Diversity and taxonomy of *Chaetomium* and chaetomium-like fungi from indoor environments

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Abstract: During a study of indoor fungi, 145 isolates belonging to *Chaetomiaceae* were cultured from air, swab and dust samples from 19 countries. Based on the phylogenetic analyses of DNA-directed RNA polymerase II second largest subunit (*rpb2*), β-tubulin (*tub2*), ITS and 28S large subunit (LSU) nrDNA sequences, together with morphological comparisons with related genera and species, 30 indoor taxa are recognised, of which 22 represent known species, seven are described as new, and one remains to be identified to species level. In our collection, 69 % of the indoor isolates with six species cluster with members of the *Chaetomium globosum* species complex, representing *Chaetomium sensu stricto*. The other indoor species fall into nine lineages that are separated from each other with several known chaetomiaceous genera occurring among them. No generic names are available for five of those lineages, and the following new genera are introduced here: *Amesia* with three indoor species, *Arcopilus* with one indoor species, *Collariella* with four indoor species, *Dichotomopilus* with seven indoor species and *Ovatospora* with two indoor species. The generic concept of *Botryotrichum* is expanded to include *Emilmuelleria* and the chaetomium-like species *B. muromum* (= *Ch. murorum*) in which two indoor species are included. The generic concept of *Subramaniula* is expanded to include several chaetomium-like taxa as well as one indoor species. *Humicola* is recognised as a distinct genus including two indoor taxa. According to this study, *Ch. globosum* is the most abundant *Chaetomiaceae* indoor species (74/145), followed by *Ch. cochliodes* (17/145), *Ch. elatum* (6/145) and *B. piluliferum* (5/145). The morphological diversity of indoor *Chaetomiaceae* as well as the morphological characteristics of the new genera are described and illustrated. This taxonomic study redefines the generic concept of *Chaetomium* and provides new insight into the phylogenetic relationships among different genera within *Chaetomiaceae*.

Key words: *Chaetomiaceae*, Indoor species, Morphological diversity, Phylogeny.

Taxonomic novelties: New genera: *Amesia* X. Wei Wang, Samson & Crous, *Arcopilus* X. Wei Wang, Samson & Crous, *Collariella* X. Wei Wang, Samson & Crous, *Dichotomopilus* X. Wei Wang, Samson & Crous, *Ovatospora* X. Wei Wang, Samson & Crous; **New species:** *Chaetomium tectifimeti* X. Wei Wang & Samson, *Collariella carteri* X. Wei Wang, Houbraken & Samson, Dichotomopilus pseudoerectus X. Wei Wang & Samson, *Dichotomopilus pseudofunicola* X. Wei Wang & Samson, *Humicola olivacea* X. Wei Wang & Samson, *Melanocarpus tardus* X. Wei Wang & Samson, *Ovatospora pseudomollicella* X. Wei Wang & Samson; **New combinations:** *Amesia atrobrunnea* (Ames) X. Wei Wang & Samson, *Amesia cymbiformis* (Lodha) X. Wei Wang & Samson, *Amesia nigricolor* (Ames) X. Wei Wang & Samson, *Amesia gelasinospora* (Aue & Müller) X. Wei Wang & Samson, *Arcopilus aureus* (Chivers) X. Wei Wang & Samson, *Arcopilus cupreus* (Ames) X. Wei Wang & Samson, *Arcopilus fusiformis* (Chivers) X. Wei Wang & Samson, *Arcopilus flavigenus* (van Warmelo) X. Wei Wang & Samson, *Arcopilus turgidopilosus* (Ames) X. Wei Wang & Samson, *Botryotrichum murorum* (Corda) X. Wei Wang & Samson, *Botryotrichum spirotrichum* (R.K. Benjamin) X. Wei Wang & Samson, *Collariella bostrychodes* (Zopf) X. Wei Wang & Samson, *Collariella causiiformis* (Ames) X. Wei Wang & Samson, *Collariella gracilis* (Udagawa) X. Wei Wang & Samson, *Collariella quadrangulata* (Chivers) X. Wei Wang & Samson, *Collariella robusta* (Ames) X. Wei Wang & Samson, *Collariella virescens* (Arx) X. Wei Wang & Samson, *Dichotomopilus dolichotrichus* (Ames) X. Wei Wang & Samson, *Dichotomopilus erectus* (Skolko & J.W. Groves) X. Wei Wang & Samson, *Dichotomopilus funicola* (Cooke) X. Wei Wang & Samson, *Dichotomopilus fusus* (Ames) X. Wei Wang & Samson, *Dichotomopilus indicus* (Corda) X. Wei Wang & Samson, *Dichotomopilus pratensis* (X.W. Wang & L. Cai) X. Wei Wang & Samson, *Dichotomopilus ramosissimus* (X.W. Wang & L. Cai) X. Wei Wang & Samson, *Dichotomopilus reflexus* (Skolko & J.W. Groves) X. Wei Wang & Samson, *Dichotomopilus subfunicola* (X.W. Wang & L. Cai) X. Wei Wang & Samson, *Dichotomopilus variostiolatus* (Carter) X. Wei Wang & Samson, *Ovatospora brasiliensis* (Batista & Pontual) X. Wei Wang & Samson, *Ovatospora medusarum* (Meyer & Lanneau) X. Wei Wang & Samson, *Ovatospora mollicella* (Ames) X. Wei Wang & Samson, *Ovatospora senegalensis* (Ames) X. Wei Wang & Samson, *Ovatospora unipora* (Aue & Müller) X. Wei Wang & Samson, *Subramaniula anamorphosa* (S.A. Ahmed et al.) X. Wei Wang & Samson, *Subramaniula cristata* (Ames) X. Wei Wang & Samson, *Subramaniula cuniculorum* (Fuckel) X. Wei Wang & Samson, *Subramaniula fusispora* (G. Smith) X. Wei Wang & Samson; **New name:** *Subramaniula flavipila* X. Wei Wang & Samson; **Neotypification:** *Chaetomium elatum* Kunze.

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INTRODUCTION

Fungal contamination in damp or water-damaged buildings has become an increasing problem worldwide (Andersen *et al.* 2011). After water damage (e.g. leaking water pipes, flooding, faulty building constructions, or severe and prolonged condensation) many building materials become good substrates for certain fungi. These growing fungi can cause adverse effects not only on the buildings but also to their occupants (Samson *et al.* 1994, WHO 2009, Samson *et al.* 2010, Flannigan & Miller 2011, Andersen *et al.* 2011, Miller & McMullin 2014). Members of the genus *Chaetomium* are capable of colonising various substrates and are well-known for their ability to degrade cellulose and to produce a variety of bioactive metabolites. More than 400 species have been described in *Chaetomium*. Some of these species have been reported to be important inhalant allergens. They contribute to the development of the symptoms of both rhinitis and asthma due to the production of mycotoxins and microbial volatile organic compounds as well as the liberation of ascospores and hyphal fragments in the indoor environment (Gonianakis *et al.* 2005, Apetrei

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et al. 2009, Polizzi et al. 2009, Mason et al. 2010, Andersen et al. 2011, Miller & McMullin 2014). *Chaetomium globosum* is the most common species of the *Chaetomiaceae* in the indoor environment (Vesper et al. 2007, Ayanbimpe et al. 2010, Straus 2011, McMullin et al. 2013, Miller & McMullin 2014), and this species can already be present in new gypsum wallboard (Andersen et al. in press). *Chaetomium globosum* has been reported to produce a variety of toxic metabolites, such as chaetoglobosins, chaetomugilins, and chaetoviridins (Andersen et al. 2011, McMullin et al. 2013, Miller & McMullin 2014), while both *Ch. elatum* and *Ch. globosum* were able to produce cochliodones in pure cultures as well as on naturally contaminated building materials (Došen et al. in press). Little is known about the other indoor *Chaetomium* species and their potential hazard to humans and buildings. Furthermore, *Ch. globosum* and several other *Chaetomium* species are reported as causal agents of onychomycosis or superficial infections (Koch & Haneke 1965, Naidu et al. 1991, Aspiroz et al. 2007, Hubka et al. 2011, de Hoog et al. 2013), and some of them are capable of opportunistically causing deep or systemic infections (Hoppin et al. 1983, Barron et al. 2003, Guppy et al. 1998, Ahmed et al. 2016).

The genus *Chaetomium* is commonly recognised by having ostiolate ascomata with a membranaceous perithecial wall covered by relatively well-developed hairs, producing fasciculate and evanescent asci and single-celled, smooth and pigmented ascospores with germ pores (Ames 1963, von Arx et al. 1986). *Chaetomium globosum*, the type species of the genus, was first described by Kunze (Kunze & Schmidt 1817). The taxonomy of *Chaetomium* has been studied by several authors (Corda 1840, Zopf 1881, Chivers 1915, Skolko & Groves 1948, 1953, Sörgel 1960, Ames 1963, Mazzucchetti 1965, Seth 1970, Dreyfuss 1976, Millner 1977, Millner et al. 1977, von Arx et al. 1984). von Arx et al. (1986) re-defined the taxonomic concept of *Ch. globosum*. They included species that produce globose to ovate or obovate ascomata with a wall consisting of *textura intricata*, covered by a diverse morphology of ascomatal hairs ranging from erect, flexuous to regularly coiled. The ascomata contain clavate (or slightly fusiform), evanescent asci, and the ascospores are limoniform and bilaterally-flattened shaped, and have an apical germ pore. Following this concept 28 species were reduced to synonymy with *Ch. globosum*. The species concept of *Ch. globosum* sensu von Arx was not supported by a recent study (Asgari & Zare 2011). For example, von Arx et al. (1986) treated *Ch. coarctatum* as one of the synonyms of *Ch. globosum*. Based on three genomic loci (ITS region, partial LSU rDNA and partial β-tubulin gene sequences), the phylogenetic analysis of Asgari & Zare (2011) indicated a distant relationship between the authentic isolate of *Ch. globosum* (CBS 148.51) and the ex-type strain of *Ch. coarctatum* (CBS 162.62). On the basis of phylogenetic inference of six loci and morphological characters, *Ch. globosum* was again revised by Wang et al. (2016), and six species that were treated as synonyms of *Ch. globosum* by von Arx et al. (1986) were resurrected. Furthermore, the non-ostiolate genus *Chaetomidium* was also synonymised with *Chaetomium* (Wang et al. 2016).

The aim of the present study was to conduct a global investigation of the species diversity of indoor *Chaetomiaceae* in the context of advanced taxonomy and chemical analysis. The results would not only be a useful tool for the identification of indoor *Chaetomiaceae* and evaluation of their chemical potential, but also provide new insights into the phylogeny of the *Chaetomiaceae*.

MATERIALS AND METHODS

Isolates

This study is based on a collection of isolates from indoor environments of 19 countries which are housed in the working collection of the Department of Applied and Industrial Mycology (DTO), and of those which were assigned to species of *Chaetomiaceae* and housed in the public collection of the CBS-KNAW Fungal Biodiversity Centre, Utrecht, The Netherlands (CBS). The strains isolated from dust were collected and isolated as previously described (Amend et al. 2010). Briefly, sterilised dust stream collectors (Indoor Biotechnologies) were attached to domestic vacuum cleaners for collection. Samples were filtered through a 2-mm sieve and refrigerated at 4 °C until further processing. The samples were analysed by a modified dilution-to-extinction plating technique (Visagie et al. 2014). Air samples were collected approx 1 m above the ground with a viable impaction sampler (MAS 100 Merck) and indoor surfaces (i.e. walls, ceilings) were sampled with a swab (Greiner Bio-One, Alphen aan de Rijn, The Netherlands). The air and swab samples were analysed using standard microbiological techniques. Agar media used for the isolation of the *Chaetomiaceae* strains include malt extract agar (Oxoid Ltd, Hampshire, UK) and dichloran 18 % glycerol (DG18: Oxoid Ltd, Hampshire, UK) agar. Petri dishes were incubated at room temperature or 25 °C, and inspected regularly. Metabolite extraction was performed on a subset of the representative isolates comprising the major indoor species in *Chaetomiaceae*. All the isolates used in this study are listed in Table 1.

DNA phylogeny

Genomic DNA was extracted from 7- to 15-d-old cultures grown on oatmeal agar (OA) using the UltraClean™ Microbial DNA Isolation Kit (Mo Bio Laboratories, Inc., Solana Beach, CA, USA) following the manufacturer's instructions. The primers used for PCR amplification and sequencing included: RPB2AM-1bf & RPB2AM-7R (Miller & Huhndorf 2005) for the second largest subunit of DNA-directed RNA polymerase II (*rpb2*) gene region; ITS5 & ITS4 (White et al. 1990) for the internal transcribed spacer regions (ITS) and intervening 5.8S nrRNA gene region, NL1 & NL4 (O'Donnell 1993) for the D1/D2 domains of the 28S nrDNA (LSU); T1 (O'Donnell & Cigelnik 1997) and TUB4Rd (Groenewald et al. 2013) for the partial beta-tubulin (*tub2*) gene region. The PCR conditions were the same as those described by Wang et al. (2016). Each of the amplicons was sequenced with the ABI Prism® Big Dye™ Terminator v. 3.1 Cycle Sequencing Kit. Samples were analysed on an ABI PRISM 3710 xl Genetic Analyzer. Consensus sequences for each locus were assembled using the forward and reverse sequences with the programme MEGA v. 6 (Tamura et al. 2013). Novel sequences generated in this study were deposited in GenBank (http://www.ncbi.nlm.nih.gov, Table 1).

