FUSE

Fungal Systematics and Evolution

VOLUME 8
DECEMBER 2021
PAGES 65–80

doi.org/10.3114/fuse.2021.08.06

Hysterangiales revisited: expanded phylogeny reveals new genera and two new suborders

N. Davoodian[1*], T. Lebel[1,2], M.A. Castellano[3], K. Hosaka[4]

[1]Royal Botanic Gardens Victoria, South Yarra, VIC 3141, Australia
[2]Botanic Gardens and State Herbarium of South Australia, Adelaide, SA 5001, Australia; Royal Botanic Gardens Victoria, South Yarra, VIC 3141, Australia
[3]US Department of Agriculture Forest Service, Northern Research Station, Corvallis, OR 97331, USA
[4]National Museum of Nature and Science, Tsukuba, Ibaraki 305-0005, Japan (ORCID: 0000-0002-4469-8303)

*Corresponding author: Naveed.Davoodian@rbg.vic.gov.au

Key words:
atp6
Phallogaster
phylogenetics
tef1
Trappea

Abstract: *Hysterangiales* (*Phallomycetidae*, *Agaricomycetes, Basidiomycota*) is a diverse, nearly cosmopolitan order of predominantly hypogeous, sequestrate, ectomycorrhizal fungi. Expanding on previously published phylogenies, we significantly increased sampling of *Hysterangiales* specimens, emphasizing representatives from Australia. Using protein-coding genes *atp6* (adenosine triphosphate synthase subunit 6) and *tef1* (translation elongation factor 1-α), we recovered 26 provisional novel genera, and corroborated existing genera and families. Further, two new suborders (*Phallogastrineae subord. nov*. and *Hysterangineae subord. nov*.) and a new family (*Phallogastraceae fam. nov*.) are described, and three new combinations made to *Phallogaster*. Aspects of classification and biogeography are presented.

Citation: Davoodian N, Lebel T, Castellano MA, Hosaka K (2021). *Hysterangiales* revisited: expanded phylogeny reveals new genera and two new suborders. *Fungal Systematics and Evolution* **8**: 65–80. doi: 10.3114/fuse.2021.08.06
Received: 22 January 2021; **Accepted:** 9July 2021; **Effectively published online:** 29 July 2021
Corresponding editor: P.W. Crous

INTRODUCTION

Hysterangiales (*Phallomycetidae*, *Agaricomycetes, Basidiomycota*) was established in 2006 to accommodate a phylogenetically refined *Hysterangiaceae* and relatives (Hosaka *et al.* 2006). *Hysterangiales* comprises a wide array of predominantly hypogeous, sequestrate, ectomycorrhizal fungi, but some taxa in the basal lineage (*Phallogastraceae*) are epigeous and non-mycorrhizal. *Hysterangiales* possess a range of unusual morphologies (Fig. 1), such as basidiomes with a powdery spore mass (and often with a sterile core) in the *Mesophelliaceae* (Trappe *et al.* 1996), the gelatinized or cartilaginous gleba with translucent columella in *Gallaceaceae* and *Hysterangiaceae*, or the utricle-encased spores of many *Mesophelliaceae* and *Hysterangiaceae* (Castellano & Beever 1994; Fig. 2). Like many truffle-like fungi, *Hysterangiales* often have distinct odours, which attract small animals for spore dispersal via mycophagy (*e.g*. Fogel & Trappe 1978, Claridge & May 1994). The characteristics of being mostly hypogeous and nearly universally dependent on other organisms for dispersal, combined with their worldwide (excluding Antarctica) distribution and diversity, have led to the consideration of multiple biogeographic scenarios for *Hysterangiales*, ranging from ancient Pangaean vicariance to recent long-distance dispersal (Hosaka *et al.* 2008).

Hysterangiales taxa are remarkably abundant and highly diverse in Australia (a major impetus for the present study), particularly the endemic family *Mesophelliaceae*. Ectomycorrhizal *Myrtaceae* and *Nothofagaceae* species are the primary symbionts of *Hysterangiales* in Australasia. Another impetus for the present study is that numerous novel Australasian *Hysterangiales* taxa yet to be formally described have been known for over a decade but generic boundaries were not strongly supported (Hosaka 2005, Hosaka *et al.* 2006, 2008). We expanded on previous work initiated by Hosaka *et al.* (2006, 2008) by sampling extensively from Australian specimens, which corroborated known genera (both formally described and provisional) and families, and elucidated additional provisional novel genera.

MATERIALS AND METHODS

Collections referred to in this study are housed at various fungaria including AD, ATH, BRI, OSC, and MEL. Collections were initially sorted into morphotaxa based on macro- and micro-characters, and a broad selection of material encompassing as many genera as possible were then sampled for molecular analyses. This included some material from non-Australasian taxa that had not previously been sampled, to better support previous taxonomic hypotheses. Thin sections of fungal tissue were mounted in KOH, Melzers' reagent and occasionally Congo Red + KOH to examine peridium and glebal structure, and spore size, shape, presence of a utricle, and ornamentation. Imaging was completed using either an Olympus BX-52 microscope with DP-73 camera and measurement tools using Olympus cellSens standard (v. 1.16) or a Zeiss/Moticam 10 camera system.

Adenosine triphosphate synthase subunit 6 (*atp6*; mitochondrial) and translation elongation factor 1-α (*tef1*;

Fig. 1. Examples of a range of basidiome morphologies in *Hysterangiales*. **A–C**. *Phallogastraceae* **A.** "*Gen. prov*. 1" (AU, photo credit M. Castellano). **B.** *Phallogaster* (*Trappea*) *phillipsii* (photo credit N. Siegel). **C.** *Phallogaster saccatus* (photo credit D. Mitchell/B. Roody); **D–F.** *Gallaceaceae.* **D.** *Austrogautieria* sp. (NZ, photo credit K. Hosaka). **E.** *Gallacea eburnea* (photo credit N. Siegel). **F.** *Gallacea scleroderma* (photo credit N. Siegel); **G–I.** *Hysterangiaceae.* **G.** *Aroramyces* sp. (AU, photo credit M. Castellano). **H.** *Hysterangium* sp. (AU, photo credit Castellano). **I.** *Hysterangium* sp. (NZ, photo credit K. Hosaka); **J–L.** *Mesophelliaceae.* **J.** *Chondrogaster* sp. (photo credit M. Castellano). **K.** "*Gen. prov*. 3" (photo credit M. Castellano). **L.** *Mesophellia* sp. (photo credit D. Catcheside); **M–O.** *Mesophelliaceae.* **M.** *Nothocastoreum cretaceum* (photo credit D. Catcheside). **N.** *Castoreum radicatum* (photo credit M. Castellano). **O.** *Gummiglobus pachythrix* (photo credit M. Castellano). Scale bars = 10 mm.

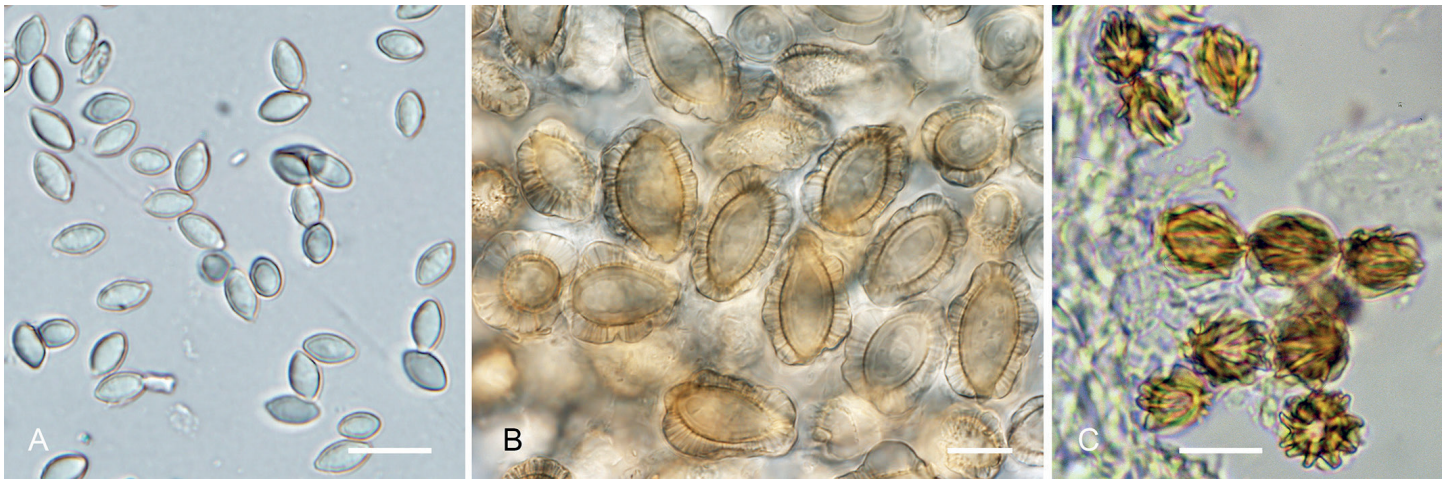


Fig. 2. Three spore types observed in *Hysterangiales*. **A.** *Mesophellia brevispora* (photo credit M. Castellano): smooth, no utricle. **B.** "*Genus prov.* 7" (photo credit N. Davoodian): ornamented, utricle present. **C.** *Austrogautieria* (photo credit T. Lebel): ribbed, no utricle. Scale bars = 10 µm.

