Hydnophanerochaete and Odontoefibula, two new genera of phanerochaetoid fungi (Polyporales, Basidiomycota) from East Asia

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Abstract
Two new genera with phylogenetic affinities to Phanerochaete s.l. are presented, namely Hydnophanerochaete and Odontoefibula. The generic type of Hydnophanerochaete is Phanerochaete odontoidea. Odontoefibula is established based on a new species: O. orientalis (generic type). Both genera have effused basidiocarps with odontioid hymenial surface, simple-septate generative hyphae, cystidia lacking, clavate basidia and ellipsoid basidiospores that are smooth, thin-walled, inamyloid, non-dextrinoid and acyanophilous. Hydnophanerochaete is additionally characterised by a compact texture in the subiculum with thick-walled generative hyphae and quasi-binding hyphae. Odontoefibula has a dense texture of subiculum with thin- to slightly thick-walled hyphae and further a dark reddish reaction of basidiocarps when treated with KOH. Multi-marker phylogenetic analyses based on sequences, inferred from the ITS+nuc 28S+rpb1+rpb2+tef1 dataset, indicate that Hydnophanerochaete and Odontoefibula are placed in the Meruliaceae and Donkia clades of Phanerochaetaeae, respectively. Phanerochaete subodontoidea is a synonym of P. odontoidea, according to morphological and molecular evidence.

Keywords
Meruliciae, multi-marker phylogeny, new species, Phanerochaetaceae, phlebioid clade
Introduction

The genus *Phanerochaete* P. Karst., typified by *P. alnea* (Fr.) P. Karst., belongs to Polyporales Gäum of the Basidiomycota R.T. Moore and is one of the largest genera of corticoid fungi, including over 150 names according to Index Fungorum (http://www.indexfungorum.org/). Basidiocarps are typically membranaceous, effused, with various hymenial surfaces (i.e. smooth, tuberculate, odontioid, hydnoid, merulioid or poroid). Microscopically, *Phanerochaete* has a monomitic hyphal system, ordinarily simple-septate generative hyphae (rare clamp connections can be found in the subiculum), ellipsoid to cylindrical thin-walled basidiospores and clavate basidia. *Phanerochaete* has a monomitic hyphal system, ordinarily simple-septate generative hyphae (rare clamp connections can be found in the subiculum), ellipsoid to cylindrical thin-walled basidiospores and clavate basidia. *Phanerochaete* is widespread and grows on diverse woody substrates (i.e. twigs and branches or trunks of angiosperms or gymnosperms), causing a white rot. *Phanerochaete* s.l. has attracted increasing study interest due to its abundant taxonomic diversity and potential applications in the field of biodegradation and bioconversion (Sánchez 2009).

*Phanerochaete* was traditionally treated as a genus in the broad sense (Eriksson et al. 1978; Burdsall 1985; Wu 1990). In recent years, *Phanerochaete* has been shown to be a polyphyletic group with members distributed throughout the phlebioid clade of Polyporales (De Koker et al. 2003; Wu et al. 2010; Floudas and Hibbett 2015; Miettinen et al. 2016), which was recently recognised as three families: Phanerochaetaceae Jülich, Irpicaceae Spirin & Zmitr and Meruliaceae Rea (Justo et al. 2017). Based on the combined morphological and molecular approaches, many studies have been conducted to revise the generic concept of *Phanerochaete* s.l. Some segregated genera have been recovered or proposed, e.g. *Efibula* Sheng H. Wu, *Hydnophlebia* Parmasto, *Phaeophlebiopsis* Floudas & Hibbett, *Phlebiopsis* Jülich, *Rhizochaete* Gresl., Nakasone & Rajchenb. and *Scopuloides* (Massae) Höhn. & Litsch. (Wu 1990; Greslebin et al. 2004; Wu et al. 2010; Floudas and Hibbett 2015).

*Phanerochaete odontoidea* Sheng H. Wu and *P. subodonoida* Sheng H. Wu were described from Taiwan (Wu 2000). Both species have ceraceous basidiocarps with odontioid to hydnoid hymenial surface, compact subiculum, but no cystidia. These species have been shown to be phylogenetically far from the core *Phanerochaete* clade (Wu et al. 2010; Ghabad-Nejhad et al. 2015; Wu et al. 2018) and were placed by Justo et al. (2017) in Meruliaceae. In this study, we evaluate the generic placement of *P. odontoidea* and *P. subodonoida*, as well as morphologically similar species. To accommodate our target taxa, we found it necessary to introduce two new genera placed within Meruliaceae and Phanerochaetaceae, respectively.

When *Phanerochaete odontoidea* and *P. subodonoida* were described, they were separated by basidiospore width (Wu 2000). After 2000, we have accumulated more collections identified as *P. odontoidea* and *P. subodonoida* from China, Japan, Taiwan and Vietnam. To better reflect their morphological variations, this study provides updated morphological and molecular evidence for revising their species concepts.
Table 1. Species and sequences used in the phylogenetic analyses. Newly generated sequences are set in bold.

