



## Towards a natural classification of annulatasceae-like taxa II: introducing five new genera and eighteen new species from freshwater

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### Abstract

Annulatasceae is an interesting and taxonomically confused family as some family members have been placed in different orders/families in Diaporthomycetidae. Although taxonomic changes have been carried out for some genera, many are questionable or their placements are unstable due to a lack of DNA sequence data. In this study, a survey of freshwater annulatasceae-like species resulted in 23 new taxa, including five new genera (*Aquidictyomyces*, *Fusoidigranularius*, *Longivarius*, *Neodiluvicola* and *Obliquiminima*) and 18 new species in 12 genera, i.e. *Annulatasceus* (*A. changmaiensis*, *A. nakhonensis* and *A. songkhlaensis*), *Aquapteridospora* (*A. aquatica*), *Aquidictyomyces* (*A. appendiculatus*), *Cancellidium* (*C. thailandense*), *Conlarium* (*C. subglobosum*), *Dictyosporella* (*D. changmaiensis* and *D. ellipsoidea*), *Distoseptispora* (*D. fasciculata*, *D. saprophytica* and *D. songkhlaensis*), *Fluminicola* (*F. striata*), *Junewangia* (*J. thailandica*), *Obliquiminima* (*O. hyalina*), *Sporidesmiella* (*S. obovoidia*) and *Sporidesmium* (*S. appendiculatum* and *S. changmaiense*). *Annulatasceus*

*aquatorbae* and *A. nilensis* are excluded from *Annulatasacus sensu stricto*, and placed in two new genera *Longivarius* and *Fusoidigranularius*, respectively. *Diluviicola capensis* is a new geographical record in Thailand, and *D. aquatica* is transferred to a new genus *Neodiluviicola* as *N. aquatica*. *Obliquiminima* which is morphologically similar to *Ayria* is introduced as a new sexual genus in Cancellidiaceae. *Dictyosporella Chiangmaiensis* is introduced as the second sexual morph in the genus. *Fluminicola thailandensis* is synonymized under *F. saprophytica* and *Distoseptispora submersa* is synonymized under *D. tectonae*. Strain HKUCC 3710 under the name *Cateractispora recepticuli* is rectified as the type strain of *Cateractispora receptaculorum*. We report a new geographical and habitat record of *Acrodictys porosiseptata* from freshwater in Thailand; a new geographical record of *Conlarium aquaticum* in China; and a new geographical record of *Diluviicola capensis* in Thailand. All taxa are identified based on morphology and phylogenetic analyses of a combined LSU, ITS, TEF and RPB2 DNA sequence data. An updated review for Annulatasaceae, as well as its sexual and asexual allies, is provided under each entry based on our new data.

**Key words** – 23 new taxa – apical ring – Diaporthomycetidae – submerged wood – taxonomy

## Introduction

Since freshwater fungi was recognized as a distinctive group (Ingold 1942, 1951, 1955), plenty of freshwater species have been discovered (Su et al. 2016, Zhang et al. 2017, Luo et al. 2019, Dong et al. 2020a, b). In the previous studies of freshwater fungi along a north–south latitudinal gradient in the Asian/Australian region (Hyde et al. 2016a), many taxa characterized by small ascomata, with or without long necks, unitunicate, cylindrical asci with an apical ring and fusiform, hyaline ascospores were discovered and morphologically placed in Annulatasaceae (Hyde 1992, Ho et al. 2002, Cai et al. 2003, Luo et al. 2004, Vijaykrishna et al. 2006, Hu et al. 2010). Although phylogenetic analyses have shown that Annulatasaceae members are polyphyletic in nature (Abdel-Wahab et al. 2011, Zelski 2015), they did not revise the taxonomy as DNA sequence data was limited.

A recent study of annulatasaceae-like taxa was carried out by Zhang et al. (2017) based on phylogenetic and evolutionary studies. They established a new order Atractosporales and six new families Atractosporaceae, Barbatosphaeriaceae, Conlariaceae, Lentomitellaceae, Pseudoproboscisporaceae and Woswasiaceae, to accommodate the taxa that morphologically belong in Annulatasaceae. Although the new order and families have been established, a number of them are based on limited data so that some appear to be phylogenetically unstable. For example, some studies showed Atractosporales was not monophyletic, as its three families Atractosporaceae, Conlariaceae and Pseudoproboscisporaceae did not form a well-supported clade and was related to other families (Luo et al. 2019, Hyde et al. 2020); Lentomitellaceae was established for a single genus *Lentomitella* (Zhang et al. 2017), and later was synonymized under Xenosporaceae that comprises three additional genera (Réblová et al. 2018); *Dictyosporella* was referred to Diaporthomycetidae genera *incertae sedis* (Zhang et al. 2017), and now is placed in Junewangiaceae (Luo et al. 2019); Barbatosphaeriaceae and Woswasiaceae were established to accommodate some annulatasaceae-like genera (Zhang et al. 2017), and later some were referred to Diaporthomycetidae genera *incertae sedis* because of weak phylogenetic relationships between family members (Luo et al. 2019). It clearly demonstrates that the taxonomy of these fungi is unresolved and changes from time to time.

In this study, 30 new freshwater collections are identified as Annulatasaceae and annulatasaceae-like taxa. Annulatascales, along with morphologically similar orders (Atractosporales, Cancellidiales, Conlariales and Sporidesmiales) and families (Junewangiaceae, Papulosaceae and Pseudoproboscisporaceae), as well as Distoseptisporales and Acrodictyaceae which are morphologically similar to Sporidesmiales and Junewangiaceae, are treated. Based on an updated phylogenetic study of Zhang et al. (2017) and our new collections obtained from China and

Thailand, five new genera and 18 new species are introduced. In addition, three new combinations, three new geographical records and one new freshwater habitat record are presented.

## **Materials & Methods**

### **Specimens collection, examination and single spore isolation**

Decaying wood samples were collected from freshwater streams in China and Thailand. Specimens were placed in zip-lock plastic bags lined with some wetted cotton and taken to the laboratory. The specimens were incubated in moist plastic boxes at room temperature for 1–2 weeks and performed morphological observations. Fruit bodies or colonies were examined using a Nikon SMZ-171 dissecting microscope. Fungal structures were photographed with a Nikon ECLIPSE Ni compound microscope fitted with a Canon EOS 600D/750D digital camera. Single spore isolations were made from ascospores or conidia onto potato dextrose agar (PDA) at room temperature. All details of morphological approaches used herein were based on Chomnunti et al. (2014) and Senanayake et al. (2020). Tarosoft (R) Image Frame Work program was used for measurement. Images used for figures were processed with Adobe Photoshop CS5 software (Adobe Systems, USA). Herbarium specimens (dry wood with fungal material) were deposited in the herbarium of Mae Fah Luang University (MFLU), Chiang Rai, Thailand and herbarium of Cryptogams, Kunming Institute of Botany Academia Sinica (HKAS), Kunming, China. Living cultures were deposited in Mae Fah Luang University Culture Collection (MFLUCC) and Kunming Institute of Botany Culture Collection (KUMCC). Facesoffungi and Index Fungorum numbers were registered as in Jayasiri et al. (2015) and Index Fungorum (2021), respectively.

### **DNA extraction, PCR amplification and sequencing**

Single germinated spores were grown on PDA for 15–30 days at room temperature to obtain pure cultures. A Biospin Fungus Genomic DNA Extraction Kit (Bioer Technology Co., Hangzhou, China) was used to extract total genomic DNA from fresh mycelia according to the manufacturer's instructions. DNA amplification was performed by polymerase chain reaction (PCR). LSU, SSU, ITS, TEF and RPB2 sequences were amplified using primer pairs LR0R/LR5, NS1/NS4, ITS5/ITS4, 983F/2218R and fRPB2-5F/fRPB2-7cR, respectively (Vilgalys & Hester 1990, White et al. 1990, Rehner & Samuels 1994, Liu et al. 1999). The amplifications were carried out as outlined in Dong et al. (2020a). PCR thermal cycles for the amplification followed Su et al. (2015) and Luo et al. (2018). PCR products were checked on 1% agarose electrophoresis gels stained with Gel Red. The sequencing reactions were carried out by Shanghai Sangon Biological Engineering Technology and Services Co., Shanghai, China.

### **Phylogenetic analyses**

Raw sequences generated in this study were checked with Finch TV version 1.4.0 and single gene for each strain was blasted in NCBI to confirm the correctness of sequences obtained from company. A multigene phylogenetic tree was constructed based on nucleotide BLAST of each newly generated sequences and recent publications (Zhang et al. 2017, Luo et al. 2019, Hyde et al. 2020). All sequences used in this study are listed in supplementary Table 1. Alignments for each dataset of LSU, ITS, TEF and RPB2 were done using MAFFT v. 7.409 online version (Kato & Standley 2016) and manually verified with BioEdit v.7.2.5 Biological Sequence Alignment Editor (Ibis BioSciences, CA). Each dataset were concatenated with Mesquite v. 3.11. Maximum likelihood (ML) and bayesian inference (BI) were used for phylogenetic tree inference. The ML and BI analyses were performed with RAxML-HPC v.8 and MrBayes on XSEDE in CIPRES Science Gateway, respectively (Miller et al. 2010, 2015). Six simultaneous Markov chains were run for one million generations and trees were sampled every 100 generation (resulting in 10000 trees). The first 2500 trees, representing the burn-in phase of the analyses, were discarded and the remaining 7500 trees were used for calculating posterior probabilities (PP) in the majority rule consensus tree (Larget & Simon 1999). Phylogenetic trees were viewed with FigTree v. 1.4.03

(<http://tree.bio.ed.ac.uk/>) and edited with Microsoft Office PowerPoint 2007 (Microsoft Corporation, WA, United States).

## Results

### Phylogenetic analyses

A combined LSU, ITS, TEF and RPB2 sequence dataset was analysed for species of Diaporthomycetidae. The dataset comprised 302 strains with an alignment length of 4094 total characters. The RAxML analysis resulted in a best scoring likelihood tree selected with a final value for the combined dataset  $\ln L = -106812.195770$ . The matrix had 3085 distinct alignment patterns, with 58.07% of undetermined characters or gaps. Estimated base frequencies are as follows: A = 0.241268, C = 0.258993, G = 0.286731, T = 0.213008; substitution rates AC = 1.360157, AG = 2.912312, AT = 1.476237, CG = 1.108880, CT = 7.249310, GT = 1.000000; gamma distribution shape parameter  $a = 0.430061$ . All phylogenetic trees (ML and BI) were similar in topologies, and the RAxML tree is shown in Fig. 1.

Clade 1 represents the order Conlariales with a single family Conlariaceae, which accommodates two genera *Conlarium* and *Riomyces*. *Riomyces* clusters within *Conlarium* but they have entirely different morphological characteristics (Ferrer et al. 2012, Liu et al. 2012). We introduce one new species *C. subglobosum* and add one new strain MFLUCC 18-1417 of *C. aquaticum* based on morphology and phylogeny.

Clade 2 represents the order Sporidesmiales with a single family Sporidesmiaceae. We introduce two new species *S. appendiculatum* and *S. Chiangmaiense*, which cluster with *S. minigelatinosa* with moderate bootstrap support.

Clade 3 represents the new genus *Aquidictyomyces*, typified by *A. appendiculatus*, which clusters with Trichosphaeriaceae with weak bootstrap support. *Aquidictyomyces* phylogenetically belongs in the subclass Diaporthomycetidae, but referred to Diaporthomycetidae genera *incertae sedis*.

Clade 4 represents the family Junewangiaceae with three genera *Dictyosporella*, *Junewangia* and *Sporidesmiella*. *Dictyosporella* clusters with *Junewangia* but they are not well-separated. The polyphyletic nature of *Dictyosporella* and *Junewangia* are shown in clade 4. The new species *Dictyosporella Chiangmaiensis* and new collection *D. Guizhouensis* cluster in the same subclade with the type species *D. aquatica*, while the new species *D. ellipsoidea* clusters in the same subclade with *Junewangia lamma* and *J. sphaerospora*. The new species *Junewangia thailandica* clusters in another subclade with *J. aquatica*, *J. globulosa* and *D. hydei*. *Sporidesmiella* species cluster in a well-supported subclade, and herein we introduce a new species *S. obovoidia* which clusters well with our new collection *S. hyalosperma*.

Clade 5 represents the family Pseudoproboscisporaceae which comprises *Diluviicola*, *Pseudoproboscispora*, the new genus *Neodiluviicola*, and one species *Cataractispora receptaculorum*, and one unidentified strain R-038. Pseudoproboscisporaceae is referred to Diaporthomycetidae families *incertae sedis*.

Clade 6 represents the order Atractosporales with a single family Atractosporaceae. Two genera *Atractospora* and *Rubellisphaeria* cluster in a well-supported clade. We add a new strain KUMCC 18-0051 of *A. ellipsoidea*, which clusters with the other two strains A411-3 and R-008 with high bootstrap support.

Clade 7 represents the family Papulosaceae with four genera *Brunneospora*, *Fluminicola*, *Papulosa* and *Wongia*. We introduce a new species *Fluminicola striata*, which forms a basal branch with other *Fluminicola* species. *Fluminicola thailandensis* is synonymized with *F. saprophytica*. Papulosaceae is referred to Diaporthomycetidae families *incertae sedis*.

Clade 8 represents the family Acrodictyaceae with a single genus *Acrodictys*. We add a new strain MFLUCC 11-0299 of *A. porosiseptata* collected from freshwater habitat. Acrodictyaceae is referred to Diaporthomycetidae families *incertae sedis*.

Clade 9 represents the order Cancellidiales with a single family Cancellidiaceae. We introduce a new species *Cancellidium thailandense* and add two new strains of *C. atrobrunneum* and *C. griseonigrum*. A new genus *Obliquiminima* is introduced, which forms a sister clade with *Cancellidium* with high bootstrap support.

Clade 10 represents the order Annulatascales with a single family Annulatasceae. The genera in Annulatasceae do not cluster well but *Annulusmagnus* and *Ascitendus* have a good affinity. We introduce three new species *Annulatascus Chiangmaiensis*, *Annula. nakhonensis* and *Annula. songkhlaensis*, which cluster well with the type species *Annula. velatisporus*. Two new genera *Fusoidigranularius* and *Longivarius* are introduced in Annulatasceae because they phylogenetically and morphologically do not belong in *Annulatascus*, and therefore they are excluded from this genus.

Clade 11 represents the order Distoseptisporales with two families Aquapteridosporaceae and Distoseptisporaceae. Aquapteridosporaceae comprises a single genus *Aquapteridospora*. *Pleurophragmium bambusinum* clusters within *Aquapteridospora* with high bootstrap support but morphologically does not belong in *Aquapteridospora*. We introduce a new species *A. aquatica*, which clusters with *P. bambusinum*, but morphologically must be in *Aquapteridospora*. Distoseptisporaceae comprises a single genus *Distoseptispora* with our three new species *D. fasciculata*, *D. saprophytica* and *D. songkhlaensis*. In addition, *D. submersa* is synonymized under *D. tectonae*.

## Taxonomy

Six orders, viz. Annulatascales, Atractosporales, Cancellidiales, Conlariales, Distoseptisporales and Sporidesmiales, four families, viz. Acrodictyaceae, Junewangiaceae, Papulosaceae and Pseudoproboscisporaceae, are reviewed and one Diaporthomycetidae genera *incertae sedis Aquidictyomyces* is introduced as follows. Classification of annulatasceae-like taxa in this study is shown in Table 1.

**Annulatascales** M.J. D'souza, Maharachch. & K.D. Hyde, Fungal Diversity 72: 212 (2015)

Type family – Annulatasceae S.W. Wong, K.D. Hyde & E.B.G. Jones

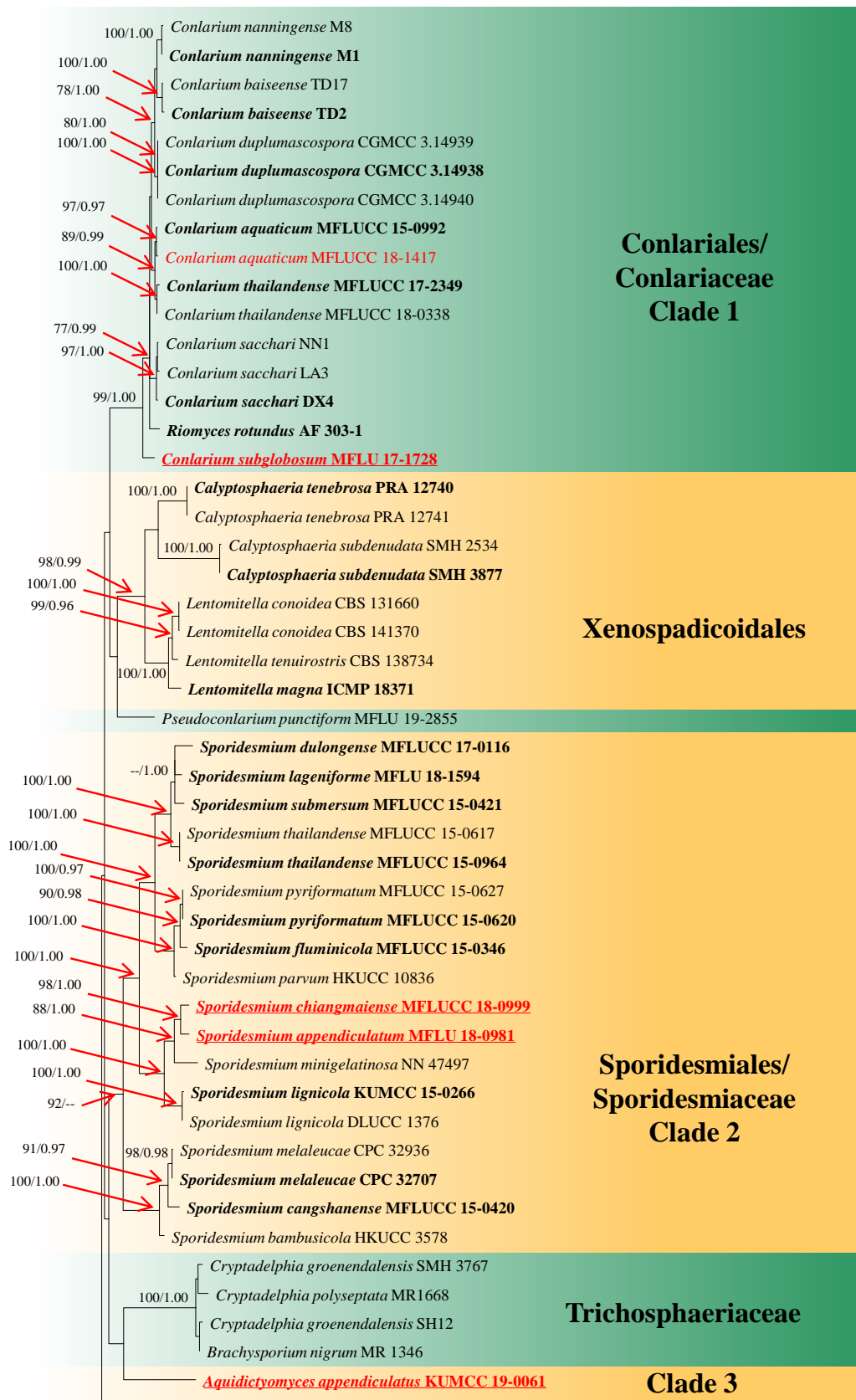
Notes – Annulatascales was introduced to accommodate a single family Annulatasceae (Maharachchikumbura et al. 2015). Annulatascales is an interesting order that comprises 20 genera as listed in Maharachchikumbura et al. (2016) and now retain 11 genera in Hyde et al. (2020), including one Annulatascales genera *incertae sedis*, *Clohiesia*. Annulatascales has similar morphological characteristics of ascomata, asci and ascospores with many orders/families in Diaporthomycetidae, e.g. Atractosporaceae, Cancellidiales, Conlariales, Junewangiaceae, Papulosaceae, Pseudoproboscisporaceae, Sporidesmiales.

**Annulatasceae** S.W. Wong, K.D. Hyde & E.B.G. Jones, Syst. Ascom. 16(1-2): 18 (1998)

Type genus – *Annulatascus* K.D. Hyde

Notes – Annulatasceae represents an assemblage of many genera that are characterized by unilocular ascomata with a neck, cylindrical asci with a massive, J-, refractive, cylindrical to flaring, doughnut-shaped, apical ring and mostly fusiform, hyaline ascospores (Hyde et al. 2020). Maharachchikumbura et al. (2016) accepted 20 genera in the family and some were later transferred to other families or Diaporthomycetidae genera *incertae sedis* based on molecular data (Zhang et al. 2017, Réblová et al. 2018, Luo et al. 2019). For example, *Dictyosporella*, which has annulatasceae-like sexual morph and helicoid conidia, was first transferred to Diaporthomycetidae genera *incertae sedis* together with an annulatasceae-like sexual morph (Zhang et al. 2017), and now is placed in Junewangiaceae based on strong molecular evidence (Luo et al. 2019); *Diluvicola*, which has cylindrical asci with a large apical ring and fusiform ascospores with polar caps, was transferred to Pseudoproboscisporaceae (Zhang et al. 2017); *Pseudoannulatascus*, which has ascomata with a long neck, cylindrical asci with a large apical ring, and long fusiform ascospores with sheaths, was transferred to Xenosporidiales (Réblová et al.

2018). These excluded genera imply that several morphological characteristics, e.g. cylindrical asci with a relatively massive, refractive apical ring and fusiform ascospores, are not detailed enough to classify Annulatascaceae taxa.



**Figure 1** – RAxML tree generated from combined LSU, ITS, TEF and RPB2 sequence data. Bootstrap support values for maximum likelihood (the first value) equal to or greater than 75% and

Bayesian posterior probabilities (the second value) equal to or greater than 0.95 are placed near the branches as ML/BYPP. The tree is rooted to *Aureobasidium pullulans* CBS 584.75 and *Dothidea inculpta* CBS 189.58. The ex-type strains are indicated in bold and newly generated sequences are indicated in red. The new species introduced in this study are underlined.

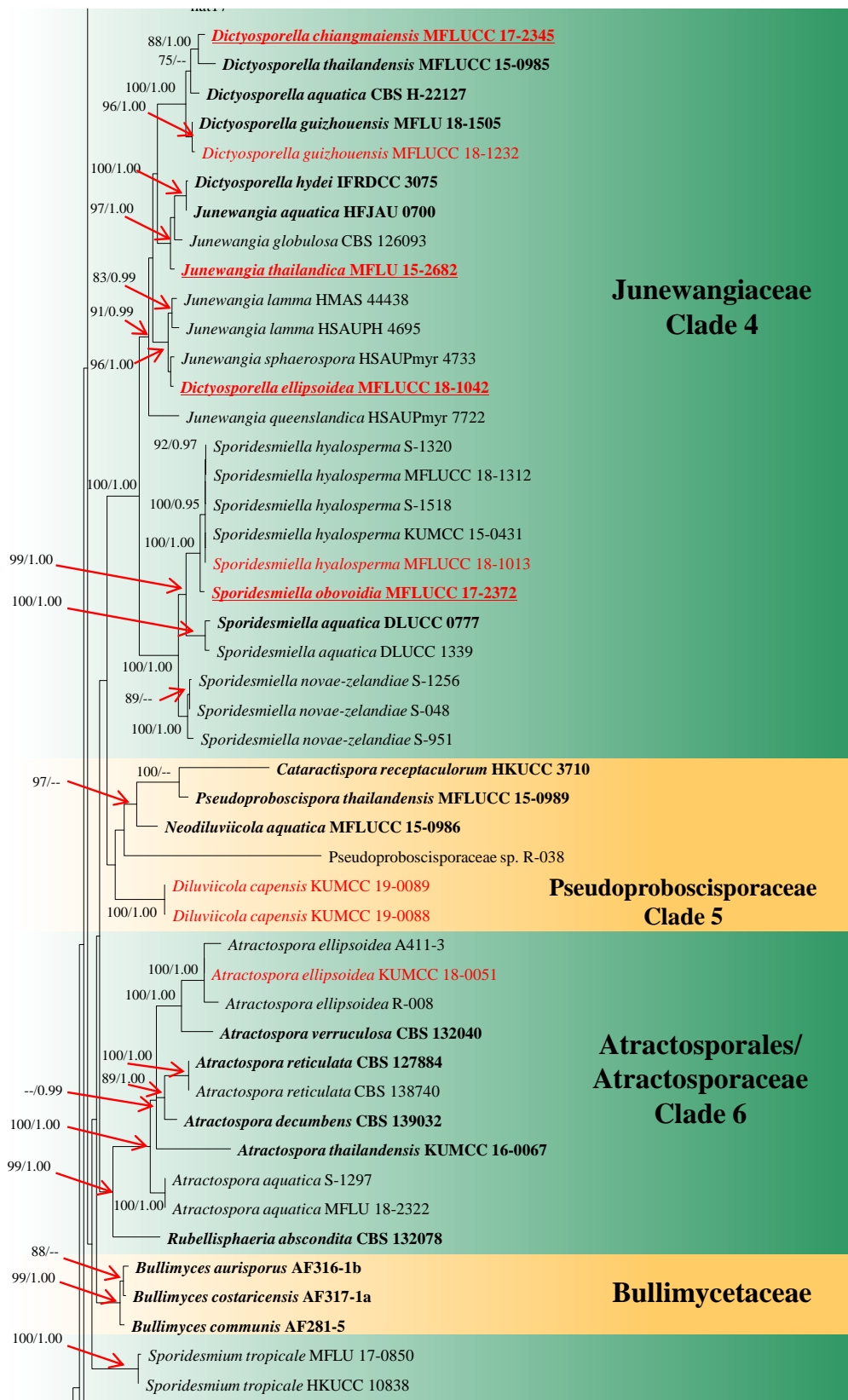


Figure 1 – Continued.

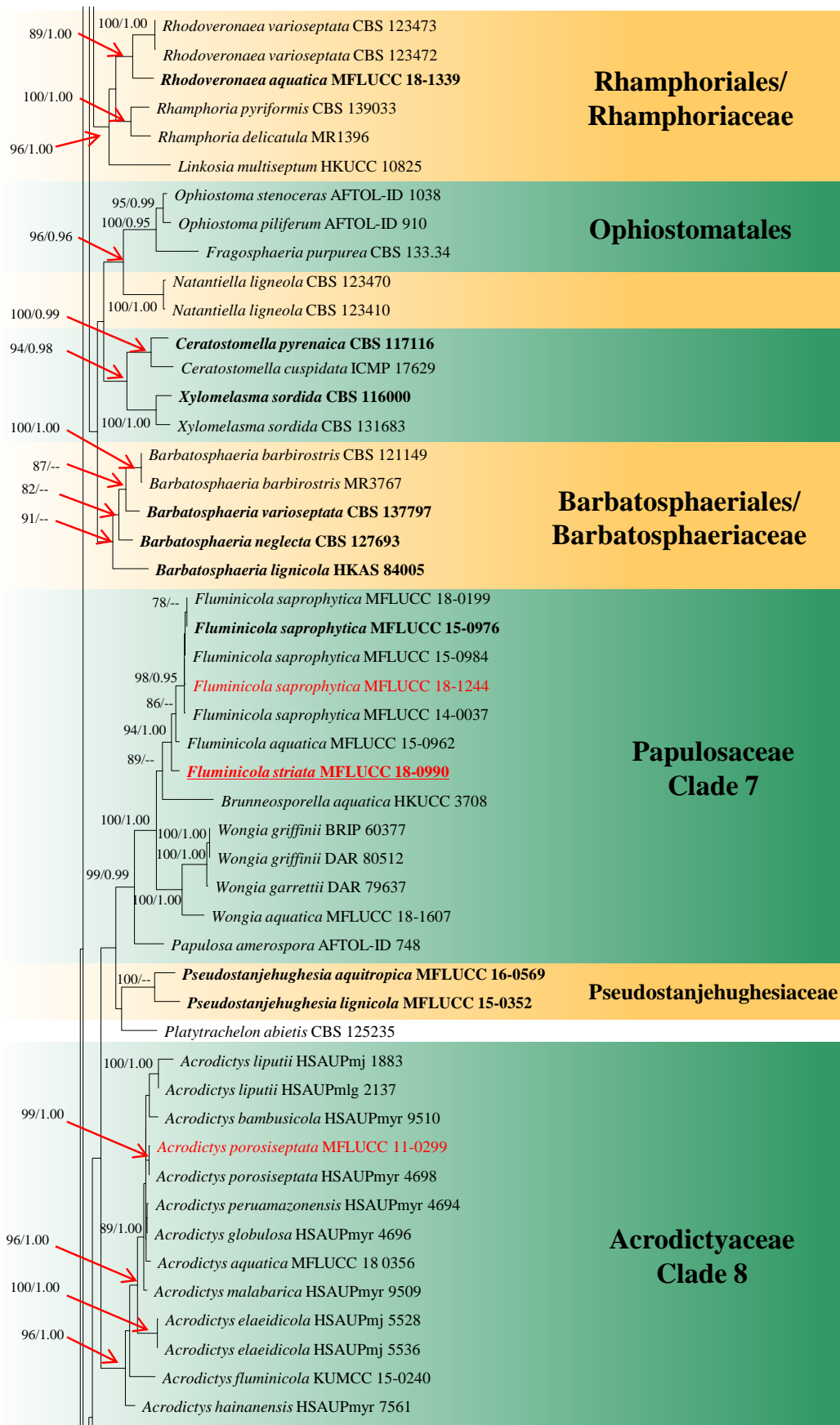


Figure 1 – Continued.



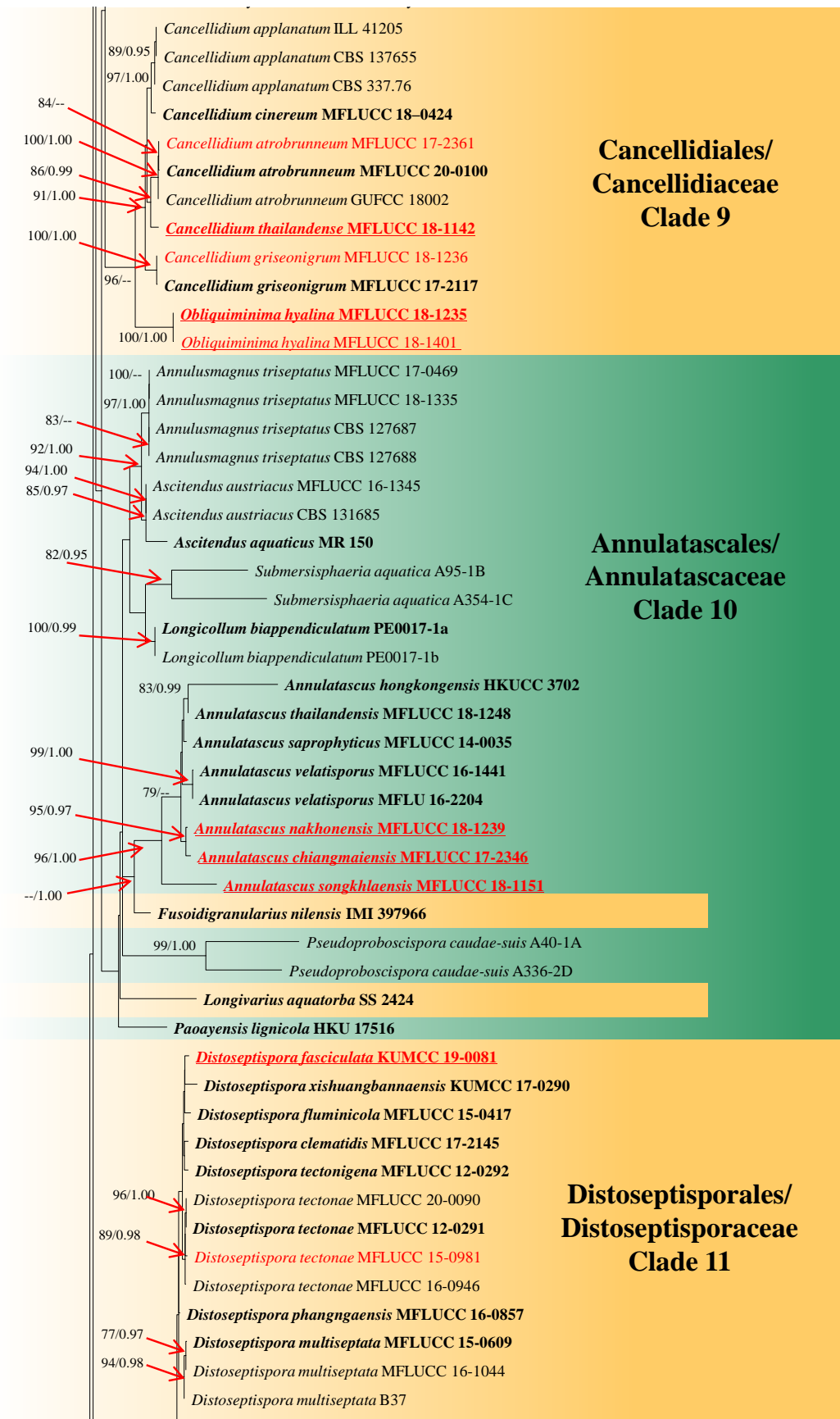


Figure 1 – Continued.

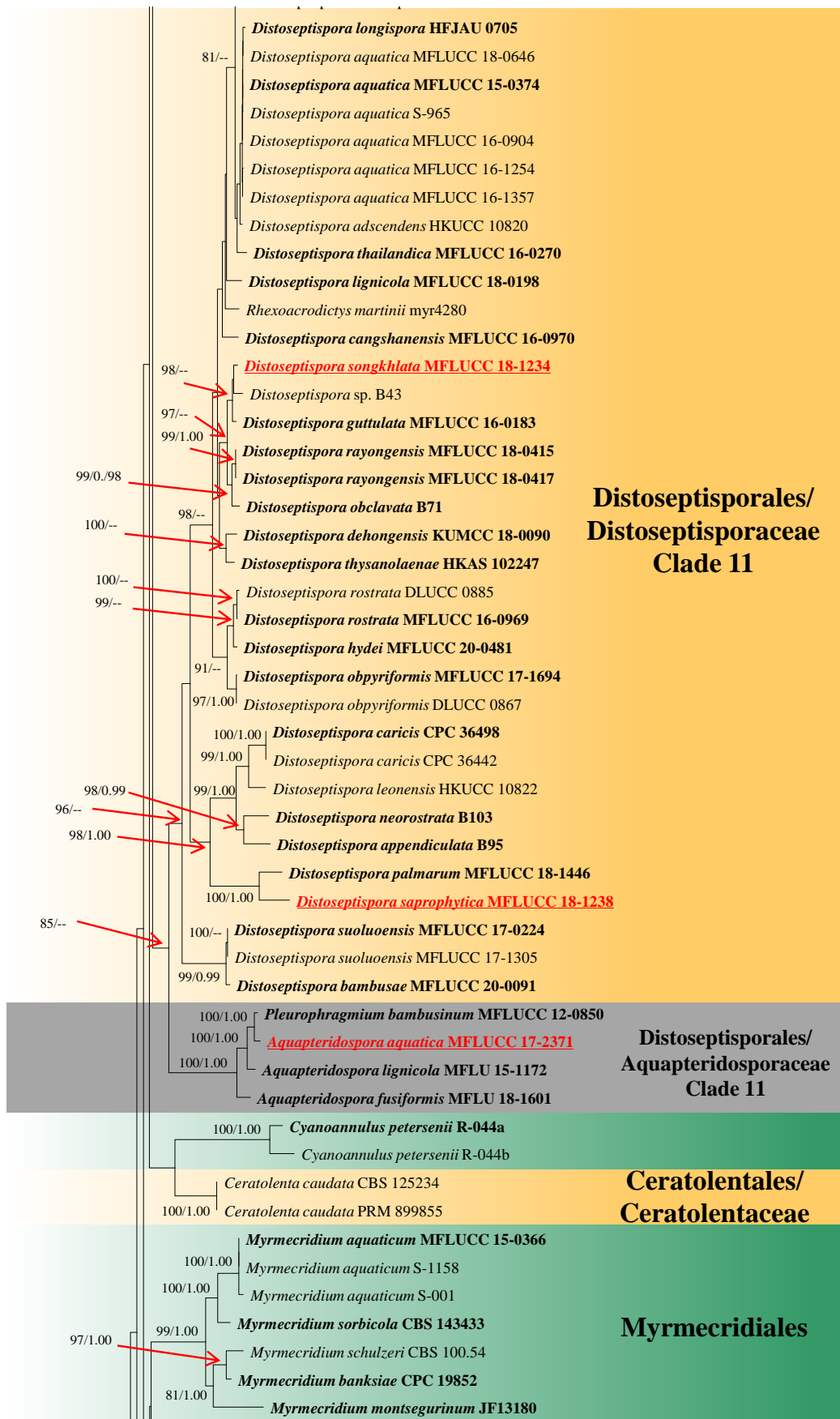
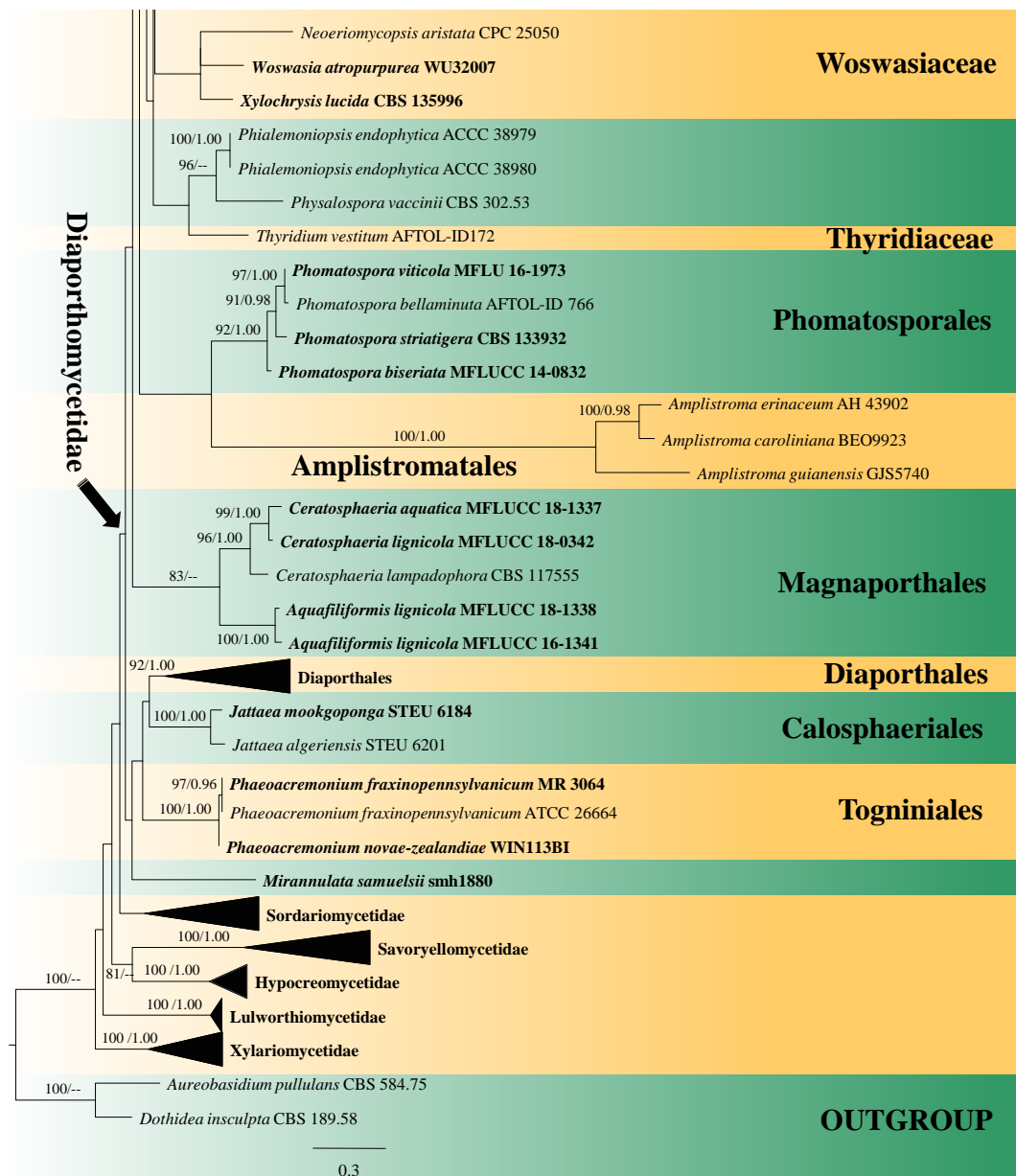


Figure 1 – Continued.



**Figure 1** – Continued.

The latest treatment for Annulatascaceae was carried out by Hyde et al. (2020) and they accepted ten genera in the family based on current data. However, only five genera, viz. *Annulatascus*, *Annulusmagnus*, *Ascitendus*, *Longicollum* and *Submersisphaeria*, were supported by molecular data. All members of Annulatascaceae form a weakly-supported clade in all studies (Luo et al. 2019, Hyde et al. 2020, this study, Fig. 1). In addition, most taxa only have LSU sequence data in GenBank. Thus, more collections with sufficient DNA sequences are needed to reappraise Annulatascaceae. This study accepts 13 genera in Annulatascaceae including two newly introduced genera *Fusoidigranularius* and *Longivarius*, and one genus *Aquaticola* which was referred to Diaporthomycetidae genera *incertae sedis* (Table 1).