nuclear) nucleotide sequence data for *Hysterangiales* available on GenBank were downloaded. Further, new *atp6* and *tef1* sequences were generated for 99 *Hysterangiales* specimens, as well as one specimen of *Phallales* and one specimen of *Cantharellales* to use as outgroup (Table 1). For these newly sequenced specimens, DNA was extracted from dried herbarium material with the E.Z.N.A. Forensic DNA Kit (Omega Bio-tek). A portion of the mitochondrial protein-coding gene *atp6* was PCR amplified with ATP6-3 and ATP6-2 primers (Kretzer & Bruns 1999) using the following cycling protocol: 95 °C for 5 min; 8 cycles of 94 °C for 35 s, 37 °C for 55 s, 72 °C for 60 s; 35 cycles of 72 °C for 60 s, 94 °C for 35 s, 45 °C for 55 s; 72 °C for 2 min. A portion of the nuclear protein-coding gene *tef1* was PCR amplified with *EF1*-983F and *EF1*-1567R, or *EF1*-1953R, primers (Rehner & Buckley 2005) using the following cycling protocol: 95 °C for 5 min; 10 cycles of 94 °C for 30 s, 65 °C for 60 s, 72 °C for 90 s; 30 cycles of 94 °C for 45 s, 55 °C for 60 s, 72 °C for 70 s; 72 °C for 5 min. Sanger sequencing was conducted in forward and reverse directions at the Australian Genome Research Facility (Melbourne, Victoria, Australia). Sequences are deposited in GenBank (Table 1).

Each gene was aligned using MAFFT online (Katoh *et al.* 2017), visually inspected, and manually adjusted as required. Phylogenetic analyses of each individual gene were conducted using the methods outlined in the next paragraph. Dendrograms from these analyses were then compared using PHYLO.IO (Robinson *et al.* 2016) to assess concordance. The topologies between each gene were found to be almost completely concordant at the generic level and below, corroborating all genera and species (with the exception of specimen H381 which appeared in different positions). Also, many relationships between genera were corroborated between *atp6* and *tef1*. In the individual gene analyses, higher taxonomic levels (e.g. family, suborder) were either not recovered or recovered with low support.

After the assessment of the individual gene phylogenies, *atp6* and *tef1* were concatenated, resulting in an alignment of 1 464 sites long with 223 terminals. MrBayesS v. 3.2.7a (Ronquist *et al*. 2012) was used via the CIPRES REST API (Miller *et al.* 2015) for Bayesian inference (BI) analysis. An analysis using default priors and the following parameters was run for 20 000 000 generations; nstopts: 6, nucmodelopts: 4by4, rateopts: gamma, nrunsval: 2, nchainsval: 4, tempval: 0.200, swapfreqval: 1, nswapsval: 1, samplefreqval: 1 000, burninfracval: 0.5, vparam.stopval: 0.003, sump_burninfrac: 0.5, sumpnruns: 2, sumt_burninfrac: 0.5, sumtnruns: 2, sumtntrees: 1. The average potential scale reduction factor reported for all parameters was 1.038. The alignment and resultant consensus phylogram is deposited in TreeBASE under study number 27527. To corroborate our topology and support values, we conducted additional separate analyses using different outgroup taxa (*Geastrales*), extended generations (ranging from 22 000 000 to 59 000 000), different models of rate variation among sites, and different partitions *i.e.* one partition, two partition (each gene), or multi-partition (codon positions for each gene, as well as introns for *tef1*) analyses. We also conducted maximum likelihood (ML) analysis using RAxML software (Stamatakis *et al*. 2008) via the CIPRES REST API with the following options; dna_gtrcat: GTRGAMMA, select_analysis: fa, choose_bootstrap: x, bootstrap_value: 1 000. Taxon names at individual terminals in the phylogram are field-based, verbatim identifications, from various mycologists.

RESULTS

The BI analysis recovered *Hysterangiales* (Bayesian posterior probability, bpp = 1) with the four constituent families *Gallaceaceae*, *Hysterangiaceae*, *Mesophelliaceae*, and *Phallogastraceae fam. nov*. (all bpp = 1), containing numerous described and undescribed genera (Supplementary Fig. S1, Fig. 3 - Parts 1,2,3). In total, 26 provisional undescribed genera were inferred (25 *Hysterangiales* and 1 *Phallales*). The results of the additional BI analyses and ML analysis were not substantively different from our primary BI analysis, corroborating all taxa indicated in Fig. 3 and Table 1. *Phallogastraceae* is accommodated by a newly established suborder, *Phallogastrineae* (described below, Fig. 3 - Part 1), and the families *Mesophelliaceae* (Fig. 3 - Part 1), *Hysterangiaceae* (Fig. 3 - Part 2) and *Gallaceae* (Fig. 3 - Part 3) are accommodated in the new suborder *Hysterangineae*. *Trappeaceae* is not in *Hysterangiales*, since the type species of *Trappea*, *T. darkeri*, is inferred to be in *Phallales* based on this and previous analyses (Hosaka *et al.* 2006, Sulzbacher *et al.* 2016; Fig. 3 - Part 3, Table 1). Neither *Trappea pinyonensis* nor *T. phillipsii* belong in *Trappea* given their position within *Phallogastraceae* (Xu & Luo 2003, Hosaka *et al.* 2006; Fig. 3 - Part 1); the combination to

Phallogaster is made here. It should be noted that true *Protubera* lies outside of *Hysterangiales*, since the type (*P. maracuja*) and related species belong in *Protophallaceae*, *Phallales* (Trierveiler-Pereira *et al.* 2014). Thus, *Protubera hautuensis*, *P. nothofagi*, and all other taxa appearing in Fig. 3 - Part 3) labelled as *Protubera* are not true members of the genus (this includes *P. canescens*, which is a synonym of *Ileodictyon gracile* in *Phallaceae*, *Phallales*).

Taxonomy

Order *Hysterangiales* K. Hosaka & Castellano

Phallogastrineae Castellano, T. Lebel, Davoodian & K. Hosaka, ***subord. nov.*** MycoBank MB 838485.

Basidiomes sequestrate, small (0.2 cm wide) to larger (up to 5 cm long and 3 cm wide), subglobose to irregularly subovoid, with a tapered to irregularly shaped base, single or caespitose, with white rhizomorphs (rhizomorphs sometimes discolouring pinkish). Basidiome surface smooth to velvety to finely tomentose, white to clay white (discolouring pinkish to salmon buff to reddish or faint lilac). *Peridium* 160–2 000 µm thick. *Columella* branched, whitish to semi-translucent, gelatinized. *Gleba* varies from green, olivaceous green, greyish olive to pale olive; gelatinized, loculate, locules small. *Basidia* clavate to narrowly clavate to irregularly cylindrical, thin-walled, hyaline, 6–8-spored. *Sterigmata* small to indistinct. *Spores* smooth, elongate-ellipsoid to oblong, thin-walled, utricle absent, hyaline singly, olive buff to honey yellow or pale green in mass. *Clamp connections* present.

Phylogenetic taxon definition of the suborder: The largest crown clade containing *Phallogaster saccatus* Morgan 1893, but not *Hysterangium clathroides* Vittad. 1831, *Mesophellia arenaria* Berk. 1857, and *Gallacea scleroderma* (Cooke) Lloyd 1905. This is a maximum crown-clade definition (Hibbett *et al.* 2018).

Type family: Phallogastraceae Castellano, T. Lebel, Davoodian & K. Hosaka *non Phallogastraceae* Locq., *De Taxia Fungorum*: *I. Syllabus* **1A**: 56. 1974.

Phallogastraceae Castellano, T. Lebel, Davoodian & K. Hosaka, ***fam. nov.*** MycoBank MB 838484.

Basidiomes sequestrate, small (0.2 cm wide) to larger (up to 5 cm long and 3 cm wide), subglobose to irregularly subovoid, with a tapered to irregularly shaped base, single or caespitose, with white rhizomorphs (rhizomorphs sometimes discolouring pinkish). Basidiome surface smooth to velvety to finely tomentose, white to clay white (discolouring pinkish to salmon buff to reddish or faint lilac). *Peridium* 160–2 000 µm thick. *Columella* branched, whitish to semi-translucent, gelatinized. *Gleba* varies from green, olivaceous green, greyish olive to pale olive; gelatinized, loculate, locules small. *Basidia* clavate to narrowly clavate to irregularly cylindrical, thin-walled, hyaline, 6–8-spored. *Sterigmata* small to indistinct. *Spores* smooth, elongate-ellipsoid to oblong, thin-walled, utricle absent, hyaline singly, olive buff to honey yellow or pale green in mass. *Clamp connections* present. *Odour* sometimes fetid. Species apparently saprotrophic, occurring on decaying wood or leaves, or partially buried in litter.