| Taxon                     | Strain/Specimen | ITS     | nuc 28S | rpb1 | rpb2 | tef1 |
|---------------------------|-----------------|---------|---------|------|------|------|
| Antrodia serialis         | KHL 12010 (GB)  | JX109844| JX109844| –    | –    | JX109870 | JX109898 |
| Aunantiporus croceus      | Miettinen-16483 | KY948745| KY948901| KY948927| –    | –    |
| Bjerkandera adusta        | HHB-12826-3p    | KP134983| KP135198| KP134784| KP134913| KT305938 |
| Bjerkandera aff. centroamericana | L-13104-sp    | KY948791| KY948855| KY948936| –    | –    |
| Bysosmerulius corium     | FP-102382       | KP135007| KP135230| KP134802| KP134921| –    |
| Candelabrochaete africana| FP-102987-3p    | KP135294| KP135199| KP134872| KP134975| –    |
| Ceracomyces serpens      | HHB-15692-3p    | KP135031| KP135200| KP134785| KP134914| –    |
| Ceriporia alachuanana    | FP-103881-3p    | KP135341| KP135201| KP134845| KP134896| –    |
| Ceriporia reticulata     | KHL 11981 (GB)  | –      | –      | –    | –    | JX109899 |
| Ceriporia reticulata     | RLG-11354-3p    | KP135041| KP135204| KP134794| KP134922| –    |
| Ceriporiopsis aneirina   | HHB-15629-3p    | KP135023| KP135207| KP134795| –    | –    |
| Ceriporiopsis carnegiate | RLG-7277-T      | KY948792| KY948854| KY948935| –    | –    |
| Ceriporiopsis finbriata  | Dai 11672       | KJ698633| KJ698637| –    | –    | –    |
| Ceriporiopsis gilvescens | L-3519-3p       | KY948761| –      | KY948919| –    | –    |
| Ceriporiopsis gilvescens | Niemela-5515    | –      | HQ659222| –    | –    | –    |
| Ceriporiopsis guidella   | HUBO 7659       | FJ496687| FJ496722| –    | –    | –    |
| Ceriporiopsis kunmingensis| C.L. Zhao 152   | KX081072| KX081074| –    | –    | –    |
| Ceriporiopsis lagerheimii| 58240           | KX008365| KX081077| –    | –    | –    |
| Ceriporiopsis pseudoplacenta| Miettinen 18997 (H) | KY948744| KY948902| KY948926| –    | –    |
| Cerrena unicolor          | FD-299          | KP135304| KP135209| KP134874| KP134968| –    |
| Climacodon sanguineus    | BR5020180728797 | KX810931| KX810932| –    | –    | KX810934 |
| Climacodon septentrionalis| AFTOL-767       | AY854082| AY684165| AY864872| AY780941| AY885151 |
| Crustodontia chrysocreas I | HHB-6333-3p    | KP135358| KP135263| KP134861| KP134908| –    |
| Crustodontia chrysocreas II | FBCC307      | LN611114| LN611114| –    | –    | –    |
| Daedalea quercina         | FP-56429        | KY948809| KY948883| KY948989| –    | –    |
| Datronia mollis           | RLG6304sp       | JN165002| JN164791| JN164818| JN164872| JN164901 |
| Donkia pulcherrima I      | GC 1707-11      | LC378994| LC379152| LC379157| LC387351| LC387371 |
| Donkia pulcherrima II     | AH39127         | –      | –      | –    | –    | KX810937 |
| Donkia pulcherrima II     | Gothenburg-2022 | KX752609| KX752591| –    | –    | –    |
| Efibula americana         | FP-102165       | KP135016| KP135256| KP134808| KP134916| –    |
| Emmia lacerata           | FP-55521-T      | KP135024| KP135202| KP134805| KP134915| –    |
| Fomitopsis pinicola       | AFTOL-770       | AY854083| AY684164| AY864874| AY780941| AY885152 |
| Gelatoporia subvermispora| FD-354          | KP135312| KP135212| KP134879| –    | –    |
| Geliporus exilisporus I   | GC 1702-15      | LC378995| LC379153| LC379158| LC387352| LC387372 |
| Geliporus exilisporus II  | Dai 2172        | KU598211| KU598216| –    | –    | –    |
| Gloeoporus pannocinctus   | L-15726-3p      | KP135060| KP135214| KP134867| KP134973| –    |
| Grammothelopis puiggarii  | RP 134          | KP859299| KP859308| –    | –    | –    |
| Hapalopilus nidulans      | FD-512          | KP135419| –      | KP134809| –    | –    |
| Taxon                                      | Strain/Specimen   | ITS          | nuc 28S       | rpb1         | rpb2         | tef1         |
|-------------------------------------------|-------------------|--------------|---------------|--------------|--------------|--------------|
| *Hapalopilus nidulans*                    | Josef Vlasak      | –            | KX752623      | –            | –            | –            |
| *Hapalopilus ochraceolateritius*          | Miettinen-16992.1 | KY948741     | KY948891      | KY948965     | –            | –            |
| *Heterobasidion annosum*                  | AFTOL-ID 470      | DQ206988     | –             | DQ667160     | –            | DQ028584     |
| *Heterobasidion annosum*                  | DAOM-73191        | –            | AF287866      | –            | AY544206     | –            |
| *Hydnaphanerochaete odontoida*            | Chen 1376         | LC363485     | –             | –            | –            | –            |
| *Hydnaphanerochaete odontoida*            | GC 1308-45        | LC363486     | LC363492      | LC363497     | LC387353     | LC387373     |
| *Hydnaphanerochaete odontoida*            | GC 1607-20        | LC378996     | –             | –            | –            | –            |
| *Hydnaphanerochaete odontoida*            | GC 1710-59        | LC378997     | –             | –            | –            | –            |
| *Hydnaphanerochaete odontoida*            | WEI 15-309        | LC378998     | –             | –            | –            | –            |
| *Hydnaphanerochaete odontoida*            | WEI 15-348        | LC378999     | –             | –            | –            | –            |
| *Hydnaphanerochaete odontoida*            | Wu 0106-35        | LC379000     | LC379154      | LC379159     | LC387354     | LC387374     |
| *Hydnaphanerochaete odontoida* (Phanerochaete subodontoida)* | Wu 911206-38     | LC379001     | –             | –            | –            | –            |
| *Hydnaphanerochaete odontoida*            | Wu 9310-29        | LC379002     | –             | –            | –            | –            |
| *Hydnaphanerochaete odontoida*            | Wu 9310-8         | MF399408     | GQ470653      | LC314328     | LC387355     | LC387375     |
| *Hydnaphanerochaete odontoida* (Phanerochaete subodontoida)* | CWN00776         | LC363487     | GQ470663      | LC363498     | LC387356     | LC387376     |
| *Hydropylebia chrysorhiza*                | FD-282            | KP135338     | KP135217      | KP134848     | KP134897     | –            |
| *Hydropylebia omnivora I*                 | KKN-112-Sp        | KP135334     | KP135216      | KP134846     | –            | –            |
| *Hydropylebia omnivora II*                | ME-497            | KP135332     | KP135218      | KP134847     | –            | –            |
| *Hydropolyergus fimbriatus*               | Meijer3729 (O)    | JN649346     | JN649346      | –            | JX109875     | JX109904     |
| *Hyphoderma mutatum*                      | HHB-15479-Sp      | KP135296     | KP135221      | KP134870     | KP134967     | –            |
| *Hyphoderma setigerum*                    | CHWC 1209-9       | –            | –             | –             | –           | LC387357     | LC270919     |
| *Hyphoderma setigerum*                    | FD-312            | KP135297     | KP135222      | KP134871     | –            | –            |
| *Hyphodermella corrugata*                 | MA-Fungi 24238    | FN600378     | JN939586      | –            | –            | –            |
| *Hyphodermella poroides*                  | Dai 10848         | KX008368     | KX011853      | –            | –            | –            |
| *Hyphodermella rosae*                     | FP-150552         | KP134978     | KP135223      | KP134823     | KP134939     | –            |
| *Traxes lacteus*                          | DO 421/951208 (O) | –            | –             | –             | –            | JX109882     | JX109911     |
| *Traxes lacteus*                          | FD-9              | KP135026     | KP135224      | KP134806     | –            | –            |
| *Leptoporus mollis*                       | TJV–93–174T       | KY948795     | EU402510      | KY948957     | –            | –            |
| *Lilaceophlebia livida I*                 | FBCC937           | LN611122     | LN611122      | –            | –            | –            |
| *Lilaceophlebia livida II*                | FP-135046-sp      | KY948758     | KY948850      | KY948917     | –            | –            |
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| Taxon                     | Strain/Specimen   | ITS   | nuc 28S | rpb1     | rpb2     | tef1     |