Besides the sequences generated in this study, additional sequences were retrieved from GenBank. The sequence datasets were aligned using MAFFT v. 7 (Katoh & Standley 2013), and manually optimised using BioEdit v. 5.0.9 (Hall 1999). Congruency between the four loci was tested using the 70 % reciprocal bootstrap criterion (Mason-Gamer & Kellogg 1996, Gueidan et al. 2007, Lombard et al. 2010).

Table 1. Details of strains included in this study.

Genus and species	Culture accession number(s)[1]	Previous name	Origin	GenBank accession numbers[2]			
				ITS	LSU	*rpb2*	*tub2*
Achaetomium							
Ach. globosum	CBS 332.67 T		Rhizosphere, Lucknow, India	**KX976570**	**KX976695**	**KX976793**	**KX976911**
Ach. luteum	CBS 618.68		Cucurbita rhizosphere, Delhi, India	**KX976571**	**KX976696**	**KX976794**	**KX976912**
	CBS 544.83		Rosa stem, Lahore, Pakistan	**KX976572**	**KX976697**	**KX976795**	**KX976913**
Ach. macrosporum	CBS 152.97 T		Leaf litter, Uttar Pradesh, India	**KX976573**	**KX976698**	**KX976796**	**KX976914**
	CBS 532.94		Mangrove mud, Japan	**KX976574**	**KX976699**	**KX976797**	**KX976915**
Ach. strumarium	CBS 333.67 T		Soil, Lucknow, India	AY681204	AY681170	KC503254	AY681238
Amesia gen. nov.							
Am. atrobrunnea	**CBS 379.66* T**	*Ch. atrobrunneum*	Mouldy mattress, Solomon Islands	JX280771	JX280666	**KX976798**	**KX976916**
	CBS 250.75		Air, Uttar Pradesh, India	**KX976575**	**KX976700**	**KX976799**	**KX976917**
Am. cymbiformis	**CBS 175.84**	*Ch. cymbiforme*	Tent rope, Solomon Islands	**KX976576**	**KX976701**	**KX976800**	**KX976918**
	CBS 176.84*		Case liner, Georgia, USA	**KX976577**	**KX976702**	**KX976801**	**KX976919**
Am. nigricolor	CBS 600.66 T	*Ch. nigricolor*	Vegetable detritus, India	**KX976578**	**KX976703**	**KX976802**	**KX976920**
	CBS 291.83*		Paper, India	**KX976579**	**KX976704**	**KX976803**	**KX976921**
Am. gelasinospora	CBS 673.80 T	*Ch. gelasinosporum*	Soil, Qus, Egypt	**KX976580**	**KX976705**	**KX976804**	**KX976922**
	CBS 643.83		Sandy soil, Gawa, Nigeria	**KX976581**	**KX976706**	**KX976805**	**KX976923**
Arcopilus							
Ar. aureus	CBS 153.52	*Ch. aureum*	Virginia, USA	**KX976582**	**KX976707**	**KX976806**	**KX976924**
	CBS 538.73		Dung of hyrax, East Africa	**KX976583**	**KX976708**	**KX976807**	**KX976925**
Ar. cupreus	CBS 560.80	*Ch. cupreum*	Dung of moose, Mietta Hot Springs, Canada	**KX976584**	**KX976709**	**KX976808**	**KX976926**
Ar. fusiformis	CBS 484.85	*Ch. fusiforme*	Dung of rodent, Newberry Mts., Nevada, USA	**KX976585**	**KX976710**	**KX976809**	**KX976927**
	CBS 485.85		Wood chip, Hiltin Falls, Ontario, Canada	**KX976586**	**KX976711**	**KX976810**	**KX976928**
Ar. flavigenus	CBS 337.67 T	*Ch. flavigenum*	Soil, Johannesburg, South Africa	**KX976587**	**KX976712**	**KX976811**	**KX976929**
Ar. turgidopilosus	**CBS 169.52* T**	*Ch. turgidopilosum*	Top of storage tent, USA	**KX976588**	**KX976713**	**KX976812**	**KX976930**
Botryotrichum							
B. atrogriseum	CBS 130.28 T		Dung of rabbit, The Netherlands	**KX976589**	**KX976714**	**KX976813**	**KX976931**
	CBS 604.69		Corn field soil, Waterloo, Ontario, Canada	**KX976590**	**KX976715**	**KX976814**	**KX976932**
B. murorum	CBS 163.52	*Ch. murorum*	Great Smoky Mts., Tennessee, USA	**KX976591**	**KX976716**	**KX976815**	**KX976933**
	CBS 173.68		Liquor cerebrospinalis of *Homo sapiens*, Netherlands	**KX976592**	**KX976717**	**KX976816**	**KX976934**
	DTO 324-G9*; DTO 324-H9		Air, China	**KX976593**	**KX976718**	**KX976817**	**KX976935**
	DTO 333-E6* (= IBT 42175)		Ceiling tile, Denmark	**KX976594**	**KX976719**	**KX976818**	**KX976936**
B. peruvianum	CBS 460.90		Dung of herbivore, Massanella, Spain	**KX976623**	**KX976720**	**KX976819**	**KX976937**
	CBS 421.93		Air, La Habana, Cuba	**KX976596**	**KX976721**	**KX976820**	**KX976938**
B. piluliferum	CBS 654.79		Pastry, Enschede, Netherlands	**KX976597**	**KX976722**	**KX976821**	**KX976939**
	CBS 105.14		Unknown	**KX976598**	**KX976723**	**KX976822**	**KX976940**
	DTO 194-F7		Plaster wall, The Netherlands	**KX976599**	**KX976724**	**KX976823**	**KX976941**
	DTO 254-B8*; DTO 254-B9		Wall in villa, Utrecht, The Netherlands	**KX976600**	**KX976725**	**KX976824**	**KX976942**
B. spirotrichum	CBS 211.55 T	*Emilmuelleria spirotricha*	Dung of deer, California, USA	**KX976601**	**KX976726**	**KX976825**	**KX976943**
	CBS 828.71		Dung of donkey, Algeria	**KX976602**	**KX976727**	**KX976826**	**KX976944**
*Chaetomium sensu stricto***							
C. cervicicola	**DTO 318-G6**		Dust, Mexico	**KX976603**	**KX976728**	**KX976827**	**KX976945**
C. coarctatum	**DTO 324-H2***		Air, China	**KX976604**	**KX976729**	**KX976828**	**KX976946**
C. cochliodes	**DTO 013-C2**		Air, Maastricht, The Netherlands	**KX976605**			**KX976947**
	DTO 089-E2		Air, Eindhoven, The Netherlands	**KX976606**			**KX976948**

(*continued on next page*)

Table 1. (Continued).

Genus and species	Culture accession number(s)[1]	Previous name	Origin	GenBank accession numbers[2]			
				ITS	LSU	*rpb2*	*tub2*
	DTO 319-B5; DTO 319-B6		Dust, South Africa	**KX976607**	**KX976730**	**KX976829**	**KX976949**
	DTO 318-I1*; DTO 318-H2; DTO 318-H4;DTO 318-H5; DTO 318-H7; DTO 318-H8; DTO 318-I3; DTO 318-I5; DTO 318-I6;DTO 318-I8; DTO 318-I9; DTO 319-A1; DTO 319-B5; DTO 319-B6; DTO 325-F7		Dust, USA	**KX976608**			**KX976950**
C. elatum	**DTO 318-H9*; DTO 318-G7**		Dust, USA	**KX976609**	**KX976731**	**KX976830**	**KX976951**
	DTO 319-B3*		Dust, Australia	**KX976610**	**KX976732**	**KX976831**	**KX976952**
	DTO 333-E5		Dust, Denmark	**KX976611**			**KX976953**
	CBS 142034 neoT (= DTO 333-E9 = IBT 42179)		Cardboard, Denmark	**KX976612**	**KX976733**	**KX976832**	**KX976954**
	DTO 333-F8 (= IBT 42329)		Gypsum, Denmark	**KX976613**			**KX976955**
C. globosum	**DTO 134-D9; DTO 134-E1; DTO 134-E2; DTO 134-E3; DTO 134-E4; DTO 134-E5**		Air, Algeria	**KX976614**			**KX976956**
	DTO 318-G3; DTO 318-G4; DTO 318-G5		Dust, Canada	**KX976615**			**KX976957**
	DTO 324-D7; DTO 324-G8; DTO 324-H1; DTO 324-H4; DTO 324-H5; DTO 324-I1; DTO 324-I2; DTO 324-I3; DTO 324-I4; DTO 324-I5; DTO 324-I6; DTO 324-I7; DTO 324-I8; DTO 324-I9; DTO 325-A1; DTO 325-A2; DTO 325-A3; DTO 325-A4		Air, China	**KX976616**			**KX976958**
	CBS 666.82*		Chili powder, China	**KX976617**	**KX976734**	**KX976833**	**KX976959**
	DTO 333-D7 (= IBT 42328); DTO 333-D8 (= IBT 42326); DTO 333-D9 (= IBT 42327); DTO 333-F4 (= IBT 42297); DTO 333-F5 (= IBT 42299); DTO 333-F6 (= IBT 42301); DTO 333-F7 (= IBT 42325); DTO 333-F9		Gypsum, Denmark	**KX976618**			**KX976960**
	DTO 333-E1 (= IBT 41766); DTO 333-E8 (= IBT 42177)		Plywood, Denmark	**KX976619**			**KX976961**
	DTO 333-E3* (= IBT 41800)		Linoleum, Denmark	**KX976620**	**KX976735**	**KX976834**	**KX976962**
	DTO 333-E4 (= IBT 41801)		Carpet, Denmark	**KX976621**			**KX976963**
	DTO 333-E7 (= IBT 42176)		Oriented strand board, Denmark	**KX976622**			**KX976964**
	CBS 112386; DTO 340-I2		Indoor environment, Germany	**KX976623**			**KX976965**
	DTO 012-F3		Air, Hamburg, Germany	**KX976624**			**KX976966**
	DTO 012-D2		Air, Koln, Germany	**KX976625**			**KX976967**
	DTO 237-D4		Air, Indonesia	**KX976626**			**KX976968**
	DTO 319-B2*; DTO 319-A3; DTO 319-A4; DTO 319-A5; DTO 319-A6; DTO 319-A7; DTO 319-A8; DTO 319-A9; DTO 319-B1		Dust, Mexico	**KX976627**	**KX976736**	**KX976835**	**KX976969**
	DTO 085-E8; DTO 085-F5; DTO 085-F6		Air, Baarn, The Netherlands	**KX976628**			**KX976970**
	DTO 122-H9		Air, Gorinchem, The Netherlands	**KX976629**			**KX976971**
	DTO 123-D4		Air, Zutphen, The Netherlands	**KX976630**			**KX976972**
	DTO 264-C1		Wall in house, Wassenaar, The Netherlands	**KX976631**			**KX976973**

Table 1. (Continued).