***Annulatascus*** K.D. Hyde, Aust. Syst. Bot. 5(1): 118 (1992)

Type species – *Annulatascus velatisporus* K.D. Hyde

Notes – *Annulatascus* was introduced by Hyde (1992) with *A. velatisporus* as the type species. Considering the poor condition and the dearth of sequence data of the holotype, an epitype of *A. velatisporus* was designated with a morphological description and DNA sequence data for the precise delineation of this taxon (Dayarathne et al. 2016). Dayarathne et al. (2016) observed smaller

ascospores ( $22\text{--}25 \times 7\text{--}9 \mu\text{m}$  vs.  $26\text{--}42 \times 9\text{--}12 \mu\text{m}$ ) from the holotype BRIP 17373 and stated that the relatively wide range of ascospore length described by Hyde (1992) might be a result of observing more than one collection.

**Table 1** Classification of annulatasceae-like taxa in this study

Class	Order	Family	Genus	Species treated in this study	Notes	
Diaporthomycetidae	Annulatascales	Annulatasceae	<i>Annulatascus</i>	<i>A. chiangmaiensis</i>	new species	
				<i>A. nakhonensis</i>	new species	
				<i>A. songkhlaensis</i>	new species	
			<i>Annulusmagnus</i>			
			<i>Aqualignicola</i>			
			<i>Aquaticola</i>			
			<i>Ascitendus</i>			
			<i>Ayria</i>			
			<i>Cataractispora</i>		<i>C. receptaculorum</i> in Pseudoproboscisporaceae	
			<i>Chaetorostrum</i>			
			<i>Fusoidigranularius</i>		<i>F. nilensis</i>	new genus new combination
			<i>Longicollum</i>			
			<i>Longivarius</i>		<i>L. aquatorbae</i>	new genus new combination
			<i>Submersisphaeria</i>			
			<i>Vertexicola</i>			
<i>Clohiesia</i>						
	Annulatascales genera <i>incertae sedis</i>					
	Atractosporales	Atractosporaceae	<i>Atractospora</i>	<i>A. ellipsoidea</i>	new collection	
			<i>Rubellisphaeria</i>			
	Cancellidiales	Cancellidiaceae	<i>Cancellidium</i>	<i>C. atrobrunneum</i>	new collection	
				<i>C. griseonigrum</i>	new collection	
				<i>C. thailandense</i>	new species	
			<i>Obliquiminima</i>		new genus	
				<i>O. hyalina</i>	new species	
	Conlariales	Conlariaceae	<i>Conlarium</i>	<i>C. aquaticum</i>	new geographical record	
				<i>C. subglobosum</i>	new species	
			<i>Riomyces</i>			
	Distoseptisporales	Aquapteridosporaceae	<i>Aquapteridospora</i>	<i>A. aquatica</i>	new species	

**Table 1** Continued.

Class	Order	Family	Genus	Species treated in this study	Notes
		Distoseptisporaceae	<i>Distoseptispora</i>	<i>D. fasciculata</i> <i>D. saprophytica</i> <i>D. songkhlaensis</i> <i>D. tectonae</i>	new species new species new species new synonym
	Sporidesmiales	Sporidesmiaceae	<i>Sporidesmium</i>	<i>S. appendiculatum</i> <i>S. Chiangmaiense</i>	new species new species
	Diaporthomycetidae families <i>incertae sedis</i>	Acrodictyaceae	<i>Acrodictys</i>	<i>A. porosiseptata</i>	new geographical and habitat record
		Junewangiaceae	<i>Dictyosporella</i>	<i>D. Chiangmaiensis</i> <i>D. ellipsoidea</i> <i>D. Guizhouensis</i>	new species new species new collection
			<i>Junewangia</i> <i>Sporidesmiella</i>	<i>J. thailandica</i> <i>S. hyalosperma</i> <i>S. obovoidia</i>	new species new collection new species
		Papulosaceae	<i>Brunneosporella</i> <i>Fluminicola</i>	<i>F. saprophytica</i> <i>F. striata</i>	new synonym new species
			<i>Papulosa</i> <i>Wongia</i>		
		Pseudoproboscisporaceae	<i>Cataractispora?</i>		Pending awaiting sequence data from <i>C. aquatica</i>
			<i>Diluviicola</i> <i>Neodiluviicola</i>	<i>D. capensis</i>	new geographical record new genus
			<i>Pseudoproboscispora</i> <i>Aquidictyomyces</i>	<i>N. aquatica</i>	new combination
Diaporthomycetidae genera <i>incertae sedis</i>				<i>A. appendiculatus</i>	new species

Several strains, i.e. A70-18, HKUCC 3701, R047, PE0011-9a, PE0011-9b and PE0011-9c, named under *Annulatascus velatisporus* are deposited in GenBank and they clustered with ex-epitype strains MFLU 16-2204 and MFLUCC 16-1441 in a clade with moderate bootstrap support (Dayarathne et al. 2016). However, all these strains clustered separately from ex-epitype strains in different clades in Hyde et al. (2020) and our preliminary phylogenetic tree (data not shown). Strains A70-18, HKUCC 3701 and R047 are likely to be other different species based on a comparison of DNA sequence data from single gene and phylogenetic analyses (Hyde et al. 2020, our preliminary analysis), but their morphs were not described in

Ranghoo et al. (1999) and Raja et al. (2003). Three strains PE0011-9a, PE0011-9b and PE0011-9c were sequenced by Dayarathne et al. (2016), but their morphs were not specifically described and illustrated in the dissertation of Zelski (2015). Because these six strains were not formally published and our preliminary multigene analysis show that they are phylogenetically different species to *A. velatisporus*, we exclude them and retain the ex-epitype strains of *A. velatisporus* (MFLU 16-2204 and MFLUCC 16-1441) in our phylogenetic tree (Fig. 1).

*Annulatascus* comprises 20 epithets in Index Fungorum (2021) and its polyphyletic nature has been shown in previous studies (Luo et al. 2015, Zhang et al. 2017, Hyde et al. 2020) and in this study (Fig. 1). The latest treatment for *Annulatascus* was provided by Hyde et al. (2020). The phylogenetic placements of most *Annulatascus* species have not been confirmed by molecular data. Presently, six sequenced species of *Annulatascus* cluster in Annulatascaceae, but *A. aquatorbae* and *A. nilensis* are phylogenetically distant from the type species *A. velatisporus* (Luo et al. 2015, Hyde et al. 2020, this study, Fig. 1). Based on morphology and phylogeny, *A. aquatorbae* and *A. nilensis* are excluded from *Annulatascus* and transferred to two new genera, *Fusoidigranularius* and *Longivarius*, respectively (see notes under *Fusoidigranularius* and *Longivarius*). In addition, we introduce three new species in *Annulatascus*, which were collected from submerged wood in freshwater in Thailand.

***Annulatascus chiangmaiensis*** X.D. Yu, W. Dong & H. Zhang, sp. nov.

Fig. 2

Index Fungorum number: IF557443; Facesoffungi number: FoF 09541

Etymology – referring to Chiang Mai, where the holotype was collected

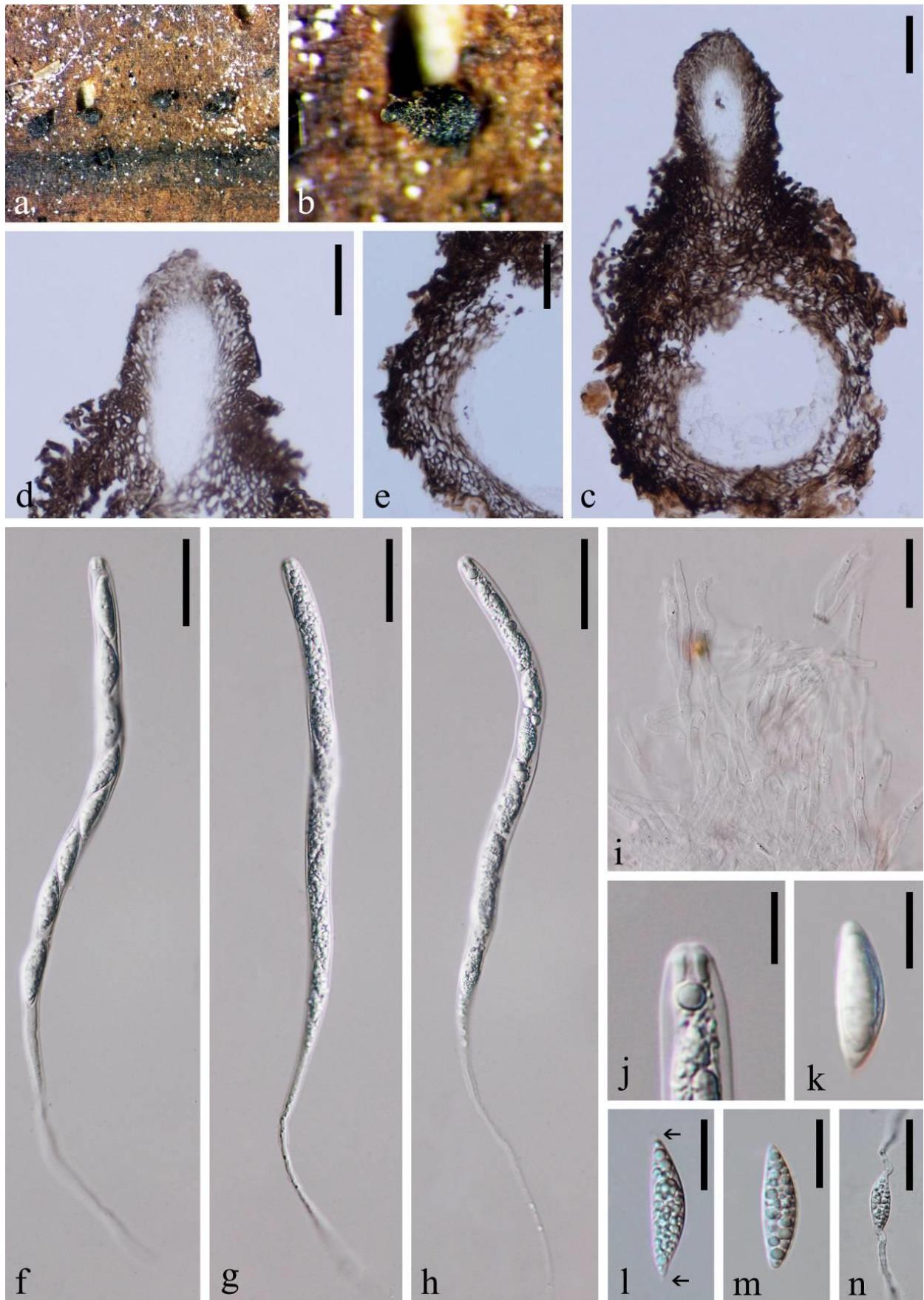
Holotype – MFLU 17-1708

*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 330–380 µm high, 260–300 µm diam., scattered, superficial, pyriform to subglobose, black, carbonaceous, ostiolate, with a centric or ecentric neck. *Necks* 125–150 × 80–100 µm, black, often oblique to host substrate. *Peridium* 45–80 µm thick, comprising several layers of dark brown to black, thick-walled cells of *textura angularis*, with inwardly compressed cells. *Paraphyses* up to 7.2 µm diam. at the widest, tapering towards the apex, dense, hypha-like, septate, constricted at septa, unbranched, hyaline. *Asci* 190–375 × 9.5–10.5 µm ( $\bar{x}$  = 295 × 10 µm, n = 5), 8-spored, unitunicate, cylindrical, apex truncate, with a large, refractive, wedge-shaped, apical ring, 4–7.5 × 5–7 µm, long pedicellate, up to 160 µm long. *Ascospores* 20–30 × 6–8 µm ( $\bar{x}$  = 25 × 7.2 µm, n = 20), uniseriate, fusiform, slightly curved, mostly aseptate, obscurely 1-septate when germinated, minutely guttulate, hyaline, thin-walled, smooth, sometimes with bipolar, short, cellular, tapering, hyaline apiculi, without gelatinous sheath. Asexual morph: Undetermined.

Material examined – Thailand, Chiang Mai Province, Mushroom Research Centre, on submerged wood in a stream, 1 September 2017, X.D. Yu, 23A (MFLU 17-1708, holotype), ex-type living culture MFLUCC 17-2346.

Notes – The ascospores of *Annulatascus chiangmaiensis* are sometimes equipped with a short, cellular apiculi, which are similar to *A. apiculatus* (Barbosa et al. 2008). However, *A. apiculatus* has immersed to semi-immersed ascomata with a long neck, contrasting with the superficial ascomata with a short neck of *A. chiangmaiensis*. In addition, *A. chiangmaiensis* has longer asci (190–375 × 9.5–10.5 µm vs. 175–250 × 10–13 µm), wider ascial apical ring (4–7.5 × 5–7 µm vs. 6–7.2 × 1.8–2.4 µm) and smaller ascospores (20–30 × 6–8 µm vs. 23–36.5 × 8.8–10 µm). *Annulatascus apiculatus* has 0–3-septate ascospores, while *A. chiangmaiensis* has obscurely 1-septate ascospores at maturity. Sequence data of *A. apiculatus* are lacking, but the two species can be separated by distinct morphology.

The morphological characteristics of *Annulatascus chiangmaiensis*, such as cylindrical asci with a long pedicel and wedge-shaped apical ring, fusiform, hyaline ascospores with bipolar, short apiculi, are similar to *Dictyosporella thailandensis* (Zhang et al. 2017). However, *D. thailandensis* differs in having immersed ascomata, an indistinct, small apical ring and 3-septate ascospores. Phylogenetic analysis places *A. chiangmaiensis* in Annulatascaceae, while *D. thailandensis* in Junewangiaceae (Fig. 1).



**Figure 2** – *Annulatascus chiangmaiensis* (MFLU 17-1708, holotype). a, b Ascomata on host substrate. c Vertical section of ascoma. d Structure of neck. e Structure of peridium. f–h Unitunicate asci. i Paraphyses. j Apical ring. k–m Ascospores (l note the bipolar apiculi). n Germinated ascospore. Scale bars: c–i = 50  $\mu$ m, j–m = 15  $\mu$ m, n = 30  $\mu$ m.

*Annulatascus nakhonensis* W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 3

Index Fungorum number: IF557444; Facesoffungi number: FoF 09542

Etymology – referring to Nakhon Si Thammarat, where the holotype was collected

Holotype – MFLU 18-1543

*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 275–375 µm high, 320–325 µm diam., scattered to gregarious, semi-immersed, often lying horizontally to the host substrate, ellipsoidal or subglobose, black, coriaceous, with a lateral neck. *Necks* 80–120 × 45–55 µm, black, conical, oblique to host substrate. *Peridium* 35–80 µm thick, uneven in thickness, comprising several layers of thin-walled cells of *textura angularis*, outer layer dark brown with compressed cells, inwardly hyaline with large cells. *Paraphyses* 5–6 µm diam., sparse, hypha-like, septate, slightly constricted at septa, unbranched, hyaline. *Asci* 240–340 × 10–13 µm ( $\bar{x}$  = 285 × 11.5 µm, n = 10), 8-spored, unitunicate, cylindrical, apex rounded, with a large, refractive, wedge-shaped, apical ring, 4–4.3 × 5.3–5.5 µm, long pedicellate, up to 120 µm long. *Ascospores* 24–28.5 × 8–10 µm ( $\bar{x}$  = 26.8 × 9.2 µm, n = 10), uniseriate, fusiform, straight or curved, aseptate, minutely guttulate, hyaline, thin-walled, smooth, with a gelatinous, thin sheath that is often folded at one side, showing an entirely covered, ellipsoidal, mucilaginous sheath in Indian Ink. Asexual morph: Undetermined.

Culture characteristics – On PDA, colony circular, reaching 20 mm in 25 days at 25°C, white from above, yellowish white from below, surface rough, dry, with sparse mycelium, umbonate, entire at edge.

Material examined – Thailand, Nakhon Si Thammarat Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat670 (MFLU 18-1543, holotype), ex-type living culture MFLUCC 18-1239; *ibid.*, HKAS 105013, isotype, ex-isotype living culture KUMCC 19-0029.

Notes – *Annulatascus nakhonensis* clusters with *A. Chiangmaiensis* with high bootstrap support (Fig. 1). Both species have fusiform, hyaline, aseptate ascospores, but they can be distinguished by several aspects. *Annulatascus nakhonensis* has semi-immersed ascomata, ascospores with a gelatinous, often folded sheath and without appendages. In contrast, *A. Chiangmaiensis* has superficial ascomata, ascospores with bipolar, short, cellular apiculi and without gelatinous sheath. A nucleotide comparison between *A. nakhonensis* and *A. Chiangmaiensis* shows a difference of 6 and 18 nucleotides in LSU and ITS sequence data, respectively, which indicates that they are distinct species according to guidelines of Jeewon & Hyde (2016).

*Annulatascus songkhlaensis* W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 4

Index Fungorum number: IF557445; Facesoffungi number: FoF 09543

Etymology – referring to songkhla, where the holotype was collected

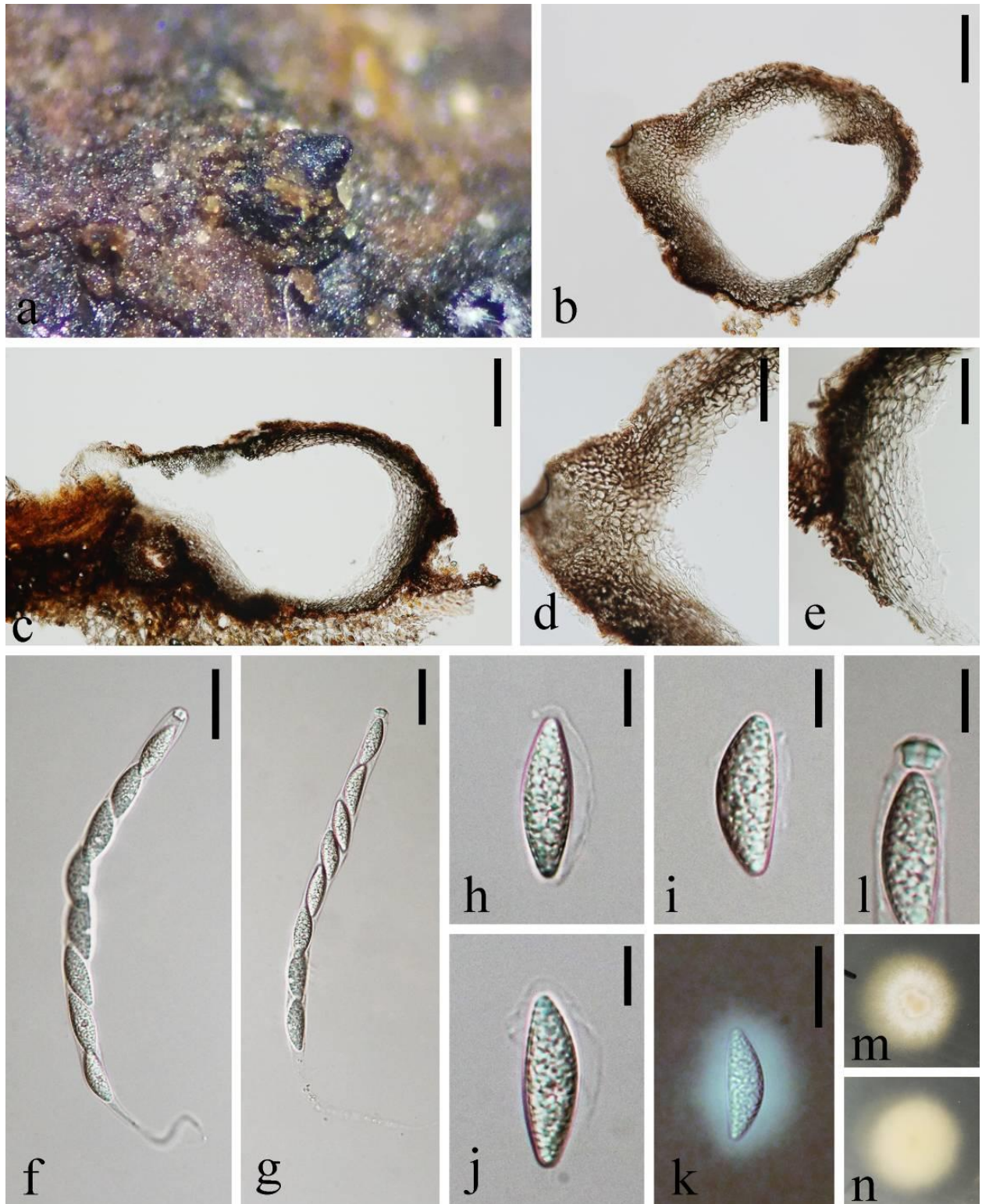
Holotype – MFLU 18-1564

*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 180–200 µm high, 290–310 µm diam., scattered to gregarious, immersed with neck erumpent through host substrate, ellipsoidal, black, coriaceous, ostiolate, with a centric or lateral neck. *Necks* 100–130 × 55–85 µm, black, subcylindrical or conical, tapering towards apex, oblique or upright to host substrate. *Peridium* 20–40 µm thick, comprising 11–14 layers of thick-walled cells of *textura angularis*, outer layer dark brown to black with large cells, inwardly pale brown to hyaline, with compressed cells. *Paraphyses* up to 7.5 µm diam. at the base, tapering towards the apex, dense, hypha-like, septate, slightly constricted at septa, unbranched, hyaline. *Asci* 285–355 × 11–12 µm ( $\bar{x}$  = 315 × 11.2 µm, n = 10), 8-spored, unitunicate, cylindrical, apex truncate, long pedicellate, with a large, refractive, wedge-shaped, apical ring, 5–5.5 × 6.5–6.7 µm. *Ascospores* 30–35 × 9–10.5 µm ( $\bar{x}$  = 32 × 9.9 µm, n = 20), uniseriate, fusiform, straight or slightly curved, aseptate or occasionally 1-septate, not constricted at the septum, minutely guttulate, hyaline, thin-walled, smooth, with an irregular, mucilaginous sheath, sometimes with short, cellular, tapering, hyaline apiculi at one or both ends. Asexual morph: Undetermined.

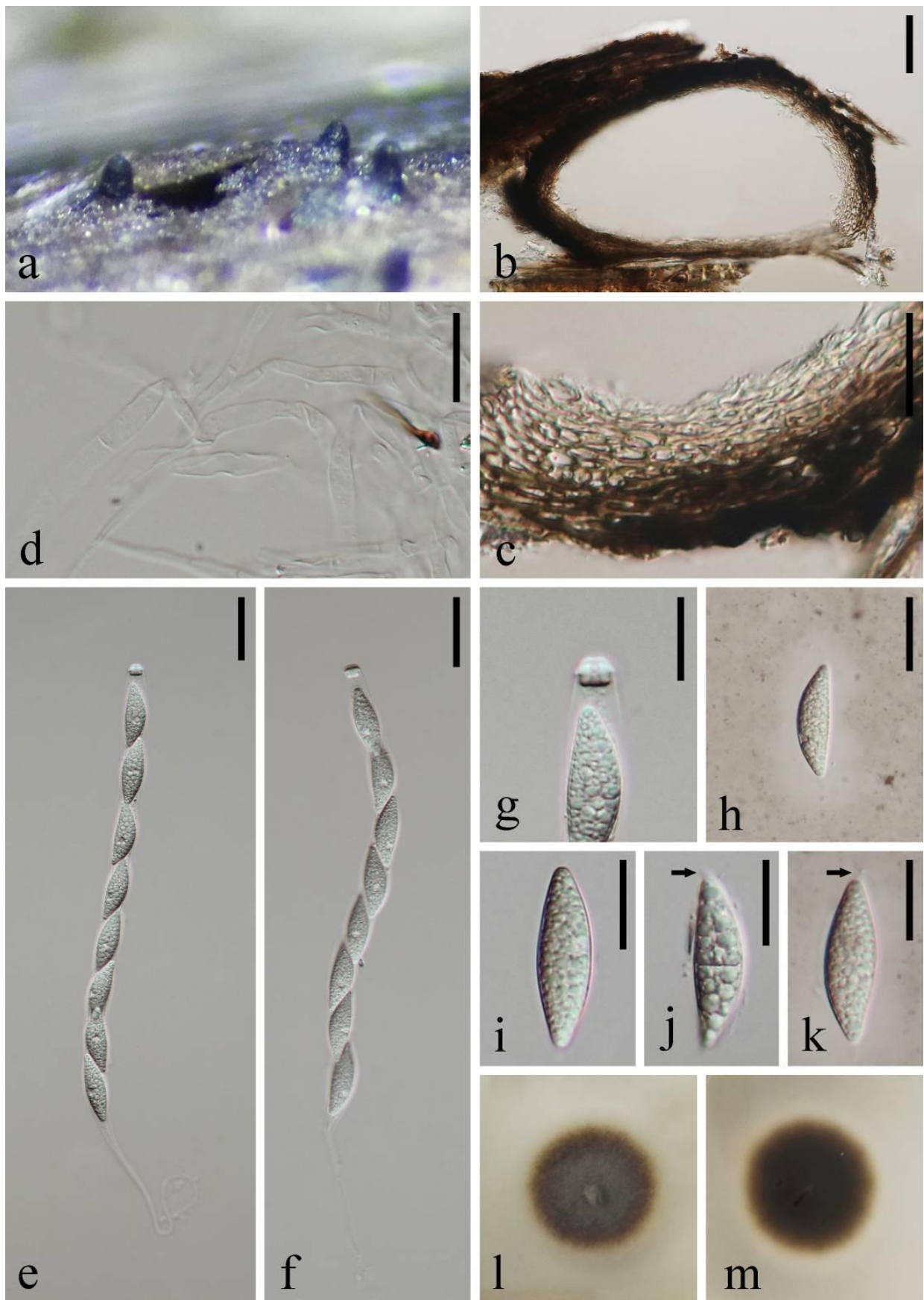
Culture characteristics – On PDA, colony circular, reaching 15 mm in 13 days at 25°C, gray from above, dark brown from below, surface rough, dry, with sparse mycelium, flat, entire at edge.



Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat826 (MFLU 18-1564, holotype), ex-type living culture MFLUCC 18-1151; *ibid.*, HKAS 105004, isotype, ex-isotype living culture KUMCC 19-0020.



**Figure 3** – *Annulatascus nakhonensis* (MFLU 18-1543, holotype). a Appearance of necks of ascomata on host. b, c Vertical section of ascomata. d, e Structure of peridium. f, g Unitunicate asci. h–j Ascospores in water showing folded sheaths. k Ascospore in Indian Ink showing an entire sheath. l Apical ring. m, n Colony on PDA (up-front, down-reverse). Scale bars: b, c = 100  $\mu$ m, d, e = 50  $\mu$ m, f, g = 30  $\mu$ m, h–j, l = 10  $\mu$ m, k = 20  $\mu$ m.



**Figure 4** – *Annulatascus songkhlaensis* (MFLU 18-1564, holotype). a Appearance of necks of ascomata on host. b Vertical section of ascoma. c Structure of peridium. d Paraphyses. e, f Unitunicate asci. g Apical ring. h–k Ascospores (h, k ascospores in Indian Ink showing the

irregular, mucilaginous sheath; j, k note the short apiculi as arrowed). l, m Colony on PDA (left-front, right-reverse). Scale bars: b = 50  $\mu\text{m}$ , c, d, h = 20  $\mu\text{m}$ , e, f = 30  $\mu\text{m}$ , g, i–k = 15  $\mu\text{m}$ .

Notes – *Annulatascus songkhlaensis* is basal to other *Annulatascus* species in our multigene phylogeny (Fig. 1). *Annulatascus songkhlaensis* is similar to *A. Chiangmaiensis* in having short, cellular apiculi at one or both ends of ascospores, but they can be distinguished by the ascospore size (30–35  $\times$  9–10.5  $\mu\text{m}$  vs. 20–30  $\times$  6–8  $\mu\text{m}$ ). *Annulatascus songkhlaensis* has immersed ascomata with neck erumpent through host substrate, while *A. Chiangmaiensis* has superficial ascomata. Molecular evidence supports them to be different species (Fig. 1). *Annulatascus songkhlaensis* has similar ascospore size with *A. apiculatus*, and both species have a short, cellular apiculi (Barbosa et al. 2008). However, *A. songkhlaensis* has longer asci (285–355  $\times$  11–12  $\mu\text{m}$  vs. 175–250  $\times$  10–13  $\mu\text{m}$ ), wider apical ring (5–5.5  $\times$  6.5–6.7  $\mu\text{m}$  vs. 6–7.2  $\times$  1.8–2.4  $\mu\text{m}$ ) and less septate of ascospores (mostly 1-septate vs. 0–3-septate) than *A. apiculatus*.

***Aquaticola*** W.H. Ho, C.K.M. Tsui, Hodgkiss & K.D. Hyde, Fungal Diversity Res. Ser. 3: 88 (1999)

Type species – *Aquaticola hyalomura* W.H. Ho, C.K.M. Tsui, Hodgkiss & K.D. Hyde

Notes – *Aquaticola* was introduced to accommodate *A. ellipsoidea* and *A. hyalomura* (type), which were collected from wood submerged in freshwater (Ho et al. 1999b). *Aquaticola ellipsoidea* was later transferred to *Atractospora* based on original description and two reference sequences (Réblová et al. 2016). *Aquaticola* is characterized by white to dark brown ascomata with a cylindrical neck, broadly oblong to long cylindrical asci with rounded to truncate apex, with a small apical ring, and ellipsoidal, septate or aseptate ascospores, with or without a sheath (Ho et al. 1999b). However, the features are shown to be broad and *Aquaticola* is an obviously heterogeneous assemblage as four accepted species represent different morphotypes (Ho et al. 1999b, Tsui et al. 2003).

*Aquaticola* was placed in Annulatascaceae by Maharachchikumbura et al. (2016). It was later referred to Diaporthomycetidae genera *incertae sedis*, because of the unstable relationship of the type species *A. hyalomura* (R-038) in phylogenetic and evolutionary analyses (Zhang et al. 2017). However, Réblová et al. (2016) indicated that the specimen R038 collected by Campbell & Shearer (2004) was misidentified and confirmed by its author Carol Shearer. Thus, there is no evidence to infer the phylogenetic placement of *A. hyalomura*. Due to their heterogeneous morphology and lack of DNA evidence derived from all *Aquaticola* species, we follow Maharachchikumbura et al. (2016) and retain *Aquaticola* in Annulatascaceae until more evidence appears. The strain R-038 is named as Pseudoproboscisporaceae sp. in our phylogenetic tree (Fig. 1).

***Fusoidigranularius*** W. Dong, H. Zhang & K.D. Hyde, gen. nov.

Index Fungorum number: IF557491; Facesoffungi number: FoF 09544

Etymology – in reference to its fusoid ascospores with a large granular sheath

*Saprobic* on submerged wood. Sexual morph: *Ascomata* solitary or gregarious, immersed, obpyriform, oriented horizontally to the host substrate, black, coriaceous, with ostiolate papilla, with an upward bend, relatively long neck growing laterally, periphysate. *Peridium* comprising several layers of thick-walled, flattened cells of *textura angularis*, outer layer dark brown and encrusted with pigmented particles, hyaline and unencrusted inwardly. *Paraphyses* rarely septate, hyaline, unbranched, tapering distally. *Asci* 8-spored, unitunicate, cylindrical, long pedicellate, persistent, with a large, refractive, J-, apical ring. *Ascospores* uniseriate to overlapping uniseriate, fusoid, 5–9(–11)-septate, hyaline, smooth-walled, with a large, gelatinous, irregular, granular sheath. Asexual morph: Undetermined.

Type species – *Fusoidigranularius nilensis* (Abdel-Wahab & Abdel-Aziz) W. Dong, H. Zhang & K.D. Hyde

Notes – *Annulatascus nilensis* was collected from submerged stems of *Phragmites australis* in the river Nile in Egypt (Abdel-Wahab et al. 2011). It clustered with *Annulatascus* species with

weak bootstrap support, and was placed in *Annulatascus* based on limited data (Abdel-Wahab et al. 2011). *Annulatascus nilensis* appears to have typical morphological characteristics of *Annulatascus*, such as cylindrical asci, long pedicel, and a large, refractive apical ring (Abdel-Wahab et al. 2011). However, *A. nilensis* has immersed ascomata that oriented horizontally to the host substrate and with an upwardly bending neck growing laterally, which are distinctive from *Annulatascus*, and even from Annulatascaceae. In addition, *A. nilensis* has 5–9(–11)-septate ascospores with an irregular, granular sheath that differ from *Annulatascus* species, including our three new species. Phylogenetically, *A. nilensis* forms a separated clade from *Annulatascus* in our updated phylogenetic tree (Fig. 1), which corroborates other studies (Hyde et al. 2018, 2020, Luo et al. 2019). The new genus *Fusoidigranularius* is, therefore, established to accommodate *A. nilensis* based on distinct morphology and phylogenetic analyses.

The ascomata lying horizontally is the key feature of two annulatascaceae-like families, Atractosporaceae and Pseudoproboscisporaceae. However, the ascomata of Atractosporaceae and Pseudoproboscisporaceae are semi-immersed to nearly superficial and they have aseptate or few septate ascospores (Zhang et al. 2017). A new collection of *Fluminicola saprophytica* (MFLUCC 18-1244) found in this study also has immersed ascomata that oriented horizontally to the host substrate and with an upward bend neck growing laterally (Fig. 26), which are similar to *Fusoidigranularius*. However, they can be distinguished by septation and shape of ascospores. Although *Fusoidigranularius* has a weak relationship with Annulatascaceae members (Fig. 1), it is temporarily placed in Annulatascaceae based on current phylogenetic analysis.

***Fusoidigranularius nilensis*** (Abdel-Wahab & Abdel-Aziz) W. Dong, H. Zhang & K.D. Hyde, comb. nov.

Index Fungorum number: IF557492; Facesoffungi number: FoF 09545

Basionym – *Annulatascus nilensis* Abdel-Wahab & Abdel-Aziz, IMA Fungus 2(1): 3 (2011)

Holotype – IMI 397966

Known distribution (based on molecular data) – Egypt

Known habitat (based on molecular data) – freshwater

For description of this fungus see Abdel-Wahab et al. (2011)

***Longivarius*** W. Dong, H. Zhang & K.D. Hyde, gen. nov.

Index Fungorum number: IF557493; Facesoffungi number: FoF 09546

Etymology – in reference to its long neck and various colour of ascospore cells

*Saprobic* on submerged wood. Sexual morph: *Ascomata* solitary, semi-immersed or superficial, globose, brown to dark brown, ostiolate, periphysate, with a prominent neck. *Neck* relatively long, cylindrical, curving or becoming erect. *Peridium* thick-walled, brown, comprising pseudoparenchymatous cells. *Paraphyses* filiform, septate, hyaline, simple to rarely branched. *Asci* 8-spored, unitunicate, cylindrical, short pedicellate, with a distinct, wedge-shaped, J-, apical ring. *Ascospores* uniseriate to overlapping biseriate in the ascus, fusoid to lunate, straight to slightly curved, 3-septate, central cells brown, end cells subhyaline, smooth-walled, without appendages or sheath. Asexual morph: Undetermined.

Type species – *Longivarius aquatorbae* (Boonyuen & Sri-indr.) W. Dong, H. Zhang & K.D. Hyde

Notes – *Annulatascus aquatorbae* was collected from submerged wood test block of *Erythrophleum teysmannii* in Thailand (Boonyuen et al. 2012). It was placed in *Annulatascus* based on its cylindrical asci with a relatively large, refractive apical ring and 3-septate ascospores (Boonyuen et al. 2012). However, *A. aquatorbae* is distinctive by unevenly colored ascospores with brown central cells and subhyaline end cells, contrasting with the hyaline ascospores of other *Annulatascus* species, including our three new species. In addition, *A. aquatorbae* forms a separated clade from *Annulatascus* species in our updated phylogenetic tree (Fig. 1), which corroborates other studies (Luo et al. 2015, 2019, Hyde et al. 2018, 2020). *Annulatascus aquatorbae* has been missing for almost 20 years since it was first collected in Thailand in 2003

(Boonyuen et al. 2012). In order to widen the taxonomic study of Annulatascaceae, we establish a new genus *Longivarius* to accommodate *A. aquatorbae* based on distinct morphology and phylogenetic analyses.

The unevenly colored ascospores are key generic features of several genera, such as *Ascitendus* (Annulatascaceae) (Campbell & Shearer 2004), *Byssothecium* (Massarinaceae) (Pem et al. 2019, Dong et al. 2020b) and *Savoryella* (Savoryellaceae) (Dayarathne et al. 2019). *Longivarius* is related to *Ascitendus* in Annulatascaceae, but they are in two distinct clades (Fig. 1). *Longivarius* is similar to *Ascitendus* in having dark ascomata with a prominent neck, cylindrical asci with a distinct apical ring, and 3-septate, fusiform ascospores. However, the asci of *Longivarius* have a wedge-shaped apical ring, while they are cylindrical to flaring in *Ascitendus*. In addition, the ascospores of *Longivarius* have darker central cells and paler end cells. This character is also described in *Ascitendus*, but not as obviously as in *Longivarius*. Phylogenetic analysis supports them to be different genera (Fig. 1). Although *Longivarius* has a weak relationship with Annulatascaceae members (Fig. 1), it is temporarily placed in Annulatascaceae based on current phylogenetic analysis.

***Longivarius aquatorbae*** (Boonyuen & Sri-indr.) W. Dong, H. Zhang & K.D. Hyde, comb. nov.

Index Fungorum number: IF558026; Facesoffungi number: FoF 09547

Basionym – *Annulatascus aquatorbae* Boonyuen & Sri-indr. [as 'aquatorba'], Mycologia 104(3): 752 (2012)

Holotype – BBH 29936

Known distribution (based on molecular data) – Thailand

Known habitat (based on molecular data) – freshwater

For description of this fungus see Boonyuen et al. (2012)

**Atractosporales** H. Zhang, K.D. Hyde & Maharachch., Fungal Diversity 85: 88 (2017)

Type family – Atractosporaceae H. Zhang, K.D. Hyde & Maharachch.

Notes – Atractosporales was introduced to accommodate three families, i.e. Atractosporaceae, Conlariaceae and Pseudoproboscisporaceae, based on morphology and multigene analyses (Zhang et al. 2017). Atractosporaceae and Pseudoproboscisporaceae are comparable as ascomata in both families are often parallel or oblique to the host substrate, while the ascomata in Conlariaceae have an upright neck (Ferrer et al. 2012, Liu et al. 2012, Réblová et al. 2016, Zhang et al. 2017). With more samples populated in the phylogenetic analyses, three families did not form a monophyletic clade and had relationships with other families, Cancellidiaceae and Junewangiaceae (Luo et al. 2019, Hyde et al. 2020). Luo et al. (2019) therefore excluded Conlariaceae and Pseudoproboscisporaceae to the order and referred them in Diaporthomycetidae families *incertae sedis*. Hyde et al. (2021) established a new order Conlariales to accommodate Conlariaceae based on a divergence time study, and retain Pseudoproboscisporaceae in Diaporthomycetidae families *incertae sedis*. Our phylogenetic analysis show that Conlariales clusters distantly from Atractosporaceae and Pseudoproboscisporaceae, and has relationship with Xenosporales, while Pseudoproboscisporaceae clusters with Junewangiaceae (Fig. 1).

**Atractosporaceae** H. Zhang, K.D. Hyde & Maharachch., Fungal Diversity 85: 88 (2017)

Type genus – *Atractospora* Réblová & J. Fourn.

Notes – Atractosporaceae was established for two freshwater genera *Atractospora* and *Rubellisphaeria*, which have pigmented ascomata with a lateral neck and hyaline ascospores (Zhang et al. 2017). The divergence time study also supported it as a distinct family (Hongsanant et al. 2017, Hyde et al. 2017, Zhang et al. 2017). The ascomata with a lateral neck which are upright or oblique to the host substrate are the common characteristics in several annulatascaceae-like taxa in different families, e.g. *Diluvicola* (Pseudoproboscisporaceae), *Fusoidigranularius* (Annulatascaceae), *Neodiluvicola* (Pseudoproboscisporaceae) and *Obliquiminima* (Cancellidiaceae). The asexual morph of Atractosporaceae is undetermined.

*Atractospora* Réblová & J. Fourn., Mycol. Progr. 15(no. 21): 8 (2016)

Type species – *Atractospora reticulata* Réblová & J. Fourn.

Notes – *Atractospora* was introduced by Réblová et al. (2016) to accommodate three new species and one new combination which were transferred from *Aquaticola*. *Atractospora* differs from *Aquaticola* by its ascomata lying horizontally on the substrate and fusiform ascospores (Ho et al. 1999b, Tsui et al. 2003, Réblová et al. 2016). All six *Atractospora* species, including our new collection of *A. ellipsoidea*, were collected from freshwater habitats (Ho et al. 1999b, Réblová et al. 2016, Zhang et al. 2017, Luo et al. 2019).