|---------------------------|-------------------|-------|---------|----------|----------|----------|
| Lopharia cinerascens      | FP-105043-sp      | JN165019 | JN164813 | JN164840 | JN164874 | –         |
| Latoporzia albomarginata  | GC 1702-1         | **LC379003** | **LC379155** | **LC379160** | **LC387358** | **LC387377** |
| Merulius taxicolor         | SK 0075 (GB)      | JX109847 | JX109847 | –         | JX109873 | JX109901 |
| Merulius tremellus         | ES2008-2 (GB)     | JX109859 | –        | –         | JX109916 | –         |
| Merulius tremellus         | FD-323            | KP135231 | KP134856 | KP134900 | –         | –         |
| Mycoacia fuscotina         | HHH-10782-Sp      | KP135365 | KP135265 | KP134857 | KP134910 | –         |
| Mycoacia fuscotina         | KHL 13275 (GB)    | –       | –        | –         | JX109908 | –         |
| Mycoacia notobifari         | HHH-4273-Sp       | KP135369 | KP135266 | KP134858 | KP134911 | –         |
| Obba rivulosa              | FP-135416-Sp      | KP135309 | KP135208 | KP134878 | KP134962 | –         |
| Odontoefibula orientalis   | GC 1604-130       | **LC363489** | **LC363494** | **LC363500** | **LC387359** | **LC387378** |
| Odontoefibula orientalis   | GC 1703-76        | **LC379004** | **LC379156** | **LC379161** | **LC387360** | **LC387379** |
| Odontoefibula orientalis   | Wu 0805-59        | **LC363488** | **LC363493** | **LC363499** | **LC387361** | **LC387380** |
| Odontoefibula orientalis   | Wu 0910-57        | **LC363490** | **LC363495** | **LC363501** | **LC387362** | **LC387381** |
| Odoria alborubescens       | BP106943          | MG097864 | MG097867 | MG213724 | MG213723 | –         |
| Oxychaete ceveringiitus    | Schigel-5216      | KX752596 | KX752596 | –         | –         | –         |
| Phaeothlebiopsis caribbeana| HHH-6990          | KP135415 | KP135243 | KP134810 | KP134931 | –         |
| Phaeothlebiopsis peniophoroids | FP-150577       | KP135417 | KP135273 | KP134813 | KP134933 | –         |
| Phanerina meloa            | WEI 17-224        | **LC387333** | **LC387340** | **LC387345** | **LC387363** | **LC387382** |
| Phanerochaete arizonica    | RLG-10248-Sp      | KP135170 | KP135239 | KP134830 | KP134949 | –         |
| Phanerochaete chryso sporium| HHH-6251-Sp      | KP135094 | KP135246 | KP134842 | KP134954 | –         |
| Phanerochaete ericina      | HHH-2288          | KP135167 | KP135247 | KP134834 | KP134950 | –         |
| Phanerochaete exilis       | HHH-6988          | KP135001 | KP135236 | KP134799 | KP134918 | –         |
| Phanerochaete laevis       | HHH-15519-Sp      | KP135149 | KP135249 | KP134836 | KP134952 | –         |
| Phanerochaete livescens    | Wu 0711-81        | **LC387334** | MF110289 | **LC387346** | **LC387364** | LC270920 |
| Phanerochaete magnolata    | HHH-9829-Sp       | KP135089 | KP135237 | KP134838 | KP134955 | –         |
| Phanerochaete pseudosanguinea | FD-244            | KP135098 | KP135251 | KP134827 | KP134942 | –         |
| Phanerochaete rhodella     | FD-18             | KP135187 | KP135258 | KP134832 | KP134948 | –         |
| Phanerochaete sp.          | HHH-11463         | KP134994 | KP135235 | KP134797 | KP134892 | –         |
| Phanerochaete taiwani ana  | Wu 0112-13        | MF399412 | GQ470665 | LC314332 | **LC387365** | **LC387383** |
| Phelbia acerina            | FD-301            | KP135378 | KP135260 | KP134862 | –         | –         |
| Phelbia acanthocystis I    | GC 1703-30        | **LC387338** | **LC387343** | – | **LC387366** | **LC387384** |
| Phelbia acanthocystis II   | FP150571          | KY948767 | KY948844 | KY948914 | –         | –         |
| Phelbia albida             | GB-1833           | KY948748 | KY948889 | KY948960 | –         | –         |
| Phelbia brevispora         | FBCC1463          | LN611135 | LN611135 | –         | –         | –         |
| Phelbia centri frugia      | HHH-9239-Sp       | KP135380 | KP135262 | KP134844 | KP134974 | –         |
| Phelbia coccineofulva      | HHH-11466-sp      | KY948766 | KY948851 | KY948915 | –         | –         |
| Phelbia deflectens         | FCUG 1568         | AF141619 | AF141619 | –         | –         | –         |
| Phelbia firma              | Edman K268        | EU118654 | EU118654 | –         | JX109890 | –         |
| Phelbia floridensis        | HHH-9905-Sp       | KP135383 | KP135264 | KP134863 | KP134899 | –         |
| Phelbia hydnoida           | HHH-1993-sp       | KY948778 | KY948853 | KY948921 | –         | –         |
| Phelbia lilascens          | FCUG 1801         | AF141621 | AF141621 | –         | –         | –         |
| Taxon                        | Strain/Specimen | ITS     | nuc 28S     | rpb1     | rpb2     | tef1     |
|-----------------------------|-----------------|---------|-------------|----------|----------|----------|
| Phlebia ochraceofulva       | FBCC295         | LN611116| LN611116    | –        | –        | –        |
| Phlebia radiata             | AFTOL-484       | AY854087| AF287885    | AY864881 | AY218502 | AY885156 |
| Phlebia setulosa            | HHB-6891-Sp     | KP135382| KP135267    | KP134864 | KP134901 | –        |
| Phlebia sp.                 | FD-427          | KP135342| –           | KP134849 | –        | –        |
| Phlebia sp.                 | GC 1703-31      | LC387339| LC387344    | LC387347 | LC387367 | LC387385 |
| Phlebia sp.                 | GC 1708-118     | LC387337| LC387342    | LC387349 | LC387368 | LC387386 |
| Phlebia sp.                 | GC 1710-83      | LC387336| LC387341    | LC387350 | LC387369 | LC387387 |
| Phlebia sp.                 | HHB-17984       | KP135359| KP135261    | KP134860 | KP134907 | –        |
| Phlebia sp.                 | HHB-18295       | KP135405| KP135269    | KP134814 | KP134938 | –        |
| Phlebia subochracea I       | HBB-8715-sp     | KY948770| KY948846    | KY948913 | –        | –        |
| Phlebia subochracea II      | HBB-8494-sp     | KY948768| KY948845    | KY948912 | –        | –        |
| Phlebia subserialis         | KCHG 1434       | AFI41631| AF141631    | –        | –        | –        |
| Phlebia uda                 | FP-101544-Sp    | KP135361| KP135232    | KP134859 | KP134909 | –        |
| Phlebia unica               | KHL 11786 (GB)  | EU118657| EU118657    | –        | JX109861 | JX109889 |
| Phlebiopsis crassa          | KKN-86-Sp       | KP135394| KP135215    | KP134820 | KP134928 | –        |
| Phlebiopsis gigantea        | FP-70857-Sp     | KP135390| KP135272    | KP134821 | KP134930 | –        |
| Phlebiopsis ravenelli       | FP-110129-Sp    | KP135362| KP135274    | KP134850 | KP134898 | –        |
| Phlebioria cubalinalis      | Dai 13168       | KC782526| KC782528    | –        | –        | –        |
| Pirex concentricus          | OSC-41587       | KP134984| KP135275    | KP134843 | KP134940 | –        |
| Rhizochaete filamentososa   | HBB-3169-Sp     | KP135410| KP135278    | KP134818 | KP134935 | –        |
| Rhizochaete radicata        | FD-123          | KP135407| KP135279    | KP134816 | KP134937 | –        |
| Rhizochaete rubescens       | Wu 0910-45      | LC387355| MF110294    | LC387348 | LC387370 | LC270925 |
| Riopa metamorphosa          | Viacheslav Spirin2395 (H) | XK752601| XK752601    | XK752628 | –        | –        |
| Sarcodontia crocea          | OMC-1488        | KY948798| KY948903    | KY948928 | –        | –        |
| Scopuloides rimosa I        | HBB-7042-Sp     | KP135350| KP135282    | KP134853 | KP134903 | –        |
| Scopuloides rimosa II       | RLG-5104        | KP135351| KP135283    | KP134852 | KP134904 | –        |
| Skeletocutis nivea           | ES2008-1 (GB)   | JX109858| JX109858    | –        | JX109886 | JX109915 |
| Stecherinum ochraceum       | KHL 11902 (GB)  | JQ031130| JQ031130    | –        | JX109865 | JX109893 |
| Stereum hirsutum            | AFTOL-ID 492    | AY854063| –           | AY864885 | AY218520 | AY885159 |
| Stereum hirsutum            | FPL-8805        | –        | AF393078    | –        | –        | –        |
| Terana caerulea             | FP-104073       | KP134980| KP135276    | KP134865 | KP134960 | –        |
| Trametes versicolor          | FP-135156-sp    | JN164919| JN164809    | JN164825 | JN164850 | DQ028603 |
| Trametopsis cervina         | TJV–93–216T     | JN165020| JN164796    | JN164839 | JN164877 | JN164882 |
| Tyromyces chioneus          | FD-4            | KP135311| KP135291    | KP134891 | KP134977 | –        |