Genus and species	Culture accession number(s)[1]	Previous name	Origin	GenBank accession numbers[2]			
				ITS	LSU	*rpb2*	*tub2*
	DTO 272-I1		Wall, Utrecht, The Netherlands	**KX976632**			**KX976974**
	DTO 086-D6		Archive material, Gorinchem, The Netherlands	**KX976633**			**KX976975**
	DTO 126-B6		Indoor environment, Den Haag, The Netherlands	**KX976634**			**KX976976**
	DTO 011-F7; DTO 012-F2		Wall paper, Loosdrecht, The Netherlands	**KX976635**			**KX976977**
	DTO 319-B4		Dust, South Africa	**KX976636**			**KX976978**
	DTO 319-C3		Dust, Thailand	**KX976637**			**KX976979**
	DTO 319-C9		Dust, Uruguay	**KX976638**			**KX976980**
	DTO 318-H3; DTO 318-H6; DTO 318-I4; DTO 319-C5; DTO 319-C6		Dust, USA	**KX976639**			**KX976981**
	CBS 148.51		Stored cotton, District of Columbia, USA	GU563374	GU563363	KF001801	JF772459
C. tectifimeti	**CBS 142032 T (= DTO 318-G8)***		Dust, USA	**KX976640**	**KX976737**	**KX976836**	**KX976982**
Collariella							
Col. bostrychodes	CBS 163.73	*Ch. bostrychodes*	Dung of antelope, East Africa	**KX976641**	**KX976738**	**KX976837**	**KX976983**
	CBS 586.83		Soil, Germany	**KX976642**	**KX976739**	**KX976838**	**KX976984**
	DTO 319-C4		Dust, Indonesia	**KX976643**			**KX976985**
	DTO 324-H3; DTO 324-H6*		Air, China	**KX976644**	**KX976740**	**KX976839**	**KX976986**
	CBS 121706		Commercial honey, Spain	**KX976645**			**KX976987**
Col. causiiformis	**CBS 792.83* T**	*Ch. causiiform*	Sweatband of helmet liner, Solomon Islands	**KX976646**	**KX976741**	**KX976840**	**KX976988**
Col. carteri	**CBS 128.85* T**		Air, British Columbia, Canada	**KX976647**	**KX976742**	**KX976841**	**KX976989**
Col. gracilis	CBS 146.60 T	*Ch. gracile*	Soil, Tsu, Mie, Japan	**KX976648**	**KX976743**	**KX976842**	**KX976990**
	CBS 249.75*		Air, Uttar Pradesh, India	**KX976649**	**KX976744**	**KX976843**	**KX976991**
Col. quadrangulata	CBS 142.58	*Ch. quadrangulatum*	Soil, French Polynesia	**KX976650**	**KX976745**	**KX976844**	**KX976992**
	CBS 152.59		Dung of rabbit, Derbyshire, Chatsworth Park, England	**KX976651**	**KX976746**	**KX976845**	**KX976993**
Col. robusta	CBS 551.83 T	*Ch. robustum*	Litter, Portland Parish, Jamaica	**KX976652**	**KX976747**	**KX976846**	**KX976994**
	CBS 508.84		Woodlot soil, Ocho Rios, Jamaica	**KX976653**	**KX976748**	**KX976847**	**KX976995**
Col. virescens	CBS 148.68 T	*Ch. virescens*	Agricultural soil, Lahore, Pakistan	**KX976654**	**KX976749**	**KX976848**	**KX976996**
	CBS 547.75		Wheat straw compost, Ludhiana, Punjab	**KX976655**	**KX976750**	**KX976849**	**KX976997**
Corynascella							
Cor. humicola	CBS 337.72 T		Soil, Piedmont, North Carolina, USA	**KX976656**	**KX976751**	**KX976850**	**KX976998**
	CBS 379.74		Soil, Piedmont, North Carolina, USA	**KX976657**	**KX976752**	**KX976851**	**KX976999**
Dichotomopilus							
D. dolichotrichus	CBS 162.48 T	*Ch. dolichotrichum*	Great Smoky Mts., USA	HM449049	HM449063	**KX976852**	JF772462
	CGMCC 3.14189		Discarded cloth, Longjing, Jilin Province, China	HM449048	HM449062	**KX976853**	JF772455
D. erectus	CBS 140.56 T	*Ch. erectum*	*Petroselinum sativum*, USA	HM449044	HM449058	**KX976854**	JF772458
	CGMCC 3.12900		Soil, Anqiu, Shandong Province, China	KC109760	KC109760	**KX976855**	KC109778
D. funicola	CBS 159.52 eT	*Ch. funicola*	Germany	GU563369	GU563354	**KX976856**	JF772461
	CBS 136.38		Unknown	HM449046	HM449060	**KX976857**	JF772457
	DTO 333-F1*; DTO 333-F2*		Dust, outdoors, Denmark	**KX976658**	**KX976753**	KX976858	**KX977000**
	DTO 318-I2		Dust, USA	**KX976659**			**KX977001**
D. fusus	CBS 372.66 T	*Ch. fusum*	Leaf litter, Bataan, Costa Rica	**KX976660**	**KX976754**	**KX976859**	**KX977002**
	CBS 114.83		*Tectona grandis* or calyx, Jamaica	**KX976661**	**KX976755**	**KX976860**	**KX977003**
D. indicus	CGMCC 3.14184 eT	*Ch. indicum*	Rhizosphere of *Panax notoginseng*, Yunnan, China	GU563367	GU563360	**KX976861**	JF772453

(*continued on next page*)

Table 1. (Continued).

Genus and species	Culture accession number(s)[1]	Previous name	Origin	GenBank accession numbers[2]			
				ITS	LSU	*rpb2*	*tub2*
	CGMCC 3.14182		Rhizosphere of *Panax notoginseng*, Yunnan, China	GU563366	GU563358	**KX976862**	JF772451
	DTO 333-E2*		Feather, Denmark	**KX976662**	**KX976756**	**KX976863**	**KX977004**
	DTO 333-F3*		Dust, outdoors, Denmark	**KX976663**	**KX976757**	**KX976864**	**KX977005**
	DTO 319-B8*		Dust, South Africa	**KX976664**	**KX976758**	**KX976865**	**KX977006**
D. pratensis	CBS 133396 T (= CGMCC 3.14181)	*Ch. pratense*	Soil, Huangnan, Qinghai Province	GU563372	GU563357	**KX976866**	JF772450
	CBS 804.83		Wood of celar, Switzerland	**KX976665**	**KX976759**	**KX976867**	**KX977007**
	CBS 860.68*	*Ch. indicum*	Air, Germany	**KX976666**	**KX976760**	**KX976868**	**KX977008**
D. pseudoerectus	**CBS 252.75* T**		Air, Uttar Pradesh, India	**KX976667**	**KX976761**	**KX976869**	**KX977009**
D. pseudofunicola	**CBS 142033 T (= DTO 318-I7)***		Dust, USA	**KX976668**	**KX976762**	**KX976870**	**KX977010**
D. ramosissimus	CGMCC 3.14183 T	*Ch. ramosissimum*	Rhizosphere of *Panax Notoginseng*, Yunnan, China	GU563371	GU563361	**KX976871**	JF772452
	CGMCC 3.12930		Soil, Huanggang, Hubei Province	HM449045	HM449059	**KX976872**	JF772449
D. reflexus	CBS 157.49 T	*Ch. reflexum*	Germinating seed, Toledo, Ohio, USA	HM449051	HM449055	**KX976873**	JF772460
	CBS 141.56		Seed, Edmonton, Alberta, Canada	**KX976669**	**KX976763**	**KX976874**	**KX977011**
D. subfunicola	CGMCC 3.12892 T	*Ch. subfunicola*	Soil, Shihezi, Xinjiang Autonomous Region	JX867125	JX867125	**KX976875**	JX867122
	CGMCC 3. 9466		Rhizosphere of *Panax Notoginseng*, Yunnan, China	GU563368	GU563353	**KX976876**	JF772446
	CBS 812.73*		Pistol belt, New Guinea	**KX976670**	**KX976764**	**KX976877**	**KX977012**
	CBS 794.83*		Paper, Switzerland	**KX976671**	**KX976765**	**KX976878**	**KX977013**
D. variostiolatus	**CBS 179.84* T**	*Ch. variostiolatum*	Tarpaulin, New Guinea	**KX976672**	**KX976766**	**KX976879**	**KX977014**
	DTO 319-A2*		Dust, USA	**KX976673**	**KX976767**	**KX976880**	**KX977015**
	DTO 319-B9*; DTO 319-C1		Dust, Thailand	**KX976674**	**KX976768**	**KX976881**	**KX977016**
Humicola							
H. fuscoatra	CBS 118.14 T		Soil, Norway	**KX976675**	**KX976769**	**KX976882**	**KX977017**
H. olivacea	**CBS 142031 T (= DTO 319-C7)***		Dust, USA	**KX976676**	**KX976770**	**KX976883**	**KX977018**
Humicola sp.	**DTO 318-G9; DTO 318-H1**		Dust, Mexico	**KX976677**	**KX976771**	**KX976884**	**KX977019**
	DTO 319-B7*		Dust, South Africa	**KX976678**	**KX976772**	**KX976885**	**KX977020**
Melanocarpus							
Me. albomyces	CBS 638.94 T		Chicken nest straw, Nevada, USA	**KX976679**	**KX976773**	**KX976886**	**KX977021**
	CBS 747.70		Coal pit refuse, UK	**KX976680**	**KX976774**	**KX976887**	**KX977022**
Me. tardus	**CBS 541.76* T**		Cotton jacket, Switzerland	**KX976681**	**KX976775**	**KX976888**	**KX977023**
Myceliophthora							
My. fergusii	CBS 406.69 T		Mushroom compost, Pennsylvania, USA	HQ871794	**KX976776**	HQ871815	**KX977024**
My. heterothallica	CBS 202.75		Garden soil, Giessen, Germany	HQ871771	KM655354	HQ871798	**KX977025**
My. lutea	CBS 145.77 neoT		Hay, Newmarket, UK	HQ871775	KM655351	HQ871816	**KX977026**
My. sepedonium	CBS 111.69 T		Soil, Allahabad, India	HQ871751	**KX976777**	HQ871827	**KX977027**
My. thermophila	CBS 669.85		Cellulase, USA	HQ871767	**KX976778**	HQ871806	**KX977028**
	CBS 381.97		*Homo sapiens*, Unknown	HQ871766	**KX976779**	HQ871805	**KX977029**
Ovatospora							
O. brasiliensis	CBS 130174	*Ch. brasiliense*	Soil, Colombia	**KX976682**	**KX976780**	**KX976895**	**KX977030**
	CBS 140.50*		Moist jute cloth, Calcutta, India	**KX976683**	**KX976781**	**KX976896**	**KX977031**
O. medusarum	CBS 148.67 T	*Ch. medusarum*	Soil, Zaire	**KX976684**	**KX976782**	**KX976897**	**KX977032**
O. mollicella	CBS 583.83 T	*Ch. mollicellum*	Dung of spotted skunk, Washington, USA	**KX976685**	**KX976783**	**KX976898**	**KX977033**
O. pseudomollicella	**CBS 251.75* T**		Air, Uttar Pradesh, India	**KX976686**	**KX976784**	**KX976899**	**KX977034**
O. senegalensis	CBS 728.84 T	*Ch. senegalense*	Plant remains, Senegal	**KX976687**	**KX976785**	**KX976900**	**KX977035**
	CBS 798.83		Dung of gazelle, Israel	**KX976688**	**KX976786**	**KX976901**	**KX977036**

Table 1. (Continued).

Genus and species	Culture accession number(s)[1]	Previous name	Origin	GenBank accession numbers[2]			
				ITS	LSU	*rpb2*	*tub2*
O. unipora	CBS 109.83 T	*Ch. uniporum*	Soil, Egypt	**KX976689**	**KX976787**	**KX976902**	**KX977037**
Subramaniula							
S. anamorphosa	CBS 137114 T	*Ch. anamorphosum*	Peritonitis of *Homo sapiens*, Kuwait	KP862598	KP970641	KP900667	KP900704
S. asteroides	CBS 123294 T		Keratitis of *Homo sapiens, USA*	HQ906667	JX280731	KP900666	KP900703
	CBS 128466		Corneal ulcer of *Homo sapiens*, USA	JX280843	JX280732	KP900656	KP900695
S. cristata	CBS 156.52 T	*Ch. cristatum*	Dung of rabbit, Virginia, USA	**KX976690**	**KX976788**	**KX976903**	**KX977038**
	DTO 324-H8*; DTO 324-H7		Air, China	**KX976691**	**KX976789**	**KX976904**	**KX977039**
S. cuniculorum	CBS 800.83	*Ch. cuniculorum*	Soil, Spain	**KX976692**	**KX976790**	**KX976905**	**KX977040**
S. fusispora	CBS 199.84	*Ch. fusisporum*	Dung of marmot, Alberta, Canada	KP862601	KP970645	KP900653	KP900707
S. flavipila	CBS 446.66 T	*Ch. irregulare*	Dead leaves, Bulgaria	KP862600	KP970647	KP900669	KP900706
	CBS 227.82		Dung, Spain	KP862599	KP970646	KP900668	KP900705
S. obscura	CBS 132916 T		Tinea pedis of *Homo sapiens,* Kuwait	KP862595	KP970653	KP900662	KP900700
S. thielavioides	CBS 122.78 T		Dung of nilgai, Delhi Zoo, India	KP862597	KP970654	KP900670	KP900708
	CBS 560.84		Dung of herbivore, Delhi, India	KP862596	KP970655	KP900672	KP900710
Thielavia							
T. appendiculata	CBS 731.68		Dung of rabbit, Wales	KM655330	KM655369	**KX976906**	**KX977041**
T. fragilis	CBS 456.73 T		Rhizosphere of *Pennisetum typhoideum* in garden soil, Tamil Nadu, India	**KX976693**	**KX976791**	**KX976907**	**KX977042**
T. hyrcaniae	CBS 353.62 T		Sand dune soil, Iran	KM655329	KM655368	**KX976908**	**KX977043**
T. kuwaitensis	CBS 945.72 T		Desert soil, Kuwait	KM655332	KM655371	**KX976909**	**KX977044**
T. terricola	CBS 165.88		Barren soil, North Carolina, USA	**KX976694**	**KX976792**	**KX976910**	**KX977045**
Microascus trigonosporus	CBS 218.31 T		USA	LM652443	HG380436	DQ470908	LM652655

T, eT and neoT denote ex-type, ex-epitype and ex-neotype cultures respectively.
[1] The isolates from the indoor environments are highlighted in bold.
[2] The newly generated sequences in this study are shown in bold; where multiple culture numbers are listed in the row only the sequences from the first culture was deposited in GenBank.
* The isolates that were analysed for their metabolite production.
** Here only the sequences of the representatives of indoor *Chaetomium sensu stricto* species are provided. For the information of other *Chaetomium* species please see in our previous study (Wang *et al.* 2016).

