–8.5 × 2.5–3 µm, and growth on *Larix* and *Picea* in the Tianshan Mountains.

Phylogenetically, 13 samples of *Hirschioporus tianschanicus* formed a distinct lineage with strong support (100% ML/MP, 1.00 BPPs), nested in the *H. abietinus* complex and is closely related to *H. abietinus*, *H. beijingensis* and *H. pubescens*. Referring to DNA data, the nucleotide differences betwen *H. abietinus* and *H. tianschanicus* are more than 3% in the ITS regions. Morphologically, *H. abietinus* and "*H. abietinus*" are readily distinguished from *H. tianschanicus* by shorter basidiospores (5.2–7.4 µm, 5.2–7.3 µm in length vs. 6–8.5 µm in length), the absence of cystidioles and smooth hyphae in the dissepiments. Phylogenetically, both the nucleotide differences between *H. tianschanicus* and *H. beijingensis*, and between *H. tianschanicus* and *H. pubescens* are more than 3% in the ITS regions.

Morphologically, both *Hirschioporus chinensis* and *H. pubescens* differ from *H. tianschanicus* by wider basidiospores (3–4 µm vs. 2.5–3 µm in width); *H. beijingensis* differs from *H. tianschanicus* by larger pores (2–4 vs. 4–6 per mm) and the presence of hyphal pegs; *H. montanus* differs from *H. tianschanicus* by a pileal surface of dense fibrous tomentum and narrower basidiospores ($Q > 2.8$ vs. $Q = 2.39–2.7$).

Additional specimens examined – CHINA. Xinjiang, Altay, Baihaba Nat. Forest Park, on fallen trunk of *Larix*, 10.IX.2015, *Dai 15849* (BJFC019950); Fukang, Tianchi Nat. Res, on fallen trunk of *Larix*, *Dai 19080* (BJFC027550), *Dai 19085* (BJFC027555), *Dai 19086* (BJFC027556); on fallen trunk of *Picea*, 12.IX.2018, *Dai 19055* (BJFC027525), *Dai 19057* (BJFC027527), *Dai 19064* (BJFC027534); Gongliu, Xitianshan Nat. Res., on fallen trunk of *Picea*, 14.IX.2015, *Dai 15944* (BJFC020045); Hami, Baishitou Nat. Res., on fallen trunk of *Larix*, 14.IX.2018, *Dai 19076* (BJFC027547); Nileke, Qiolma, on fallen trunk of *Picea*, 9.VII.2018, *Cui 16849* (BJFC030148), *Cui 16850* (BJFC030149); Tekes, Qiongkushitai, on fallen trunk of *Picea*, 20.IX.2021, *Cui 19235* (BJFC); Urumqi, Xibaiyanggou Forest Farm, on fallen trunk of *Picea*, 11.IX.2021, *Cui 18779* (BJFC).

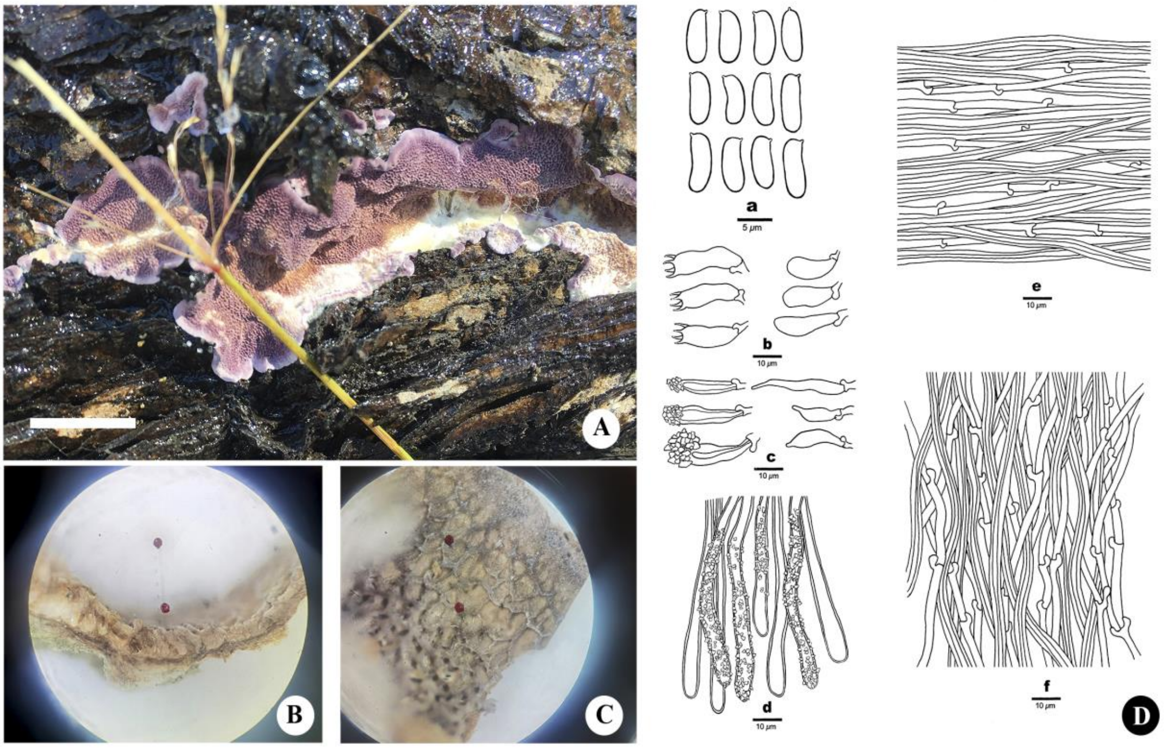

Figure 11 – A Basidiomata of *Hirschioporus tianschanicus* (*Dai 19067*). B Longitudinal section; C. Hymenophore. D Microscopic structures of *H. tianschanicus* (*Dai 19067*). a Basidiospores. b Basidia and basidioles. c Cystidia and cystidioles. d Hyphae at dissepiment edge. e Hyphae from context. f Hyphae from trama. Scale bars: A = 1 cm, B = 5 mm, C = 1 mm.

The differences among taxa in the *Hirschioporus abietinus* complex, as *H. abietinus*, "*H. abietinus*", *H. beijingensis*, *H. chinensis*, *H. pubescens*, *H. montanus*, *H. tianschanicus* and *Hirschioporus* sp, are listed in Table 3.

Table 3 Morphological characteristics of the taxa within the *Hirschioporus abietinus* complex. (+: present, -: absent)

Species	Basidiomata	Context	Pileal surface	Pore surface	Pores (Per mm)	Basidiospores (µm)	Encrusted cystidia & width (µm)	Cystidioles	Hyphal pegs	Hyphae at dissepiment edges	Distribution
H. abietinus	Effused-reflexed to pileate	Thin	Pubescent or velvet when juvenile, sparse to adpressed velutinate with age, indistinctly zonate to azonate	Bright purplish, fading to ochraceous	Angular, deeply lacerated with age, 4–6	5.2–7.4 × 2.3–3, Q = 2.22–2.67	Fusoid, 4–7	–	+	Smooth	Throughout the coniferous forest regions of North Hemisphere. Usually in temperate zone, but also in warm temperate and subtropical zones
"*H. abietinus*"	Usually resupinate to effused-reflexed, occasionally pileate	Thin	Pubescent when juvenile, becoming loosely adpressed velutinate with age, concentrically sulcate with narrow zones	Fawn to grayish violet, becoming snuff brown to milky coffee	Angular, strongly lacerated with age, 4–6	5.2–7.3 × 2.5–3.2, Q = 1.93–2.41	Two types: fusoid to subulate cystidia, 5–6.5; skeletocystidia capitate to clavate, thick-walled to almost solid, 5.5–9	–	+	Encrusted	Temperate Eurasia
H. beijingensis	Mostly resupinate to effused-reflexed	Thin	Loosely adpressed velutinate, indistinctly zonate to azonate	Light purple, becoming vinaceous brown and grayish brown	Angular to irpicoid, 2–4	5–7 × 3–3.5, Q = 1.82–2.00	Clavate to capitate, 4.5–8	–	+	Smooth	North China

Table 3 Continued.

Species	**Basidiomata**	**Context**	**Pileal surface**	**Pore surface**	**Pores (Per mm)**	**Basidiospores (µm)**	**Encrusted cystidia & width (µm)**	**Cystidioles**	**Hyphal pegs**	**Hyphae at dissepiment edges**	**Distribution**
H. chinensis	Usually effused-reflexed sometimes pileate	Thin	Loosely velutinate; indistinctly zonate to azonate	Pale purplish to clay pink to clay buff	Angular to irpicoid, 2–4	6–7.4 × 3–3.7, Q = 1.84–2.10	Capitate to subulate, 3–5	–	–	Smooth, slightly swollen at tips	Warm temperate subtropical China
H. montanus	Usually pileate, sometimes effused-reflexed	Distinctly thick	Full of densely fibrous tomentum; indistinctly zonate	Violet to vinaceous brown to fuscous	Angular, slightly lacerated with age, 4–6	5.2–7.1 × 1.9–2.3, Q = 2.83–3.04	Narrowly subulate to clavate capitated, 3.5–6	–	–	Smooth	Himalayan area
H. pubescens	Effused-reflexed to pileate	Thick	Pubescent; concentrically sulcate with narrow zones	Light purple, becoming grayish brown to vinaceous brown	Angular to almost irpicoid, 2–4	5.8–7.6 × 3–4, Q = 1.88–2	Two types: fusoid to subulate cystidia, 3.5–5; capitated cystidia, 4.5–9	–	+	Encrusted, slightly swollen.	Northeast Asia
H. tianschanicus	Resupinate to effused-reflexed	Thin	Adpressed velutinate; concentrically sulcate with narrow zones	Light purple, becoming grayish brown to vinaceous brown	Angular, deeply lacerated with age, 4–6	6–8.5 × 2.5–3, Q = 2.39–2.70	Fusoid, 4–8	+	–	Usually encrusted with small purple crystals	Central Asia.

Other taxa of *Hirschioporus*

Hirschioporus acontextus Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 12

MycoBank number: MB 849273; Facesoffungi number: FoF 14436

Type – CHINA. Jilin, Antu, Changbaishan Nat. Res., on fallen trunk of *Abies*, 24.VII.2022, *Dai 23793* (Holotype BJFC039037).

Etymology – *Acontextus* (Lat.): refers to the species having an extremely thin to almost absent context.

Basidiomata – Annual, usually effused-reflexed, occasionally pileate; corky when fresh, rigid and brittle upon drying. Pilei usually laterally fused, projecting up to 1.5 cm, 3 cm wide and 2 mm thick at base. Pileal surface white to gray when fresh and dry, concentrically indistinctly sulcate or azonate, rough, loosely adpressed velutinate; margin concolorous with pileal surface, acute, lobed. Hymenophore hydnoid to sublamellate, vinaceous to clay buff, paler towards the margin when fresh, fading to olivaceous buff with age, pale grayish brown when dry; pores radially elongated to lamellate, becoming distinctly dentate with age, 1–2 per mm; dissepiments thin, strongly lacerated with age. Sterile margin indistinct. Context thin, transparent between tubes, duplex, the upper layer white to cream, soft, sparse to velutinate layer present in pileate basidiomata, the lower layer extremely thin to almost absent. Tubes brown, up to 2 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae pale yellowish in KOH, distinctly thick-walled; IKI–, CB+; tissues unchanged in KOH.

Context – Generative hyphae hyaline, thin-walled, rarely branched, 2–4 µm in diam.; skeletal hyphae dominant, thick-walled, unbranched, more or less fleuxous, interwoven, 3–5 µm in diam.

Tubes – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–3 µm in diam.; skeletal hyphae thick-walled with a wide lumen, unbranched, loosely interwoven to subparallel along the trama, 3–5 µm in diam., skeletal hyphae at dissepiment edges apically encrusted, cystidia-like.

Hymenium – Cystidia fusoid, thick-walled, abundant, usually apically encrusted, 17–26 × 3.5–6 µm; hyphal pegs rarely present; basidia clavate, with four sterigmata and a basal clamp connection, 18–20 × 4–5.5 µm; basidioles similar with basidia in shape, but smaller.

Spores – Basidiospores allantoid, hyaline, thin-walled, smooth, IKI–, CB–, (5–)5.3–6.7(–7.3) × (2.1–)2.2–2.8 µm, L = 5.90 µm, W = 2.35 µm, Q = 2.11–2.54 (n = 120/4).

Type of rot – White rot.

Distribution and ecology – Our studied samples were collected from northeastern China. The phylogeny (Fig. 4) shows that one specimen (KUC20131001-03, ITS: KJ668436) from Republic of Korea and our samples form an independent lineage. So far, the species has a distribution in northeast Asia. *Hirschioporus acontextus* grows on recently fallen trunks and branches of *Abies*, *Larix* and *Picea*.

Notes – *Hirschioporus acontextus* is characterized by effused-reflexed, occasionally pileate basidiomata, extremely thin context with azonate sparse velutinate pileal surface, hydnoid to sublamellate hymenophore, allantoid basidiospores, 5.3–6.7 × 2.2–2.8 µm.

Phylogenetically, *Hirschioporus acontextus* is closely related to *H. fuscoviolaceus* and "*H. fuscoviolaceus*" (Fig. 4), but a 24-base-pair difference is identified between *H. acontextus* and *H. fuscoviolaceus*, which accounts for > 2% of the nucleotides in the ITS regions. Morphologically, *H. fuscoviolaceus* differs from *H. acontextus* by longer basidiospores (6.5–8.7 × 2.5–3.1 vs. 5.3–6.7 × 2.2–2.8 µm). The nucleotide difference in the ITS regions between "*H. fuscoviolaceus*" and *H. acontextus* is more than 1.5%. "*H. fuscoviolaceus*" differs from *H. acontextus* by its irpicoid to hydnoid hymenophore, which always remains poroid towards the margin and shorter basidiospores (L = 5.12 µm, W = 2.32 µm vs. L = 5.9 µm, W = 2.35 µm in average).

Additional specimens examined – CHINA. Heilongjiang, Wuying, Fenglin Nat. Res., on fallen trunk of *Larix*, 28. VIII. 2014, *Cui11830* (BJFC016893); on fallen trunk of *Picea*, 25. VIII.2014, *Cui11451* (BJFC016693); 31.VIII.2014, *Cui 12067* (BJFC016985). Jilin, Antu, Changbaishan Nat. Res., Huangsongpu, on dead tree of *Abies*, 18.IX.2018, *Dai19096* (BJFC027566); on dead branch of *Abies*, 18.IX.2018, *Dai19097* (BJFC027567); on fallen trunk of *Abies*, 18.IX.2018, *Dai19098* (BJFC027568); on fallen trunk of *Larix*, 18.IX.2018, *Dai19089* (BJFC027559), *Dai19091* (BJFC027561), *Dai19092* (BJFC027562); 23.IX.2018, *Dai19456* (BJFC027923), *Dai19458* (BJFC027925); 24.VII.2022, *Dai23776* (BJFC039020).

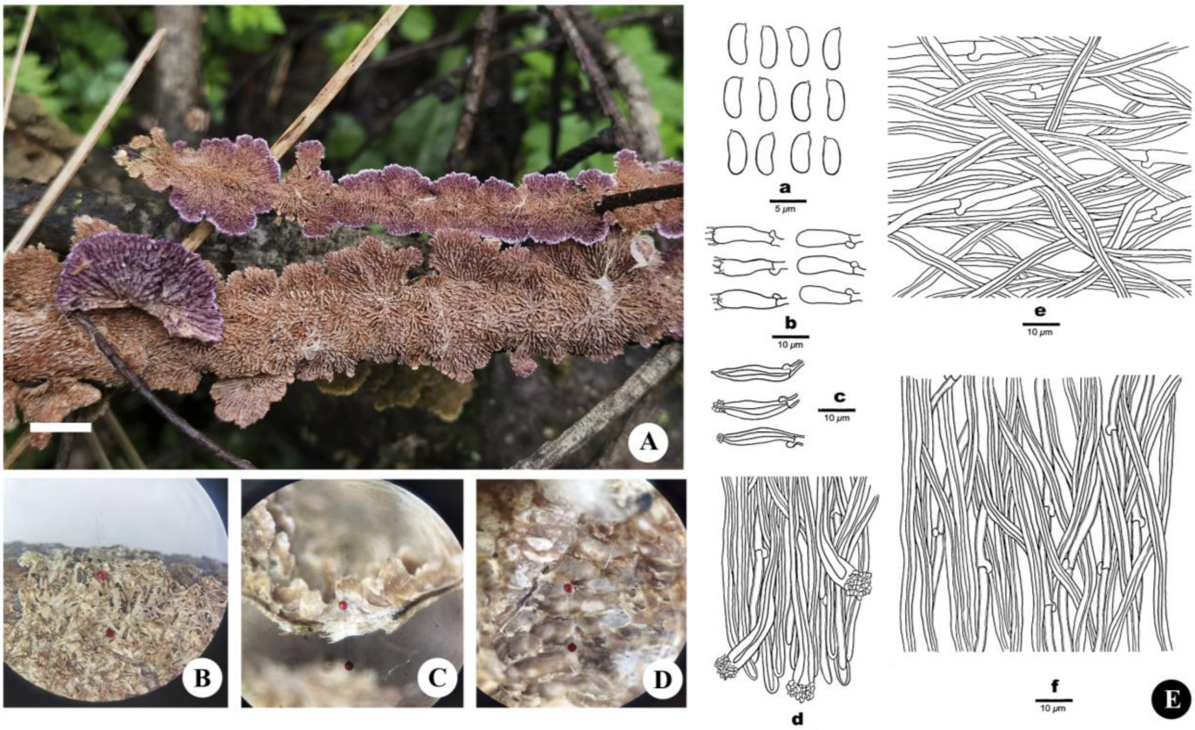

Figure 12 – A–B Basidiomata of *Hirschioporus acontextus* (*Dai 23793*). C Longitudinal section. D Hymenophore. E Microscopic structures of *H. acontextus* (*Dai 23793*). a Basidiospores. b Basidia and basidioles. c Cystidia. d Hyphae at dissepiment edge. e Hyphae from context. f Hyphae from trama. Scale bars: A = 1 cm, B–C = 5 mm, D = 1 mm.

Hirschioporus fuscoviolaceus (Ehrenb.) Donk, Mededelingen van het botanisch Museum en Herbarium van de Rijksuniversiteit Utrecht 9: 169 (1933)

≡ *Sistotrema fuscoviolaceum* Ehrenb., Sylv. mycol. berol. (Berlin): 30 (1817).

≡ *Trichaptum fuscoviolaceum* (Ehrenb.) Ryvarden (1972).

Type locality – GERMANY.

Description – Basidiomata annual, usually effused-reflexed, rarely pileate or resupinate, imbricate, usually laterally fused; pilei projecting up to 1.5 cm, 8 cm wide and 5 mm thick at base. Pileal surface white to gray, azonate, velutinate to pubescent; margin white to pale brown. Hymenophore irpicoid to hydnoid or sublamellate, bright purplish to grayish violet when fresh, fading to ochraceous with age, grayish brown when dry, short lamellate to radially elongated or dentate; lamella or teeth 1–3 per mm. Context duplex, up to 1 mm thick, the upper layer white to cream, finely pubescent, the lower layer darker and tough. Tubes concolorous with pores. Cystidia fusoid, thick-walled, abundant, usually apically encrusted or smooth, embedded or projecting from hymenium up to 15 µm, 5–9 µm in diam., arising from embedded tramal skeletal hyphae. Hyphal pegs present. Basidiospores cylindric, slightly curved, hyaline, smooth, IKI–, CB–, 6.5–8.7(–9) × (2.4–)2.5–3.1(–3.2) µm, L = 7.85 µm, W = 2.87 µm, Q = 2.57–2.88 (n = 120/4).

Distribution and ecology – *Hirschioporus fuscoviolaceus* is widely distributed throughout the coniferous forests of the Northern Hemisphere. It prefers to grow on *Pinus* but also occurs on *Abies*, *Larix* and *Picea*.

Notes – *Hirschioporus fuscoviolaceus* is characterized by mostly effused-reflexed basidiomata, irpicoid to hydnoid hymenophore, the upper layer dense and cottony, long cylindric, slightly curved basidiospores, 6.5–8.7 × 2.5–3.1 µm. Morphologically, *H. fuscoviolaceus* is separated from the *H. abietinus* complex by its hydnoid hymenophore with radially elongated lamella.

Biological activities – Antitumor (Dai et al. 2009); antibacterial and antioxidant (Nowacka et al. 2015).

Specimens examined – BELARUS. Homyelskaya Voblasts, Prypytski Nat. Park, on stump of *Pinus*, 15.X.2019, *Dai 20963* (BJFC032622); 16.X.2019, *Dai 20988* (BJFC032647); on fallen trunk of *Pinus*, 16.X.2019, Dai 20984 (BJFC032643), Dai 20987 (BJFC032646); 17.X.2019, *Dai 21008* (BJFC032667), *Dai 21009* (BJFC032668), *Dai21011* (BJFC032670); 18.X.2019, *Dai 21021* (BJFC032680). CHINA. Xinjiang, Altay, Baihaba Nat. Forest Park, on fallen trunk of *Larix*, 10.IX.2015, *Dai 15840* (BJFC019941). CZECH REPUBLIC. Hluboka, Bezdrev, Jaderny, on fallen trunk of *Pinus sylvatica*, 30.X.2016, JV 1610/ 32 (JV). ITALY. Roma, Castol Fusano, on fallen trunk of *Pinus*, 26.IV.2005, *Dai 6539* (BJFC002680).

"*Hirschioporus fuscoviolaceus*" Fig. 13

Description – Basidiomata annual, effused-reflexed to pileate, corky when fresh, rigid upon drying; pilei imbricate, usually laterally fused; single pileus projecting up to 1.5 cm, 3 cm wide and 2 mm thick at base. Pileal surface white to gray when fresh and dry, concentrically sulcate with narrow zones, villose to velutinate; margin concolorous with pileal surface, acute, lobed. Hymenophore irpicoid to hydnoid, light purple or buff when fresh, ochraceous to pale brown or grayish brown with age or when dry. Pores radially elongated to labyrinthine usually remaining poroid towards the margin, 1–3 per mm, dissepiments thin, entire, deeply lacerated to dentate with age. Sterile margin indistinct. Context duplex, thin, the upper layer cream, soft, the lower layer extremely thin. Tubes brown, up to 2 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia fusoid to subclavate, slightly thick-walled, sometimes apically encrusted, 15–30 × 5–6.5 µm. Hyphal pegs present. Basidiospores allantoid, hyaline, thin-walled, smooth, IKI–, CB–, (4–)4.3–6.5 × (1.9–)2–3 µm, L = 5.12 µm, W = 2.32 µm, Q = 1.89–2.60 (n = 120/4).

Distribution and ecology – "*Hirschioporus fuscoviolaceus*" has a distribution from temperate to subtropical zones of Eurasia and grows on gymnosperms, such as *Cunninghamia*, *Keteleeria*, *Larix* and *Pinus*.

Notes – This taxon is characterized by effused-reflexed to pileate basidiomata, a poroid to irpicoid or hydnoid hymenophore with pale-colored pores, distinctly small basidiospores, 4.3–6.5 × 2–3 µm, and a wide distribution from the temperate to subtropical zones. According to our study, the nucleotide difference in the ITS regions between *Hirschioporus fuscoviolaceus* and "*H. fuscoviolaceus*" is more than 2%. Morphologically, *H. fuscoviolaceus* differs from "*H. fuscoviolaceus*" by larger basidiospores (6.5–8.7 × 2.5–3.1 µm vs. 4.3–6.5 × 2–3 µm). So, these two taxa represent two independent species. *H. fuscoviolaceus* was originally described from Germany, but several taxa described from Europe were treated as synonyms of *H. fuscoviolaceus*. "*H. fuscoviolaceus*" is also found in Finland. So, "*H. fuscoviolaceus*" may be one of the synonyms of *H. fuscoviolaceus*, but, because we did not study the types of these synonyms, we treat this taxon as "*H. fuscoviolaceus*" in this study.

Specimens examined – CHINA. Anhui, Yellow Mt., on dead tree of *Cunninghamia lanceolata*, 10.X.2004, *Dai 6031* (BJFC002700). Fujian, Wuyi Mt., on dead tree of *Pinus massoniana*, 18.X.2005, *Dai 7196* (BJFC002702). Guangdong, Shixing, Chebaling Nat. Res., on *Pinus massoniana*, 26.VI.2010, *Cui 8850* (BJFC007790). Heilongjiang, Wuyiling, Wuyiling Nat. Res., 29.VIII.2014, *Cui11870* (BJFC016907). Jiangxi, Jinggangshan, Jinggangshan Nat. Res., on dead tree of *Cunninghamia lanceolata*, 22.IX.2008, *Dai 10576* (BJFC004825); Yushan, Sanqingshan Scenic Spot, on dead branch of *Pinus massoniana*, 26.VII.2015, *Dai 15431* (BJFC019537). Inner Mongolia, Arxan Nat. Forest Park, on charred trunk of *Larix*, 24.VIII.2020, *Dai 21636* (BJFC035537). Sichuan, Xichang, Luoji Mts., on fallen gymnosperm branch, 17.VIII.2019, *Cui 17609* (BJFC034468). Yunnan, Lanping, Luoguqing Nat. Res., on fallen trunk of *Picea*, 3.IX.2021, *Dai 22771* (BJFC037344); Mouding, Huafoshan Nat. Res., on fallen trunk of *Keteleeria fortunei*, 31. VIII. 2021, *Dai 22644* (BJFC037218); Weixi, Laojunshan Nat. Res., on fallen trunk of *Picea*, 21.IX.2011, *Cui 10439* (BJFC011334); Xinshengqiao Nat. Res., on stump of *Pinus yunnanensis*, 2.IX.2021, *Dai 22730* (BJFC037303).