**Materials and methods**

**Morphological studies**

The specimens used for illustrations and descriptions are deposited at the herbarium of National Museum of Natural Science of ROC (TNM, acronym according to Index Herbariorum; http://sweetgum.nybg.org/science/ih/). Free-hand thin sections of basidiocarps were mounted in three mounting media for microscopic studies: 5% (w/v) KOH with 1% (w/v) phloxine was used for observation and measurements; Melzer's reagent (IKI) was utilised to check amyloidity and dextrinoidity; and Cotton Blue (CB, Fluka 61335) was employed to determine cyanophily. Sections were studied with a Leica DM2500 (Leica, Wetzlar) microscope. Drawings were done with the aid of a
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drawing tube. We followed the method for measurements of microscopic characters by Wu (1990). The abbreviations below were used when presenting statistical measurements of basidiospores: \( L \) = mean basidiospore length, \( W \) = mean basidiospore width, \( Q \) = variation in \( L/W \) ratio, \( n \) = number of measured spores. The terminology of microscopic characters follows Wu (1990).

**DNA extraction and sequencing**

Dried specimens or mycelia grown on MEA were used for isolating genomic DNA. The material was first fragmented into a fine powder with the aid of liquid nitrogen and a TissueLyser II (Qiagen, Hilden, Germany). DNA was obtained using the Plant Genomic DNA Extraction Miniprep System (Viogene-Biotek Corp., New Taipei, Taiwan) based on the manufacturer’s instructions. Five genetic markers were amplified in this study: nuc rDNA ITS1-5.8S-ITS2 (ITS) using primer pair ITS1/ITS4 (White et al. 1990); D1-D2 domains of nuc 28S rDNA (nuc 28S) using primer pair LR0R/LR5 (http://www2.clarku.edu/faculty/dhibbett/Protocols_Folder/Primers/Primers.pdf); RNA polymerase II largest subunit (\( rpb1 \)) using primer pair RPB1-Af/RPB1-Cr (Stiller and Hall 1997; Matheny et al. 2002) or alternative primers RPB1- 2f, RPB1-2.1f, RPB1-2.2f and RPB1-2.1r (Froslev et al. 2005); RNA polymerase II second largest subunit (\( rpb2 \)) using primer pair RPB2-f5F/RPB2-b7.1R (Liu et al. 1999; Matheny 2005); and translation elongation factor 1-\( \alpha \) (\( tef1 \)) using primer pair EF1-983F/EF1-2212R (Rehner and Buckley 2005). The PCR protocols for ITS and nuc 28S gene regions were as follows: initial denaturation at 95 °C for 5 min, followed by 40 cycles at 94 °C for 45 s, 53 °C for ITS and 50 °C for nuc 28S for 45 s and 72 °C for 45 s and a final extension of 72 °C for 10 min. The PCR protocols for \( rpb1 \), \( rpb2 \) and \( tef1 \) include initial denaturation at 94 °C for 2 min, followed by 35 cycles at 94 °C for 40 s, 60 °C for 40 s and 72 °C for 2 min and a final extension of 72 °C for 10 min. PCR products were purified and sequenced by the MB Mission Biotech Company (Taipei, Taiwan). Newly obtained sequences for each of the five markers were assembled and manually adjusted using BioEdit (Hall 1999) and then submitted to the DNA Data Bank of Japan (DDBJ) (http://www.ddbj.nig.ac.jp/; Table 1). We have verified the accuracy and identity of consensus sequences by comparing with sequences in GenBank (https://www.ncbi.nlm.nih.gov/genbank/).

**Phylogenetic analyses**

Two datasets were compiled for phylogenetic analyses: the ITS+nuc 28S+\( rpb1 \)+\( rpb2 \)+\( tef1 \) dataset was analysed to confirm the generic placement of target species within the phlebioid clade of Polyporales. The ITS dataset was used to get better resolutions on species level within the Hydnophanerochaete clade of Meruliaceae. The selection of strains and species for the 5-marker dataset was based on Binder et al. (2013), Flou-
Alignment was done with MAFFT v. 7 using two strategies: Q-INS-I for ITS and FFT-NS-I for nuc 28S, rpb1, rpb2 and tef1 (Katoh and Standley 2013). The resulting alignments were manually adjusted in Mega 7 (Kumar et al. 2016). Heterobasidion annosum (Fr.) Bref. and Stereum hirsutum (Willd.) Pers., belonging to Russulales Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David, were chosen as the outgroup in the 5-marker dataset. Phlebia coccineofulva Schwein., belonging to Meruliaceae, was assigned as the outgroup in the ITS dataset. Optimised datasets were deposited at TreeBASE (submission ID 22932).