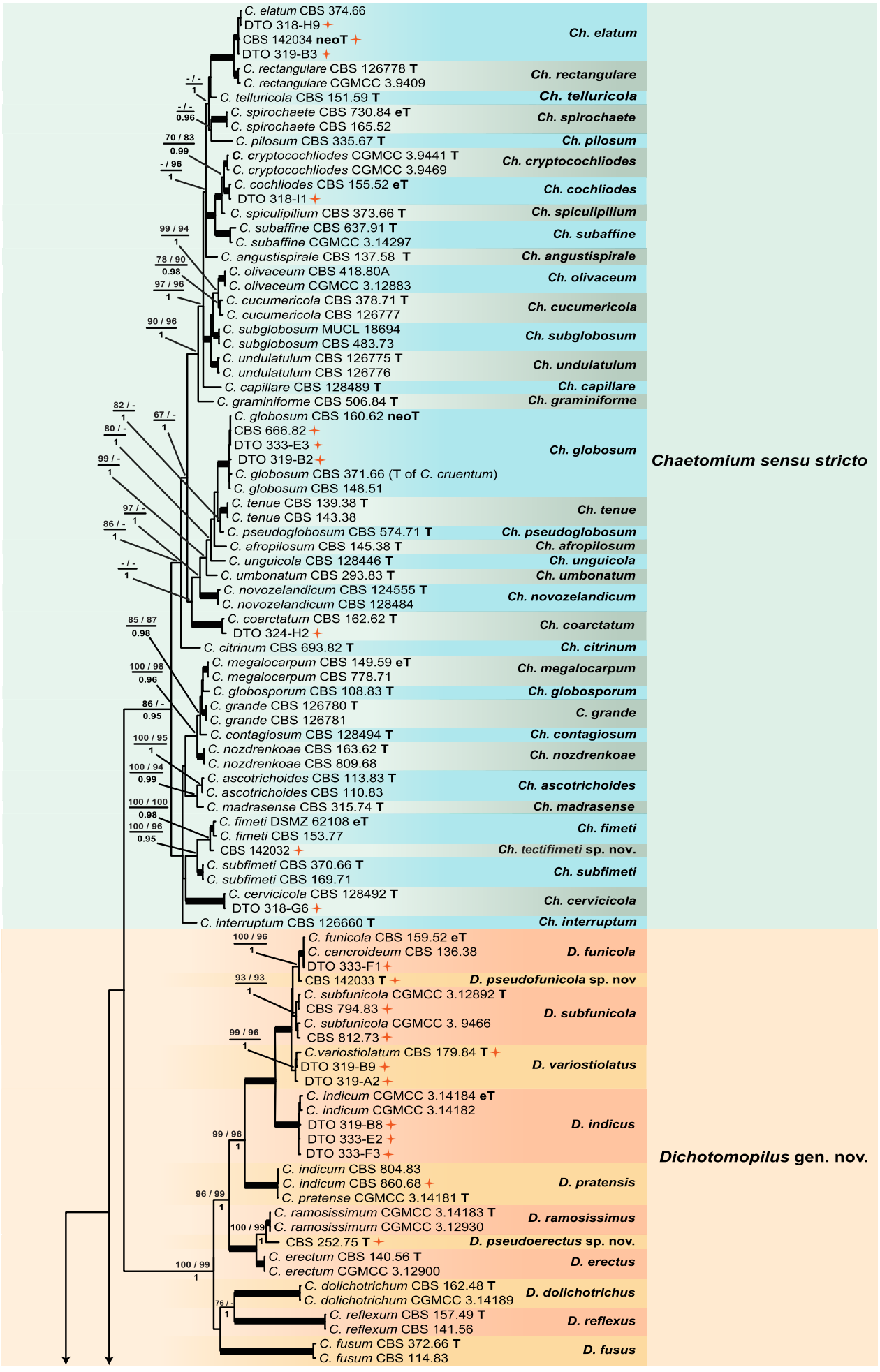
The ITS region was used to initially screen the collection of fungi from the indoor environments in order to select members of the *Chaetomiaceae*. The *tub2* gene region was used to recognise the species diversity within the indoor *Chaetomiaceae* isolates. The phylogenetic placement of the indoor isolates was determined using four loci (ITS, partial LSU, *tub2* and partial *rpb2*) on the basis of the evaluation in a previous study (Wang *et al.* 2016), and representatives of related species and genera in the *Chaetomiaceae* were included as references in the final phylogenetic analyses. Phylogenetic analyses were based on Bayesian inference (BI), Maximum Likelihood (ML) and Maximum Parsimony (MP) as described previously (Wang *et al.* 2016). For BI, the best evolutionary model for each locus was determined using MrModeltest v. 2.0 (Nylander 2004). Obtained trees were viewed in FigTree v. 1.1.2 (Rambaut 2009). The alignment and derived trees were deposited in TreeBASE (submission ID 20347; http://treebase.org/treebase-web/home.html).

Morphology

Colony morphology was determined by inoculating strains onto four different media (Samson *et al.* 2010): OA, potato carrot agar (PCA), malt extract agar (MEA, Oxoid), and Dichloran 18 % glycerol agar (DG18), incubated in the dark at 25 °C for 7 d. Microscopic observation was performed using methods previously described (Wang *et al.* 2016). Morphological descriptions are mainly based on OA, sometimes on PCA. For the observations of the asexual morphology, SNA (spezieller nährstoffarmer agar) was used (Samson *et al.* 2010).

Metabolite extraction of pure cultures

Metabolite profiling was performed on 15-d-old cultures grown on MEA and potato dextrose agar (PDA) (Samson *et al.* 2010), where three agar plugs (6 mm diam) were cut across one colony from each agar medium and pooled in a 2 mL Eppendorf tube. One mL extraction solvent (ethyl acetate-2-propanol (3:1; vol/vol) containing 1 % formic acid) was added to each vial and the plugs were extracted in a sonication bath for 60 min. The extract was then transferred to a clean 2 mL Eppendorf tube and evaporated to dryness in a stream of N_2. The dried extract was subsequently re-dissolved in 400 µL methanol in a sonication bath for 30 min, centrifuged for 3 min at 15 000 g, and transferred to a clean auto sampler vial.


C. elatum CBS 374.66
DTO 318-H9
CBS 142034 neoT
DTO 319-B3
Ch. elatum
C. rectangulare CBS 126778 T
C. rectangulare CGMCC 3.9409
Ch. rectangulare
C. telluricola CBS 151.59 T
Ch. telluricola
C. spirochaete CBS 730.84 eT
C. spirochaete CBS 165.52
Ch. spirochaete
C. pilosum CBS 335.67 T
Ch. pilosum
C. cryptocochliodes CGMCC 3.9441 T
C. cryptocochliodes CGMCC 3.9469
Ch. cryptocochliodes
C. cochliodes CBS 155.52 eT
DTO 318-I1
Ch. cochliodes
C. spiculipilium CBS 373.66 T
Ch. spiculipilium
C. subaffine CBS 637.91 T
C. subaffine CGMCC 3.14297
Ch. subaffine
C. angustispirale CBS 137.58 T
Ch. angustispirale
C. olivaceum CBS 418.80A
C. olivaceum CGMCC 3.12883
Ch. olivaceum
C. cucumericola CBS 378.71 T
C. cucumericola CBS 126777
Ch. cucumericola
C. subglobosum MUCL 18694
C. subglobosum CBS 483.73
Ch. subglobosum
C. undulatulum CBS 126775 T
C. undulatulum CBS 126776
Ch. undulatulum
C. capillare CBS 128489 T
Ch. capillare
C. graminiforme CBS 506.84 T
Ch. graminiforme
C. globosum CBS 160.62 neoT
CBS 666.82
DTO 333-E3
DTO 319-B2
C. globosum CBS 371.66 (T of C. cruentum)
C. globosum CBS 148.51
Ch. globosum
C. tenue CBS 139.38 T
C. tenue CBS 143.38
Ch. tenue
C. pseudoglobosum CBS 574.71 T
Ch. pseudoglobosum
C. afropilosum CBS 145.38 T
Ch. afropilosum
C. unguicola CBS 128446 T
Ch. unguicola
C. umbonatum CBS 293.83 T
Ch. umbonatum
C. novozelandicum CBS 124555 T
C. novozelandicum CBS 128484
Ch. novozelandicum
C. coarctatum CBS 162.62 T
DTO 324-H2
Ch. coarctatum
C. citrinum CBS 693.82 T
Ch. citrinum
C. megalocarpum CBS 149.59 eT
C. megalocarpum CBS 778.71
Ch. megalocarpum
C. globosporum CBS 108.83 T
Ch. globosporum
C. grande CBS 126780 T
C. grande CBS 126781
C. grande
C. contagiosum CBS 128494 T
Ch. contagiosum
C. nozdrenkoae CBS 163.62 T
C. nozdrenkoae CBS 809.68
Ch. nozdrenkoae
C. ascotrichoides CBS 113.83 T
C. ascotrichoides CBS 110.83
Ch. ascotrichoides
C. madrasense CBS 315.74 T
Ch. madrasense
C. fimeti DSMZ 62108 eT
C. fimeti CBS 153.77
Ch. fimeti
CBS 142032
Ch. tectifimeti sp. nov.
C. subfimeti CBS 370.66 T
C. subfimeti CBS 169.71
Ch. subfimeti
C. cervicicola CBS 128492 T
DTO 318-G6
Ch. cervicicola
C. interruptum CBS 126660 T
Ch. interruptum
Chaetomium sensu stricto
C. funicola CBS 159.52 eT
C. cancroideum CBS 136.38
DTO 333-F1
D. funicola
CBS 142033 T
D. pseudofunicola sp. nov
C. subfunicola CGMCC 3.12892 T
CBS 794.83
C. subfunicola CGMCC 3. 9466
CBS 812.73
D. subfunicola
C.variostiolatum CBS 179.84 T
DTO 319-B9
DTO 319-A2
D. variostiolatus
C. indicum CGMCC 3.14184 eT
C. indicum CGMCC 3.14182
DTO 319-B8
DTO 333-E2
DTO 333-F3
D. indicus
C. indicum CBS 804.83
C. indicum CBS 860.68
C. pratense CGMCC 3.14181 T
D. pratensis
C. ramosissimum CGMCC 3.14183 T
C. ramosissimum CGMCC 3.12930
D. ramosissimus
CBS 252.75 T
D. pseudoerectus sp. nov.
C. erectum CBS 140.56 T
C. erectum CGMCC 3.12900
D. erectus
C. dolichotrichum CBS 162.48 T
C. dolichotrichum CGMCC 3.14189
D. dolichotrichus
C. reflexum CBS 157.49 T
C. reflexum CBS 141.56
D. reflexus
C. fusum CBS 372.66 T
C. fusum CBS 114.83
D. fusus
Dichotomopilus gen. nov.

UHPLC-DAD-QTOF-MS analyses

Samples (0.5 µL) were analysed using ultra-high performance liquid chromatography-diode array detection-quadrupole time of flight mass spectrometry (UHPLC-DAD-QTOF-MS) on an Agilent Infinity 1290 UHPLC system (Agilent Technologies, Santa Clara, California, USA) equipped with a DAD detector scanning 200–640 nm. Metabolites were separated on an Agilent Poroshell 120 phenylhexyl column (2.1 × 250 mm, 2.7 µm) using a linear gradient of solvents consisting of water (A) and acetonitrile (B) buffered with 20 mM formic acid. The gradient started at 10 % B and increased to 100 % in 15 min where it was held for 2 min (Kildgård *et al.* 2014). The flow rate was 0.35 mL/min and the column temperature was 60 °C. Mass spectrometry detection was performed in ESI^+ mode on an Agilent 6545 QTOF MS equipped with Dual Jet Stream electrospray ion source, using hexakis-(2,2,3,3-tetrafluoropropoxy) phosphazene as the lock mass. Other MS parameters, including Auto-MS/HRMS, can be found in Kildgård *et al.* (2014).