*Atractospora ellipsoidea* (W.H. Ho, C.K.M. Tsui, Hodgkiss & K.D. Hyde) Réblová & J. Fourn., Mycol. Progr. 15(no. 21): 13 (2016) Fig. 5

Facesoffungi number: FoF 09548

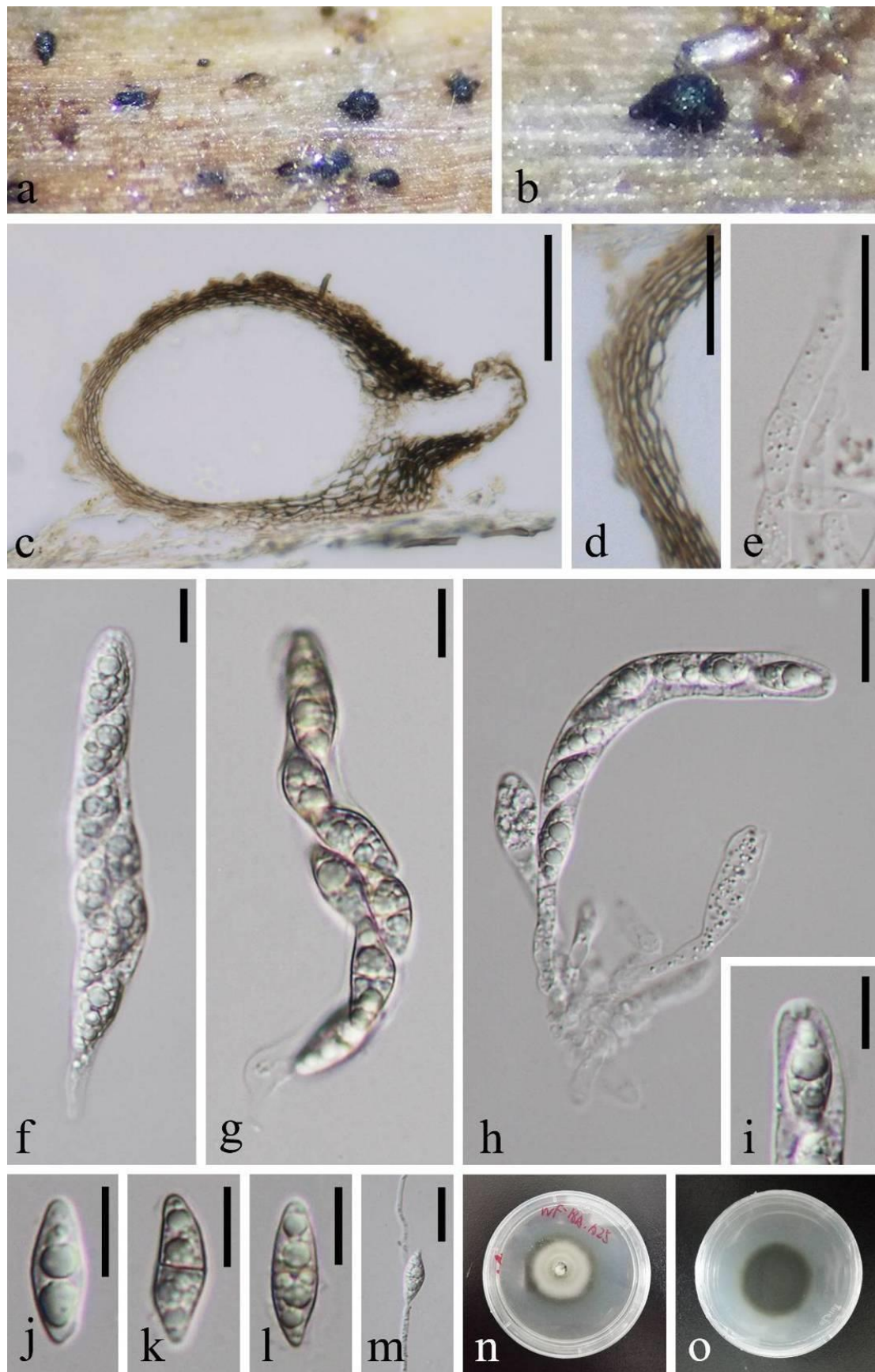
*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 90–120 µm high, 120–140 µm diam., scattered, superficial, ellipsoidal, dark brown to black, lying horizontally on the substrate, coriaceous, ostiolate, with a lateral neck. *Necks* 40–60 µm long, black, cylindrical, curving upwards, comprising single layer of brown to dark brown cells of *textura angularis*. *Peridium* 8.5–12 µm thick at upper part, comprising 5–7 layers of brown to dark brown, thin-walled, compressed cells of *textura angularis*; 35–40 µm thick near the base where below the neck, comprising 9–11 layers of brown to dark brown, thick-walled, large cells of *textura angularis*. *Paraphyses* 5 µm diam., sparse, hypha-like, uneven subcylindrical, septate, constricted at septa, unbranched, hyaline. *Asci* 75–120 × 10–14 µm ( $\bar{x}$  = 98 × 11.5 µm, n = 10), 8-spored, unitunicate, subcylindrical, wider in the middle part, apex slightly truncate, pedicellate, with a small, refractive apical ring, 2.7–3 × 2.3–2.5 µm. *Ascospores* 16–19 × 6–7.5 µm ( $\bar{x}$  = 17.8 × 6.5 µm, n = 10), overlapping uniseriate, or partially biseriate in the middle part, hyaline when young, becoming pale brown when mature, ellipsoidal, rounded or slightly acute at both ends, straight or curved, two apices occasionally reverse bending, aseptate when young, 1-septate when mature, not constricted at septum, guttulate, thin-walled, smooth, without a mucilaginous sheath. Asexual morph: Undetermined.

Culture characteristics – On PDA, colony circular, reaching 30 mm in 65 days at 25°C, gray-dark brown from above, dark brown to black from below, surface rough, dry, with sparse mycelium, flat, entire at edge.

Material examined – China, Yunnan Province, Pingbian City, on submerged wood in a stream, 20 September 2017, W. Dong, WF18A (MFLU 18-1182), living culture KUMCC 18-0051; *ibid.*, HKAS 101702.

Notes – Although the type material of *Aquaticola ellipsoidea* was unavailable for morphological examination, Réblová et al. (2016) transferred *A. ellipsoidea* to *Atractospora* based on original description (Ho et al. 1999b) and two reference sequences, AY590290 and AY316356 (Raja et al. 2003, Campbell & Shearer 2004). We name our new collection KUMCC 18-0051 as *A. ellipsoidea* considering its very similar morphological characteristics with the holotype (Ho et al. 1999b), except for septa of the ascospores. We observed 1-septate ascospores when mature, while they were aseptate in the holotype (Ho et al. 1999b). This is probably because the holotype was examined when young or large guttules obscured the septa (Réblová et al. 2016). In this study, we confirm *A. ellipsoidea* in *Atractospora* with morphological and molecular data derived from our new collection KUMCC 18-0051.

KUMCC 18-0051 forms a strongly supported clade with two strains of *Atractospora ellipsoidea* (A411–3 and R008) (Fig. 1). We found 16 nucleotide differences in LSU sequence data between A411–3 and R008 (LSU: AY316356, AY590290), which phylogenetically appears to be different species. Unfortunately, no other sequence data can be compared for A411–3 and R008. Morphological characteristics for the two strains are unavailable (Raja et al. 2003, Campbell & Shearer 2004), therefore their real identities are undetermined. Nevertheless, the morphology strongly confirms our collection to be *A. ellipsoidea*.



**Figure 5** – *Atractospora ellipsoidea* (MFLU 18-1182). a, b Ascomata on host substrate. c Vertical section of ascoma. d Structure of peridium. e Paraphyses. f–h Unitunicate asci. i Apical ring. j–l Ascospores. m Germinated ascospore. n, o Colony on PDA (left-front, right-reverse). Scale bars: c = 50  $\mu$ m, d, e, h, m = 20  $\mu$ m, f, g, i–l = 10  $\mu$ m.

**Cancellidiales** K.D. Hyde & Hongsanan, Fungal Diversity: 10.1007/s13225-021-00469-7 (2021)

Type family – Cancellidiaceae K.D. Hyde & Hongsanan

Notes – Cancellidiales was introduced to accommodate a single family Cancellidiaceae with a genus *Cancellidium*. The establishment of Cancellidiales was supported by divergence time study that the stem age was estimated as 137 MYA which fell in the range of an order (Hyde et al. 2021).

**Cancellidiaceae** K.D. Hyde & Hongsanan, Fungal Diversity: 10.1007/s13225-021-00469-7 (2021)

Type genus – *Cancellidium* Tubaki

Notes – Cancellidiaceae was established for an asexual genus *Cancellidium* based on a divergence time study (Hyde et al. 2021). In this study, we propose a new genus *Obliquiminima* in the family, which is the first sexual morph linked by molecular data and morphologically similar to Annulatasceae species.

***Cancellidium*** Tubaki, Trans. Mycol. Soc. Japan 16(4): 357 (1975)

Type species – *Cancellidium applanatum* Tubaki

Notes – *Cancellidium* is characterized by shiny, obovate to obcordate conidia which are composed of parallel rows of cells encapsulating strings of monilioid cells (Tubaki 1975, Yeung et al. 2006). Since the type species *C. applanatum* was sequenced (Pratibha et al. 2014, Zelski et al. 2014), more species were added to the genus and the placement of *Cancellidium* was discussed accordingly. *Cancellidium* was referred to Sordariomycetidae genera *incertae sedis* (Hyde et al. 2020), later was classified in a newly established family Cancellidiaceae based on a divergence time study (Hyde et al. 2021). The sexual morph of *Cancellidium* is unknown. We introduce a new asexual species in the genus and provide several new collections of *C. atrobrunneum* and *C. griseonigrum*.

***Cancellidium atrobrunneum*** D.F. Bao, Z.L. Luo, K.D. Hyde & H.Y. Su, Fungal Diversity: 10.1007/s13225-021-00469-7 (2021) Fig. 6

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies effuse, gregarious, dark brown to black, olivaceous, shiny. Mycelium partly immersed, partly superficial on substratum, consisting of septate, thin-walled, hyaline hyphae. Conidiophores absent. Conidiogenous cells 17–20 × 3–4.5 μm ( $\bar{x}$  = 18 × 4 μm, n = 5), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, pale brown to hyaline, thick-walled, smooth. Conidia 120–150 × 70–100 μm ( $\bar{x}$  = 137 × 85 μm, n = 10), solitary, dry, thin-walled, smooth-walled, ovoid, ellipsoidal, or irregular, with rounded ends, dictyoseptate, olivaceous brown to dark brown, composed of several parallel, adherent rows radiating from base. Rows 3–6.5 μm wide, septate, containing rectangular and moniliform cells.

Culture characteristics – On PDA, colony irregular, reaching 15 mm in 30 days at 25°C, grey from above, dark from below, surface rough, dry, with dense mycelium, raised, curled at edge.

Material examined – Thailand, Chiang Mai Province, on submerged wood in a stream, 1 September 2017, X.D. Yu, 3A (MFLU 17-1720), living culture MFLUCC 17-2361.

Notes – *Cancellidium atrobrunneum* was collected from a submerged wood in a freshwater stream in Thailand (Hyde et al. 2021). Our new collection MFLUCC 17-2361 has very similar morphological characteristics with *C. atrobrunneum* in all aspects. Multigene analysis supports them to be the same species (Fig. 1).

***Cancellidium griseonigrum*** J. Yang & K.D. Hyde, Fungal Diversity: 10.1007/s13225-021-00469-7 (2021) Fig. 7

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies effuse, gregarious, black, shiny. Mycelium partly immersed, partly superficial on substratum, consisting of septate, thin-walled, hyaline hyphae. Conidiophores absent. Conidiogenous cells holoblastic, monoblastic. Conidia 205–270 × 115–150 μm ( $\bar{x}$  = 245 × 133 μm, n = 10), solitary, dry, thin-walled, smooth-walled, broadly fusiform, ellipsoidal, with tapering



ends, olivaceous brown to black, easily cracked when mounted in water, composed of many parallel adherent, rows. Rows 3–6.5  $\mu\text{m}$  wide, septate, constricted at septa, brown to olivaceous brown, radiate from conidial base.

Culture characteristics – On PDA, colony irregular, reaching 15 mm in 33 days at 25°C, gray brown from above, dark brown from below, surface rough, dry, with dense mycelium, raised, curled at edge.

Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat147 (MFLU 18-1537), living culture MFLUCC 18-1236; *ibid.*, HKAS 105010, living culture KUMCC 19-0026.

Notes – *Cancellidium griseonigrum* was collected from submerged wood in a freshwater stream in Thailand (Hyde et al. 2021). Our new collection MFLUCC 18-1236 has overlapping conidial size and very similar morphology with the holotype of *C. griseonigrum*. A nucleotide comparison and multigene analysis indicate our collection to be *C. griseonigrum* (Fig. 1).

***Cancellidium thailandense*** W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 8

Index Fungorum number: IF558034; Facesoffungi number: FoF 09556

Etymology – in reference to Thailand, where the holotype was collected

Holotype – MFLU 18-1510

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies effuse, gregarious, black, shiny. Mycelium partly immersed, partly superficial on substratum, consisting of septate, thin-walled, hyaline hyphae. Conidiophores 25–55  $\times$  3.5–4  $\mu\text{m}$  ( $\bar{x}$  = 40  $\times$  3.75  $\mu\text{m}$ , n = 5), micronematous, mononematous, subcylindrical, flexuous, 0–2-septate, slightly constricted at septa, unbranched, pale brown, thick-walled, smooth. Conidiogenous cells 15–18  $\times$  3.5–4.7  $\mu\text{m}$  ( $\bar{x}$  = 16.5  $\times$  4  $\mu\text{m}$ , n = 5), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, pale brown, thick-walled, smooth. Conidia 78–105  $\times$  60–100  $\mu\text{m}$  ( $\bar{x}$  = 90.5  $\times$  85  $\mu\text{m}$ , n = 10), solitary, dry, thin-walled, smooth-walled, subglobose, ellipsoidal, dictyoseptate, olivaceous, easily cracked when mounted in water, composed of many parallel adherent, rows. Rows 3–6  $\mu\text{m}$  wide, septate, constricted at septa, olivaceous, radiate from conidial base.

Culture characteristics – On PDA, colony irregular, reaching 8 mm in 30 days at 25°C, black from above and below, surface rough, dry, with dense mycelium, raised, undulate at edge.

Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, 20180511 (MFLU 18-1510, holotype), ex-type living culture MFLUCC 18-1142; *ibid.*, HKAS 104995, isotype, ex-isotype living culture KUMCC 19-0012.

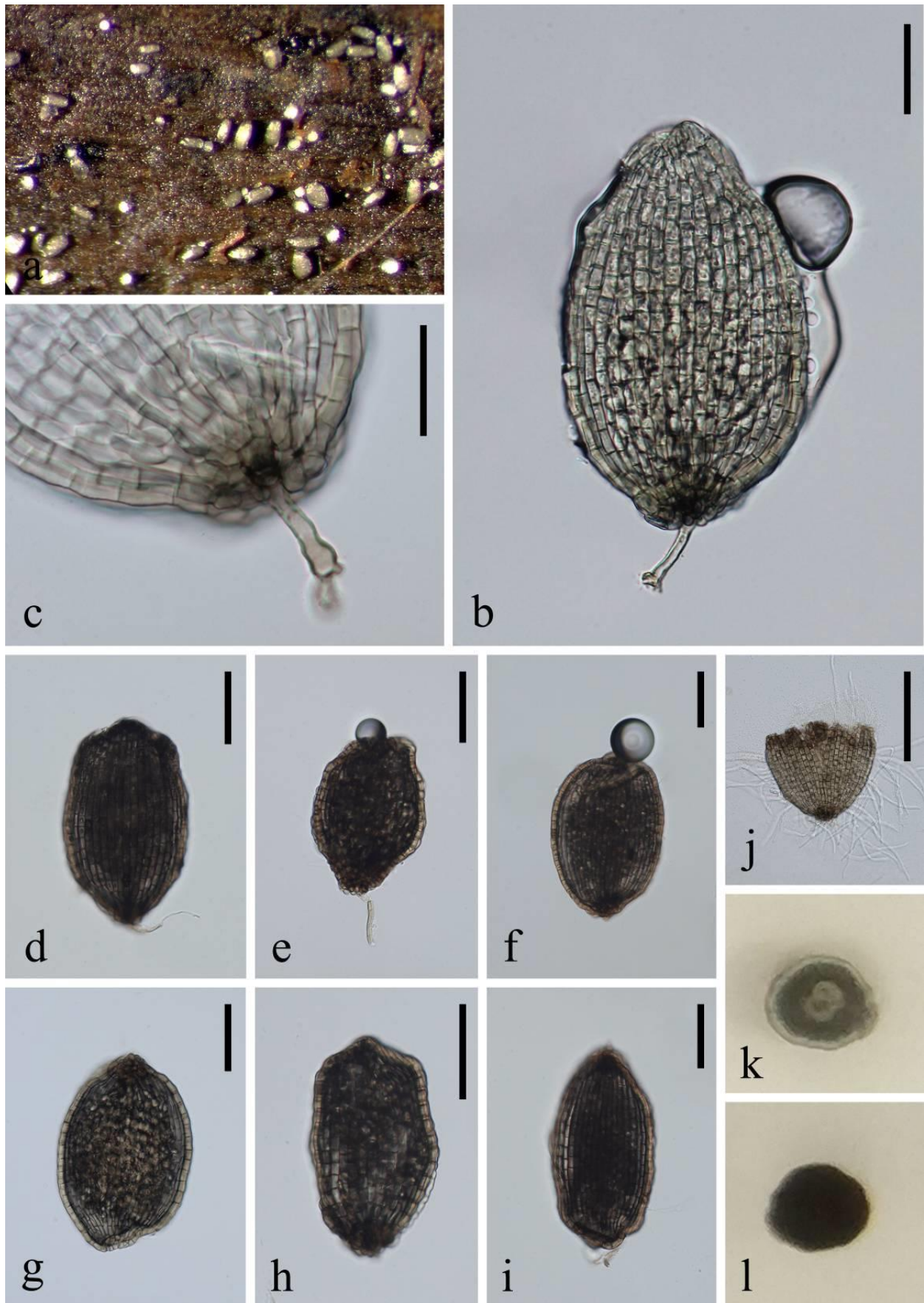
Notes – *Cancellidium thailandense* is similar to other species in the genus in having monoblastic, terminal conidiogenous cells, and dictyoseptate conidia comprising of many parallel adherent rows. However, *C. thailandense* differs by subglobose, olivaceous conidia (Tubaki 1975, Yeung et al. 2006, Pratibha et al. 2014, Zelski et al. 2014, Hyde et al. 2021). Multigene analysis supports it to be a new species in the genus (Fig. 1).

***Obliquiminima*** W. Dong, H. Zhang & K.D. Hyde, gen. nov.

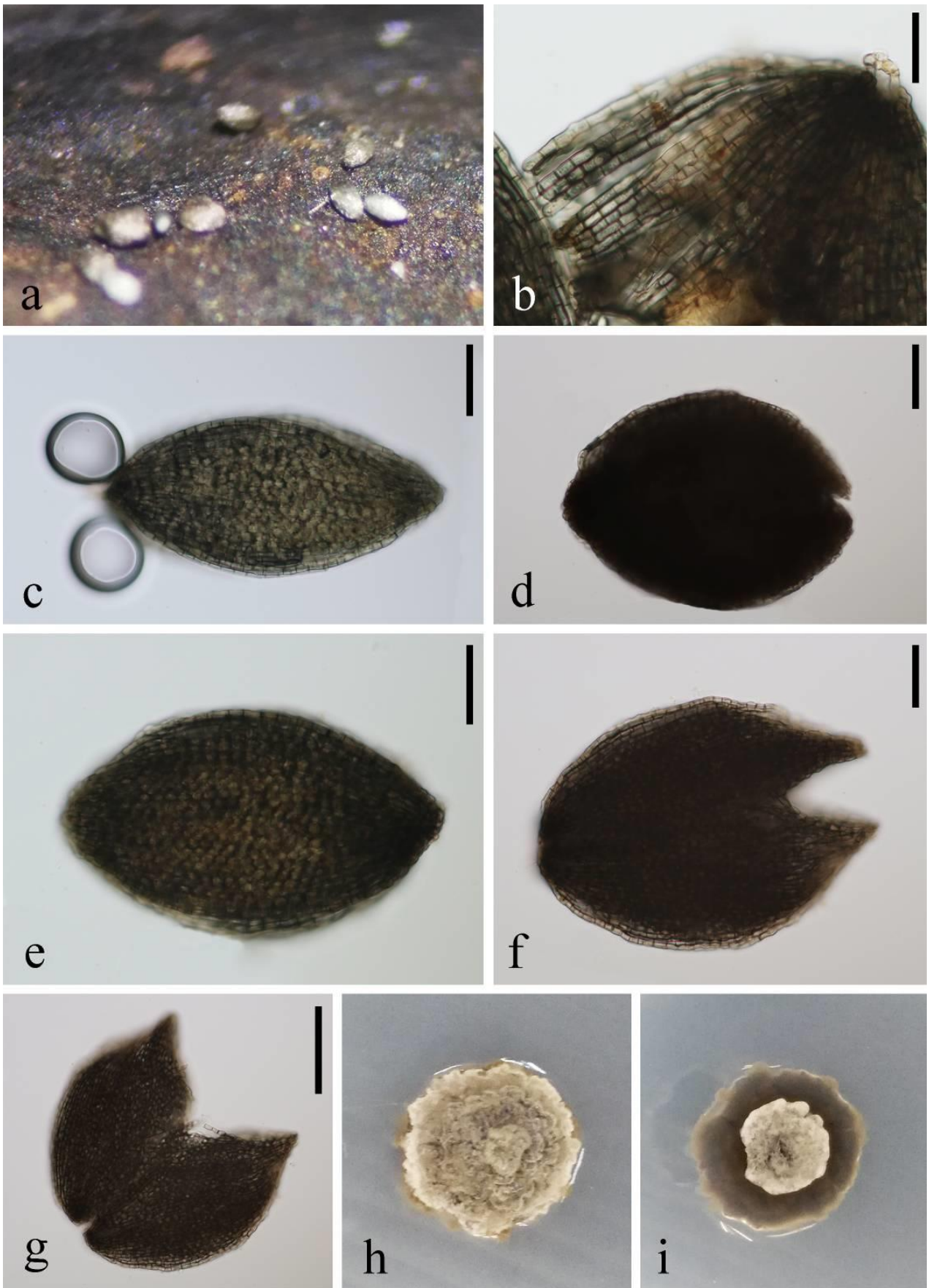
Index Fungorum number: IF558035; Facesoffungi number: FoF 09557

Etymology – in reference to its neck growing oblique to the host substrate and small ascomata

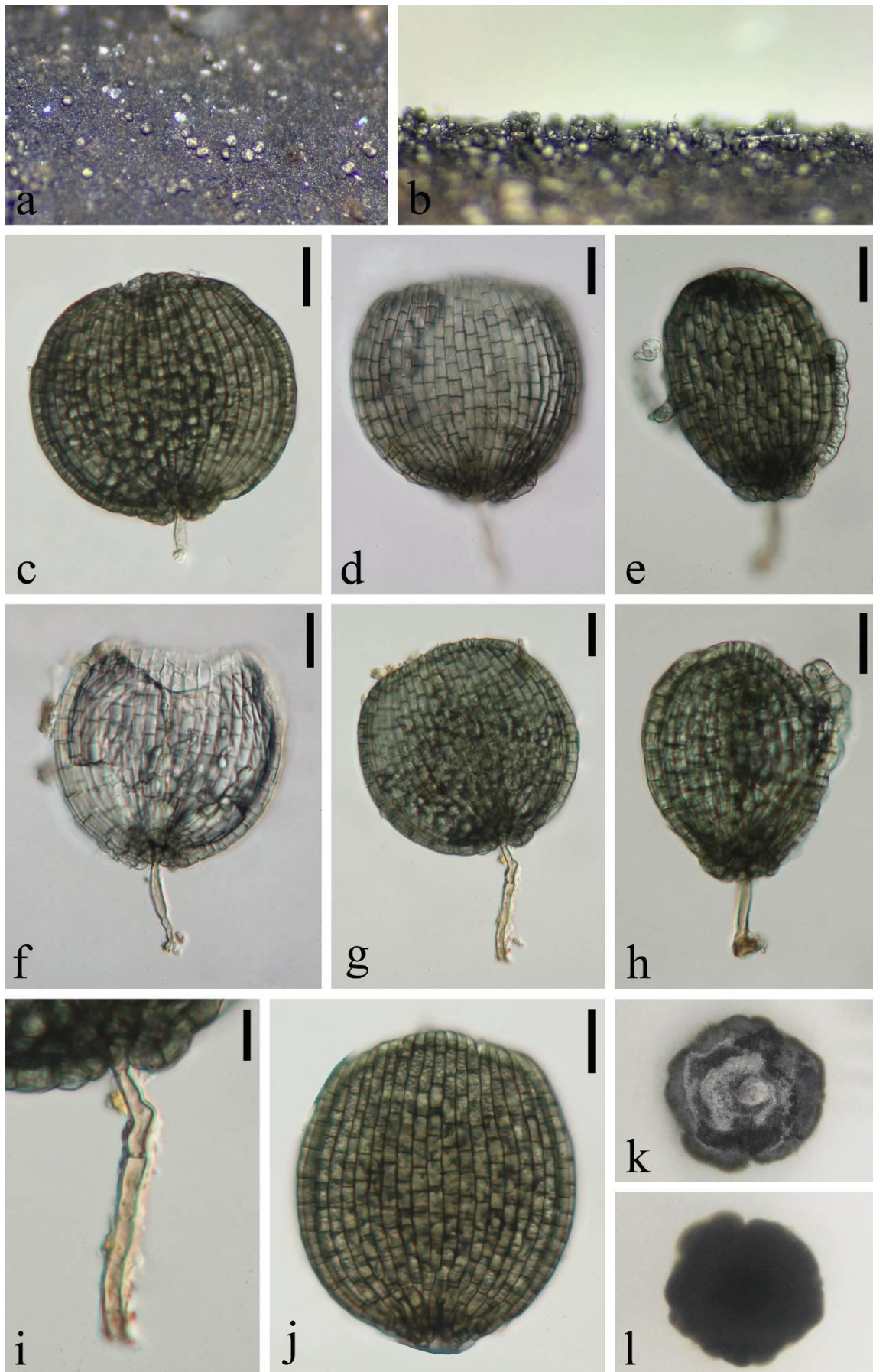
*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* tiny, scattered, superficial, ellipsoidal to subglobose, black, coriaceous, ostiolate, with a lateral neck. *Necks* short, black, cylindrical, oblique to the host substrate. *Peridium* comprising several layers of dark brown to black, thick-walled, compressed cells of *textura angularis*. *Paraphyses* tapering towards the apex, dense, hypha-like, septate, unbranched, hyaline. *Asci* 8-spored, unitunicate, narrowly obclavate, slightly truncate at apex, sessile, with a small, refractive apical ring. *Ascospores* uni- to bi-seriate, oval, narrowly ellipsoidal, straight, aseptate, guttulate, hyaline, thin-walled, smooth, with a thin gelatinous sheath. Asexual morph: Undetermined.



**Figure 6** – *Cancellidium atrobrunneum* (MFLU 17-1720). a Colonies on submerged wood. b, c Conidia with conidiogenous cells. d–i Conidia. j Germinated conidium. k, l Colony on PDA (up-front, down-reverse). Scale bars: b = 30  $\mu$ m, c = 20  $\mu$ m, d–i = 50  $\mu$ m, j = 100  $\mu$ m.



**Figure 7** – *Cancellidium griseonigrum* (MFLU 18-1537). a Colonies on submerged wood. b–g Conidia (b note the parallel rows of cells). h, i Colony on PDA (left-front, right-reverse). Scale bars: b = 30  $\mu$ m, c–f = 50  $\mu$ m, g = 100  $\mu$ m.



**Figure 8** – *Cancellidium thailandense* (MFLU 18-1510, holotype). a, b Colonies on submerged wood. c–e, j Conidia. f–i Conidiophores with conidia. k, l Colony on PDA (up-front, down-reverse). Scale bars: c–h, j = 20  $\mu$ m, i = 10  $\mu$ m.

Type species – *Obliquiminima hyalina* W. Dong, H. Zhang & K.D. Hyde

Notes – *Obliquiminima* forms a sister clade with a hyphomycetous genus *Cancellidium* in Cancellidiaceae with high bootstrap support (Fig. 1). *Cancellidium* is characterized by dictyosporous conidia arising from small conidiophores (Tubaki 1975). No sexual morphs are reported in *Cancellidium*, thus the morphology between *Cancellidium* and *Obliquiminima* cannot be compared. Our multigene analysis supports *Obliquiminima* to be a new genus in Cancellidiaceae (Fig. 1).

*Obliquiminima* can be compared to an annulatasceae-like genus *Ayria* in having ellipsoidal, aseptate, hyaline, finely guttulate ascospores (Fryar & Hyde 2004). However, *Obliquiminima* differs in having superficial ascomata, with a lateral neck that oblique to the host substrate, narrowly obclavate asci with a refractive apical ring. In contrast, *Ayria* has immersed ascomata that become superficial at maturity, clavate asci without an apical ring (Fryar & Hyde 2004). *Ayria* also has a neck, but which was not described in detail for two species, *A. appendiculata* and *A. nubispora* (Fryar & Hyde 2004, Raja et al. 2009). *Ayria* is placed in Annulatasceae based on morphology, but it lacks molecular data (Hyde et al. 2020). Sequence data for *Ayria* are needed to infer the phylogenetic relationships between *Ayria* and *Obliquiminima*.

***Obliquiminima hyalina*** W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 9

Index Fungorum number: IF558036; Facesoffungi number: FoF 09557

Etymology – in reference to hyaline ascospores of the fungus

Holotype – MFLU 18-1521

*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 130–150 µm high, 140–160 µm diam., scattered, superficial, ellipsoidal to subglobose, black, coriaceous, ostiolate, with a lateral neck. *Necks* short, black, cylindrical, oblique to the substrate surface. *Peridium* 10–15 µm thick, comprising 5–7 layers of dark brown to black, thick-walled, compressed cells of *textura angularis*. *Paraphyses* up to 15 µm diam. at the base, tapering towards the apex, dense, hypha-like, septate, constricted at septa, unbranched, hyaline. *Asci* 150–215 × 16–20.5 µm ( $\bar{x}$  = 178 × 18.5 µm, n = 20), 8-spored, unitunicate, narrowly obclavate, slightly truncate at apex, sessile, with a small, refractive, discoid, apical ring, 2.4 × 4.2 µm. *Ascospores* 30.5–37.5 × 9–12.5 µm ( $\bar{x}$  = 34.5 × 10.5 µm, n = 10), uni- to bi-seriate, oval, narrowly ellipsoidal, straight, aseptate, 3-septate when germinated, finely guttulate, hyaline, thin-walled, smooth, with a thin gelatinous sheath. Asexual morph: Undetermined.

Culture characteristics – On PDA, colony circular, reaching 20 mm in 47 days at 25°C, gray brown from above, dark brown from below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat142 (MFLU 18-1521, holotype), ex-type living culture MFLUCC 18-1235; *ibid.*, HKAS 105009, isotype, ex-isotype living culture KUMCC 19-0025; chestnut hill, on submerged wood in a stream, 10 May 2018, W. Dong, hat459 (MFLU 18-1529), living culture MFLUCC 18-1401; *ibid.*, HKAS 105046, living culture KUMCC 19-0065.

**Conlariales** K.D. Hyde & Hongsanan, Fungal Diversity: 10.1007/s13225-021-00469-7 (2021)

Type family – Conlariaceae H. Zhang, K.D. Hyde & Maharachch

Notes – Conlariales was introduced to accommodate Conlariaceae which was previously placed in Atractosporales (Hyde et al. 2021). The divergence time estimated the stem age of Conlariales was 138 MYA, which fell in the range of an order (Hyde et al. 2021).

**Conlariaceae** H. Zhang, K.D. Hyde & Maharachch., Fungal Diversity 85: 90 (2017)

Type genus – *Conlarium* F. Liu & L. Cai

Notes – Conlariaceae was established to accommodate a single holomorphic genus *Conlarium* (Zhang et al. 2017). Luo et al. (2019) included another sexual genus *Riomyces* in the family based on multigene analysis. In our phylogenetic analysis (Fig. 1), *Riomyces* clusters within

*Conlarium* with good bootstrap support. However, the two genera have entirely different characteristics. *Conlarium* has a long neck of ascomata, cylindrical asci with a large apical ring and fusiform ascospores, while *Riomyces* has a short neck of ascomata, asci without an apical ring, and broadly ellipsoidal-fusiform ascospores with an irregular, expanding sheath (Ferrer et al. 2012, Liu et al. 2012). The asexual morph of *Conlarium* has muriform, brown and irregular-shaped conidia, while the asexual morph of *Riomyces* is undetermined. To clarify the relationships between *Conlarium* and *Riomyces*, more collections are needed for these two genera. Conlariaceae was placed in Atractosporales based on limited data (Zhang et al. 2017), and later was shown to be phylogenetically distant from the type family Atractosporaceae in Luo et al. (2019). Hyde et al. (2021) established a new order Conlariales to accommodate this family based on a divergence time study.

***Conlarium*** F. Liu & L. Cai, Mycologia 104(5): 1180 (2012)

Type species – *Conlarium dupliciascosporum* F. Liu & L. Cai

Notes – *Conlarium* is the only holomorphic genus in the family and characterized by dark brown to black ascomata with a long, cylindrical neck, cylindrical asci with a short pedicellate and a large apical ring, fusiform, hyaline ascospores, with or without globose or papillary appendages, and muriform, irregular-shaped conidia (Liu et al. 2012). *Conlarium* comprises terrestrial and freshwater species described from natural substrate and artificial culture (Liu et al. 2012, Zhang et al. 2017, Phookamsak et al. 2019, Xie et al. 2019). We introduce a new asexual species in *Conlarium*, which is collected from submerged wood in freshwater in Thailand. A new collection of *C. aquaticum* from China is also described and illustrated.

***Conlarium aquaticum*** W. Dong, H. Zhang & K.D. Hyde, Fungal Diversity 85: 92 (2017) Fig. 10

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies sporodochial, punctiform, gregarious, raised, black. Mycelium partly immersed, partly superficial on substratum, consisting of septate, thin-walled, hyaline hyphae. Conidiophores absent or reduced to conidiogenous cells. Conidiogenous cells up to 22 µm long, holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, hyaline, smooth. Conidia 22.5–52 × 18–31 µm ( $\bar{x}$  = 33 × 24 µm, n = 25), acrogenous, solitary, dry, thin-walled, smooth-walled, ellipsoidal, clavate, obovoid, subglobose, or irregular-shaped, muriform, multi-septate, slightly constricted at septa, dark brown, olive brown on the surface, with a hyaline or pale brown, cuneiform base.

Culture characteristics – On PDA, colony circular, reaching 10 mm in 27 days at 25°C, gray-brown from above, black from below, surface rough, dry, with sparse mycelium, raised, entire at edge.

Material examined – China, Yunnan Province, Dehong City, on submerged wood in a stream, 25 November 2017, G.N. Wang, H26A (MFLU 18-1181), living culture MFLUCC 18-1417; *ibid.*, HKAS 101744, living culture KUMCC 18-0096.

Notes – *Conlarium aquaticum* was initially collected from a freshwater stream in Thailand (Zhang et al. 2017). Although our new collection has smaller conidia than the holotype (22.5–52 × 18–31 µm vs. 45–70 × 20–57 µm), phylogenetic analysis and single gene comparison support them to be the same species (Fig. 1). This is a new geographical record of *C. aquaticum* in China.

***Conlarium subglobosum*** X.D. Yu, W. Dong & H. Zhang, sp. nov.

Fig. 11

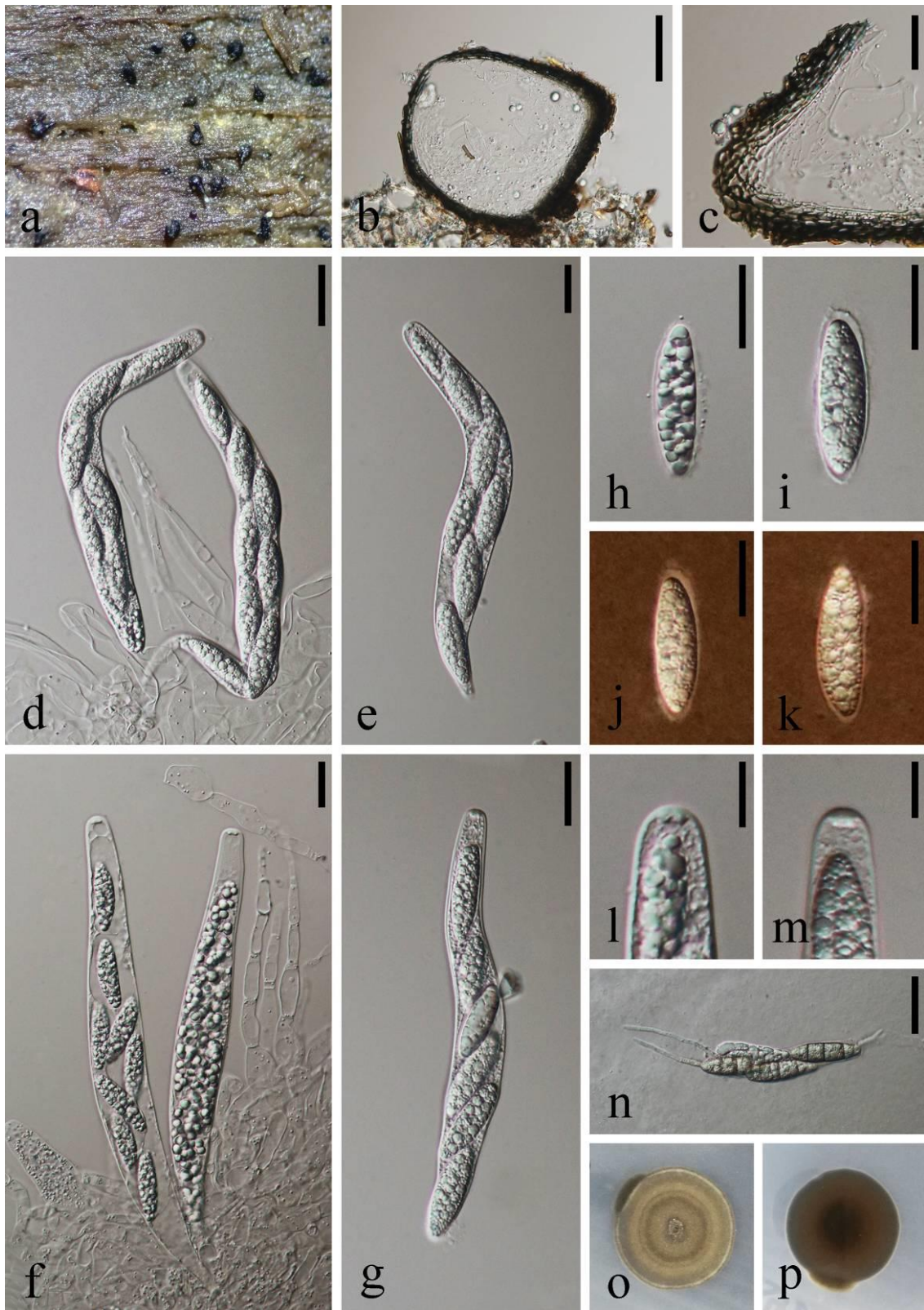
Index Fungorum number: IF558037; Facesoffungi number: FoF 09558

Etymology – in reference to subglobose conidia

Holotype – MFLU 17-1728

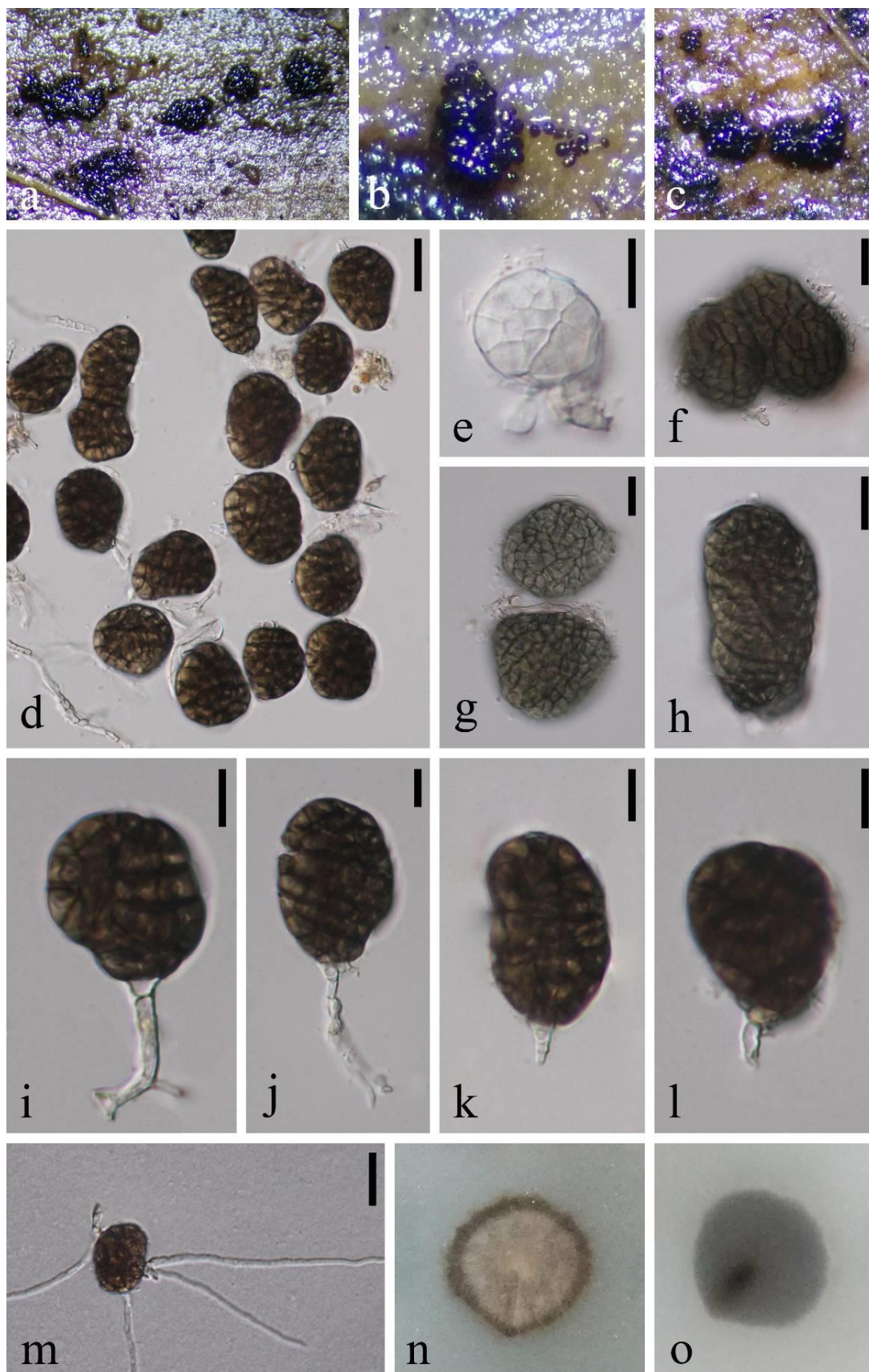
*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies sporodochial, punctiform, gregarious, raised, brown. Mycelium partly immersed, partly superficial on substratum, consisting of septate, thin-walled, hyaline hyphae. Conidiophores absent or reduced to conidiogenous cells. Conidiogenous cells holoblastic,

integrated, determinate. *Conidia* 14.5–24  $\mu\text{m}$  diam. ( $\bar{x}$  = 18.5  $\mu\text{m}$ , n = 40), acrogenous, solitary, dry, thin-walled, smooth, subglobose, dictyoseptate, slightly constricted at septa, brown to dark brown, with a protruding, cuneiform, pale brown base, with a small, sub-rounded, dark brown ornamentation on the surface of each cell.