Type genus: *Phallogaster* Morgan, *J. Cincinnati Soc. Nat. Hist.* **15**: 171. 1893.

Notes: *Phallogastraceae* Locq. (1974) is invalid in accordance with Art. 39:1 of the Shenzen code. This is the only clade in *Hysterangiales* with an apparently non-mycorrhizal habit. Although the number of taxa is thus far very limited, the phylogenetic relationships within the family/suborder strongly indicate reciprocal monophyly of the Northern Hemisphere ("*Phallogaster* clade") and Southern Hemisphere clades ("*Gen. prov*. 1") (Fig. 3 - Part 1).

In addition to a traditional morphology-based description for the corresponding suborder (*Phallogastrineae subord. nov.*), we have also applied a phylogenetic taxon definition for the suborder (see Hibbett *et al.* 2018). More taxon sampling in the future may require further amendment of the morphological definition of the suborder, whereas our phylogenetic taxon definition of *Phallogastrinae* will remain stable.

Phallogaster pinyonensis (States) K. Hosaka, Castellano, Davoodian & T. Lebel, ***comb. nov.*** MycoBank MB 838487.
Basionym: *Trappea pinyonensis* States, *Mycotaxon* **41**: 128. 1991. MycoBank MB 129849.

Typus: **USA**, Arizona, Walnut Canyon National Monument, Coconino County, on sandy soil under *Pinus edulis*, 10 Oct. 1986, *J. States* AHF-530 (**holotype** ASC).

Phallogaster phillipsii (Harkn.) K. Hosaka, Castellano, Davoodian & T. Lebel, ***comb. nov.*** MycoBank MB 840085.
Basionym: *Hysterangium phillipsii* Harkn., *Proceedings of the California Academy of Sciences* **1**(8): 255. 1899. MycoBank MB 187085.
Synonym: *Trappea phillipsii* (Harkn.) Castellano, *Mycotaxon* **38**: 7. 1990. MycoBank MB 127551.

Typus: **USA**, California, Wire Bridge, Placer County, in soil, associated with *Quercus*, Jan. 1899, *C.L. Phillips* (Harkness 234, **holotype** BPI)

Notes: Although the species was not included in the phylogenetic analysis in this study, it has clearly been demonstrated to be the sister taxon to *Phallogaster* (*Trappea) pinyonensis* by Hosaka *et al.* (2006). Its basidiome surfaces stain pinkish when bruised, which is also a common characteristic with other species in the genus *Phallogaster*.

Excluded taxa

Trappea cinnamomea A-S. Xu & D.Q. Luo, *Mycosystema* **22**: 192. 2003. MycoBank MB 489004.

Notes: Based on the original description of *T. cinnamomea* (Xu & Luo 2003), its basidiome surfaces have the staining reaction to pink, which is similar to *Trappea phillipsii* and *T. pinyonensis*. However, we so far have no access to the specimens and no DNA data from the species are currently available. Until more definitive evidence becomes available, we keep this taxon in the genus *Trappea*.

Hysterangineae Castellano, T. Lebel, Davoodian & K. Hosaka, ***subord. nov.*** MycoBank MB 838486.

Basidiomes sequestrate, hypogeous or epigeous, and can be small (0.1 cm wide) to larger (up to 10 cm wide), subglobose to

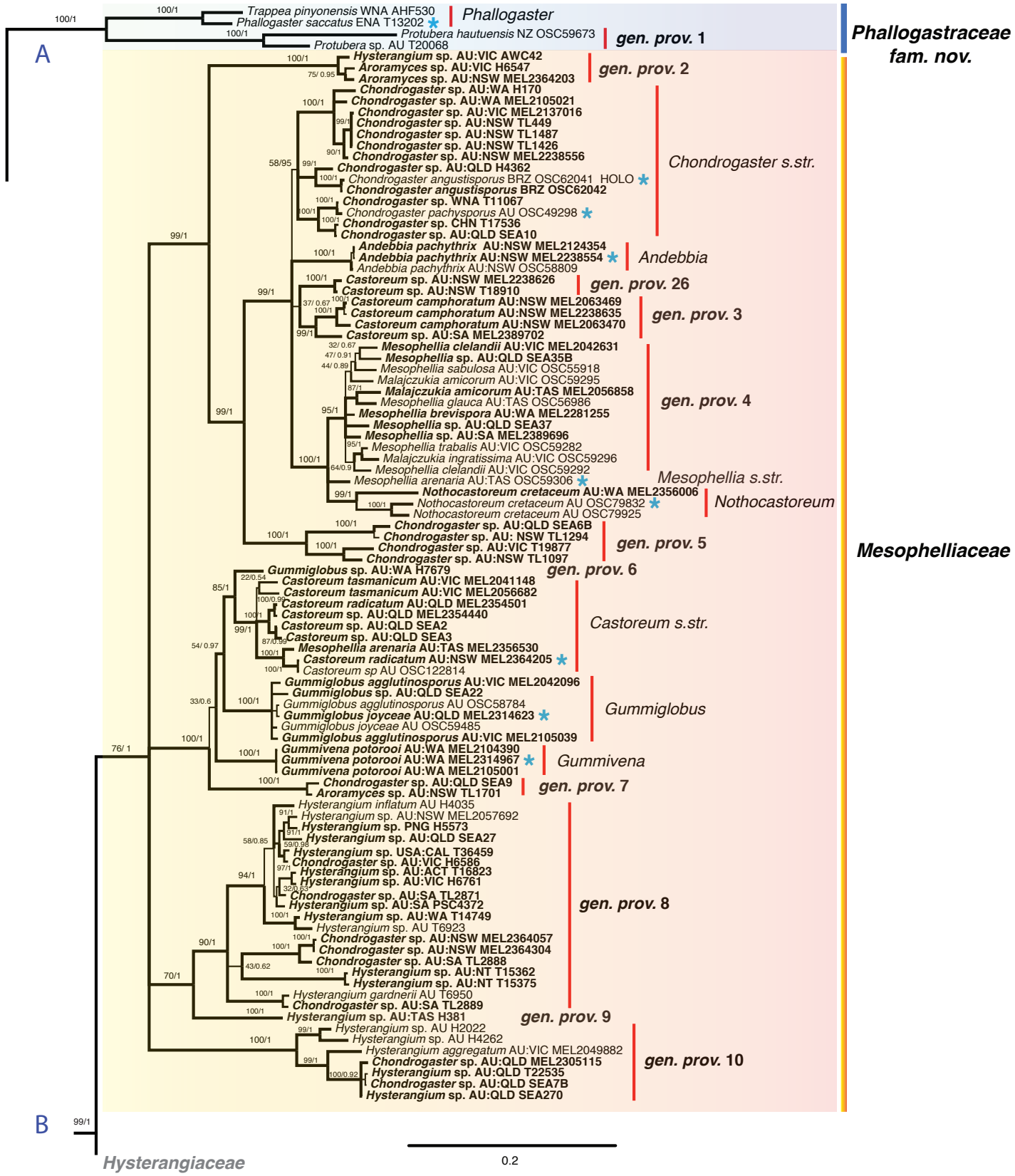


Fig. 3. Part 1. Phylogram from Bayesian analysis showing families and genera within *Hysterangiales*. Node A indicates *Phallogastrineae subord. nov.*; node B indicates *Hysterangineae subord. nov*. Maximum likelihood (ML) bootstrap values / Bayesian posterior probabilities (bpp) are shown at the nodes. The scale bar shows substitutions per site. Where bpp ≥ 0.95 and ML bootstrap ≥ 70%, branches are thickened. Type species indicated by a blue asterisk *. The asterisk in parentheses (*) denotes *Ileodictyon,* the currently accepted genus for *Protubera canescens*. Australian (AU) States and Territories indicated by: WA (Western Australia), NT (Northern Territory), QLD (Queensland), NSW (New South Wales), VIC (Victoria), TAS (Tasmania), SA (South Australia). United States (USA) states indicated by: ARIZ (Arizona), CAL (California), COL (Colorado), ID (Idaho), OR (Oregon). Other geographic areas indicated as follows: NZ (New Zealand), NewCal (New Caledonia), PNG (Papua New Guinea), BRZ (Brazil), MEX (Mexico), WNA (western North America), ENA (eastern North America), CHN (China), Guyana (Guyana), SSA (southern South America), NSA (northern South America), ASIA (Asia), SEASIA (southeast Asia), SING (Singapore), THAI (Thailand), IND (India), EUR (Europe), COSTA (Costa Rica), ZIMB (Zimbabwe).