Secondary metabolites were identified by aggressive dereplication of the full HRMS (high resolution mass spectrometry) data against a list of possible known compounds that have been described in the literature as well as comparison to 1 500 fungal secondary metabolites. All samples were further analysed for peaks not detected by the previous approach, and those were matched against Antibase2012 for a tentative identification. Metabolites that did not match were considered as novel compounds and their elemental composition was determined from the accurate mass (±2 ppm) and isotopic pattern (Kildgård *et al.* 2014, Došen *et al.* in press). The peak areas of $[M+H]^+$, $[M+Na]^+$ or $[M+H_2O]^+$ of all the compounds, including the tentatively identified and the novel compounds, were then integrated in the Agilent MassHunter Quant software using extracted ion chromatograms ±12 ppm and the peak areas for multivariate data analysis.

RESULTS

Isolates

A total of 145 indoor isolates (Table 1, in bold font) were identified as members of *Chaetomiaceae* after the ITS sequencing. A further selection of 45 representative indoor isolates was made based on the *tub2* gene sequences, combined with an examination of the macro- and micromorphology. Similar isolates were excluded and strains that possibly represent different species were included in the detailed morphological examination and four-locus analyses. Thirty-eight representative isolates (Table 1, marked with *) were included in the metabolite analysis.

Phylogeny

The phylogenetic analysis of *tub2* gene region placed the indoor isolates into 30 well-supported clades in 10 distinct monophyletic lineages (Tables 1, 2). The preliminary identification based on the *tub2* locus was confirmed by the four-locus analysis on the basis of a dataset consisting of 45 representative indoor isolates and representative isolates of related genera and species. Only the concatenated phylogenetic tree was presented with the bootstrap proportions ($\geq$ 50 %) from ML or MP analyses and posterior probabilities ($\geq$ 0.95) from Bayesian analyses plotted on the phylogramme to show statistical support (Fig. 1).

The multigene analyses contained 183 strains, including *Microascus trigonosporus* (CBS 218.31) as outgroup taxon. No topological conflicts were found when comparing the 70 % bootstrap reciprocal tree topologies based on the *rpb2* and *tub2* datasets. The minor incongruences observed for the ITS and LSU sequence data set failed to resolve some of the species, especially those in the *Ch. globosum* species complex recovered by each of the two protein-coding gene regions used here. All four loci were combined following recommendations of Cunningham (1997). The concatenated alignment consisted of 2 790 characters (including alignment gaps): 525, 968, 724 and 573 characters used in the *rpb2*, *tub2*, ITS and LSU partitions, respectively. Of these, 1 122 characters were constant, 339 characters parsimony-uninformative and 1 265 characters parsimony-informative. For the Bayesian inference, a GTR+I+G model was selected for *rpb2*, ITS and LSU and a HKY+I+G model for *tub2*. These models were incorporated into the analysis. A total of 23 822 trees were generated during the Bayesian inference, of which 5 956 trees were discarded as the "burnin-phase" and posterior probabilities (PP) were calculated from the remaining 17 866 trees. The BI consensus tree and PP confirmed the tree topologies and bootstrap support (BS) values obtained with the ML and MP analyses. The MP analysis yielded 136 equally most parsimonious trees (TL = 11 252; CI = 0.299; RI = 0.822; RC = 0.245). The BI consensus tree is presented (Fig. 1) with the respective MP- and ML-BS values indicated at the nodes.

The concatenated phylogenetic analyses revealed the *Ch. globosum* species complex (Wang *et al.* 2016) (MP-BS = 86; ML-BS $\leq$ 50; PP = 0.95) and 13 other monophyletic clades (Fig. 1). Six known genera were supported: *Achaetomium* including the type species *A. globosum* (MP-BS = 100; ML-BS = 89; PP = 0.95), *Corynascella* represented by the type species *Cor. humicola* (MP-BS = 100; ML-BS = 100; PP = 1.0), *Humicola* represented by the type species *H. fuscoatra* (MP-BS = 92; ML-BS = 95; PP = 0.99), *Melanocarpus* represented by the type species *Me. albomyces* (MP-BS = 93; ML-BS = 97; PP = 0.99), *Myceliophthora* including the type species *My. lutea* (MP-BS = 96; ML-BS = 99; PP = 0.97), and *Thielavia* including five species (MP-BS = 98; ML-BS = 98; PP = 0.99). *Emilmuelleria* and *Ch. murorum* clustered in the *Botryotrichum* clade (MP-BS = 100; ML-BS = 99; PP = 1.0), which is represented by the type species *B. piluliferum* and two other *Botryotrichum* species. *Chaetomium cristatum*, *Ch. cuniculorum*, *Ch. irregulare*, *Ch. anamorphosum* and *Ch. fusisporum* clustered in the *Subramaniula* clade (MP-BS = 100; ML-BS = 100; PP = 1.0)

Fig. 1. Consensus phylogram (50 % majority rule) resulting from a Bayesian analysis of the concatenated *rpb2*, *tub2*, ITS and LSU gene region alignment, with the confidence values of bootstrap proportions from the MP analysis (before the backslash), the ML analysis (after the backslash) above branches, and the posterior probabilities from the Bayesian analysis below branches. The "–" means lacking statistical support (<50 % for bootstrap proportions from ML or MP analyses; <0.95 for posterior probabilities from Bayesian analyses). The branches with full statistical support (MP-BS = 100 %; ML-BS = 100 %; PP = 1.0) are highlighted by thickened branches. Generic novelties are indicated with "gen. nov." after the genus name and the genus names of the species are abbreviated to facilitate layout of the tree. Genus and species clades are discriminated with boxes of different colours. The 45 isolates from the indoor environment are indicated with a red star on the right side of the culture number; these isolates are representative of all the indoor species recognised in this study. The scale bar shows the expected number of changes per site. The tree is rooted with *Microascus trigonosporus* strain CBS 218.31 (see Table 1 for GenBank accession numbers).

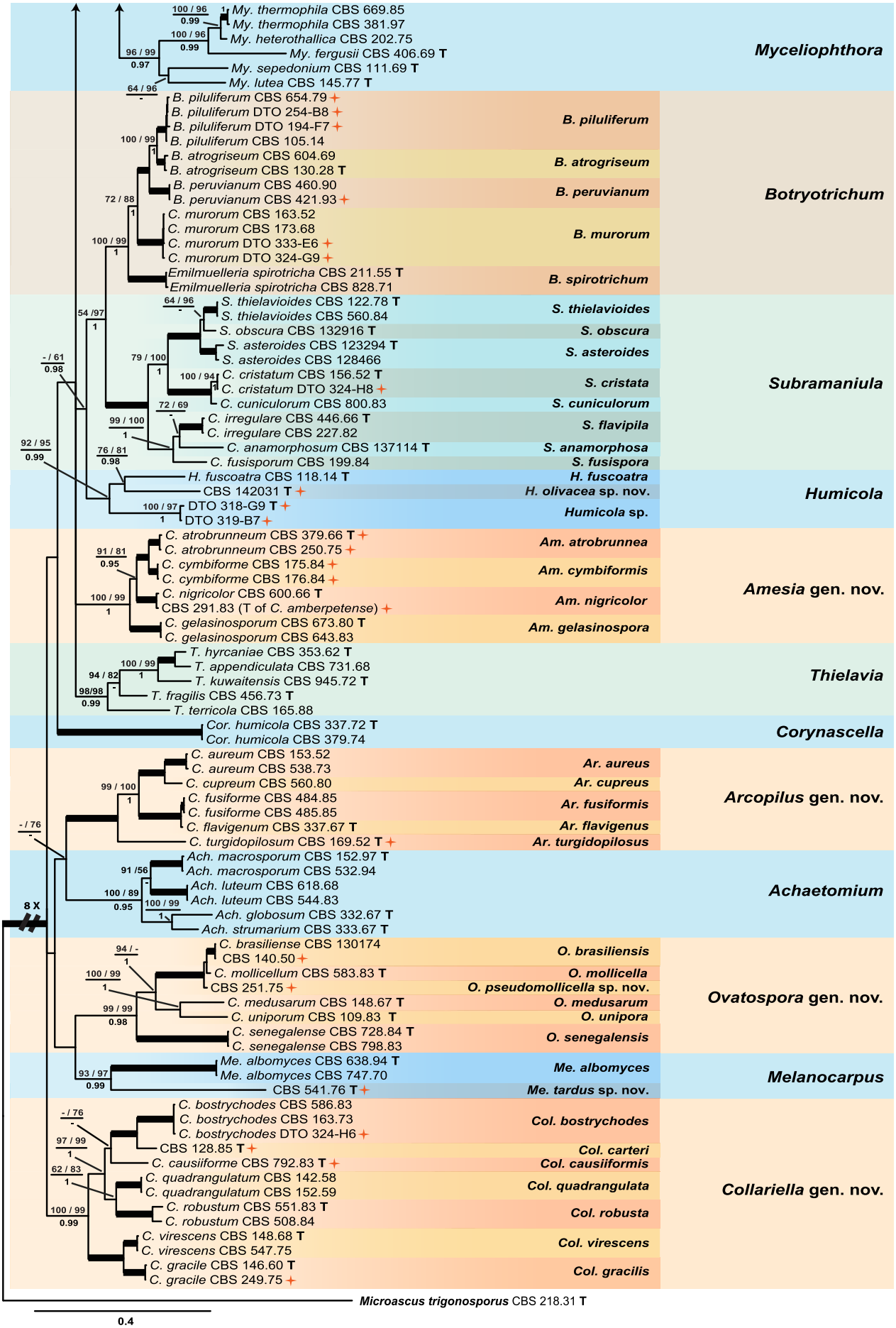


Fig. 1. (Continued).

Table 2. A summary of indoor *Chaetomiaceae*.

Species names	Algeria	Australia	Canada	China	Cuba	Denmark	Germany	India	Indonesia	Mexico	The Netherlands	New Guinea	Solomon Islands	South Africa	Spain	Switzerland	Thailand	Uruguay	USA	Total	
																				Per species	Per genus
Amesia atrobrunnea								1					1							**2**	**5**
Am. cymbiformis													1						1	**2**	
Am. nigricolor								1												**1**	
Arcopilus turgidopilosus																			1	**1**	**1**
Botryotrichum murorum				2		1														**3**	**8**
B. piluliferum											4									**5**	
B. peruvianum					1																
Chaetomium cervicicola										1										**1**	**100**
Ch. coarctatum				1																**1**	
Ch. cochliodes											3			2					12	**17**	
Ch. elatum		1				3													2	**6**	
Ch. globosum	6		3	19		13	3		1	9	11			1			1	1	6	**74**	
Ch. testifimeti																			1	**1**	
Collariella bostrychodes				2					1						1					**4**	**7**
Col. causiiformis													1							**1**	
Col. carteri			1																	**1**	
Col. gracilis								1												**1**	
Dichotomopilus funicola						2													1	**3**	**15**
D. indicus						2								1						**3**	
D. pratensis							1													**1**	
D. pseudoerectus								1												**1**	
D. pseudofunicola																			1	**1**	
D. subfunicola												1				1				**2**	
D. variostiolatus												1					2		1	**4**	
Humicola olivacea																			1	**1**	**4**
Humicola sp.										2				1						**3**	
Melanocarpus tardus																1				**1**	**1**
Ovatospora brasiliensis								1												**1**	**2**
O. pseudomollicella								1												**1**	
Subramaniula cristata				2																**2**	**2**
Totals	**6**	**1**	**4**	**26**	**1**	**21**	**4**	**6**	**2**	**12**	**18**	**2**	**3**	**5**	**1**	**2**	**3**	**1**	**27**		**145**

represented by the type species *S. thielavioides*. The *Botryotrichum* and *Subramaniula* clades formed sisters to each other (MP-BS = 54; ML-BS = 97; PP = 1), which clustered closely with the *Humicola* clade with relatively low statistic support (MP-BS $\leq$ 50; ML-BS = 61; PP = 0.98).

Five highly supported monophyletic clades represent possible novel genera. The clade represented by *Ch. indicum* (MP-BS = 100; ML-BS = 99; PP = 1.0) formed a sister to the *Ch. globosum* species complex, but with no statistical support for their relationships. Four others included: the *Ch. atrobrunneum* clade (MP-BS = 100; ML-BS = 99; PP = 1.0), the *Ch. aureum* clade (MP-BS = 100; ML-BS = 100; PP = 1.0), the *Ch. brasiliense* clade (MP-BS = 99; ML-BS = 99; PP = 0.98) and the *Ch. bostrychodes* clade (MP-BS = 100; ML-BS = 99; PP = 0.99). They were distant from the *Ch. globosum* species complex and separated by the *Achaetomium*, *Botryotrichum, Corynascella, Melanocarpus, Myceliophthora, Subramaniula* and *Thielavia* generic clades. The presented topology received little to no statistical support for most of these.