The Bayesian Inference (BI) method was carried out for both datasets using MrBayes v. 3.2.6 (Ronquist et al. 2012). The Maximum Likelihood (ML) method was carried out for the 5-marker dataset using RAxML BlackBox (Stamatakis 2014). For the BI analyses, jModeltest 2.1.10 (Darriba et al. 2012) was first used to estimate separate models for each of the markers in both datasets, based on Akaike information criterion (AIC). The Markov chain Monte Carlo (MCMC) search was run for ten million generations, with four chains and trees sampled every 100 generations. The first twenty-five percent of trees were discarded as burn-in while the remaining trees were used to construct the fifty percent majority-rule consensus phylogram with posterior probabilities (PP). For the ML analysis, the best-scoring tree with proportional values of bootstrap (BS) was computed under a GTRGAMMA model with one thousand bootstrap replicates, followed by a thorough ML search. Gaps were treated as missing data. Branches were regarded as having statistical support if values of PP and/or BS were equal to or over 0.9 and 70%, respectively. Both BI and ML analyses were performed at the CIPRES Science Gateway (Miller et al. 2010; http://www.phylo.org/). Phylogenograms were visualised and edited in TreeGraph 2 (Stöver and Müller 2010) and Adobe Illustrator (Adobe Systems, Inc).

**Phylogeny results**

The final ITS+nuc 28S+rpb1+rpb2+tef1 dataset consisted of 126 sequences and 7253 characters (of which 43.7% were parsimony-informative) including gaps and the ITS dataset comprised 12 sequences and 887 characters (of which 7.7% were parsimony-informative) including gaps. In the BI analyses, since the GTR+G+I model was selected as the best model of nucleotide substitution for each of the five markers in the 5-marker dataset, it was used for the entire alignment with five partitions. The HKY+I+G model was selected as the best model of nucleotide substitution for the ITS dataset. The fifty percent majority-rule consensus phylogram with PP support values was reconstructed after the average standard deviation of split frequencies fell below 0.001. The best-scoring ML tree with BS support values was built. Phylogenetic trees of the 5-marker dataset, inferred from BI and ML algorithms, shared similar topologies and thus only the ML tree was shown (Fig. 1).
Figure 1. Phylogenetic tree inferred from Maximum Likelihood analysis of the combined ITS, nuc 28S, rpbi, rpb2 and tef1 sequences of taxa in Polyporales. Nodes are labelled with Maximum Likelihood bootstrap proportional values (BS) ≥ 70% and Bayesian Posterior Probabilities (PP) ≥ 0.9. Thickened branches obtained supports by both BS ≥ 80% and PP ≥ 0.95. The taxa studied in this study are shown in bold. The pale blue boxes indicate lineages of phanerochaetoid fungi within the phlebioid clade. Asterisks (*) represent for strains of generic type species. Scale bars = substitutions per site.
In the 5-marker analyses (Fig. 1), six main clades with high statistic supports (BS = 96–100%, PP = 1) could be recognised in the ingroup: the antrodia clade, the core polyporoid clade, the gelatoporia clade, the phlebioid clade, a residual clade and the skeletocutis-tyromyces clade. The phlebioid clade, which is the focus of this study,
included three main subclades recognised as three families (BS = 100%, PP = 1): Irpicaceae, Meruliaceae and Phanerochaetaceae. *Hydnophanerochaete odontoidea* formed a well-supported monophyletic lineage (BS = 100%, PP = 1) within Meruliaceae and was found to be closely related to a lineage consisting of strains of *Ceriporia alachuana* (Murrill) Hallenb, *Ceriporiopsis* spp., *Grammothelopsis puiggarii* (Speg.) Rajchenb. & J.E. Wright, *Hynophlebia* spp. and *Phlebia* spp. (BS = 86%, PP = 1). Sequences of *Odontoefibula orientalis* grouped together and formed a well-supported monophyletic lineage (BS = 98%, PP = 1) within the *Donkia* clade of Phanerochaetaceae (BS = 97%, PP = 1) and were most closely related to a lineage made up of strains of *Geliporus exilisporus* (Y.C. Dai & Niemelä) Yuan Yuan, Jia J. Chen & S.H. He and *Hyphodermella* spp. (BS = 98%, PP = 1).

The tree inferred from the ITS dataset (Fig. 2) showed that sequences of holotype (*CWN00776*) and paratype (*Wu 911206-38*) of *Phanerochaete subodontoidea* were clustered with sequences of *P. odontoidea* within a monophyletic lineage (PP = 1).

**Taxonomy**

*Hydnophanerochaete* Sheng H. Wu & C.C. Chen, gen. nov.

MycoBank No: MB824077

**Type species.** *Hydnophanerochaete odontoidea* (≡ *Phanerochaete odontoidea*).

**Etymology.** From hydnoid + *Phanerochaete*, referring to the hydnoid hymenial surface and a close affinity to *Phanerochaete*.

**Description.** Basidiocarps effused, adnate, ceraceous. Hymenial surface at first buff, with age turning ochraceous to pale brown, slightly tuberculate to grandinioid when young, becoming odontioid to hydnoid with age, without colour changes in KOH. Aculei conical to cylindrical, ca. 1–4 per mm, up to 700 μm long.

Hyphal system essentially monomitic; generative hyphae simple-septate. Subiculum fairly uniform, composed of a basal layer, with compact texture; generative hyphae somewhat horizontal, colourless, thick-walled; quasi-binding hyphae present near substratum, colourless. Hymenial layer thickening. Trama of aculei of compact texture; generative hyphae somewhat vertical, colourless, thick-walled. Cystidia lacking, but projecting hyphal ends in the hymenium may be present. Basidia clavate, 4-sterigmate. Basidiospores ellipsoid to cylindrical, smooth, thin-walled, inamylloid, non-dextrinoid, acyanophilous.

**Remarks.** *Hydnophanerochaete* is morphologically similar to the genus *Hydnophlebia* (Telleria et al. 2017). Both genera have resupinate basidiocarps with odontioid to hydnoid hymenial surface, a monomitic hyphal system, ordinarily simple-septate hyphae and similar basidiospore shape. However, we note three distinguishing differences. First, *Hydnophlebia* has membranaceous basidiocarps usually with rhizomorphic margin, while *Hydnophanerochaete* has ceraceous basidiocarps with fairly determinate margin. Second, occasional single or multiple clamp connections are present in sub-
Figure 2. The majority-rule consensus phylograms of the Bayesian Inference analysis of the ITS sequences of *Hydnophanerochaete odontoidea*. Nodes are labelled with Bayesian Posterior Probabilities ≥ 0.9. Scale bars = substitutions per site.

icular or aculei hyphae of *Hydnophlebia*, whereas they are lacking in hyphae of *Hydnophanerochaete*. Third, *Hydnophlebia* occasionally bears tubular to ventricose leptocystidia, which are lacking in *Hydnophanerochaete*.

Little morphological differences exist between *Hydnophanerochaete* and *Odontoefibula*: both genera have monomitic hyphal system with simple-septate hyphae and are lacking cystidia. However, *Hydnophanerochaete* is distinguished from *Odontoefibula* by its basidiocarps without colour change in KOH; additionally, its subiculum is compact, not dense.