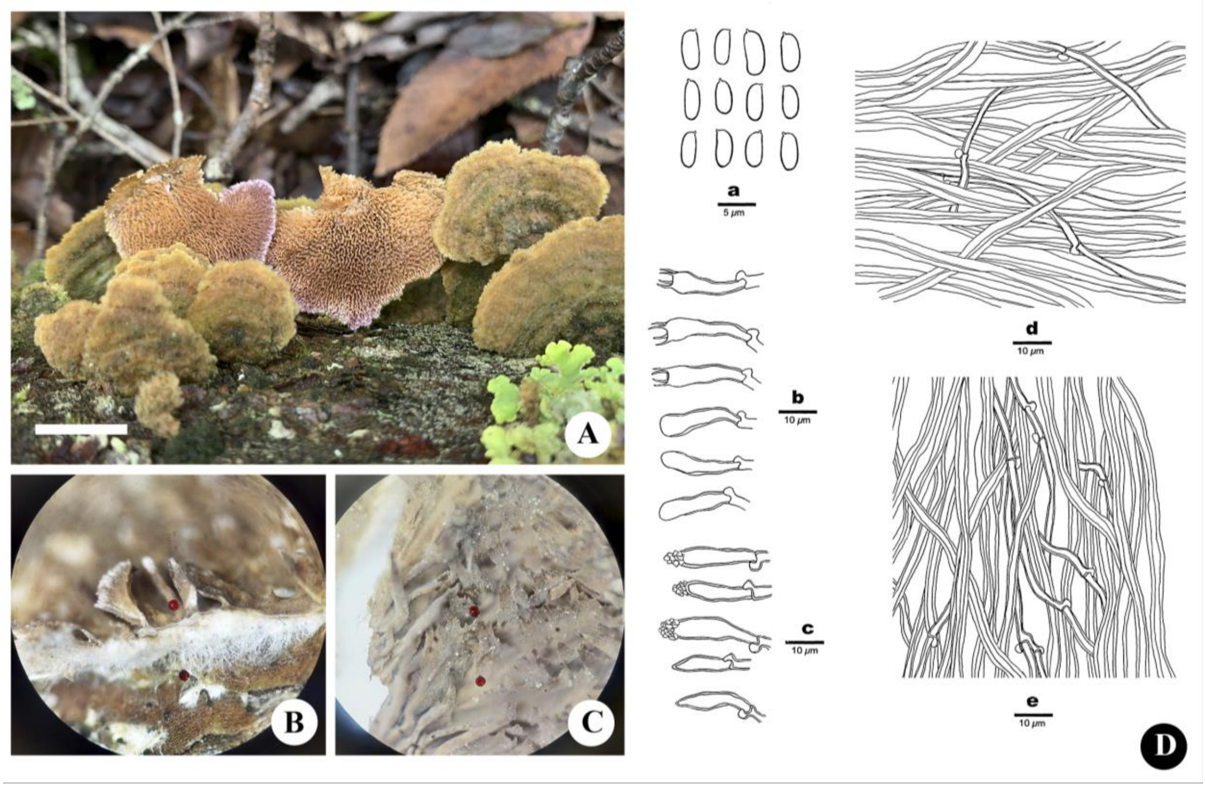

Figure 13 – A Basidiomata of "*Hirschioporus fuscoviolaceus*" (*Dai 22770*). B Longitudinal section. C Hymenophore. D. Microscopic structures of "*H. fuscoviolaceus*" (*Dai 22770*). a Basidiospores. b Basidia and basidioles. c Cystidia. d Hyphae from context. e Hyphae from trama. Scale bars: A = 1 cm, B = 5 mm, C = 1 mm.

Hirschioporus floridanus Y.C. Dai, Vlasák & Meng Zhou, sp. nov. Fig. 14

MycoBank number: MB 849274; Facesoffungi number: FoF 14437

Type – USA. Florida, Manatee, Lakewood Ranch, Braden River Nature Trail, on branch of *Pinus*, 3.II.2016, *Dolliner 642* (Holotype BJFC039888).

Etymology – *Floridanus* (Lat.): refers to the species having a distribution in Florida, USA.

Basidiomata – Annual, effused-reflexed, rarely pileate or resupinate, coriaceous when fresh, hard and rigid upon drying. Pilei usually imbricate, sometimes laterally fused, small and thin, projecting up to 1 cm, 1.5 cm wide and 3 mm thick at base. Pileal surface white to cream when fresh and dry, concentrically indistinctly sulcate or azonate, velutinate; margin concolorous with pileal surface, acute, entire. Hymenophore poroid to hydnoid, grayish brown when dry; pores distinctly radially elongated to irregular when juvenile, split to round or flattened teeth with age, usually remaining poroid towards the margin, irregular pores and teeth, 2–4 per mm, dissepiments thin, deeply lacerated to conspicuously dentate**.** Sterile margin lighter than pores. Context duplex, up to 1 mm thick, the upper layer cream, the lower layer coriaceous, consistent with tubes. Tubes brown, up to 2 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae dominant, distinctly thick-walled, IKI–, CB+; tissues unchanged in KOH.

Context – Generative hyphae hyaline, thin- to slightly thick-walled, sometimes branched, 3–6 µm in diam.; skeletal hyphae thick-walled with a narrow lumen to subsolid, unbranched, interwoven, 2–3 µm in diam.

Tubes – Generative hyphae hyaline, thin- to slightly thick-walled, occasionally branched, 2–2.5 µm in diam.; skeletal hyphae thick-walled with a narrow lumen, unbranched, subparallel along tubes, 2.5–4 µm in diam.

Hymenium – Cystidia hyaline, thick-walled, abundant, two types: clavate to ventricose cystidia usually apically encrusted, 15–30 × 4–6 µm; fusoid and smooth cystidia, 25–35 × 6–8 µm; hyphal pegs absent; basidia clavate, with four sterigmata and a basal clamp connection, 16–21 × 4–6 µm; basidioles similar to basidia in shape, but slightly smaller.

Spores – Basidiospores allantoid, hyaline, thin-walled, smooth, IKI–, CB–, 5.2–6.5(–7) × 2–2.5 µm, L = 6.01µm, W = 2.21µm, Q = 2.71 (n = 30/2).

Type of rot – White rot.

Distribution and ecology – *Hirschioporus floridanus* is so far only found from Florida, USA and grows on *Pinus*.

Notes – *Hirschioporus floridanus* is characterized by annual, effused-reflexed basidiomata, light purple to grayish brown pileal surface, irpicoid hymenophore, allantoid basidiospores, 5.2–6.5 × 2–2.5 µm, and a distribution in subtropical North America.

Phylogenetically, samples of *Hirschioporus floridanus* form an independent lineage closely related to *H. fuscoviolaceus.* A 24-base-pair difference in ITS sequences was identified between *H. floridanus* and *H. fuscoviolaceus*, which accounts for > 2% of the nucleotides. A 33-base-pair difference in ITS sequences between *H. floridanus* and "*H. fuscoviolaceus*" was identified, which accounts for >3% of the nucleotides.

Morphologically, "*Hirschioporus fuscoviolaceus*" has a distinct radially elongated to lamellate hymenophore and almost no context, while *H. floridanus* has a poroid to hydnoid hymenophore and a distinct context. All synonyms of *H. fuscoviolaceus* were described from Europe (Willdenow 1788, Kunze & Schmidt 1817, Ehrenberg 1818, Secretan 1833, Wettstein 1886, Hennings 1898). It is highly probable that the European samples of these taxa represent *H. fuscoviolaceus*. Morphologically, *H. fuscoviolaceus* differs from *H. floridanus* by bigger basidiospores (6.5–8.7 × 2.5–3.1 vs. 5.2–6.5 × 2–2.5 µm).

Lenzites abietis Lloyd, described from Colorado, USA (Lloyd 1920–1921), was treated as a synonym of *Trichaptum laricinum.* Morphologically, it has a lenzitoid hymenophore which is distinctly different from the irpicoid hymenophore of *Hirschioporus floridanus.*

Additional specimen examined – USA. Florida, Manatee, Lakewood Ranch, Braden River Nature Trail, on branch of *Pinus*, 3.II.2016, *Dolliner 640* (BJFC039887).

Pallidohirschioporus Y.C. Dai, Yuan Yuan & Meng Zhou, gen. nov.

MycoBank number: MB 849212; Facesoffungi number: FoF 14471

Etymology – *Pallidohirschioporus* (Lat.), refers to the genus being similar to *Hirschioporus* but having pale-colored basidiomata.

Type species – *Pallidohirschioporus biformis* (Fr.) Y.C. Dai, Yuan Yuan & Meng Zhou.

Description – Basidiomata annual, usually pileate, sometimes effused-reflexed, rarely resupinate; pilei flabelliform; pileal surface white, cream to ochraceous or grayish, finely adpressed velutinate to smooth with numerous narrowly concentric zones; hymenophore poroid to irpicoid or hydnoid, pale-colored, with more or less purplish tint; context duplex or homogeneous; tubes concolorous with context. Hyphal system dimitic to trimitic; generative hyphae with clamp connections; cystidia present in the hymenium, thin- to thick-walled, claviform, ventricose or lageniform, smooth or apically encrusted; basidiospores ellipsoid to cylindrical, hyaline, thin-walled, smooth, IKI–, CB–. Growing on angiosperm wood and causing a white rot.

Notes – *Pallidohirschioporus* differs from other genera of *Trichaptum s.l.* by its pileate and pale-colored basidiomata with glabrous to a finely adpressed velutinate pileal surface, poroid to irpicoid or hydnoid hymenophore, growth on angiosperms and occurrence widely from temperate to tropical areas. So far, *Pallidohirschioporus* includes *P. albus, P. biformis, P. brastagii, P. imbricatus, P. jackiae, P. parvulus, P. polycystidiatus, P. subchartaceus, P. suberosus,* and a new species, *P. versicolor*, described in this paper.

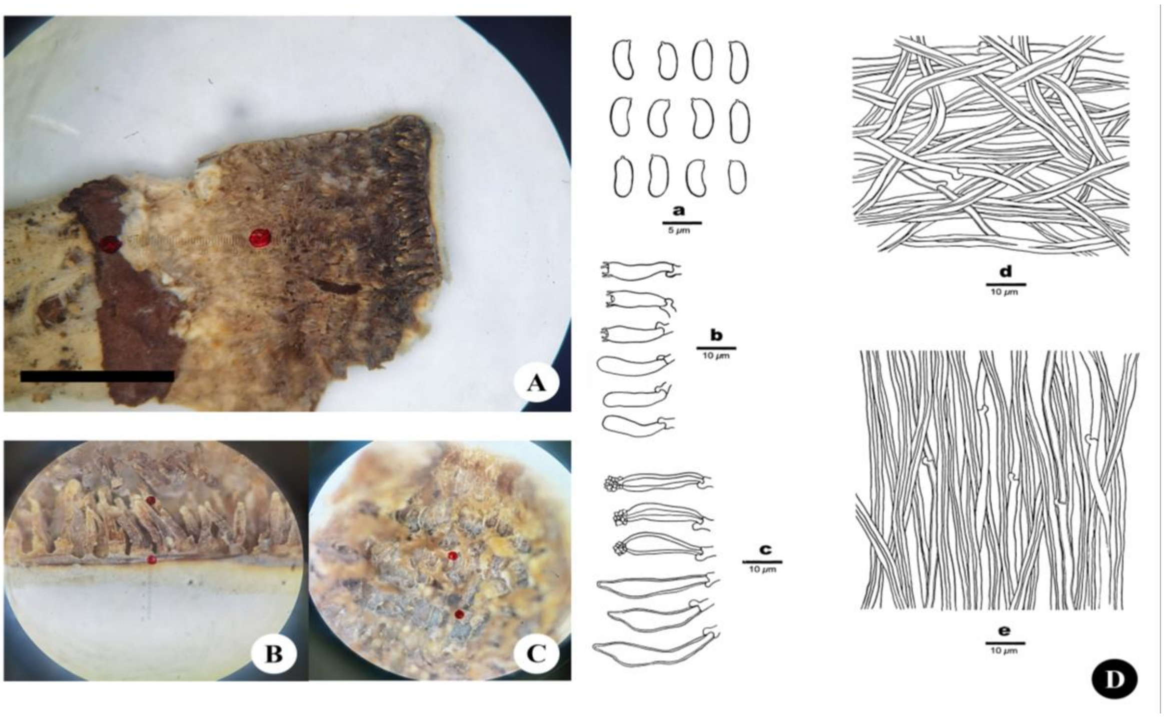

Figure 14 – A Basidiomata of *Hirschioporus floridanus* (*Dolliner 642*). B Longitudinal section. C Hymenophore. D Microscopic structures of *H. floridanus* (*Dolliner 642*). a Basidiospores. b Basidia and basidioles. c Cystidia. d Hyphae from context. e Hyphae from trama. Scale bars: A = 5 mm, B–C = 1 mm.

Key to species of *Pallidohirschioporus*
1. Hymenophore poroid to hydnoid …………………………………………………………2
1. Hymenophore poroid to irpicoid, not developing to hydnoid ………………………………6
2. Pores > 3 per mm; ……………………………………………………………………...3
2. Pores < 3 per mm ………………………………………………………………………5
3. Hymenophore completely hydnoid ………………………………………………….*P. albus*
3. Hymenophore poroid to irpicoid, lacerated to hydnoid ………………………………..…4
4. Spores 4–5 × 2–2.5 µm ……………………………………………………………..*P. brastagii*
4. Spores 5.2–6.7 × 2–2.7 µm ………………………………………………….....*P. biformis*
5. Basidiomata resupinate to effused-reflexed ……………………………………...*P. parvulus*
5. Basidiomata pileate …………………………………………………………..*P. polycystidiatus*
6. Pores 6–8 per mm; ……………………………………………………………...*P. imbricatus*
6. Pores < 5 per mm ………………………………………………………………………7
7. Pileal surface densely tomentose to adpressed velutinate ……………………………*P. versicolor*
7. Pileal surface more or less smooth ……………………………………………………….8
8. Basidiomata resupinate to effused-reflexed ……………………………………….*P. jackiae*
8. Basidiomata pileate ……………………………………………………………………9
9. Spores cylindric, slightly curved, 7.5–11 × 2–3 µm ……………………………….*P. brastagii*
9. Spores ellipsoid, 2–2.5 × 1.5–2 µm ……………………………………………….*P. suberosus*

Pallidohirschioporus albus (Ryvarden) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.
MycoBank number: MB 849275; Facesoffungi number: FoF 14438
Basionym – *Trichaptum album* Ryvarden, Syn. Fung. (Oslo) 30: 39 (2012).

Type locality – COSTA RICA.

Description – Basidiomata annual, pileate, dimidiate, imbricate; pilei projecting up to 1.5 cm, 3 cm wide and 5 mm thick. Pileal surface white, slightly zonate, pubescent and soft to touch; margin acute. Hymenophore hydnoid, pale violaceous when fresh, becoming cork-colored when dry; spines round to slightly flattened, 3–5 per mm. Context duplex, the lower layer dense and pale ochraceous separated from upper layer by a gelatinous line. Tubes up to 4 mm long. Hyphal system dimitic. Cystidia clavate, slightly thick-walled, abundant, distinctly thick-walled at pointed apex, apically encrusted with crystals falling off easily in microscopic preparations, 20–35 × 3–5 µm, projecting from hymenium up to 10 µm, with a basal clamp connection. Basidiospores allantoid, IKI–, CB–, 4.8–5.8(–6) × (1.5–)1.7–2.2(–2.5) µm, L = 5.10 µm, W = 2.05 µm, Q = 2.48 (n = 30/1).

Distribution and ecology – *Pallidohirschioporus albus* is so far only found in the highlands of central Costa Rica, and grows on angiosperms.

Notes – *Pallidohirschioporus albus* is treated as a member of *Pallidohirschioporus* by its pale-colored, annual and pileate basidiomata, and growth on angiosperm wood. The species is undoubtedly related to *P. biformis,* but is separated by the white, pubescent pilei and completely hydnoid hymenophore. Mature *P. biformis* sometimes develops a partly hydnoid hymenophore, but the hymenophore is distinctly poroid when immature. Microscopically, *P. biformis* differs from *P. albus* by larger basidiospores (5.2–6.7 × 2–2.7 µm vs. 4.8–5.8 × 1.7–2.2 µm).

Specimen examined – COSTA RICA, Punta Arenas, Vale Coto Brus, on angiosperm wood, 5.XI.2004, *Ryvarden 46906* (Holotype O).

Pallidohirschioporus biformis (Fr.) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849276; Facesoffungi number: FoF 14439

Basionym – *Polyporus biformis* Fr., in Klotzsch, Linnaea 8(4): 486 (1833).

≡ *Trichaptum biforme* (Fr.) Ryvarden, Norwegian Journal of Botany 19: 237 (1972).

Type locality – FINLAND.

Description – Basidiomata annual, pileate, variable in form, partly dimidiate, imbricate, occasionally spathulate to flabelliform, coriaceous or tough when fresh, hard corky and flexible when dry. Pileal surface white to cream when fresh, ochraceous or grayish with age, concentrically sulcate with narrow ochraceous to brown zones, finely adpressed velutinate when juvenile, becoming glabrous with age. Hymenophore poroid to irpicoid or hydnoid, light violet when fresh, light brown to pale straw colored when dry; pores angular, 3–5 per mm; dissepiments entire when juvenile, deeply lacerated to dentate with age. Context homogeneous, white to ochraceous. Tubes concolorous with pores. Hyphal system dimitic. Cystidia clavate to subulate, thin- to slightly thick-walled, abundant, embedded in hymenium or slightly projecting from hymenium, smooth or with a small apical crown of crystals 20–35 × 4–5 µm. Hyphal pegs absent. Basidiospores cylindrical, slightly curved, IKI–, CB–, 5.2–6.7(–7) × 2–2.7(–3) µm, L = 5.85 µm, W = 2.45 µm, Q = 2.33–2.42 (n = 120/4).

Distribution and ecology – *Pallidohirschioporus biformis* is a widespread species from subtropical to temperate zones in the Northern Hemisphere, and grows on angiosperms such as *Betula*, *Castanea*, *Corylus*, *Fagus*, *Populus*, *Quercus*, *Sorbus* and *Tilia*. It is also a pioneer decomposer of recently fallen angiosperm logs.

Biological activities – Enzymatic, antioxidant, antimicrobial, cytotoxicity, DNA protective, antitubercular, anti-proliferative and antitumor (Zjawiony 2007, Dai et al. 2009a, Ranadive et al. 2013, Bal et al. 2017, Balaes et al. 2017, Tamrakar et al. 2017, Yang et al. 2017, Shnyreva et al. 2018, Payamnoor et al. 2020).

Notes – *Pallidohirschioporus biformis* is a very common species, widely distributed in temperate to subtropical areas of Europe, North America and Asia. It is characterized by annual, dimidiate basidiomata with imbricate coriaceous pilei, pale-colored poroid to irpicoid or lacerated to hydnoid hymenophore with small pores when juvenile (> 3 per mm), finely adpressed velutinate to glabrous pileal surface and cylindrical basidiospores of 5.2–6.7 × 2–2.7 µm. This species was originally described in Finland, and we studied some samples from Belarus and Slovakia where have similar ecological environment to the type locality. Since this species is so common, we believe our studied samples represent the real *P. biformis.*

Specimens examined – BELARUS. Brestskaya Voblasts, Izin Biologgical Sanctuary, on stump of *Quercus*, 17.X.2019, *Dai 21014* (BJFC032673); Mahilyowskaya, Svislach-Byarezina Projecting Nat. Park, on fallen trunk of *Betula*, 14.X.2019, *Dai 20913* (BJFC032572), *Dai 20920* (BJFC032579). CHINA. Hebei, Wulingshan Nat. Res., on dead tree of *Betula*, 29.VII.2009, *Cui 6833* (BJFC005320), *Cui 6862* (BJFC005349). Guangdong, Liannan, 16.V.2009, *Dai 10971* (BJFC005215). Heilongjiang, Heihe, Shengshan Nat. Res., on fallen trunk of *Betula*, 26. VIII. 2014, *Dai 14531* (BJFC017797); Jiayin, Maolangou Nat. Forest Park, on dead tree of *Betula*, 30.VIII.2014, *Cui 11959* (BJFC016936). Inner Mongolia, Ningcheng, Heilihe Nat. Res., on fallen trunk of *Betula*, 18.X.2015, *Dai 16061* (BJFC020155), *Dai 16067* (BJFC020161). Jiangxi, Jinggang Mt., 23.IX.2008, *Dai 10598* (BJFC004847). Jilin, Antu, Changbaishan Nat. Res., on dead tree of *Betula*, 18.IX.2018, *Dai 19095* (BJFC027565), *Dai 19099* (BJFC027569), *Dai 19104* (BJFC027569). Qinghai, Menyuan, Xianmi Forest Park, on fallen trunk of *Betula*, 5.IX.2018, *Dai 19012* (BJFC027482), *Dai 19022* (BJFC027492). Shaanxi, Foping, Foping Nat. Res., on fallen trunk of *Betula*, 14.VIII.2019, Dai 20302 (BJFC031970). Shanxi, Jiaocheng, Pangquangou Nat. Res., on dead tree of *Betula*, 12.X.2004, *Yuan 844* (BJFC002712); Jiexiu, Mianshan Forest Park, on dead tree of *Acer*, 8.X.2018, *Dai 19190* (BJFC027657). Sichuan, Xiaojin, Jiajin Mt., 17.X.2012, *Cui 10728* (BJFC013650). Xinjiang, Xinyuan, Nalati Scenic Spot, on fallen trunk of *Populus*, 22.VIII.2004, Wei 1651 (IFP 007265). Yunnan, Xianggelila, Potatso Nat. Park, on fallen trunk of *Betula*, 6.IX.2021, *Dai 22922* (BJFC037495); on dead tree of *Betula*, 7.IX.2021, *Dai 23006* (BJFC037579). JAPAN. Tokyo, 29.VII.2009, *Cui 7213* (BJFC005700). USA. Boston, Tomsend Island, on fallen angiosperm trunk, 20.IV.2015, *Dai 16018* (BJFC020119); Michigan, Ann Arbor, on fallen angiosperm trunk, XI.2017, *Dai 19466* (BJFC027933); on fallen trunk of *Betula*, 19.VII.2012, *Dai 12746* (BJFC013053), *Dai 12748* (BJFC013055). SLOVAKIA. Sninský Kamen, Vihorlat Mt., on fallen angiosperm trunk, IX.1986, JV 8209/55 (JV); Dranec hill, vicinity of Dukla pass, on fallen trunk of *Fagus sylvatica*, IX.1986, JV 8209/5 (JV).

Pallidohirschioporus brastagii (Corner) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849277; Facesoffungi number: FoF 14440

Basionym – *Trametes brastagii* Corner, Beih. Nova Hedwigia 97:83 (1989).

≡ *Trichaptum brastagii* (Corner) T. Hatt., Mycoscience 46 (5): 306 (2005).

Type locality – INDONESIA.

Description – Basidiomata annual, pileate; pilei applanate, flabelliform to spathulate, densely imbricate. Pileal surface pale orange, ochraceous to pink buff when fresh, straw yellow to grayish buff when dry, zonate, slightly silky, velutinous near the base, glabrous towards margin; margin thin and acute, entire to lobed. Hymenophore poroid to irpicoid or hydnoid, cream to buff or grayish orange when fresh, buff yellow when dry; pores angular near the margin, irpicoid towards base, 4–5 per mm; dissepiments deeply lacerated to conspicuously dentate. Context homogeneous, whitish, leathery, flexible. Tubes concolorous with context. Hyphal system dimitic. Cystidia fusoid, thick-walled with pointed apex, abundant, with a basal clamp connection, 10–20 × 4–5.5 µm. Basidiospores short cylindrical, hyaline, thin-walled, smooth, IKI–, CB–, (3.5–)4–5(–5.6) × (1.9–)2–2.5 µm, L = 4.75 µm, W = 2.06 µm, Q = 2.20–2.40 (n = 90/3).

Distribution and ecology – *Pallidohirschioporus brastagii* is a widespread species in the tropical regions of Asia and Australia, and grows on angiosperm wood.

Notes – This species is similar to *Pallidohirschioporus biformis*, but the latter has longer basidiospores (5.2–6.7 µm vs. 4–5 in µm length, Gilbertson & Ryvarden 1987). It is a very common species in tropical Asia and Australia, and we have studied many samples. Although we did not studied its type material, we believe all our studied samples represent *P. brastagii*, and propose the combination.

Specimens examined – AUSTRALIA, Queensland, Cairns, Crater Lake Nat. Park, on fallen angiosperm trunk, 17.V.2018, *Dai 18804* (BJFC027272), *Dai 18808* (BJFC027276); on fallen angiosperm branch, 17.V.2018, *Cui 16753* (BJFC030052). CHINA. Yunnan, Laiyanghe Forest Park, 6.VI.2011, *Dai 12224* (BJFC010507), *Dai 12227* (BJFC010510); Mengla, Shangyong Nat. Res., on dead angiosperm tree, 20.VIII.2019, *Dai 20656* (BJFC032323); Pingbian, Daweishan Forest Park, on fallen angiosperm trunk, 26.VI.2019, *Dai 19784* (BJFC031459); on rotten bamboo, *Dai 19836* (BJFC031511); Wenshan, Laojunshan Nat. Res., on fallen angiosperm trunk, 12.XII.2018, *Dai 19417* (BJFC027885); Xianggelila, Potatso Nat. Park, on fallen trunk of *Betula*, 6.IX.2021, *Dai 22919* (BJFC037491), *Dai 22919* (BJFC037492); on dead tree of *Betula*, 6.IX.2021, *Dai 22921* (BJFC037494); 7.IX.2021, *Dai 23002* (BJFC037575); Xishuangbanna Nat. Res., 7.VI.2011, *Dai 12316* (BJFC010597).

Pallidohirschioporus imbricatus (Y.C. Dai & B.K. Cui) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849278; Facesoffungi number: FoF 14441

Basionym – *Trichaptum imbricatum* Y.C. Dai & B.K. Cui, Mycol. Progr. 8(4): 282 (2009).

Type locality – CHINA.

Description – Basidiomata annual, pileate, leathery when fresh, becoming hard corky upon drying; pilei semicircular, imbricate, single pileus projecting up to 1.5 cm, 2 cm wide and 2 mm thick at the base. Pileal surface cinnamon buff when fresh, olivaceous buff to clay buff when dry, azonate, with radially aligned striations, finely velutinate when fresh and juvenile, more or less glabrous with age, slightly warted at the base; margin acute, wavy, strongly incurved when dry. Hymenophore poroid, white to cream when fresh, honey yellow when dry; pores angular, 6–8 per mm; dissepiments thin, entire to slightly lacerated. Context homogeneous, cream when dry, corky, up to 0.2 mm thick. Tubes cinnamon brown when dry, darker than context, hard corky when dry. Hyphal system dimitic. Cystidia short clavate, thin-walled, apically encrusted, mostly embedded in hymenium, 10–13 × 4.5–6 µm. Hyphal pegs absent. Basidiospores cylindrical, hyaline, thin-walled, smooth, IKI–, CB–, (5.8–)6–7.3(–7.6) × (1.9–)2–2.9(–3) µm, L = 6.68 µm, W = 2.28 µm, Q = 2.93 (n = 30/1).

Distribution and ecology – *Pallidohirschioporus imbricatus* is so far only found in Hainan, tropical China, and grows on fallen angiosperm trunks.

Notes – *Pallidohirschioporus imbricatus* is characterized by typical imbricate basidiomata, small and regular pores of 6–8 per mm. *P. brastagii* has small imbricate basidiomata and occurs in tropical China, too, but it differs from *P. imbricatus* by larger pores (4–5 per mm vs. 6–8 per mm), and shorter basidiospores (4–5 ×2–2.5 µm vs. 6–7.3 ×2–2.9 µm).

Specimens examined – CHINA. Hainan, Ledong, Jianfengling Nat. Res., on fallen trunk of *Reevesia longipetiolata*, 17.XI.2007, *Dai 9254* (Holotype, IFP015786); Wuzhishan, Wuzhishan Nat. Res., on fallen angiosperm trunk, 24.XI.2007, *Cui 5384* (BJFC003425).

Pallidohirschioporus jackiae (Corner) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849279; Facesoffungi number: FoF 14442

Basionym – *Trichaptum jackiae* Corner, Beih. Nova Hedwigia 86: 223 (1987).

Type locality – SINGAPORE.

For a detailed description of *Pallidohirschioporus jackiae*, see Corner (1987).

Distribution and ecology – *Pallidohirschioporus jackiae* is known from the type locality only, and grows on *Jackia ornata*.