**Figure 9** – *Obliquiminima hyalina* (MFLU 18-1521, holotype). a Ascomata on host substrate. b Vertical section of ascoma. c Structure of peridium. d–g Unitunicate asci. h, i Ascospores in water. j, k Ascospores in Indian Ink. l, m Apical rings. n Germinated ascospores. o, p Colony on

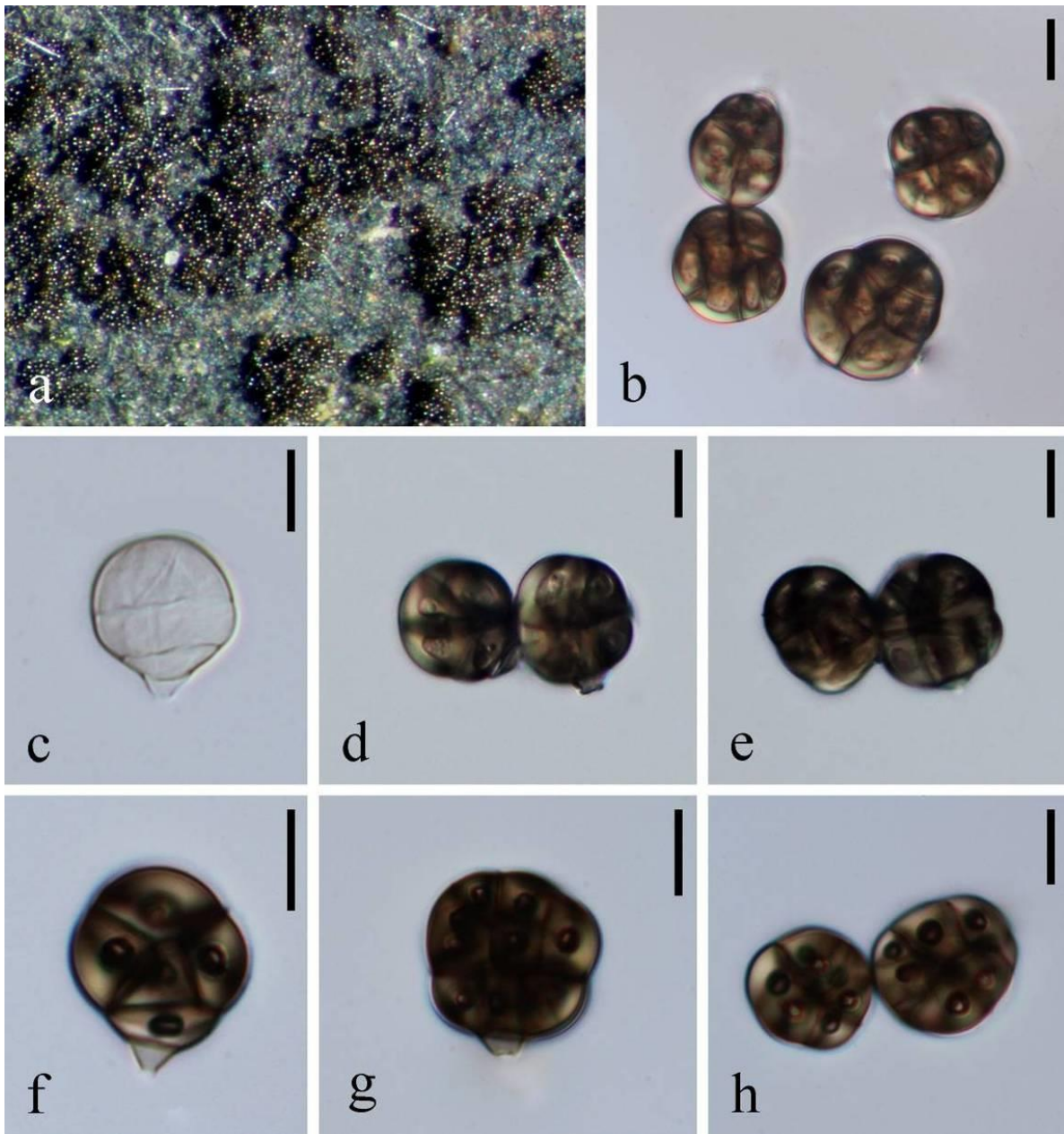
PDA (left-front, right-reverse). Scale bars: b = 50  $\mu\text{m}$ , c, e, f, h–k = 20  $\mu\text{m}$ , d, g, n = 30  $\mu\text{m}$ , l, m = 10  $\mu\text{m}$ .



**Figure 10** – *Conlarium aquaticum* (MFLU 18-1181). a–c Colonies on submerged wood. d–h Conidia (e immature conidium; f–h note the muriform surface of conidia). i–l Conidia with



conidiogenous cells. m Germinated conidium. n, o Colony on PDA (left-front, right-reverse). Scale bars: d, f–h, m = 20  $\mu$ m, e, i–l = 10  $\mu$ m.



**Figure 11** – *Conlarium subglobosum* (MFLU 17-1728, holotype). a Colonies on submerged wood. b–h Conidia. Scale bars: b–h = 10  $\mu$ m.

Material examined – Thailand, Chiang Mai Province, Mushroom Research Centre, on submerged wood in a stream, 1 September 2017, X.D. Yu, 17A (MFLU 17-1728, holotype).

Notes – Our new collection MFLU 17-1728 forms a basal branch to other *Conlarium* species and the genus *Riomyces* with high bootstrap support (Fig. 1). MFLU 17-1728 must be placed in *Conlarium* because of its typical conidia of *Conlarium*. MFLU 17-1728 is similar to *C. thailandense* in having a dark brown ornamentation on the surface of each cell (Phookamsak et al. 2019), but the conidial shape and size and molecular evidence support them to be different species (Fig. 1). The new collection also resembles a phylogenetically unrelated species *Junewangia thailandica* in conidial characteristics, but differs in having punctiform colonies and lacking conidiophores. We therefore identify MFLU 17-1728 as a new species in *Conlarium*, namely as *C. subglobosum*. We sequenced from the conidia as the culture was contaminated.

**Distoseptisporales** Z.L. Luo, K.D. Hyde & H.Y. Su, *Fungal Diversity* 99: 482 (2019)

Type family – Distoseptisporaceae K.D. Hyde & McKenzie

Notes – Distoseptisporales was introduced to accommodate a single family Distoseptisporaceae and one genus *Aquapteridospora* based on morphology and multigene analysis (Luo et al. 2019). Hyde et al. (2021) raised *Aquapteridospora* as a new family Aquapteridosporaceae regarding to their divergence time study (110 MYA). Hyde et al. (2020) mentioned that Distoseptisporales status might need revision as its divergence time was estimated as 102 MYA which fell in the range of family status (50–130 MYA), while it was 158 MYA in Hyde et al. (2021). In this study, we follow Hyde et al. (2021) and accept the order Distoseptisporales with two families Aquapteridosporaceae and Distoseptisporaceae.

**Aquapteridosporaceae** K.D. Hyde & Hongsanan, *Fungal Diversity*: 10.1007/s13225-021-00469-7 (2021)

Type genus – *Aquapteridospora* J. Yang, K.D. Hyde & Maharachch.

Notes – Aquapteridosporaceae was established to accommodate a single genus *Aquapteridospora* which was formerly referred to Distoseptisporales genera *incertae sedis* (Luo et al. 2019, Hyde et al. 2021). The divergence time for Aquapteridosporaceae has been estimated as 110 MYA, which falls in the range of a family (50–130 MYA) (Hyde et al. 2021).

***Aquapteridospora*** J. Yang, K.D. Hyde & Maharachch., *Cryptog. Mycol.* 36(4): 474 (2015)

Type species – *Aquapteridospora lignicola* J. Yang, K.D. Hyde & Maharachch.

Notes – *Aquapteridospora* is characterized by polyblastic conidiogenous cells, fusiform, 3-septate, thin-walled conidia with pale to dark brown central cells and paler end cells, often with a conspicuous sheath (Yang et al. 2015). In our multigene analysis (Fig. 1), *Pleurophragmium bambusinum* clusters within *Aquapteridospora* with high bootstrap support. However, *P. bambusinum* has ellipsoidal, thick-walled, evenly coloured conidia without a sheath (Dai et al. 2017), which indicate that it does not belong in *Aquapteridospora*.

*Pleurophragmium* is an old genus that comprises over 40 epithets in Index Fungorum (2021). The sequence data of the type species *P. bicolor* is lacking, and *Pleurophragmium* was shown to be polyphyletic in Dai et al. (2017). *Pleurophragmium* is characterized by unbranched conidiophores, polyblastic, sympodial conidiogenous cells, and ellipsoidal to fusiform, or clavate, brown, 0–7-septate conidia with pointed bases (Ellis 1971, Ma et al. 2014). Morphologically, *Aquapteridospora* and *Pleurophragmium* are not congeneric. Although *P. bambusinum* clusters within *Aquapteridospora*, we do not synonymize *P. bambusinum* under *Aquapteridospora* due to its unusual morphological characteristics with other *Aquapteridospora* species. In addition, all *Aquapteridospora* species were found from freshwater (Yang et al. 2015, Luo et al. 2019), while *P. bambusinum* was collected from dead culms of bamboo (Dai et al. 2017). The new collections and sequences of *P. bambusinum* and type species *P. bicolor* are needed to reappraise their placements. We introduce a new species in *Aquapteridospora*, which is morphologically similar to the type species *A. lignicola*.

***Aquapteridospora aquatica*** X.D. Yu, W. Dong & H. Zhang, sp. nov.

Fig. 12

Index Fungorum number: IF558031; Facesoffungi number: FoF 09552

Etymology – in reference to the aquatic habitat

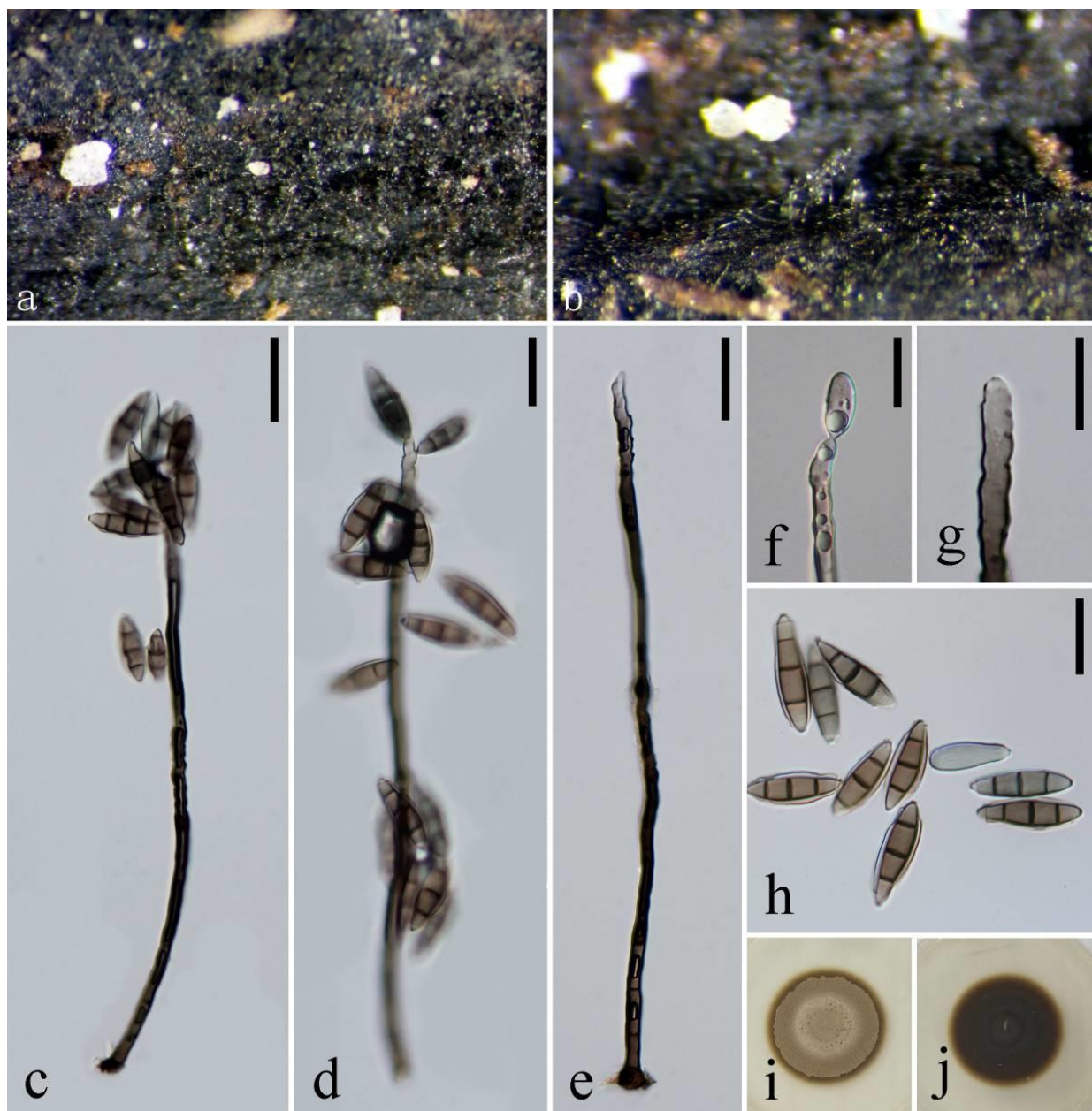
Holotype – MFLU 17-1730

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, hairy, gregarious, dark brown. Mycelium partly immersed, partly superficial on host substrate, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores 125–215 × 3–5 µm ( $\bar{x}$  = 175 × 4 µm, n = 10), macronematous, mononematous, erect, subcylindrical, flexuous, septate, slightly constricted at septa, unbranched, dark brown to black, thin-walled, smooth. Conidiogenous cells 10–85 × 4–5.5 µm ( $\bar{x}$  = 47 × 4.5 µm, n = 5), holoblastic, polyblastic, integrated, terminal, becoming intercalary, subcylindrical, pale

brown, smooth, sympodial proliferations, bearing several prominent, rounded, dark brown to black denticles. *Conidia* 19–27.5 × 5–7.5 μm ( $\bar{x}$  = 24 × 6 μm, n = 20), acropleurogenous, solitary, dry, thin-walled, smooth, fusiform, slightly tapering towards the apex, straight or slightly curved, 3-septate, slightly constricted at septa, cells often unequally coloured, olivaceous or brown in the middle cells, paler in the bipolar cells, often with a conspicuous, gelatinous, thin sheath, partially covering the conidia, 0.5–1.5 μm thick.

Culture characteristics – On PDA, colony circular, reaching 20 mm in 27 days at 25°C, gray-brown from above, dark brown from below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – Thailand, Chiang Mai Province, Mushroom Research Centre, on submerged wood in a stream, 1 September 2017, X.D. Yu, 20A (MFLU 17-1730, holotype), ex-type living culture MFLUCC 17-2371.



**Figure 12** – *Aquapteridospora aquatica* (MFLU 17-1730, holotype). a, b Colonies on submerged wood. c–e Conidiophores with conidia. f Conidiogenous cell bearing young conidium. g Conidiogenous cell. h Conidia. i, j Colony on PDA (left-front, right-reverse). Scale bars: c = 30 μm, d, e, h = 20 μm, f, g = 10 μm.

Notes – *Aquapteridospora aquatica* differs from its phylogenetically closest species *Pleurophragmium bambusinum* in having fusiform, unequally coloured, thin-walled conidia with a conspicuous, gelatinous, thin sheath. In contrast, *P. bambusinum* has ellipsoidal, equally coloured, thick-walled conidia without a sheath (Dai et al. 2017). *Aquapteridospora aquatica* is morphologically similar to the generic type *A. lignicola*, in having fusiform, 3-septate, unequally coloured conidia with a conspicuous sheath. The conidia of *A. aquatica* have tapering ends, while they have obtuse ends in *A. lignicola*. A nucleotide comparison between *A. aquatica* and *A. lignicola* shows a difference of 5 and 56 nucleotides in LSU and ITS sequence data, respectively, which supports them to be different species.

**Distoseptisporaceae** K.D. Hyde & McKenzie, Fungal Diversity 80: 402 (2016)

Type genus – *Distoseptispora* K.D. Hyde, McKenzie & Maharachch.

Notes – Distoseptisporaceae was introduced to accommodate a single genus *Distoseptispora* (Su et al. 2016). Distoseptisporaceae can be confused with Sporidesmiaceae in having distoseptate, obclavate or cylindrical conidia with tapering apices and truncate ends (Su et al. 2016). However, phylogenetic analyses separate them in different families (Hyde et al. 2020, this study, Fig. 1). The sexual morph has been reported in Sporidesmiaceae and is morphologically similar to Annulatascaceae species (Zhang et al. 2017, Luo et al. 2019), while no sexual morph is found in Distoseptisporaceae.

***Distoseptispora*** K.D. Hyde, McKenzie & Maharachch., Fungal Diversity 80: 402 (2016)

Type species – *Distoseptispora fluminicola* McKenzie

Notes – *Distoseptispora* was introduced to accommodate species segregated from *Sporidesmium* with relatively short conidiophores, and long cylindrical, darker conidia with slightly paler, rounded apices (Su et al. 2016). However, *D. lignicola* and *D. obclavata* have paler conidia (Luo et al. 2019). The sexual morph of *Sporidesmium* has been linked to two annulatascaceae-like taxa, *S. lignicola* and *S. thailandense* (Zhang et al. 2017, Luo et al. 2019), while no sexual morph are reported for *Distoseptispora*. Phylogenetic analyses place *Distoseptispora* and *Sporidesmium* in Distoseptisporaceae and Sporidesmiaceae, respectively (Hyde et al. 2020, this study, Fig. 1). All *Distoseptispora* species have sequence data in GenBank and they clustered in a well-supported clade (Fig. 1). However, the morphological characteristics are not much correlated with their phylogenetic relationships as discussed in Monkai et al. (2020). The euseptate species *Distoseptispora rayongensis* clusters with the distoseptate species *D. obclavata* with strong bootstrap support; the new species *D. songkhlaensis* having distoseptate conidia clusters with an euseptate species *D. guttulata* in a well-supported clade; the euseptate species *D. suoluoenensis* clusters with the distoseptate species *D. bambusae* in a distinct subclade within *Distoseptispora* (Fig. 1). Above examples reveal that the conidial septa in *Distoseptispora* species are not informative for generic delineation, but are highly informative at the species level. The asexual morphs of *Distoseptispora* are morphologically quite similar, thus their sexual morphs would be useful to better understand the taxonomy of *Distoseptispora* species. *Distoseptispora* species were commonly found from freshwater in China and Thailand (Su et al. 2016, Luo et al. 2018, 2019, Yang et al. 2018, Hyde et al. 2019, 2020). We introduce three new asexual species collected from submerged wood in Thailand.

***Distoseptispora fasciculata*** W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 13

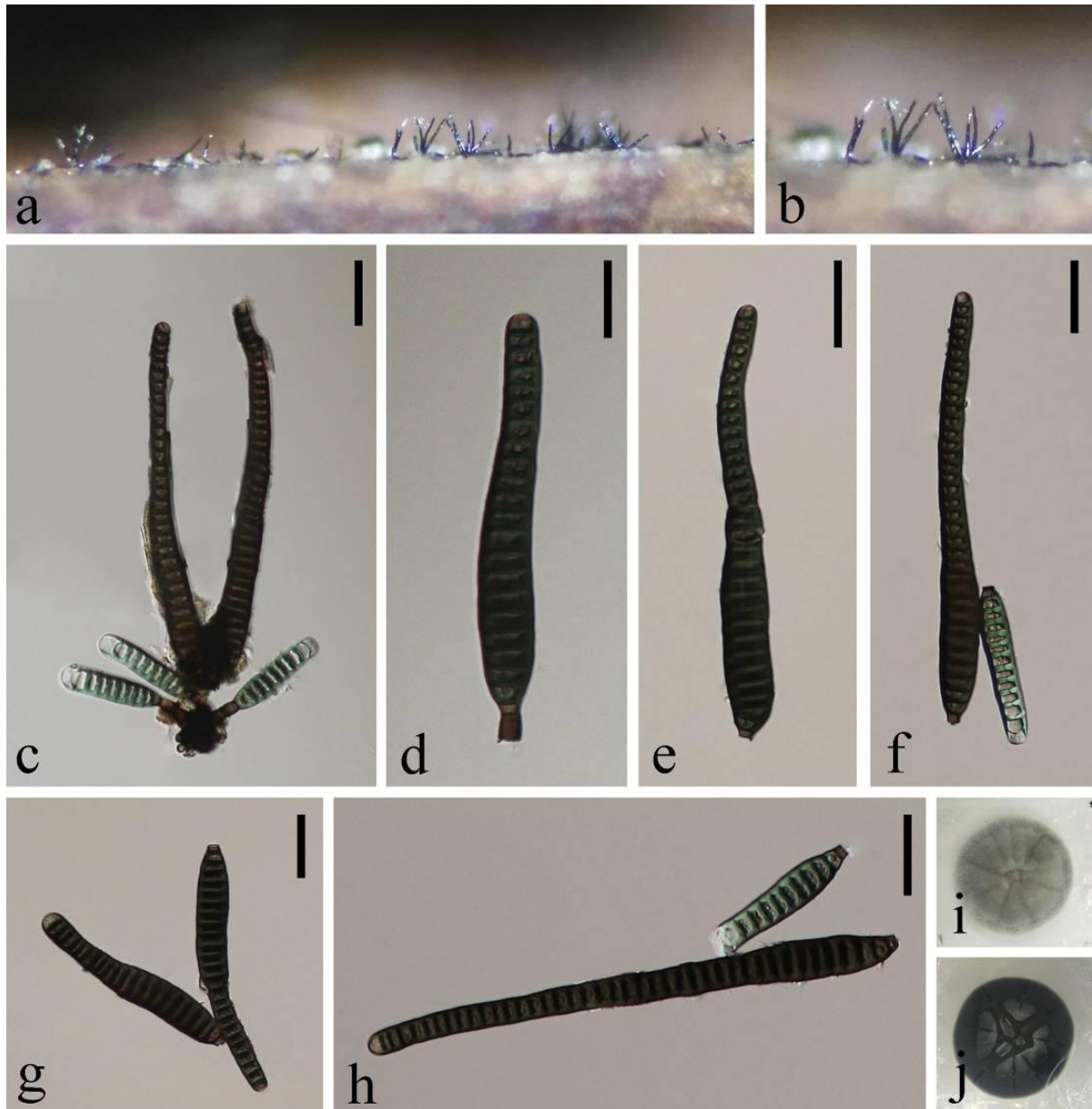
Index Fungorum number: IF558028; Facesoffungi number: FoF 09549

Etymology – name reflects the fasciculate conidiophores

Holotype – MFLU 18-1714

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, hairy, erect, gregarious, dark brown to black. Mycelium partly immersed, partly superficial on host substrate, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores 12–16 × 5–6 μm ( $\bar{x}$  = 14 × 5.7 μm, n = 10),

macronematous, mononematous, fasciculate, erect, cylindrical, straight, 0-1-septate, slightly constricted at septum, unbranched, brown, thin-walled, smooth. *Conidiogenous cells* 7–9 × 5–7 μm ( $\bar{x}$  = 7.5 × 6.5 μm, n = 5), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, brown, smooth. *Conidia* 46–200 × 10–16.5 μm ( $\bar{x}$  = 112 × 13.5 μm, n = 15), acrogenous, solitary, dry, thin-walled, smooth, subcylindrical to obclavate, mostly curved, 10–40-distoseptate, olivaceous when young, dark brown when mature, rounded at apex, with a protruding, cuneiform base and faintly pigmented scar.



**Figure 13** – *Distoseptispora fasciculata* (MFLU 18-1714, holotype). a, b Colonies on submerged wood. c Fasciculate conidiophores with conidia. d–h Conidia. i, j Colony on PDA (up-front, down-reverse). Scale bars: c, e–h = 30 μm, d = 20 μm.

Culture characteristics – On PDA, colony circular, reaching 30 mm in 23 days at 25°C, gray from above, dark brown to black from below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – Thailand, Nakhon Si Thammarat Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat6113 (MFLU 18-1714, holotype), ex-type living culture KUMCC 19-0081.

Notes – *Distoseptispora fasciculata* is similar to its phylogenetically closest species *D. fluminicola* and *D. xishuangbannaensis* in conidial shape, but differs in having dark brown conidia when mature (brown in *D. fluminicola* and green in *D. xishuangbannaensis*) (Su et al. 2016, Tibpromma et al. 2018). The conidiophores of *D. fasciculata* are obviously fasciculate, while they are solitary in *D. fluminicola* and *D. xishuangbannaensis* (Su et al. 2016, Tibpromma et al. 2018). Multigene analysis clearly supports the introduction of a new species (Fig. 1).

***Distoseptispora saprophytica*** W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 14

Index Fungorum number: IF558029; Facesoffungi number: FoF 09550

Etymology – in reference to saprobic life mode of the fungus

Holotype – MFLU 18-1568

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, hairy, gregarious, brown. Mycelium partly immersed, partly superficial on host substrate, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores 50–140 × 3.2–4.2 μm ( $\bar{x}$  = 92 × 3.5 μm, n = 10), macronematous, mononematous, erect, cylindrical, straight or slightly flexuous, or occasionally sharply curving near the base, septate, slightly constricted at septa, unbranched, brown, thin-walled, smooth. Conidiogenous cells 5–11.5 × 3–4.5 μm ( $\bar{x}$  = 8.5 × 3.5 μm, n = 10), holoblastic, mono- to poly-blastic, integrated, determinate, terminal, subcylindrical, brown, smooth. Conidia 14.5–30 × 4.5–7.5 μm ( $\bar{x}$  = 22 × 6 μm, n = 25), acrogenous, solitary or occasionally catenate, dry, thin-walled, smooth, subcylindrical to obclavate, straight or curved, 2–6-distoseptate, slightly constricted at septa, olivaceous to brown, rounded at apex, with a truncate base and faintly pigmented scar.

Culture characteristics – On PDA, colony circular, reaching 15 mm in 25 days at 25°C, white-brown from above, black from below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat162 (MFLU 18-1568, holotype), ex-type living culture MFLUCC 18-1238.

Notes – *Distoseptispora saprophytica* clusters with *D. palmarum* with strong bootstrap support (Fig. 1). *Distoseptispora saprophytica* differs from *D. palmarum* in having shorter and thinner (14.5–30 × 4.5–7.5 μm vs. 35–180 × 7–11 μm), less septate (2–6 vs. 7–27) conidia and different conidial shape (mostly subcylindrical vs. mostly obclavate) (Hyde et al. 2019). The relatively longer conidiophores, mono- to poly-blastic conidiogenous cells, with short, subcylindrical and occasionally catenate conidia of *D. saprophytica* are distinctive in the genus.

***Distoseptispora songkhlaensis*** W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 15

Index Fungorum number: IF558030; Facesoffungi number: FoF 09551

Etymology – in reference to Songkhla, from where the holotype was collected

Holotype – MFLU 18-1538

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, hairy, gregarious, brown. Mycelium partly immersed, partly superficial on host substrate, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores 70–90 × 4–5.5 μm ( $\bar{x}$  = 76 × 4.7 μm, n = 10), macronematous, mononematous, erect, cylindrical, slender, straight or slightly flexuous, septate, slightly constricted at septa, unbranched, brown, thin-walled, smooth. Conidiogenous cells 15.2–16.5 × 4–5 μm ( $\bar{x}$  = 15.7 × 4.5 μm, n = 10), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, tapering towards the apex, brown, smooth. Conidia 44–125 × 9–14.5 μm ( $\bar{x}$  = 90 × 11.5 μm, n = 25), acrogenous, solitary, dry, thin-walled, smooth, obclavate, straight or curved, 9–16-distoseptate, slightly or occasionally deeply constricted at septa, olivaceous to brown, rounded at apex, with a protruding, cuneiform base and faintly to heavily pigmented scar.

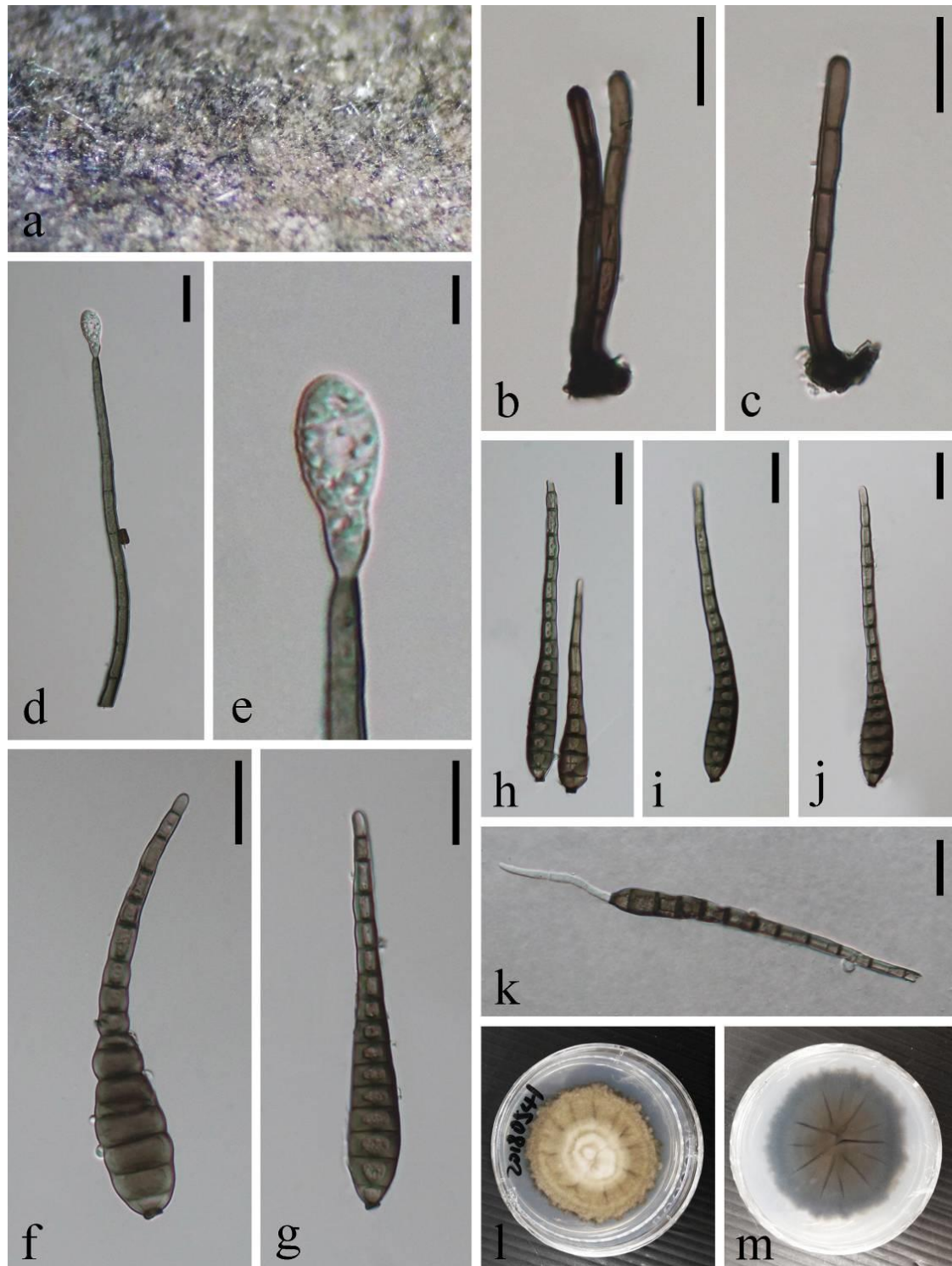
Culture characteristics – On PDA, colony circular, reaching 40 mm in 30 days at 25°C, white-brown from above, black from below, surface rough, dry, with dense mycelium, raised, undulate at edge.



**Figure 14** – *Distoseptispora saprophytica* (MFLU 18-1568, holotype). a, b Colonies on submerged wood. c, d Conidiophores with conidia. e, f Conidiophores. g–l Conidia. m Germinated conidia. n, o Colony on PDA (left-front, right-reverse). Scale bars: c–f, m = 20  $\mu$ m, g–l = 10  $\mu$ m.

Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat141 (MFLU 18-1538, holotype), ex-type living culture MFLUCC 18-1234.

Notes – *Distoseptispora songkhlaensis* clusters with *Distoseptispora* sp. DLUCC B43 and *D. guttulata* with high bootstrap support (Fig. 1). *Distoseptispora songkhlaensis* is similar to *D. guttulata* in having obclavate conidia, but differs in having shorter and wider conidia ( $44\text{--}125 \times 9\text{--}14.5 \mu\text{m}$  vs.  $75\text{--}165 \times 7\text{--}11 \mu\text{m}$ ) (Yang et al. 2018). A nucleotide comparison between *D. songkhlaensis* and *D. guttulata* shows a difference of 3 and 28 nucleotides in LSU and ITS sequence data, respectively, which indicates that they are different species (Jeewon & Hyde 2016).



**Figure 15** – *Distoseptispora songkhlaensis* (MFLU 18-1538, holotype). a Colonies on submerged wood. b, c Conidiophores. d Conidiophore with immature conidium. e Conidiogenous cell with



immature conidium. f–j Conidia. k Germinated conidium. l, m Colony on PDA (left-front, right-reverse). Scale bars: b–d, f–k = 20  $\mu\text{m}$ , e = 5  $\mu\text{m}$ .

Strain DLUCC B43 was named as *D. guttulata* based on their similar morphological characters (Luo et al. 2019). However, there are 4 and 44 nucleotide differences in LSU and ITS sequence data between DLUCC B43 and ex-type strain of *D. guttulata* MFLUCC 16-0183, respectively, which indicates that they are different species. DLUCC B43 clusters with our new species *D. songkhlaensis* (Fig. 1), but they are different species as the former has quite longer conidia (70–520  $\times$  8.5–10.5  $\mu\text{m}$  vs. 44–125  $\times$  9–14.5  $\mu\text{m}$ ) and more septa (9–27 vs. 9–16). In addition, there are 4 and 28 nucleotide differences in LSU and ITS sequence data between DLUCC B43 and *D. songkhlaensis*, which also support them to be different species. Presently, we do not name DLUCC B43 as a new species until new collections are obtained.

***Distoseptispora tectonae*** Doilom & K.D. Hyde, Fungal Diversity 80: 222 (2016) Fig. 16

Synonym – *Distoseptispora submersa* Z.L. Luo, K.D. Hyde & H.Y. Su, Mycosphere 9(3): 454 (2018)

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, hairy, gregarious, dark brown to black. Mycelium partly immersed, partly superficial on host substrate, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores 19.5–50  $\times$  4.5–5.5  $\mu\text{m}$  ( $\bar{x}$  = 30  $\times$  5  $\mu\text{m}$ , n = 10), macronematous, mononematous, erect, cylindrical, straight or slightly flexuous, septate, slightly constricted at septa, robust at the base, unbranched, brown, thin-walled, smooth. Conidiogenous cells 6.7–9  $\times$  4–5.5  $\mu\text{m}$  ( $\bar{x}$  = 7.5  $\times$  4.7  $\mu\text{m}$ , n = 10), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, brown, smooth. Conidia 45–270  $\times$  11–16  $\mu\text{m}$  ( $\bar{x}$  = 165  $\times$  13.5  $\mu\text{m}$ , n = 20), acrogenous, solitary, dry, thin-walled, smooth, obclavate, mostly curved, 10–40-distoseptate, brown to dark brown, olivaceous, rounded at apex, with a truncate base and faintly to heavily pigmented scar.

Culture characteristics – On PDA, colony circular, reaching 40 mm in 25 days at 25°C, gray to dark gray from above, dark brown to black from below, surface rough, dry, with dense mycelium, raised, entire at edge.

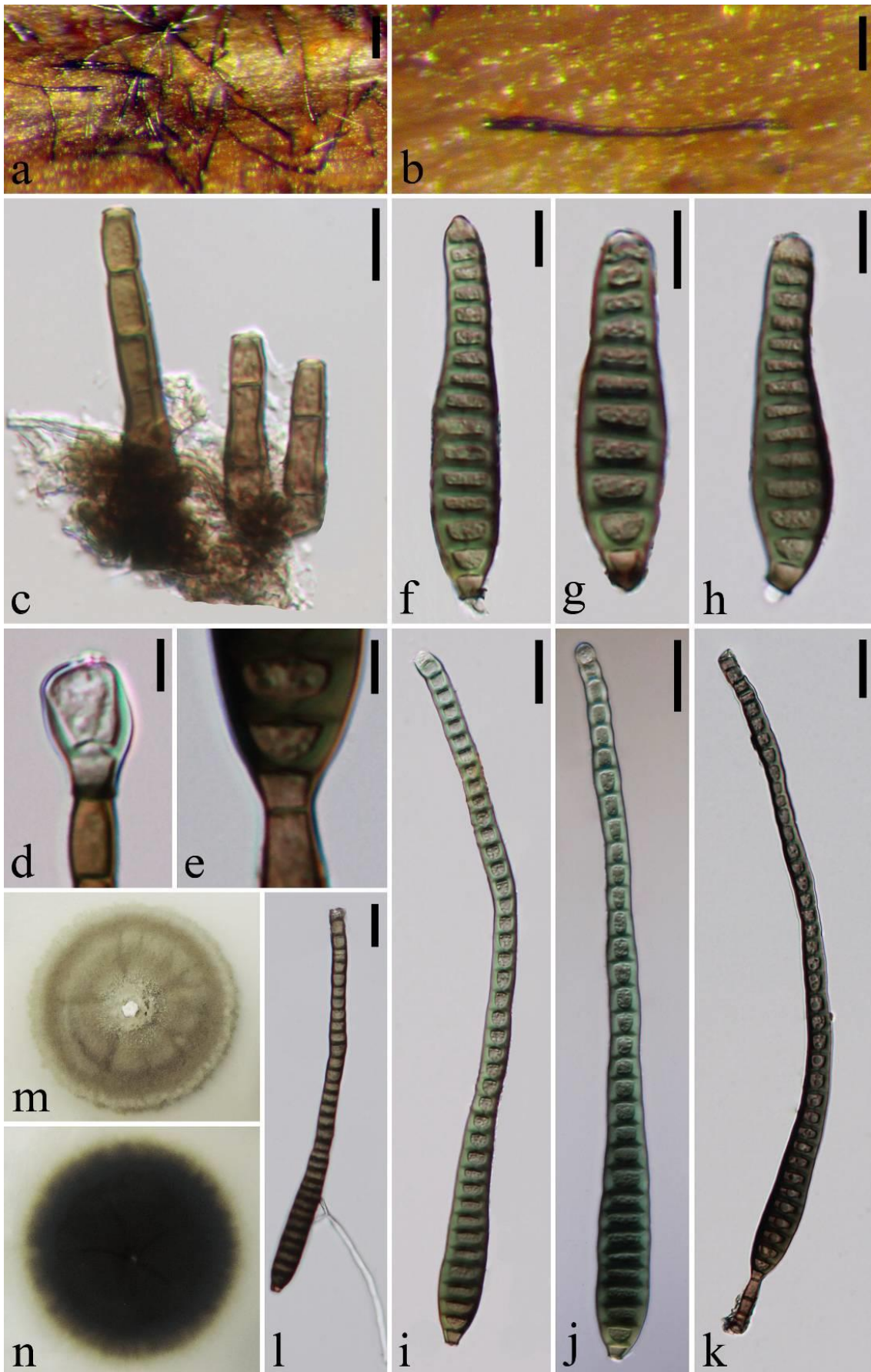
Material examined – Thailand, Prachuap Khiri Khan Province, on submerged wood in a stream, 30 July 2015, W. Dong, 45B (MFLU 15-2693), living culture MFLUCC 15-0981.