*Phanerodontia* Hjortstam & Ryvarden, a recently proposed genus typified by *P. dentata* Hjortstam & Ryvarden (Hjortstam and Ryvarden 2010), is also morphologically similar to *Hydnophanerochaete*. However, the latter has a compact subiculum and quasi-binding hyphae near the substratum. *Phanerodontia* accommodates four species (*P. chrysosporium* (Burds.) Hjortstam & Ryvarden, *P. dentata*, *P. irpicoides* (Hjortstam) Hjortstam & Ryvarden and *P. magnoliae* (Berk. & M.A. Curtis) Hjortstam & Ryvarden), all of them possessing long leptocystidia (Hjortstam and Ryvarden 2010), whereas this structure is lacking in *Hydnophanerochaete*. Moreover, phylogenetically, strains of two species (*P. chrysosporium* and *P. magnoliae*) were recovered in Phanerochaetaceae which is only distantly related to *Hydnophanerochaete* (Fig. 1). However, the generic type has not been sequenced so far.

*Hydnophanerochaete odontoidea* (Sheng H. Wu) Sheng H. Wu & C.C. Chen, comb. nov.
MycoBank No: MB824078
Figs. 3a and 4

**Basionym.** *Phanerochaete odontoidea* Sheng H. Wu, Botanical Bulletin of the Academia Sinica 41: 169, 2000.
Synonym. *Phanerochaete subodontoidea* Sheng H. Wu, Botanical Bulletin of the Academia Sinica 41: 172, 2000.

Holotype. TAIWAN. Ilan: Fushan Botanical Garden, 24°46’N, 121°35’E, 600 m alt., on fallen branch of angiosperm, leg. S.H. Wu et al., 7 Aug 1991, *Wu 910807-11* (TNM F14816).

Description. Basidiocarps annual, effused, adnate, ceraceous, somewhat brittle, 50–200 μm thick in section (aculei excluded). Hymenial surface initially buff, with age turning ochraceous to pale brown, no colour changes in KOH, tuberculate to grandinoid when young, becoming odontioid to hydnoid with age, extensively cracked; margin paler to whitish, fairly determinate. Aculei conical to cylindrical, usually separate, with obtuse to acute apex, 1–4 per mm, up to 100–700 × 100–250 μm.

Hyphal system basically monomitic, some specimens with quasi-binding hyphae near substratum; generative hyphae simple-septate. Subiculum fairly uniform, composed of a basal layer of compact texture; generative hyphae mainly horizontal, colourless, 4–6 μm diam., with 0.8–1 μm thick walls; quasi-binding hyphae sometimes present near substratum, colourless, 1–3 μm diam. Hymenial layer thickening, with compact texture, generative hyphae somewhat vertical, colourless, 3–6 μm diam., slightly thick-walled. Trama of aculei of compact texture; generative hyphae mainly vertical, other features similar to those in subiculum; crystal masses present near apex. Cystidia lacking, but projecting hyphal ends in the hymenium may be present. Basidia clavate, 14–18 × 4.5–5.5 μm, 4-sterigate. Basidiospores narrowly ellipsoid to cylindrical, adaxially slightly concave, smooth, thin-walled, homogeneous, inamyloid, non-dextrinoid, acyanophilous, 6–8.1 × 2.5–3.3 μm (Table 2). See also Wu (2000) for descriptions and illustrations.

Habitat. On fallen branches of angiosperms or gymnosperms.

Distribution. Hitherto known from subtropical to temperate regions of China (Yunnan), Japan, Taiwan and Vietnam.

Additional specimens examined. CHINA. Yunnan: Deqing Tibetan Autonomous Prefecture, Deqin County, Xiayubeng Village, Shenhu Trail, 3500 m alt., on fallen branch of gymnosperm, leg. C.C. Chen, 14 Aug 2013, *GC 1308-45* (TNM F27660). JAPAN. Honshu: Nagano Prefecture, Nagano City, Myoko-Togakushi Renzan National Park, 36°45’35”N, 138°04’20”E, 1235 m alt., on branch of *Quercus* sp., leg. C.C. Chen & C. L. Chen, 29 July 2016, *GC 1607-20* (TNM F30785). TAIWAN. Chiayi: Yushan National Park, Nanhui Forest Road, 23°28’N, 120°54’E, 1850 m alt., on fallen branch of angiosperm, leg. S.H. Wu & S.Z. Chen, 13 Oct 1993, *Wu 9310-8* (paratype of *P. odontoidea*, TNM F14824); *Wu 9310-29* (TNM F14826); 1800 m alt., on fallen branch of angiosperm, leg. S.H. Wu & S.Z. Chen, 13 Jun 1996, *Wu 9606-55* (TNM F5085). Ilan: Fushan Botanical Garden, 24°46’N, 121°35’E, 650 m alt., on fallen branch of angiosperm, leg. S.H. Wu et al., 28 Jun 2002, *Wu 0106-35* (TNM F13460). Nantou: Tungpu Township, Leleku, 1450 m alt., on fallen rotten wood, leg. W.N. Chou, 13 Apr 1994, *CWN 00776* (holotype of *P. subodontoidea*, TNM F14836). Kaohsiung: Maolin District, Tona Nursery, 22°54’N, 120°44’E, 850 m alt., on fallen branch of angiosperm, leg. S.Z. Chen, 31 Mar 2005, *Chen 1376* (TNM F18764).
Figure 3. Basidiocarp surfaces a Hydnophanerochaete odontoidea (holotype of Phanerochaete subodontoidae, CWN 00776) b Odontoefibula orientalis (holotype, Wu 0910-57). Scale bar: 1 mm.

Figure 4. Hydnophanerochaete odontoidea (holotype of Phanerochaete subodontoidae, CWN 00776) a Part of the vertical section of subiculum near substratum b Quasi-binding hyphae. Scale bar: 5 μm (a–b).
Hydnophanerochaete and Odontoefibula, two new genera...

New Taipei: Chinshan District, Yangmingshan National Park, Yulu Historical Trail, 25°10’N, 121°35’E, 516 m alt., on fallen branch of angiosperm, leg. C.C. Chen, C.L. Wei, W.C. Chen & S. Li, 26 Aug 2015, WEI 15-309 (TNM F29370); WEI 15-348 (TNM F29384). Taichung: Chiapaotai, 850 m alt., on fallen branch of angiosperm, leg. S.H. Wu, 6 Dec 1991, Wu 911206-38 (paratype of P. subodontoidea, TNM F14818). VIETNAM. Lam Dong: Bi Doup Nui Ba National Park, 12°10’45"N, 108°40’48"E, 1447 m alt., on fallen branch of angiosperm, leg. C.C. Chen, 15 Oct 2017, GC 1710-59 (TNM F31365).

Remarks. Phanerochaete subodontoidea morphologically resembles Phanerochaete odontoidea, whereas they were distinguished merely based on the width of basidiospores [P. odontoidea: 2.6–3 μm vs. P. subodontoidea: 3–3.7 μm, Wu (2000)]. However, after carefully measuring the basidiospore size of available specimens of these two species, we found basidiospore ranges are highly overlapping (Table 2). Additionally, the ITS sequences of the holotype of P. subodontoidea (CWN 00776) is almost identical to the ITS sequences of the paratype of P. odontoidea (Wu 9310-8). We failed to obtain sequences from the holotype of P. odontoidea (Wu 910807-11), but Wu 9310-8 was confirmed as conspecific with the holotype by morphological comparison. Thus, based on morphological and molecular evidence (Fig. 2), P. subodontoidea is treated as a synonym of P. odontoidea. A paratype specimen named P. odontoidea (Wu 9311-46) probably belongs to the genus Flavodon Ryvarden based on preliminary BLAST results of nuc 28S sequences. However, this specimen was not included in this study.