Notes – According to the original description by Corner (1987), *Pallidohirschioporus jackiae* is characterized by its pale wood-colored effused-reflexed basidiomata, glabrous pileal surface, angular to sublabyrinthine hymenophore with pores of 2–5 per mm and occurrence in tropical rainforest, which shows it is more similar to *Pallidohirschioporus brastagii* rather than *Trichaptum s.s.* However, *P. brastagii* differs from *P. jackiae* by pileate basidiomata and larger basidiospores (4–5 × 2–2.5 µm vs. 3–3.8 × 2–2.5 µm). Therefore, *P. jackiae* is treated as a member of *Pallidohirschioporus* and the new combination is proposed.

Pallidohirschioporus parvulus (Yasuda) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849280; Facesoffungi number: FoF 14443

Basionym – *Irpex parvulus* Yasuda, Bot. Mag., Tokyo 35: 254 (Jap. sect.) (1923).

≡ *Trichaptum parvulum* (Yasuda) T. Hatt. & Ryvarden, Mycotaxon 50: 41 (1994).

Type locality – JAPAN.

For a detailed description of *Pallidohirschioporus parvulus*, see Hattori & Ryvarden (1994) and Núñez & Ryvarden (2001).

Distribution and ecology – *Pallidohirschioporus parvulus* is found so far from temperate regions of Japan and China and grows on angiosperm wood.

Notes – Hattori & Ryvarden (1994) examined the type specimen and mentioned that characteristics of *Pallidohirschioporus parvulus*, including the ochraceous to pale brown, cartilaginous basidiomata, irregular hymenophore and numerous small ventricose to clavate cystidia with apical crystals, and growth on angiosperm wood in Asia, which are consistent with definition of *Pallidohirschioporus*. So, the above combination is proposed. In addition, *P. parvulus* is readily distinguished from other *Pallidohirschioporus* species by its mostly resupinate basidiomata, presence of a gelatinous layer between tubes and context, and hydnoid hymenophore.

Pallidohirschioporus polycystidiatus (Pilát) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849281; Facesoffungi number: FoF 14444

Basionym – *Poria polycystidiata* Pilát, Bull. trimest. Soc. mycol. Fr. 49 (3–4): 277 (1933).

≡ *Trichaptum polycystidiatum* (Pilát) Y.C. Dai, Karstenia 40 (1–2): 28 (2000).

= *Hirschioporus quercinus* Parmasto in Parmasto & Parmasto, Biblthca Mycol. 115: 137 (1987).

= *Trichaptum quercinum* (Parmasto) Y.C. Dai, Fungal Science, Taipei 11(3, 4): 100 (1996).

Type locality – RUSSIA.

Description – Basidiomata annual, pileate to effused-reflexed; pilei dimidiate to flabelliform or petaloid, imbricate, flexible to tough, single pileus projecting up to 2 cm, 4 cm wide and 3 mm thick. Pileal surface gray to buff, becoming almost whitish with age, zonate, pubescent or tomentose when juvenile, becoming glabrous with age; margin acute. Hymenophore poroid to irpicoid or almost hydnoid, purple to pale violaceous when fresh, fading to gray or almost black with age; pores of 3 per mm when juvenile. Context homogeneous, pale buff, azonate, tough-fibrous, up to 1 mm thick. Tubes or spines concolorous with context, up to 2 mm long. Hyphal system dimitic. Cystidia capitate, thick-walled, abundant, smooth or apically encrusted, 18–30 × 3–9 µm and projecting from hymenium up to 10 µm. Basidiospores cylindrical to slightly allantoid, IKI–, CB–, (4.3–)4.5–6.2(–7) × 1.8–2.3(–2.4) µm, L = 5.47 µm, W = 2.08 µm, Q = 2.56–2.65 (n = 90/3).

Distribution and ecology – *Pallidohirschioporus polycystidiatus* is widely distributed from northern and central China and the Russian Far East; it grows mostly on *Quercus mongolica*.

Notes – This species was originally described from the Russian Far East (Pilát 1933), and then it was re-described as *Hirschioporus quercinus* Parmasto from the Russian Far East, too (Parmasto & Parmasto 1987). The types of both taxa were collected on *Quercus mongolica*, and our studied materials were collected on *Quercus mongolica* from Heilongjiang, Northeast China, which is very close to the Russian Far East. So, we believe our studied samples represent *Pallidohirschioporus polycystidiatus*. *P. polycystidiatus* is undoubtedly related to *P. biformis* but has, generally, smaller basidiomata and its hymenophore is darker than that of *P. biformis*. In addition, *P. biformis* has slightly larger basidiospores (5.2–6.7 × 2–2.7 µm vs. 4.5–6.2 × 1.8–2.3 µm).

Specimens examined – CHINA. Heilongjiang, Huma, Nanwenghe Nat. Res., on fallen trunk of *Quercus mongolica*, 27.VIII.2014, *Dai 14686* (BJFC017838). Jiangsu, Nanjing, Zijinshan Park, on fallen trunk of *Quercus*, 10.X.2003, *Dai 5232* (BJFC002722), *Dai 5242* (BJFC002719). Jilin, Antu, Changbaishan Nat. Res., on fallen branch of *Quercus mongolica*, 18. IX. 2018, *Dai 19100* (BJFC027570), Dai 19102 (BJFC027572); on dead tree of *Quercus mongolica*, 18. IX. 2018, *Dai*

19101 (BJFC027571); on dead branch of *Quercus mongolica*, 18.IX.2018, *Dai 19103* (BJFC027573). Tianjin, Ji, Panshan Scenic Spot, on fallen trunk of *Quercus mongolica*, 1.VIII.2009, *Cui 6986* (BJFC005473), *Cui 7028* (BJFC005515).

Pallidohirschioporus subchartaceus (Murrill) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849282; Facesoffungi number: FoF 14445

Basionym – *Coriolus subchartaceus* Murrill, N. Amer. Fl. (New York) 9(1): 24 (1907a).

≡ *Hirschioporus subchartaceus* (Murrill) Bondartsev & Singer, Annls mycol. 39(1): 63 (1941).

≡ *Trichaptum subchartaceum* (Murrill) Ryvarden [as '*subchartaceus*'], Norw. Jl Bot. 19: 237 (1972).

Type locality – USA.

Description – Basidiomata annual, effused-reflexed or pileate; pilei dimidiate to elongate, usually laterally fused. Pileal surface gray to pale buff, nearly smooth to finely adpressed velutinate with numerous narrow concentric zones; margin cream, blunt. Hymenophore poroid, purple to violaceous when juvenile, fading to pale buff with age; pores round to angular, 3–4 per mm; dissepiments thick and entire when juvenile, slightly lacerated with age. Context pale buff, duplex, the upper layer soft, fibrous, the lower layer firm, corky. Tubes concolorous with pores, up to 3 mm long. Hyphal system dimitic. Cystidia narrowly subulate to clavate, thin- to slightly thick-walled, abundant, apically encrusted, 5–7 um in diam., projecting from hymenium up to 20 μm, with a basal clamp connection. Basidiospores cylindric, slightly curved, hyaline, thin-walled, smooth, IKI–, CB–, 7.5–11 × 2–3 μm (Gilbertson & Ryvarden 1987).

Distribution and ecology – *Pallidohirschioporus subchartaceus* has a distribution in temperate areas of North America, and grows on *Populus*.

Notes – This species is readily identified in the field by its violaceous pore surface, thick basidiomata, and restriction to *Populus*. *P. biformis* may be sympatric but has thin, often petaloid and flabelliform basidiomata and occurs on many angiosperm species and develops a hydnoid hymenophore at maturity.

Biological activities – Antioxidant (Upadhyaya 2018).

Specimen examined – CANADA. Alberata, Whitecourt, on fallen trunk of *Populus*, 24.VIII.1971, *J. A. Traquair 380* (ALTA 6758, BJFC002724).

Pallidohirschioporus suberosus (Corner) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849283; Facesoffungi number: FoF 14446

Basionym – *Trichaptum suberosum* Corner, Beih. Nova Hedwigia 86: 230 (1987).

Type locality – MALAYSIA.

For a detailed description of *Pallidohirschioporus suberosus*, see Corner (1987) and Hattori (2001a).

Distribution and ecology – *Pallidohirschioporus suberosus* is so far only known from the type locality (Peninsular Malaysia), and grows on angiosperm wood.

Notes – *Pallidohirschioporus suberosus* was originally described from Malaysia, and characterized by annual, flabelliform, white to cream basidiomata with almost glabrous upper surface, poroid to irpicoid hymenophore, a trimitic hyphal system, the presence of smooth cystidia and growth on angiosperms. These characteristics fit the definition of *Pallidohirschioporus* rather than that of *Trichaptum*. Therefore, we propose the above combination. *P. suberosus* is readily distinguished from other *Pallidohirschioporus* species by having a unique trimitic hyphal system, smooth cystidia and short basidiospores, 2–2.5 × 1.5–2 µm (Hattori 2001a).

Pallidohirschioporus versicolor Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 15

MycoBank number: MB 849284; Facesoffungi number: FoF 14447

Type – CHINA. Yunnan, Yongping, Baotaishan Nat. Park, on fallen trunk of *Castanopsis*, 7.XI.2018, *Dai 19331* (Holotype BJFC027800).

Etymology – *Versicolor* (Lat.): refers to the species having a variably colored hymenophore.

Basidiomata – Annual, pileate, effused-reflexed or resupinate, corky when fresh, hard corky up on drying. Pilei dimidiate, usually imbricate, sometimes laterally fused, projecting up to 5 cm, 8 cm wide and 4 mm thick at base. Pileal surface white to cream or pale buff when fresh, cream to pale buff when dry with narrowly concentrically sulcate zones, densely tomentose to adpressed velutinate; margin paler than pileal surface, acute, entire or slightly lobed. Hymenophore poroid, light purple when juvenile, becoming yellow buff with age, grayish purple to vinaceous brown when dry, sometimes glancing; pores angular to irregular or labyrinthine, 2–4 per mm; dissepiments thick, entire, lacerated with age. Sterile margin more grayish than pores, white to pinkish, up to 3 mm wide. Context cream, up to 1 mm thick. Tubes grayish purple to vinaceous brown, up to 3 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae distinctly thick-walled, slightly dextrinoid, CB+; tissues unchanged in KOH.

Context – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–4 µm in diam.; skeletal hyphae thick-walled, unbranched, regularly arranged, 4–6 µm in diam.

Tubes – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–2.5 µm in diam.; skeletal hyphae thick-walled with a narrow lumen, unbranched, interwoven, 2.5–3.5 µm in diam.; skeletal hyphae at dissepiment edges usually with cystidia-like tips.

Hymenium – Cystidia fusoid, thick-walled, abundant, usually apically encrusted, 22–30 × 5–7 µm; hyphal pegs absent; basidia clavate, with four sterigmata and a basal clamp connection, slightly thickening towards base, 16–20 × 4–5 µm, basidioles similar to basidia in shape, but slightly smaller.

Spores – Basidiospores cylindric to allantoid, hyaline, thin-walled, smooth, IKI–, CB–, (5–)5.5–7.7(–8) × (1.8–)1.9–2.3(–2.5) µm, L = 6.38 µm, W = 2.10 µm, Q = 2.83–3.15 (n = 90/3).

Type of rot – White rot.

Distribution and ecology – *Pallidohirschioporus versicolor* has a distribution in the East Himalayan area of northern Yunnan and Eastern Tibet, and grows on fallen trunks, branches and stumps of Fagaceae and Rosaceae, including *Betula*, *Castanopsis*, *Prunus*, *Quercus*, *Sorbus* etc. *P. versicolor* may sporulate seasonally and presumably in the rainy season, because fresh specimens collected in November are almost sterile, but samples collected during a rainy season are fertile.

Notes – *Pallidohirschioporus versicolor* is characterized by annual, pileate to effused-reflexed basidiomata, a variably colored hymenophore, large pores, 2–4 per mm, narrow cylindric to allantoid basidiospores measuring 5.5–7.7 × 1.9–2.3 µm, and growth on angiosperm wood in the Himalayan area. Phylogenetically, eleven samples of *P. versicolor* form a distinct lineage with strong support (99% ML, 1.00 BPP), and the species is closely related to *P. biformis*, *P. brastagii* and *P. imbricatus*. However, *P. biformis* differs from *P. versicolor* by a completely pileate basidiomata and finely adpressed velutinate to glabrous pileal surface with numerous narrow dark brown concentric zones and wider basidiospores (5.2–6.7 × 2–2.7 µm Q= 2.33–2.42 vs. 5.5–7.7 × 1.9–2.3 µm Q = 2.83–3.15). *P. brastagii* is distinguished from *P. versicolor* by its small pilei sometimes with a lateral stipe-like base, and shorter basidiospores (3.5–4.8 × 2–2.5 µm vs. 5.5–7.7 × 1.9–2.3 µm). *P. imbricatus* differs from *P. versicolor* by a cream to honey yellow pore surface and smaller pores (6–8 per mm vs. 2–4 per mm).

Additional specimens examined – CHINA. Tibet, Nyingchi, Bome, Yigong Tea Plantation, 23.X.2021, on fallen angiosperm trunk, 25.X.2021, *Dai 23520* (BJFC038092); on fallen trunk of *Quercus*, *Dai 23375* (BJFC037946), *Dai 23384* (BJFC037955); 25.X.2021, *Dai 23495* (BJFC038067); on stump of *Quercus,* 24.X.2021, *Dai 23460* (BJFC038032), *Dai 23461* (BJFC038033); Gadinggou, 25.IX.2010, *Cui 9701* (BJFC008638). Yunnan, Binchuan, Jizu Mt., on fallen angiosperm trunk, 14.IX.2018, *Cui 16972* (BJFC030271), *Cui 16974* (BJFC030273); on fallen trunk of *Quercus,* 14.IX.2018, *Dai 19327* (BJFC027796); on fallen angiosperm trunk, 7.XI.2018, *Dai 19366* (BJFC027834); Deqin, Baimaxueshan Nat. Res., on fallen trunk of *Sorbus*, 5.IX.2021, *Dai 22844* (BJFC037417), *Dai 22845* (BJFC037418), on dead branch of *Sorbus*, 5.IX.2021, *Dai 22867* (BJFC037440); Lanping, Changyanshan Nat. Res., on fallen branch of *Betula*, 18.IX.2011, *Cui 10323* (BJFC011218). Lushui, Gaoligong Nat. Res., on fallen angiosperm trunk, 7.XI.2019, *Cui 18121* (BJFC034980); Yongping, Baotaishan Nat. Park, on fallen trunk of *Castanopsis*, 7.XI.2018, *Dai 19331* (BJFC027800); on fallen trunk of *Prunus*, 7.XI.2018, *Dai 19332* (BJFC027801).

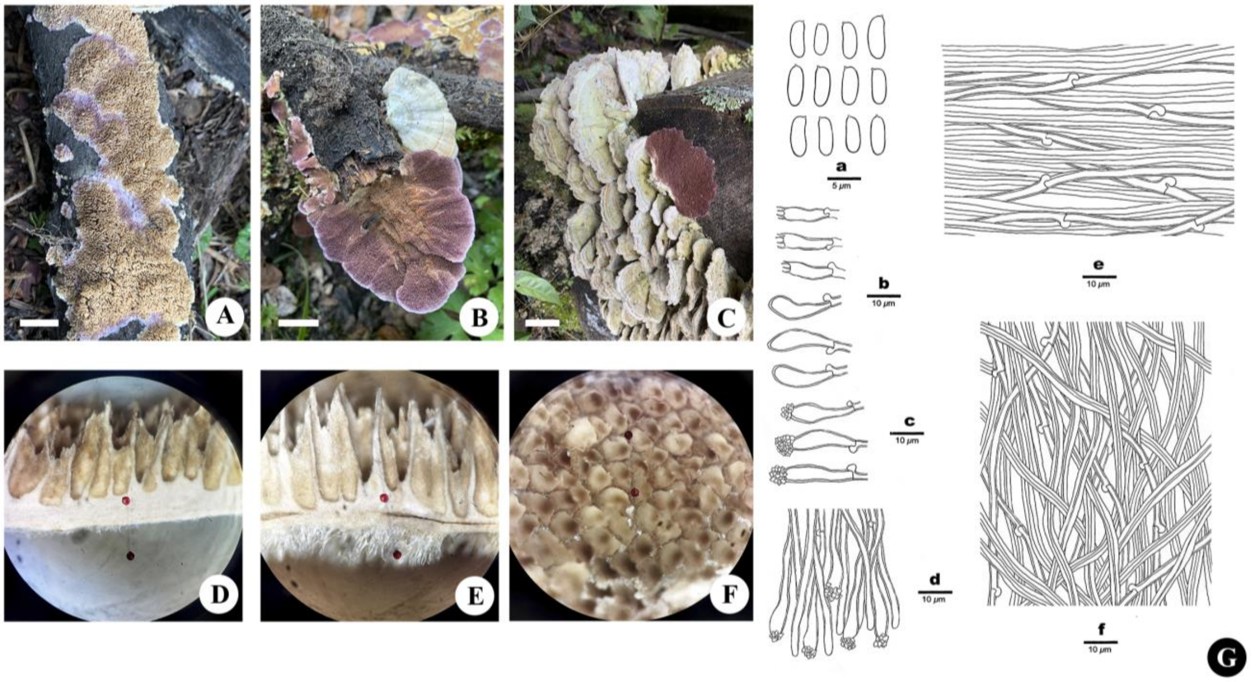

Figure 15 – A–C Basidiomata of *Pallidohirschioporus versicolor* (*Dai 22845*, *Dai 19331*, *Dai 23460*). D–E Longitudinal section. F Hymenophore. G Microscopic structures of *P. versicolor* (*Dai 19331*). a Basidiospores. b Basidia and basidioles. c Cystidia. d Hyphae at dissepiment edge. e Hyphae from context. f. Hyphae from trama. Scale bars: A–C = 1 cm, D–F = 1 mm.

Perennihirschioporus Y.C. Dai, Yuan Yuan & Meng Zhou, gen. nov.

MycoBank number: MB 849213; Facesoffungi number: FoF 14472

Etymology – *Perennihirschioporus* (Lat.), refers to the genus being similar to *Hirschioporus* but producing perennial basidiomata.

Type species – *Perennihirschioporus perennis* (Y.C. Dai & H.S. Yuan) Y.C. Dai, Yuan Yuan & Meng Zhou.

Description – Basidiomata mostly perennial, pileate to effused-reflexed, rarely resupinate; pilei triquetrous, applanate to broadly attached; pileal surface blackish brown, velutinate or hairless, rough, slightly warted; hymenophore irpicoid, daedaleoid to lamellate, brown; pores or lamella 1–4 per mm in regular parts; context homogeneous; tubes concolorous with context. Hyphal system dimitic to trimitic; generative hyphae with clamp connections; skeletal hyphae yellowish, thick-walled with a narrow lumen; cystidia claviform, ventricose or lageniform, thin- to thick-walled, smooth or apically encrusted, 12–16 × 5–7 µm; basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–. Growing on angiosperm woods in pantropical areas, usually in semi-arid climate regions and causing a white rot.

Notes – *Perennihirschioporus* differs from other genera among *Trichaptum s.l.* by large, perennial, brown basidiomata with a glabrous pileal surface when mature, mostly irpicoid, daedaleoid to lamellate hymenophore, yellowish skeletal hyphae, small basidiospores (< 6 µm in length), and occurrence in pantropical areas.

So far, five species *Perennihirschioporus agricola*, *P. daedaleus*, *P. fumosoavellaneus*, *P. perennis* and *P. variabilis*, are included in *Perennihirschioporus.*

Key to species of *Perennihirschioporus*

1\. Hymenophore poroid …………………………………………………………………..2

1\. Hymenophore irpicoid, daedaleoid to lamellate ……………………………………………3

2\. Spores 4–4.5 × 1.9–2.2 µm …………………………………………………...*P. variabilis*

2\. Spores 4.5–6 × 2.2–2.5 µm ……………………………………………….…*P. daedaleus*

3 Basidiomata effused-reflexed to pileate, pore surface vinaceous brown to umber; hyphal system dimitic …………………………………………………………………….....*P. perennis*

3 Basidiomata pileate, pore surface pale brown to avellaneus; hyphal system trimitic …………….4

4\. Pores 1–3 per mm; basidiospores 4–5 × 2.5–3 µm ………………………………….*P. agricola*

4\. Pores 3–4 per mm; basidiospores 3.6–4 × 2.5–3 µm ………………………..*P. fumosoavellaneus*

Perennihirschioporus agricola (Vlasák & J. Vlasák) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849285; Facesoffungi number: FoF 14448

Basionym – *Trichaptum agricola* Vlasák & J. Vlasák, Mycosphere 8(6): 1219 (2017).

Type locality – COSTA RICA.

Description – Basidiomata annual to perennial, pileate; pilei applanate or broadly attached, single pileus projecting up to 5 cm, 8 cm wide and 2 cm thick. Pileal surface light brown, later with a silvery shine, azonate or sometimes slightly concentrically sulcate near the margin, velutinate to glabrous, becoming warted or with irregular outgrows with age; margin obtuse to acute. Hymenophore poroid, brown; pores mostly angular, sometimes radially elongated or labyrinthine, 1–3 per mm; dissepiments thin, entire. Context homogeneous, up to 10 mm thick, tough, brown, with several distinct growth zones, about 2 mm thick. Tube layer up to 10 mm thick, indistinctly stratified. Hyphal system trimitic; generative hyphae with clamp connections; skeletal hyphae yellowish, thick-walled with a narrow lumen. Cystidia ventricose to fusoid, slightly thick-walled, abundantly apically encrusted, 10–20 × 4–7 µm. Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, 4–5 × 2.5–3 µm (Vlasák & Vlasák 2017).

Distribution and ecology – *Perennihirschioporus agricola* is so far only known from Costa Rica, and grows on angiosperm wood in an arid environment affected by human activities. All known specimens were collected on cattle fence props.

Notes – The species differs from other *Perennihirschioporus* species by brown basidiomata with only indistinct violet tint on hymenial surface, and large, entire and regular pores of 1–3 per mm and a trimitic hyphal system.

Specimen examined – COSTA RICA. Guanacaste, Ahogados, on fallen angiosperm trunk, 31.VII. 2014, *JV 1407/97* (JV); Puntarenas, La Ensenada Lodge, on fallen angiosperm trunk, 22.IV.2015, *JV 1504/75-J* (Holotype PRM 945505, JV); Rincon Mt., Guachipelin, III.2022, *JV 2203/79* (BJFC039894, JV).

Perennihirschioporus daedaleus Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 16

MycoBank number: MB 849286; Facesoffungi number: FoF 14449

Type – MALAYSIA. Selangor, Kota Damansara, Community Forest Res., on fallen angiosperm trunk, 6.XI.2019, *Dai 21143* (Holotype BJFC032797).

Etymology – *Daedaleus* (Lat.): refers to the species having a daedaleoid hymenophore.

Basidiomata – Perennial, pileate, solitary, consistency hard corky to woody hard; pilei triquetrous, projecting up to 3 cm, 5 cm wide and 4.1 cm thick at base. Pileal surface buff to brown when fresh and dry, hairless, rough, slightly warted; margin brown, acute, entire. Hymenophore daedaleoid to lamellate, dark brown when fresh and dry; pores or lamella 0.5–1 per mm, radially elongated or daedaleoid near the margin; dissepiments wavy, thick, entire. Sterile margin indistinct. Context homogeneous, brown, hard corky, very thin to almost absent, up to 0.1 mm thick. Tubes concolorous with context, up to 4 cm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae dominant, yellowish, distinctly thick-walled with a narrow lumen to subsolid, IKI–, CB+; tissues darkening in KOH.

Context – Generative hyphae hyaline, thin-walled, rarely branched, 2–2.5 µm in diam.; skeletal hyphae thick-walled with a narrow lumen to subsolid, unbranched, interwoven, 2–3 µm in diam.

Tubes – Generative hyphae hyaline, thin-walled, occasionally branched, 2–3.5 µm in diam.; skeletal hyphae thick-walled with a narrow lumen, unbranched, interwoven, 3–4 µm in diam.; hyphae at dissepiment edges smooth.

Hymenium – Cystidia fusoid to subulate, slightly thick-walled, abundant, usually apically encrusted, 17–25 × 4–7.5 µm, projecting from hymenium up to 5 µm, with a basal clamp connection; hyphal pegs absent; basidia clavate with four sterigmata and a basal clamp connection, 16–23 × 3.5–4.5 µm, basidioles similar to basidia in shape, but slightly smaller.

Spores – Basidiospores oblong ellipsoid to cylindric, hyaline, thin-walled, smooth, IKI–, CB–, (3.5–)3.8–4.8(–5) × 1.9–2.3(–2.5) µm, L = 4.12 µm, W = 2.44 µm, Q = 1.55–1.86 (n = 60/2).

Type of rot – White rot.

Distribution and ecology – *Perennihirschioporus daedaleus* is so far only found in the tropical forests of Malaysia, and grows on angiosperm trunks.

Notes – Morphologically, *Perennihirschioporus daedaleus* is characterized by perennial, large and triquetrous basidiomata, and a daedaleoid to lamellate hymenophore. Phylogenetically, two samples of the species formed a distinct lineage with strong support (100% ML, 1.00 BPP) that is distant from other species in the genus.

Perennihirschioporus variabilis was originally described from Venezuela (Ryvarden & Iturriaga 2003), and has similar daedaleoid to lamellate hymenophore as *P. daedaleus*. However, *P. variabilis* is distantly related to *P. daedaleus* (Fig. 4). In addition, *P. variabilis* differs from *P. daedaleus* by its pileate to effused-reflexed basidiomata, and larger basidiospores (4.5–6 × 2.2–2.5 µm vs. 3.8–4.8 × 1.9–2.3 µm). *P. agricola*, *P. fumosoavellaneus*, *P. perennis* share similar poroid hymenophores that are readily distinguished from *P. daedaleus*.

Additional specimen examined – MALAYSIA. Selangor, Kota Damansara, Community Forest Res., on fallen angiosperm trunk, 6.XI.2019, *Cui 18235* (BJFC035094).