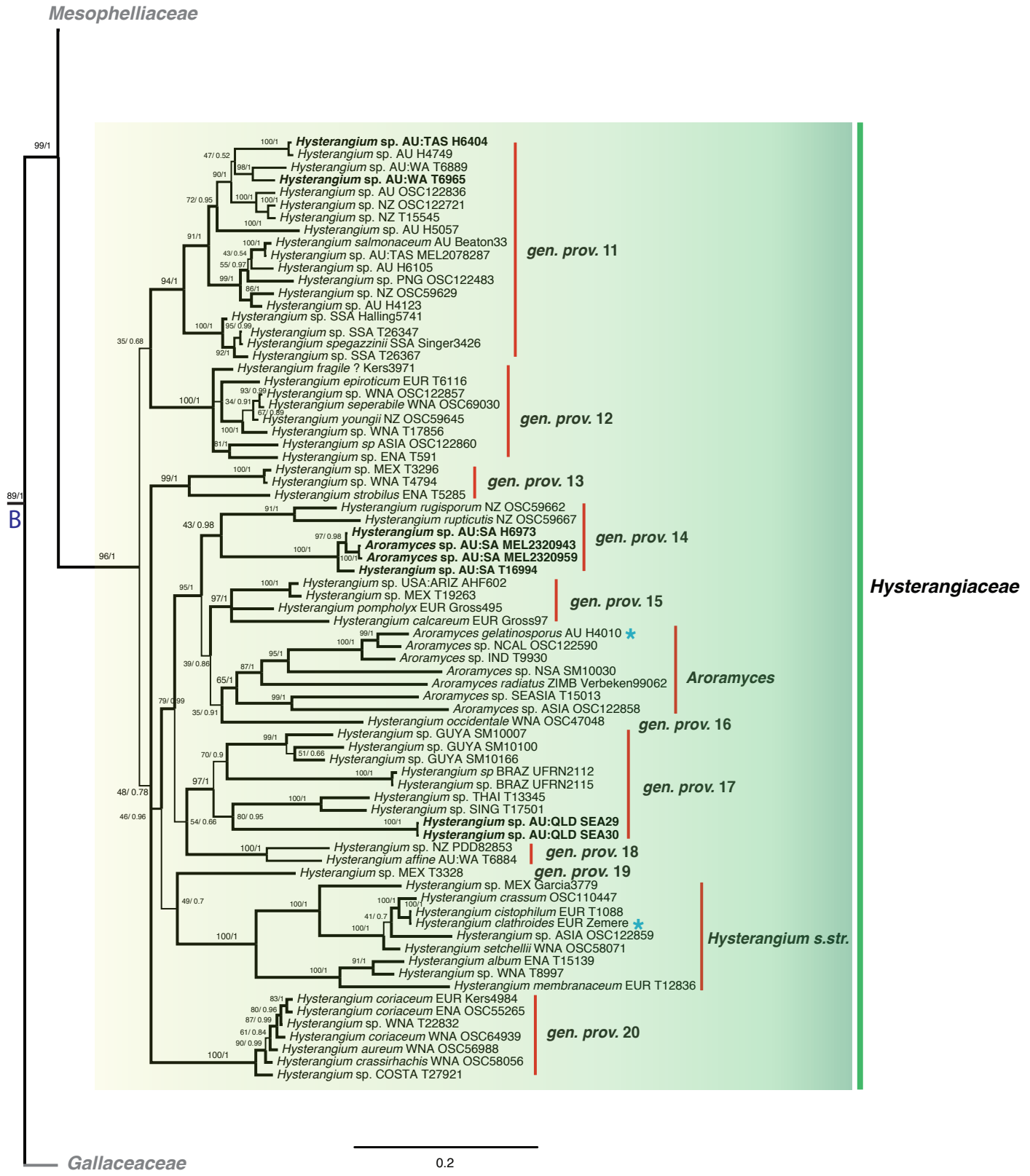


Fig. 3. (Continued) - Part 2.

irregularly subovoid without tapered base, single or gregarious, often covered with adhering sand and soil or encased in debris and rootlets, usually with conspicuous white to off-white rhizomorphs at base or along sides of basidiomata. Basidiome surface smooth to velvety to finely tomentose, often white to off-white in colour and often discolouring pinkish, reddish, yellowish or brownish, but purple to violet in some species. Peridium adherent to often readily separable from gleba, elastic, glutinous or hard and brittle, 1–4-layered, sometimes incorporating mycorrhizae. *Columella* branched, whitish to semi-translucent and gelatinized or a soft to corky or rubbery central core or lacking such structures. *Gleba* varies from green, olivaceous green, greyish olive, brown to ochraceous or pinkish; gelatinous to cartilaginous or with a powdery spore mass at maturity, often with labyrinthine to elongated to circular locules. *Basidia* clavate to narrowly clavate to irregularly cylindrical,

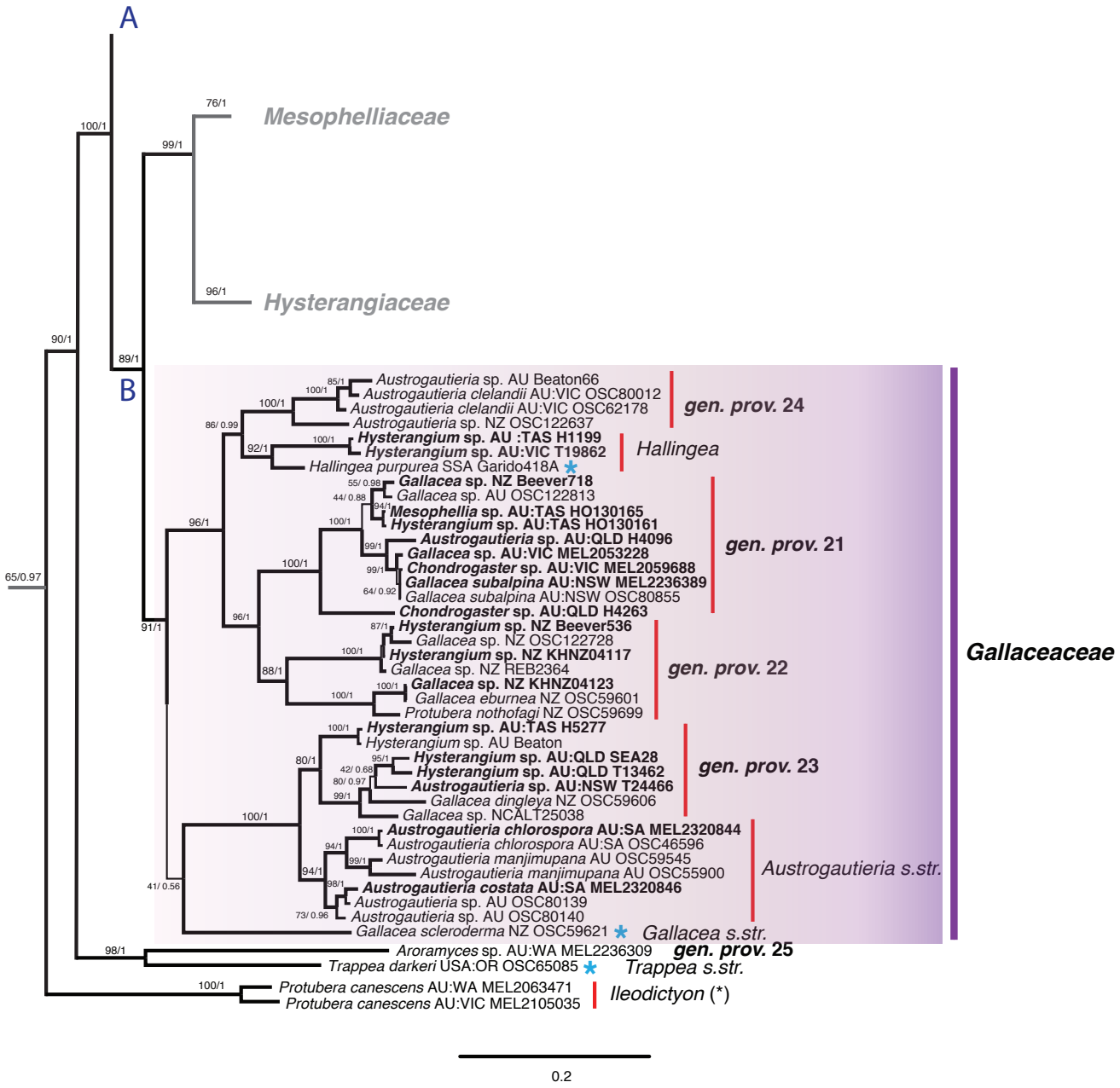


Fig. 3. (Continued) - Part 3.

thin-walled, hyaline, mostly 4-spored. *Spores* ellipsoid to oblong to fusoid, smooth to minutely verrucose or with long spines beneath a utricle, or sometimes with longitudinal ridges, thin- to thick-walled, often covered with a wrinkled to inflated or ephemeral utricle, hyaline, pale green, or brown in KOH, inamyloid, sometimes weakly dextrinoid. *Odour* faint, fetid, or sometimes sweet. *Clamp connections* present or absent. All species are presumably ectomycorrhizal with various vascular plants including *Dipterocarpaceae, Fagaceae, Myrtaceae, Nothofagaceae*, and *Pinaceae*.

Phylogenetic taxon definition of the suborder: The largest crown clade containing *Hysterangium clathroides* Vittad. 1831, but not *Phallogaster saccatus* Morgan 1893. This is a maximum crown-clade definition (Hibbett *et al*. 2018).