Four known species were originally isolated from indoor environments or from materials associated with human lives, namely *Ch. atrobrunneum* (ex-type CBS 379.66, from mouldy mattress), *Ch. causiiforme* (ex-type CBS 792.83, from sweatband of helmet liner), *Ch. turgidopilosum* (ex-type CBS 169.52, from top of a storage tent) and *Ch. variostiolatum* (ex-type CBS 179.84, from tarpaulin). Twenty-eight other representative indoor isolates clustered in 18 known species clades with high statistical support (MP-BS $\geq$ 93; ML-BS $\geq$ 93; PP = 1.0), which were represented by their ex-type cultures (seven species), ex-epitype cultures (three species), ex-neotype culture (*Ch. globosum*), or representative strains (seven species), respectively.

Two isolates (DTO 319-B7 and DTO 318-G9) formed a sister clade to another indoor isolate (DTO 319-C7) and clustered with *H. fuscoatra* (ex-type CBS 118.14), the type species of *Humicola*. The isolate CBS 541.76, which is deposited as *Thielavia minuta* in the CBS collection, formed a sister lineage to the type species of *Melanocarpus* (*M. albomyces*, ex-type CBS 638.94), which was distant from the core *Thielavia* clade. The isolate CBS 251.75 formed a sister lineage to the ex-type of *Ch. mollicellum* and the *Ch. brasiliense* clade (MP-BS = 100; ML-BS = 100; PP = 1.0). Three other isolates (DTO 318-G8, DTO 318-I7 and CBS 252.75) clustered close to but separated from their closest relatives: *Ch. fimeti*, *Ch. funicola* or *Ch. ramosissimum*, respectively. These isolates represent possible novel phylogenetic species.

Metabolite profiling

A subset of isolates (Table 3) was extracted and analysed in order to compare their metabolite production. The species names used in this paragraph are based on the newly proposed taxonomy mentioned below. The analyses showed that more than 68 metabolites could be detected, and the structure of 31 compounds is unknown. The majority of the detected metabolites (known and uncharacterised) were produced by isolates belonging to *Chaetomium sensu stricto* and *Dichotomopilus*. Table 3 shows the production of 35 known and six unknown metabolites at species level. In general there were no species specific metabolites produced by one species alone, with the exception of the production of chaetosemin A, chaetoquadrin A, I and K by *H. olivacea* (DTO 319-C7) and sterigmatocystin by *Humicola* sp. (DTO 319-B7). Other metabolites were produced by isolates belonging to various genera and species. For example, cochliodinol A was produced by *C. globosum*, *D. pratensis*, *B. murorum*, *B. piluliferum*, *S. cristata*, *A. nigricolor*, *O. brasiliensis* and *O. pseudomollicella*, and cochliodinol B was produced by *C. cochliodes*, *C. pseudofimeti*, *D. subfunicola*, *D. variostiolatus*, *D. funicola*, *A. cymbiformis*, *Col. bostrychodes* and *Col. carteri*. There were metabolites that were genus specific, as can be seen from Table 3. Some metabolites, like chaetoindicin, SB236049, SB236050 and SB238569, were only found in genus *Dichotomopilus*, while others were restricted to genus *Chaetomium sensu stricto*. Chaetoglobosins A and C, chaetomugilin D and prochaetoglobosins I-IV were only produced by *C. coarctacum* and *C. globosum* whereas chaetocin A, chaetomin and chaetoviridin B/C were only found in *C. cochloides* and *C. pseudofimeti*.

TAXONOMY

Being the type species, *Chaetomium globosum* is affiliated with the *Ch. globosum* species complex (Wang *et al.* 2016). This species complex was confirmed as a monophyletic lineage in this study, which represents *Chaetomium sensu stricto*. Thirty species found in indoor environments could be accommodated in 10 genera of the *Chaetomiaceae*. Five new genera are established and seven new species described. One *Humicola* species represented by three indoor isolates remains to be compared with other known *Humicola* species and this will be done in future phylogenetic and morphological studies. All the species obtained from indoor substrates, and each of the recognised novel genera in this study are described and illustrated below. The generic concepts of *Subramaniula* and *Botryotrichum* are also expanded.

Amesia X. Wei Wang, Samson & Crous, **gen. nov.** MycoBank MB818829. Fig. 2.
Etymology: Named after L.M. Marion Ames for his contribution to our knowledge of the taxonomy of the *Chaetomiaceae*.

Type species: *Amesia atrobrunnea* (Ames) X. Wei Wang & Samson (= *Ch. atrobrunneum*)

Ascomata superficial, ostiolate, spherical, ellipsoid or ovate with walls of *textura angularis*, *intricata* or *epidermoidea* in surface view. *Terminal hairs* straight, flexuous, undulate or spirally coiled. *Lateral hairs* straight, flexuous, or similar to terminal hairs, but shorter. *Asci* fasciculate, clavate, broadly clavate or fusiform, stalked, with 8 biseriate or irregularly arranged ascospores, evanescent. *Ascospores* brown at maturity, usually fusiform, elongate ovate to ovate, with an apical or sub-apical germ pore. *Asexual morph* unknown.

Notes: Several species of *Amesia* were investigated. These species exhibit a high morphological diversity in both ascomatal hairs and ascospore morphology. An ITS/LSU analysis indicated it to be a monophyletic lineage (de Hoog *et al.* 2013). Our four-locus phylogeny confirmed the ITS/LSU phylogeny. More

Table 3. Metabolite production by representatives in each of the indoor genera.

Metabolites	Genus	*Amesia*			*Arcopilus*	*Botryotrichum*		*Chaetomium*					*Collariella*				*Dichotomopilus*							*Humicola*	*Melanocarpus*	*Ovumospora*		*Subramaniula*
	Species	*Am. atrobrunnea*	*Am. cymbiformis*	*Am. nigricolor*	*Ar. turgidopilosus*	*B. murorum*	*B. piluliferum*	*Ch. coarctatum*	*Ch. cochliodes*	*Ch. elatum*	*Ch. globosum*	*Ch. testifimeti*	*Col. bostrychodes*	*Col. causiiformis*	*Col. carteri*	*Col. gracilis*	*D. funicola*	*D. indicus*	*D. pratensis*	*D. pseudoerectus*	*D. pseudofunicola*	*D. subfunicola*	*D. variostiolatus*	*H. olivacea*	*Humicola* sp.	*Melanocarpus tardus*	*O. brasiliensis*	*O. pseudomollicella*	*S. cristata*
Chaetochalasin A		–	–	–	–	–	–	+	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetocin A		–	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetocin C		–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–
Chaetocochin C		–	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoglobosins A and C		–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoindicin		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	–	–	–	–	–
Chaetomin		–	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetomugilin D		–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoquadrin E		–	–	–	–	+	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	+	+	+	–	–	–
Chaetoquadrins A, I and K		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–
Chaetosemin A		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–
Chaetoviridin A		–	–	–	–	+	–	–	+	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoviridin B/C		–	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoviridin E		–	–	–	–	–	–	–	+	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–
Chetoseminudin A		–	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cochliodinol A		–	–	+	–	+	+	–	–	–	+	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	+	+
Cochliodinol B		–	+	–	–	–	–	–	+	–	–	+	+	–	+	–	+	–	–	–	–	+	+	–	–	–	–	–
Cochliodones 1–3		–	–	–	+	–	–	+	–	+	+	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Dihydroxychaetocin		–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–
Mollicellin C		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–
Mollicellin E		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	+	+	–
Prenisatin		–	+	+	–	+	–	+	+	+	+	+	+	–	+	+	+	+	+	+	+	+	+	–	–	+	+	+
Prochaetoglobosins I–IV		–	–	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rotiorinol		–	–	–	–	–	–	–	+	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sterigmatocystin		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–

(*continued on next page*)

Table 3. (Continued).

Metabolites	Genus	*Amesia*			*Arcopilus*	*Botryotrichum*	*Chaetomium*					*Collariella*				*Dichotomopilus*						*Humicola*		*Melanocarpus*	*Ovumospora*		*Subramaniula*
	Species	*Am. atrobrunnea*	*Am. cymbiformis*	*Am. nigricolor*	*Ar. turgidopilosus*	*B. murorum*	*B. piluliferum*	*Ch. coarctatum*	*Ch. cochlioides*	*Ch. elatum*	*Ch. globosum*	*Ch. testilimetii*	*Col. bostrychoides*	*Col. causiiformis*	*Col. carteri*	*Col. gracilis*	*D. funicola*	*D. indicus*	*D. pratensis*	*D. pseudoerectus*	*D. pseudofunicola*	*D. subfunicola*	*D. variostiolatus*	*H. olivacea*	*Humicola* sp.	*Melanocarpus tardus*	*O. brasiliensis*	*O. pseudomollicella*	*S. cristata*
SB236049/SB236050/SB238569	–	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	-	-	-	-	-
$C_{16}H_{23}NO_2$		-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
$C_{16}H_{23}NO_3$		-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
$C_{18}H_{28}O_6$		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-
$C_{28}H_{40}O_7$		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
MW306		+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-
MW665		-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-

investigation with larger sampling is required to find the close relative(s) of this genus.

Amesia atrobrunnea (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818832. Fig. 3.
Basionym: *Chaetomium atrobrunneum* Ames, Mycologia 41: 641. 1949.

Ascomata superficial, ostiolate, fuscous black to black in reflected light, subglobose or ovate, 80–160 µm high, 70–140 µm diam. *Ascomatal wall* brown, *textura angularis* in surface view. *Terminal hairs* seta-like or flexuous, sometimes branched, smooth, brown, 2.5–4 µm diam. near the base. *Lateral hairs* similar and shorter. *Asci* fasciculate, clavate or fusiform, spore-bearing part 18.5–29 × 8.5–11.5 µm, stalks 9.5–21 µm long, with 8 irregularly arranged ascospores, evanescent. *Ascospores* olivaceous brown when mature, fusiform or elongate pyriform, (8–)8.5–10.5(–11) × 4.5–5.5(–6) µm, with an apical or slightly subapical germ pore at the more attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge, about 41–47 mm diam in 7 d at 25 °C, fuscous black to black owing to ascomata together with masses of ascoapores maturing within 7 d, without aerial mycelium, with fawn to greyish sepia exudates diffusing into the medium, reverse greyish sepia to black. Colonies on PCA with an entire edge, about 39–45 mm diam in 7 d at 25 °C, translucent, vinaceous buff and floccose due to ascomata mixed with aerial hyphae, without coloured exudates; reverse uncoloured. Colonies on MEA with an entire edge, about 36–42 mm diam in 7 d at 25 °C, with greyish white and floccose mycelium, looser and white to pale olivaceous buff texture in the central part due to ascomata mixed with aerial hyphae, reverse ochraceous. Colonies on DG18 with an entire edge, about 18–24 mm diam in 7 d at 25 °C, sterile, with white and floccose aerial mycelium, without coloured exudates; reverse uncoloured.

Specimens examined: **India**, isolated from air by Kamal; culture CBS 250.75. **Solomon Islands**, isolated from mouldy mattress by G.W. Martin and deposited in the CBS collection by H.K. Seth, ex-type culture CBS 379.66.

Notes: Several isolates of this species have been reported to cause human systemic and deep infection (Abbott *et al.* 1995, de Hoog *et al.* 2013). Our previous temperature test (Li *et al.* 2012) demonstrated its potential as an invasive human pathogen: the optimum growth temperature is 30–34 °C, and maximum growth temperature 47 °C.

Amesia cymbiformis (Lodha) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818833. Fig. 4.
Basionym: *Chaetomium cymbiforme* Lodha, J. Indian Bot. Soc. 43:127. 1963.
Synonym: *Chaetomium serpentinum* Ames ex Carter, Canad. J. Bot. 61: 2605. 1983.

Ascomata superficial, ostiolate, greyish sepia when young and olivaceous to dark olivaceous because of the ascospores mass in reflected light, subglobose or ovate, 95–180 µm high, 90–150 µm diam. *Ascomatal wall* brown, *textura angularis* in surface view. *Terminal hairs* flexuous, sometimes recurved, smooth, brown, 2–3.5 µm diam. near the base. *Lateral hairs*

flexuous and shorter. *Asci* fasciculate, clavate or fusiform, spore-bearing part 16–26 × 10.5–13 µm, stalks 7–15 µm long, with 8 irregularly arranged ascospores, evanescent. *Ascospores* olivaceous brown when mature, ovate or ellipsoidal, with attenuated ends, (7–)8–9(–9.5) × (5.5–)6–6.5(–7) µm, with an apical or slightly subapical germ pore at the more attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge, about 33–39 mm diam in 7 d at 25 °C, translucent when young, then greenish olivaceous to olivaceous owing to ascomata together with masses of ascospores, without aerial mycelium, with olivaceous buff to pale luteous exudates diffusing into the medium, reverse pale luteous to grey olivaceous. Colonies on PCA with an entire edge, about 31–37 mm diam in 7 d at 25 °C, translucent, with loose and pale smoke grey aerial hyphae, without coloured exudates; reverse uncoloured. Colonies on MEA white with an entire edge, about 34–40 mm diam in 7 d at 25 °C, non-sporulating, with white and floccose aerial hyphae, without coloured exudates, reverse ochraceous. Colonies on DG18 white with an entire edge, about 11–17 mm diam in 7 d at 25 °C, non-sporulating, with white and floccose aerial mycelium, without coloured exudates; reverse uncoloured.