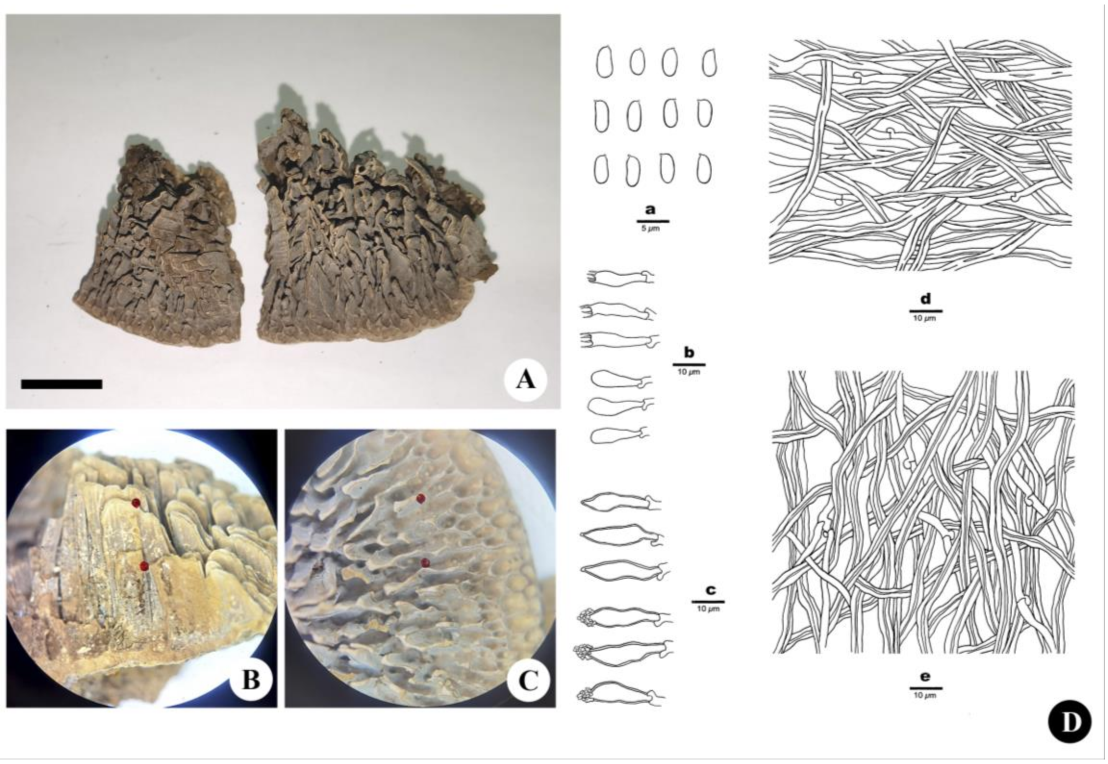

Figure 16 – A Basidiomata of *Perennihirschioporus daedaleus* (*Dai 21143*). B Longitudinal section. C Hymenophore. D Microscopic structures of *P. daedaleus* (*Dai 21143*). a Basidiospores.

b Basidia and basidioles. c Cystidia. d Hyphae from context. e Hyphae from trama. Scale bars: A = 1 cm, B–C = 5 mm.

Perennihirschioporus fumosoavellaneus (Romell) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849287; Facesoffungi number: FoF 14450

Basionym – *Trametes fumosoavellanea* Romell, K. svenska Vetensk-Akad. Handl., ny följd 26: 37 (1901).

≡ *Trichaptum fumosoavellaneum* (Romell) Rajchenb. & Bianchin., Nordic Jl Bot. 11(2): 225 (1991).

Type locality – PARAGUAY.

Description – Basidiomata perennial, pileate; pilei dimidiate to triquetrous, broadly attached at the base, more or less decurrent, single pileus projecting up to 16 cm, 17 cm wide and 14 cm thick at base. Pileal surface pale brown to subavellaneous, azonate, sometimes sulcate, velutinate to tomentose, often covered with mosses with age; margin blunt, generally darker than center, and with an obvious violaceous tint. Hymenophore poroid, violaceous when fresh, dark reddish gray to dark reddish brown when dry; pores round, rarely elongated, 3–4 per mm. Context homogeneous or with distinct light-colored growing bands and layers, corky, up to 4 cm thick, concolorous with the pileal surface. Tubes up to 10 cm long. Hyphal system trimitic; generative hyphae with clamp connections; skeletal hyphae yellow, thick-walled with a narrow lumen. Cystidia claviform, ventricose or lageniform, slightly thick-walled, apically encrusted, 12–16 × 5–7 µm. Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, (3.5–)3.6–4(–4.3) × (2.2–)2.5–3 µm, L = 3.94 µm, W = 2.71 µm, Q = 1.31–1.59 (n = 60/3).

Distribution and ecology – *Perennihirschioporus fumosoavellaneus* has a distribution in Argentina, Brazil, Colombia, Costa Rica and Paraguay, and grows in arid localities on angiosperm wood. Rajchenberg & Bianchinotti (1991) mentioned that the species is restricted to subtropical areas of the dry Chaco Forest of South America.

Notes – The species was reported as the largest *Trichaptum s.l.* species ever found with very large pilei up to 40 cm in diam. (Rajchenberg & Bianchinotti 1991). *Perennihirschioporus fumosoavellaneus* is closely related to *P. agricola* with similar thick context, entire pores, a trimitic hyphal system, and similar basidiospores. Nevertheless, *P. fumosoavellaneus* is distinguished from *P. agricola* by smaller pores (3–4 per mm vs. 1–3 per mm) and usually has a distinct violet tint.

Specimens examined – BRAZIL. Piauí, Caracol, 2011, *URM84103* (URM84103). COSTA RICA. Guanacaste Prov., Lomas Bardubal Biological Reserve, on living angiosperm, 27.VII.2016, *JV 1607/79-J* (JV); Rincón Mt., Guachipelín, on dead oak wood, 10. III.2022, *JV 2203/80-J* (BJFC, JV).

Perennihirschioporus perennis (Y.C. Dai & H.S. Yuan) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849288; Facesoffungi number: FoF 14451

Basionym – *Trichaptum perenne* Y.C. Dai & H.S. Yuan, Mycol. Progr. 8(4): 283 (2009).

Type locality – CHINA.

Description – Basidiomata perennial, pileate to effused-reflexed, corky when fresh, becoming hard corky upon drying; pilei triquetrous, single pileus projecting up to 6 cm, 10 cm wide and 5 cm thick at the base. Pileal surface greenish gray to clay buff when fresh, clay buff to fawn when dry, azonate, finely velutinate, hairless, rough, slightly warted, often covered by moss; margin obtuse. Hymenophore poroid, vinaceous brown when fresh, slightly shining, milky coffee to snuff brown or umber when dry; pores round to angular, occasionally elongate, 2–3 per mm; dissepiments thick, entire. Context homogeneous, brown, hard corky when dry, up to 5 mm thick. Tubes grayish yellow, distinctly paler than the pores, hard corky, up to 4.5 cm long. Hyphal system dimitic; generative hyphae with clamp connections; skeletal hyphae yellow, thick-walled with a narrow lumen. Cystidia short clavate, hyaline, thin-walled, apically encrusted, 12–17 × 3.5–5.5 µm.

Basidiospores oblong ellipsoid, hyaline, thin-walled, smooth, more or less tapering, IKI–, CB–, (3.9–)4–5.2 × (1.9–)2–2.5(–2.8) µm, L = 4.68 µm, W = 2.36 µm, Q = 1.98 (n = 43/3).

Distribution and ecology – *Perennihirschioporus perennis* is so far only found in Yunnan, southwest China, and grows mostly on woods of Fagaceae. Most of the studied samples are almost sterile even when collected in autumn, suggesting its sporulation may be seasonal and occurs in the spring (Dai et al. 2009).

Notes – This species has typical *Perennihirschioporus* characteristics, such as perennial basidiomata, large pores and oblong-ellipsoid basidiospores. *P. perennis* is distinguished from other species in the genus by vinaceous brown to umber triquetrous basidiomata and regular angular pores.

Specimens examined – CHINA. Yunnan, Gaoligong Mt., Baihualing Nat. Res., alt. 1800 m, on trunk of living angiosperm tree, 23.IX.2007, *Yuan 3892* (BJFC002716); 26.X.2009, *Cui 8253* (BJFC006742), *Cui 8241* (BJFC006730), *Cui 8213* (BJFC006702), *Cui 8164* (BJFC006653); on trunk of living *Lithocarpus*, 22.IX.2007, *Yuan 3800* (Holotype, IFP015787); on dead tree of *Quercus*, 22.IX.2007, *Yuan 3820* (IFP015789); Binchuan, Jizu Mt., on living tree of *Quercus*, 6.XI.2018, *Dai 19295* (BJFC027764).

Perennihirschioporus variabilis (Ryvarden & Iturr.) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849289; Facesoffungi number: FoF 14452

Basionym – *Trichaptum variabilis* Ryvarden & Iturr., Mycologia 95(6): 1074 (2003).

Type locality – VENEZUELA.

Description – Basidiomata perennial, variable in form, effused reflexed to pileate or resupinate; pilei semicircular to elongate, woody hard, single pileus projecting up to 4 cm long, 10 cm wide and 2 cm thick at the base. Pileal surface deep ochraceous to brown, concentrically zonate, smooth to slightly tuberculate; margin acute. Hymenophore sometimes poroid to daedaleoid, sometimes irpicoid, violet-brown; pores angular to daedaleoid or irregular, 1–2 per mm in regular parts, radially elongated or daedaleoid to 5 mm long, with dissepiments becoming wavy with age, and sometimes dentate. Context homogenous, deep olivaceous brown, up to 1 cm thick. Tubes concolorous with pores, up to 1 cm long. Hyphal system dimitic; generative hyphae with clamp connections; skeletal hyphae yellow, thick-walled with a narrow lumen. Cystidia fusoid to rounded, thick-walled, abundant, with an apical crown of small crystals, 12–16 × 4–6 µm. Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, 4–5 × (2.2–)2.3–3 µm, L = 4.86 µm, W = 2.68 µm, Q = 1.66–1.96 (n = 40 /2).

Distribution and ecology – *Perennihirschioporus variabilis* has a distribution in tropical America, and grows on angiosperm wood.

Notes – The species is reminiscent of *Perennihirschioporus fumosoavellaneus* which, however, has smaller pores (3–4 per mm vs. 1–2 per mm).

Specimens examined – BRAZIL. Piauí, Caracol, Serra das Confusões, 2012, *B856* (URM 83836). FRENCH GUIANA. Coralie, Sentier Molokoi, 1.IX.2019, *JV 1909/4-J* (BJFC033006, JV). MEXICO. Baja California Sur, VII.2017, *JV 1707/40-J* (RUM, BJFC039890, JV). VENEZUELA. Bolívar, Municipio Sifontes, Tumeremo, carretera Tumeremo-Bochinche. 17.XI.1994, *Ryvarden 35177* (Holotype, O); Las Nieves, 12.VI.1995, *Ryvarden 37787* (O, duplicate BJFC012606).

Nigrohirschioporus Y.C. Dai, Yuan Yuan & Meng Zhou, gen. nov.

MycoBank number: MB 849214; Facesoffungi number: FoF 14473

Etymology – *Nigrohirschioporus* (Lat.), refers to the genus being similar to *Hirschioporus* but producing more or less blackish basidiomata.

Type species – *Nigrohirschioporus sector* (Ehrenb.) Y.C. Dai, Yuan Yuan & Meng Zhou.

Description – Basidiomata annual to perennial, resupinate to effused-reflexed or pileate, coriaceous to woody hard; pileal surface blackish, dark purplish to grayish brown, adpressed velutinate to glabrous; hymenophore hydnoid, irpicoid to poroid, tubes and context concolorous with pileal surface. Hyphal system dimitic to trimitic; generative hyphae with clamp connections; cystidia present; basidiospores cylindrical to ellipsoid, slightly curved, hyaline thin-walled smooth, IKI–, CB–. Growing mostly on angiosperm wood in pantropical areas and causing a white rot.

Notes – *Nigrohirschioporus* differs from other genera among *Trichaptum s.l.* by blackish and woody hard basidiomata with obvious small pores or teeth, sometimes the presence of skeletocystidia, and growth mostly on angiosperms in pantropical areas. *Nigrohirschioporus* includes *N. agglutinatus*, *N. bulbocystidiatus, N. confertus, N. deviatus*, *N. fissilis, N. griseofuscus*, *N. molestus*, *N. nigrivineus* and *N. sector.* In addition, two new species, *N. submurinus* and *N. trimiticus* are described in this paper.

Key to species of *Nigrohirschioporus*

1. Basidiomata annual to perennial ……………………………………………………………2
1. Basidiomata annual ……………………………………………………………………5
2. Basidiomata resupinate ……………………………………………………...*N. deviatus*
2. Basidiomata effused-reflexed to pileate …………………………………………………..3
3. Pores 5–8 per mm ………………………………………………………...*N. nigrivineus*
3. Pores < 8 per mm ………………………………………………………………………4
4. Pore surface pale orange, pores 13–16 per mm …………………………...*N. agglutinatus*
4. Pore surface dark purplish to grayish brown, pores 8–10 per mm ………………..*N. durus*
5. Basidiomata completely resupinate ……………………………………………………6
5. Basidiomata resupinate to effused-reflexed or pileate ………………………………………7
6. Hymenophore poroid to irpicoid, pores 2–4 per mm …………………………*N. bulbocystidiatus*
6. Hymenophore poroid, pores 6–9 per mm …………………………………..*N. submurinus*
7. Hymenophore hydnoid to irpicoid ……………………………………………………..8
7. Hymenophore poroid ………………………………………………………………….9
8. Spores broadly ellipsoid, 4–4.8 × 3–3.5 µm ……………………………………..*N. molestus*
8. Spores cylindric, slightly curved, 5.9–7 × 1.5–2 µm ……………………...*N. griseofuscus*
9. Hyphal system trimitic …………………………………………………………………..10
9. Hyphal system dimitic ………………………………………………………………….11
10. Spores ellipsoid, 4–4.5 × 1.8–2.2 µm, often collapsed …………………………...*N. confertus*
10. Spores cylindric to slightly allantoid, 5–6 × 2.4–2.7 µm, not collapsed …………….*N. trimiticus*
11. Basidiospores cylindrical, 6.4–10 × 2.3–3.2 µm……………………………………..*N. fissilis*
11. Basidiospores narrowly ellipsoid, 5–6.4 × 2.2–2.5 µm …………………………………*N. sector*

Nigrohirschioporus agglutinatus (Corner) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849290; Facesoffungi number: FoF 14453

Basionym – *Trichaptum agglutinatum* Corner, Beihefte zur Nova Hedwigia 86: 204 (1987).

Type locality – MALAYSIA.

Description – Basidiomata annual to perennial, effused-reflexed; pilei applanate, semicircular to elongate. Pileal surface almost black, hairless, rough; margin obtuse and entire. Hymenophore poroid, pale orange; pores angular to round, 13–16 per mm. Context almost black, agglutinated and horny, rigid, without a crust. Tubes pale orange to almost black near the context, horny, up to 4 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia ventricose, thick-walled, abundant, apically encrusted, 12–25 × 6–10 µm. Basidiospores ellipsoid, hyaline, thin-walled, IKI–, CB–, (2.2)2.4–3(3.1) × (1.3–)1.4–1.9 µm, L = 2.75 µm, W = 1.66 µm, Q = 1.66 (n = 30 /1).

Distribution and ecology – *Nigrohirschioporus agglutinatus* is so far known from Borneo only, and grows on angiosperm wood.

Notes – This species is characterized by the agglutinated basidiomata with woody hard context, extremely small pores, ventricose hymenial cystidia and small basidiospores.

Specimen examined – MALAYSIA. Borneo, Kinabalu Mt., alt. 3000 m, 27.VI.1961, *327781* (Holotype E00297278).

Nigrohirschioporus bulbocystidiatus (Ryvarden) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849291; Facesoffungi number: FoF 14454

Basionym – *Trichaptum bulbocystidiatum* Ryvarden [as ‘bulbocystidium’], Syn. Fung. (Oslo) 32: 64 (2014).

Type locality – COSTA RICA.

For a detailed description of *Nigrohirschioporus bulbocystidiatus*, see Ryvarden (2014).

Distribution and ecology – *Nigrohirschioporus bulbocystidiatus* is known only from Costa Rica, and grows on angiosperm wood.

Notes – Ryvarden (2014) mentioned some doubt about the species when he described it, since basidiospores were not observed. However, the bulbous cystidia and the grayish resupinate basidiomata with irregular large pores (2–3 per mm) are unique characters of the species. Moreover, the sequence of the type specimen from GenBank nested within *N. sector*. So, fresh samples and a further study of *Nigrohirschioporus bulbocystidiatus* are needed to confirm its taxonomic status.

Nigrohirschioporus confertus (Vlasák & J. Vlasák) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849292; Facesoffungi number: FoF 14455

Basionym – *Trichaptum confertum* Vlasák & J. Vlasák, Mycosphere 8(6): 1220 (2017).

Type locality – COSTA RICA.

For a detailed description of *Nigrohirschioporus confertus*, see Vlasák and Vlasák (2017).

Distribution and ecology – *Nigrohirschioporus confertus* is a common species from Costa Rica and grows on angiosperm wood.

Notes – This species is distinguished from other members of the genus by dark to grayish black, imbricate and thin pilei (1 mm thick) with purplish to bluish tints when fresh, small pores, 6–8 per mm, and basidiospores, 4–4.5 × 1.8–2.2 µm.

Nigrohirschioporus deviatus (Ryvarden) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849293; Facesoffungi number: FoF 14456

Basionym – *Trichaptum deviatum* Ryvarden, Syn. Fung. (Oslo) 32: 65 (2014).

Type locality – VENEZUELA.

For a detailed description of *Nigrohirschioporus deviatus*, see Ryvarden (2014).

Distribution and ecology – *Nigrohirschioporus deviatus* is only known from the type locality in Venezuela, and grows on angiosperm wood.

Notes – The species can be identified by its perennial, resupinate and distinct thin basidiomata with dark brown to almost black and extremely thin subiculum (0.1mm) which contrasts sharply with the grayish tubes, growth on angiosperm wood and occurrence in the neotropical zones of Venezuela (Ryvarden 2014).

Nigrohirschioporus durus (Jungh.) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849294; Facesoffungi number: FoF 14457

Basionym – *Polyporus durus* Jungh., Verh. Batav. Genootsch. Kunst. Wet. 17(2): 62 (1838).

≡ *Nigroporus durus* (Jungh.) Murrill, Bulletin of the Torrey Botanical Club 34: 471 (1907b)

≡ *Trichaptum durum* (Jungh.) Corner, Beihefte zur Nova Hedwigia 86: 219 (1987)

≡ *Osmoporus durus* (Jungh.) G.H. Cunn., Bulletin of the New Zealand Department of Scientific and Industrial Research 164: 245 (1965)

Type locality – INDONESIA.

Description – Basidiomata perennial, usually pileate, occasionally effused-reflexed; pilei applanate or imbricate in effused-reflexed form. Pileal surface fuliginous purplish becoming blackish towards base, mostly azonate, first finely tomentose becoming hairless, tuberculose or warted with age; margin obtuse, velutinate, purplish, pale vinaceous when dry. Hymenophore poroid, dark vinaceous umber (darker than the flesh), fuliginous umber with a purple tinge even to black, stone hard when dry; pores round and entire, almost invisible to the naked eye, 8–10 per mm; dissepiments thick, entire. Context vinaceous umber brown, fibrous woody to bone hard when dry, indistinctly zoned with a narrow dark line at the upper side, up to 10 mm thick. Hyphae system dimitic; generative hyphae with clamp connections. Cystidia ventricose to subclavate or subcylindric, thin-walled, some with a few crystals or granules at the apex, infrequent, 7–13 × 5–6 µm. Basidiospores broadly ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, 3.5–4.5 (–5) × 2–2.5 (–3) µm, L = 4.03 µm, W = 2.36 µm Q = 1.56–1.68. (n = 90/3).

Distribution and ecology – *Nigrohirschioporus durus* has a distribution in subtropical to tropical regions of Africa, Asia and Australia, and grows on very hard angiosperm wood. It is a common polypore in tropical Asia and East Africa (Ryvarden & Johansen 1980, Corner 1987).

Notes – The species is readily recognized in the field by its warted pileal surface, woody hard texture and almost invisible pores. It used to be a member of *Nigroporus*, and was transferred to *Trichaptum* because its cystidia (Corner 1987). In this study, we confirm that samples of the species formed a well-supported lineage (100/MP, 1/BI) nested in the *Nigrohirschioporus* clade. It is closely related to *N. submiurinus* which, however, has resupinate basidiomata and grows on gymnosperm wood. It is a common species in tropical Asia, Africa and Australia, and we have studied many samples. Although we did not study its type material, we believe our studied samples from Singapore represent *Nigrohirschioporus durus*, and propose the above combination.

Specimens examined – CHINA. Fujian, Yongjing, Huboliao Nat. Res., 26.X.2013, *Cui 11327* (BJFC015443). Guangdong, Shixing, Chebaling Nat. Res., 25.VI.2010, *Cui 8807* (BJFC007747). Guangxi, Shangsi, Shiwandashan Forest Park, 26.VII.2012, *He 20120726-2* (BJFC014523); 24.VII.2012, *He 20120724-11* (BJFC014517). Yunnan, Mengla, Shangyong Nat. Res., on dead angiosperm tree, 20.VIII.2019, *Dai 20642* (BJFC032309); Xishuangbanna Nat. Res., 7.VI.2011, *Dai 12305* (BJFC010587); Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, 31.X.2009, *Cui 8353* (BJFC006842), *Cui 8350* (BJFC006839). SRI LANKA. Avissawella, Salgala Forest, on fallen angiosperm trunk, 3.III.2019, *Dai 19640* (BJFC031317); Colombo, Dombagaskarda Forest Res., on fallen angiosperm trunk, 27.II.2019, *Dai 19497* (BJFC031177), *Dai 19498* (BJFC031178). SINGAPORE. Bukit Timah Nature Reserve, on fallen angiosperm trunk, 19.VII.2017, *Dai 17822* (BJFC025354), *Dai 17834* (BJFC025364). VIETNAM. Lam Tong, Le Duang, Da Lat Bidu Punu Iba National Park, on ground of *Pinus* forest, 16.X.2017, *Dai 18419* (BJFC025939).

Nigrohirschioporus fissilis (Kossmann & Drechsler-Santos) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849295; Facesoffungi number: FoF 14458

Basionym – *Trichaptum fissile* Kossmann & Drechsler-Santos, in Kossmann, Costa-Rezende, Góes-Neto & Drechsler-Santos, Phytotaxa 482(2): 200 (2021).

Type locality – BRAZIL.

For a detailed description of *Nigrohirschioporus fissilis*, see Kossmann et al. (2021).

Distribution and ecology – *Nigrohirschioporus fissilis* was found on Santa Catarina Island, Brazil, on branches and trunks of living and dead angiosperm species, such as, *Laguncularia*, *Avicennia* and *Schinus* in mangrove forests.

Notes – *Nigrohirschioporus fissilis* is closely related to *N. sector*, *N. deviatus* and *N. griseofuscus*. *N. sector* was also described from Santa Catarina Island, but has thin, mostly pileate basidiomata, and basidiospores are 6–7 × 2–2.5 µm (Ryvarden 2014), while *N. fissilis* usually has resupinate to effused-reflexed basidiomata and basidiospores are 6.4–10 × 2.3–3.2 µm (Kossmann et al. 2021). *N. griseofuscus* and *N. deviatus* are readily distinguishable from *N. fissilis* by smaller basidiospores (5.9–7 × 1.5–2 µm in *T. griseofuscus*, 4.5–6 × 1.7–2 µm in *N. deviatus* vs. 6.4–10× 2.3–3.2 µm in *N. fissilis*, Ryvarden 2014).

Nigrohirschioporus griseofuscus (Mont.) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849296; Facesoffungi number: FoF 14459

Basionym – *Irpex griseofuscus* Mont., Annls Sci. Nat., Bot., sér. 4 1: 137 (1854).

≡ *Trichaptum griseofuscum* (Mont.) Ryvarden & Iturr., Mycologia 95 (6): 1074 (2003)

Type locality – FRENCH GUIANA.

Description – Basidiomata annual, effused-reflexed to pileate, occasionally resupinate; pilei semicircular to elongated, flexible and tough; single pileus projecting up to 2 cm, 4 cm wide and 4.5 mm thick. Pileal surface pale brown to clay brown, faintly zonate, adpressed velutinate; margin acute. Hymenophore poroid to hydnoid, brown; pores angular, shallow in juvenile, split to dentate with age, pores or teeth 1–3 per mm. Context duplex, up to 0.5 mm thick, the upper layer being the adpressed tomentum, the lower layer dense. Teeth concolorous with context, up to 4 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia hyaline, two types: fusoid cystidia abundant in the hymenium, slightly thick-walled, apically encrusted or smooth, 12–16 × 4–6 µm; skeletocystidia capitate to clavate, thick-walled to almost solid, from the contextual skeletal hyphae, bending into the hymenium. Basidiospores cylindric, slightly curved, hyaline, thin-walled, smooth, IKI–, CB–, (5.5–)5.9–7(–7.8) × 1.5–2 (–2.2) µm, L = 6.36 µm, W = 1.96 µm, Q = 3.17–3.30 (n = 60/2).

Distribution and ecology – *Nigrohirschioporus griseofuscus* is a common species found in northeastern South America, and grows on angiosperm trunks.

Notes – The species is unique in the genus by its clay to brown basidiomata and coarsely hydnoid hymenophore (Ryvarden & Iturriaga 2003). However, we studied some samples of *Nigrohirschioporus griseofuscus* from the type locality, some are poroid, while others are hydnoid, and their sequences are identical with O506455 from Brazil. We also found the skeletocystidia in *N. griseofuscus* like in *N. fissilis* and *N. bulbocystidiatus*, which only was being shown in an illustration or a short discussion in some studies (Núñez & Ryvarden 2001, Gibertoni et al. 2011, Kossmann et al. 2021). *N. griseofuscus* is phylogenetically related to *N. sector*, but *N. sector* has thin, flexible, generally small, effused-reflexed to pileate basidiomata, smaller pores (4–7 per mm vs. 1–3 per mm) and wider spores (5–6.4 × 2.2–2.5 µm vs. 5.9–7 × 1.5–2 µm).

Specimens examined – BRAZIL. Amapá, Porto Grande, Floresta Estadual do Amapá, 2014, *URM 87184 & B3942* (URM 87184). FRENCH GUIANA, Roura, Camp Cayman, 27.VIII.2018, *JV 1808/103* (BJFC032925, JV); Coralie, Sentier Molokoi, 1.IX.2019, *JV 1909/6* (BJFC033007, JV); Remire-Montjoly, Rorota Lake, 23.VIII.2018, *JV 1808/27* (JV).

Nigrohirschioporus molestus (Corner) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849297; Facesoffungi number: FoF 14460

Basionym – *Trametes molesta* Corner [as '*Tramete*'], Beih. Nova Hedwigia 97: 125 (1989).

≡ *Trichaptum molestum* (Corner) T. Hatt. & Sotome, Mycoscience 54 (4): 299 (2013).

Type locality – MALAYSIA.

For a detailed description of *Nigrohirschioporus molestus*, see Hattori & Sotome (2013).

Distribution and ecology – *Nigrohirschioporus molestus* is known only from Malaysia, and grows on angiosperm wood.

Notes – Morphologically, this species is characterized by a pale-colored context, dark brown pileal surface with soft spongy tomentum, irpicoid hymenophore, a trimitic hyphal system and ventricose to clavate cystidia. These characteristics fit the definition of *Nigrohirschioporus* in Hirschioporaceae rather than Trichaptaceae. Meanwhile, its pale-colored context and dark brown pileal surface indicate that it is similar to *Nigrohirschioporus agglutinatus*, but *N. agglutinatus* differs from *N. molestus* in having smaller pores (13–16 per mm vs. 3–4 per mm) and smaller basidiospores (2.4–3 × 1.4–1.9 µm vs. 4–4.8 × 4–4.8 × 3–3.5 µm).

Nigrohirschioporus nigrivineus (Corner) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849298; Facesoffungi number: FoF 14461

Basionym – *Trametes nigrivinea* Corner, Beih. Nova Hedwig. 97:128 (1989).

≡ *Nigrofomes nigrivineus* (Corner) T. Hatt. & Sotome, Mycoscience 54 (4): 300 (2013).

Type locality – PAPUA NEW GUINEA.

For a detailed description of *Nigrohirschioporus nigrivineus*, see Hattori & Sotome (2013).