Type family: Hysterangiaceae E. Fisch., in Engler & Prantl, *Nat. Pflanzenfam.*, Teil. I (Leipzig): 304. 1899. [1900]

Notes: The *Hysterangineae* is exclusively composed of sequestrate taxa which are ectomycorrhizal with various vascular plants insofar as inferred from available studies. Most species in *Hysterangineae* have rather specific ectomycorrhizal hosts, usually restricted to a single plant family. For example, species distributed in the Southern Hemisphere are associated with *Myrtaceae* (mostly with *Eucalyptus* spp. and/or *Kunzea*/*Leptospermum* spp.) or *Nothofagaceae* (Castellano & Beever 1994, Hosaka *et al*. 2008).

This suborder is much more speciose than *Phallogastrineae* and many more new species, especially from Australia, remain to be described for all three families, *i.e*., *Hysterangiaceae, Mesophelliaceae* and *Gallaceaceae*. We believe that the family-level phylogeny is robust (Fig. 3, Supplementary Fig. S1), but more taxon sampling in the future may require further amendment of the morphological definition of the suborder. Therefore, as is the case for *Phallogastrineae*, we have also applied a phylogenetic taxon definition approach as summarized by Hibbett *et al.* (2018).

Table 1. Tabulation of specimens and sequences used in this study. Clade names are from Fig. 3. Generic names (genus verbatim determination) without a species name (species verbatim determination) are based on field identification; collections with species names (species verbatim determination) were examined micromorphologically. Australian (AUS) States and Territories indicated by: WA (Western Australia), NT (Northern Territory), QLD (Queensland), NSW (New South Wales), VIC (Victoria), TAS (Tasmania), SA (South Australia). Extra-Australian areas are indicated in bold. United States (USA) states indicated by: AZ (Arizona), CA (California), CO (Colorado), ID (Idaho), OR (Oregon). Other geographic areas indicated as follows: NZ (New Zealand), NEWCAL (New Caledonia), PNG (Papua New Guinea), BRZ (Brazil), MEX (Mexico), WNA (western North America), ENA (eastern North America), CHN (China), GUYANA (Guyana), SSA (southern South America), NSA (northern South America), ASIA (Asia), SEASIA (southeast Asia), SING (Singapore), THAI (Thailand), IND (India), EUR (Europe), COSTA (Costa Rica), ZIMB (Zimbabwe). Novel DNA sequences generated for this study are indicated by GenBank accessions in **bold**.

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
Cantharellaceae	*Cantharellus*	sp.	TL2893	SA	**MT828543**	**MW302303**	*Cantharellaceae*	(*Cantharellales*)
Geastrum	*Geastrum*	*fimbriatum*	OSC60730	USA - OR	DQ218887	DQ219226	*Geastraceae*	(*Geastrales*)
	Geastrum	*floriforme*	OSC29328	USA - CO	DQ218769	DQ219227	*Geastraceae*	(*Geastrales*)
	Geastrum	*fornicatum*	MEL2087743	NSW	DQ218888	DQ219228	*Geastraceae*	(*Geastrales*)
	Geastrum	*pectinatum*	MEL2096557	VIC	DQ218889	DQ219229	*Geastraceae*	(*Geastrales*)
	Geastrum	*recolligens*	OSC41996	USA - ID	DQ218770	DQ219230	*Geastraceae*	(*Geastrales*)
Geastrum (*Radiigera*)	*Radiigera*	*fuscogleba*	OSC58979	—	DQ218896	DQ219234	*Geastraceae*	(*Geastrales*)
Gen. prov. 25 Lebel & Davoodian	*Aroramyces*	sp.	MEL2236309	WA	**MW438321**	**MW302302**	*Trappeaceae*	(*Phallales*)
Trappea	*Trappea*	*darkeri*	OSC65085	USA - OR	DQ218938	DQ219292	*Trappeaceae*	(*Phallales*)
Ileodictyon	*Protubera* [*Ileodictyon*]	*canescens* [*gracile*]	MEL2063471	WA	DQ218931	DQ219283	*Clathraceae*	(*Phallales*)
	Protubera [*Ileodictyon*]	*canescens* [*gracile*]	MEL2105035	VIC	DQ218932	DQ219284	*Clathraceae*	(*Phallales*)
Phallogaster	*Trappea*	*pinyonensis*	AHF530	WNA	DQ218884	DQ219221	*Phallogastraceae*	*Phallogastrineae* (*Hysterangiales*)
	Phallogaster	*saccatus*	T13202	ENA	DQ218882	DQ219217	*Phallogastraceae*	*Phallogastrineae* (*Hysterangiales*)
Gen. prov. 1 Hosaka	*Protubera*	sp.	T20068	AUS	DQ218883	DQ219220	*Phallogastraceae*	*Phallogastrineae* (*Hysterangiales*)
	Protubera	*hautuensis*	OSC59673	NZ	DQ218801	DQ219218	*Phallogastraceae*	*Phallogastrineae* (*Hysterangiales*)
Gen. prov. 24 Castellano & Hosaka	*Austrogautieria*	sp.	Beaton66	AUS	DQ218820	DQ219133	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	sp.	OSC122637	NZ	DQ218819	DQ219132	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	*clelandii*	OSC62178	VIC	DQ218816	DQ219126	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	*clelandii*	OSC80012	VIC	DQ218817	DQ219127	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
Hallingea	*Hallingea*	*purpurea*	Garido418A	SSA	n/a	DQ219145	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H1199	TAS	**MW449866**	**MW302288**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	indet.		T19862	VIC	**MW048610**	**MW302289**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 21 Hosaka	*Austrogautieria*	sp.	H4096	QLD	**MW417403**	**MW302309**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	MEL2059688	VIC	**MW048613**	**MW302306**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	H4263	QLD	**MW048615**	**MW302290**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	sp.	Beever718	NZ	**MW449882**	**MW302308**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	sp.	OSC122813	AUS	DQ218829	DQ219144	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	sp.	MEL2053228	VIC	**MW048612**	**MW264846**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)

Table 1. (Continued).

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
	Gallacea	*subalpina*	MEL2236389	NSW	**MW048614**	**MW302307**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	*subalpina*	OSC80855	NSW	DQ218827	DQ219142	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	HO130161	TAS	**MW438331**	**MW302304**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	sp.	HO130165	TAS	**MW048611**	**MW302305**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 22 Castellano	*Gallacea*	sp.	OSC122728	NZ	DQ218828	DQ219143	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	sp.	REB2364	NZ	DQ218825	DQ219140	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	sp.	KHNZ04123	NZ	**MW449865**	**MW302293**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	*eburnea*	OSC59601	NZ	DQ218766	DQ219138	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	Beever536	NZ	**MW417402**	**MW302291**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	KHNZ04117	NZ	**MW438330**	**MW302292**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Protubera	*nothofagi*	OSC59699	NZ	AY574786	DQ219219	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 23 Hosaka	*Austrogauteria*	sp.	T24466	NSW	**MW438326**	**MW302299**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	sp.	T25038	NEWCAL	DQ218826	DQ219141	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Gallacea	*dingleyae*	OSC59606	NZ	DQ218824	DQ219137	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H5277	TAS	**MW048616**	**MW302294**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	SEA28	QLD	**MW438329**	**MW302297**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T13462	QLD	**MW048617**	**MW302298**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	KandGBeaton	AUS	DQ218790	DQ219174	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
Austrogautieria	*Austrogautieria*	sp.	OSC80139	AUS	DQ218763	DQ219130	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	sp.	OSC80140	AUS	DQ218764	DQ219131	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	*chlorospora*	MEL2320844	SA	**MW048618**	**MW302295**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	*chlorospora*	OSC46596	AUS	DQ218761	DQ219125	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	*costata*	MEL2320846	SA	**MW438327**	**MW302296**	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	*manjimupana*	OSC55900	AUS	DQ218818	DQ219128	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
	Austrogautieria	*manjimupana*	OSC59545	AUS	DQ218762	DQ219129	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
Gallacea	*Gallacea*	*scleroderma*	OSC59621	NZ	AY574787	DQ219139	*Gallaceaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 11 Hosaka	*Hysterangium*	sp.	H6404	TAS	**MW417406**	**MW302282**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 11 Hosaka	*Hysterangium*	sp.	Halling5741	SSA	DQ218781	DQ219158	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 11 Hosaka	*Hysterangium*	sp.	T26347	SSA	DQ218873	DQ219204	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T26367	SSA	DQ218874	DQ219205	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	OSC122836	AUS	DQ218865	DQ219196	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)

Table 1. (Continued).