Specimens examined: **Solomon Islands**, isolated from tent rope, deposited in the CBS collection by J.C. Krug, culture CBS 175.84 (ex-culture of *Ch. serpentinum*). **USA**, Atlanta, isolated from case liner, deposited in the CBS collection by J.C. Krug, culture CBS 176.84.

Notes: *Amesia cymbiformis* is closely related to *Am. atrobrunnea* (Fig. 1), but can be easily distinguished from *Am. atrobrunnea* (Fig. 3) by the shape and size of its ascospores (Fig. 4). Isolate CBS 175.84 was originally studied by Ames and named as *C. serpentinum* without description. Carter (1983) validly published this name after the description of *Ch. cymbiforme* that was originally isolated from cow dung in india (Lodha 1964). After studying the type specimen of *Ch. cymbiforme* and the ex-culture of *Ch. serpentinum*, von Arx *et al.* (1986) synonymised *Ch. cymbiforme* with *Ch. cymbiforme*. Here we followed von Arx *et al.* (1986) to accept *Ch. cymbiforme* as the *basionym* of this species.

Amesia nigricolor (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818834. Fig. 5.
Basionym: *Chaetomium nigricolor* Ames, Mycologia 42: 654. 1950.
Synonym: *Chaetomium amberpetense* Rao & Reddy, Mycopath. Mycol. Appl. 24: 114. 1964.

Ascomata superficial, ostiolate, olivaceous grey in reflected light due to ascomatal hairs, subglobose to ovate, 140–300 µm high, 100–255 µm diam. *Ascomatal wall* brown, *textura intricata* or *epidermoidea* in surface view. *Terminal hairs* undulate to loosely coiled with erect or flexuous lower part, conspicuously rough (granulate), greyish sepia to brown, septate, 3–4.5 µm diam in the undulate or coiled upper portion. *Lateral hairs* flexuous, undulate or apically circinate. *Asci* fasciculate, clavate to fusiform, spore-bearing part 13.5–21 × 7.5–10.5 µm, stalks 6–11.5 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* olivaceous brown when mature, ovate, (5.5–)6–7(–7.5) × 4–5(–5.5) µm, with an apical germ pore at the attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire edge, about 42–48 mm diam in 7 d at 25 °C, with sparse white aerial hyphae, with ochraceous to fulvous exudates diffusing into the medium, reverse pale luteous to amber. Colonies on PCA with entire edge, about 35–41 mm diam in 7 d at 25 °C, with sparse white to pale buff aerial hyphae; reverse uncoloured. Colonies on MEA with entire edge, about 47–53 mm diam in 7 d at 25 °C, with white floccose aerial mycelium, reverse sienna with pale edge. Colony on DG18 with entire edge, about 17–23 mm diam in 7 d at 25 °C, buff with sparse white aerial hyphae, without coloured exudates; reverse uncoloured.

Specimen examined: **India**, Bihar, isolated from paper, culture CBS 291.83 (ex-type culture of *Ch. amberpetense*).

Notes: *Amesia nigricolor* is morphologically similar to members of the genus *Ovatospora*, especially in ascospore morphology. This species differs in possessing ascospores attenuated at one end and slightly apiculate at the other end. In contrast, the ascospores of the *Ovatospora* species are attenuated at one and typically round at the other end. A few isolates of *Am. nigricolor* were isolated from patients, both superficial and deep infections (de Hoog *et al.* 2013).

Arcopilus X. Wei Wang, Samson & Crous, **gen. nov.** MycoBank MB818835. Fig. 6.
Etymology: Name refers to the arcuate terminal ascomatal hairs in most of the species in this genus.

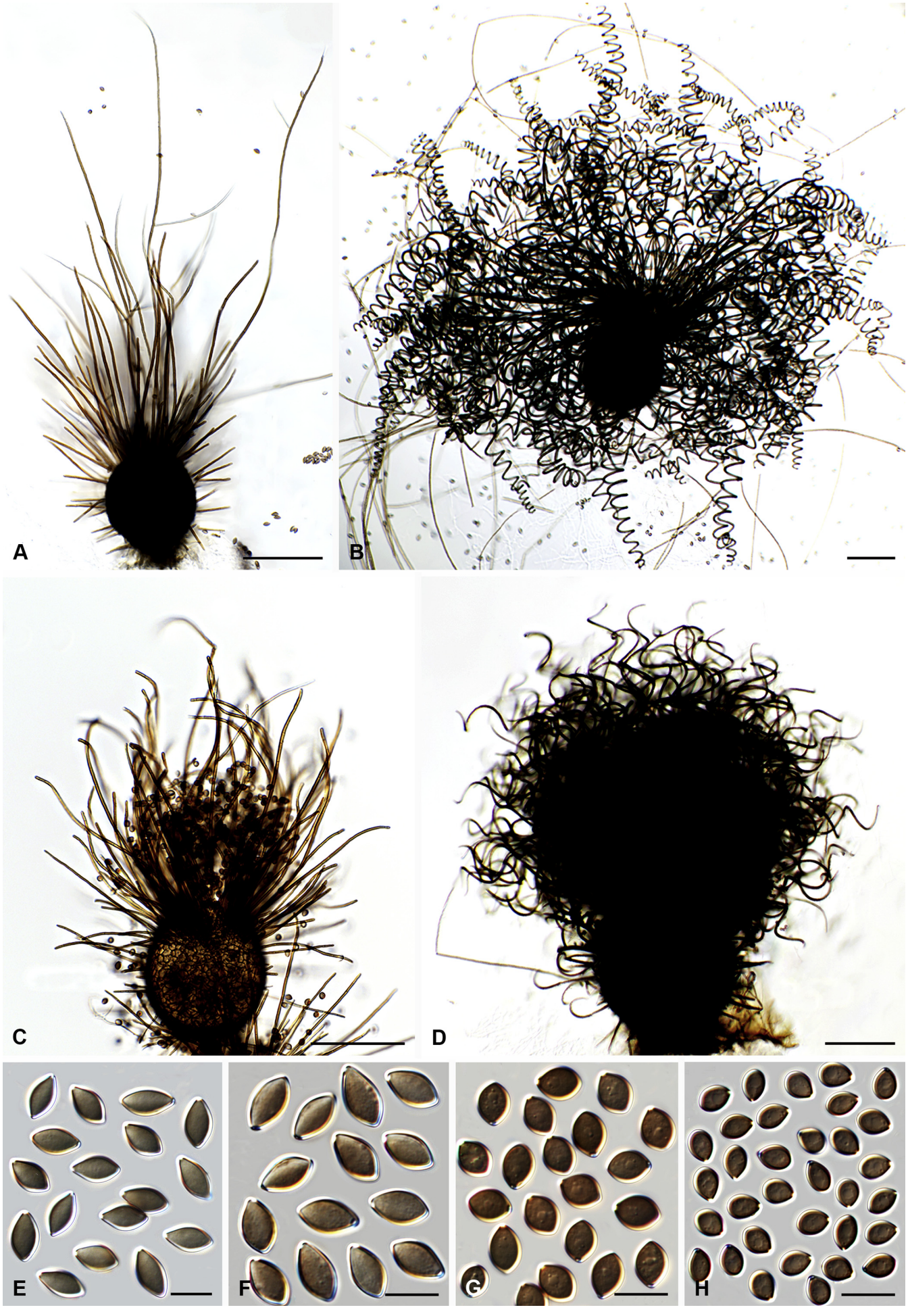
Type species: *Arcopilus aureus* (Chivers) X. Wei Wang & Samson (= *Ch. aureum*)

Colonies usually with yellow to orange or red to rust exudates. *Ascomata* superficial, ostiolate, subglobose or ovate with brown walls of *textura angularis* in surface view. *Terminal hairs* usually arcuate, with apeces incurved, circinate to coiled. *Lateral hairs* flexuous or apically incurved. *Asci* fasciculate, clavate, with 8 biseriate or irregularly arranged ascospores, evanescent. *Ascospores* brown when mature, more or less inequilateral, fusiform, elongate fusiform, navicular, reniform, lunate or limoniform, sometimes bilaterally flattened, with one or two apical germ pores. *Asexual morph* unknown.

Notes: This genus usually has arcuate ascomatal hairs, and often exhibits a colourful colony due to its ascomata and exudates. Ascospores of the species in this genus are relatively diverse (Fig. 6). Only one indoor species was examined in detail in this study. More morphological research is required to delimit species within the genus.

Arcopilus turgidopilosus (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818836. Fig. 7.
Basionym: *Chaetomium turgidopilosum* Ames, Mycologia 41: 639. 1949.