Notes – *Distoseptispora tectonae* was initially collected from a dead twig of *Tectona grandis* (Hyde et al. 2016b). Luo et al. (2018) introduced one phylogenetically close species *D. submersa* based on larger conidiophores (55–73  $\times$  7–9  $\mu\text{m}$  vs. up to 40  $\times$  4–6  $\mu\text{m}$ ). A recent new collection which has larger conidiophores (34–95  $\times$  5–8  $\mu\text{m}$  vs. up to 40  $\times$  4–6  $\mu\text{m}$ ) than the holotype of *D. tectonae* was, however, identified as *D. tectonae* (Sun et al. 2020). It indicates that the conidiophore dimension can be varied in *D. tectonae*, and *D. submersa* is likely to be a synonym of *D. tectonae*. A nucleotide comparison between *D. tectonae* and *D. submersa* shows a difference of four (include two gaps), two and three nucleotides in ITS, TEF and RPB2 sequence data, respectively, which indicates that they are conspecific (Jeewon & Hyde 2016). Our phylogenetic analysis clearly shows they are the same species (Fig. 1). We therefore synonymize *D. submersa* with *D. tectonae*.

Our new collection MFLUCC 15-0981 clusters with three collections of *D. tectonae* with high bootstrap support (Fig. 1). It has slightly longer conidiophores (up to 50  $\mu\text{m}$  vs. up to 40  $\mu\text{m}$ ) and longer conidia (45–270  $\times$  11–16  $\mu\text{m}$  vs. 90–170  $\times$  11–16  $\mu\text{m}$ ) than the holotype of *D. tectonae* (Hyde et al. 2016b). Except brown conidia described by Hyde et al. (2016b) and Sun et al. (2020), we found olivaceous conidia in our collection. Phylogenetic analysis supports MFLUCC 15-0981 to be *D. tectonae*.

**Sporidesmiales** Crous, Persoonia 40: 377 (2018)

Type family – Sporidesmiaceae Fr.



**Figure 16** – *Distoseptispora tectonae* (MFLU 15-2693). a, b Colonies on submerged wood. c Conidiophores. d, e Conidiogenous cells with conidia. f–k Conidia. l Germinated conidium.

m, n Colony on PDA (up-front, down-reverse). Scale bars: a = 100  $\mu\text{m}$ , b = 50  $\mu\text{m}$ , c, f–h = 10  $\mu\text{m}$ , d, e = 5  $\mu\text{m}$ , i–l = 20  $\mu\text{m}$ .

Notes – Sporidesmiales was established by Crous et al. (2018) for a single family Sporidesmiaceae. The ordinal status was confirmed by Hyde et al. (2021) based on a divergence time study. The divergence time was estimated as 133 MYA, which fell in the range of an order (Hyde et al. 2021).

**Sporidesmiaceae** Fr. [as ‘Sporidemiacei’], Summa veg. Scand., Sectio Post. (Stockholm): 504 (1849)

Type genus – *Sporidesmium* Link

Notes – Sporidesmiaceae was widely used since the molecular work was carried out by Su et al. (2016). Sporidesmiaceae comprises a single genus *Sporidesmium*, however, *Sporidesmium* has been shown to be polyphyletic (Yang et al. 2018, Liu et al. 2019). Some sporidesmium-like taxa, which are phylogenetically distant from Sporidesmiaceae *sensu stricto*, have been placed in Distoseptisporaceae (Su et al. 2016), while others are uncertain. Distoseptisporaceae and Sporidesmiaceae are morphologically very similar, and DNA sequence data is the main evidence to delimit the two families. The family status of Sporidesmiaceae was confirmed by Hyde et al. (2020) based on a divergence time study.

***Sporidesmium*** Link, Mag. Gesell. naturf. Freunde, Berlin 3(1-2): 41 (1809)

Type species – *Sporidesmium ehrenbergii* M.B. Ellis

Notes – *Sporidesmium* is broadly characterized by solitary or gregarious conidiophores, monoblastic conidiogenous cells, and pale brown to brown, cylindrical, fusiform, obclavate, obpyriform, sometimes rostrate conidia with hyaline apex and truncate base (Ellis 1971, Su et al. 2016). These morphological characteristics are common in asexual hyphomycetes, which result in almost 500 epithets in *Sporidesmium* (Index Fungorum 2021). Based on morphological characteristics of conidiophores, conidiogenous cells and conidia, some new genera were segregated from *Sporidesmium*, e.g. *Distoseptispora*, *Ellisembia*, *Repetophragma* and *Sporidesmiella* (Subramanian 1992, Hernandez-Gutierrez & Sutton 1997, Su et al. 2016). *Ellisembia*, however, previously segregated from *Sporidesmium* due to the distoseptate conidia, is now synonymized with *Sporidesmium* based on molecular evidence (Su et al. 2016). The polyphyletic nature of *Sporidesmium* has been shown based on phylogenetic analyses (Shenoy et al. 2006, Yang et al. 2018, Liu et al. 2019).

Sequence data of the type species *Sporidesmium ehrenbergii* is lacking. Several *Sporidesmium* species, which were confirmed by molecular data, are represented as *Sporidesmium sensu stricto*, and this is accepted by Su et al. (2016) and Yang et al. (2018). *Sporidesmium sensu lato* species were scattered in Hypocreomycetidae, Sordariomycetidae and Xylariomycetidae, and some clustered with Papulosaceae in Diaporthomycetidae (Yang et al. 2018). Sexual morph of *Sporidesmium*, *S. thailandense*, was first reported by Zhang et al. (2017) based on molecular data, and re-collected by Yang et al. (2018). Luo et al. (2019) reported the second sexual morph *S. lignicola*, which differs from *S. thailandense* in having smaller asci and aseptate, smaller ascospores. The morphological characteristics of sexual morphs, such as immersed ascomata with neck erumpent through host substrate, cylindrical asci with a distinct, refractive, wedge-shaped, apical ring, and fusiform, hyaline ascospores, are similar to *Annulatascus* (Annulatascaceae) and *Fluminicola* (Papulosaceae).

The asexual morphs of *Sporidesmium* are commonly found in freshwater in China and Thailand (Su et al. 2016, Yang et al. 2018, Luo et al. 2019). We introduce two new species in *Sporidesmium* which were collected from submerged wood in Thailand. Phylogenetic analysis places them in *Sporidesmium sensu stricto* (Fig. 1). The information of many *Sporidesmium* species are lost as they were published since in 1800s or early 1900s. Therefore, the new species are introduced based on available literature and molecular data.

***Sporidesmium appendiculatum*** G.N. Wang, W. Dong & H. Zhang, sp. nov.

Fig. 17

Index Fungorum number: IF558032; Facesoffungi number: FoF 09553

Etymology – in reference to apical appendage of the conidia

Holotype – MFLU 18-0981

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. *Colonies* superficial, effuse, gregarious, hairy, black. *Mycelium* partly immersed, composed of septate, brown, thin-walled hyphae. *Conidiophores* 33–60 × 4.8–6.2 μm ( $\bar{x}$  = 42.5 × 5.5 μm, n = 10), macronematous, mononematous, erect, cylindrical, straight or slightly flexuous, septate, with dark bands at the septa, robust at the base, unbranched, brown to dark brown, smooth. *Conidiogenous cells* 16.5–20.5 × 3.7–5.5 μm ( $\bar{x}$  = 18.5 × 4.9 μm, n = 10), holoblastic, monoblastic, integrated, determinate, terminal, cylindrical or flask-shaped, slightly tapering towards the conidial base, brown to dark brown, smooth. *Conidia* 40–55 × 12–16 μm ( $\bar{x}$  = 49.5 × 14 μm, n = 10), acrogenous, solitary, dry, thin-walled, smooth-walled, obclavate with a protruding, truncate, cuneiform, darker base, tapering towards apex, pale brown to hyaline in apical two cells, straight or curved, brown in water, olivaceous in Congo red, 9–11-distoseptate, guttulate, apex with 1–3 hyaline, hypha-like appendages, up to 22 μm long, and with a conspicuous, gelatinous, oblong, hyaline sheath, covering apical two cells.

Material examined – Thailand, Chiang Mai Province, on submerged wood in a stream, 29 March 2018, G.N. Wang, L4 (MFLU 18-0981, holotype).

Notes – *Sporidesmium appendiculatum* is distinctive in the genus in having both appendage and sheath. *Sporidesmium appendiculatum* is similar to *S. minigelatinosum* in having obclavate conidia with an apical sheath. However, it differs by wider conidia (40–55 × 12–16 μm vs. 36–50 × 6–8 μm) and hypha-like appendages (Matsushima 1971). The obclavate conidia with an apical sheath of *S. appendiculatum* also resemble those of *S. aquaticivaginatam*, *S. guizhouense* and *S. olivaceoconidium* (Hyde et al. 2016b, Liu et al. 2019). However, *S. appendiculatum* is distinctive by 1–3 hyaline, hypha-like appendages at the apex, and molecular evidence places *S. appendiculatum* in *Sporidesmium sensu stricto* (Fig. 1) and *S. aquaticivaginatam*, *S. guizhouense* and *S. olivaceoconidium* in *Sporidesmium sensu lato* (Liu et al. 2019).

***Sporidesmium chiangmaiense*** X.D. Yu, W. Dong & H. Zhang, sp. nov.

Fig. 18

Index Fungorum number: IF558033; Facesoffungi number: FoF 09554

Etymology – in reference to Chiang Mai, where the holotype was collected

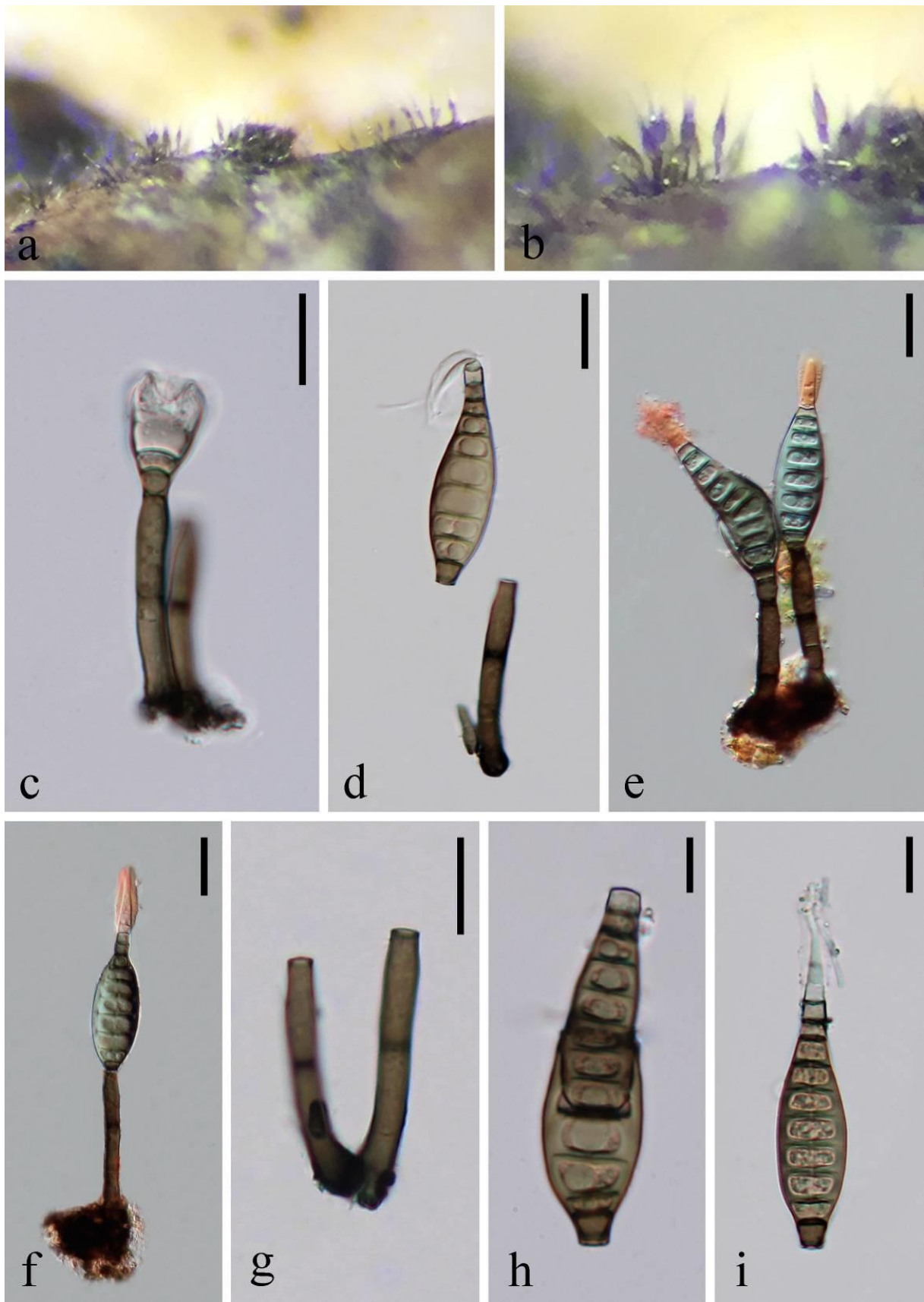
Holotype – MFLU 18-1013

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. *Colonies* superficial, effuse, gregarious, hairy, black. *Mycelium* partly immersed, composed of septate, brown, thin-walled hyphae. *Conidiophores* 29–54 × 3.8–5 μm ( $\bar{x}$  = 37 × 4.5 μm, n = 10), macronematous, mononematous, fasciculate, erect, cylindrical, straight or flexuous, septate, with dark bands at the septa, unbranched, brown or olivaceous, smooth. *Conidiogenous cells* 18–20 × 4–5.3 μm ( $\bar{x}$  = 19 × 5 μm, n = 10), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, brown or olivaceous, smooth. *Conidia* 54–71.5 × 10.5–14 μm ( $\bar{x}$  = 62 × 12 μm, n = 15), acrogenous, solitary, dry, thin-walled, smooth, obclavate to fusiform, straight or curved, pale olivaceous or brown, with a truncate, cuneiform base, tapering towards apex, pale brown to hyaline in apical cells, (8–)12-distoseptate, guttulate, apex with a hyaline, filamentous appendage, up to 40 μm long, and often with a conspicuous, gelatinous, oblong, hyaline sheath, covering apical 2–3 cells.

Material examined – Thailand, Chiang Mai Province, on submerged wood in a stream, 29 March 2018, X.D. Yu, Y36 (MFLU 18-1013, holotype), ex-type living culture MFLUCC 18-0999.

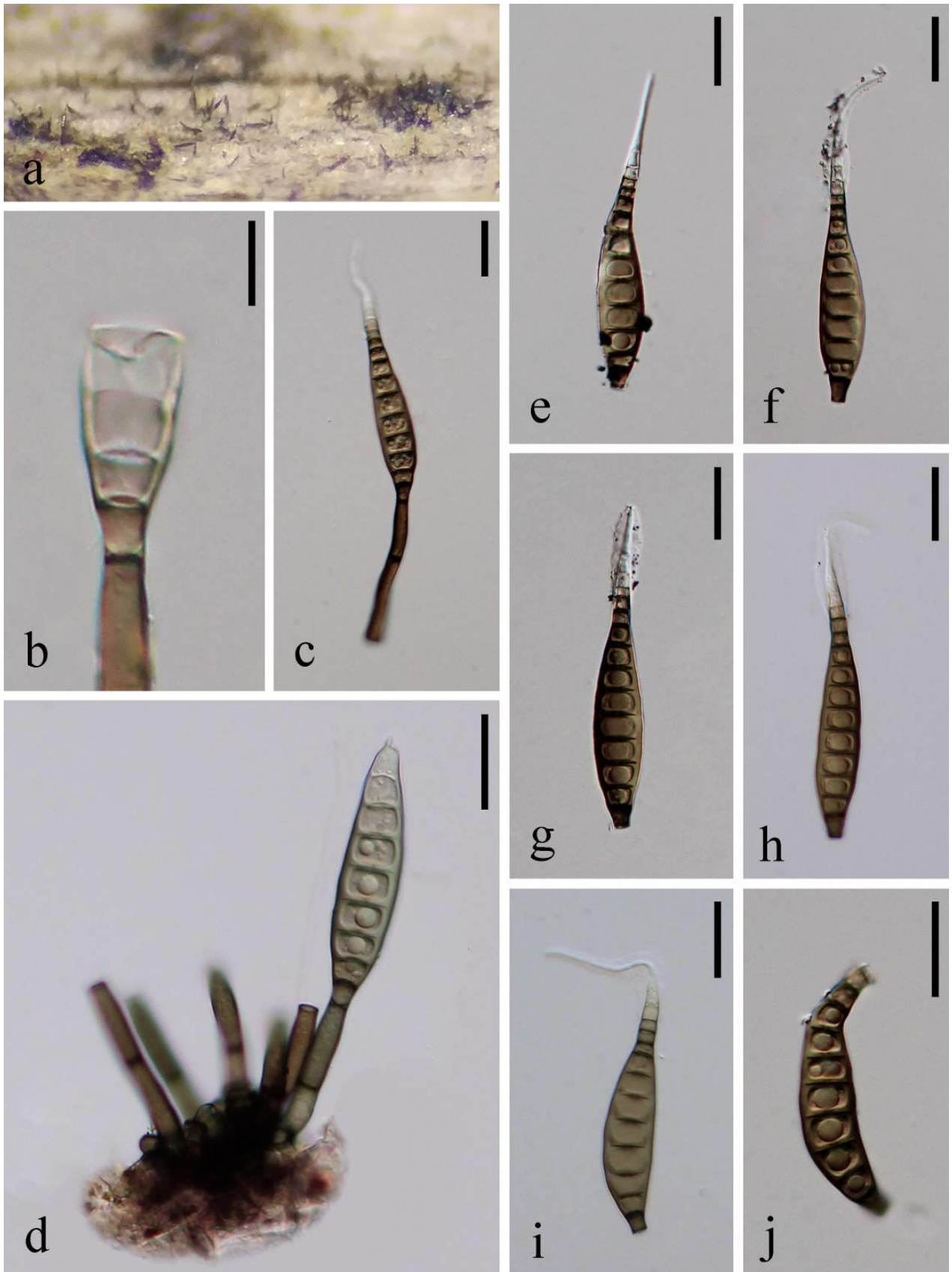
Notes – *Sporidesmium chiangmaiense* clusters with *S. appendiculatum* with high bootstrap support (Fig. 1). They share similar morphological characteristics in having obclavate, olivaceous or brown conidia with an apical appendage and sheath. However, *S. chiangmaiense* has longer conidia (54–71.5 × 10.5–14 μm vs. 40–55 × 12–16 μm), longer (up to 40 μm long vs. up to 22 μm long) and single appendage. A nucleotide comparison between *S. chiangmaiense* and *S.*

*appendiculatum* shows a difference of 4 and 44 nucleotides in LSU and ITS sequence data, respectively, which supports them to be different species (Jeewon & Hyde 2016).



**Figure 17** – *Sporidesmium appendiculatum* (MFLU 18-0981, holotype). a, b Colonies on submerged wood. c–f Conidiophores with conidia (e, f materials stained with Congo red).

g Conidiophores. h–i Conidia (h two overlapping conidia). Scale bars: c, d, g = 15  $\mu\text{m}$ , e, f = 20  $\mu\text{m}$ , h, i = 10  $\mu\text{m}$ .



**Figure 18** – *Sporidesmium chiangmaiense* (MFLU 18-1013, holotype). a Colonies on submerged wood. b–d Conidiophores with conidia. e–j Conidia. Scale bars: b = 10  $\mu\text{m}$ , c–j = 20  $\mu\text{m}$ .

## Diaporthomycetidae families *incertae sedis*

**Acrodictyaceae** J.W. Xia & X.G. Zhang, Scientific Reports 7(no. 7888): 2 (2017)

Type genus – *Acrodictys* M.B. Ellis

Notes – Acrodictyaceae was introduced to accommodate a single genus *Acrodictys* characterized by acrogenous, obovoid to pyriform, muriform conidia (Xia et al. 2017). The phylogenetic position of Acrodictyaceae is unstable, as it clusters with Junewangiaceae, Papulosaceae or Sporidesmiaceae in different studies (Xia et al. 2017, Luo et al. 2019, Hyde et al. 2020). All these three families have annulatasceae-like sexual morphs, e.g. *Dictyosporella thailandensis* in Junewangiaceae, *Fluminicola aquatica* in Papulosaceae, and *Sporidesmium thailandense* in Sporidesmiaceae (Zhang et al. 2017). However, no sexual morph is linked to Acrodictyaceae. Although the placement of Acrodictyaceae is unstable, it clusters with Diaporthomycetidae families in all studies (Luo et al. 2019, Hyde et al. 2020, this study, Fig. 1). We therefore refer Acrodictyaceae to Diaporthomycetidae families *incertae sedis*.

**Acrodictys** M.B. Ellis, Mycol. Pap. 79: 5 (1961)

Type species – *Acrodictys bambusicola* M.B. Ellis

Notes – *Acrodictys* was introduced to accommodate species having conidiophores often with successive terminal proliferations, and variable-shaped, dictyoseptate, pale brown to dark blackish brown conidia (Ellis 1961). The type species *A. bambusicola* was initially collected in Venezuela (Ellis 1961), later collected and sequenced from China (Xia et al. 2017). *Acrodictys* is confused with *Junewangia* as both genera have long conidiophores with percurrent proliferations, and dictyoseptate conidia often with a protruding base (Xia et al. 2017). However, phylogenetic analysis places them in Acrodictyaceae and Junewangiaceae, respectively (Fig. 1). The latest treatment was carried out by Luo et al. (2019), who introduced a new species *A. fluminicola* and a new combination *A. aquatica* in *Acrodictys*. We redescribe and illustrate *A. porosiseptata* in this study.

**Acrodictys porosiseptata** G.Z. Zhao, Mycol. Progr. 10(1): 74 (2011)

Fig. 19

Facesoffungi number: FoF 09555

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, scattered, hairy, blackish brown. Mycelium partly immersed, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores 90–160 × 3–5.5 μm ( $\bar{x}$  = 133 × 4.5 μm, n = 10), macronematous, mononematous, erect, cylindrical, narrower and paler toward the apex, straight or flexuous, septate, slightly constricted at septa, unbranched, brown to dark brown, smooth, with one or more successive, terminal, percurrent proliferations. Conidiogenous cells 13–15 × 2.5–3.7 μm ( $\bar{x}$  = 13.5 × 3 μm, n = 5), holoblastic, monoblastic, integrated, terminal, lageniform, pale brown, smooth. Conidia 20–26 × 12.5–14 μm ( $\bar{x}$  = 24 × 13 μm, n = 15), acrogenous, solitary, dry, thin-walled, smooth-walled, broadly clavate, obpyriform, dictyoseptate, usually with 4–5 transverse and 2 longitudinal septa, and 1–2 oblique septa at the apex, with several conspicuous pores on the surface, brown to dark brown, smooth, with a protruding, subhyaline, obconical or cuneiform, truncate base, 3–4.5 μm long, 5–5.5 μm wide at the top, 1.8–2.7 μm wide at the base. Conidial secession schizolytic.

Culture characteristics – On PDA, colony circular, reaching 10 mm in 12 days at 25°C, grey from above, black from below, surface rough, dry, with dense mycelium, umbonate, entire at edge.

Material examined – Thailand, Chiang Rai Province, on submerged wood in a stream, 26 February 2011, H. Zhang, e18 (MFLU 11-1044), living culture MFLUCC 11-0299.

Notes – *Acrodictys porosiseptata* was initially collected from dead stem of *Bambusa* sp. in China (Zhao et al. 2011). Xia et al. (2017) recollected this species from dead branches of an unidentified bamboo and provided sequence data. Our new collection MFLUCC 11-0299 has slightly shorter conidia than the holotype (20–26 × 12.5–14 μm vs. 25–30 × 13.5–16.5 μm), but has overlapping conidial size (20–26 × 12.5–14 μm vs. 20–36.5 × 13.5–15.5 μm) with collections of

Xia et al. (2017). MFLUCC 11-0299 has identical LSU and ITS sequence data with *A. porosiseptata* HSAUP H4698, and phylogenetic analysis also supports them to be the same species (Fig. 1). This is a new geographical and habitat record of *A. porosiseptata* from freshwater in Thailand.

**Junewangiaceae** J.W. Xia & X.G. Zhang, Scientific Reports 7(no. 7888): 12 (2017)

Type genus – *Junewangia* W.A. Baker & Morgan-Jones

Notes – Junewangiaceae was established to accommodate a single genus *Junewangia*, characterized by macronematous, cylindrical conidiophores, monoblastic conidiogenous cells with narrow or flaring collarete, and oval, ellipsoidal to spherical conidia (Xia et al. 2017). Other two genera, *Dictyosporella* and *Sporidesmiella*, were later included in the family based on multigene analyses (Luo et al. 2019). *Sporidesmiella* differs from other genera in having long conidiophores without collarete, and cuneate to obovoid conidia with fewer septa (Kirk 1982, Luo et al. 2019). *Dictyosporella* and *Junewangia* have muriform conidia, but the latter differs in having long conidiophores (Ariyawansa et al. 2015, Xia et al. 2017, Song et al. 2018a). Hyde et al. (2020) referred *Sporidesmiella* to Diaporthomycetidae genera *incertae sedis* because *Sporidesmiella* clustered in a separated clade with Junewangiaceae. However, in our phylogenetic analysis, the three genera *Dictyosporella*, *Junewangia* and *Sporidesmiella* constitute a well-supported clade with strong ML and BYPP bootstrap support (Fig. 1), which is accordant with Luo et al. (2019). Thus, we accept these three genera in Junewangiaceae. The family placement of Junewangiaceae is undetermined and referred to Diaporthomycetidae genera *incertae sedis* in this study.

**Dictyosporella** Abdel-Aziz, Fungal Diversity 75: 143 (2015)

Type species – *Dictyosporella aquatica* Abdel-Aziz

Notes – *Dictyosporella* was introduced for an aquatic hyphomycetous species *D. aquatica* that is characterized by dictyoseptate conidia which are helicoid when young and becoming masses of cells at maturity (Ariyawansa et al. 2015). Other three asexual species, i.e. *D. ellipsoidea*, *D. guizhouensis* and *D. hydei*, also have dictyoseptate conidia, but they are not helicoid when young (Song et al. 2018a, Yuan et al. 2020, this study). *Dictyosporella ellipsoidea* and *D. guizhouensis* have separating cells at the conidial base, while the other two species *D. aquatica* and *D. hydei* lack this structure.

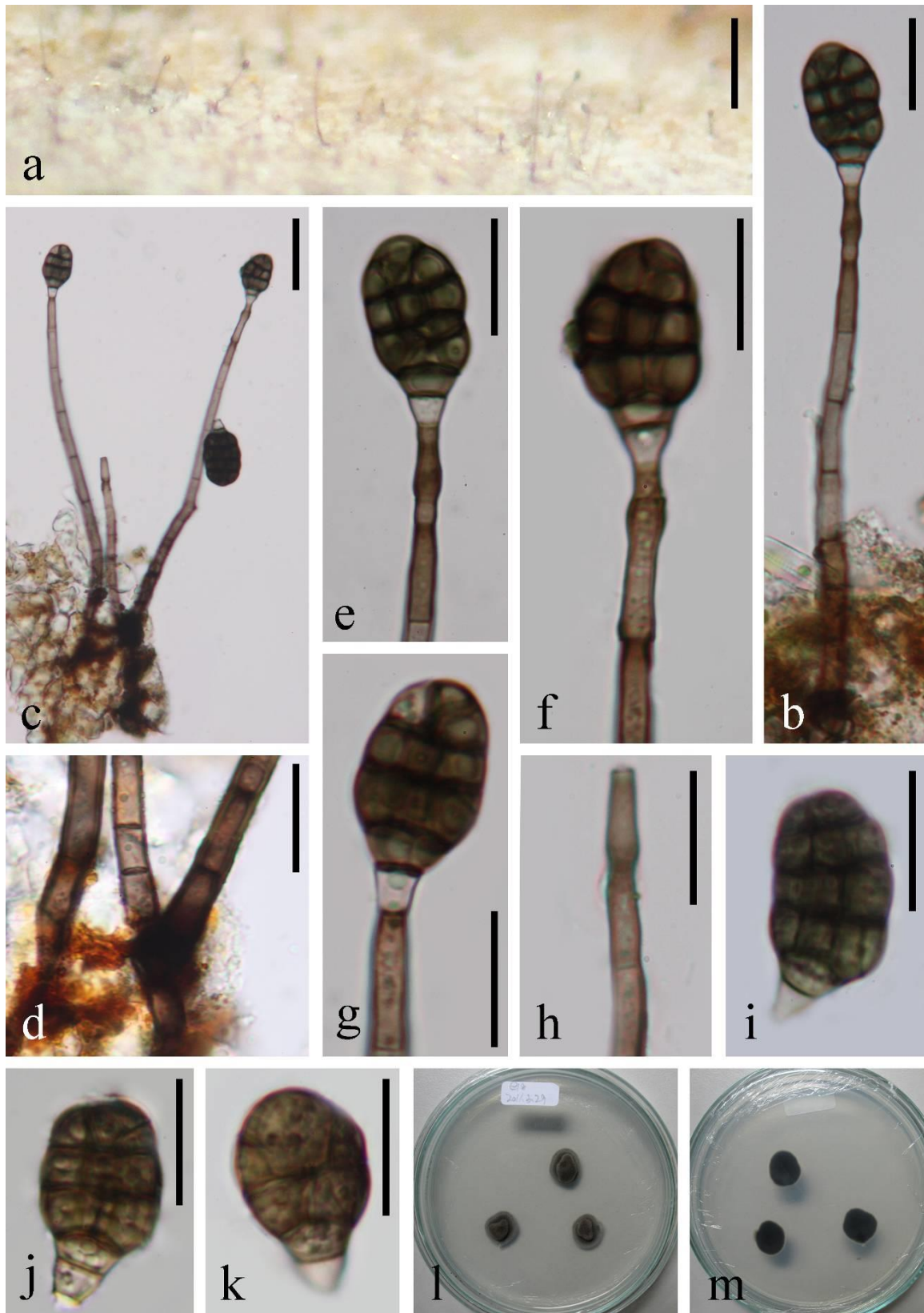
*Dictyosporella* is polyphyletic as shown in our phylogenetic tree (Fig. 1). *Dictyosporella aquatica* clusters with *D. guizhouensis* and other two sexual species *D. Chiangmaiensis* and *D. thailandensis* in a well-supported clade (Fig. 1). While, *Dictyosporella hydei* clusters with *Junewangia aquatica* and *D. ellipsoidea* clusters with *Junewangia sphaerospora* in a separated clade, which is distant from the type species *D. aquatica*.

*Dictyosporella hydei* cannot be placed in *Junewangia* because of the absence of macronematous conidiophores and conidiogenous cells with narrow or flaring collarete (Song et al. 2018a). Only LSU sequence data is available for *D. hydei*, which has one nucleotide difference with *J. aquatica*. *Dictyosporella hydei* differs from *J. aquatica* in having micronematous, closely packed conidiophores without percurrent proliferations, and larger, globose to broadly cylindrical conidia (22–50 × 15–26 μm vs. 17–20 × 14–18 μm) comprising multiple angular, subglobose cells (Song et al. 2018a, b). *Dictyosporella ellipsoidea* also morphologically does not belong in *Junewangia* due to its sporodochial, punctiform colonies, dictyoseptate conidia with a separating cell, and lacking a macronematous conidiophore with percurrent proliferations (see notes under *D. ellipsoidea*). The relationships between the two genera *Dictyosporella* and *Junewangia* are unclear until evidence is obtained in future.

The sexual morph of *Dictyosporella*, *D. thailandensis*, was introduced based on molecular data, and characterized by annulatasceae-like characteristics: immersed ascomata with neck erumpent through host substrate, cylindrical asci with a long pedicel and small, refractive, wedge-shaped apical ring, and fusiform, hyaline, 3-septate ascospores with filamentous bipolar appendages (Zhang et al. 2017). In this study, we introduce one new sexual morph (*D.*



*chiangmaiensis*) and one new asexual morph (*D. ellipsoidea*) in the genus and provide a new collection for *D. guizhouensis*.



**Figure 19** – *Acrodictys porosiseptata* (MFLU 11-1044). a Colonies on submerged wood. b, c Conidiophores with conidia. d Bases of conidiophores. e–g Conidiogenous cells with conidia. h Upper part of conidiophore showing proliferations. i–k Conidia. l, m Colony on PDA (left-front, right-reverse). Scale bars: a = 150  $\mu$ m, b, d–k = 15  $\mu$ m, c = 30  $\mu$ m.

*Dictyosporella chiangmaiensis* X.D. Yu, W. Dong & H. Zhang, sp. nov.

Fig. 20

Index Fungorum number: IF558043; Facesoffungi number: FoF 09559

Etymology – in reference to Chiang Mai, from where the holotype was collected

Holotype – MFLU 17-1707

*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 170–200 µm high, 105–140 µm diam., scattered to gregarious, immersed with neck erumpent through host surface, ovoid to pyriform, brown, coriaceous, ostiolate, with a central neck. *Necks* short, hyaline to pale brown, cylindrical, upright to the substrate surface, often covered with a mass of white spores. *Peridium* 10–15 µm thick, comprising several layers of brown to hyaline, thick-walled, compressed cells of *textura porrecta*. *Paraphyses* up to 3.5 µm diam. at the base, tapering towards the apex, dense, hypha-like, septate, constricted at septa, unbranched, hyaline. *Asci* 113–138 × 13–15 µm ( $\bar{x}$  = 125 × 14 µm, n = 10), 8-spored, unitunicate, narrowly clavate to fusiform, slightly tapering and rounded at apex, pedicellate, with an indistinct, small, refractive, wedge-shaped, apical ring, 1.7–2.2 × 2–4 µm. *Ascospores* 16–24.5 × 6.5–8.7 µm ( $\bar{x}$  = 20.5 × 7.5 µm, n = 30), uni- to bi-seriate, mostly broadly clavate, sometimes fusiform, straight or slightly curved, 3-septate, constricted at septa, the second cell often larger than others, guttulate, hyaline, thin-walled, smooth, without mucilaginous sheath. Asexual morph: Undetermined.

Material examined – Thailand, Chiang Mai Province, on submerged wood in a stream, 1 September 2017, X.D. Yu, 22A (MFLU 17-1707, holotype), ex-type living culture MFLUCC 17-2345.

Notes – *Dictyosporella chiangmaiensis* clusters with *D. thailandensis* with high bootstrap support (Fig. 1). *Dictyosporella chiangmaiensis* is similar to *D. thailandensis* in having immersed ascomata with a subhyaline neck erumpent through host substrate, asci with a small apical ring and hyaline, 3-septate ascospores (Zhang et al. 2017). However, *D. chiangmaiensis* has broadly clavate ascospores with larger second cells and without appendages. In contrast, *D. thailandensis* has fusiform ascospores with bipolar filamentous appendages (Zhang et al. 2017). Phylogenetic analysis also supports *D. chiangmaiensis* to be a new species in the genus.

*Dictyosporella ellipsoidea* W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 21

Index Fungorum number: IF558044; Facesoffungi number: FoF 09560

Etymology – in reference to mostly ellipsoidal conidia of this fungus

Holotype – MFLU 18-1209

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. *Colonies* sporodochial, punctiform, gregarious or scattered, raised, black. *Mycelium* partly immersed, partly superficial on substratum, consisting of septate, thin-walled, hyaline hyphae. *Conidiophores* mostly absent or reduced to conidiogenous cells. *Conidiogenous cells* 5.5–12 × 3–4.5 µm ( $\bar{x}$  = 8.5 × 3.7 µm, n = 5), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, hyaline, smooth. *Separating cells* 8–15 × 6.5–12.5 µm, inflated cylindrical, wedge-shaped or irregular, hyaline, smooth, thin-walled. *Conidia* 30–46 × 17.5–28.5 µm ( $\bar{x}$  = 36 × 22 µm, n = 35), acrogenous, solitary, dry, thin-walled, smooth-walled, ellipsoidal to broadly clavate, subglobose, or irregular-shaped, dictyoseptate, slightly constricted at septa, brown to dark brown, with a truncate base.

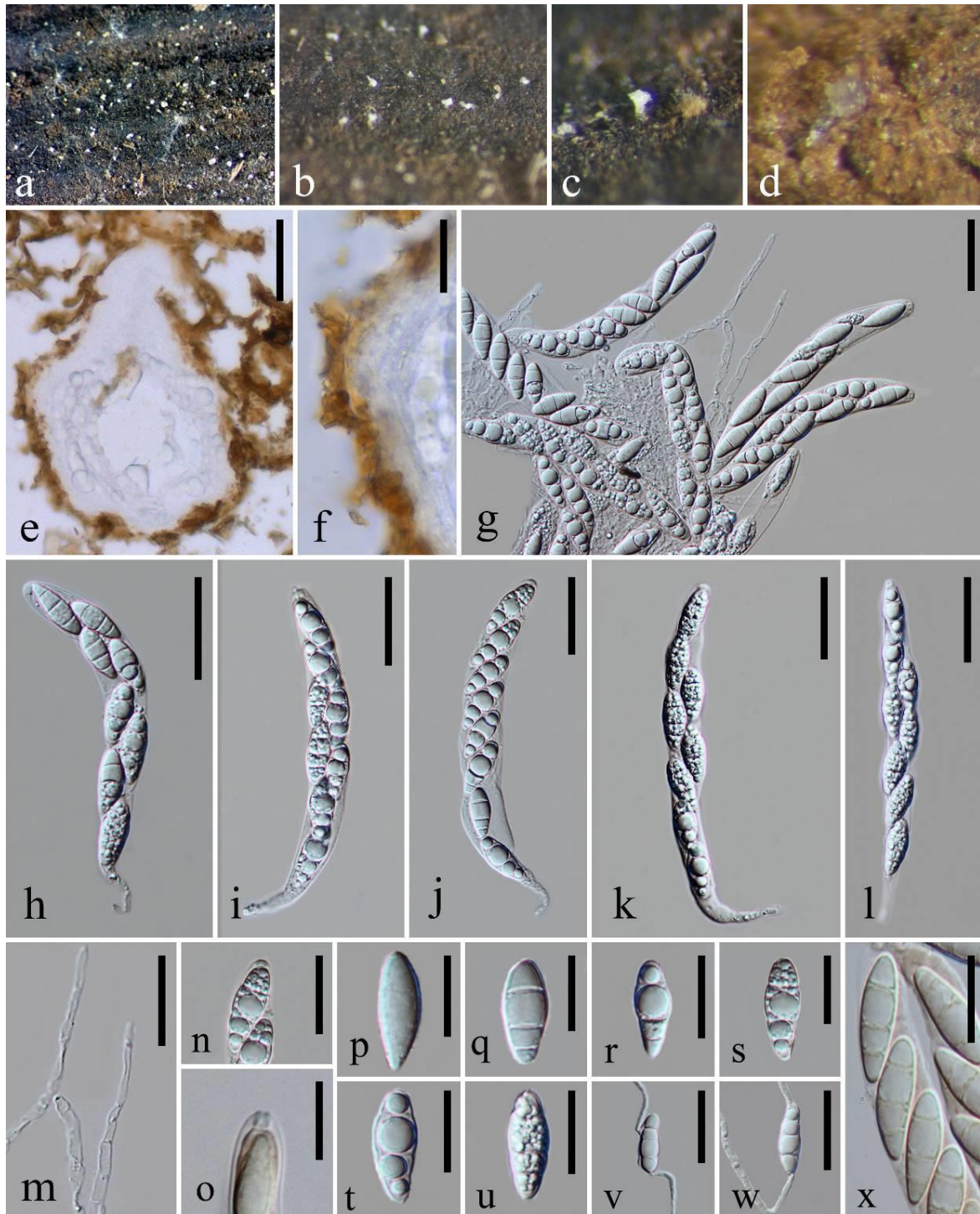
Culture characteristics – On PDA, colony irregular, reaching 10 mm in 15 days at 25°C, dark grey from above, black from below, surface wrinkled, dry, with dense mycelium, raised, undulate at edge.

Material examined – China, Yunnan Province, Dehong City, on submerged wood in a stream, 25 November 2017, G.N. Wang, H158A (MFLU 18-1209, holotype), ex-type living culture MFLUCC 18-1042; *ibid.*, HKAS 101741, isotype, ex-isotype living culture KUMCC 18-0093.