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
	Hysterangium	sp.	T15545	NZ	DQ218837	DQ219161	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H4123	AUS	DQ218845	DQ219176	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H4749	AUS	DQ218861	DQ219192	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H5057	AUS	DQ218862	DQ219193	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H6105	AUS	DQ218864	DQ219195	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	MEL2078287	TAS	DQ218843	DQ219173	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	OSC122483	PNG	DQ218867	DQ219198	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	OSC122721	NZ	DQ218866	DQ219197	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	OSC59629	NZ	DQ218853	DQ219184	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	"irregular"	T6965	WA	**MW438322**	**MW302283**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*"rhodocarpum"*	T6889	WA	DQ218858	DQ219189	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*salmonaceum*	Beaton33	AUS	DQ218785	DQ219165	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*spegazzinii*	Singer3426	SSA	DQ218787	n/a	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 12 Castellano	*Hysterangium*	sp.	OSC122857	WNA	DQ218851	DQ219182	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	OSC122860	ASIA	DQ218860	DQ219191	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T17856	WNA	DQ218857	DQ219188	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T591	ENA	DQ218840	DQ219170	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*epiroticum*	T6116	EUR	DQ218779	DQ219155	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*fragile*	Kers3971	—	DQ218780	DQ219156	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*separabile*	OSC69030	WNA	DQ218786	DQ219166	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*youngii*	OSC59645	NZ	DQ218789	DQ219169	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 13 Castellano	*Hysterangium*	sp.	T3296	MEX	DQ218842	DQ219172	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T4794	WNA	DQ218846	DQ219177	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*strobilus*	T5285	ENA	DQ218788	DQ219168	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 14 Lebel	*Aroramyces*	sp.	MEL2320943	SA	**MW218374**	**MW302286**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	sp.	MEL2320959	SA	**MW218375**	**MW302287**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*rugisporum*	OSC59662	NZ	DQ218784	DQ219164	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*rupticutis*	OSC59667	NZ	DQ218838	n/a	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterogaster	sp.	H6973	SA	**MW218372**	**MW302284**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterogaster	sp.	T16994	VIC	**MW218373**	**MW302285**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 15 Castellano	*Hysterangium*	sp.	AHF602	USA - AZ	DQ218854	DQ219185	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)

Table 1. (Continued).

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
	Hysterangium	sp.	T19263	MEX	DQ218849	DQ219180	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*calcareum*	Gross97	EUR	DQ218776	DQ219149	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*pompholyx*	Gross495	EUR	DQ218783	DQ219163	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Aroramyces	*Aroramyces*	*gelatinosporus*	H4010	AUS	DQ218809	DQ219118	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	*radiatus*	Verbeken99062	ZIMB	DQ218810	DQ219119	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	sp.	OSC122590	NEWCAL	DQ218814	DQ219123	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	sp.	OSC122858	ASIA	DQ218813	DQ219122	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	sp.	SM10030	NSA	DQ218815	DQ219124	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	sp.	T15013	SEASIA	DQ218811	DQ219120	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	sp.	T9930	IND	DQ218812	DQ219121	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 16 Lebel & Castellano	*Hysterangium*	*occidentale*	OSC47048	WNA	AY574825	DQ219162	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 17 Lebel & Castellano	*Hysterangium*	sp.	SEA29	QLD	**MW438328**	**MW302300**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	SEA30	QLD	**MW438323**	**MW302301**	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	SM10007	GUYANA	DQ218869	DQ219200	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	SM10100	GUYANA	DQ218870	DQ219201	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	SM10166	GUYANA	DQ218871	DQ219202	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T13345	THAI	DQ218872	DQ219203	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T17501	SING	DQ218841	DQ219171	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	UFRN2112	BRZ	LT635647	LT635645	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	UFRN2115	BRZ	LT635648	LT635646	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 18 Castellano & Lebel	*Hysterangium*	sp.	PDD82853	NZ	DQ218868	DQ219199	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*affine*	T6884	AUS	DQ218831	n/a	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 19 Castellano	*Hysterangium*	sp.	T3328	MEX	DQ218852	DQ219183	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Hysterangium	*Hysterangium*	sp.	Garcia3779	MEX	DQ218847	DQ219178	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	OSC122859	ASIA	DQ218859	DQ219190	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T8997	WNA	DQ218876	DQ219207	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*album*	T15139	ENA	DQ218774	DQ219147	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*cistophilum*	T1088	EUR	DQ218777	DQ219150	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*clathroides*	Zemere	EUR	DQ218832	DQ219151	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*crassum*	OSC110447	—	AY574827	DQ219154	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*membranaceum*	T12836	EUR	DQ218782	DQ219160	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)

Table 1. (Continued).

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
	Hysterangium	*setchellii*	OSC58071	WNA	DQ218839	DQ219167	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 20 Castellano	*Hysterangium*	sp.	T22832	WNA	DQ218850	DQ219181	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T27921	COSTA	DQ218875	DQ219206	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*aureum*	OSC56988	WNA	DQ218775	DQ219148	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*coriaceum*	Kers4984	EUR	DQ218833	n/a	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*coriaceum*	OSC55265	ENA	DQ218834	n/a	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*coriaceum*	OSC64939	WNA	AY574826	DQ219152	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*crassirhachis*	OSC58056	WNA	DQ218778	DQ219153	*Hysterangiaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 2 Lebel	*Aroramyces*	sp.	H6547	VIC	**MW417410**	**MW302213**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Aroramyces	sp.	MEL2364203	NSW	**MW417417**	**MW302214**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	AWC42	VIC	**MW417411**	**MW302212**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Chondrogaster	*Chondrogaster*	sp.	H170	WA	**MW438325**	**MW302215**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	H4362	QLD	**MW449881**	**MW302217**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	MEL2137016	VIC	**MW417412**	**MW302218**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL449	NSW	**MW417415**	**MW302219**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL1487	NSW	**MW417414**	**MW302220**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL1426	NSW	**MW417413**	**MW302221**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	T17536	CHN	**MW449874**	**MW302224**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	SEA10	QLD	**MW449868**	**MW302225**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	T11067	WNA	**MW438324**	**MW302223**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	MEL2238556	NSW	**MW417405**	**MW302226**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	*angustisporus*	MEL2105021	WA	**MW417407**	**MW302216**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	*angustisporus*	OSC62041	BRZ	DQ218822	DQ219135	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	*angustisporus*	OSC62042	BRZ	**MW449876**	**MW302222**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	*pachysporus*	OSC49298	AUS	DQ218823	DQ219136	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Andebbia	*Andebbia*	*pachythrix*	MEL2124354	NSW	**MW449879**	**MW302227**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Andebbia	*pachythrix*	MEL2238554	NSW	**MW449880**	**MW302228**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Andebbia	*pachythrix*	OSC58809	NSW	DQ218808	DQ219117	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 26 Castellano	*Castoreum*	sp.	MEL2238626	NSW	**MW449869**	**MW302229**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	sp.	T18910	NSW	**MW417409**	**MW302230**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 3 Castellano	*Castoreum*	sp.	MEL2389702	SA	**MW417408**	**MW302241**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)

Table 1. (Continued).

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
	Castoreum	*camphoratum*	MEL2063469	NSW	**MW417404**	**MW302231**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	*camphoratum*	MEL2238635	NSW	**MW417416**	**MW302232**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	*camphoratum*	MEL2063470	NSW	**MW449877**	**MW302233**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 4 Castellano & Lebel	*Malajczukia*	*amicorum*	MEL2056858	TAS	**MW449867**	**MW302235**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Malajczukia	*amicorum*	OSC59295	VIC	DQ218792	DQ219208	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Malajczukia	*ingratissima*	OSC59296	VIC	DQ218793	DQ219209	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	sp.	SEA37	QLD	**MW449875**	**MW302237**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	sp.	MEL2389696	SA	**MW449870**	**MW302238**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	sp.	SEA35B	QLD	**MW438333**	**MW302239**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	*brevispora*	MEL2281255	WA	**MW449872**	**MW302236**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	*clelandii*	MEL2042631	VIC	**MW449878**	**MW302234**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	*clelandii*	OSC59292	VIC	DQ218795	DQ219211	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	*glauca*	OSC56986	TAS	DQ218878	DQ219212	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	*sabulosa*	OSC55918	VIC	DQ218879	DQ219213	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophelllia	*trabalis*	OSC59282	VIC	DQ218880	DQ219214	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Mesophellia	*Mesophellia*	*arenaria*	OSC59306	TAS	DQ218877	DQ219210	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Nothocastoreum	*Nothocastoreum*	*cretaceum*	MEL2356006	WA	**MW246680**	**MW302240**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Nothocastoreum	*cretaceum*	OSC79832	AUS	DQ218881	DQ219215	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Nothocastoreum	*cretaceum*	OSC79925	AUS	n/a	DQ219216	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 5 Lebel	*Chondrogaster*	sp.	SEA6B	QLD	**MW246665**	**MW302273**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL1294	NSW	**MW246677**	**MW302274**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	T19877	VIC	**MW246684**	**MW302275**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL1097	NSW	**MW246685**	**MW302276**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 6 Lebel & Davoodian	*Gummiglobus*	sp.	H7679	WA	**MW449873**	**MW302242**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Castoreum	*Castoreum*	sp.	SEA2	QLD	**MW246674**	**MW302246**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	sp.	SEA3	QLD	**MW246668**	**MW302247**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	sp.	OSC122814	AUS	DQ218821	DQ219134	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	*radicatum*	MEL2354501	QLD	**MW246672**	**MW302244**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	*radicatum*	MEL2364205	NSW	**MW246690**	**MW302250**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	*tasmanicum*	MEL2041148	VIC	**MW246695**	**MW302243**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Castoreum	*tasmanicum*	MEL2056682	VIC	**MW246683**	**MW302248**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)

Table 1. (Continued).