Distribution and ecology – The species is known only from Papua New Guinea, and grows on fallen wood in a montane forest.

Notes – Hattori & Sotome (2013) pointed out that there is a clear distinction between *Nigrofomes nigrivineus* and *N. melanoporus*, by the presence of clamp connections in the contextual generative hyphae. Currently, only one specimen of *N. nigrivineus* is known and without molecular sequence data (Hattori & Sotome 2013). *Nigrofomes nigrivineus* is the only species in the genus *Nigrofomes* with clamp connections on the reproductive hyphae (Zhou et al. 2020). Therefore, the phylogenetic relationship of *Nigrofomes nigrivineus* with other species are unknown.

Hattori & Sotome (2013) also mentioned that *Trichaptum durum* (*Nigrohirschioporus durus*) resembles *Nigrofomes nigrivineus* (*Nigrohirschioporus nigrivineus*) by a similar dark-colored context, the presence of hymenial cystidia and ellipsoid basidiospores, but the former has a fuliginous purplish to grayish pileal surface without a crust (Corner 1987). More fresh samples and molecular data are needed to confirm the relationship of the two species.

Nigrohirschioporus nigrivineus is characterized by ventricose, encrusted cystidia and short ellipsoid basidiospores measuring 3.5–4.5 × 2–3 µm, these characters demonstrate the similarity of *N. nigrivineus* and *N. durus*. We believe that the presence of clamp connections in generative hyphae is a more stable morphological characteristic for distinguishing species, hence the proposed the above combination.

Nigrohirschioporus sector (Ehrenb.) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849299; Facesoffungi number: FoF 14462

Basionym – *Boletus sector* Ehrenb., in Nees von Esenbeck (Ed.), Horae Physicae Berolinenses: 10, 18:6 (1820).

≡ *Trichaptum sector* (Ehrenb.) Kreisel, Monografias Ciencias Universidad de Habana 16: 84 (1971).

≡ *Polyporus sector* (Ehrenb.) Fr., Systema Mycologicum 1: 505 (1821)

Type locality – BRAZIL.

Description – Basidiomata annual, pileate with a narrow base; pilei spathulate to flabelliform, usually laterally fused imbricate; single pileus up to 7 cm in radius. Pileal surface pale fuscous, vinaceous or vinaceous buff to snuff brown, finely tomentose to velutinate, sub-scaly towards the margin, with sepia or fuscous brown zones; margin entire to lobed. Hymenophore poroid, fuscous to dark vinaceous gray, vinaceous towards the margin; pores angular, 4–7 per mm; dissepiments more or less undulate, subcoriaceous, concolorous with pileal surface, up to 2 mm thick. Tubes dark fuscous to date brown, up to 2 mm long. Hyphae dimitic; generative hyphae with clamp connections. Cystidia subclavate to subventricose with an obtuse tip, thin- or slightly thick-walled, apically encrusted, 24 × 3–5 µm. Basidiospores oblong-ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, 5–6.4(–7) × (2–)2.2–2.5 µm, L = 5.9 µm, W = 2.2 µm, Q = 2.589–2.81 (n = 90/3).

Distribution and ecology – *Nigrohirschioporus sector* is a common species distributed in subtropical to tropical regions of America, and grows on angiosperm wood.

Notes – This species is readily recognized by its darkened pore surface, thin and flexible pilei with tomentose upper surface. Vlasák & Vlasák (2017) mentioned that two sequences of *N. sector* from Brazil (type locality) in GenBank may represent yet another species, even though it is closely related to *Nigrohirschioporus sector*, but they did not study any Brazilian material. We examined some samples from Brazil, combined with the morphological evidence, and confirmed that *N.* cf. *sector* including BR67 (KP859297 from GenBank) and our three samples represent a new species, *N. trimiticus*.

Biological activities – Antioxidant (Saparrat et al. 2000).

Specimens examined – BRAZIL. Amapá, Porto Grande, Floresta Estadual do Amapá, 2014, *URM 89911 & B3799* (URM 89911); Pará, Melgaço Floresta Nacional de Caxiuanã, 2013, *AS 2707 & URM MPEG* (URM MPEG). COSTA RICA. Golfito, Playa Nicuesa, 18.IV.2017, *JV 1704/50*

(JV); Rincón Mt., VIII.2014, *JV 1408/8-J* (BJFC039889, JV); 22.IV.2015, *JV 1504/61* (JV). FRENCH GUIANA. Roura, Camp Cayman, 27.VIII.2018, *JV 1808/108* (BJFC032926, JV).

Nigrohirschioporus submurinus Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 17

MycoBank number: MB 849300; Facesoffungi number: FoF 14463

Type – VIETNAM. Lam Dong, Lac Duong District, Bidoup Nui Ba Nat. Park, on rotten wood of *Pinus*, 15.X.2017, *Dai 18392* (Holotype BJFC025913).

Etymology – *Submurinus* (Lat.): refers to the species having pale mouse gray pores when dry.

Basidiomata – Annual, resupinate; corky when fresh, becoming brittle upon drying, up to 5 cm long, 2 cm wide and 1 mm thick at center. Hymenophore poroid, pale mouse gray when dry; pores angular when juvenile, becoming irregular and partly split with age, 6–9 per mm; dissepiments thin, entire. Sterile margin thin to almost absent. Subiculum homogeneous, smoke gray, corky, very thin to almost absent, thinner than 0.1 mm**.** Tubes mouse-gray, up to 1 mm long.

Hyphal structure – Hyphal system dimitic; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae distinctly thick-walled, slightly dextrinoid, CB+; tissues unchanged in KOH.

Subiculum – Generative hyphae hyaline, slightly thick-walled, occasionally branched, 2–3 µm in diam.; skeletal hyphae brownish, thick-walled with a narrow lumen to subsolid, unbranched, flexuous, interwoven, 3–4 µm in diam.

Tubes – Generative hyphae hyaline, slightly thick-walled, occasionally branched, 1.5–2.5 µm in diam.; skeletal hyphae thick-walled with a medium lumen, unbranched, loosely interwoven, 3–6 µm in diam.; hyphae at dissepiment edges usually apically encrusted with a few fine crystals.

Hymenium – Cystidia fusoid with a long neck, abundant, thin-walled, smooth, 17–35 × 4–5.5 µm, with a basal clamp connection; cystidioles present, fusoid, thin-walled, smooth, 10–15 × 4–4.5 µm; hyphal pegs absent; basidia barrel-shaped, with four sterigmata and a basal clamp connection, 12–17 × 3.5–6.5 µm; basidioles similar to basidia in shape, but slightly thinner.

Spores – Basidiospores oblong ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, (3.6–)3.8–4.8(–5) × (2.1–)2.2–3 µm, L = 4.14 µm, W = 2.54 µm, Q = 1.62 (n = 30/1).

Type of rot – White rot.

Distribution and ecology – *Nigrohirschioporus submurinus* to date, is found only from Vietnam, and grows on rotten wood of *Pinus*.

Notes – *Nigrohirschioporus submurinus* is characterized by annual, resupinate basidiomata with a thin subiculum, small and pale mouse gray pores of 6–9 per mm, smooth cystidia with a long neck, dissepimental hyphae with fine crystals, oblong ellipsoid basidiospores, 3.8–4.8 ×2.2–3 µm, and growth on rotten wood of *Pinus* in Vietnam. Phylogenetically, *N. submurinus* is closely related to *N. durus*. However, *N. durus* is readily distinguished from *N. submurinus* by its perennial, pileate to effuse-reflexed basidiomata, dark vinaceous umber pore surface and growth on angiosperm wood.

Nigrohirschioporus trimiticus Y.C. Dai, Yuan Yuan & Meng Zhou, sp. nov. Fig. 18

MycoBank number: MB 849301; Facesoffungi number: FoF 14464

Type – BRAZIL. Rondônia, Porto Velho, 2012, *B696* (Holotype URM 83880).

Etymology – *Trimiticus* (Lat.): refers to the species having a trimitic hyphal system in the tube trama.

Basidiomata – Annual, pileate or effused-reflexed; corky when fresh, hard corky when dry. Pilei usually imbricate, small, projecting up to 1 cm, 2 cm wide and 3 mm thick at base. Pileal surface white to pale buff when fresh, grayish brown when dry, loosely adpressed velutinate to smooth, faintly zonate. Hymenophore poroid to irpicoid, olivaceous buff when fresh, honey to grayish brown when dry; pores angular when juvenile, becoming irpicoid with age, 3–5 per mm; dissepiments thin, entire when juvenile, strongly lacerated with age. Context pale brown, up to 0.5 mm thick. Tubes pale brown, up to 2.5 mm long.

Hyphal structure – Hyphal system trimitic in tubes, dimitic in context; generative hyphae with clamp connections, hyaline, slightly thick-walled; skeletal hyphae pale yellowish in KOH, distinctly thick-walled, slightly dextrinoid, CB+; binding hyphae thick-walled; tissues unchanged in KOH.

Context – Generative hyphae hyaline, slightly thick-walled, rarely branched, 3–5 µm in diam.; skeletal hyphae thick-walled with a wide lumen, unbranched, interwoven, 4–7 µm in diam.

Tubes – Generative hyphae hyaline, slightly thick-walled, rarely branched, 2–4 µm in diam.; skeletal hyphae thick-walled, branched, interwoven, 3–7 µm in diam.; binding hyphae thick-walled with a narrow lumen, frequent branched, interwoven, 1.5–2 µm in diam.

Hymenium – Cystidia clavate to fusoid, thick-walled, abundant, usually apically encrusted, 15–23 × 4–5 µm; hyphal pegs absent; basidia clavate, with four sterigmata and a basal clamp connection, 20–25 × 4–6 µm; basidioles similar with basidia in shape, but smaller.

Spores – Basidiospores cylindric to slightly allantoid, hyaline, thin-walled, smooth, IKI–, CB–, 5–6(–6.2) × (2.2–)2.4–2.7(–3) µm, L = 5.78 µm, W = 2.51 µm, Q = 2.30 (n = 30/1).

Type of rot – White rot.

Distribution and ecology – *Nigrohirschioporus trimiticus* to date, is found in Amazonia only.

Notes – *Nigrohirschioporus trimiticus* is characterized by annual, pileate or effused-reflexed basidiomata, irpicoid hymenophore and a trimitic hyphal system in the trama and cylindric to slightly allantoid basidiospores, 5–6 ×2.4–2.7 µm. Phylogenetically, four samples of *N. trimiticus* formed an independent lineage which is closely related to *N. sector*, *N. fissilis* and *N. griseofuscus.* The latter three species differ from *N. trimiticus* in having a dimitic hyphal system in the tube trama and longer basidiospores (> 6 µm in length vs. 5–6 × 2.4–2.7 µm).

Additional specimens examined – BRAZIL. Amapá, Porto Grande, State Forest of Amapá, 2014, *URM 89926 & B34*71 (URM 89926); Pará, Melgaço Caxiuanã National Forest, 2013, *URM 90290 & B4105* (URM 90290).

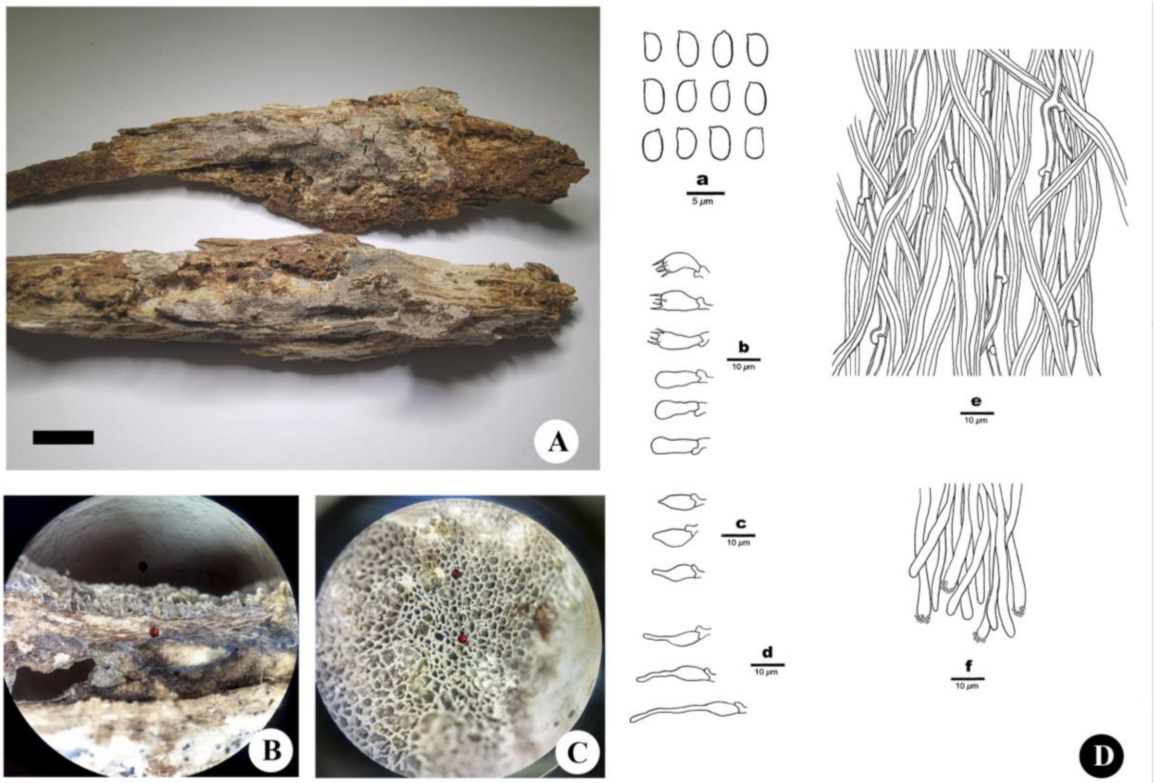

Figure 17 – A Basidiomata of *Nigrohirschioporus submurinus* (*Dai 18392*). B Longitudinal section. C Hymenophore. D Microscopic structures of *N. submurinus* (*Dai 18392*). a Basidiospores. b Basidia and basidioles. c Cystidioles. d Cystidia. e Hyphae from trama. f Hyphae at dissepiment edge. Scale bars: A = 1 cm, B–C = 1 mm.

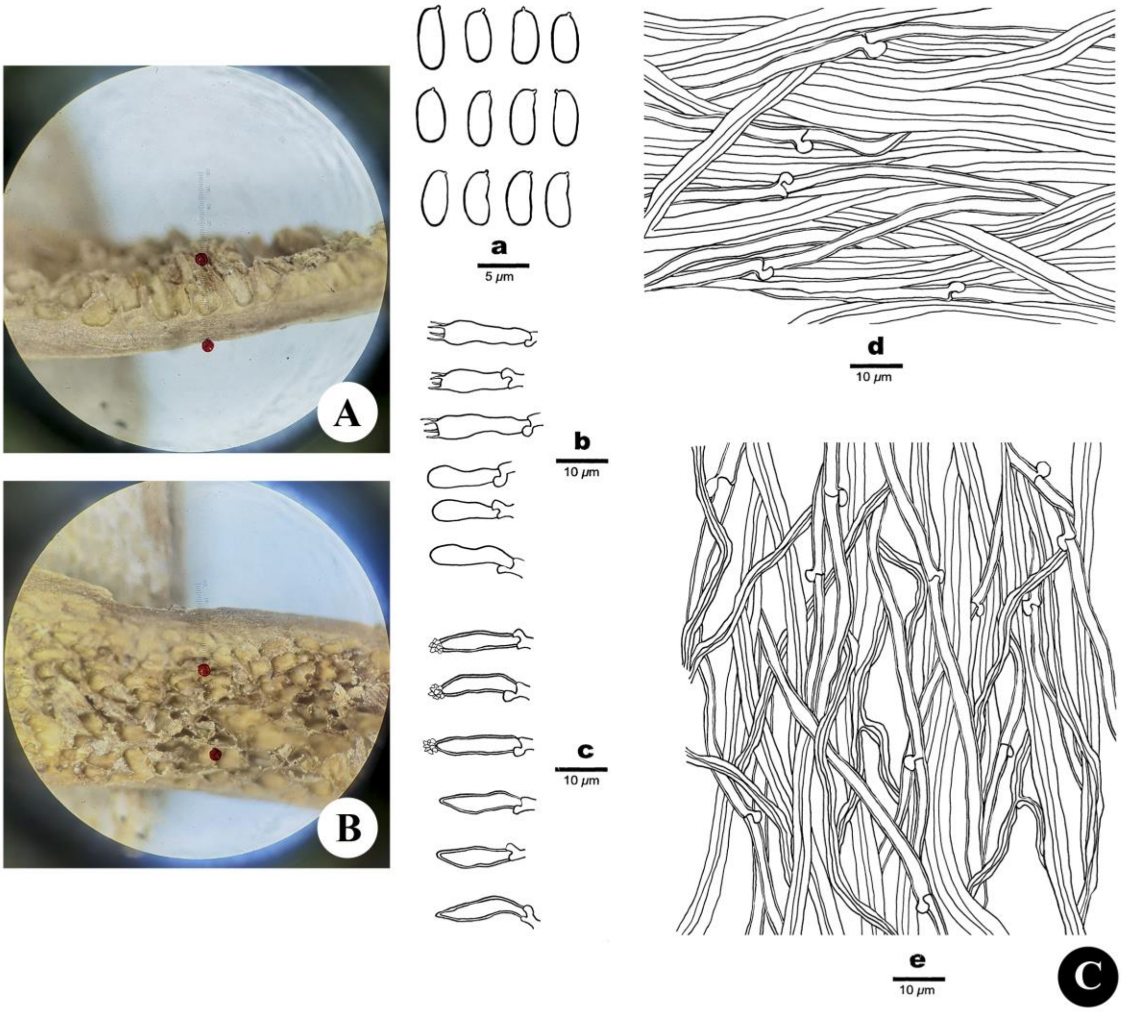

Figure 18 – A Longitudinal section of *Nigrohirschioporus trimiticus* (*B696*). B Hymenophore. C Microscopic structures of *N. trimiticus* (*B696*). a Basidiospores. b Basidia and basidioles. c Cystidia. d Hyphae from context. e Hyphae from trama. Scale bars: A = 2 mm, B = 1 mm.

Trichaptaceae Y.C. Dai, Yuan Yuan & Meng Zhou, fam. nov.

MycoBank number: MB 849209; Facesoffungi number: FoF 14470

Type genus – *Trichaptum* Murrill, Bull. Torrey bot. Club 31(11): 608 (1904).

Habitat – Growing on angiosperm wood, occurring in tropical and subtropical areas and causing a white rot.

Basidiomata annual to perennial, mostly pileate to effused-reflexed, pileal surface strongly strigose to hispid; hymenophore poroid to irpicoid or daedaleoid to lamellate, brownish with slightly violet tint; context distinctly duplex. Hyphal system dimitic, generative hyphae with clamp connections; ventricose to subulate cystidia present, basidiospores cylindrical to ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–.

Notes – Samples of Trichaptaceae nested in Clade B with robust support (Figs 4–5), and the sole genus *Trichaptum* is included in the family

Trichaptum Murrill, Bulletin of the Torrey Botanical Club 31 (11): 608 (1904)

Type species – *Trichaptum perrottetii* (Lév.) Ryvarden.

Description – Basidiomata annual to perennial, pileate to effused-reflexed or resupinate; pileal surface blackish, gray or dirty white, strongly strigose to hispid; hymenophore poroid to irpicoid, mostly brownish with slightly violet tint when actively growing; context distinctly duplex, lower part dense and dark, upper part white and sparse; tubes brownish to clay buff. Hyphal system dimitic, generative hyphae with clamp connections; cystidia present in the hymenium, thin- to thick-walled, ventricose to subulate or narrowly fusoid with long narrow necks, smooth or apically encrusted; basidiospores cylindrical to ellipsoid, often slightly curved, hyaline, thin-walled, smooth, IKI–, CB–. Growing on angiosperm wood, occurring in tropical and subtropical areas and causing a white rot.

Notes – *Trichaptum* accommodates species that have large basidiomata with a strigose to hispid pileal surface. So far, *T anomalum*, *T. byssogenum*, *T. perrottetii*, *T. perpusillum*, *T. resacarium* and *T. strigosum* are included in the genus.

Key to species of *Trichaptum*

1. Basidiomata usually resupinate, rarely effused-reflexed …………………*Trichaptum resacarium*
1. Basidiomata pileate to effused-reflexed ………………………………………………………..2
2. Pores round to angular, 6–7 per mm ……………………………………………..*T. perpusillum*
2. Pores angular to irpicoid, < 5 per mm ………………………………………………………3
3. Pore surface snuff brown to cigar brown …………………………………………*T. perrottetii*
3. Pore surface light grayish brown to wood-colored or pale vinaceous buff ………………………3
3. Pores 2–4 per mm; basidiospores < 5.5 µm in length ……………………………...*T. strigosum*
3. Pores 1–3 per mm; basidiospores > 5.5 µm in length ……………………………………………4
4. Basidiospores 5.5–8 × 2–2.5 µm …………………………………………...*T. byssogenum*
4. Basidiospores 7–8 × 4–4.5 µm ……………………………………………………*T. anomalum*

Trichaptum anomalum (Lloyd) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849302; Facesoffungi number: FoF 14466

Basionym – *Polystictus anomalus* Lloyd Mycol. Writ. (Cincinnati) 5: 791 (1918).

Type locality – AUSTRALIA.

For a description of *Hirschioporus anomalus*, see Lloyd (1918).

Distribution and ecology – *Pallidohirschioporus anomalus* was described from New South Wales, Australia, growing on angiosperm wood. Its previous record in China (Teng 1963) is doubtful.

Notes – *Trichaptum anomalum* was originally described as *Polystictus anomalus* Lloyd (Lloyd 1918), and is characterized by effused-reflexed basidiomata with a hirsute to strigose upper surface, irpicoid to daedaleoid hymenophore with large pores of 2 per mm, brownish context and cylindric basidiospores of 7–8 × 4–4.5 µm (Lloyd 1918), because of these characteristics Teng (1963) combined it as *Hirschioporus anomalus* (Lloyd) Teng according to the morphological definition of *Hirschioporus*. However, the taxonomic status of *H. anomalus* was not mentioned when *Hirschioporus* was incorporated into *Trichaptum*. Because the species has hirsute to strigose upper surface, clavate to subulate cystidia, distribution in tropical area, and growth on angiosperms. The features are more similar to *Trichaptum* rather than *Hirschioporus*, so, *T. anomalum* is proposed.

Trichaptum byssogenum (Jungh.) Ryvarden, Norwegian Journal of Botany 19: 237 (1972)

Type locality – INDONESIA.

Description – Basidiomata annual to perennial, mostly effused-reflexed, occasionally pileate or resupinate; pilei semicircular, imbricate, broadly attached, laterally fused in rows, tough, single pileus projecting up to 8 cm, 15 cm wide and up to 1.2 cm thick. Pileal surface gray to ochraceous or milky coffee, concentrically sulcate and radially striate, hispid to tomentose, more adpressed towards the margin. Hymenophore poroid to irpicoid or semi-daedaleoid, ochre to wood-colored or pale vinaceous buff; pores round to angular, 1–3 per mm; dissepiments thin, entire when juvenile, split with age, finally almost irpicoid. Context duplex, upper layer clay buff to wood-colored, hispid, up to 7 mm thick, lower layer buff, up to 0.3 mm. Tubes concolorous with context, up to 5 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia subventricose to subulate, hyaline, slightly thick-walled, usually with an apical crown of yellow crystals, 12–15 × 4–5.5 µm, projecting from the hymenium. Basidiospores cylindric to ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, (4.5–)5.2–7 × 3–4(–4.3) µm, L = 5.83 µm, W = 3.45 µm, Q = 1.59–1.76 (n = 150/5).

Distribution and ecology – *Trichaptum byssogenum* has a pantropical distribution, and grows on both gymnosperms and angiosperms, occurring not only in forests, but also on construction wood and fences.

Biological activities – Enzymatic (Machado et al. 2005).

Notes – The species is readily recognized by effused-reflexed basidiomata, a coarsely strigose to hispid upper surface, grayish tan to whitish, purplish to dull purplish brown hymenophore, angular to irpicoid pores of 1–3 per mm, or sometimes lamellate towards the margin, subventricose to subulate cystidia and cylindric to ellipsoid basidiospores, 5.2–7 × 3–4 µm. In addition, the spore dimensions of the species are variable according to different authors: 8–10 × 3–4 µm (Overholts 1953), 6.5–9 × 3.5–4 µm (Corner 1987), 5.5–7 × 3.5–4 µm (Ryvarden & Johansen 1980). 5.5–8 × 2–2.5 µm (Gilbertson & Lindsay 1987), 5–6.8 × 1.4–3.2 µm (Wright & Deschamps 1975), and 4–5.5 × 2–2.5 µm (Cunningham 1965).

Specimens examined – AUSTRALIA. Queensland, Cairns, Mt. Whitfield Coservation Park, on construction wood, 18.V.2018, *Dai 18850* (BJFC027318), *Dai 18851* (BJFC027319). CHINA. Fujian, Fuzhou Forest Park, on fallen angiosperm wood, 4.VI.2021, *Dai 22342* (BJFC036930). Hainan, Danzhou, 7.V.2009, *Dai 10752* (BJFC004996). Taiwan, Hualian, Tailuge Forest Park, 21.XI.2009, on fallen trunk of *Prunus*, *Dai 11543* (BJFC007412). Zhejiang, Lishui, Guyanhuaxiang, on fallen angiosperm trunk, 13.VIII.2015, *Dai 15555* (BJFC019660). COSTA RICA. Puntarenas, Dominical, Hacienda Barú, on angiosperm wood, 21.IV.2017, *JV 1704/82* (JV). THAILAND. Chiang Mai, on fallen angiosperm trunk, 25.VII.2016, *Dai 16758* (BJFC022865); Thale Ban Nat. Park, on angiosperm wood, 25.XI.2004, *J. Kout 0411/9* (JV). USA. Florida, Everglades, Long Pine Key, on *Pinus*, 22.IV.2009, *JV 0904/94* (JV); Sarasota, on *Pinus*, 30.XII.2015, *Dolliner 632* (JV). Virgin Islands, on angiosperm wood, 4.IX.2004, *JV 0409/22-J* (JV). PUERTO RICO. San Juan, on palm, XII.2011, *JV 1112/5-J* (BJFC039893, JV).

Trichaptum perpusillum (Corner) T. Hatt., Mycoscience 44(4): 271 (2003)

Type locality – MALAYSIA.

For a detailed description of *Trichaptum perpusillum*, see Hattori (2003).

Distribution and ecology – *Trichaptum perpusillum* is known only from Sarawak, Malaysia, and grows on angiosperm wood.

Notes – The species is a member of *Trichaptum* and characterized by pale ochraceous, rough basidiomata with hispid to strigose pileal surface, a dimitic hyphal system and encrusted hymenial cystidia. In addition, *T. perpusillum* has regular and completely entire pores, whitish context, and subglobose basidiospores and these are the unique to the genus.

Trichaptum perrottetii (Lév.) Ryvarden, Norwegian Journal of Botany 19: 237 (1972)

Type locality – FRENCH GUIANA.