Notes – In our phylogenetic analysis, our collection MFLUCC 18-1042 clusters in *Junewangia* with good bootstrap support (Fig. 1). However, MFLUCC 18-1042 morphologically belongs in *Dictyosporella* due to the sporodochial, punctiform colonies, dictyoseptate conidia with a separating cell and without macronematous conidiophores (Song et al. 2018a, Yuan et al. 2020).

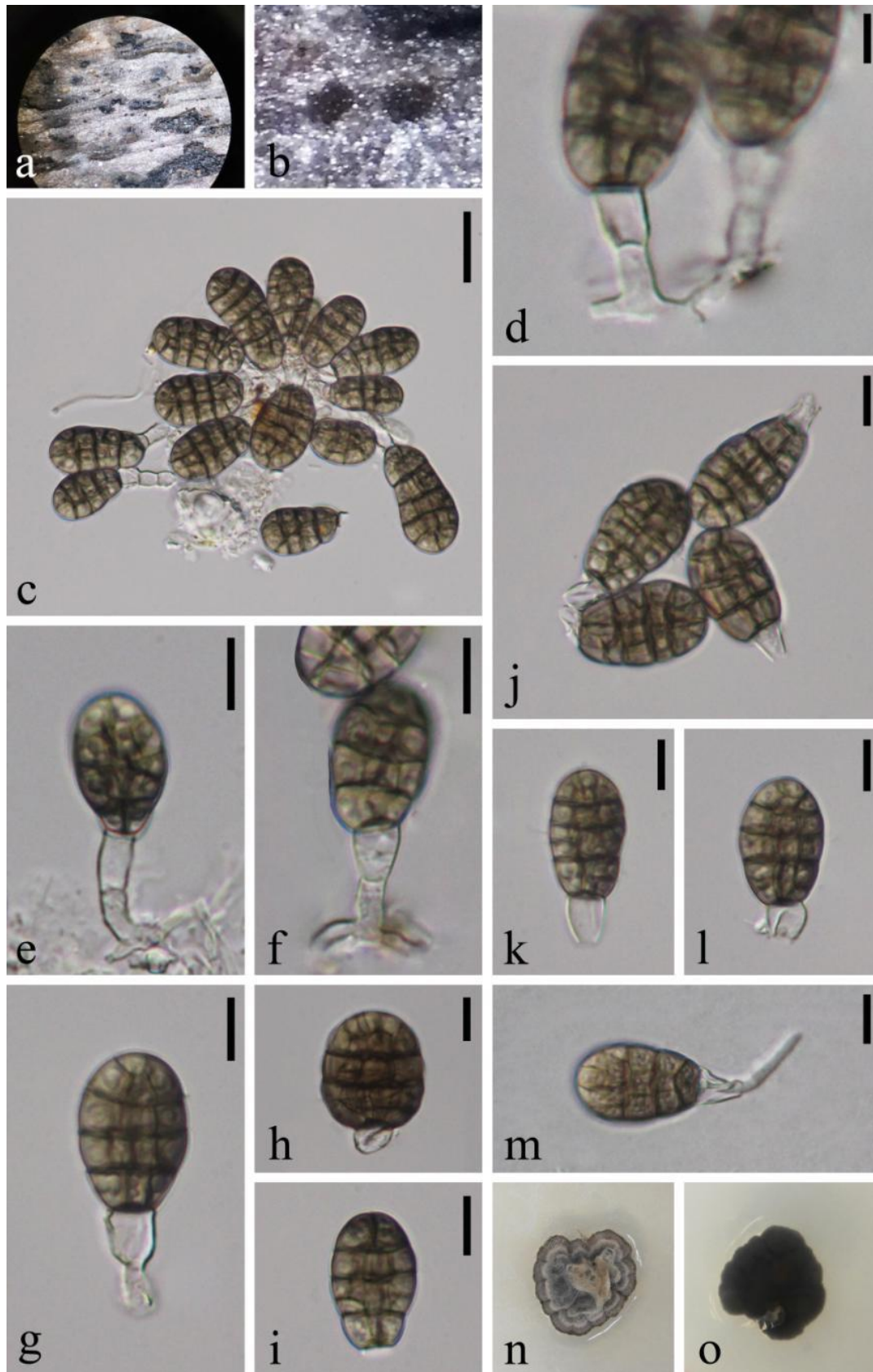
Whereas, *Junewangia* is characterized by effuse, hairy colonies, macronematous, long conidiophores with slightly flaring collarette and percurrent proliferations, and oval to subspherical conidia with several oblique septa and a protuberant, truncate basal cell (Baker et al. 2002). Therefore, we identify our collection as a new species in *Dictyosporella*, namely *D. ellipsoidea*.

*Dictyosporella ellipsoidea* differs from other *Dictyosporella* asexual species, i.e. *D. aquatica*, *D. hydei* and *D. guizhouensis*, in having mostly ellipsoidal conidia with an inflated cylindrical, wedge-shaped or irregular separating cell.



**Figure 20** – *Dictyosporella chiangmaiensis* (MFLU 17-1707, holotype). a–d Appearance of ascomatal necks on host. e Vertical section of ascoma. f Structure of peridium. g–l Unitunicate asci. m Paraphyses. n, o Apical rings (o in melzer's reagent). p–u Ascospores in water. x Ascospores in

melzer's reagent. v, w Germinated ascospores. Scale bars: e = 50  $\mu\text{m}$ , f, n, w = 20  $\mu\text{m}$ , g-l, v = 30  $\mu\text{m}$ , m, o-u, x = 15  $\mu\text{m}$ .



**Figure 21** – *Dictyosporella ellipsoidea* (MFLU 18-1209, holotype). a, b Colonies on submerged wood. c–f Conidiogenous cells with conidia. g–l Conidia. m Germinated conidium. n, o Colony on PDA (left-front, right-reverse). Scale bars: c = 20  $\mu\text{m}$ , d = 5  $\mu\text{m}$ , e–m = 10  $\mu\text{m}$ .

***Dictyosporella guizhouensis*** J. Yang & K.D. Hyde, Fungal Diversity 104: 93 (2020) Fig. 22

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. *Colonies* sporodochial, punctiform, gregarious or scattered, raised, black. *Mycelium* partly immersed, partly superficial on substratum, consisting of septate, thin-walled, hyaline hyphae. *Conidiophores* absent or reduced to conidiogenous cells. *Conidiogenous cells* holoblastic, monoblastic, integrated, determinate. *Separating cells* 6–28 × 6–10 μm ( $\bar{x}$  = 15 × 8 μm, n = 10), subglobose, ellipsoidal, or irregular-shaped, aseptate, sometimes 1–2-septate, hyaline, smooth, thin-walled. *Conidia* 15–24 × 11–17 μm ( $\bar{x}$  = 19 × 14 μm, n = 35), acrogenous, solitary, dry, thin-walled, smooth-walled, oblate ellipsoidal, subglobose, or irregular-shaped, dictyoseptate, constricted at septa, pale brown to dark brown, with a rounded or truncate base.

Culture characteristics – On PDA, colony circular, reaching 5 mm in 7 days at 25°C, reddish brown to white from above, yellowish brown from below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – China, Yunnan Province, Dehong City, on submerged wood in a stream, 25 November 2017, G.N. Wang, H3B (MFLU 18-1179), living culture MFLUCC 18-1232; *ibid.*, HKAS 101727, living culture KUMCC 18-0077.

Notes – Our new collection MFLUCC 18-1232 clusters with *Dictyosporella guizhouensis* MFLU 18-1505 with high bootstrap support (Fig. 1). They have identical LSU sequence data and seven (including one gap) nucleotide differences in ITS sequence data between MFLUCC 18-1232 and MFLU 18-1505. No protein coding genes can be compared. MFLUCC 18-1232 has very similar morphological characteristics and overlapping conidial size with the holotype of *D. guizhouensis* (Yuan et al. 2020). Based on multigene analysis, single gene comparison and their similar morphological characteristics, we identify our collection as *D. guizhouensis*.

***Junewangia*** W.A. Baker & Morgan-Jones, Mycotaxon 81: 307 (2002)

Type species – *Junewangia sphaerospora* W.A. Baker & Morgan-Jones

Notes – *Junewangia* was introduced to accommodate the species having macronematous, mononematous conidiophores with slightly flaring collarette and percurrent proliferations, and oval to subspherical conidia with several oblique septa and a protuberant, truncate basal cell (Baker et al. 2002). Xia et al. (2017) provided sequence data for three species, i.e. *J. lamma*, *J. queenslandica* and *J. sphaerospora* (type), and establish a new family Junewangiaceae to accommodate *Junewangia*. Except for *J. obliqua*, all *Junewangia* species have sequence data in GenBank. *Junewangia* is shown to be polyphyletic as *Junewangia* species cluster with *Dictyosporella hydei* and *D. ellipsoidea* in two separated clades (Fig. 1). The polyphyletic nature of *Junewangia* needs to be resolved with more collections and DNA sequence data. We introduce a new species in *Junewangia*, which was collected from submerged wood in freshwater in Thailand.

***Junewangia thailandica*** W. Dong, H. Zhang & K.D. Hyde, sp. nov. Fig. 23

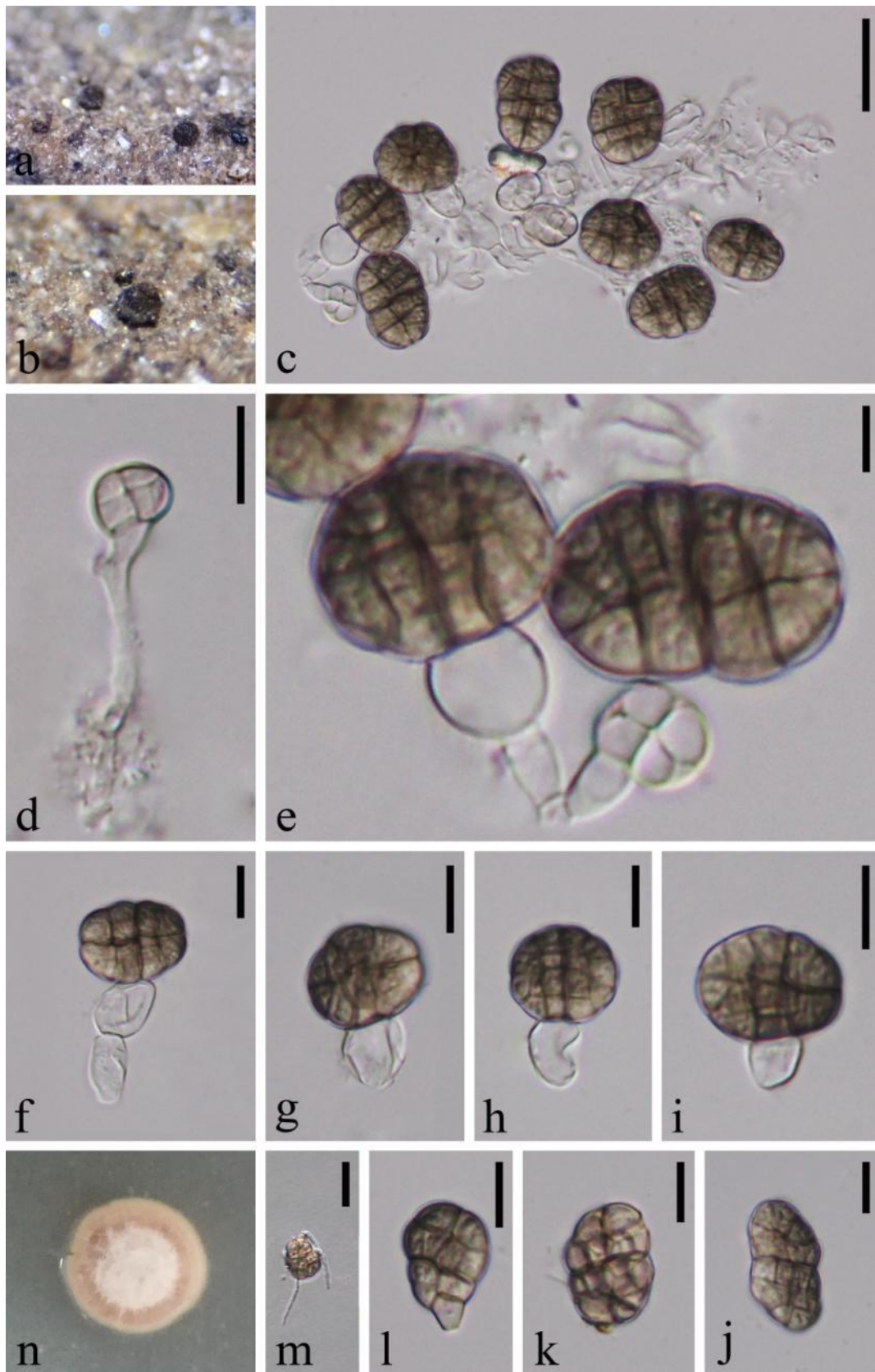
Index Fungorum number: IF558045; Facesoffungi number: FoF 09561

Etymology – in reference to the host location, Thailand, where the holotype was collected

Holotype – MFLU 15-2682

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. *Colonies* superficial, effuse, gregarious, hairy, brown. *Mycelium* mostly immersed, composed of septate, branched, pale brown, thin-walled hyphae. *Conidiophores* 70–195 × 4–5.5 μm ( $\bar{x}$  = 120 × 4.5 μm, n = 10), macronematous, mononematous, erect, cylindrical, straight or slightly flexuous, septate, slightly constricted and flaring at septa, swollen at the base, unbranched, brown, paler towards the apex, smooth. *Conidiogenous cells* holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, pale brown, smooth, with 3–7 successive percurrent proliferations. *Conidia* 22–32.5 × 16.5–23 μm ( $\bar{x}$  = 26 × 19.5 μm, n = 20), acrogenous, solitary, dry, thin-walled, smooth-walled, broadly ellipsoidal to subglobose, dictyoseptate, with longitudinal, transverse and oblique septa, constricted at septa, pale brown to dark brown, guttulate,

with a protruding basal cell; basal cells  $2.4\text{--}4.2 \times 3\text{--}5 \mu\text{m}$  ( $\bar{x} = 3.2 \times 4.4 \mu\text{m}$ ,  $n = 10$ ), wedge-shaped or subcylindrical, truncate, pale brown to subhyaline.



**Figure 22** – *Dictyosporrella guizhouensis* (MFLU 18-1179, holotype). a, b Colonies on submerged wood. c, e–l Conidia. d Conidiogenous cell with immature conidium. m Germinated conidium. n Colony on PDA (from front). Scale bars: c, m =  $20 \mu\text{m}$ , d, f–l =  $10 \mu\text{m}$ , e =  $5 \mu\text{m}$ .



**Figure 23** – *Junewangia thailandica* (MFLU 15-2682, holotype). a, b Colonies on submerged wood. c–h Conidiophores with conidia. i Conidiogenous cell with conidium. j, k Conidia.

l Germinated conidium. m, n Colony on PDA (left-front, right-reverse). Scale bars: a = 100  $\mu\text{m}$ , b = 50  $\mu\text{m}$ , c, f, g = 20  $\mu\text{m}$ , d, e, h, j–l = 10  $\mu\text{m}$ , i = 5  $\mu\text{m}$ .

Culture characteristics – On PDA, colony circular, slow growing, reaching 5 mm in 30 days at 25°C, grey from above, dark grey from below, surface rough, dry, with sparse mycelium, raised, entire at edge.

Material examined – Thailand, Prachuap Khiri Khan Province, on submerged wood in a stream, 30 July 2015, K.D. Hyde, 130A (MFLU 15-2682, holotype).

Notes – *Junewangia thailandica* forms a distinct branch with all sequenced *Junewangia* species (Fig. 1). *Junewangia thailandica* is similar to an unsequenced species *J. obliqua* in conidial shape, but *J. thailandica* differs in having longer conidiophores (up to 195  $\mu\text{m}$  vs. up to 120  $\mu\text{m}$ ) and conidial septa (mostly longitudinal, transverse and sometimes oblique septa in *J. thailandica* vs. numerous oblique septa in *J. obliqua*) (Baker et al. 2002). Thus, we introduce *Junewangia thailandica* sp. nov. in this study.

***Sporidesmiella*** P.M. Kirk, Trans. Br. mycol. Soc. 79(3): 479 (1982)

Type species – *Sporidesmiella claviformis* P.M. Kirk

Notes – Due to the heterogeneous characteristics of *Sporidesmium*, *Sporidesmiella* was proposed for species having cuneate to obovoid conidia with fewer septa (Kirk 1982). *Sporidesmiella* comprises almost 50 epithets in Index Fungorum (2021). It has been shown to be polyphyletic as *S. fusiformis* clusters in Melanommataceae (Dothideomycetes) (Shenoy et al. 2006), while *S. aquatica*, *S. hyalosperma* and *S. novae-zelandiae* cluster in Junewangiaceae (Sordariomycetes) (Luo et al. 2019). Molecular data of the type species *S. claviformis* is needed to resolve the polyphyletic nature. *Sporidesmium* has been phylogenetically linked to two sexual morphs, *S. lignicola* and *S. thailandense*, which are morphologically similar to Annulatasceae (Zhang et al. 2017, Luo et al. 2019), while the sexual morph of *Sporidesmiella* is undetermined. In this study, we introduce a new asexual species in *Sporidesmiella* based on phylogenetic analysis (Fig. 1), a key provided by Ma et al. (2012) and the recent literature. A new collection of *S. hyalosperma* from freshwater in China is also provided.

***Sporidesmiella hyalosperma*** (Corda) P.M. Kirk, Trans. Br. mycol. Soc. 79(3): 481 (1982)

Fig. 24

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, gregarious, hairy, pale brown. Mycelium mostly immersed, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores 90–110  $\times$  3.5–4.7  $\mu\text{m}$  ( $\bar{x}$  = 103  $\times$  4  $\mu\text{m}$ , n = 10), macronematous, mononematous, erect, cylindrical, straight or slightly flexuous, septate, slightly constricted at septa, robust at the base, unbranched, pale brown to brown, paler towards the apex, smooth. Conidiogenous cells 35–48  $\times$  4–4.5  $\mu\text{m}$  ( $\bar{x}$  = 42  $\times$  4.2  $\mu\text{m}$ , n = 5), holoblastic, polyblastic, integrated, with sympodial proliferations, terminal, cylindrical, brown, smooth. Conidia 18.5–25  $\times$  8–10.5  $\mu\text{m}$  ( $\bar{x}$  = 21  $\times$  9.5  $\mu\text{m}$ , n = 20), acrogenous, pleuroacrogenous, solitary, dry, thin-walled, smooth-walled, obovoid or broadly clavate, subcylindrical, (3–)4-distoseptate, olivaceous brown, with a truncate base and faintly pigmented scar.

Culture characteristics – On PDA, colony circular, reaching 15 mm in 30 days at 25°C, reddish brown from above and below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – China, Yunnan Province, Pingbian City, on submerged wood in a stream, 20 September 2017, W. Dong, WF1A (MFLU 18-1200), living culture MFLUCC 18-1013; *ibid.*, HKAS 101705, living culture KUMCC 18-0054.

Notes – *Sporidesmiella hyalosperma* was first published in 1837 and named as *Helminthosporium hyalospermum* (Index Fungorum 2021). The current name *S. hyalosperma* proposed by Kirk (1982) is widely used for modern classification since its sequence data was



obtained from a freshwater collection (Luo et al. 2019). Our new collection MFLUCC 18-1013 has shorter conidiophores ( $90\text{--}110 \times 3.5\text{--}4.7 \mu\text{m}$  vs.  $116\text{--}144 \times 5\text{--}7 \mu\text{m}$ ) than collections of Luo et al. (2019) and slightly thinner conidia ( $18.5\text{--}25 \times 8\text{--}10.5 \mu\text{m}$  vs.  $22\text{--}26 \times 12\text{--}14.5 \mu\text{m}$ ) than those of Kirk (1982). Kirk (1982) described monoblastic conidiogenous cells in *S. hyalosperma*, while Luo et al. (2019) and our study found polyblastic conidiogenous cells. Multigene phylogenetic analysis and base pair comparison support our collection to be *S. hyalosperma* (Fig. 1).

*Sporidesmiella obovoidia* X.D. Yu, W. Dong & H. Zhang, sp. nov.

Fig. 25

Index Fungorum number: IF558078; Facesoffungi number: FoF 09562

Etymology – in reference to obovoid conidia of the fungus

Holotype – MFLU 17-1731

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. Colonies superficial, effuse, gregarious, hairy, dark brown to black. Mycelium mostly immersed, composed of septate, branched, pale brown, thin-walled hyphae. Conidiophores  $80\text{--}125 \times 3.5\text{--}4.5 \mu\text{m}$  ( $\bar{x} = 96 \times 4 \mu\text{m}$ ,  $n = 10$ ), macronematous, mononematous, erect, cylindrical, straight or flexuous, septate, not constricted at septa, slightly robust at the base, unbranched, brown, smooth. Conidiogenous cells  $10\text{--}40 \times 3\text{--}4 \mu\text{m}$  ( $\bar{x} = 27 \times 3.7 \mu\text{m}$ ,  $n = 10$ ), holoblastic, polyblastic, integrated, with sympodial proliferations, terminal and intercalary, cylindrical, brown, smooth. Conidia  $20\text{--}25 \times 9\text{--}11.5 \mu\text{m}$  ( $\bar{x} = 22 \times 10 \mu\text{m}$ ,  $n = 20$ ), acrogenous, pleuroacrogenous, solitary, dry, thin-walled, smooth-walled, mostly obovoid, or broadly clavate, (3–)4-distoseptate, brown or olivaceous brown, often with some small, sub-rounded hollows in each cell, with a truncate base and faintly pigmented scar.

Culture characteristics – On PDA, colony circular, reaching 20 mm in 25 days at 25°C, grey-dark brown from above, black from below, surface rough, dry, with dense mycelium, umbonate, entire at edge.

Material examined – Thailand, Chiang Mai Province, Mushroom Research Centre, on submerged wood in a stream, 1 September 2017, X.D. Yu, 21A (MFLU 17-1731, holotype), ex-type living culture MFLUCC 17-2372.

Notes – *Sporidesmiella obovoidia* clusters with *S. hyalosperma* with strong bootstrap support (Fig. 1). *Sporidesmiella obovoidia* is similar to *S. hyalosperma* in having polyblastic conidiogenous cells with sympodial proliferations, and obovoid, 3–4-distoseptate, brown conidia (Luo et al. 2019). However, *S. obovoidia* differs in having longer conidia ( $20\text{--}25 \times 9\text{--}11.5 \mu\text{m}$  vs.  $17\text{--}21 \times 8\text{--}10 \mu\text{m}$ ). In addition, *S. obovoidia* often has some small, sub-rounded hollows in each cell, which are not observed in *S. hyalosperma*. A nucleotide comparison between *S. obovoidia* and *S. hyalosperma* shows a difference of 7, 23 and 12 nucleotides in LSU, ITS and TEF sequence data, respectively, which supports them to be different species (Jeewon & Hyde 2016).

**Papulosaceae** Winka & O.E. Erikss., Mycoscience 41(2): 102 (2000)

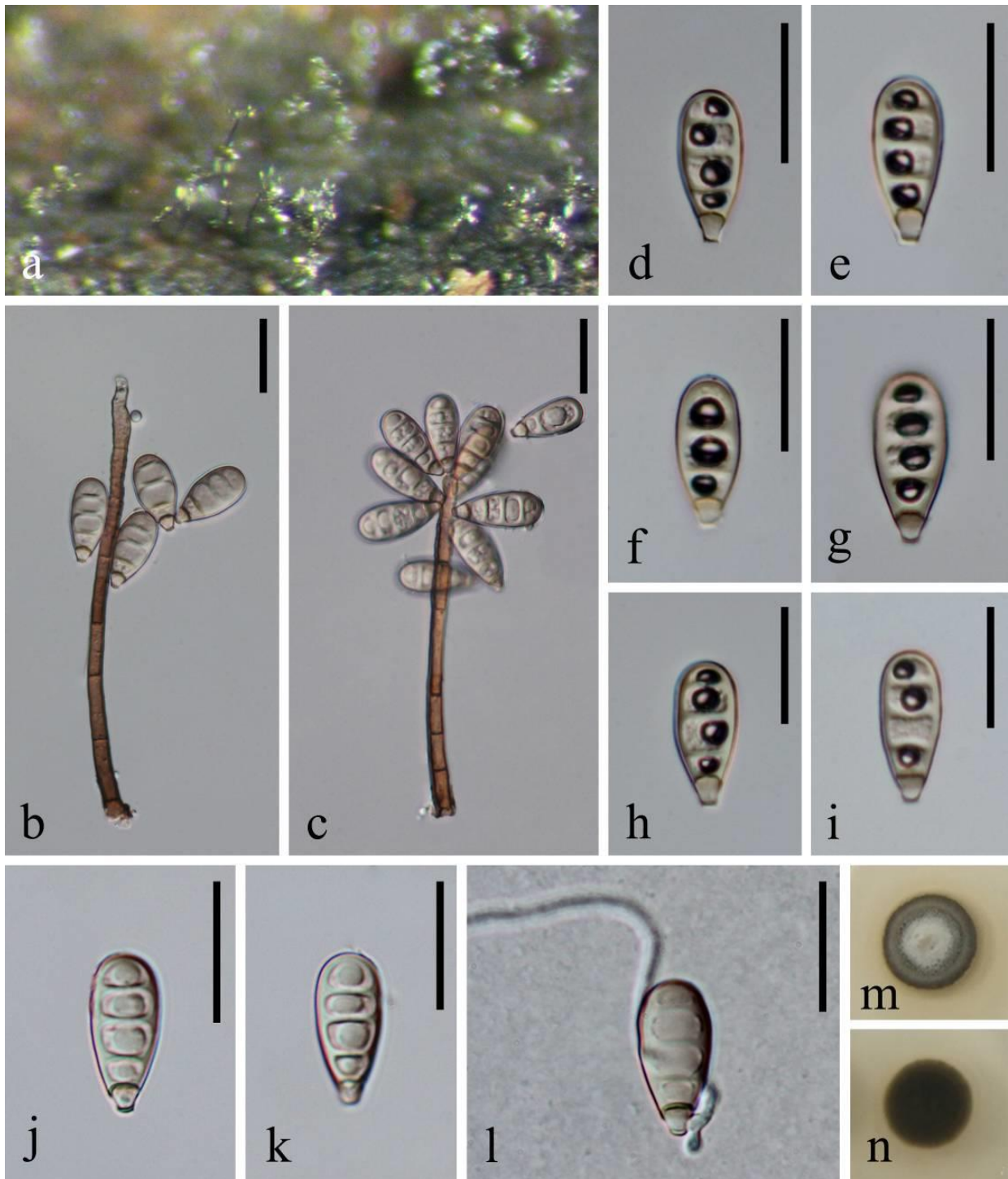
Type genus – *Papulosa* Kohlm. & Volkm.-Kohlm.

Notes – Papulosaceae was established by Winka & Eriksson (2000) to accommodate a single genus *Papulosa* with *P. amerospora* as the type species. Currently, four genera, viz. *Brunneosporella*, *Fluminicola*, *Papulosa* and *Wongia*, are accepted in Papulosaceae based on multigene analyses (Khemmuk et al. 2016, Luo et al. 2019, Hyde et al. 2020, this study, Fig. 1). *Platytrachelon* was placed in Papulosaceae by Zhang et al. (2017), but not accepted by Luo et al. (2019), and recently was referred to Diaporthomycetidae genera *incertae sedis* (Hyde et al. 2020). Papulosaceae is one of the families to accommodate annulatasaceae-like taxa *Fluminicola*, which is characterized by cylindrical asci with a relatively small, discoid apical ring and hyaline, fusiform ascospores (Zhang et al. 2017). These characteristics can be easily distinguished from the other three genera in the family.



**Figure 24** – *Sporidesmiella hyalosperma* (MFLU 18-1200). a Colonies on submerged wood. b–f Conidiophores, conidiogenous cells and conidia. g–j Conidiogenous cells with conidia.

k–p Conidia. q Germinated conidium. r, s Colony on PDA (left-front, right-reverse). Scale bars: b = 50  $\mu$ m, c–f = 20  $\mu$ m, g–q = 10  $\mu$ m.



**Figure 25** – *Sporidesmiella obovoidia* (MFLU 17-1731, holotype). a Colonies on submerged wood. b, c Conidiophores with conidia. d–k Conidia (d–i note the dark ornamentations on the surface). l Germinated conidium. m, n Colony on PDA (up-front, down-reverse). Scale bars: b–l = 20  $\mu$ m.

***Fluminicola*** S.W. Wong, K.D. Hyde & E.B.G. Jones, Fungal Diversity Res. Ser. 2: 190 (1999)

Type species – *Fluminicola bipolaris* S.W. Wong, K.D. Hyde & E.B.G. Jones

Notes – *Fluminicola* was introduced for a freshwater species *F. bipolaris*, and placed in Annulatascaceae based on morphology (Wong et al. 1999b). It is distinctive from other annulatascaceae-like genera in having immersed ascomata with a relatively long, upright neck

erumpent through host substrate, and irregular bifurcate or cup-like bipolar appendages of ascospores, which are tiny and hyaline and difficult to be observed (Wong et al. 1999b, Zhang et al. 2017). Zhang et al. (2017) transferred *Fluminicola* to Papulosaceae based on sequence data from their three new species. The sequence data of the type species *F. bipolaris* is lacking and it has been missing for nearly 30 years since it was first collected from Philippines in 1994 (Wong et al. 1999b). Nevertheless, the molecular data of *F. bipolaris* is needed to confirm its generic status in Papulosaceae. In this study, we introduce a new species *F. striata* and synonymize *F. thailandensis* with *F. saprophytica*.

***Fluminicola saprophytica*** W. Dong, H. Zhang & K.D. Hyde, Fungal Diversity 85: 100 (2017)

Fig. 26

Synonym – *Fluminicola thailandensis* W. Dong, H. Zhang & K.D. Hyde, Fungal Diversity 85: 100 (2017)

*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 80–120 µm high, 220–250 µm diam., scattered to gregarious, immersed with neck erumpent through host substrate, compressed ellipsoidal, black, coriaceous, ostiolate, with a lateral neck. *Necks* relatively long, black, cylindrical, upright, periphysate. *Peridium* 10–30 µm thick, comprising 5–7 layers of thin-walled, large cells of *textura angularis*, dark brown to black in outer layer, inwardly pale brown to hyaline, poorly developed and flattened at the base, composed of 2–3 layers of pale brown to hyaline, thin-walled, compressed cells of *textura angularis*. *Paraphyses* cylindrical, unbranched, hyaline, septate. *Asci* 95–120 × 8.8–13 µm ( $\bar{x}$  = 110 × 10.5 µm, n = 15), 8-spored, unitunicate, cylindrical, apex rounded, long or short pedicellate, with a relatively small, refractive, discoid, apical ring. *Ascospores* 15–20 × 4.5–7 µm ( $\bar{x}$  = 17 × 6 µm, n = 20), overlapping uniseriate, fusiform, straight, obscurely 3-septate, guttulate, hyaline, thin-walled, smooth, often with bipolar cap-like or bifurcate appendages which are obvious in Indian Ink, sometimes with a thin mucilaginous sheath. Asexual morph: Undetermined.

Culture characteristics – On PDA, colony circular, reaching 15 mm in 12 days at 25°C, white-yellowish brown from above, dark brown from below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – Thailand, Satun Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat287 (MFLU 18-1567), living culture MFLUCC 18-1244; *ibid.*, HKAS 105019, KUMCC 19-0035.

Notes – *Fluminicola saprophytica* was introduced by Zhang et al. (2017) and distinguished to its phylogenetically closest species *F. thailandensis* by shorter asci and thinner ascospores. Luo et al. (2019) identified another two collections as *F. thailandensis*. A nucleotide comparison shows that five strains including our new strain MFLUCC 18-1244 have nearly identical sequence data (Table 2), which indicate that they are conspecific (Jeewon & Hyde 2016). Multigene analysis also supports them to be the same species (Fig. 1). Morphologically, they have overlapping dimensions of the asci and ascospores, ranging from 95–193 × 8–15 µm in asci and 14–21 × 4.5–9 µm in ascospores (Zhang et al. 2017, Luo et al. 2019). The appendages and sheaths of *F. saprophytica* are inconspicuous in the holotype, but they can be seen in our new collection MFLUCC 18-1244 and in Luo et al. (2019). The ascomata of *F. saprophytica* are subglobose and with a central neck in the type collection MFLUCC 15-0976 (Zhang et al. 2017) and another collection MFLUCC 14-0037 (Luo et al. 2019), however, they are compressed ellipsoidal with a lateral neck in our new collection MFLUCC 18-1244. It is likely to be a result of the direction of hand section.

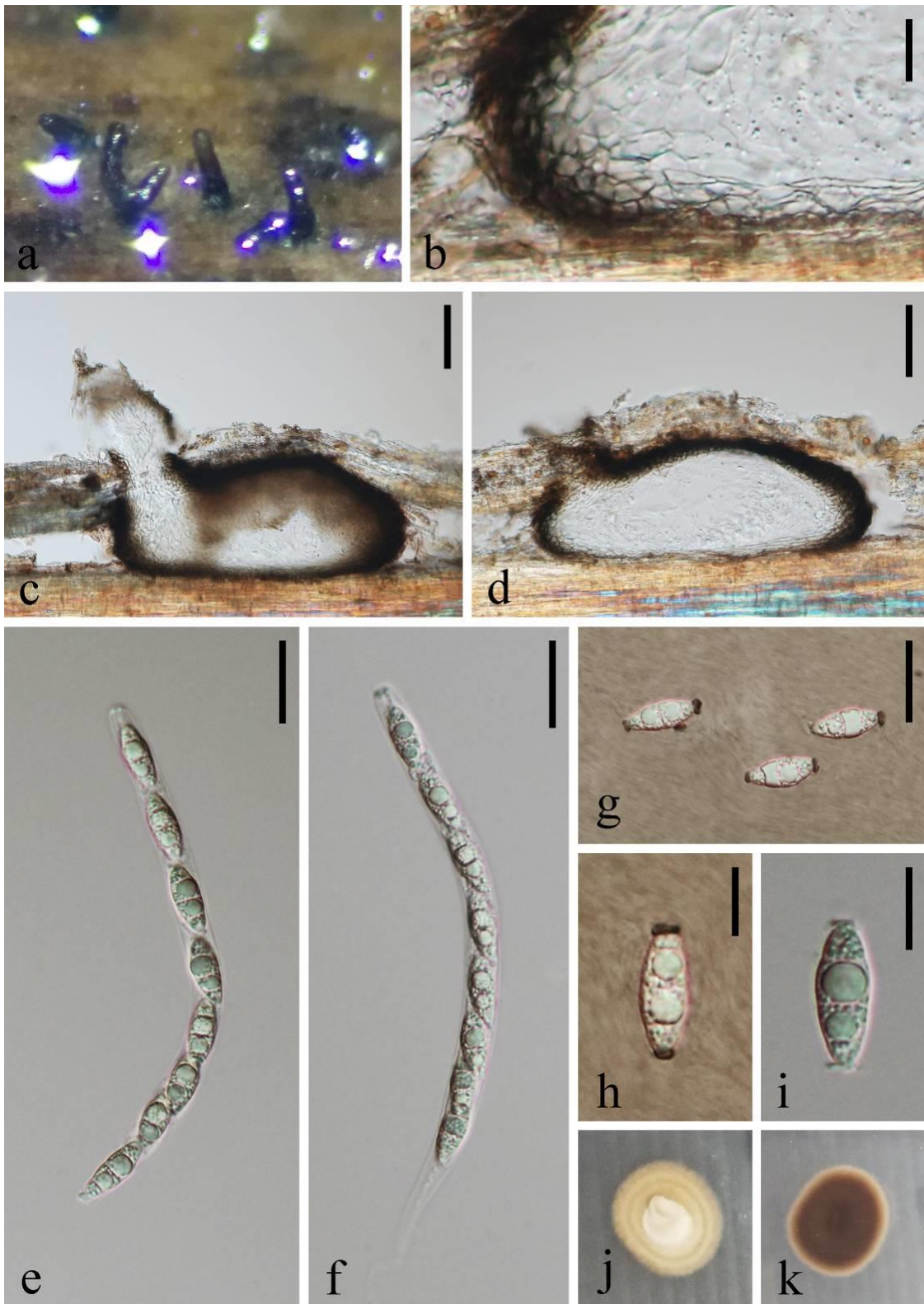
***Fluminicola striata*** X.D. Yu, W. Dong & H. Zhang, sp. nov.

Fig. 27

Index Fungorum number: IF558079; Facesoffungi number: FoF 09563

Etymology – in reference to the distinctive striations on the ascospores wall

Holotype – MFLU 18-1004



**Figure 26** – *Fluminicola saprophytica* (MFLU 18-1567). a Appearance of necks of ascomata on host. b Structure of peridium. c, d Vertical sections of ascomata. e, f Unitunicate asci. g, h Ascospores in Indian Ink. i Ascospore in water. j, k Colony on PDA (left-front, right-reverse). Scale bars: b, h, i = 10  $\mu$ m, c, d = 50  $\mu$ m, e–g = 20  $\mu$ m.

*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* 85–125  $\mu$ m high, 95–140  $\mu$ m diam., scattered, immersed with neck erumpent through host substrate, subglobose to ellipsoidal, dark brown to black, coriaceous, ostiolate, with a neck. *Necks* relatively long,

subhyaline to pale yellowish brown, cylindrical, upright, periphysate. *Peridium* 20–25 µm thick, comprising several layers of thin-walled, hyaline to brown, compressed cells of *textura angularis*. *Paraphyses* sparse or absent. *Asci* 160–180 × 10–14 µm ( $\bar{x}$  = 170 × 12.5 µm, n = 10), 8-spored, unitunicate, cylindrical and slightly wider in the middle, apex truncate, short pedicellate, with an indistinct, refractive, relatively small, discoid apical ring, 2–2.5 × 3–3.3 µm. *Ascospores* 18.5–26.5 × 5.5–8.7 µm ( $\bar{x}$  = 22 × 7 µm, n = 30), obliquely uniseriate in the middle of asci, arranged distantly from apical ring, fusiform, with rounded ends, straight, 3–4-septate, not constricted at the septa, guttulate, hyaline, thin-walled, with distinctive striations, sometimes with bipolar bifurcate appendages, without sheath. Asexual morph: Undetermined.

**Table 2** Comparison of polymorphic nucleotides for five isolates of *Fluminicola saprophytica*

Isolates	LSU			ITS													TEF					References
	261	423	762	107	108	109	110	142	143	144	170	177	356	489	514	525	97	175	592	673	808	
<b>MFLUCC 15-0976 (type)</b>	C	C	G	C	T	G	G	A	T	C	T	T	T	T	A	-	C	G	C	C	C	Zhang et al. 2017
MFLUCC 15-0984	.	.	.	.	.	.	.	.	.	.	.	C	C	C	T	-	Sequence not available					Zhang et al. 2017
MFLUCC 18-1244	T	.	.	-	-	-	-	-	.	.	.	C	C	C	T	T	T	A	T	.	T	This study
MFLUCC 14-0037	.	T	-	-	-	-	T	C	A	C	C	C	C	C	T	T	.	.	.	G	.	Luo et al. 2019
MFLUCC 18-0199	.	.	.	Sequence not available													Sequence not available					Luo et al. 2019

Material examined – Thailand, Phayao Province, on submerged wood in a stream, 23 February 2018, X.D. Yu, Y26 (MFLU 18-1004, **holotype**), ex-type living culture MFLUCC 18-0990.

Notes – *Fluminicola striata* is similar to other species in the genus in having immersed ascomata with a neck erumpent through host substrate, cylindrical asci with an indistinct, refractive, relatively small, discoid apical ring, and fusiform, hyaline, septate ascospores with bipolar bifurcate appendages (Zhang et al. 2017). However, *F. striata* differs in having obvious striations on the ascospore surface. Multigene analysis supports it to be a new species in *Fluminicola* (Fig. 1).

### **Pseudoproboscisporaceae** H. Zhang, K.D. Hyde & Maharachch., Fungal Diversity 85: 93 (2017)

Type genus – *Pseudoproboscispora* Punith.

Notes – Pseudoproboscisporaceae was established to accommodate two annulatasaceae-like genera, *Diluvicola* and *Pseudoproboscispora* (Zhang et al. 2017). Pseudoproboscisporaceae differs from other families by ascomata often lying horizontally on the host substrate, with a lateral neck, and fusiform ascospores with bipolar filamentous appendages, which are initially coiled then unfurl to form long threads (Zhang et al. 2017). Pseudoproboscisporaceae was accommodated in Atractosporales based on phylogenetic analysis, morphology and its occurrence in freshwater habitat (Zhang et al. 2017). However, this family was shown to phylogenetically not belong to Atractosporales, and clustered with Junewangiaceae in Luo et al. (2019) and *Cancellidium* in Hyde et al. (2020). In this study, Pseudoproboscisporaceae forms a sister clade with Junewangiaceae with weak

bootstrap support (Fig. 1), which concurs with phylogenies reported by Luo et al. (2019). Since Pseudoproboscisporaceae did not cluster consistently with any families in Diaporthomycetidae, we refer it to Diaporthomycetidae families *incertae sedis*.