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
	Fusicastoreum	sp.	MEL2354440	QLD	**MW246667**	**MW302245**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Mesophellia	*arenaria*	MEL2356530	TAS	**MW246688**	**MW302249**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gummiglobus	*Gummiglobus*	sp.	SEA22	QLD	**MW246691**	**MW302252**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Gummiglobus	*agglutinosporus*	OSC58784	AUS	DQ218830	n/a	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Gummiglobus	*agglutinosporus*	MEL2042096	VIC	**MW246693**	**MW302251**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Gummiglobus	*agglutinosporus*	MEL2105039	VIC	**MW246670**	**MW302254**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Gummiglobus	*joyceae*	MEL2314623	QLD	**MW438332**	**MW302253**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Gummiglobus	*joyceae*	OSC59485	AUS	DQ218772	n/a	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gummivena	*Gummivena*	*potorooi*	MEL2104390	WA	**MW246678**	**MW302255**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Gummivena	*potorooi*	MEL2314967	WA	**MW246696**	**MW302256**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Gummivena	*potorooi*	MEL2105001	WA	**MW246673**	**MW302257**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 7 Davoodian, Lebel & Castellano	*Aroramyces*	sp.	TL1701	NSW	**MT947437**	**MT947438**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	SEA9	QLD	**MT947436**	**MW264847**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 8 Hosaka	*Chondrogaster*	sp.	H6586	VIC	**MW246682**	**MW302260**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL2871	SA	**MW246692**	**MW302262**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	MEL2364057	NSW	**MW246671**	**MW302267**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	MEL2364304	NSW	**MW246697**	**MW302268**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL2888	SA	**MW246689**	**MW302269**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	TL2889	SA	**MW246687**	**MW302270**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T16823	ACT	**MW246686**	**MW302258**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T36459	USA - CA	**MW246694**	**MW302259**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	PSC4372	SA	**MW246679**	**MW302261**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H6761	VIC	**MW246666**	**MW302263**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	SEA27	QLD	**MW246681**	**MW302265**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H5573	PNG	**MW246669**	**MW302264**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T14749	WA	**MW246698**	**MW302266**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T6923	AUS	DQ218855	DQ219186	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T15362	NT	**MW246675**	**MW302271**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T15375	NT	**MW246676**	**MW302272**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	MEL2057692	NSW	DQ218848	DQ219179	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)

Table 1. (Continued).

Clade	Genus verbatim determination	Species verbatim determination	Collector or Herbarium ID	Geography	ATP6	TEF1	Family	Suborder (Order)
	Hysterangium	*gardnerii*	T6950	AUS	DQ218835	DQ219157	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*inflatum*	H4035	AUS	DQ218836	DQ219159	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 9 Davoodian	*Hysterangium*	sp.	H381	TAS	**MW449871**	**MW302281**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
Gen. prov. 10 Hosaka	*Chondrogaster*	sp.	MEL2305115	QLD	**MW449861**	**MW302277**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Chondrogaster	sp.	SEA7B	QLD	**MW449864**	**MW302280**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H2022	AUS	DQ218856	DQ219187	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	H4262	AUS	DQ218773	DQ219146	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	T22535	QLD	**MW449862**	**MW302278**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	sp.	SEA270	QLD	**MW449863**	**MW302279**	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)
	Hysterangium	*aggregatum*	MEL2049882	VIC	DQ218844	DQ219175	*Mesophelliaceae*	*Hysterangineae* (*Hysterangiales*)

DISCUSSION

In addition to revealing new taxa, our analysis highlights prominent biogeographic patterns in *Hysterangiales*. Trans-Tasman distributions are numerous throughout *Hysterangiales*; almost every New Zealand lineage inferred in our phylogram is sister to an Australian lineage, at various taxonomic scales. Gondwanan disjunctions are also represented, for example "*Gen. prov.* 17" (Fig. 3 - Part 2) contains an Australian and paleotropical clade sister to a northeastern South American clade. Some human-mediated introduction events are apparent as well *e.g. Chondrogaster angustisporus* (OSC62041 - holotype) is from planted *Eucalyptus* in Brazil (Giachini *et al*. 2000). Hosaka *et al*. (2008) postulated that the *Hysterangiales* originated in Australia or Eastern Gondwana and expanded in range over time, possibly through long-distance dispersal. Sheedy *et al.* (2016) inferred that *Hysterangiales* was the first group of *Agaricomycetes* to become sequestrate in Australia (*ca.* 83 million years ago). The rate of sequestration of *Agaricomycetes* was inferred to have increased in Australia after separation from Antarctica, the timing of which overlaps with the radiation of potential mycorrhizal plant associates as well as the emergence of specialized mycophagous marsupials. Although periods of aridification were evidently not the sole driver of sequestration, they likely had a major influence on the diversity of sequestrate fungi in Australia, including *Hysterangiales* (Sheedy *et al.* 2016).

Our analysis indicates phylogenetic signals for some prominent macroscopic features. In the *Mesophelliaceae*, the clade unifying *Gummivena*, *Gummiglobus*, and *Castoreum* is comprised of species that have gummy-like mycelium and/or outer glebal tissue (Fig. 1N, O). Species in the clade containing *Chondrogaster*, *Andebbia*, *Mesophellia*, *Nothocastoreum*, and related provisional genera have a powdery spore mass at maturity and also incorporate roots and soil in a multi-layered mycelial crust surrounding the basidiome (in *Nothocastoreum* this falls off easily and remains in the soil) (Fig. 1J–M). In provisional genera 8 through 10, the basidiomes are typically encased in a mycelial soil crust, and the glebal tissue is gelatinized. Macroscopic characters of *Hysterangiaceae* overlap somewhat with various clades in the *Mesophelliaceae* and *Gallaceaceae*, including having a gelatinized gleba and varying degrees of rhizomorph development across the surface of basidiomes (Fig. 1G–I). In *Gallaceaceae*, most lineages have a firm, cartilaginous peridium surrounding a gelatinized gleba (Fig. 1D–F), and spores lacking an utricle (Fig. 2A). The condition of having ridged spores (Fig. 2C) is not monophyletic in *Hysterangiales*; this character was previously thought to be diagnostic for the genus *Austrogautieria* (Stewart & Trappe 1985) but now appears in two well-supported, distinct clades in *Gallaceaceae* (*Austrogautieria* and "*Gen. prov*. 24"; Fig. 3 - Part 3).

Numerous provisional genera and species have been revealed in this study, which will be described by the respective authors of this paper and other collaborators in upcoming publications. We believe our current approach of recognising numerous provisional genera is a more accurate and conservative estimate of diversity than to lump them into fewer, larger genera. In addition to strong phylogenetic signals, each provisional genus is readily distinguishable by macroscopic and microscopic characters, but species level differentiation within genera requires more sampling in many of these taxa. Moreover, our phylogenetic analyses show that some existing genera, such as *Castoreum* and *Gummiglobus* in *Mesophelliaceae*, are closely related to each other within their respective families, but our provisional genera are more distantly related to these existing genera (Fig. 3, Supplementary Fig. S1). More sampling throughout Australasia and South America will likely uncover additional clades and aid in further refining generic and specific boundaries.

ACKNOWLEDGEMENTS

A special thanks to Dr S. Abell (James Cook University and Australian Tropical Herbarium) for access to *Hysterangiales* collections and early collaboration on this diverse lineage. This project was completed with funding and support from the Australian Biological Resources Study (grant RF217-63: Truffle-like fungi [*Basidiomycetes*]: taxonomy, systematics and a revised classification for all Australian taxa), BioPlatforms Australia, the Friends of the Botanic Gardens Victoria, and the Royal Botanic Gardens Victoria. Dr M. Castellano was also supported in part by the ABRS grant RF217. Dr M. Smith at the University of Florida is thanked for helpful comments to this manuscript. Much appreciation also to the curation staff at the National Herbarium of Victoria (MEL), Queensland State Herbarium (BRI), and State Herbarium of South Australia (AD) for assistance with loans and processing of material. Assistance with processing material and sequencing was provided by technical staff at MEL: R. Jordan, Dr M. Hirst and A. Boxshall. This study was financed in part by JSPS KAKENHI Grants 24680085 and 20K06805 to Dr K. Hosaka.

Conflict of interest: The authors declare that there is no conflict of interest.

REFERENCES

Castellano MA, Beever RE (1994). Truffle-like *Basidiomycotina* of New Zealand: *Gallacea*, *Hysterangium*, *Phallobata*, and *Protubera*. *New Zealand Journal of Botany* **32**: 305–328.

Claridge AW, May TW (1994). Mycophagy among Australian mammals. *Australian Journal of Ecology* **19**: 251–275.

Fogel R, Trappe JM (1978). Fungus consumption (mycophagy) by small animals. *Northwest Science* **52**: 1–31.