Odontoefibula C.C. Chen & Sheng H. Wu, gen. nov.
MycoBank No: MB824075

Type species. Odontoefibula orientalis.

Etymology. From odonto (= tooth-like) + efibula (= without clamp connection), referring to the odontioid hymenial surface and simple-septate hyphae of the genus.

Description. Basidiocarps annual, resupinate, effused, adnate, membranaceous to ceraceous. Hymenial surface at first honey yellow, becoming ochraceous to pale brown with age, turning dark reddish in KOH, initially smooth to slightly tuberculate, becoming grandinioid to odontioid with age. Aculei conical to cylindrical, separate or fused, up to 0.3 mm long.

Hyphal system monomitic; hyphae normally simple-septate. Subiculum uniform, with dense texture; basal hyphae interwoven, somewhat horizontal or with irregular orientation, colourless, thin- to slightly thick-walled; subicular hyphae somewhat vertical, colourless, thin- to slightly thick-walled. Subhymenium not clearly differentiated from subiculum. Central trama of fairly dense texture; hyphae vertical, colourless, thin- to slightly thick-walled. Cystidia lacking, but projecting hyphal ends in the hymenium may be present. Basidia clavate to narrowly clavate, 4-sterigmate. Basidiospores ellipsoid, smooth, thin-walled, inamyloid, non-dextrinoid, acyanophilous.
Table 2. Aculei and basidiospore measurements of basidiocarps.

| Species                    | Specimens | Aculei (per mm) | Range (μm) | L (μm) | W (μm) | Q   | n  |
|----------------------------|-----------|-----------------|------------|--------|--------|-----|----|
| Hydnophanerochaete odontoidea | Chen 1376 | 1–3             | (6–) 6.3–7.3 (–7.5) ´ (2.5–) 2.8–3.3 (–3.5) | 6.8    | 3      | 2.2 | 30 |
|                            | CWN 00776-1† | 1–3          | (6–) 6.8–8 (–8.5) ´ (2.5–) 2.7–3.2 (–3.5) | 7.4    | 2.9    | 2.5 | 30 |
|                            | GC 1308-45† | 2–3           | (6.5–) 6.7–7.6 (–8) ´ (2.8–) 2.8–3.3 (–3.8) | 7.2    | 3.1    | 2.3 | 30 |
|                            | GC 1607-20 | 2–3           | (7–) 7.4–9 (–10) ´ (2.8–) 2.9–3.5 (–4) | 8.2    | 3.2    | 2.6 | 30 |
|                            | WEI 15-309 | 2–3           | (6–) 6.1–7 (–7.5) ´ (2.5–) 2.7–3 (–3.3) | 6.5    | 2.9    | 2.3 | 30 |
|                            | WEI 15-348 | 2–3           | 6–6.9 (–7.5) ´ (2.5–) 2.8–3.3 (–3.5) | 6.5    | 3      | 2.1 | 30 |
|                            | Wu 0106-35† | 2–3           | (6–) 6.4–7.8 (–8) ´ (2.5–) 2.8–3.1 (–3.3) | 7.1    | 2.9    | 2.4 | 30 |
|                            | Wu 910807-11† | 3–4        | (6–) 6.1–7 (–8) ´ (2.5–) 2.5–2.9 (–3.3) | 6.5    | 2.7    | 2.5 | 30 |
|                            | Wu 911206-38‡ | 2–3         | (6–) 6.3–7.7 (–8) ´ (2.8–) 2.9–3.2 (–3.5) | 7      | 3      | 2.3 | 30 |
|                            | Wu 9310-8 §, † | 2–4     | (6–) 6.5–8 (–8.5) ´ (2.5–) 2.8–3.2 (–3.5) | 7.2    | 3      | 2.4 | 30 |
|                            | Wu 9310-29 | 2–4           | (6–) 6.9–8.1 (–9) ´ (2.5–) 2.7–3.3 (–3.7) | 7.4    | 3      | 2.5 | 30 |
| Odontoefibula orientalis   | GC 1604-130† | 4–5          | (5–) 5.4–6.6 (–7) ´ (2.5–) 2.8–3.3 (–3.6) | 6      | 3.1    | 1.96| 30 |
|                            | GC 1703-76† | 4–5          | (5.5–) 5.8–7.4 (–8) ´ (3–) 3.2–3.9 (–4) | 6.6    | 3.5    | 1.85| 30 |
|                            | Wu 0805-59† | 3–5          | (5–) 5.1–6.2 (–7) ´ (2.5–) 2.9–3.4 (–3.6) | 5.6    | 3.2    | 1.79| 30 |
|                            | Wu 0807-53 | 3–6          | (5–) 5.4–6.4 (–7) ´ (3–) 3.1–3.7 (–4) | 5.9    | 3.4    | 1.71| 30 |
|                            | Wu 0910-57§, † | 3–6 | (5–) 5.4–6.1 (–6.5) (2.8–) 2.9–3.4 (–3.6) | 5.7    | 3.2    | 1.81| 30 |

† Holotype and paratype of Phanerochaete odontoidea.
‡ Holotype and paratype of P. subodontoidea.
§ Holotype of Odontoefibula orientalis.
†† Used in phylogenetic analyses of the 5-marker dataset.

Remarks. Phaneroites Hjortstam & Ryvarden, a monotypic genus introduced to accommodate P. subquercinus (Henn.) Hjortstam & Ryvarden, resembles Odontoefibula in having odontioid hymenial surface and a monomitic hyphal system with ordinarily simple-septate hyphae. However, Phaneroites is distinguished from Odontoefibula by having thin-walled subicular hyphae, a few clamped septa on hyphae next to the substratum and subcapitate cystidia (Hjortstam and Ryvarden 2010). Moreover, basidiocarps of Odontoefibula turn dark reddish in KOH, while this reaction was not reported from Phaneroites.

Odontoefibula orientalis C.C. Chen & Sheng H. Wu, sp. nov.
MycoBank No: 824076
Figs. 3b and 5

Holotype. CHINA. Beijing: Xiangshan Park, 39°59’N, 116°11’E, 70 m alt., on fallen trunk of Amygdalus davidiana (Carrière) de vos ex Henry, leg. S.H. Wu, 14 Oct 2009, Wu 0910-57 (TNM F23847).

Etymology. From orientalis (= Eastern world), where the specimens were collected.

Description. Basidiocarps annual, effused, adnate, membranaceous to subcereous, somewhat brittle, 200–400 μm thick in section (aculei excluded). The hymenial surface at first honey yellow, darkening to ochraceous to pale brown with age, turning
Hydnophanerochaete and Odontoefibula, two new genera...

...dark reddish in KOH, slightly tuberculate when young, becoming odontioid with age, extensively cracked; margin paler, thinning out, slightly filamentous. Aculei conical to cylindrical, usually fused at the base, with rounded to obtuse apex, 3–6 per mm, ca. 0.1–0.3 × 0.1–0.2 mm.