Strain HKUCC 3710 bearing the name “*Cataractispora recepticuli*” clusters in Pseudoproboscisporaceae and it was presumed to be a synonym of *Pseudoproboscispora aquatica* based on the comparison of photo plate of *C. recepticuli* and *P. aquatica* (Cai et al. 2006, Zhang et al. 2017). However, HKUCC 3710 (holotype HKU(M) 5239) has been formally published as *Cataractispora receptaculorum* in Ho et al. (2004). The ascospore appendages of *C. receptaculorum* are initially in the form of mucilaginous pads and then unfurl readily in water to form long threads and do not coil as a proboscis (Ho et al. 2004). Whereas, appendages of *P. aquatica* are at first coiled, proboscis-like at each end and then uncoil in water to form long threads (Wong & Hyde 1999a). In our phlogenetic tree (Fig. 1), *C. receptaculorum* clusters with *P. thailandensis* but they have over 70 nucleotide difference in LSU sequence data which also support them to be different genera. Considering the morphological similarity of annulatasceae-like taxa and the lack of sequence data from the type species *C. aquatica*, we retain *Cataractispora* in Annulatasceae as suggested by Hyde et al. (2020).

Zhang et al. (2017) introduced *Pseudoproboscispora thailandensis* in Pseudoproboscisporaceae, however, another species *P. caudae-suis* clusters in Annulatasceae (Fig. 1). *Pseudoproboscispora caudae-suis* was transferred from *Ceriospora* based on its morphological similarity to *P. aquatica* (type) (Campbell et al. 2003). However, species in *Pseudoproboscispora*, such as *P. aquatica* and *P. thailandensis*, as well as their relatives *Cataractispora*, *Diluvicola* and *Neodiluvicola*, have filamentous appendages, which initially coiled or proboscis-like or cap-like then unfurl to form long threads. Whereas, *P. caudae-suis* has tail-like appendages that straight and persistent near base and coiled towards the apex (holotype IMI 38506) (Ingold 1951). In addition, the asci of *P. caudae-suis* have an apical pore, which is never seen in *Pseudoproboscispora*, even in Pseudoproboscisporaceae (Ingold 1951, Zhang et al. 2017, this study). Phylogenetically, two strains A40-1A and A336-2D which are both under the name *P. caudae-suis* (Campbell et al. 2003) cluster in Annulatasceae rather than in Pseudoproboscisporaceae (Fig. 1). Also, at least one strain was probably misidentified as they have more than 100 nucleotide differences in LSU sequence data. Although *P. caudae-suis* morphologically does not belong in *Pseudoproboscispora*, we do not exclude it from *Pseudoproboscispora* until sequence data from epitype of *P. caudae-suis* and *P. aquatica* are obtained.

In this study, we provide a new collection of *Diluvicola capensis*, the type species of *Diluvicola*, with DNA sequence data which is phylogenetically distant from *D. aquatica*. Thus, *D. aquatica* is transferred to a new genus *Neodiluvicola* based on morphology and phylogeny.

***Diluvicola*** K.D. Hyde, S.W. Wong & E.B.G. Jones, Fungal Diversity Res. Ser. 1: 141 (1998)

Type species – *Diluvicola capensis* K.D. Hyde, S.W. Wong & E.B.G. Jones

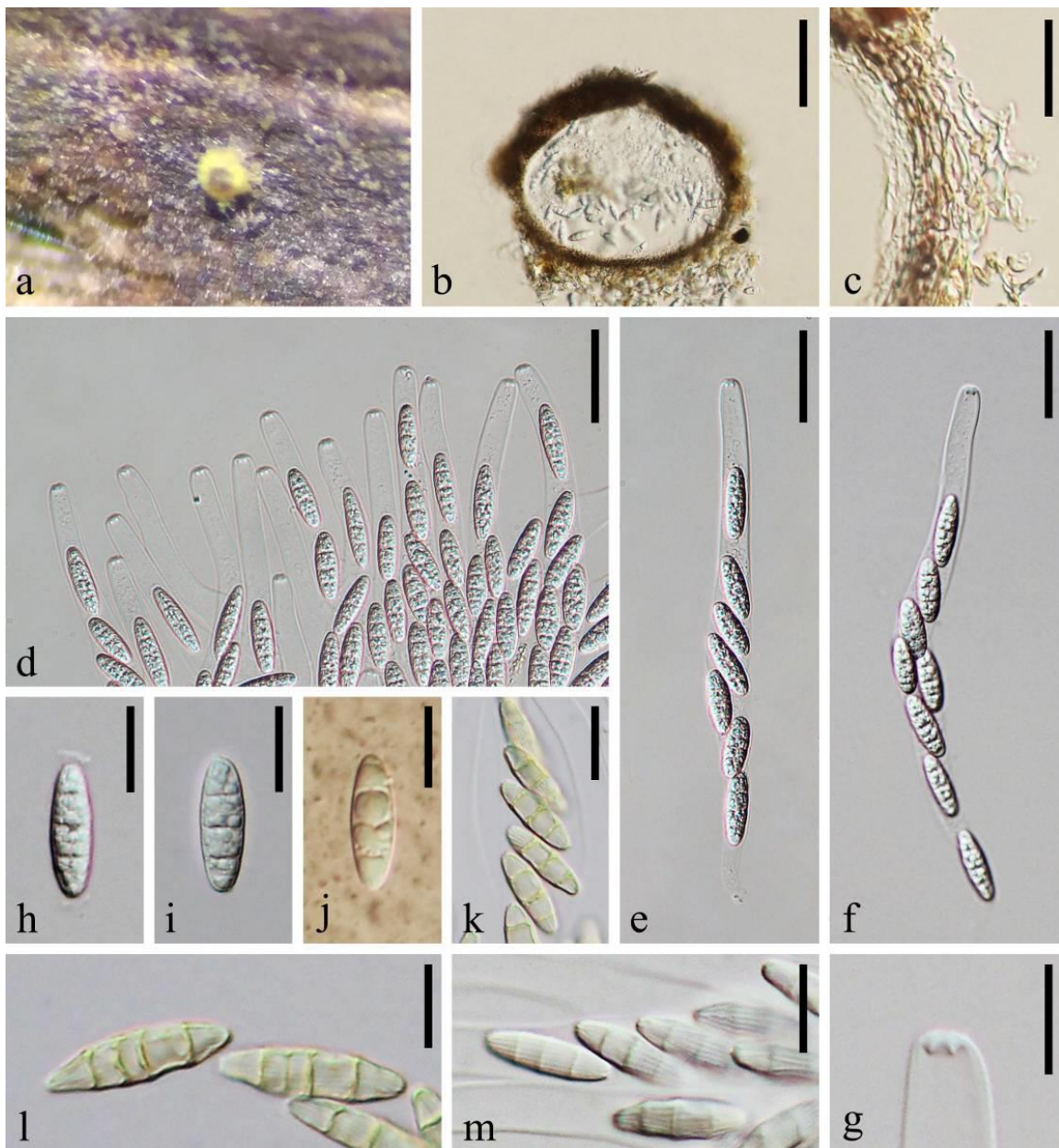
Notes – *Diluvicola* was introduced for a freshwater species *D. capensis* collected from Brunei (Hyde et al. 1998). *Diluvicola* is unique in having bipolar conical caps attached to ascospore tips and detached once released in water, with a flexible filament which unfurls from within the caps (Hyde et al. 1998). Zhang et al. (2017) introduced a new species *D. aquatica* based on its similar ascomata lying horizontally on the host substrate and unfurling mechanisms of ascospore appendages with *D. capensis*. We provide sequence data for *D. capensis* with a description and illustration, and transfer *D. aquatica* to a new genus *Neodiluvicola* based on morphology and phylogeny (see notes under *Neodiluvicola*).

***Diluvicola capensis*** K.D. Hyde, S.W. Wong & E.B.G. Jones, Fungal Diversity 1: 134 (1998)

Fig. 28

Facesoffungi number: FoF 09564

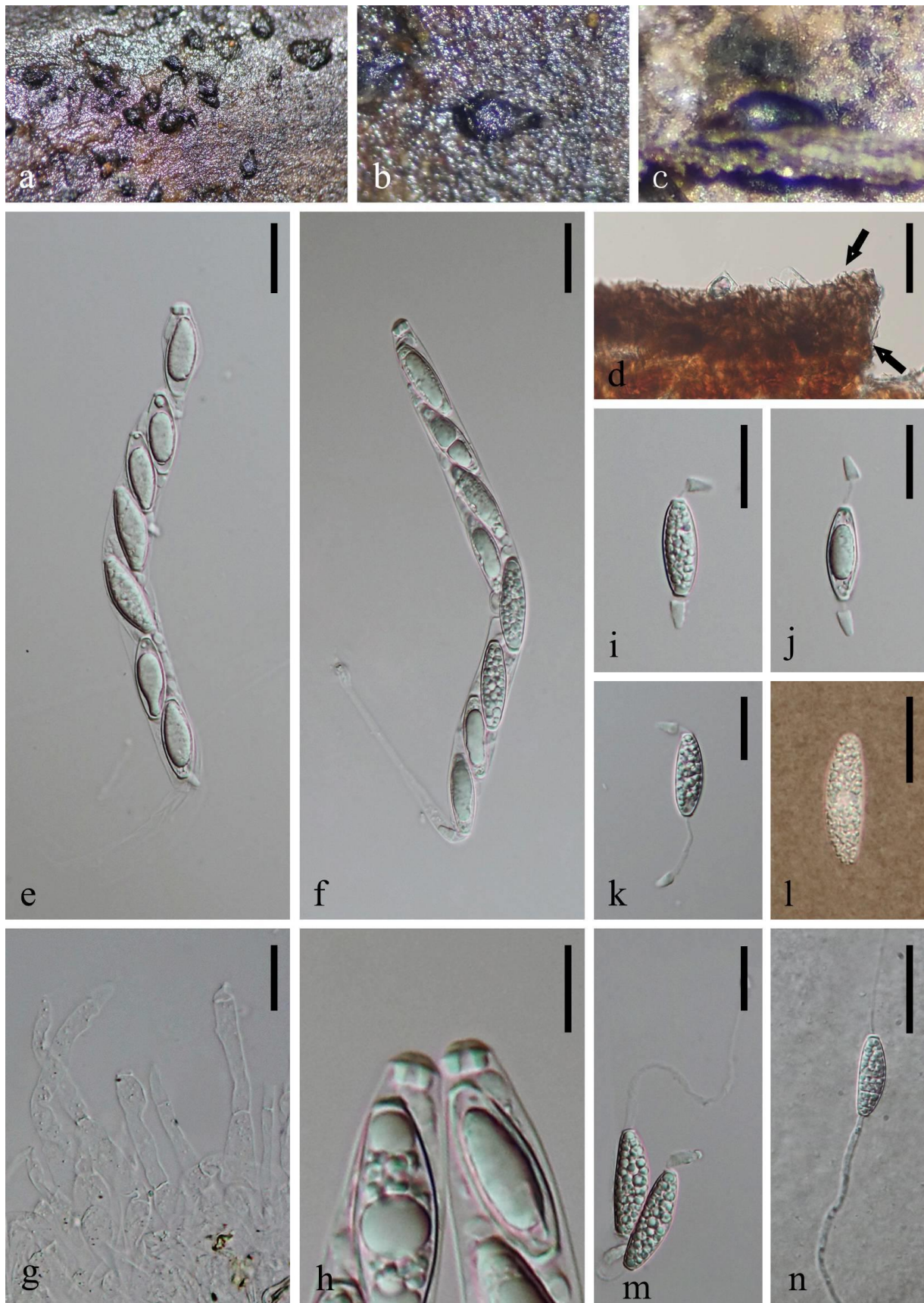
*Saprobic* on submerged wood in freshwater. Sexual morph: *Ascomata* scattered to gregarious, semi-immersed or superficial, ellipsoidal to obpyriform, black, lying horizontally on the host substrate, coriaceous, soft, ostiolate, with a lateral, short neck. *Peridium* very thin, easily cracked, comprising few layers of brown cells. *Paraphyses* 11.5  $\mu\text{m}$  diam. at the widest, tapering, uneven subcylindrical, septate, constricted at septa, unbranched, hyaline. *Asci* 190–210  $\times$  13–15  $\mu\text{m}$  ( $\bar{x}$  = 200  $\times$  14  $\mu\text{m}$ , n = 5), 8-spored, unitunicate, cylindrical, apex slightly truncate, tapering pedicellate, with a large, refractive, wedge-shaped, apical ring, 2.8–3  $\times$  4.4–4.9  $\mu\text{m}$ . *Ascospores* 25–30  $\times$  8.3–10  $\mu\text{m}$  ( $\bar{x}$  = 27  $\times$  9.2  $\mu\text{m}$ , n = 35), obliquely uniseriate, hyaline, fusiform, with truncate ends, straight or slightly curved, aseptate, 2–3-septate when germinated, minutely guttulate, thin-walled, smooth, with bipolar caps. *Caps* 6–7.5  $\times$  3–3.8  $\mu\text{m}$  ( $\bar{x}$  = 6.7  $\times$  3.5  $\mu\text{m}$ , n = 10), conical, attached at each ascospore tip and detached once released in water, with a single sticky, thin, flexible filament unfurls from within the caps. The end of the filament is connected to the collar-like structure at the ascospore tip and eventually forming a long thread-like polar appendage. Asexual morph: Undetermined.



**Figure 27** – *Fluminicola striata* (MFLU 18-1004, holotype). a Appearance of necks of ascomata on host. b Vertical section of ascoma. c Structure of peridium. d–f Unitunicate asci. g Apical ring.



h–m Ascospores (j ascospore in Indian Ink; k, l ascospores in Melzer’s reagent). Scale bars: b = 50  $\mu\text{m}$ , c, k = 20  $\mu\text{m}$ , d–f = 30  $\mu\text{m}$ , g, l = 10  $\mu\text{m}$ , h–j, m = 15  $\mu\text{m}$ .



**Figure 28** – *Diluviicola capensis* (MFLU 18-1717). a, b Ascomata on host substrate. c Section of ascoma. d Squashed peridium as arrowed. e, f Unitunicate asci. g Paraphyses. h Apical rings.

i–m Ascospores (1 ascospore in Indian Ink). n Germinated ascospore. Scale bars: d, n = 30  $\mu\text{m}$ , e–g, i–m = 20  $\mu\text{m}$ , h = 10  $\mu\text{m}$ .

Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, hat393 (MFLU 18-1717), living culture KUMCC 19-0088; *ibid.*, HKAS 105071; *ibid.*, hat108N, KUMCC 19-0089.

Notes – *Diluvicola capensis* was initially collected from a freshwater stream in Brunei (Hyde et al. 1998). Our Thai specimen KUMCC 19-0088 resembles the holotype of *D. capensis* in all aspects of morphological characteristics, except for shorter asci (190–210  $\times$  13–15  $\mu\text{m}$  vs. 266–326  $\times$  11–14  $\mu\text{m}$ ). This is a new geographical record of *D. capensis* in Thailand. *Diluvicola capensis* forms a basal clade in Pseudoproboscisporaceae but with low bootstrap support. Morphologically, *D. capensis* fits well with familial concept of Pseudoproboscisporaceae by ascomata lying horizontally on the host substrate, with a lateral neck, and fusiform ascospores with bipolar caps which attached at each ascospore tip and detached once released in water.

***Neodiluvicola*** W. Dong & H. Zhang, gen. nov.

Index Fungorum number: IF558080; Facesoffungi number: FoF 09565

Etymology – in reference to the morphologically similar genus *Diluvicola*

*Saprobic* on submerged bamboo or wood. Sexual morph: *Ascomata* scattered or solitary, semi-immersed to superficial, subglobose or ellipsoidal, black, with a lateral, short neck. *Necks* black, lying horizontally on the host substrate or curving upwards. *Peridium* thin, comprising several layers of dark brown to black, compressed cells of *textura angularis*. *Paraphyses* numerous, cylindrical, unbranched, hyaline, septate, tapering towards the apex. *Asci* 8-spored, unitunicate, clavate to subcylindrical, pedicellate, with a distinct, refractive, wedge-shaped, apical ring. *Ascospores* obliquely uni-seriate or partially biserial or sometimes triserial, fusiform, straight or slightly curved, aseptate or occasionally 1-septate, hyaline, thin-walled, with bipolar filamentous appendages. *Appendages* initially coiled in the bipolar chambers of ascospores then unfurl from within the chambers after releasing. Asexual morph: Undetermined.

Type species – *Neodiluvicola aquatica* (W. Dong et al.) W. Dong & H. Zhang

Notes – *Diluvicola aquatica* was introduced based on its morphological similarities with the type species *D. capensis* in having black ascomata with a short, lateral neck and the same unfurling mechanism of ascospore appendages (Hyde et al. 1998, Zhang et al. 2017). However, *D. aquatica* is phylogenetically distant from *D. capensis* and forms a basal branch to *Cataractispora* and *Pseudoproboscispora* (Fig. 1). We notice that *D. aquatica* and *D. capensis* have different unfurling mechanisms of appendages. The appendages of *D. aquatica* initially coiled in the chambers of ascospores then unfurl from within the chambers after their release (Zhang et al. 2017). In contrast, the appendages of *D. capensis* are coiled in the conical cap which detached from the tip of ascospores once released in water and unfurl from within the cap (Hyde et al. 1998, this study). In addition, *D. aquatica* has clavate asci, while *D. capensis* has cylindrical asci.

*Pseudoproboscispora* has a similar appendage unfurling mechanism that is initially coiled and then unfurls in water to form long threads (Wong et al. 1999a), but lacks bipolar chambers containing coiled appendages. Instead, its appendages are initially proboscis-like, which also differ from *D. aquatica*. Therefore, we establish a new genus *Neodiluvicola* to accommodate *D. aquatica*. Different unfurling mechanisms of ascospore appendages of three genera and one species in Pseudoproboscisporaceae are summarized in Table 3.

***Neodiluvicola aquatica*** (W. Dong, H. Zhang & K.D. Hyde) W. Dong & H. Zhang, comb. nov.

Fig. 29

Index Fungorum number: IF558081; Facesoffungi number: FoF 09566

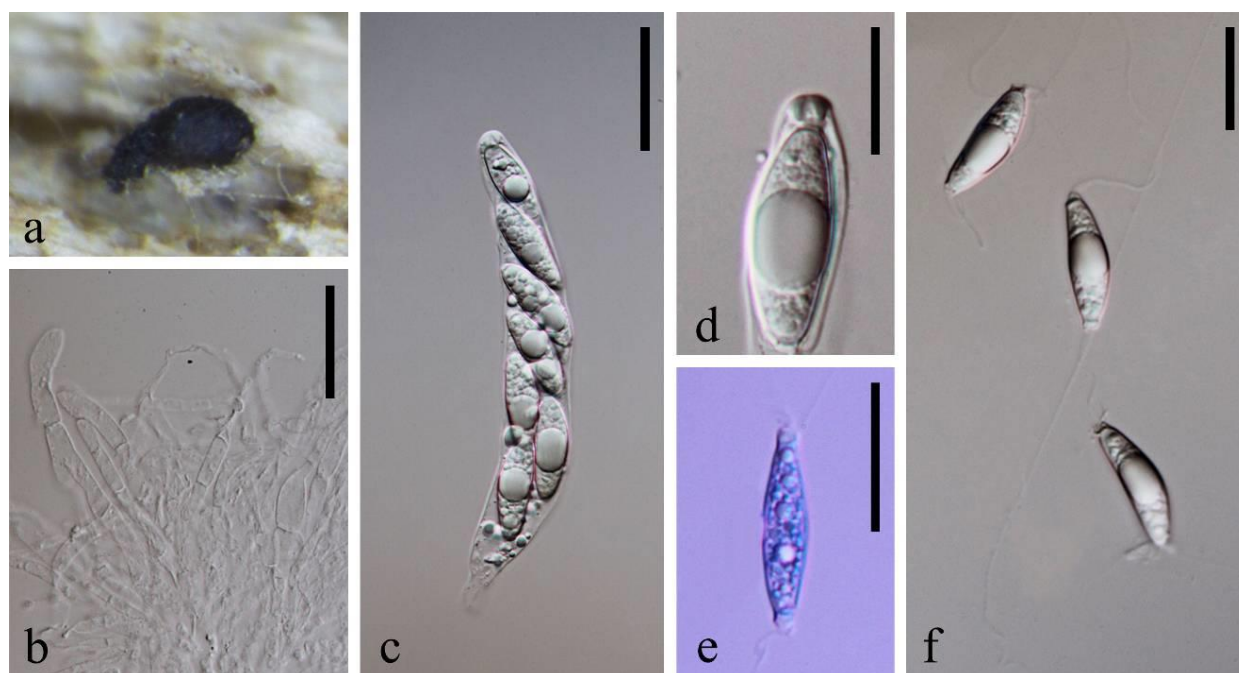
Basionym – *Diluvicola aquatica* W. Dong, H. Zhang & K.D. Hyde, Fungal Diversity 85: 93 (2017)

Holotype – MFLU 15-2701

Known distribution – (based on molecular data) – Thailand

Known habitat – (based on molecular data) – freshwater

For description of this fungus see Zhang et al. (2017)



**Figure 29** – *Neodiluviicola aquatica* (MFLU 15-2701). a Ascoma on host substrate. b Paraphyses. c Unitunicate ascus. d Apical ring. e, f Ascospores (e ascospore in cotton blue reagent). Scale bars: b, c = 30  $\mu$ m, d = 15  $\mu$ m, e, f = 20  $\mu$ m.

#### **Diaporthomycetidae genera *incertae sedis***

***Aquidictyomyces*** W. Dong, H. Zhang & K.D. Hyde, gen. nov.

Index Fungorum number: IF558082; Facesoffungi number: FoF 09567

Etymology – in reference to aquatic habitat where the fungus was collected and dictyoseptate conidia

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. *Colonies* superficial, effuse, gregarious, hairy, pale brown. *Mycelium* mostly immersed, composed of septate, branched, pale brown, thin-walled hyphae. *Conidiophores* macronematous, mononematous, erect, cylindrical, straight or slightly flexuous, septate, robust at the base, unbranched, brown, paler at the apex, smooth. *Conidiogenous cells* holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, pale brown, smooth. *Conidia* acrogenous, solitary, dry, thin-walled, smooth-walled, ginger-shaped, pale brown, dictyoseptate, constricted at septa, with one primary central, longitudinal septa, with transverse or oblique septa, with some protuberances at the apex, rounded or truncate at the base, with two tapering arms curving upwards at two sides, attached fibroid, hyaline appendages.

Type species – *Aquidictyomyces appendiculatus* W. Dong, H. Zhang & K.D. Hyde

Notes – Based on a blastn search of NCBI's GenBank, the closest hits using LSU sequence of *Aquidictyomyces appendiculatus* are some annulatasceae-like genera in Diaporthomycetidae, viz. *Barbatosphaeria* (92.97%), *Bullimyces* (93.32%), *Ceratolenta* (93.10%) and *Conlarium* (92.99%). However, they can be easily distinguished by conidial shape. Our phylogenetic analysis shows that *A. appendiculatus* forms a distinct lineage in Diaporthomycetidae and has a weak relationship with Trichosphaeriaceae (Fig. 1). Morphologically, *A. appendiculatus* does not fit with the familial concept of Trichosphaeriaceae and any of other families in Diaporthomycetidae (Hyde et al. 2020).

We therefore place *A. appendiculatus* in a new genus *Aquidictyomyces*, and refer it to Diaporthomycetidae genera *incertae sedis*.

**Table 3** Different unfurling mechanisms of ascospore appendages of *Cataractispora receptaculorum*, *Diluviicola*, *Neodiluviicola* and *Pseudoproboscispora*

Taxa	Unfurling mechanisms	References
<i>Cataractispora receptaculorum</i>	Initially in the form of mucilaginous pads and then unfurl readily in water to form long threads	Ho et al. 2004
<i>Diluviicola</i>	Initially coiled in the conical cap which detached from the tip of ascospores once released in water and unfurl from within the cap	Hyde et al. 1998, this study
<i>Neodiluviicola</i>	Initially coiled in the chambers of ascospores then unfurl from within the chambers after releasing	Zhang et al. 2017
<i>Pseudoproboscispora</i>	Initially coiled as proboscis-like and then unfurl in water to form long threads	Wong et al. 1999a, Zhang et al. 2017

*Aquidictyomyces appendiculatus* W. Dong, H. Zhang & K.D. Hyde, sp. nov.

Fig. 30

Index Fungorum number: IF558083; Facesoffungi number: FoF 09568

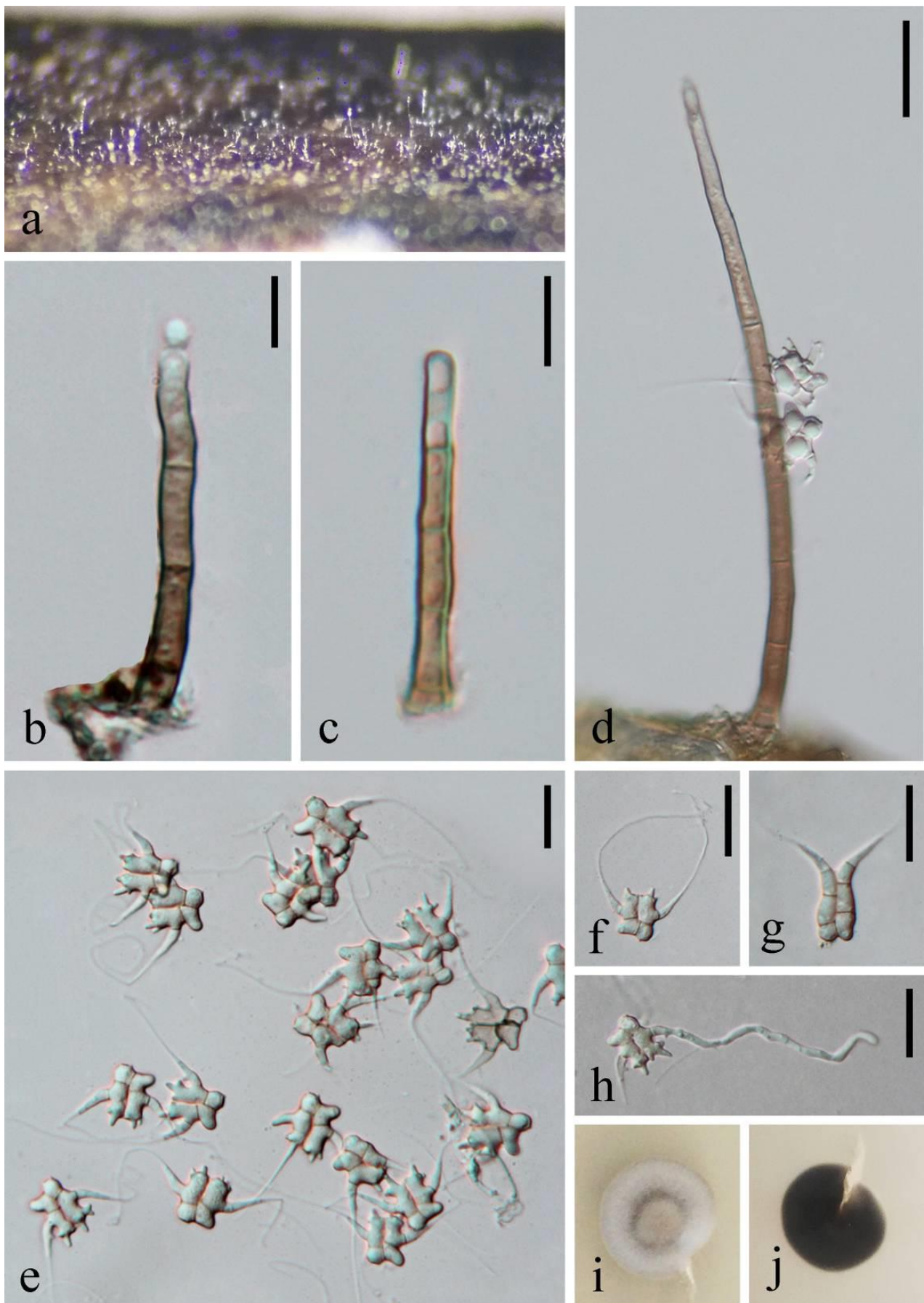
Etymology – in reference to the long appendages of the fungus

Holotype – MFLU 18-1528

*Saprobic* on submerged wood in freshwater. Sexual morph: Undetermined. Asexual morph: Hyphomycetous. *Colonies* superficial, effuse, gregarious, hairy, pale brown. *Mycelium* mostly immersed, composed of septate, branched, pale brown, thin-walled hyphae. *Conidiophores* 35–140 × 3–4.5 μm ( $\bar{x}$  = 85 × 4 μm, n = 10), macronematous, mononematous, erect, cylindrical, straight or slightly flexuous, septate, robust at the base, unbranched, brown, paler at the apex, smooth. *Conidiogenous cells* 5–50 × 2.5–3.5 μm ( $\bar{x}$  = 22 × 3 μm, n = 10), holoblastic, monoblastic, integrated, determinate, terminal, subcylindrical, pale brown, smooth. *Conidia* 11–14.5 × 7–9.5 μm ( $\bar{x}$  = 13 × 8.5 μm, n = 20), acrogenous, solitary, dry, thin-walled, smooth-walled, ginger-shaped, hyaline to pale brown, dictyoseptate, with one primary central, longitudinal, straight or curved septum, mostly with two transverse or oblique septa, constricted at septa, with 4–8 protuberances at the apex, rounded or truncate at the base, with two tapering, persistent arms curving upwards at two sides of the body, attached fibroid, hyaline appendages, 4–9 μm long for arms and 17–45 μm long for appendages.

Culture characteristics – On PDA, colony circular, slow growing, reaching 7 mm in 30 days at 25°C, white and pale brown from above, black from below, surface rough, dry, with dense mycelium, raised, entire at edge.

Material examined – Thailand, Songkhla Province, on submerged wood in a stream, 10 May 2018, W. Dong, 20180517 (MFLU 18-1528, holotype), ex-type living culture KUMCC 19-0061; *ibid.*, HKAS 105043, isotype.



**Figure 30** – *Aquidictyomyces appendiculatus* (MFLU 18-1528, holotype). a Colonies on submerged wood. b–d Conidiophores with conidia. e–g Conidia. h Germinated conidium. i, j Colony on PDA (left-front, right-reverse). Scale bars: b, c = 10  $\mu$ m, d–h = 15  $\mu$ m.

## Discussion

Since Maharachchikumbura et al. (2015) established Annulatascales to accommodate Annulatasceae with 18 genera, taxonomic studies on Annulatascales attracted the attention of researchers as these genera were scattered in several unrelated clades in Diaporthomycetidae (Luo et al. 2015, Zhang et al. 2017, Hyde et al. 2020). In addition, the placements of several genera are unclear due to lack of DNA sequence data, e.g. *Aqualignicola*, *Ayria*, *Chaetorostrum*, *Clohiesia* and *Vertexicola* (Hyde et al. 2020). The monophyly of Annulatascales is not well-supported in our phylogenetic analysis, except *Annulusmagnus* and *Ascitendus* which cluster together with good bootstrap support (Fig. 1). *Annulusmagnus*, *Ascitendus*, *Longicollum* and *Submersisphaeria* group together in a distinct clade in all recent studies (Luo et al. 2019, Hyde et al. 2020) and this study, but without bootstrap support. In our evolutionary tree (data not shown), these four genera also constitute a separate clade to *Annulatascus*. The divergence time of this clade is estimated as 137 MYA that falls in the range for family status (50–150 MYA) suggested by Hyde et al. (2017). However, we do not place these four genera in a new family now due to their weak relationships (Fig. 1). We consider that the higher ranking of taxa should be proposed only when sufficient morphological data are obtained and the phylogenetic relationships of these genera are clear enough, but the relatively long necks of *Annulusmagnus*, *Longicollum* and *Submersisphaeria* (Wong et al. 1999c, Campbell et al. 2003, Zelski et al. 2011) will be one of the characters to separate families in Annulatascales. Although *Paoayensis* clusters in Annulatascales (Luo et al. 2019, Hyde et al. 2020; this study, Fig. 1), its 2–6-spored asci and absence of large apical ring do not support *Paoayensis* in Annulatascales (Cabanela et al. 2007). *Paoayensis* is currently referred to Sordariomycetes genera *incertae sedis* (Luo et al. 2019, Hyde et al. 2020, Wijayawardene et al. 2020). The placements of two new genera *Fusoidigranularius* and *Longivarius* are also unstable in Annulatasceae as shown in different papers (Zhang et al. 2017, Luo et al. 2019, Hyde et al. 2020, this study). We place them in Annulatasceae based on current phylogenetic analysis.

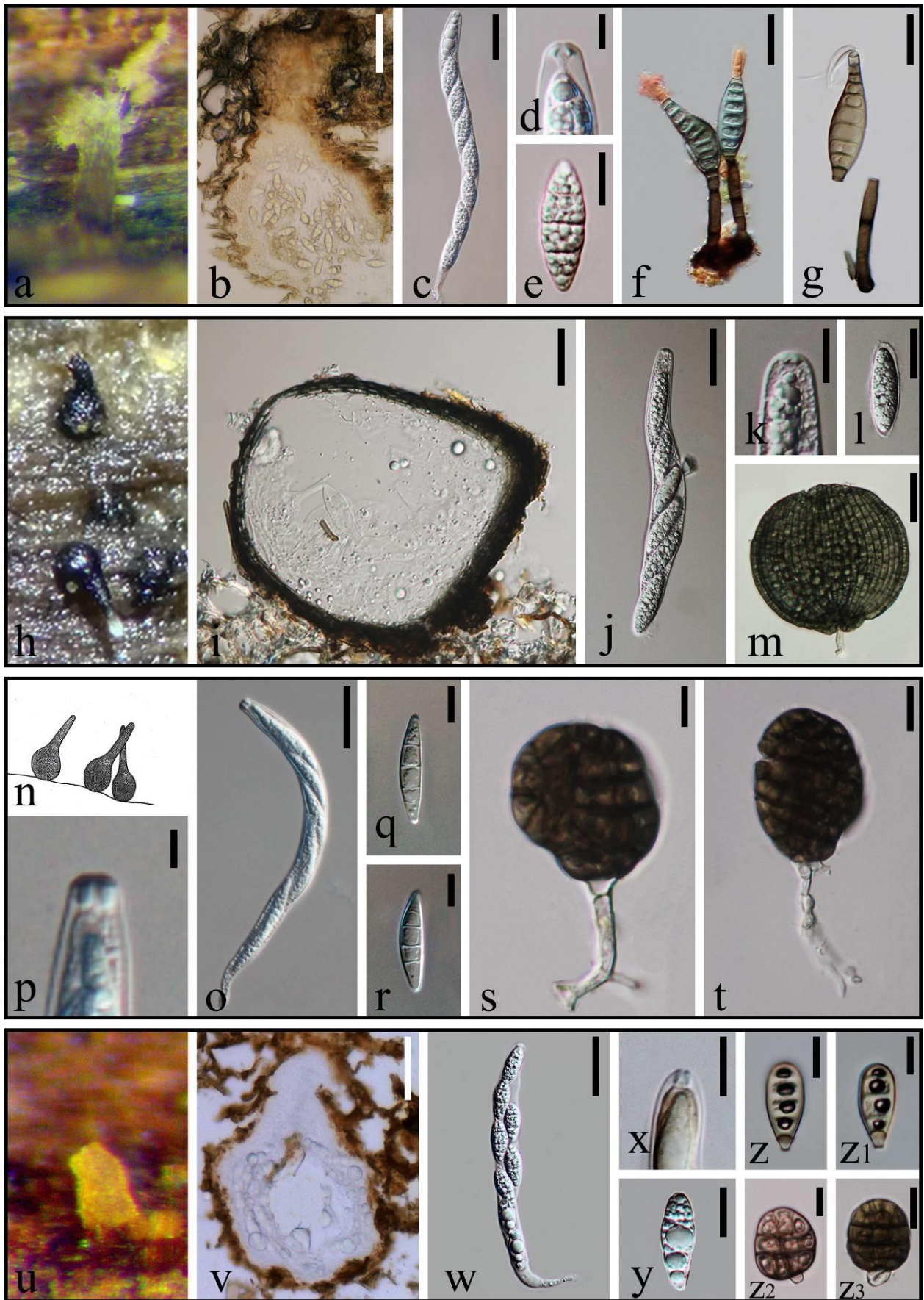
The morphological characteristics of all sequenced genera in Annulatasceae are summarized in Table 4. These genera are similar to the type genus *Annulatascus* in having ascomata with necks, but *Ascitendus* has a minute papilla and other genera have relatively longer necks than *Annulatascus*, especially the neck of *Longicollum* is up to 370 µm long (Zelski et al. 2011). Of these genera, only *Fusoidigranularius* has a long pedicel which is similar to *Annulatascus*, but the ascospores of *Fusoidigranularius* are entirely different from *Annulatascus*. All genera have similar ascospore shape and colour, except that *Ascitendus* and *Longivarius* have unevenly coloured ascospores and *Submersisphaeria* has brown ascospores. Although these genera share few morphological characteristics, all of them have cylindrical asci with a large apical ring. The phylogenetic relationships of these genera are unclear and more data are needed to clarify their taxonomy. A narrower definition of Annulatasceae cannot be provided in this study, until Annulatasceae members form a monophyletic clade with a good bootstrap support.

The genera that morphologically resemble *Annulatascus* but are phylogenetically distant from Annulatasceae and those that lack sequence data, are treated as annulatasceae-like taxa, e.g. *Diluvicola*, *Flumicola* and *Pseudoproboscispora*. A natural classification of annulatasceae-like taxa was carried out by Zhang et al. (2017) with introducing a new order and six new families. However, several taxa are uncertain and referred to Diaporthomycetidae genera *incertae sedis* (*Aquaticola*) or temporarily in Annulatasceae (*viz.* *Aqualignicola*, *Ayria*, *Cataractispora*, *Chaetorostrum* and *Vertexicola*) (Hyde et al. 2020).

In previous taxonomic studies, most researchers focused on morphological characteristics of ascomata, asci and ascospores of annulatasceae-like species, and neglected their asexual morphs. Asexual morphs of Annulatasceae are poorly studied and Zelski et al. (2011) reported one taeniolella-like asexual morph from culture of *Chaetorostrum quincemilensis* which was placed in Annulatasceae, but without support from molecular data. Zhang et al. (2017) and Luo et al. (2019) linked annulatasceae-like taxa to several asexual genera, i.e. *Dictyosporella* and *Sporidesmium*, based on sequence data. This provided more evidence to separate annulatasceae-

**Table 4** Morphological characteristics of *Annulatascus*, *Annulusmagnus*, *Ascitendus*, *Fusoidigranularius*, *Longicollum*, *Longivarius* and *Submersisphaeria*

Genera	Ascomata	Asci		Ascospores			Appendage or sheath	References
		Shape	Apical ring	Shape	Colour	Septation		
<i>Annulatascus</i>	With a short neck	Cylindrical, mostly long pedicellate	3–8 × 2–7 µm	Fusiform	Hyaline	Mostly aseptate	With inconspicuous appendages and often with a thin or large sheath	Hyde 1992, Ho et al. 1999a, Luo et al. 2015, Dayarathne et al. 2016, Hyde et al. 2020, this study
<i>Annulusmagnus</i>	With a long neck, hyaline at the apex	Cylindrical, short pedicellate	3 × 5.5 µm	Fusiform	Hyaline	3-septate	With a thin mucilaginous sheath, which comprises episporial fibrillar material	Wong et al. 1999c
<i>Ascitendus</i>	With a minute papilla	Cylindrical, short or long pedicellate	2.5–3.5 × 3–3.8 µm	Ellipsoidal to fusiform	Central cells pale brown, end cells subhyaline to pale brown	3-septate	No	Campbell & Shearer 2004
<i>Fusoidigranularius</i>	With an upward bend, relatively long neck growing laterally	Cylindrical, long pedicellate	3–4 × 5–6 µm	Long fusoid	Hyaline	5–9(–11)-septate	With a large, gelatinous, irregular, granular sheath	Abdel-Wahab et al. 2011
<i>Longicollum</i>	With a long neck	Cylindrical, short pedicellate	2–4 × 3–5 µm	Broadly ellipsoidal	Hyaline	Aseptate	With short hyaline, bipolar, ephemeral, mucilaginous appendages	Zelski et al. 2011
<i>Longivarius</i>	With a relatively long neck, curving or becoming erect	Cylindrical, short pedicellate	5.0–7.5 µm wide	Fusoid to lunate	Central cells brown, end cells subhyaline	3-septate	No	Boonyuen et al. 2012
<i>Submersisphaeria</i>	With a long neck	Cylindrical, short pedicellate	4–6 × 5–6 µm	Ellipsoidal to oval	Brown	1-septate	With very small, hyaline, cap-like appendages	Campbell et al. 2003



**Figure 31** – Annulatasceae-like morphs and some asexual morphs. a–g Sporidesmiales spp. a–e *Sporidesmium thailandense* (MFLU 15-2709, holotype). f, g *S. appendiculatum* (MFLU 18-0981, holotype). h–m Cancellidiales spp. h–i *Obliquiminima hyalina* (MFLU 18-1521, holotype).



m *Cancellidium thailandense* (MFLU 18-1510, holotype). n–t Conlariales spp. n–r *Conlarium duplumascospora* (HMAS243129, holotype). s, t *C. aquaticum* (MFLU 18-1181). u–z<sub>3</sub> Junewangiaceae spp. u *Dictyosporella thailandensis* (MFLU 15-2706, holotype). v–y *D. Chiangmaiensis* (MFLU 17-1707, holotype). z, z<sub>1</sub> *Sporidesmiella obovoidia* (MFLU 17-1731, holotype). z<sub>2</sub> *Junewangia thailandica* (MFLU 15-2682, holotype). z<sub>3</sub> *Dictyosporella ellipsoidea* (MFLU 18-1209, holotype). a, h, n, u Ascomata. b, i, v Vertical sections of ascomata. c, j, o, w Unitunicate asci. d, k, p, x Apical rings. e, l, q, r, y Ascospores. f, g Conidiophores with conidia. m, s, t, z–z<sub>3</sub> Conidia. Scale bars: b, v = 50 μm, c, f, i, j, m, o, w = 30 μm, d, p = 5 μm, e, k, q–t, x–z<sub>2</sub> = 10 μm, g, l, z<sub>3</sub> = 20 μm.

like taxa with morphological characteristics of their asexual morphs. However, there are few reports on annulatasceae-like taxa reproducing conidia in culture, as well as from our new collections. It is likely that sexual morphs of annulatasceae-like taxa are not common in southwest of China and Thailand as observed during our continuous study on freshwater fungi since 2010 (Zhang et al. 2011, 2013, 2016, Dong et al. 2018, 2020a, b, 2021, Yu et al. 2018, Wang et al. 2019). The NCBI blast results show that our 30 collections have affinities to Annulatasceae or annulatasceae-like taxa, however, 19 of them are asexual morphs.