Giachini A, Castellano MA, Trappe JM (2000). Ectomycorrhizal fungi in *Eucalyptus* and *Pinus* plantations in southern Brazil. *Mycologia* **92**: 1166–1177.

Hibbett DS, Blackwell M, James TY, *et al.* (2018). Phylogenetic taxon definitions for *Fungi*, *Dikarya*, *Ascomycota* and *Basidiomycota*. *IMA Fungus* **9**: 291–298.

Hosaka K (2005). *Systematics, phylogeny, and biogeography of the Hysterangiales and related taxa (Phallomycetidae, Homobasidiomycetes)*. PhD dissertation. Botany Department, Oregon State University, Oregon, USA.

Hosaka K, Bates ST, Beever RE, *et al.* (2006). Molecular phylogenetics of the gomphoid-phalloid fungi with an establishment of the new subclass *Phallomycetidae* and two new orders. *Mycologia* **98**: 949–959.

Hosaka K, Castellano MA, Spatafora JW (2008). Biogeography of *Hysterangiales* (*Phallomycetidae, Basidiomycota*). *Mycological Research* **112**: 448–462.

Katoh K, Rozewicki J, Yamada KD (2017). MAFFT online service: multiple sequence alignment, interactive sequence choice and visualization. *Briefings in Bioinformatics* **20**: 1160–1166.

Kretzer AM, Bruns TD (1999). Use of *atp6* in fungal phylogenetics: an example from the *Boletales*. *Molecular Phylogenetics and Evolution* **13**: 483–492.

Miller MA, Schwartz T, Pickett BE, *et al.* (2015). A RESTful API for access to phylogenetic tools via the CIPRES science gateway. *Evolutionary Bioinformatics* **11**: EBO–S21501.

Rehner SA, Buckley E (2005). A *Beauveria* phylogeny inferred from nuclear ITS and *EF1-α* sequences: evidence for cryptic diversification and links to *Cordyceps* teleomorphs. *Mycologia* **97**: 84–98.

Robinson O, Dylus D, Dessimoz C (2016). *Phylo.io*: interactive viewing and comparison of large phylogenetic trees on the web. *Molecular Biology and Evolution* **33**: 2163–2166.

Ronquist F, Teslenko M, Van Der Mark P, *et al.* (2012). MrBayes 3.2: efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* **61**: 539–542.

Sheedy EM, Martin AF, Ryberg M, *et al.* (2016). Dating the emergence of truffle-like fungi in Australia, by using an augmented meta-analysis. *Australian Systematic Botany* **29**: 284–302.

Stamatakis A, Hoover P, Rougemont J (2008). A rapid bootstrap algorithm for the RAxML web servers. *Systematic Biology* **57**: 758–771.

Stewart EL, Trappe JM (1985). The new genus *Austrogautieria* (*Basidiomycotina*), segregate from *Gautieria*. *Mycologia* **77**: 674–687.

Sulzbacher MA, Grebenc T, Cabral TS, *et al.* (2016). *Restingomyces*, a new sequestrate genus from the Brazilian Atlantic rainforest that is phylogenetically related to early-diverging taxa in *Trappeaceae* (*Phallales*). *Mycologia* **108**: 954–966.

Trappe JM, Castellano MA, Malajczuk N (1996). Australasia truffle-like fungi. VII. *Mesophellia* (*Basidiomycotina, Mesophelliaceae*). *Australian Systematic Botany* **9**: 773–802.

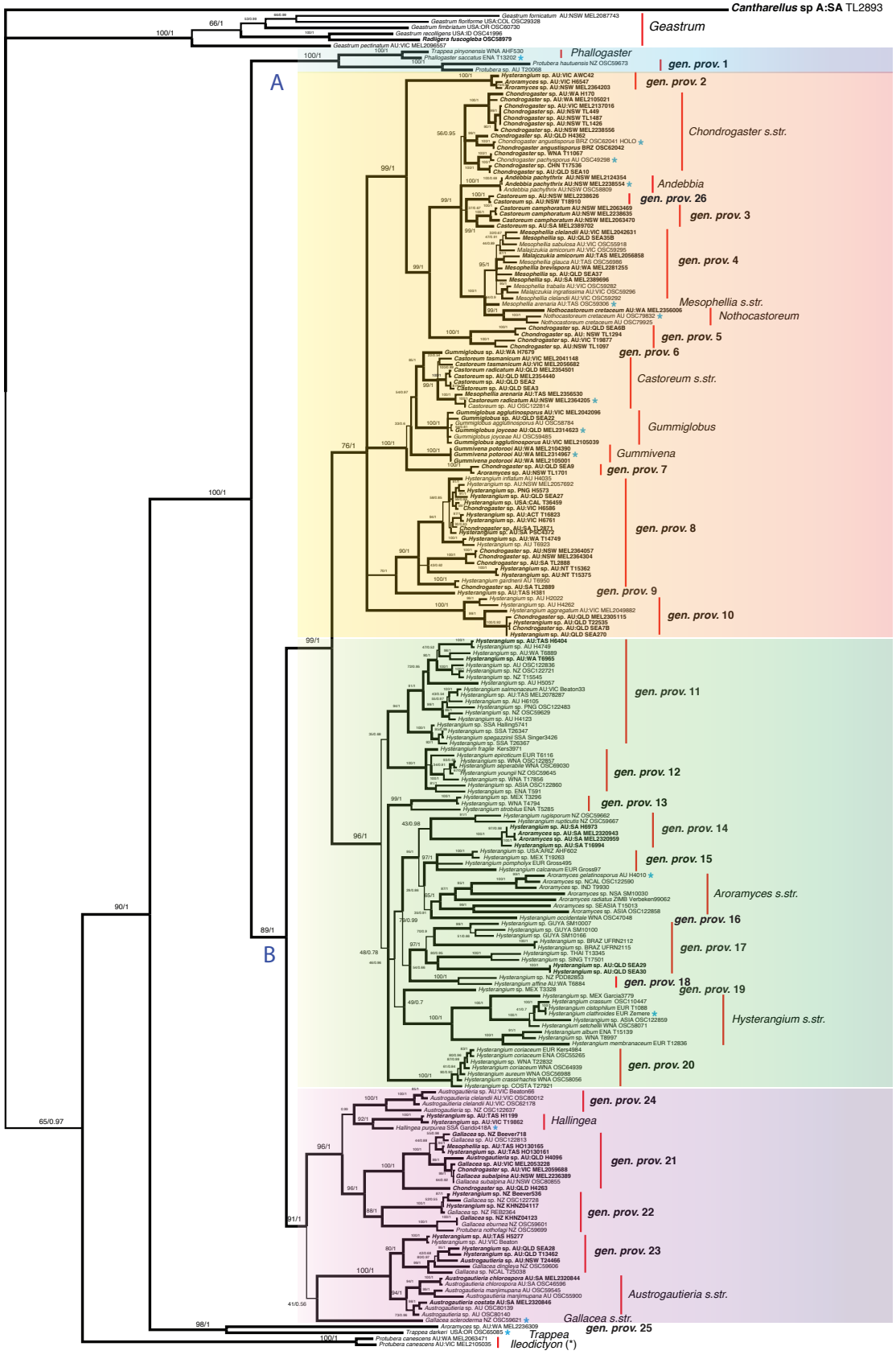
Trierveiler-Pereira L, Meijer AA, Hosaka K, *et al.* (2014). Updates on *Protubera* (*Protophallaceae, Phallales*) and additional notes on *P. maracuja*. *Mycoscience* **55**: 35–42.

Xu A-S, Luo D-Q (2003). A new species in the genus *Trappea*. *Mycosystema* **22**: 191–194.

Supplementary Material: http://fuse-journal.org/

Fig. S1. Overview Phylogram from Bayesian analysis showing relationship between *Hysterangiales*, some *Phallales* and outgroups (OG). Node A indicates *Phallogastrineae subord. nov.*; node B indicates *Hysterangineae subord. nov.* Maximum likelihood (ML) bootstrap values / Bayesian posterior probabilities (bpp) are shown at the nodes. Where bpp ≥ 0.95 and ML bootstrap ≥ 70 %, branches are thickened. Type species indicated by a blue asterisk *. The asterisk in parentheses (*) denotes the currently accepted genus for *Protubera canescens*, *Ileodictyon*. Countries and States indicated with same acronyms as Fig. 3.

Figure S1



Supplementary Fig. S1. Overview Phylogram from Bayesian analysis showing relationship between *Hysterangiales*, some *Phallales* and outgroups (OG). Node A indicates *Phallogastrineae subord. nov.*; node B indicates *Hysterangineae subord. nov.* Maximum likelihood (ML) bootstrap values / Bayesian posterior probabilities (bpp) are shown at the nodes. Where bpp ≥ 0.95 and ML bootstrap ≥ 70 %, branches are thickened. Type species indicated by a blue asterisk *. The asterisk in parentheses (*) denotes the currently accepted genus for *Protubera canescens*, *Ileodictyon*. Countries and States indicated with same acronyms as Fig. 3.