Description – Basidiomata annual to perennial, pileate, tough and flexible when fresh; pilei semicircular, mostly broadly attached; single pileus projecting up to 7 cm, 15 cm wide and 10 mm thick. Pileal surface grayish brown to dark brown, paler towards margin, strigose; margin acute, strigose, up to 10 mm in diam. Hymenophore poroid to daedaleoid, snuff brown to cigar brown; pores angular to sinuous, 2–3 per mm; dissepiments thin, lacerated. Context duplex, the upper layer hirsute to strigose, up to 8 mm thick, the lower very thin, brown to dark ochraceous, up to 0.4 mm thick. Tubes deep brown, up to 5 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia subulate to ventricose with a tapering apex, smooth or with an apical crown of crystals, 10–22 × 4–6 µm, slightly projecting from hymenium. Basidiospores subcylindrical to oblong ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, (5.5–)5.8–7 × (2–)2.5–3.1(–3.5) µm, L = 6.20 µm, W = 2.91 µm, Q = 2.03–2.26 (n = 60/2).

Distribution and ecology – *Trichaptum perrottetii* is a common species in subtropical to tropical regions of America, and grows on angiosperm wood.

Notes – The species is readily recognized in the field due to its upper surface with dense dark stiff hairs and the snuff brown to cigar brown pore surface. *Trichaptum byssogenum* and *T. strigosum* resemble *T. perrottetii*, but *T. byssogenus* has a tomentose pileal surface and effused-reflexed basidiomata, *T. strigosum* has shorter basidiospores (4.3–5.9 × 2.5–3 µm vs. 5.8–7 × 2.5–3.1 µm).

Ryvarden (1981) studied the type specimens of several Polyporaceae fungi described by J.H. Léveillé and indicated that the type specimen of *Trichaptum* Murrill was the same specimen used by Montagne & Berkeley when they described *Trametes trichomallus* in 1849. Furthermore, the label of the specimen was mixed up with an incorrectly labeled “Java, M. Perrottet” tag placed in a label bag printed with “Guyane Francaise M. Poileau”. So, the corrected locality of the type specimen of *Trichaptum perrottetii* is French Guiana.

Biological activities – Antivirus (Walder et al. 1995).

Specimens examined – BRAZIL, Rondônia, Porto Velho, Parque Natural Municipal, 2013, *URM MPEG & B2626* (URM). COSTA RICA, Carpintera mountain, on decayed wood, 23.VII.1932 (BJFC002717). FRENCH GUIANA, Roura, Camp Cayman, 27.VIII.2018, *JV 1808/101* (BJFC032924, JV); 28.VIII.2019, *JV 1908/45* (BJFC033001, JV); Piauí, Caracol, 2011, *URM 83816 & B522* (URM 83816).

Trichaptum resacarium Vlasák & J. Vlasák, Mycosphere 8 (6): 1221 (2017)

Type locality – USA.

For a detailed description of *Trichaptum resacarium*, see Vlasák & Vlasák (2017).

Distribution and ecology – *Trichaptum resacarium* to date, is known only from Texas, USA and grows on angiosperm wood (Vlasák & Vlasák 2017).

Notes – *Trichaptum resacarium* is similar to *T. byssogenum* but distinguished by poorly developed pilei, dark hymenial surface, blackish hairs on pileal surface, and smaller basidiospores (3.5–4 × 2 µm vs. 5.2–7 × 3–4 µm).

Trichaptum strigosum Corner, Beih., Nova Hedwigia 86: 228 (1987)

Type locality – BRAZIL.

Description – Basidiomata annual, pileate; pilei applanate, dimidiate, single pileus projecting up to 3.7 cm in radius. Pileal surface fuscous brown, slightly purplish towards margin, densely hispid to strigose; margin acute, up to 2 mm. Hymenophore poroid, grayish brown, slightly purple towards margin; pores subangular to elongate or irregular, 2–5 per mm. Context duplex, the upper layer fibrous, up to 8 mm thick, the lower layer corky, up to 0.4 mm thick. Tubes grayish brown, up to 2 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia subventricose, thin- to slightly thick-walled apically encrusted, 10–24 × 2–5 µm, projecting from hymenium. Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, 4.3–5.9(–6) × (2.4–)2.5–3(–3.2) µm, L = 5.19 µm, W = 2.86 µm, Q = 1.81 (n = 30/1).

Distribution and ecology – *Trichaptum strigosum* has a distribution in subtropical to tropical America, and grows on angiosperms.

Notes – *Trichaptum strigosum* and *T. perrottetii* share a similar habitat and densely hispid strigose pileal surface, but the later has snuff brown to cigar brown pore surface and bigger basidiospores (5.8–7 × 2.5–3.1 µm vs. 4.3–5.9 × 2.5–3 µm). The sample we studied and sequenced was from Florida, where has similar ecological environment to South America, the type locality. In addition, the species used to be treated as *T. perrottetii*, but its grayish brown pore surface, distinct strigosefmbriate margin and short basidiospores showed a difference from *T. perrottetii* of type locality, French Guiana and fitted the original description of *T. strigosum*.

Specimen examined – USA. Florida, 2.X.2010, *JV 1012/2* (BJFC039891, JV).

Podocarpioporus Y.C. Dai, Yuan Yuan & Meng Zhou, gen. nov.

MycoBank number: MB 849215; Facesoffungi number: FoF 14474

Type species – *Podocarpioporus podocarpi* (Y.C. Dai) Y.C. Dai, Yuan Yuan & Meng Zhou.

Etymology – *Podocarpioporus* (Lat.) refers to the species of the genus having a poroid hymenophore and growing on Podocarpaceae.

Description – Basidiomata annual, resupinate or effused-reflexed to pileate; hymenophore poroid to irpicoid. Hyphal system dimitic; generative hyphae with clamp connections; skeletal hyphae occasionally with simple septa, IKI–, CB+; tissue darkening but otherwise unchanged in KOH. Cystidia encrusted at the apex or not; basidiospores allantoid, hyaline, thin-walled, smooth, IKI–, CB–. Growing on wood of Podocarpaceae.

Notes – This genus is unique in Trichaptaceae and Hirschioporaceae because of the poroid to irpicoid hymenophore, narrow allantoid basidiospores, distinctly long subulate hymenial cystidia, and growth on species of Podocarpaceae.

Podocarpioporus podocarpi (Y.C. Dai) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849303; Facesoffungi number: FoF 14465

Basionym – *Trichaptum podocarpi* Y.C. Dai, Mycol. Progr. 8(4): 284 (2009).

Type locality – CHINA.

Description – Basidiomata annual, resupinate, soft to soft leathery, without odor or taste when fresh, becoming hard corky upon drying, up to 50 cm long, 10 cm wide, and 0.3 cm thick. Hymenophore poroid to irpicoid, cinnamon, fawn, vinaceous buff to clay pink buff when fresh, becoming brown when bruised, clay buff to grayish brown upon drying; pores angular, 1–3 per mm; dissepiments thin, entire when juvenile, becoming strongly lacerated to irpicoid with age. Sterile margin distinct, cream when fresh, pink buff when dry, up to 1 mm wide. Subiculum grayish brown and soft leathery when dry, up to 0.5 mm thick. Tubes concolorous with pores, corky, up to 2.5 mm long. Hyphal system dimitic; generative hyphae with clamp connections. Cystidia clavate to subulate, abundant, hyaline, thick-walled, apically encrusted, distinctly projecting from hymenium, 28–70 × 5–8 µm; cystidioles absent. Basidiospores cylindric to allantoid, hyaline, thin-walled, smooth, IKI–, CB–, (4.5–)5–7(–7.2) × (1.5–)1.8–2.2(–2.3) µm, L = 6.15 µm, W = 1.98 µm, Q = 3.11 (n = 61/1).

Specimens examined – CHINA. Hainan, Ledong, Jianfengling Nat. Res., on rotten wood of *Podocarpus*, 18.XI.2007, *Dai 9305* (BJFC002726); Lingshui, Diaoluoshan Nat. Res., on rotten wood of *Podocarpus*, 24.XI.2002, *Dai 4529* (IFP 018992); on fallen trunk of *Podocarpus*, 21.XI.2007, *Dai 9356* (Holotype BJFC002727); 29.V.2008, *Dai 9853* (IFP015797).

Distribution and ecology – *Podocarpioporus podocarpi* is known from Hainan, China, and is only known to grow on wood of *Podocarpus*.

Notes – *Podocarpioporus podocarpi* resembles *P. vinaceobrunneus* by sharing vinaceous brown and strongly lacerated pores. However, *P. podocarpi* has fully resupinate basidiomata.

Podocarpioporus vinaceobrunneus (Corner) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849304; Facesoffungi number: FoF 14467

Basionym – *Gloeophyllum vinaceobrunneum* Corner [as ‘vinaceibrunneum’], Beih. Nova Hedwigia 86: 66 (1987).

≡ *Trichaptum vinaceobrunneum* (Corner) T. Hatt., Mycoscience 42 (1): 19 (2001b).

Type locality – MALAYSIA.

For a detailed description of *Podocarpioporus vinaceobrunneus,* see Hattori (2001b).

Distribution and ecology – *Podocarpioporus vinaceobrunneus* is known only from Malaysia, and grows on wood of *Dacrydium*.

Notes – *Podocarpioporus vinaceobrunneus* is characterized by poroid to irpicoid hymenophore, distinctly long subulate cystidia of 25–45 × 5–7.5 µm, narrow cylindric to allantoid basidiospores of 6–7 × 1.2–1.8 µm and growth on *Dacrydium*. These characteristics show it is more similar to *Podocarpioporus podocarpi* rather than *Trichaptum s.l.*, so, we proposed above combination. This species differs from *Podocarpioporus podocarpi* by effused-reflexed to pileate basidiomata, shorter cystidia (25–45 × 5–7.5 µm vs. 28–70 × 5–8 µm) and thinner basidiospores (6–7 × 1.2–1.8 µm vs. 5–7 × 1.8–2.2 µm, Hattori 2001b).

Pseudotrichaptum Y.C. Dai, Yuan Yuan & Meng Zhou, gen. nov.

MycoBank number: MB 849216; Facesoffungi number: FoF 14475

Etymology – *Pseudotrichaptum* (Lat.) refers to the genus being morphologically similar to *Trichaptum* but phylogenetically distant.

Type species – *Pseudotrichaptum laricinum* (P. Karst.) Y.C. Dai, Yuan Yuan & Meng Zhou.

Description – Basidiomata annual, pileate or effused-reflexed, coriaceous to tough; pileal surface cream to pale buff with distinct concentric sulcate zones, covered by mosses with age; hymenophore lamellate; lamella purplish, thin, entire and wavy, dichotomously forked near margin; context duplex. Hyphal system dimitic; generative hyphae with clamp connections, skeletal hyphae pale yellowish in KOH; cystidia apically encrusted; basidiospores allantoid. Growing on gymnosperm wood.

Notes – *Pseudotrichaptum* differs from other genera in *Trichaptum s.l.* by its coriaceous pilei with purplish lamellate hymenophore, duplex context and allantoid basidiospores. *Pseudotrichaptum* is established to accommodate the species *P. laricinum* in the order Hymenochaetales. According to the phylogenetic analyses, samples of *Pseudotrichaptum laricinum* form an independent clade within the Hymenochaetales distantly related to another member of *Trichaptum s.l.* Based on the phylogeny and morphology, we set up a new genus *Pseudotrichaptum* to accommodate *P. laricinum*.

Pseudotrichaptum laricinum (P. Karst.) Y.C. Dai, Yuan Yuan & Meng Zhou, comb. nov.

MycoBank number: MB 849305; Facesoffungi number: FoF 14468

Basionym – *Lenzites laricinus* P. Karst., Acta Soc. Fauna Flora Fenn. 27(no. 4): 4 (1905).

≡ *Hirschioporus laricinus* (P. Karst.) Teram., Bull. Tokyo Univ. Forests: 212 (1951)

≡ *Trichaptum laricinum* (P. Karst.) Ryvarden [as 'laricinus'], Norwegian Journal of Botany 19: 237 (1972).

Type locality – RUSSIA.

Description – Basidiomata annual, pileate, occasionally effused-reflexed, imbricate, coriaceous when fresh, rigid upon drying; pilei sometimes laterally fused, single pileus projecting up to 5 cm, 7 cm wide and 5 mm thick. Pileal surface cream to pale buff when fresh and dry, rough, with distinct narrow concentric sulcate zones, pubescent to adpressed velutinate, usually covered by mosses with age. Hymenophore lamellate, vinaceous brown to fuscous when fresh, grayish purple to vinaceous brown when dry; lamella thin, entire and wavy, dichotomously forked near margin; lamella 1–2 per mm. Sterile margin concolorous with lamella. Context duplex, up to 1 mm thick, the upper layer cream to pale wood-colored, the lower layer pale purplish brown, hard coriaceous, continuous with tubes. Tubes vinaceous brown, up to 4 mm long. Hyphal system dimitic; generative hyphae with clamp connections; tissues unchanged in KOH. Cystidia fusoid to ampullaceous, thick-walled, usually apically encrusted, 25–32 × 4–8.5 µm; hyphal pegs absent; basidia clavate with four sterigmata and a basal clamp connection, slightly thickening towards base, 21–26 × 4–5.5 µm. Basidiospores allantoid, hyaline, thin-walled, smooth, IKI–, CB–, (5.2–)5.5–7.7(–7.9) × (1.9–)2–2.2(–2.4) µm, L = 6.47 µm, W = 2.12 µm, Q = 2.87–3.30 (n = 90/3).

Distribution and ecology – *Pseudotrichaptum laricinum* has a distribution in the boreal forests of the Northern Hemisphere, and grows on wood of *Abies*, *Larix, Picea* and *Pinus*.

Notes – *Pseudotrichaptum laricinum* is a rare boreal species known from the boreal forests of the Northern Hemisphere. It is characterized by annual, pileate or effused-reflexed basidiomata, dark purple surface, lamellate hymenophore and allantoid basidiospores. *P. laricinum* is combined based on *Trichaptum laricinum* which was originally descripted as *Lenzites laricinus* P. Karst. from Siberia, Russia. Macrae & Aoshima (1966) give a complete listing of synonyms of *T. laricinum* and confirmed the sequence of RLG-4665 and RLG-6936 (GenBank: U63471 & U63477) represent the real *T. laricinum*. This result also acknowledged by Ryvarden & Gilbertson, who combined Lenzites laricinus as *Trichaptum laricinum* and subsequent studies (Ryvarden & Gilbertson 1994, Vlasák & Vlasák 2017, Kossmann et al. 2021).

The phylogeny using a combined dataset of four genes demonstrates that samples of

P. laricinum including U63471 & U63477 in GenBank form a monophyletic lineage within the Hymenochaetales but shows no affinity to the other genera among *Trichaptum s.l.* The *Trichaptum*-like basidiomata and purplish hymenophore make Pseudotrichaptum confusable with *Trichaptum*, but *Pseudotrichaptum* has entire lamellate hymenophore and hard coriaceous basidiomata, which distinguish it from *Trichaptum s.l.*

Specimens examined – CHINA. Inner Mongolia, Arxan, Jingouhe Forest Farm, on charred stump of *Larix*, 3.IX.2021, *Yuan 99* (BJFC038362). Jilin, Antu, Changbaishan Nat. Res., on fallen trunk of *Abies*, 23.IX.2018, *Dai 19455* (BJFC027922); on fallen trunk of *Larix*, 11.VIII.1997, *Dai 2369* (BJFC002704); 16.VIII.1997, *Dai 2525* (BJFC002706); on fallen trunk of *Picea*, 23.VII.2022, *Dai 23782* (BJFC027924); on fallen trunk of *Pinus*, 23.IX.2018, *Dai 19457* (BJFC027924).

Divergence time estimation for *Trichaptum s.l.*

Molecular clock analysis based on a combined dataset (Dataset III) from108 samples was carried out. This dataset resulted in a concatenated alignment of 4200 characters with GTR+I+G as the best-fit evolutionary model. Chain convergence was indicated by the ESSs above 2010.

The results of divergence time estimation show (Fig. 19) that the Hymenochaetales emerged with a mean stem age of 253.92 Mya [95% highest posterior density (HPD) of 228.22–277.63 Mya] and a mean crown age of 226.24 Mya (95% HPD of 199.64–251.97 Mya), which is consistent with previous studies (Wang et al. 2021, He 2019). Divergence times of estimated taxa in the Hymenochaetales is shown in Table 4.

Hirschioporaceae occurs in a mean stem age of 121.25 Mya (95% HPD of 98.18–146.87 Mya) and a mean crown age of 99 Mya (95% HPD of 76.37–123.49 Mya); Trichaptaceae occurs in a mean stem age of 103.3 Mya (95% HPD of 77.28–130.33 Mya) and a mean crown age of 78.99 Mya (95% HPD of 49.99–108.21 Mya).

In Hirschioporaceae, *Hirschioporus* (mean crown age 45.15 Mya) and *Pallidohirschioporus* (mean crown age 28.06 Mya) share the same mean stem age of 73.55 Mya (95% HPD of 52.99–96.8 Mya); *Perennihirschioporus* (mean crown age 31.86 Mya) and *Nigrohirschioporus* (mean crown age 39.31 Mya) share the same mean stem age of 79.57 Mya (95% HPD of 57.67–105.06 Mya). Regarding two other genera witin Hymenochaetales, *Podocarpioporus* and *Pseudotrichaptum* emerge with mean stem ages of 91.33 Mya (95 % HPD of 48.73–136.18 Mya) and 80.71 Mya (95% HPD of 50.18–111.38 Mya), respectively.

The historical biogeography of *Trichaptum s.l.*

The combined dataset for ancestral state reconstruction (Dataset IV) of 40 samples resulted in a concatenated alignment of 3014 characters with GTR+I+G as the best-fit evolutionary model. The inferred historical biogeographic scenarios from the analyses using RASP are shown in Fig. 20. The results of the Statistical Dispersal Extinction Cladogenesis (S-DEC) analysis suggest a complex biogeographic history for Trichaptaceae and Hirschioporaceae. 25 dispersal events and four vicariance events explain the current distribution of Hirschioporaceae, and three dispersal events and one vicariance event explain the current distribution of Trichaptaceae (Fig. 20).

The RASP analysis of distribution within *Trichaptum s.l.* supports the notion that the tropical areas (Node-a) have the highest probability of being the ancestral area of Hirschioporaceae and Trichaptaceae (Fig. 20). The species in Hirschioporaceae (Clade I–IV) probably first appeared in tropical areas as early as 99 Mya. Species within Trichaptaceae (Clade V) may first appear in the tropics as early as 78.99 Mya. In addition, ancestral species of *Hirschioporus* probably arose in temperate areas at about 45.15 Mya (95% HPD of 30.88–62.43 Mya), of *Pallidohirschioporus* probably in tropical areas around 28.06 Mya (95% HPD of 16.63–42.97 Mya), and of *Perennihirschioporus* and *Nigrohirschioporus* probably in tropical areas around 21.86 Mya (95% HPD of 12.07–35.49 Mya) and 39.31 Mya (95% HPD of 23.83–59.23 Mya), respectively.

The RASP analysis of trait evolution of basidiomata supports the notion that 35 dispersal events, four vicariance events and one extinction event explain the evolution of basidiomata traits within Hirschioporaceae, and seven dispersal events and one extinction event explain the evolution of basidiomata traits within Trichaptaceae (Fig. 21). Node-a suggests that the common ancestor morphology of Hirschioporaceae and Trichaptaceae may have been polymorphic, without forming a specialized basidiomata; Node-b indicates that the common ancestor morphology of species within Hirschioporaceae may have been pileate; and Node-c suggests that the common ancestor morphology of Trichaptaceae may have been polymorphic. Additionally, the ancestral basidiomata of *Hirschioporus* (Clade I) within Hirschioporaceae maybe effused-reflexed, while the ancestral morphology of the *Pallidohirschioporus* (Clade II) and *Perennihirschioporus* (Clade IV) genera may have been pileate. The ancestral morphology of the *Nigrohirschioporus* (Clade III) may have been polymorphic.

Table 4 Divergence times of estimated taxa in Hymenochaetales.

Families	**Genera**	**Mean of stem age (Ma) in MCC tree**	**Posterior probabilities in BI tree (stem age)**	**Mean of crown age (Ma) in MCC tree**	**Posterior probabilities in BI tree (crown age)**
Oxyporaceae		226.24	1	188.61	1
	Rigidoporus	188.61	1	34.66	1
	Leucophellinus	136.67	0.97	*	
	Bridgeoporus	136.67	0.97	*	
Chaetoporellaceae		198.64	0.93	96.14	1
	Kneiffiella	198.64	0.93	96.14	1
Hyphodontiaceae		176.56	1	64.84	1
	Hyphodontia	176.56	1	64.84	1
Schizoporaceae		176.56	1	149.47	0.99
	Fasciodontia	149.47	0.99	16.32	1
	Lyomyces	130.58	0.89	99.91	1
	Xylodon	130.58	0.89	101.5	1
Hymenochaetaceae		170.87	0.98	143.63	1
	Hymenochaete	143.63	1	*	
	Fomitiporia	118.29	0.95	9.4	1
	Porodaedalea	118.29	0.95	*	
Coltriciaceae		170.87	0.98	70.58	1
	Coltricia	170.87	0.98	70.58	1
Neoantrodiellaceae		146.85	0.96	9.8	1
	Neoantrodiella	146.85	0.96	9.8	1
Nigrofomitaceae		80.71	0.98	19.37	1
	Nigrofomes	80.71	0.98	19.37	1
uncertain	*Fibricium*	133.49	0.98	*	
	Basidioradulum	91.33	0.93	*	
	Podocarpioporus	91.33	0.93	*	
	Pesudotrichaptum	80.71	0.98	*	
Trichaptaceae		103.3	0.96	78.99	1
	Trichaptum	103.3	0.96	78.99	1
Hirschioporaceae		121.25	1	99	1
	Nigrohirschioporus	79.57	0.88	39.31	1
	Perennihirschioporus	79.57	0.88	31.86	1
	Hirschioporus	73.55	1	45.15	1
	Pallidohirschioporus	73.55	1	28.06	1

Node	Mean of stem age (Ma) in MCC tree	95 % HPD(stem age)	Mean of crown age (Ma) in MCC tree	95 % HPD(crown age)
A:Ascomycota Basidiomycota	463.91	414.61-582	419.82	347.39-401.58
B:Dacrymycetes Agaricomycetes	345.74	322.89-372.16	106.39/ 309.75	45.09-206.64/ 301.85-318.68
C: Hymenochaetale	253.92	228.22-277.63	226.24	199.64-251.97
D: Agaricales/ Boletales	152.93	126.27-182.39	109.07/ 68.39	101.29-117.73/ 34.73-105.44
E: Oxyporaceae	226.24	199.64-251.97	188.61	135.94-232
F: Chaetoporellace	198.64	170.09-227.32	96.14	56.79-142.07
G: Schizoporaceae/ Hyphodontiaceae	176.56	144.84-207.16	149.47 /16.32	116.73-180.64/ 29.1-109.09
H:Hymenochaetac / Coltriciaceae	170.87	152.14-193.34	143.63 / 70.58	136.2-152.2 / 36.69-109.85
I:Neoantrodiellace	146.85	119.86-174.86	9.8	3.02-20.43
J*:Hirschioporace	121.25	98.18-146.87	99	76.37-123.49
K*:Trichaptumace	103.3	77.28-130.33	78.99	49.99-108.21
L:Nigrofomitaceae	80.71	50.18-111.38	19.37	7.95-36.26

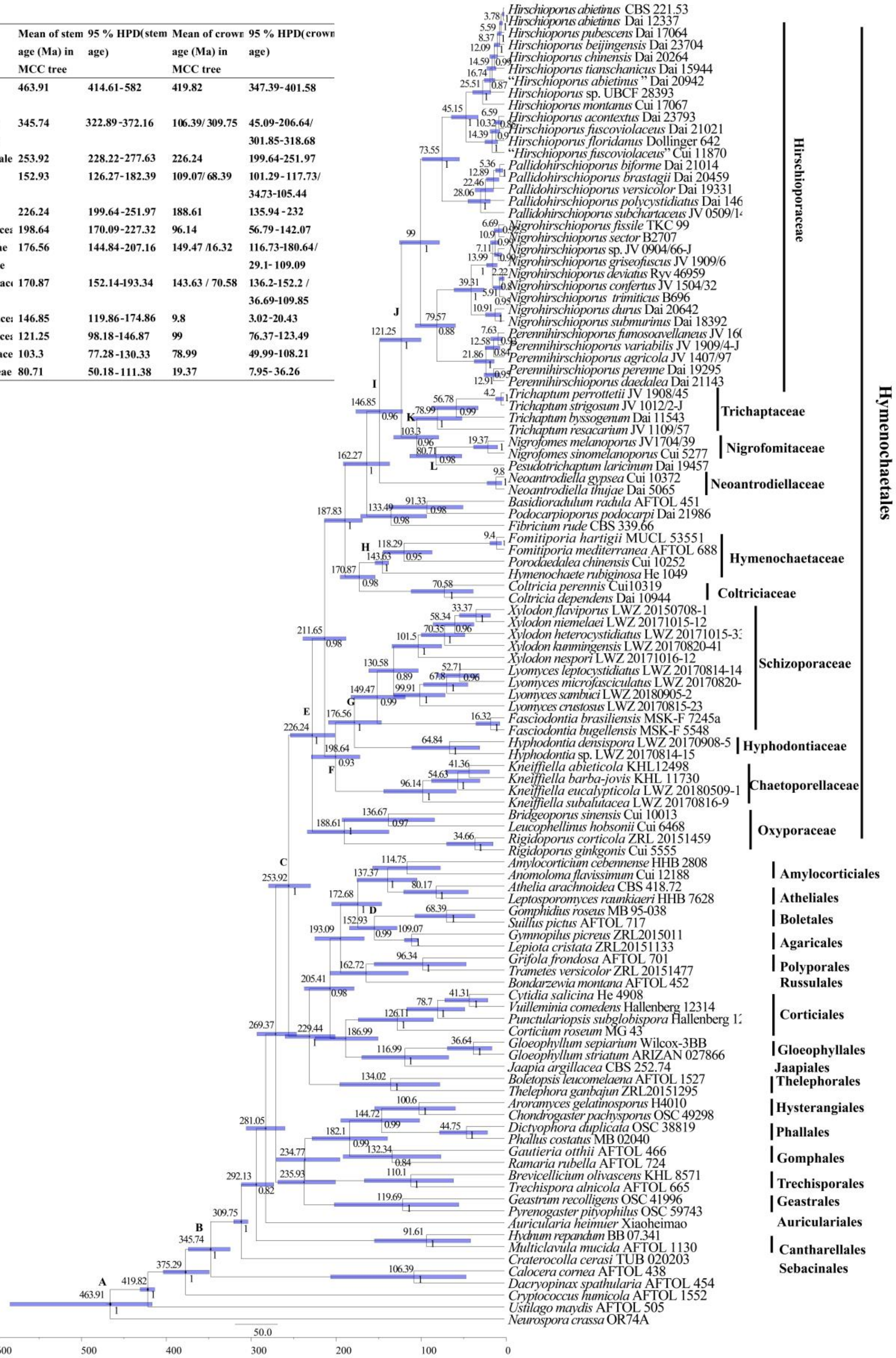

Figure 19 – Maximum Clade Credibility chronogram and estimated divergence times of families within the Hymenochaetales inferred from the combined dataset of ITS, nLSU and TEF1 regions. The estimated divergence times of 95% highest posterior density for all clades is indicated as node

bars and for families in the Hymenochaetales are also provided in the upper left of the tree as exact numbers, while the mean divergence times of clades and the Bayesian posterior probabilities above 0.8 are labeled above and below the branches, respectively, at the nodes.