Hyphal system monomitic; hyphae simple-septate. Subiculum uniform, with dense texture, 200–300 μm thick; subicular hyphae somewhat vertical, colourless, 2.5–4 μm diam., 0.5–0.8 μm thick walls; hyphae near substratum interwoven, with irregular ori-

Figure 5. Odontoefibula orientalis (holotype, Wu 0910-57) a Profile of basidiocarp section b Part of the vertical section of trama c Basal hyphae d Subicular hyphae e Basidia f Basidiospores. Scale bars: 200 μm (a); 10 μm (c–d); 5 μm (e–f).
Entation, tortuous, colourless, irregularly swollen, 4–8 μm diam., 0.5–1 μm thick walls. Subhymenium not clearly differentiated from subiculum, with fairly dense texture, hyphae somewhat vertical, colourless, 3–4 μm diam., thin- to slightly thick-walled. Trama of aculei of dense texture; hyphae mainly vertical, other aspects similar to those in subiculum. Large crystal masses scattered throughout the section. Cystidia lacking, but projecting hyphal ends in the hymenium may be present. Basidia clavate to narrowly clavate, 25–40 × 6–7 μm, 4-sterigmate, often with small oily drops. Basidiospores ellipsoid, adaxially slightly concave, smooth, thin-walled, sometimes with small oily drops, inamylloid, non-dextrinoid, acyanophilous, 5.1–6.6 × 2.8–3.4 μm (Table 2).

**Habitat.** On fallen trunk of angiosperm (e.g. *Amygdalus*).

**Distribution.** Hitherto known from China (Beijing), Japan and Taiwan.

**Additional specimens examined (paratypes).** JAPAN. Honshu: Ibaraki Prefecture, Joso City, Mr. Ju-ichimen-yama, along Kinu-gawa River, on branch of *Prunus* sp., leg. S.H. Wu, 12 July 2008, *Wu 0807-53* (TNM F22091). TAIWAN. Pingtung: Laiyi Township, Pengjishan Trail, 22°30′52″N, 120°38′07″E, 248 m alt., on fallen trunk of angiosperm, leg. C.C. Chen, 25 Mar 2017, *GC 1703-76* (TNM F31460). Taichung: Hoping District, between 27–27.5 km of Dasyueshan Forestry Road, Yuanzueishan Trail, 1800 m alt., on fallen rotten trunk of angiosperm, leg. S.H. Wu, S.Z. Chen & Y.T. Wang, 22 May 2008, *Wu 0805-59* (TNM F22495). Hualien: Sioulin Township, Taroko National Park, Lushui Hiking Trail, 24°10′51″N, 121°30′10″E, 578 m alt., on fallen trunk of angiosperm, leg. C.C. Chen, 24 Apr 2016, *GC 1604-130* (TNM F31364).

**Discussion**

Our 5-marker phylogenetic analyses (Fig. 1) provided an updated taxonomic framework for evaluating generic placements of the target taxa of the phlebioid clade. The tree topologies are consistent with previous results (Wu et al. 2010; Floudas and Hibbett 2015; Justo et al. 2017; Papp and Dima 2017). Within the phlebioid clade, we recovered two monophyletic lineages of phanerochaetoid fungi (Fig. 1), which supports the status of the two genera erected here: *Hydnophanerochaete*, typified by *P. odontoidea*, is accommodated in Meruliaceae; *Odontoefibula*, typified by *O. orientalis*, is placed in *Donkia* clade of Phanerochaetaeae.

Phylogenetically, *Hydnophanerochaete* and *Odontoefibula* are independent from the nine lineages of phanerochaetoid fungi recognised by Floudas and Hibbett (2015) within the phlebioid clade: *Efibula, Hydnophlebia, Phaeophlebiopsis, “Phanerochaete” allantospora* Burds. & Gilb., *Phanerochaete* s.l., *Phanerochaete* s.s., *Phlebiopsis, Rhizochea* and *Scopuloides*. *P. allantospora* was not sampled in this study; it was placed in Irpicaceae, according to the study of Justo et al. (2017). Additionally, “*Phanerochaete* ginnisii” Sheng H. Wu represents another lineage of phanerochaetoid fungi that was not analysed in this study, nor in the study of Floudas and Hibbett
Hydnophanerochaete and Odontoefibula, two new genera...

This species was shown to be closely related to Phlebia centrifuga P. Karst (Wu et al. 2010).

The 5-marker phylogenetic analyses (Fig. 1) suggest a close relationship amongst Hydnophanerochaete odontoidea and the following taxa, which all have a monomitic hyphal system with simple-septate hyphae: Hydnophlebia, Ceriporia alachuana, Climacodon septentrionalis (Fr.) P. Karst. and Scopuloides rimosus (Cooke) Jülich. Like Hydnophanerochaete, Hydnophlebia and Scopuloides have an odontoioid to hydnoid hymenial surface. However, Hydnophlebia differs by its membraneous basidiocarps with rhizomorphic margin, occasional clamped subicular hyphae and the presence of tubular to ventricose leptocystidia (Telleria et al. 2017). Scopuloides differs by thick-walled encrusted cystidia and rather short, clavate basidia (Wu 1990). C. alachuana resembles H. odontoidea in lacking cystidia, but has a poroid hymenial surface (Ryvarden and Gilbertson 1993). C. septentrionalis has a hydnoid hymenial surface, but is clearly distinguished by its pileate basidiocarps and thick-walled encrusted cystidia (Maas Geesteranus 1971).

Quasi-binding hyphae, one of the diagnostic characters of H. odontoidea (Fig. 4), were first introduced by Wu (1990) to refer to narrow and much branched subicular hyphae with thin- to thick walls, found near the substrate. Wu (2000) omitted describing and illustrating the quasi-binding hyphae of P. odontoidea and P. subodontoidea. Quasi-binding hyphae have been reported from many species of diverse genera: Amenthelicium leoninum (Burds. & Nakasone) Sheng H. Wu, Crustodontia chrysocreas (Berk. & M.A. Curtis) Hjortstam & Ryvarden, Phlebiporia bubalina Jia J. Chen, B.K. Cui & Y.C. Dai, Phanerochaete ericina (Bourdot) J. Erikss. & Ryvarden, Pseudolagarobasidium calcarum (Cooke & Massee) Sheng H. Wu and Radulodon americanus Ryvarden (Wu 1990; Stalpers 1998; Chen and Cui 2014). In other words, this feature has a polyphyletic origin and does not seem to be very phylogenetically informative.

Within the Donkia clade (Fig. 1), systematic positions of two recently proposed taxa, Geliporus exilisporus and Hyphodermella poroides Y.C. Dai & C.L. Zhao, are confirmed in this study. Odontoefibula shares some ubiquitous features with the genera Donkia, Hyphodermella J. Erikss. & Ryvarden and Pirex Hjortstam & Ryvarden, many of which have ochraceous basidiocarps with odontoioid to hydnoid hymenial surfaces. However, to better illustrate the correspondence between molecular data and morphology, denser taxon sampling of this clade is necessary in the future.

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