Several asexual orders or families which are phylogenetically closely related to annulatasceae-like taxa are included in this study, viz. Acrodictyaceae, Cancellidiales, Conlariales, Distoseptisporales, Junewangiaceae and Sporidesmiales. Of these, annulatasceae-like morphs have been found in Sporidesmiales (*Sporidesmium lignicola* and *S. thailandense*), Cancellidiales (*Obliquiminima hyalina* gen. et sp. nov.), Conlariales (*Conlarium duplumascospora*) and Junewangiaceae (*Dictyosporella Chiangmaiensis* sp. nov. and *D. thailandensis*). The morphological characteristics of these annulatasceae-like morphs and asexual morphs which belong in the same family or order are illustrated in a combined photo plate (Fig. 31). These annulatasceae-like morphs are similar in having cylindrical asci with a distinctive, refractive, mostly wedge-shaped, apical ring, however, the ascomata can distinguish them (Fig. 31a, h, n, u). It clearly shows that their related asexual morphs can be easily distinguished with distinct morphology (Fig. 31f, g, m, s, t, z–z<sub>3</sub>). It is, therefore, necessary to study annulatasceae-like taxa together with their related asexual morphs.

It is worth mentioning that *Sporidesmium* (Sporidesmiaceae) is a complex and large genus as species are morphologically very similar and few characteristics can be compared. Although two annulatasceae-like morphs have been reported in *Sporidesmium sensu stricto* based on molecular data (Zhang et al. 2017, Luo et al. 2019), there is not enough evidence to classify those *Sporidesmium sensu lato*. We believe that with more annulatasceae-like taxa found in *Sporidesmium*, the natural classification of both sporidesmium-like and annulatasceae-like taxa will become clearer. On the other hand, the family Distoseptisporaceae which was segregated from *Sporidesmium* was thought to differ from *Sporidesmium* by the colour of conidia and the length of conidiophores (Su et al. 2016). However, these characteristics are considered not significant enough to separate these two groups and molecular evidence is the main tool for their classification. The sexual morphs of Distoseptisporaceae are therefore necessary for further comparison with Sporidesmiaceae. Whether any unsequenced annulatasceae-like taxa, e.g. *Aqualignicola*, *Ayria*, *Chaetorostrum*, *Clohiesia* and *Vertexicola*, will cluster in Distoseptisporaceae need further investigation.

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RSA5980068), the future of specialist fungi in a changing climate: baseline data for generalist and specialist fungi associated with ants, *Rhododendron* species and *Dracaena* species (grant no: DBG6080013), Impact of climate change on fungal diversity and biogeography in the Greater Mekong Subregion (grant no: RDG6130001). Kevin D. Hyde also thanks Chiang Mai University for the award of Visiting Professor. Mingkwan Doilom would like to thank the 5th batch of Postdoctoral Orientation Training Personnel in Yunnan Province (grant no: Y934283261), the 64th batch of China Postdoctoral Science Foundation (grant no: Y913082271) and Chiang Mai University for Postdoctoral research funding. Dr. Fang Liu is sincerely thanked for providing materials of *Conlarium duplumascospora* in morphological study. We thank Prof. D. Jayarama Bhat for kindly perusing this manuscript.

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**Supplementary Table 1** Taxa used in the phylogenetic analyses and their corresponding GenBank accession numbers

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Acrodictys aquatica</i>	MFLUCC 18-0356	MG835712	MG835711	–	–
<i>Acrodictys bambusicola</i>	HSAUPmyr 9510	KX033564	KU999973	–	–
<i>Acrodictys elaeidicola</i>	HSAUPmj 5528	KX033569	KU999978	–	–
<i>Acrodictys elaeidicola</i>	HSAUPmj 5536	KX033568	KU999977	–	–
<i>Acrodictys globulosa</i>	HSAUPmyr 4696	KX033562	KU999970	–	–
<i>Acrodictys hainanensis</i>	HSAUPmyr 7561	KX033565	KU999974	–	–
<i>Acrodictys liputii</i>	HSAUPmj 1883	KX033570	KU999979	–	–
<i>Acrodictys liputii</i>	HSAUPmlg 2137	KX033558	KU999966	–	–
<i>Acrodictys malabarica</i>	HSAUPmyr 9509	KX033560	KU999968	–	–
<i>Acrodictys peruamazonensis</i>	HSAUPmyr 4694	KX033561	KU999969	–	–
<i>Acrodictys porosiseptata</i>	HSAUPmyr 4698	KX033559	KU999967	–	–
<i>Acrodictys porosiseptata</i>	<b>MFLUCC 11-0299</b>	<b>MW287761</b>	<b>MW286488</b>	–	–
<i>Acrodictys fuminicola</i>	KUMCC 15-0240	MK849786	MK828642	–	–
<i>Amplistroma caroliniana</i>	BEO9923	FJ532377	–	–	–
<i>Amplistroma erinaceum</i>	AH 43902	NG_058568	–	–	–
<i>Amplistroma guianensis</i>	GJS5740	FJ532380	–	–	–
<i>Annulatascus chiangmaiensis</i>	<b>MFLUCC 17-2346</b>	<b>MW287764</b>	<b>MW286490</b>	–	–
<i>Annulatascus hongkongensis</i>	<b>HKUCC 3702</b>	<b>AF132319</b>	–	–	–
<i>Annulatascus nakhonensis</i>	<b>MFLUCC 18-1239</b>	<b>MW287779</b>	<b>MW286505</b>	<b>MW396650</b>	–
<i>Annulatascus saprophyticus</i>	MFLUCC 14-0035	KR868947	–	–	–
<i>Annulatascus songkhlaensis</i>	<b>MFLUCC 18-1151</b>	<b>MW287754</b>	<b>MW286483</b>	<b>MW396644</b>	–
<i>Annulatascus thailandensis</i>	MFLUCC 18-1248	MN733254	MN733256	–	–

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Annulatascus velatisporus</i>	MFLUCC 16-1441	KY244031	KY320183	–	–
<i>Annulatascus velatisporus</i>	MFLU 16-2204	KX772397	KX772399	–	–
<i>Annulusmagnus triseptatus</i>	MFLUCC 17-0469	MK849801	MK828655	MN194059	–
<i>Annulusmagnus triseptatus</i>	MFLUCC 17-0462	MK849800	MK828654	MN194058	–
<i>Annulusmagnus triseptatus</i>	MFLUCC 18-1335	MK849799	MK828653	MN194057	MN124539
<i>Annulusmagnus triseptatus</i>	CBS 127688	MH876116	MH864680	–	–
<i>Annulusmagnus triseptatus</i>	CBS 127687	MH876115	MH864679	–	–
<i>Annulusmagnus triseptatus</i>	CBS 128831	GQ996540	–	–	JQ429258
<i>Annulusmagnus triseptatus</i>	M.R. 2948	GQ996540	–	–	–
<i>Annulusmagnus triseptatus</i>	SMH4832	AY780049	–	–	–
<i>Annulusmagnus triseptatus</i>	A353-1F	AY590289	–	–	–
<i>Annulusmagnus triseptatus</i>	A325-1D	AY590288	–	–	–
<i>Annulusmagnus triseptatus</i>	A 413-6	AY590285	–	–	–
<i>Annulusmagnus triseptatus</i>	SMH2359	AY346257	–	–	AY780148
<i>Aquafiliformis lignicola</i>	MFLUCC 16-1341	MK835815	MK828615	MN194068	MN156511
<i>Aquafiliformis lignicola</i>	MFLUCC 18-1338	MK835814	MK828614	MN194067	MN156510
<i>Aquapteridospora aquatica</i>	<u>MFLUCC 17-2371</u>	<u>MW287767</u>	<u>MW286493</u>	–	–
<i>Aquapteridospora fusiformis</i>	MFLU 18-1601	MK849798	MK828652	MN194056	–
<i>Aquapteridospora lignicola</i>	MFLU 15-1172	KU221018	–	–	–
<i>Aquidictyomyces appendiculatus</i>	<u>KUMCC 19-0061</u>	<u>MW287756</u>	–	–	–
<i>Arecophila bambusae</i>	HKUCC 4794	AF452038	–	–	–
<i>Ascitendus aquaticus</i>	MR 150	MG813818	–	–	–
<i>Ascitendus austriacus</i>	MFLUCC 16-1345	MK849802	–	MN194060	–
<i>Ascitendus austriacus</i>	CBS 131685	GQ996539	–	–	JQ429257
<i>Ascitendus austriacus</i>	M.R. 2936	GQ996539	–	–	–
<i>Ascitendus austriacus</i>	A324-1F	AY590294	–	–	–
<i>Ascitendus austriacus</i>	A44-28A	AY590292	–	–	–
<i>Atractospora aquatica</i>	S-1297	MK849849	MK828697	MN194039	MN124528
<i>Atractospora aquatica</i>	MFLU 18-2322	MK849848	MK828696	MN194038	MN124527
<i>Atractospora decumbens</i>	CBS 139032	KT991658	NR153541	–	KT991647
<i>Atractospora ellipsoidea</i>	R 008	AY590290	–	–	–
<i>Atractospora ellipsoidea</i>	A411-3	AY316356	–	–	–
<i>Atractospora ellipsoidea</i>	KUMCC 18-0051	MW287772	MW286498	MW396655	MW504071
<i>Atractospora reticulata</i>	CBS 138740	KT991661	KT991670	–	KT991650
<i>Atractospora reticulata</i>	CBS 127884	KT991660	KT991669	–	KT991649



Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Atractospora thailandensis</i>	KUMCC 16-0067	MF374362	MF374353	MF370962	MF370951
<i>Atractospora verruculosa</i>	CBS 132040	KT991659	KT991668	–	KT991648
<i>Aureobasidium pullulans</i>	CBS 584.75	DQ470956	–	DQ471075	DQ470906
<i>Barbatosphaeria barbirostris</i>	MR3767	KM492863	KM492888	–	KM492902
<i>Barbatosphaeria barbirostris</i>	CBS 121149	EF577059	–	–	KM492903
<i>Barbatosphaeria lignicola</i>	HKAS 84005	MK849791	MK828646	MN194050	–
<i>Barbatosphaeria neglecta</i>	CBS 127693	KM492868	KM492895	–	–
<i>Barbatosphaeria varioseptata</i>	CBS 137797	KM492869	KM492896	–	KM492907
<i>Brachysporium nigrum</i>	MR 1346	KT991662	–	–	KT991652
<i>Brunneospora aquatica</i>	HKUCC 3708	AF132326	AF177154	–	–
<i>Bullimyces aurisporus</i>	AF316-1b	JF775590	–	–	–
<i>Bullimyces communis</i>	AF281-5	JF775587	–	–	–
<i>Bullimyces costaricensis</i>	AF317-1a	JF775591	–	–	–
<i>Calyptosphaeria subdenudata</i>	SMH 3877	EU527994	KY931774	–	–
<i>Calyptosphaeria subdenudata</i>	SMH 2534	EU527993	KY931775	–	–
<i>Calyptosphaeria tenebrosa</i>	PRA 12740	KY931810	KY931778	–	KY931837
<i>Calyptosphaeria tenebrosa</i>	PRA 12741	KY931809	KY931777	–	KY931836
<i>Camarops microspora</i>	CBS 649.92	AY083821	–	DQ471108	DQ470937
<i>Cancellidium applanatum</i>	ILL 41205	KF833360	–	–	–
<i>Cancellidium applanatum</i>	CBS 137655	KF833359	–	–	–
<i>Cancellidium applanatum</i>	CBS 337.76	NG_064107	MH860985	–	–
<i>Cancellidium atrobrunneum</i>	GUFCC 18002	KF460276	KF460275	–	–
<i>Cancellidium atrobrunneum</i>	MFLUCC 20–0100	MT422740	MT422724	MT436438	–
<i>Cancellidium atrobrunneum</i>	MFLUCC 17-2361	MW287769	MW286495	–	–
<i>Cancellidium cinereum</i>	MFLUCC 18–0424	MT370363	MT370353	MT370488	MT370486
<i>Cancellidium griseonigrum</i>	MFLUCC 17–2117	MT370364	MT370354	–	MT370487
<i>Cancellidium griseonigrum</i>	MFLUCC 18-1236	MW287782	MW286481	MW396653	–
<i>Cancellidium thailandense</i>	MFLUCC 18-1142	MW287757	MW286485	–	–
<i>Cataractispora receptaculorum</i>	HKUCC 3710	AF132327	–	–	–
<i>Ceratolenta caudata</i>	PRM 899855	JX066705	–	–	–
<i>Ceratolenta caudata</i>	CBS 125234	JX066704	–	–	JX066699
<i>Ceratosphaeria aquatica</i>	MFLUCC 18-1337	MK835812	MK828612	MN194065	MN156509
<i>Ceratosphaeria lampadophora</i>	CBS 117555	AY761084	–	–	–
<i>Ceratosphaeria lignicola</i>	MFLUCC 18-0342	MK835813	MK828613	MN194066	–
<i>Ceratostomella cuspidata</i>	ICMP 17629	FJ617558	KT991671	–	KT991651

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Ceratostomella pyrenaica</i>	CBS 117116	DQ076323	–	–	–
<i>Chloridium gonytrichii</i>	MFLU 11-1051	MH476568	MH476571	–	–
<i>Conlarium aquaticum</i>	MFLUCC 18-0338	MK849850	MK828698	–	–
<b><i>Conlarium aquaticum</i></b>	<b>MFLUCC 15-0992</b>	<b>MF374363</b>	<b>MF374354</b>	<b>MF370963</b>	–
<i>Conlarium aquaticum</i>	MFLUCC 18-1417	MW287759	MW286486	MW396645	–
<i>Conlarium baiseense</i>	TD17	MK164655	MK164653	–	MK572999
<b><i>Conlarium baiseense</i></b>	<b>TD2</b>	<b>MF083158</b>	<b>MF083157</b>	–	<b>MK573000</b>
<i>Conlarium duplumascospora</i>	CGMCC 3.14940	JN936993	JN936997	–	–
<i>Conlarium duplumascospora</i>	CGMCC 3.14939	JN936992	JN936996	–	–
<b><i>Conlarium duplumascospora</i></b>	<b>CGMCC 3.14938</b>	<b>JN936991</b>	<b>JN936995</b>	–	–
<i>Conlarium nanningense</i>	M8	MK164656	MK164654	–	MK572998
<b><i>Conlarium nanningense</i></b>	<b>M1</b>	<b>KX886202</b>	<b>KX886204</b>	–	<b>MK224589</b>
<b><i>Conlarium sacchari</i></b>	<b>DX4</b>	<b>MF083167</b>	<b>MF083166</b>	–	<b>MK224587</b>
<i>Conlarium sacchari</i>	LA3	MF083164	MF083163	–	MK573001
<i>Conlarium sacchari</i>	NN1	MF083161	MF083160	–	MK224588
<b><i>Conlarium subglobosum</i></b>	<b>MFLU 17-1728</b>	<b>MW287768</b>	<b>MW286494</b>	–	–
<b><i>Conlarium thailandense</i></b>	<b>MFLUCC 17-2349</b>	<b>MH624127</b>	<b>MH624129</b>	–	–
<i>Cosmospora arxii</i>	CBS 748.69	MH871181	NR_145062	KM231950	HQ897725
<i>Cryphonectria parasitica</i>	CMW 7048	JN940858	–	–	–
<i>Cryptadelphia groenendalensis</i>	SH12	EU528007	–	–	–
<i>Cryptadelphia groenendalensis</i>	SMH 3767	EU528001	–	–	–
<i>Cryptadelphia polyseptata</i>	MR1668	AY281102	–	–	–
<i>Cyanoannulus petersenii</i>	R 044b	AY316359	–	–	–
<b><i>Cyanoannulus petersenii</i></b>	<b>R 044a</b>	<b>AY316358</b>	–	–	–
<i>Cytospora elaeagni</i>	CFCC 89633	KF765693	–	KU710919	KU710956
<i>Diaporthe cyatheae</i>	YMJ 1364	JX570891	–	JX570892	JX570893
<i>Diaporthe eres</i>	AR 3538	AF408350	–	–	–
<i>Diaporthe xishuangbanica</i>	LC6744	KY011862	–	KX999176	–
<b><i>Dictyosporella aquatica</i></b>	<b>CBS H-22127</b>	<b>KT241022</b>	–	–	–
<b><i>Dictyosporella chiangmaiensis</i></b>	<b>MFLUCC 17-2345</b>	<b>MW287765</b>	<b>MW286491</b>	–	–
<b><i>Dictyosporella ellipsoidea</i></b>	<b>MFLUCC 18-1042</b>	<b>MW287758</b>	–	–	–
<b><i>Dictyosporella guizhouensis</i></b>	<b>MFLU 18-1505</b>	<b>MK593605</b>	<b>MK593606</b>	–	–
<i>Dictyosporella guizhouensis</i>	MFLUCC 18-1232	MW287760	MW286487	MW396646	–
<b><i>Dictyosporella hydei</i></b>	<b>IFRDCC 3075</b>	<b>MG813161</b>	–	–	–
<b><i>Dictyosporella thailandensis</i></b>	<b>MFLUCC 15-0985</b>	<b>MF374364</b>	<b>MF374355</b>	<b>MF370958</b>	<b>MF370952</b>

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Diluvicola capensis</i>	KUMCC 19-0088	MW287777	MW286503	MW396647	–
<i>Diluvicola capensis</i>	KUMCC 19-0089	MW287776	MW286502	MW396648	–
<i>Disculoides eucalyptorum</i>	CPC 17648	JQ685524	–	–	–
<i>Distoseptispora adscendens</i>	HKUCC 10820	DQ408561	–	–	DQ435092
<b><i>Distoseptispora appendiculata</i></b>	<b>B-95</b>	<b>MN163023</b>	<b>MN163009</b>	–	–
<i>Distoseptispora aquatica</i>	MFLUCC 16-1357	MK849796	MK828650	MN194055	–
<i>Distoseptispora aquatica</i>	MFLUCC 16-1254	MK849795	–	MN194054	MN124538
<i>Distoseptispora aquatica</i>	MFLUCC 16-0904	MK849794	MK828649	MN194053	–
<i>Distoseptispora aquatica</i>	MFLUCC 18-0646	MK849793	MK828648	MN194052	–
<i>Distoseptispora aquatica</i>	S-965	MK849792	MK828647	MN194051	MN124537
<b><i>Distoseptispora aquatica</i></b>	<b>MFLUCC 15-0374</b>	<b>KU376268</b>	–	–	–
<b><i>Distoseptispora bambusae</i></b>	<b>MFLUCC 20-0091</b>	<b>MT232718</b>	<b>MT232713</b>	<b>MT232880</b>	<b>MT232881</b>
<b><i>Distoseptispora cangshanensis</i></b>	<b>MFLUCC 16-0970</b>	<b>MG979761</b>	<b>MG979754</b>	<b>MG988419</b>	–
<b><i>Distoseptispora caricis</i></b>	<b>CPC 36498</b>	<b>MN567632</b>	<b>MN562124</b>	–	<b>MN556805</b>
<i>Distoseptispora caricis</i>	CPC 36442	–	MN562125	–	MN556806
<b><i>Distoseptispora clematidis</i></b>	<b>MFLUCC 17-2145</b>	<b>MT214617</b>	<b>MT310661</b>	–	<b>MT394721</b>
<b><i>Distoseptispora dehongensis</i></b>	<b>KUMCC 18-0090</b>	<b>MK079662</b>	<b>MK085061</b>	<b>MK087659</b>	–
<b><i>Distoseptispora fasciculata</i></b>	<b>KUMCC 19-0081</b>	<b>MW287775</b>	<b>MW286501</b>	<b>MW396656</b>	–
<b><i>Distoseptispora fluminicola</i></b>	<b>MFLUCC 15-0417</b>	<b>KU376270</b>	<b>NR_154041</b>	–	–
<i>Distoseptispora guttulata</i>	B43	MN163016	MN163011	–	–
<b><i>Distoseptispora guttulata</i></b>	<b>MFLUCC 16-0183</b>	<b>MF077554</b>	<b>MF077543</b>	–	–
<i>Distoseptispora hydei</i>	MFLUCC 20-0481	MT742830	MT734661	–	MT767128
<i>Distoseptispora leonensis</i>	HKUCC 10822	DQ408566	–	–	DQ435089
<b><i>Distoseptispora lignicola</i></b>	<b>MFLUCC 18-0198</b>	<b>MK849797</b>	<b>MK828651</b>	–	–
<b><i>Distoseptispora longispora</i></b>	<b>HFJAU 0705</b>	<b>MH555357</b>	<b>MH555359</b>	–	–
<i>Distoseptispora multiseptata</i>	B37	MN163013	–	–	–
<i>Distoseptispora multiseptata</i>	MFLUCC 16-1044	MF077555	MF077544	–	–
<b><i>Distoseptispora multiseptata</i></b>	<b>MFLUCC 15-0609</b>	<b>KX710140</b>	<b>NR_154017</b>	–	–
<b><i>Distoseptispora neurostrata</i></b>	<b>B103</b>	<b>MN163017</b>	<b>MN163008</b>	–	–
<b><i>Distoseptispora obclavata</i></b>	<b>B71</b>	<b>MN163010</b>	<b>MN163012</b>	–	–
<i>Distoseptispora obpyriformis</i>	DLUCC 0867	MG979765	MG979757	MG988423	MG988416
<b><i>Distoseptispora obpyriformis</i></b>	<b>MFLUCC 17-1694</b>	<b>MG979764</b>	–	<b>MG988422</b>	<b>MG988415</b>
<b><i>Distoseptispora palmarum</i></b>	<b>MFLUCC 18-1446</b>	<b>MK079663</b>	<b>MK085062</b>	<b>MK087660</b>	<b>MK087670</b>
<b><i>Distoseptispora phangngaensis</i></b>	<b>MFLUCC 16-0857</b>	<b>MF077556</b>	–	–	–
<b><i>Distoseptispora rayongensis</i></b>	<b>MFLUCC 18-0417</b>	<b>MH457138</b>	<b>MH457173</b>	<b>MH463254</b>	<b>MH463256</b>

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Distoseptispora rayongensis</i>	MFLUCC 18-0415	MH457137	MH457172	MH463253	MH463255
<i>Distoseptispora rostrata</i>	DLUCC 0885	MG979767	MG979759	MG988425	–
<i>Distoseptispora rostrata</i>	MFLUCC 16-0969	MG979766	MG979758	MG988424	MG988417
<i>Distoseptispora saprophytica</i>	<u>MFLUCC 18-1238</u>	<u>MW287780</u>	<u>MW286506</u>	<u>MW396651</u>	<u>MW504069</u>
<i>Distoseptispora songkhlaensis</i>	<u>MFLUCC 18-1234</u>	<u>MW287755</u>	<u>MW286482</u>	<u>MW396642</u>	–
<i>Distoseptispora suoluoensis</i>	MFLUCC 17-1305	MF077558	MF077547	–	–
<i>Distoseptispora suoluoensis</i>	MFLUCC 17-0224	MF077557	MF077546	–	–
<i>Distoseptispora tectonae</i>	MFLUCC 12-0291	KX751713	KX751711	KX751710	KX751708
<i>Distoseptispora tectonae</i>	MFLUCC 20-0090	MT232719	MT232714	–	–
<i>Distoseptispora tectonae</i>	MFLUCC 15-0981	MW287763	MW286489	MW396641	–
<i>Distoseptispora tectonae</i> (synonym <i>D. submersa</i> )	MFLUCC 16-0946	MG979768	MG979760	MG988426	MG988418
<i>Distoseptispora tectonigena</i>	MFLUCC 12-0292	KX751714	KX751712	–	KX751709
<i>Distoseptispora thailandica</i>	MFLUCC 16-0270	MH260292	MH275060	MH412767	–
<i>Distoseptispora thysanolaenae</i>	HKAS 102247	MK064091	MK045851	MK086031	–
<i>Distoseptispora xishuangbannaensis</i>	KUMCC 17-0290	MH260293	MH275061	MH412768	MH412754
<i>Dothidea insculpta</i>	CBS 189.58	DQ247802	–	DQ471081	AF107800
<i>Entosordaria perfidiosa</i>	BW3	MF488992	–	MF489011	MF489002
<i>Fluminicola aquatica</i>	MFLUCC 15-0962	MF374366	–	MF370960	–
<i>Fluminicola saprophytica</i> (synonym <i>F. thailandensis</i> )	MFLUCC 18-0199	MK849790	–	–	MN124535
<i>Fluminicola saprophytica</i> (synonym <i>F. thailandensis</i> )	MFLUCC 14-0037	MK849789	MK828644	MN194049	–
<i>Fluminicola saprophytica</i> (synonym <i>F. thailandensis</i> )	MFLUCC 15-0984	MF374368	MF374359	–	–
<i>Fluminicola saprophytica</i>	MFLUCC 15-0976	MF374367	MF374358	MF370956	–
<i>Fluminicola saprophytica</i>	MFLUCC 18-1244	MW287778	MW286504	MW396649	–
<i>Fluminicola striata</i>	<u>MFLUCC 18-0990</u>	<u>MW287770</u>	<u>MW286496</u>	–	–
<i>Fragosphaeria purpurea</i>	CBS 133.34	AB189154	–	–	–
<i>Fusicolla aquaeductuum</i>	KUMCC 18-0015	MH087221	MH087219	–	–
<i>Fusoidigranularius nilensis</i>	IMI 397966	HQ616536	–	–	–
<i>Gnomonia gnomon</i>	CBS 199.53	AF408361	–	EU221885	EU219295
<i>Jattaea algeriensis</i>	STEU 6201	EU367456	EU367446	–	–
<i>Jattaea mookgoponga</i>	STEU 6184	EU367458	–	–	–
<i>Junewangia aquatica</i>	HFJAU 0700	MG213737	MG213738	–	–
<i>Junewangia globulosa</i>	CBS 126093	MH875535	MH864078	–	–
<i>Junewangia lamma</i>	HSAUPH 4695	KU751883	KU999971	–	–
<i>Junewangia lamma</i>	HMAS 44438	KU751882	KU999961	–	–
<i>Junewangia queenslandica</i>	HSAUPmyr 7722	KX033575	KU999984	–	–

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Junewangia sphaerospora</i>	HSAUPmyr 4733	KX033572	KU999981	–	–
<i>Junewangia thailandica</i>	<b>MFLU 15-2682</b>	<b>MW287762</b>	–	–	–
<i>Lentomitella conoidea</i>	CBS 141370	KY931813	KY931784	–	KY931841
<i>Lentomitella conoidea</i>	CBS 131660	KY931812	KY931783	–	KY931840
<i>Lentomitella magna</i>	<b>ICMP 18371</b>	<b>KY931815</b>	<b>KY931786</b>	–	<b>KY931843</b>
<i>Lentomitella tenuirostris</i>	CBS 138734	KY931821	KY931792	–	KY931849
<i>Linkosia multiseptum</i>	HKUCC 10825	DQ408572	–	–	DQ435091
<i>Longicollum biappendiculatum</i>	PE0017-1b	KU975072	–	–	–
<i>Longicollum biappendiculatum</i>	<b>PE0017-1a</b>	<b>KU975071</b>	<b>KU975062</b>	–	–
<i>Longivarius aquatorbae</i>	<b>SS 2424</b>	<b>JN226107</b>	–	–	–
<i>Macrohilum eucalypti</i>	CPC 10945	DQ195793	–	–	–
<i>Melanconis stilbostoma</i>	AR3501	AF408374	–	EU221886	EU219299
<i>Mirannulata samuelsii</i>	<b>smh1880</b>	<b>AY578353</b>	–	–	–
<i>Myrmecridium aquaticum</i>	S-001	MK849805	MK828657	–	–
<i>Myrmecridium aquaticum</i>	<b>MFLUCC 15-0366</b>	<b>MK849804</b>	<b>MK828656</b>	–	–
<i>Myrmecridium aquaticum</i>	S-1158	MK849803	–	MN194061	MN124540
<i>Myrmecridium banksiae</i>	<b>CPC 19852</b>	<b>JX069855</b>	<b>JX069871</b>	–	–
<i>Myrmecridium montsecurinum</i>	<b>JF13180</b>	<b>KT991664</b>	<b>KT991674</b>	–	<b>KT991654</b>
<i>Myrmecridium schulzeri</i>	CBS 100.54	EU041826	EU041769	–	–
<i>Myrmecridium sorbicola</i>	<b>CBS 143433</b>	<b>MH107948</b>	<b>MH107901</b>	–	–
<i>Natantiella ligneola</i>	CBS 123470	FJ617556	KT991675	–	HQ878605
<i>Natantiella ligneola</i>	CBS 123410	FJ617555	KM492899	–	KM492909
<i>Nectria nigrescens</i>	AR 4211	HM484720	HM484707	HM484672	JQ014123
<i>Neodiluvicola aquatica</i>	<b>MFLUCC 15-0986</b>	<b>MF374365</b>	–	<b>MF370961</b>	<b>MF370953</b>
<i>Neoeriomycopsis aristata</i>	CPC 25050	KR476776	–	–	–
<i>Obliquiminima hyalina</i>	<b>MFLUCC 18-1235</b>	<b>MW287783</b>	<b>MW286480</b>	<b>MW396643</b>	–
<i>Obliquiminima hyalina</i>	<b>MFLUCC 18-1401</b>	<b>MW287781</b>	<b>MW286507</b>	<b>MW396652</b>	–
<i>Ophiostoma piliferum</i>	AFTOL-ID 910	DQ470955	–	DQ471074	DQ470905
<i>Ophiostoma stenoceras</i>	AFTOL-ID 1038	DQ836904	–	–	DQ836891
<i>Paoayensis lignicola</i>	<b>HKU 17516</b>	<b>EF622535</b>	–	–	–
<i>Papulosa amerospora</i>	AFTOL-ID 748	DQ470950	–	DQ471069	DQ470901
<i>Paracremonium binnewijzendii</i>	CBS 143277	MG250174	NR_157491	–	–
<i>Phaeoacremonium fraxinopennsylvanicum</i>	MR 3064	HQ878595	–	–	HQ878609
<i>Phaeoacremonium fraxinopennsylvanicum</i>	<b>ATCC 26664</b>	<b>AY761083</b>	–	–	–
<i>Phaeoacremonium novae-zealandiae</i>	<b>WIN113BI</b>	<b>AY761081</b>	–	–	–

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Phialemoniopsis endophytica</i>	ACCC 38980	KT799560	–	–	–
<i>Phialemoniopsis endophytica</i>	ACCC 38979	KT799559	–	–	–
<i>Phomatospora bellaminuta</i>	AFTOL-ID 766	FJ176857	–	–	FJ238345
<b><i>Phomatospora biseriata</i></b>	<b>MFLUCC 14-0832</b>	<b>KX549448</b>	–	–	–
<b><i>Phomatospora striatigera</i></b>	<b>CBS 133932</b>	<b>KM213618</b>	–	–	–
<b><i>Phomatospora viticola</i></b>	<b>MFLU 16-1973</b>	<b>KX549452</b>	–	–	–
<i>Phyllachora graminis</i>	TH544	KX430508	–	–	–
<i>Physalospora vaccinii</i>	CBS 302.53	DQ810232	–	–	–
<i>Platytrachelon abietis</i>	CBS 125235	JX066703	–	–	JX066698
<b><i>Pleurophragmium bambusinum</i></b>	<b>MFLUCC 12-0850</b>	<b>KU863149</b>	<b>KU940161</b>	<b>KU940213</b>	–
<i>Pleurothecium aquaticum</i>	MFLUCC 17-1331	MF399263	MF399245	–	–
<i>Pleurothecium semifecundum</i>	CBS 131271	JQ429240	–	–	JQ429270
<i>Podosordaria tulasnei</i>	CBS 128.80	KT281897	–	–	–
<b><i>Pseudoconlarium punctiform</i></b>	<b>MFLU 19-2855</b>	<b>MN897833</b>	–	–	–
<i>Pseudoplagiostoma eucalypti</i>	CBS 124807	GU973606	–	–	–
<i>Pseudoproboscispora caudae-suis</i>	A336-2D	AY094192	–	–	–
<i>Pseudoproboscispora caudae-suis</i>	A40-1A	AY094191	–	–	–
<b><i>Pseudoproboscispora thailandensis</i></b>	<b>MFLUCC 15-0989</b>	<b>MF374369</b>	–	<b>MF370959</b>	–
<i>Pseudoproboscisporaceae</i> sp.	R-038	AY590291	–	–	–
<b><i>Pseudostanjehughesia aquitropica</i></b>	<b>MFLUCC 16-0569</b>	<b>MF077559</b>	–	–	–
<b><i>Pseudostanjehughesia lignicola</i></b>	<b>MFLUCC 15-0352</b>	<b>MK849787</b>	<b>MK828643</b>	<b>MN194047</b>	<b>MN124534</b>
<i>Rhamphoria delicatula</i>	MR1396	AF261068	–	–	KT991655
<i>Rhamphoria pyriformis</i>	CBS 139033	KT991665	–	–	KT991656
<i>Rhexoacrodictys martinii</i>	myr4280	KX033566	KU999975	–	–
<b><i>Rhodoveronaea aquatica</i></b>	<b>MFLUCC 18-1339</b>	<b>MK849785</b>	<b>MK828641</b>	<b>MN194046</b>	–
<i>Rhodoveronaea varioseptata</i>	CBS 123473	FJ617560	KT991676	–	JX066700
<i>Rhodoveronaea varioseptata</i>	CBS 123472	FJ617559	MG600393	–	JX066701
<b><i>Riomyces rotundus</i></b>	<b>AF 303-1</b>	<b>JF775589</b>	–	–	–
<b><i>Rubellisphaeria abscondita</i></b>	<b>CBS 132078</b>	<b>KT991666</b>	<b>NR154424</b>	–	<b>KT991657</b>
<i>Savoryella aquatica</i>	SS00096	HQ446369	–	HQ446323	HQ446402
<i>Savoryella verrucosa</i>	SS03331	HQ446376	–	HQ446332	HQ446411
<i>Schizoparme straminea</i>	STEU 3932	AY339296	–	–	–
<i>Sporidesmiella aquatica</i>	DLUCC 1339	MK849844	–	MN194035	MN124524
<b><i>Sporidesmiella aquatica</i></b>	<b>DLUCC 0777</b>	<b>MK849843</b>	<b>MK828692</b>	<b>MN194034</b>	–
<i>Sporidesmiella hyalosperma</i>	S-1518	MK849842	MK828691	MN194033	MN124523

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Sporidesmiella hyalosperma</i>	KUMCC 15-0431	MK849841	MK828690	MN194032	MN124522
<i>Sporidesmiella hyalosperma</i>	S-1320	MK849840	MK828689	–	MN124521
<i>Sporidesmiella hyalosperma</i>	MFLUCC 18-1312	MK849839	MK828688	MN194031	MN124520
<i>Sporidesmiella hyalosperma</i>	<b>MFLUCC 18-1013</b>	<b>MW287773</b>	<b>MW286499</b>	<b>MW396654</b>	<b>MW504070</b>
<i>Sporidesmiella novae-zelandiae</i>	S-951	MK849847	MK828695	MN194037	MN124526
<i>Sporidesmiella novae-zelandiae</i>	S-048	MK849846	MK828694	–	–
<i>Sporidesmiella novae-zelandiae</i>	S-1256	MK849845	MK828693	MN194036	MN124525
<i>Sporidesmiella obovoidia</i>	<b>MFLUCC 17-2372</b>	<b>MW287766</b>	<b>MW286492</b>	–	–
<i>Sporidesmium appendiculatum</i>	<b>MFLU 18-0981</b>	<b>MW287774</b>	<b>MW286500</b>	–	–
<i>Sporidesmium aquaticum</i>	MFLUCC 15-0420	KU376273	–	–	–
<i>Sporidesmium bambusicola</i>	HKUCC 3578	DQ408562	–	–	–
<i>Sporidesmium Chiangmaiense</i>	<b>MFLUCC 18-0999</b>	<b>MW287771</b>	<b>MW286497</b>	–	–
<i>Sporidesmium dulongense</i>	MFLUCC 17-0116	MH795817	MH795812	MH801191	MH801190
<i>Sporidesmium fluminicola</i>	MFLUCC 15-0346	KU376271	–	–	–
<i>Sporidesmium lageniforme</i>	MFLU 18-1594	MK849782	MK828640	MN194044	MN124533
<i>Sporidesmium lignicola</i>	KUMCC 15-0266	MK849784	–	–	–
<i>Sporidesmium lignicola</i>	DLUCC 1376	MK849783	–	MN194045	–
<i>Sporidesmium melaleucaae</i>	CPC 32936	MH327854	MH327818	–	–
<i>Sporidesmium melaleucaae</i>	<b>CPC 32707</b>	<b>MH327853</b>	<b>MH327817</b>	–	–
<i>Sporidesmium minigelatinosa</i>	NN 47497	DQ408567	–	–	DQ435090
<i>Sporidesmium parvum</i>	HKUCC 10836	DQ408558	–	–	–
<i>Sporidesmium pyriformatum</i>	MFLUCC 15-0627	KX710143	KX710148	MF135663	MF135650
<i>Sporidesmium pyriformatum</i>	<b>MFLUCC 15-0620</b>	<b>KX710141</b>	<b>KX710146</b>	<b>MF135662</b>	<b>MF135649</b>
<i>Sporidesmium submersum</i>	MFLUCC 15-0421	KU376272	–	–	–
<i>Sporidesmium thailandense</i>	MFLUCC 15-0964	MF374370	–	MF370957	MF370955
<i>Sporidesmium thailandense</i>	MFLUCC 15-0617	MF077561	–	MF135657	–
<i>Sporidesmium tropicale</i>	MFLU 17-0850	MF077562	MF077551	–	–
<i>Sporidesmium tropicale</i>	HKUCC 10838	DQ408560	–	–	–
<i>Sporoschisma hemipsilum</i>	MFLUCC 17-1712	MK835816	MK828616	MN194069	MN156512
<i>Stilbospora macrosperma</i>	CBS 121883	JX517299	–	KF570235	KF570196
<i>Submersisphaeria aquatica</i>	A354-1C	AY094194	–	–	–
<i>Submersisphaeria aquatica</i>	A95-1B	AY094193	–	–	–
<i>Sydowiella centaureii</i>	MFLU 16-2858	KY523502	–	–	–
<i>Thyridium vestitum</i>	AFTOL-ID 172	AY544671	–	DQ471058	DQ470890
<i>Tubakia seoraksanensis</i>	CBS 127490	KP260499	–	MG592094	–

Supplementary Table 1 Continued.

Taxon	Voucher/Culture	GenBank accession numbers			
		LSU	ITS	TEF	RPB2
<i>Wongia aquatica</i>	MFLUCC 18-1607	MK849788	MK828645	MN194048	MN124536
<i>Wongia garrettii</i>	DAR 79637	–	KU850474	KU850467	–
<i>Wongia griffinii</i>	DAR 80512	KU850471	KU850473	–	–
<i>Wongia griffinii</i>	BRIP 60377	KU850470	KU850472	KU850466	–
<b><i>Woswasia atropurpurea</i></b>	<b>WU32007</b>	<b>JX233658</b>	<b>NR154480</b>	–	<b>JX233659</b>
<i>Xylaria hypoxylon</i>	CBS 122620	KY610495	KY610407	–	KY624231
<b><i>Xylochrysis lucida</i></b>	<b>CBS 135996</b>	<b>KF539911</b>	<b>NR132063</b>	–	<b>KF539913</b>
<i>Xylomelasma sordida</i>	CBS 131683	KM492871	KT991679	–	KM492910
<b><i>Xylomelasma sordida</i></b>	<b>CBS 116000</b>	<b>AY761087</b>	–	–	<b>KY931929</b>
<i>Zalerion maritima</i>	FCUL280207CP1	JN886806	KT347216	–	–
<i>Zalerion xylestrix</i>	309156	EU848592	–	–	–

Ex-type strains are in **bold**; newly generated sequences are highlighted in **red**; new species are underlined.