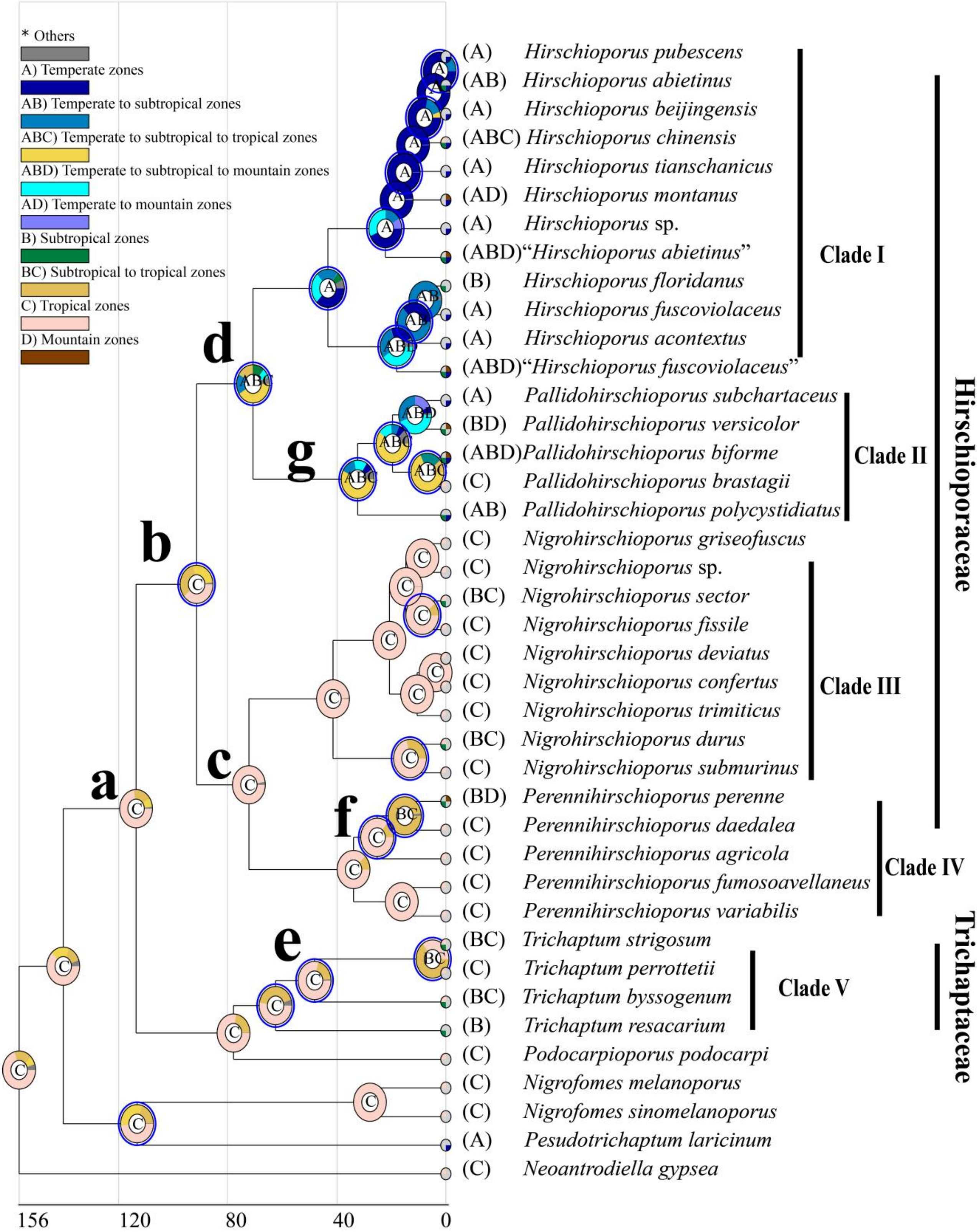

Figure 20 – The evolution of distribution within *Trichaptum s.l.* The tree was generated by the Bayesian Inference algorithms using BEAST, while the trait of the pie chart at each node was evaluated using RASP under the Bayesian Binary MCMC model. The trait represented by each color and letter in the pie chart is indicated in the upper left.

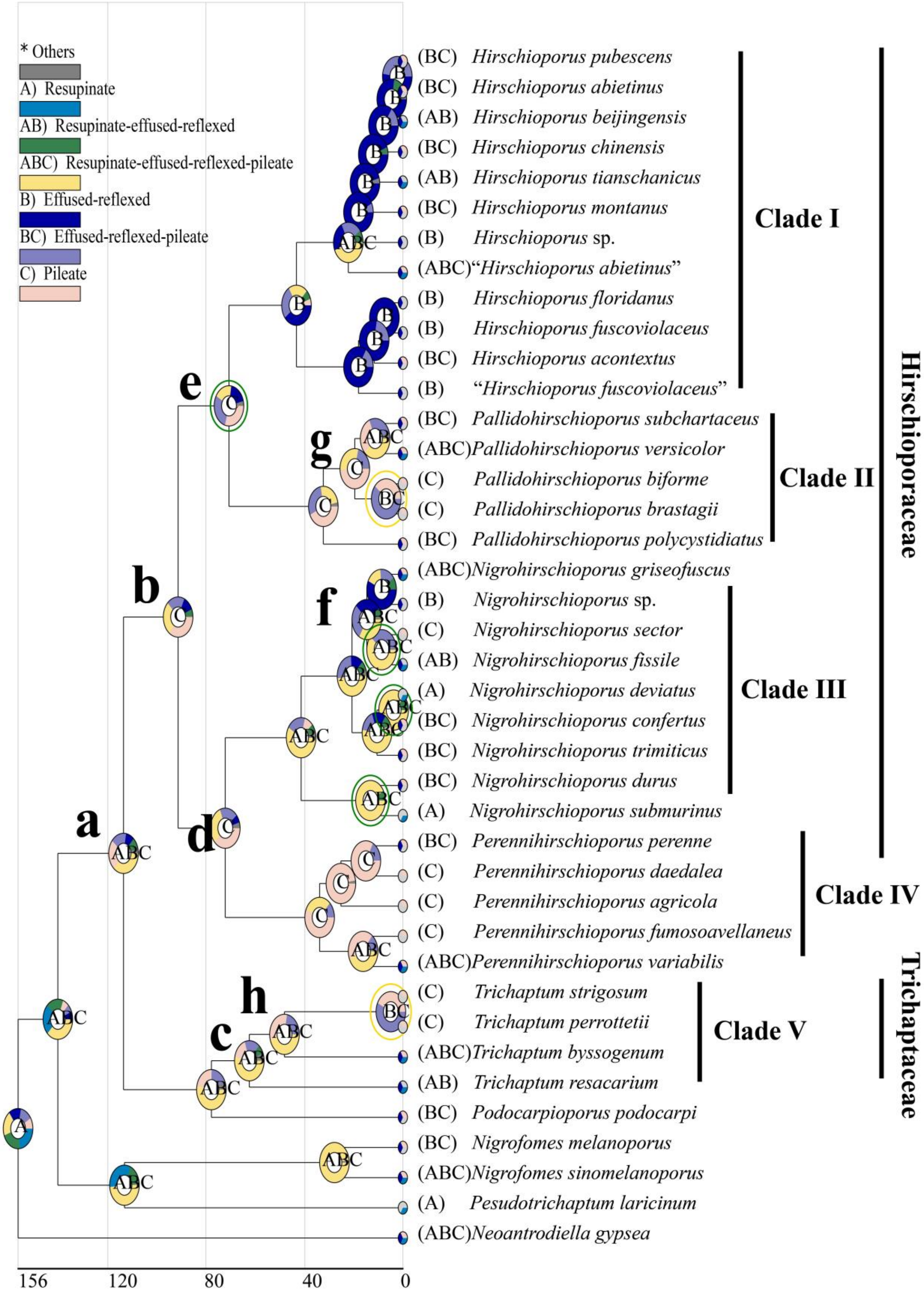

Figure 21 – Trait evolution of basidiomata within *Trichaptum s.l.* The tree was generated by the Bayesian Inference algorithms using BEAST, while the trait of the pie chart at each node was evaluated using RASP under the Bayesian Binary MCMC model. The trait represented by each color and letter in the pie chart is indicated in the upper left.

Discussion

Trichaptum was established in 1904, but its placement at family level has been disputed (Murrill 1904, Ryvarden & Johansen 1980, Gilbertson & Ryvarden 1987, Vlasák & Vlasák 2017, Kossmann et al. 2021). Currently, it is treated as incertae sedis (indexfungorum.org, mycobank.org). 72 taxa are recorded in *Trichaptum* in the database of Index Fungorum (http://www.indexfungorum.org/names/Names.asp, Jan of 2023), among them 41 are valid names in the genus, and others are synonyms or have been transferred to other genera (Ryvarden & Johansen 1980, Ryvarden 1981, Corner 1987, Dai 2000, Hattori 2001a, b). To date, 32 species are accepted in *Trichaptum.*

Hirschioporus, typified by *H. abietinus*, was treated as a member of the Polyporaceae of the Polyporales; most taxonomists treated *Hirschioporus* as a synonym of *Trichaptum* and typified by *T. perrottetii*. However, phylogenetic studies indicated that taxa of *Trichaptum* formed more than one clade (Vlasák & Vlasák 2017, Kossmann et al. 2021). Kossmann et al. (2021) mentioned that *Trichaptum s.s*. was more closely related to *Nigrofomes* than other taxa of *Trichaptum* species. So, they proposed that *Trichaptum s.s*. should be included in the Nigrofomitaceae. However, *Nigrofomes* is a genus with simple septa on generative hyphae, broadly ellipsoid to subglobose basidiospores and smooth cystidia (Zhou et al. 2018, 2020) which is fundamentally different from *Trichaptum s.l.*

Combined with morphological characteristics, phylogenetic analysis and evolutionary time estimation (Figs 5–6, 19), taxa of *Trichaptum s.l.* are divided into seven clades (I–VII). Clade A (including Clades I–IV), Clade B (including Clade V), Clade Nigrofomitaceae (*Nigrofomes*) and Clade *Neoantrodiellaceae* (*Neoantrodiella*) are at the same taxonomic rank (Figs 5–6). Therefore, the two new families Trichaptaceae and Hirschioporaceae are proposed. Four independent clades, I–IV, nested in the main Clade A. Therefore, we accept Clade I as an independent genus *Hirschioporus*, and propose three new genera, *Nigrohirschioporus, Pallidohirschioporus* and *Perennihirschioporus,* represented by Clade II, Clade III and Clade IV, respectively.

In addition, another two clades, Clade VI and Clade VII, are parallel with Clade A, Clade B, (Clade Nigrofomitaceae and Clade Neoantrodiellaceae respectively), and we propose two new genera, *Podocarpioporus* and *Pseudotrichaptum,* to represent Clade VI and Clade VII, respectively. While these two genera definitely fall under the Hymenochaetales, we do not classify them at the family level due to their limited species count and relatively recent divergence (Fig. 19).

According to our phylogenetic analyses (Figs 4–5), the so-called *Hirschioporus abietinus* in North America is different from the real *H. abietinus* in Eurasia. Many taxa described from North America were treated as synonyms of *H. abietinus*, e.g. *Polyporus parvulus* Schwein., *Polyporus favillaceus* Berk. & M.A. Curtis, *Polystictus pusio* Sacc. & Cub., *Polyporus abietinus* var. *irpiciformis* Peck, and *Polyporus abietinus* f. *thelephoroides* D.V. Baxter. Therefore, the North American synonyms of *H. abietinus* should be restudied. In our study, the samples UBCF28393 and UBCF28347 from Canada formed an independent lineage within the *Hirschioporus* clade (Fig. 4). It is temporarily treated as *Hirschioporus* sp. because we only have these sequences. The samples of UBCF28393 and UBCF28347 may represent one of these synonyms. Samples from Florida (Dolliner 640 and Dolliner 642) form an independent lineage, morphologically related to *H. fuscoviolaceus* with a similar irpicoid hymenophore, and are described as *H. floridanus*.

The sample JV 0904/66-J (MF381009) from USA was treated as *Nigrohirschioporus griseofuscus* in previous studies (Vlasák & Vlasák 2017, Kossmann et al. 2021). However, *N. griseofuscus* was described from French Guiana, and we found more than 2% nucleotide difference in the ITS sequences between *N. griseofuscus* (from French Guiana and Brazil) and JV 0904/66-J. We temporarily treat JV 0904/66-J as *Nigrohirschioporus* sp.

The systematics of *Trichaptum s.l.* are revised in the present paper; two new families, five new genera, ten new species and 28 new combinations are proposed and described. The distribution and main morphological characteristics of accepted genera in *Trichaptum s.l.* are outlined in Table 5.

Table 5 The distribution and main morphological characteristics of accepted genera in *Trichaptum s.l.*

Species	**Type locality**	**Distribution**	**Habit**	**Basidiomata**	**Pileal surface color**	**Pileal surface**	**Pore surface**	**Hymenophore**	**Pores or teeth (per mm)**	**Hyphal system**	**Hyphae at dissepiments edge**	**Hyphal pegs**	**Cystidia (μm)**	**Basidiospores (μm)**	**Host**	**References**
Hirschioporus abietinus	Germany	Europe to East Asia	A	Effused-reflexed to pileate	Cream to gray	Pubescent or velvet, sparse to adpressed velutinate with age; indistinctly zonate to azonate	bright purplish to ochraceous	Poroid	Angular, 4–6	Dimitic, hyphae hyaline	Smooth	+	Fusoid, thick-walled, usually apically encrusted, 15 × 4–7	Cylindric, slightly curved, 5.2–7.4 × 2.3–3, L = 6.35, W = 2.68, Q = 2.22–2.67	Gymno, mostly *Picea*	Ryvarden (1972)
"Hirschioporus abietinus"	N/A	Europe to East Asia	A	Usually resupinate to effused-reflexed, occasionally pileate	White to cream	Pubescent, loosely adpressed velutinate with age; concentrically sulcate with narrow zones	Fawn to grayish violet, become snuff brown to milky coffee	Poroid	Angular, 4–6	Dimitic, hyphae hyaline	Usually with skeletocystidia	+	Two types: hymenial cystidia fusoid to subulate, thin- to moderately thick-walled, apically encrusted, 25–32 × 5–6.5; skeletocystidia capitate to clavate, thick-walled to almost solid, 18–22 × 5.5–9, apex obtuse with a large mass of crystals	Cylindric, slightly curved, 5.2–7.3 × 2.5–3.2, L = 6.52, W = 2.92, Q = 1.93–2.41	Gymno, such as *Abies*, *Larix*, *Picea* and *Pinus*	This study
Hirschioporus acontextus	China	East Asia	A	Usually effused-reflexed, occasionally pileate	White to gray	Rough with loosely adpressed velutinate; indistinctly zonate to azonate	Vinaceous to clay buff, fade to olivaceous buff with age	Hydnoid to sublamellate	Radially elongated to lamellate, 1–2	Dimitic, hyphae hyaline	Apically encrusted, cystidia-like	–	Fusoid, thick-walled, usually apically encrusted, 17–26 × 3.5–6	Allantoid, 5.3–6.7 × 2.2–2.8, L = 5.90, W = 2.35, Q = 2.11–2.54	Gymno, such as *Abies*, *Larix* and *Picea*	This study
Hirschioporus beijingensis	China	East Asia	A	Mostly resupinate to effused-reflexed	Buff to olivaceous buff	Loosely adpressed velutinate; indistinctly zonate to azonate	Light purple to vinaceous brown or grayish brown	Poroid to irpicoid	Angular to irpicoid, 2–4	Dimitic, hyphae hyaline	Smooth	+	Clavate to capitate, thick-walled, usually apically encrusted, 20–30 × 4.5–8	Oblong ellipsoid, 5–7 × 3–3.5, L = 5.67, W = 3.11, Q = 1.82–2.00	Gymno, such as *Pinus tabuliformis*	This study

Table 5 Continued.

Species	**Type locality**	**Distribution**	**Habit**	**Basidiomata**	**Pileal surface color**	**Pileal surface**	**Pore surface**	**Hymenophore**	**Pores or teeth (per mm)**	**Hyphal system**	**Hyphae at dissepiments edge**	**Hyphal pegs**	**Cystidia (µm)**	**Basidiospores (µm)**	**Host**	**References**
Hirschioporus chinensis	China	East Asia	A	Usually effused-reflexed sometimes pileate	White to grayish cream	Loosely velutinate; indistinctly zonate to azonate	Pale purple to clay pink to clay buff	Poroid	Angular to irpicoid, 2–4	Dimitic, hyphae hyaline	Swollen	–	Capitated to subulate, thin- to moderately thick-walled, usually apically encrusted, 17–25 × 3–5	Cylindric to allantoid, 6–7.4 × 3–3.7, L = 6.45, W = 3.29, Q = 1.84–2.10	Gymno	This study
Hirschioporus floridanus	USA	North America	A	Effused-reflexed	White to cream	Velvet; indistinctly zonate to azonate	Light purple to grayish brown	Poroid to hydnoid	Irregular, 2–4	Dimitic, hyphae hyaline	Smooth	–	Two types: clavate to subclavate cystidia usually apically encrusted, 15–30 × 4–6; fusoid and smooth cystidia, 25–35 × 6–8	Allantoid, 5.2–6.5 × 2–2.5, L = 6.01, W = 2.21, Q = 2.71	Gymno	This study
"Hirschioporus fuscoviolaceus"	N/A	Europe to East Asia	A	Effused-reflexed to pileate	White to gray	Villose to velutinate; concentrically sulcate with narrow zones	Light purple to grayish brown, and ochraceous or pale brown by age or drying	Irpicoid to hydnoid	Radially elongated and lacerate to dentate, 1–3	Dimitic, hyphae hyaline	Smooth	+	Fusoid to subclavate, slightly thick-walled, sometimes apically encrusted, 15–30 × 5–6.5	Allantoid, 4.3–6.5 × 2–3, L = 5.41, W = 2.34, Q = 2.14–2.86	Gymno, such as *Abies*, *Cunninghamia*, *Keteleeria*, *Larix* and *Pinus*	This study
Hirschioporus fuscoviolaceus	Germany	Europe to East Asia	A	Mostly effused-reflexed	White to gray	Velvet to pubescent; azonate	Bright purplish to grayish violet when fresh, fading to ochraceous, grayish brown when dry	Irpicoid to hydnoid or sublamellae	Short lamellate to radially elongated or teeth, 1–3	Dimitic, hyphae hyaline	Smooth	+	Fusoid, thick-walled, usually apically encrusted or smooth, 23–35 × 5–9	Cylindric, slightly curved, 6.5–8.7 × 2.5–3.1, L = 7.85, W = 2.87, Q = 2.57–2.88	Gymno, mostly *Pinus*	This study

Table 5 Continued.

Species	Type locality	Distribution	Habit	Basidiomata	Pileal surface color	Pileal surface	Pore surface	Hymenophore	Pores or teeth (per mm)	Hyphal system	Hyphae at dissepiments edge	Hyphal pegs	Cystidia (µm)	Basidiospores (µm)	Host	References
Hirschioporus montanus	Nepal	South Asia to East Asia	A	Usually pileate, sometimes effused-reflexed	White to pale buff	Full of densely fibrous tomentum; indistinctly zonate to azonate	Violet to vinaceous brown or fuscous	Poroid	Angular, 4–6	Dimitic, hyphae hyaline	Smooth	–	Subulate to clavate thin- to slightly thick-walled, with a small apical crown of crystal, 21–26 × 3.5–6	Cylindric, 5.2–7.1 × 1.9–2.3, L = 6.34, W = 2.08, Q = 2.83–3.04	Gymno	Hattori et al. (2002)
Hirschioporus pubescens	China	East Asia	A	Effused-reflexed to pileate	White	Pubescent; concentrically sulcate with narrow zones	Light purple, become grayish brown to vinaceous brown	Poroid to irpicoid	Angular to almost irpicoid, 2–4	Dimitic, hyphae hyaline	Usually with encrusted cystidia	+	Two types: thin to moderately thick-walled cystidia, fusoid to subulate, usually apically encrusted, 20–35 × 3.5–5; capitated, apically encrusted, thick-walled, 22–30 × 4.5–9	Cylindric, slightly curved, 5.8–7.6 × 3–4, L = 6.60, W = 3.4, Q = 1.88–2	Gymno	This study
Hirschioporus tianschanicus	China	Central Asia to East Asia	A	Resupinate to effused-reflexed	White to cream	Adpressed velutinate; concentrically sulcate with narrow zones	Light purple, grayish brown to vinaceous brown with age	Poroid	Angular, 4–6	Dimitic, hyphae hyaline	Usually encrusted with small crystals	–	Fusoid, thick-walled, usually apically encrusted, 17–27 × 4–8; cystidioles thin-walled, smooth, 14–25 × 4–4.5	Cylindric to allantoid, 6–8.5 × 2.5–3, L = 7.05, W = 2.74, Q = 2.39–2.70	Gymno, such as *Larix*, *Picea*	This study
Nigrohirschioporus agglutinatus	Malaysia	Southeast Asia	A to P	Effused-reflexed to pileate	Almost black	Hairless, rough; azonate	Pale orange	Poroid	Round to angular, 13–16	Trimitic, hyphae hyaline	Usually with cystidia-like tips	–	Ventricose, thick-walled, apically encrusted, 12–25 × 6–10	Ellipsoid, 2.4–3 × 1.4–1.9, L = 2.75, W = 1.66, Q = 1.66	Angio	Hattori (2001a)

Table 5 Continued.

Species	Type locality	Distribution	Habit	Basidiomata	Pileal surface color	Pileal surface	Pore surface	Hymenophore	Pores or teeth (per mm)	Hyphal system	Hyphae at dissepiments edge	Hyphal pegs	Cystidia (μm)	Basidiospores (μm)	Host	References
Nigrohirschioporus bulbocystidiatus	Costa Rica	Central America	A	Resupinate	N/A	N/A	Gray	Poroid to irpicoid	Irregular to elongated, 2–3	Dimitic, hyphae hyaline	Usually with bulbous cystidia	U	Two types: hymenial cystidia slightly ventricose, apically encrusted, 30 × 6; skeletocystidia bulbous capitate, distinct thick walled, smooth, apex up to 15 in width	Unknown	Angio	Ryvarden (2014)
Nigrohirschioporus confertus	Costa Rica	Central America	A	Pileate	Dark gray to black with purplish to bluish tints, fading to brown	Adpressed velutinate to tomentose; zonate	Dark purplish to grayish brown	Poroid	Angular, 6–8	Trimitic, hyphae hyaline	With rounded ends	U	Ventricose, thin- to slightly thick-walled, apically encrusted, 10–15 × 3–5,	Ellipsoid, 4–4.5 × 1.8–2.2	Angio	Vlasák & Vlasák (2017)
Nigrohirschioporus deviatus	Venezuela	South America	A to P	Resupinate	N/A	N/A	Gray with Brown tinges	Poroid to irpicoid	Round to angular or even split, 5–7	Dimitic, hyphae hyaline	Usually with skeletocystidia	U	Two types: hymenial cystidia apically encrusted; skeletocystidia numerous in the dissepiments moderately thick-walled, 15–40 × 3–6	Cylindrical, 4.5–6 × 1.7–2	Angio	Ryvarden (2014)
Nigrohirschioporus durus	Indonesia	Southeast Asia	P	usually pileate, occasionally effused-reflexed	Fuliginous purplish becoming grayish to almost blackish	First finely tomentose and then hairless, tuberculose or warted; mostly azonate	Fuliginous umber with a purple tinge to umbrines or dark brown	Poroid	Round, 8–10	Dimitic, hyphae hyaline	Usually with rounded ends, apically encrusted	–	Ventricose and sub apiculate to subclavate or subcylindric, thin-walled, some with a few crystals or granules at the apex, 7–13 × 5–6	Broadly ellipsoid, 3.5–4.5 × 2–2.5, L = 4.03, W = 2.36, Q = 1.56–1.68	Angio	Ryvarden & Johansen (1980)

Table 5 Continued.

Species	**Type locality**	**Distribution**	**Habit**	**Basidiomata**	**Pileal surface color**	**Pileal surface**	**Pore surface**	**Hymenophore**	**Pores or teeth (per mm)**	**Hyphal system**	**Hyphae at dissepiments edge**	**Hyphal pegs**	**Cystidia (µm)**	**Basidiospores (µm)**	**Host**	**References**
Nigrohirschioporus fissilis	Brazil	South America	A	Resupinate to effused-reflexed	Whitish to cream or buff to clay buff	Velutinate; concentrically zonate	Vinaceous buff to cigar brown	Poroid	Angular, 4–8	Dimitic, hyphae hyaline	Smooth	U	Two types: hymenial cystidia clavate to fusoid, thin to moderately thick-walled, 15–20 × 5–6; skeletocystidia bulbous capitate to clavate, thick-walled to almost solid, 7–12 in width	Cylindrical, 6.4–10 × 2.3–3.2, L = 7.7, W = 2.7µm, Q = 2.2–3.4	Angio	Kossmann et al. (2021)
Nigrohirschioporus griseofuscus	French Guiana	South America	A	Effused-reflexed or pileate, occasionally resupinate	Pale brown to clay brown	Adpressed velutinate; faintly zonate	Brown	Poroid to hydnoid	Angular to dentate with age,1–3	Dimitic, hyphae hyaline	Smooth	–	Two types: hymenial cystidia fusoid cystidia, slightly thick-walled, usually apically encrusted, 12–16 × 4–6; skeletocystidia capitate to clavate, thick-walled to almost solid	Cylindric, slightly curved, 5.9–7× 1.5–2, L = 6.39, W = 1.93, Q = 3.17–3.30	Angio	Ryvarden & Iturriaga (2003)
Nigrohirschioporus molestus	Malaysia	Southeast Asia	A	Effused-reflexed to pileate	Dark fuscous brown to pale sepia brown	Spongy-tomentose; slightly sulcate with narrow blackish zones	Pale orange	Irpicoid to hydnoid	Angular to dentate, irpicoid to daedaleoid near the margin, 3–4	Trimitic, hyphae hyaline	Smooth	U	Ventricose to clavate, thin-walled, smooth, 17-28 × 5-8	Broadly ellipsoid, 4-4.8 × 3-3.5	Angio	Hattori & Sotome (2013)
Nigrohirschioporus nigrivineus	New Guinea	Oceania	P	Effused-reflexed to pileate	Purple black to brownish black with slightly rimose	Almost glabrous; azonate	Purplish brown to dark brown	Poroid	Round, 5–8	Trimitic, hyphae hyaline	Smooth	U	Ventricose, thin- to slightly thick-walled, 15-22 × 6-9	Short ellipsoid, 3.5-4.5 × 2-3	Angio	Hattori & Sotome (2013)

Table 5 Continued.

Species	Type locality	Distribution	Habit	Basidiomata	Pileal surface color	Pileal surface	Pore surface	Hymenophore	Pores or teeth (per mm)	Hyphal system	Hyphae at dissepiments edge	Hyphal pegs	Cystidia (µm)	Basidiospores (µm)	Host	References
Nigrohirschioporus sector	Brazil	South America	A	Pileate	Pale fuscous, vinaceous or vinaceous buff to snuff brown	Finely tomentose to velutinate, subscabrid towards the margin; concentrically sulcate with fuscous brown zones	Fuscous to dark vinaceous gray	Poroid	Angular, 4–7	Dimitic, hyphae hyaline	Smooth	–	Subclavate to subventricose, thin- or slightly thick-walled, apically encrusted, 24 × 3–5	Narrowly ellipsoid, 5–6.4 × 2.2–2.5, L = 5.938, W = 2.2, Q = 2.589–2.81	Angio	Alexander et al. (1989)
Nigrohirschioporus submurinus	Vietnam	Southeast Asia	A	Resupinate	N/A	N/A	Pale mouse-gray	Poroid	Angular, 6-9	Dimitic, hyphae hyaline	Usually apically encrusted with small crystals	–	Fusoid with a long neck, thin-walled, smooth, 17–35 × 4–5.5	Oblong ellipsoid, 3.8–4.8 × 2.2–3, L = 4.14, W = 2.54, Q = 1.62	Gymno	This study
Nigrohirschioporus trimiticus	Brazil	South America	A	Effused-reflexed to pileate	White to pale buff or grayish brown	Loosely adpressed velutinate to smooth; faintly zonate	Olivaceous buff to honey to grayish brown	Poroid to irpicoid	Angular to irpicoid, 3–5	Trimitic, hyphae hyaline	Smooth	–	Clavate, thick-walled, usually apically encrusted, 15–23 × 4–5	Cylindric to slightly allantoid, 5–6 × 2.4–2.7, L = 5.78, W = 2.51, Q = 2.30	–	This study
Pallidohirschioporus albus	Costa Rica	Central America	A	Pileate	White	Pubescent; slightly zonate	Pale violaceous to cork-colored	Hydnoid	Spines round to slightly flattened, 3–5	Dimitic, hyphae hyaline	Smooth	–	Clavate, slightly thick-walled, apically encrusted, 20-35 × 3-5	Allantoid, 4.8–5.8 × 1.7–2.2, L = 5.10, W = 2.05, Q = 2.48	Angio	Ryvarden (2012)
Pallidohirschioporus biformis	Finland	North Hemisphere	A	Pileate	White to ochraceous or grayish	Finely adpressed velutinate to glabrous; concentrically sulcate with narrow ochraceous to brown zones	Light violet to light brown or pale straw-colored	Poroid to irpicoid or hydnoid	Angular, 3–5	Dimitic or subtrimitic, hyphae hyaline	Usually with cystidia-like tips	–	Clavate to subulate, thin- to slightly thick-walled, 20–35 × 4–5	Cylindrical, slightly curved, 5.2–6.7 × 2–2.7, L = 5.85, W = 2.45, Q = 2.33–2.42	Angio	Ryvarden (1972), Ryvarden & Johansen (1980), Ryvarden & Gilbertson (1994)
Pallidohirschioporus brastagii	Indonesia	Southeast Asia	A	Pileate	Pale orange, ochraceous to straw-yellow or grayish buff	Slightly silky, velutinous near the base, glabrous towards margin; concentrically sulcate with narrow zones	Cream to buff or buff yellow	Poroid to irpicoid or hydnoid	Angular to almost irpicoid, 4–5	Dimitic to trimitic, hyphae hyaline	Smooth	–	Fusoid, thick-walled, encrusted at the apex, 10-20 × 4-5.5	Short cylindrical, 4–5 × 2–2.5, L = 4.75, W = 2.06, Q = 2.20–2.40	Angio	Hattori (2005)

Table 5 Continued.

Species	**Type locality**	**Distribution**	**Habit**	**Basidiomata**	**Pileal surface color**	**Pileal surface**	**Pore surface**	**Hymenophore**	**Pores or teeth (per mm)**	**Hyphal system**	**Hyphae at dissepiments edge**	**Hyphal pegs**	**Cystidia (μm)**	**Basidiospores (μm)**	**Host**	**References**
Pallidohirschioporus imbricatus	China	Southeast Asia	A	Pileate	Cinnamon-buff to olivaceous buff or clay-buff	Finely velutinate to glabrous, slightly warted at the base; azonate, with radially aligned striations	White to honey-yellow	Poroid	Angular, 6–8	Dimitic, hyphae hyaline	Smooth	–	Scattered, short clavate, thin-walled, apically encrusted, 10-13 × 4.5-6	Cylindrical, 6–7.3 × 2–2.9, L = 6.68, W = 2.28, Q = 2.93.	Angio	Dai et al. (2009b)
Pallidohirschioporus jackiae	Singapore	Southeast Asia	A	Resupinate to effused-reflexed	Pale wood-brown to pale fawn brown	Minutely subvillous to subtomentose, weathering glabrous	Pallid white to pale fawn	Poroid to irpicoid	Angular to sublabyrinthine, 2–5	Dimitic, hyphae hyaline	Smooth	U	Ventricose-fusiform, thin-walled, slightly encrusted at the apex, 12–25 × 3.5–7	Broadly ellipsoid, 3–3.8 × 2–2.5	*Jackia*	Corner (1987)
Pallidohirschioporus parvulus	Japan	East Asia	A	Mostly resupinate	N/A	N/A	Ochraceous to pale brown with a distinct pale pink hue	Hydnoid	Teeth, 2–3	Dimitic, hyphae hyaline	U	U	Two types: hymenial cystidia ventricose to cylindrical, thick-walled, usually apically encrusted, 10–15 × 4–6; skeletocystidia also present	Ellipsoid, 6–7 × 3	Angio	Hattori & Ryvarden (1994), Hattori (2001a)
Pallidohirschioporus polycystidiatus	Russia	East Asia	A	Effused-reflexed to pileate	Gray to buff, becoming almost whitish	Pubescent or tomentose to glabrous; zonate	Purple to pale violaceous, fading to gray or almost black	Poroid to irpicoid or hydnoid	Angular, 3	Dimitic, hyphae hyaline	Smooth	–	Capitate, thick-walled, smooth or apically encrusted, 18–30 × 3–9	Cylindrical, slightly allantoid, 4.5–6.2 × 1.8–2.3, L = 5.47, W = 2.08, Q = 2.56–2.65	Angio, mostly *Quercus mongolica*	Parmasto & Parmasto (1987), Núñez & Ryvarden (2001)
Pallidohirschioporus subchartaceus	USA	North America	A	Effused-reflexed to pileate	Gray to pale buff	Smooth to finely addressed velutinate; concentrically sulcate with narrow zones	Purple to violaceous, fading to pale buff	Poroid	Round to angular, 3–4	Trimitic, hyphae hyaline	Smooth	–	Subulate to clavate, thin- to slightly thick- walled, abundant, apically encrusted, 5–7 in width	Cylindric, slightly curved, 7.5–11 × 2–3	Angio, mostly *Populus*	Gilbertson & Ryvarden (1987)
Pallidohirschioporus suberosus	Malaysia	Southeast Asia	A	Pileate	White	Glabrous	White to cream	Poroid to irpicoid	Angular to irregular, 3–5	Trimitic, hyphae hyaline	U	U	Ventricose, thick-walled near the apex, smooth, 15–25 × 4–6	Short ellipsoid, 2–2.5 × 1.5–2	Angio	Hattori (2001a)

Table 5 Continued.

Species	**Type locality**	**Distribution**	**Habit**	**Basidiomata**	**Pileal surface color**	**Pileal surface**	**Pore surface**	**Hymenophore**	**Pores or teeth (per mm)**	**Hyphal system**	**Hyphae at dissepiments edge**	**Hyphal pegs**	**Cystidia (µm)**	**Basidiospores (µm)**	**Host**	**References**
Pallidohirschioporus versicolor	China	East Asia	A	Pileate, effused-reflexed or resupinate	White to cream or pale buff	Densely short tomentose to adpressed velvet; concentrically sulcate with narrow zones	Light purple or yellow buff to grayish purple to vinaceous brown	Poroid to irpicoid	Angular to irregular and labyrinthine, 2–4	Dimitic, hyphae hyaline	Usually with cystidia-like tips	–	Fusoid, thick-walled, usually apically encrusted, 22–30 × 5–7	Cylindric to allantoid, 5.5–7.7 × 1.9–2.3, L = 6.38, W = 2.10, Q = 2.83–3.15	Angio, such as Fagaceae, Rosaceae	This study
Perennihirschioporus agricola	Costa Rica	Central America	A to P	Pileate	Light brown, later with a silvery shine	Velvet to glabrous, warted with age; indistinctly zonate to azonate	Brown	Poroid	Mostly angular, radially elongated or labyrinthine, 1–3	Trimitic, skeletal hyphae yellow	Smooth	–	Ventricose to fusoid, slightly thick-walled and apically encrusted, 10–20 × 4–7	Ellipsoid, 4–5 × 2.5–3	Angio	Vlasák & Vlasák (2017)
Perennihirschioporus daedaleus	Malaysia	Southeast Asia	P	Pileate	Buff to brown	Hairless, rough, slightly warted; azonate	Dark brown	Daedaleoid to lamellate	Radially elongated to lamellate, 0.5–1	Dimitic, skeletal hyphae yellow	Smooth	–	Fusoid to subulate, slightly thick-walled, usually apically encrusted, 17–25 × 4–7.5	Oblong ellipsoid, 3.8–4.8 × 1.9–2.3, L = 4.12, W = 2.44, Q = 1.55–1.86	Angio	This study
Perennihirschioporus fumosoavellaneus	Paraguay	South America	P	Pileate	Pale brown to subavellaneous	Velutinate to velvety tomentose; azonate to sometimes sulcate, often covered with mosses with age	Violaceous to dark reddish gray or dark reddish brown	Poroid	Round, rarely elongated, 3	Trimitic, skeletal hyphae yellow	Smooth	–	Claviform, ventricose or lageniform, slightly thick-walled, apically encrusted, 12–16 × 5–7	Ellipsoid, 3.6–4 × 2.5–3, L = 3.94, W = 2.71, Q = 1.31–1.59	Angio	Rajchenberg & Bianchinotti (1991), Ryvarden & Iturriaga (2003)
Perennihirschioporus perennis	China	East Asia	P	Pileate to effused-reflexed	Greenish-gray to clay-buff or fawn	Finely velutinate to hairless, rough, slightly warted; azonate	Vinaceous brown to snuff-brown or umber	Poroid	Round to angular, occasionally elongate, 2–3	Dimitic, skeletal hyphae yellow	Smooth	–	Short clavate, hyaline, thin-walled, apically encrusted, 12–17 × 3.5–5.5	Oblong ellipsoid, 4–5.2 × 2–2.5	Angio, mostly Fagaceae	Dai et al. (2009)
Perennihirschioporus variabilis	Venezuela	South America	P	Variable in form, effused reflexed to pileate or resupinate	Deep ochraceous to brown	Dull and glabrous, smooth to slightly tuberculate; concentrically zonate	Brown	Poroid to irpicoid or daedaleoid	Angular to irregular or daedaleoid, 1–2	Dimitic, skeletal hyphae yellow	Smooth	–	Fusoid to rounded, thick-walled, apically encrusted, 12–16 × 4–6	Ellipsoid, 4–5 × 2.3–3, L = 4.86, W = 2.68, Q = 1.66–1.96	Angio	Ryvarden & Iturriaga (2003)

Table 5 Continued.

Species	**Type locality**	**Distribution**	**Habit**	**Basidiomata**	**Pileal surface color**	**Pileal surface**	**Pore surface**	**Hymenophore**	**Pores or teeth (per mm)**	**Hyphal system**	**Hyphae at dissepiments edge**	**Hyphal pegs**	**Cystidia (µm)**	**Basidiospores (µm)**	**Host**	**References**
Trichaptum anomalum	Australia	Oceania	A	Effused-reflexed	Sayal-brown to Verona-brown	Hirsute to strigose; broadly sulcate	Light mouse-gray, avellaneous or fawn	Irpicoid to daedaleoid	Angular to irpicoid, 2	Dimitic, hyphae hyaline	U	U	Clavate to subulate, thick-walled, usually apically encrusted, 20–48 × 5–10	Cylindric, 7–8 × 4–4.5	Angio	Lloyd (1918)
Trichaptum byssogenum	Java	Pantropic	A to P	Mostly effused-reflexed, occasionally pileate or resupinate	Gray to ochraceous or milky coffee	Hispid to tomentose, more adpressed towards the margin; concentrically sulcate with narrow zones	Ochre to wood-colored or pale vinaceous buff	Poroid to irpicoid or semi-daedaleoid	Round to angular, 1–3	Dimitic, hyphae hyaline	Smooth	–	Subventricose to subulate, slightly thick-walled, usually apically encrusted, 12–15 × 4–5.5	Cylindric to ellipsoid, 5.2–7 × 3–4, L = 5.83, W = 3.45, Q = 1.59–1.76	Gymno and Angio	Ryvarden & Johansen (1980), Corner (1987)
Trichaptum perpusillum	Malaysia	Southeast Asia	A	Effused-reflexed to pileate	Grayish-orange, pale ochraceous white	Hispid strigose, rough; azonate	Pale orange	Poroid	Round to angular, 6–7	Dimitic, hyphae hyaline	Smooth	U	Unknown	Subglobose or obovoid, 3.3–4 × 2.7–3.3	Angio	Hattori (2003)
Trichaptum perrottetii	French Guiana	South America	A to P	Pileate	Grayish brown to dark brown	Strigose; azonate or weakly-zonate	Snuff brown to cigar brown	Poroid to daedaleoid	Angular, 2–3	Dimitic, hyphae hyaline	Smooth	–	Subulate to ventricose, usually apically encrusted, 10–22 × 4–6	Subcylindrical to oblong ellipsoid, 5.8–7 × 2.5–3.1, L = 6.20, W = 2.91, Q = 2.03–2.2	Angio	Ryvarden (1981), Gilbertson & Ryvarden (1987)
Trichaptum resacarium	Texas, USA	Central America	A	Mostly resupinate, occasionally effused-reflexed	Grayish brown	Tomentose to hispid; concentrically sulcate with narrow zones	Dark fuliginous with purplish tint,	Poroid to irpicoid	Angular, 1–2	Dimitic, hyphae hyaline	Usually apically encrusted with a few small crystals	U	Fusoid, mostly with long narrow necks, thin- to slightly thick-walled, apically encrusted, 15–30 × 3–5	Ellipsoid, 3.5–4 × 2	Angio	Vlasák & Vlasák (2017)
Trichaptum strigosum	Brazil	South America	A	Pileate	Fuscous brown	Densely hispid to strigose; azonate	Grayish brown	Poroid	Subangular to elongate or irregular, 2–5	Dimitic, hyphae hyaline	Smooth	–	Subventricose, thin- to slightly thick-walled apically encrusted, 10–24 × 2–5	Ellipsoid, 4.3–5.9 × 2.5–3, L = 5.19, W = 2.86, Q = 1.81	Angio	Corner (1987)

Table 5 Continued.

Species	**Type locality**	**Distribution**	**Habit**	**Basidiomata**	**Pileal surface color**	**Pileal surface**	**Pore surface**	**Hymenophore**	**Pores or teeth (per mm)**	**Hyphal system**	**Hyphae at dissepiments edge**	**Hyphal pegs**	**Cystidia (µm)**	**Basidiospores (µm)**	**Host**	**References**
Podocarpioporus podocarpi	China	Southeast Asia	A	Resupinate	N/A	N/A	Vinaceous-buff to clay-pink buff, becoming brown when bruised, clay-buff to grayish-brown upon drying	Poroid to irpicoid	Angular, 1–3	Dimitic, skeletal hyphae yellow, slightly dextrinoid	Smooth	–	Clavate to subulate, thick-walled, apically encrusted, 28–70 × 5–8	Cylindric to allantoid, 5–7 × 1.8–2.2, L = 6.15, W = 1.98, Q = 3.11	*Podocarpus*	Dai et al. (2009b)
Podocarpioporus vinaceobrunneus	Malaysia	Southeast Asia	A	Effused-reflexed to pileate	Cinnamon to vinaceous fuscous brown	Tomentose; sulcate with thick tomentose zones	Light brown to vinaceous fuscous brown	Irpicoid to hydnoid	Teeth 2–3	Dimitic, skeletal hyphae yellow	Smooth	U	Ventricose to lanceolate fusiform, slightly thick–walled, apically encrusted, 25–45 × 5–7.5 (Hattori 2001), 35–90 × 4–9 (Corner 1987)	Allantoid, 6–7 × 1.2–1.8 (Hattori 2001), 6–8 × 1.7–2.3 (Corner 1987)	Dacrydium	Hattori (2001b), Corner (1987)
Pseudotrichaptum laricinum	Northern Europe	North Hemisphere	A	Pileate, occasionally effused-reflexed	Cream to pale buff	Pubescent to adpressed velvet; rough with distinct narrow concentrically sulcate zones	Fuscous to grayish purple or vinaceous brown	Lamellate	Lamella, 1–2	Dimitic, hyphae yellowish in KOH	Encrusted with small crystals	–	Fusoid to ampullaceous, thick-walled, usually apically encrusted, 25–32 × 4–8.5	Allantoid, 5.5–7.7× 2–2.2, L = 6.47, W = 2.12, Q = 2.87–3.30	Gymno, such as *Abies*, *Larix*, *Picea* and *Pinus*	Niemelä (1985), Ryvarden & Gilbertson (1994)

+: Present; –: Absent
U: Unknown
A: Annual; P: Perennial
Angio: Angiosperms; Gymno: Gymnosperms

Hennig (1966) initially proposed that the taxonomic ranking reflects geological age. Avise & John (1999) developed a taxonomic rank scale using gene-specific molecular clocks, suggesting that each taxonomic genus may indicate membership in a clade whose lineages shared a most recent common ancestor during the Pliocene (2–5 Mya), and each taxonomic order could indicate a clade whose coalescent node occurred during the Jurassic (145–205 Mya). However, these scales are not universally applicable to all organisms (Zhao et al. 2016). In subsequent studies, a series of divergence time scales for different groups of fungi were proposed (Chen et al. 2015, Zhao et al. 2016, 2017, He et al. 2019, Jung et al. 2021, Wang et al. 2021, 2022). He et al. (2019) mentioned 45 monophyletic families within the Agaricomycotina, dated with divergence times in a range of 27–178 Mya. Excluding two very young mushroom families, Hymenogastraceae (27 Mya) and Tubariaceae (54 Mya), 70–178 Mya (mean stem age) may be the emergence time of taxa at the family level. Ji et al. (2022) verified that the mean estimated stem ages of the four main clades of Polyporales proposed by Hibbett & Donoghue (2001) and Binder et al. (2013) are between 123.74 and 88.81 Mya.

Our analysis (Fig. 19) of divergence times using a dataset of two ribosomal RNA genes (ITS and nLSU rDNA) and one protein-coding gene (TEF1) suggests that species of Hirschioporaceae evolved from a common ancestor during the middle Cretaceous (ca. 130–83 Mya) with a mean stem age of 121.25 Mya (95% HPD of 98.18–146.87 Mya) and a crown age of 99 Mya (95% HPD of 76.37–123.49 Mya). The core *Trichaptum s.l.* clade, which is now treated as the Trichaptaceae, possibly emerged in the later Cretaceous (ca. 83–65 Mya) with a mean stem age of 103.3 Mya (95% HPD of 77.28–130.33 Mya) and a crown age of 78.99 Mya (95% HPD of 49.99–108.21 Mya). Our results are consistent with the suggested divergence times of the family level taxa in previous studies, and the taxonomic status of our two new families can be recognized in the divergence times.

According to the divergence time estimation of Hirschioporaceae in the current study (Fig. 19), the four major clades of Hirschioporaceae are well supported as allied lineages that originated during the middle Cretaceous period. The divergence times of the *Hirschioporus* clade (mean crown age 45.15 Mya), the *Pallidohirschioporus* clade (mean crown age 28.06 Mya), the *Perennihirschioporus* clade (mean crown age 31.86 Mya) and the *Nigrohirschioporus* clade (mean crown age 39.31 Mya) support the existence of the four specific genera, *Hirschioporus, Pallidohirschioporus, Perennihirschioporus* and *Nigrohirschioporus*.

According to our analysis (Fig. 20) based on the combined dataset (Dataset IV), species of Hirschioporaceae evolved from a common ancestor during the middle Cretaceous period (Node-b, 94–140 Mya) and tropical areas are inferred to be the most probable ancestral areas. A series of evidences suggest that there were significant submarine volcanic activities during the Cretaceous period, including an increase in the production rate of oceanic crust in mid-ocean ridges and the emergence of large igneous provinces within oceanic plates (Jenkyns 2010, Wang et al. 2018). The development of super mantle plumes may occurr during the mid-Cretaceous period (Jenkyns, 2010). Temperature variations in ancient times reached their peak during the period from100–90 million years ago. Significant submarine volcanic activities and the resulting rise in sea level and global warming resulted in higher global temperatures and nutrient components, which accelerated the process of biological system evolution (Tierney et al. 2020). In the meantime, the Cretaceous crust continued to shift, causing continents to break up and drift apart, eventually forming the present distribution of continents. This was followed by a parallel divergence into tropical groups and boreal-distributed groups around 99 Mya (Node-b). Frequent dispersal events occurred, leading to the evolution of Hirschioporaceae species from a tropical to a northern temperate distribution. Later in the Cretaceous period 73.53 Mya (Node-d), there was further parallel divergence into gymnosperm and angiosperm preference groups.

The above conclusions indicate that *Trichaptum s.l.* species may originate in the tropics and gradually migrated towards temperate regions. Meanwhile, species on angiosperms appeared earlier, and it was not until the late Cretaceous (73.53 Mya) that *Hirschioporus*, which was adapted to growing on gymnosperm wood, diverged from the common ancestor and formed a temperate distribution. This conclusion contradicts the hypothesis proposed by Alexander et al. (1989) in previous studies, which suggested that the widely distributed species had an earlier origin and were associated with gymnosperms, and that the angiosperm specialization allowed the species possessing it to persist in warmer regions.

Perennihirschioporus (Clade IV) is a genus of tropical originapproximately 7.3 Mya (Fig. 20, Node-f), species of the genus underwent a dispersal event and an isolation event: BC->BCD->BD|C, which allowed them to evolve from the tropics to subtropical environments. Later, due to geographic isolation, parallel evolution resulted in the evolution of a tropical clade and a subtropical clade in highlands. Similar evolutionary events also occurred in *Trichaptum* (Clade V), which appeared during the Late Cretaceous period (83–65 Mya). Since then, it has undergone three dispersal events and one isolation event. The Node-e indicates that around 4.2 Mya, the species underwent an isolation event: BC->BC^C->BC|C, gradually spreading from tropical regions to subtropical regions. It is speculated that genea of tropical origin may have a tendency to evolve towards subtropical regions.

The Miocene epoch (23–5 Mya) was marked by the peak period of the Himalayan orogeny, particularly in the early Miocene. This movement altered the monsoon pattern in Asia and affected glacial activities in the Northern Hemisphere. As a result of block uplift numerous mountain plateaus were formed on the plain. These mountains played a crucial role in facilitating the exchange and merging of flora between the Qinghai-Tibet Plateau and nearby regions, creating favorable conditions for the development and differentiation of species (Wu et al. 1995). By the end of the early Tertiary period (23 Mya), the Paleozoic era of the Tianshan Mountains had been eroded and flattened into a plain and the modern Tianshan Mountains were formed. This study shows that the endemic species of the Tianshan Mountains, *Hirschioporus tianschanicus* appeared around 11 Mya, while the Himalayan species *Pallidohirschioporus versicolor* appeared around 13 Mya, both of them were in the Miocene epoch (23–5 Mya). It is possible that the formation of these two species was promoted by the Himalayan orogeny.

As one of the most obvious traits of basidiomycetes, basidiomata play an essential role in the process of sexual reproduction by safeguarding reproductive organs and encouraging dispersal of basidiospores (Nagy et al. 2017). Previous studies at higher taxonomic level suggested that the ancestral form of basidiomata was resupinate and it evolved into the pileate-stipitate form over multiple generations (Hibbett & Binder 2002, Hibbett 2004, Varga et al 2019). However, there were few studies on the morphological evolution of basidiomata at the family level. Across basidiomata traits, the pileate habit is evaluated as the ancestral state of Hirschioporaceae (Fig. 21) and the ancestral state of Trichaptaceae included a variety of morphological habits (Node-a), without specialization yet. There were distinct dispersal events for basidiomata during the later Cretaceous period (Nodes d, e, 83–65 Mya). The ancestral pileate habit in Hirschioporaceae remains in *Pallidohirschioporus* and *Perennihirschioporus* but has evolved to effused-reflexed habit in *Hirschioporus.* In additon, the resupinate habit emerged in *Nigrohirschioporus* around 10.9 Mya (Node-f), but has yet to form a clade where it is the dominant form. *Pallidohirschioporus* diversified into a branch with either pileate or effused-reflexed habit around 22.46 Mya (Node-g), as well as a polymorphic clade that gradually evolved into a clade with an effused-reflexed habit around 12.8 Mya. Similarly, *Perennihirschioporus* also gradually evolved into clade with effused-reflexed habit at Node-h. Therefore, it can be inferred that the morphological evolution of species in *Trichaptum s.l.* may trend towards the resupinate habit.

According to the RASP analysis of trait evolution of basidiomata (Fig. 21), it was observed that the evolutionary processes within *Trichaptum s.l.* were unclear. Although *Nigrohirschioporus, Pallidohirschioporus,* and *Perennihirschioporus* displayed trends similar to the evolutionary level of the family, they seem to benot widely applicable standards.

The presentstudy investigated *Trichaptum s.l.* from multiple perspectives, including traditional morphology and ecology (external features, microscopic morphology, host and habitat), phylogenetics, species evolution (estimation of divergence times), biogeography (reconstruction of ancestral distribution and morphological evolution). Our study systematically clarified the phylogenetic relationships among families, genera and species of *Trichaptum s.l.* Molecular clock analysis was used to demonstrate the divergence times of different taxonomic units in *Trichaptum s.l.*, supporting the revised classification system and the rationality of establishing each taxonomic unit.

Our study provides a comprehensive information onthe species diversity of *Trichaptum s.l.* based on phylogeny of five sequence fragments (ITS, nLSU, mt-SSU, nuc-SSU, and TEF1). However, tthe amplification for RPB1 and RPB2 fragments were diffiucult, and a more effective amplification program is still needed. With the development of second and third-generation sequencing technologies, whole genome sequencing of species is expected to become a necessary means for future molecular biology-related research. This will help us to understand the genetic information of organisms.

During the field trips we found that *Pallidohirschioporus versicolor* had variable-colored basidiomata and grew on various substrates, such as fallen trunks, stumps, and fallen branches. Therefore, we speculate whether there is a certain correlation between the morphological evolution of this species and its host substrate. Is such a correlation applicable to other fungal species? However, the recorded information on the host for studiedspecimens is incomplete, and gymnosperms or angiosperms were recorded in many samples. The ecological information, such as living tree, fallen logs, stumps, fallen branches, and dead standing trees of each species is lacking. It is therefore complete data of basidiomata, host substrate and ecology are needed to record in the field, and genomics and transcriptomics techniques willbe used to further reveal the environmental adaptation mechanism of their morphological characteristics and ecological functions.

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