Ascomata superficial, ostiolate, citrine or greenish olivaceous in reflected light due to ascomatal hairs, then becoming greenish black due to ascospores aggregating on the top, subglobose or ovate, 95–155 µm high, 85–150 µm diam. *Ascomatal wall* brown, *textura angularis*, sometimes mixed with hypha-like or amorphous cells in surface view. *Terminal hairs* arcuate, apically incurved, circinate to coiled, warty, or brown, distinctly septate,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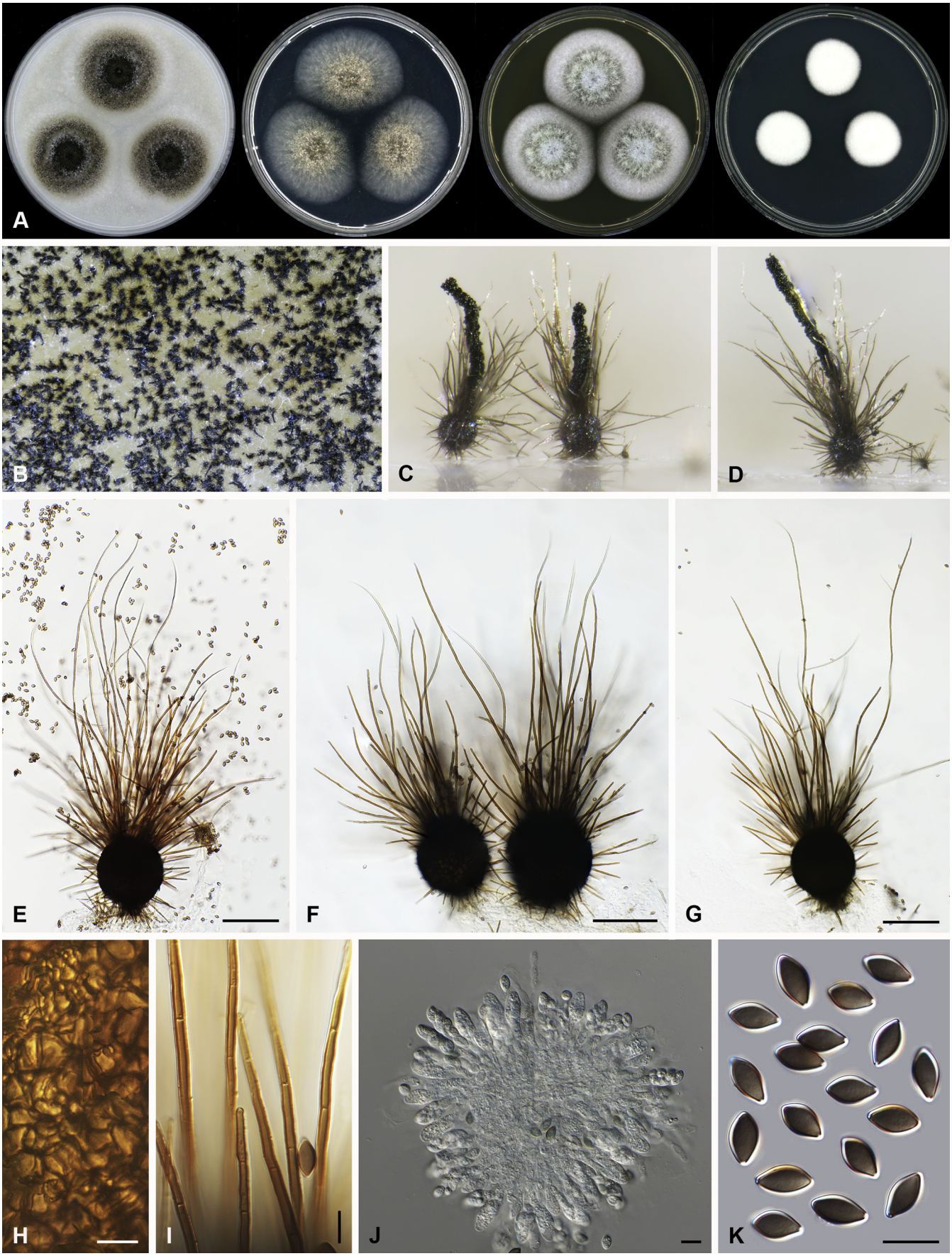
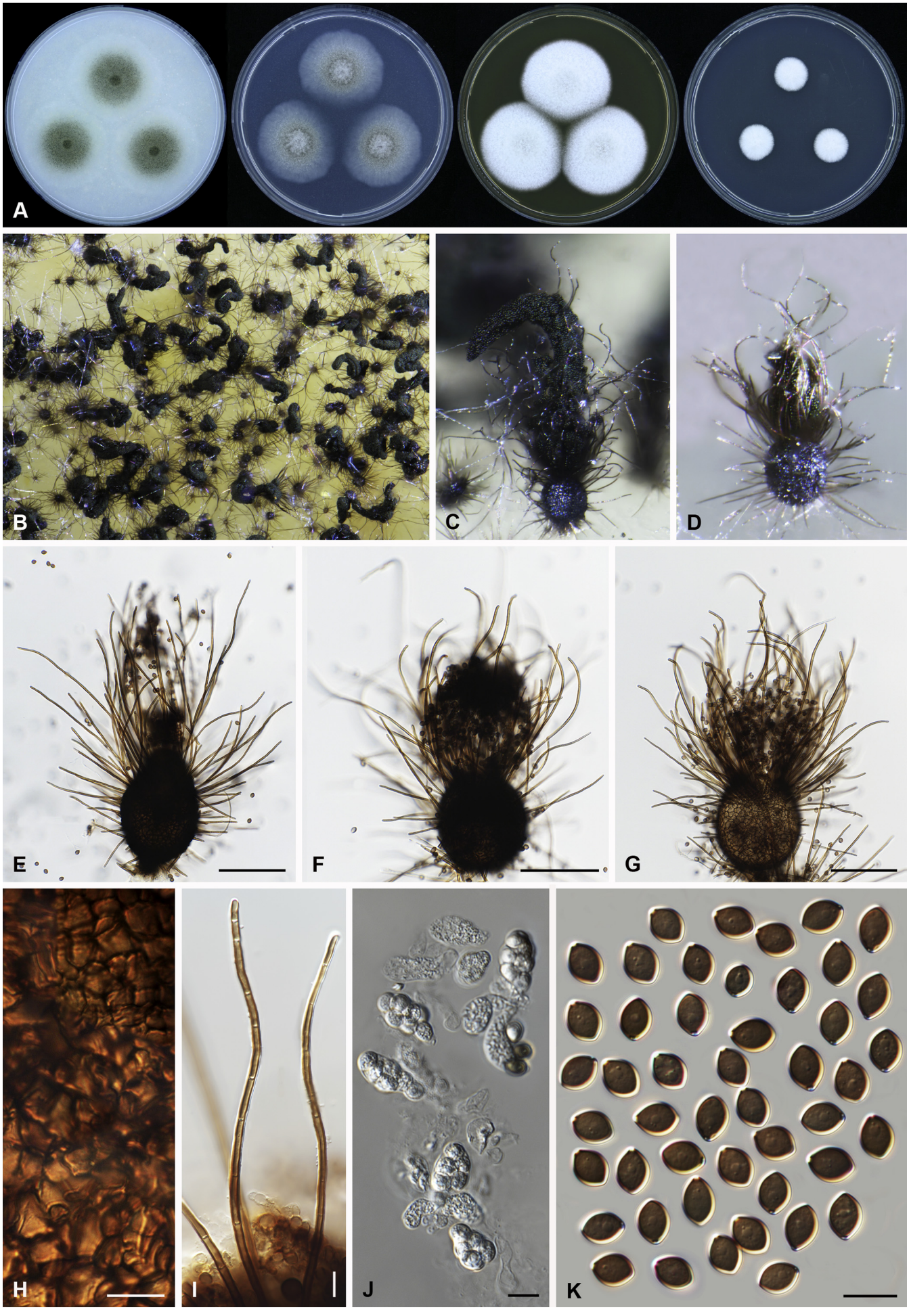


Fig. 3. *Amesia atrobrunnea* (CBS 379.66). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of ascomatal wall in surface view. I. Terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–G = 100 µm; H–K = 10 µm.

Fig. 2. Morphology of the genus *Amesia*. Ascoma: A. *Am. atrobrunnea* (CBS 379.66^{T}). B. *Am. gelasinospora* (CBS 643.83). C. *Am. cymbiformis* (CBS 176.84). D. *Am. nigricolor* (CBS 291.83). Ascospores: E. *Am. atrobrunnea* (CBS 379.66^{T}). F. *Am. gelasinospora* (CBS 643.83). G. *Am. cymbiformis* (CBS 176.84). H. *Am. nigricolor* (CBS 291.83). Scale bars: A–D = 100 µm; E–H = 10 µm.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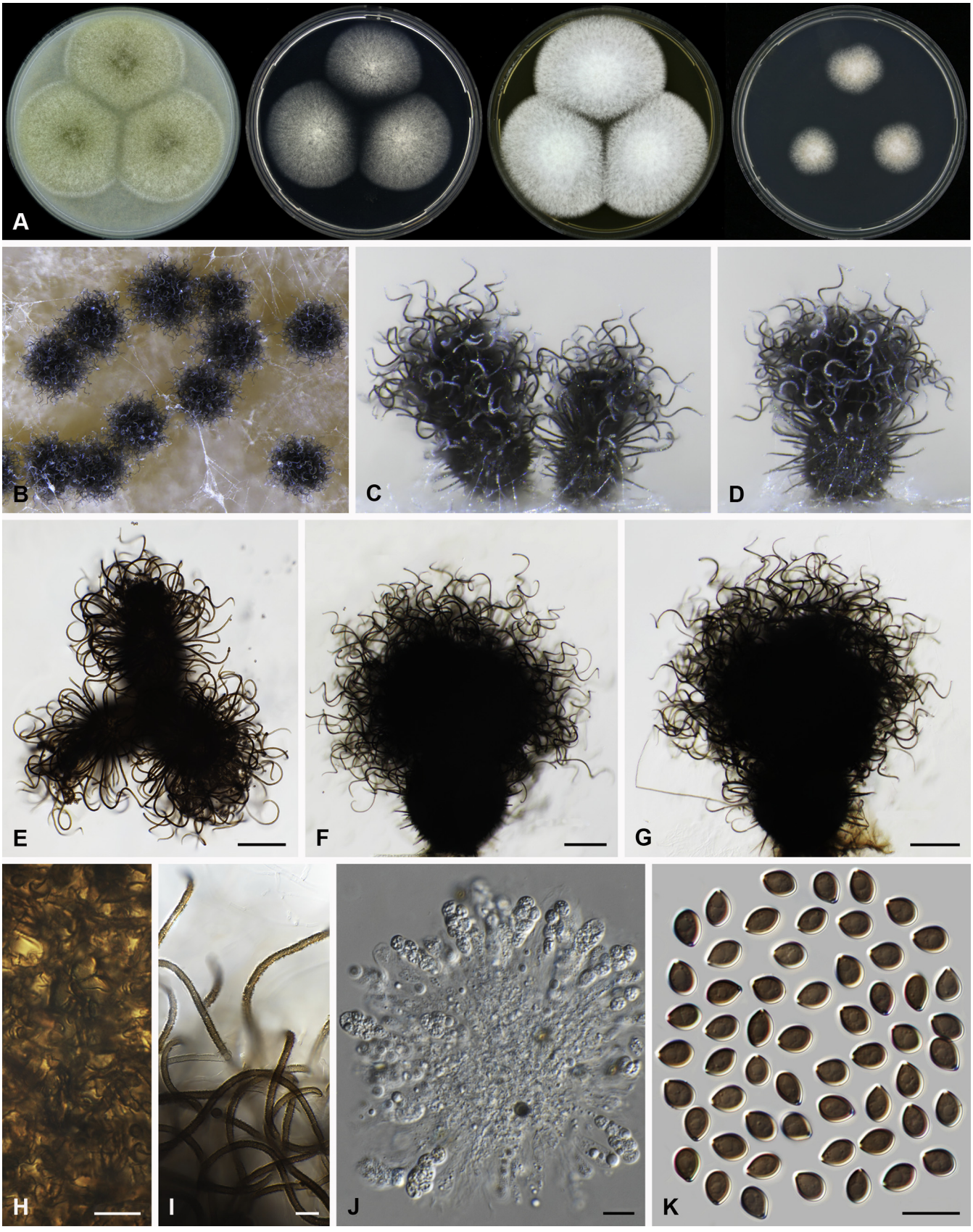


Fig. 5. *Amesia nigricolor* (CBS 291.83). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of ascomatal wall in surface view. I. Terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–G = 100 µm; H–K = 10 µm.

Fig. 4. *Amesia cymbiformis* (CBS 176.84). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of ascomatal wall in surface view. I. Terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–G = 100 µm; H–K = 10 µm.

3.5–6.5 µm diam near the base, partly ochraceous to cinnamon with the widest lower middle portion in 7–9 µm diam and a brown to dark brown tip; partly dark brown but fading and tapering towards the tips. *Lateral hairs* flexuous or recurved, ochraceous, fading and tapering towards the tips. *Asci* fasciculate, clavate, spore-bearing portion 19–28 × 8.5–12 µm, stalks 8–15 µm long, with 8 ascospores, evanescent. *Ascospores* dark brown when mature, limoniform, sometimes asymmetrical, bilaterally flattened, (8–)8.5–10.5(–11) × (6.5–)7–8(–8.5) × (5–)5.5–6.5 µm, with apical germ pores at both ends. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire edge, about 30–36 mm diam in 7 d at 25 °C, with floccose white aerial hyphae at the beginning, with amber to luteous exudates diffusing into the medium, reverse amber to luteous. Colonies on PCA with pale luteous to amber crenated edge, about 25–31 mm diam in 7 d at 25 °C, pale amber with floccose buff aerial hyphae mixed with ascomata, with amber exudates diffusing into the medium; reverse amber. Colonies on MEA with entire edge, about 34–40 mm diam in 7 d at 25 °C, with floccose white aerial mycelium, with red to pale rust exudates diffusing into the medium, reverse rust. Colony growth on DG18 pale rosy buff with entire edge, about 7–13 mm diam in 7 d at 25 °C, without coloured exudates; reverse uncoloured.

Specimen examined: **USA**, isolated from top of storage tent by G.W. Martin, ex-type culture CBS 169.52.

Notes: The ascospores of *Ar. turgidopilosus* are sometimes asymmetrical, but less inequilateral than most of the other species known in this genus (Fig. 6). Furthermore, this species is distinct from the other species by its swollen ascomatal hairs (Fig. 7I). Phylogenetic inference places this species in a basal position to the other known species in the genus.

Botryotrichum Sacc. & Marchal, *Bull. Soc. R. Bot. Belg.* 24(1): 66. 1885.
Synonym: *Emilmuelleria* Arx, Sydowia 38: 6. 1985.

Type species: *Botryotrichum piluliferum* Sacc. & Marchal

Notes: *Botryotrichum piluliferum* was first described as an asexual species based on an isolate from Belgium (Saccardo 1886). Daniels (1961) induced perithecia from soil-buried cellulose films with a culture of *B. piluliferum*, and named the induced organism as *Ch. piluliferum*, the sexual morph of *B. piluliferum*. *Chaetomium piluliferum* was noted to be closely related to *Ch. murorum* by ellipsoid ascospores and unbranched ascomatal hairs with circinate tips (Daniels 1961, von Arx *et al.* 1986). Our phylogenetic analyses strongly support a monophyletic lineage containing *B. piluliferum*, two other *Botryotrichum* species, *Ch. murorum* and *E. spirotricha*, the type species of the monotypic genus *Emilmuelleria*. This lineage is more closely related to the genus *Subramaniula* than to the other lineages in the *Chaetomiaceae*. Since their sister relationships received low bootstrap support (MP-BS = 54), we prefer to keep these two clades as two separate genera for now.

Three indoor species of *Botryotrichum* are described below. More research based on a higher number of strains and species is required to better delimit this genus.

Botryotrichum murorum (Corda) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818837. Figs 8, 9.
Basionym: *Chaetomium murorum* Corda, Icon. Fung. 1: 24. 1837.

Ascomata superficial, ostiolate, grey olivaceous, olivaceous to brown vinaceous in reflected light due to ascomatal hairs, subglobose or ovate, 160–320 µm high, 150–270 µm diam. *Ascomatal wall* brown, *textura intricata* or *epidermoidea* in surface view. *Terminal hairs* usually over four times longer than ascoma, flexuous or undulate, often circinate at the apex (DTO 324-G9, Fig. 8), or undulate, usually apically straight, occasionally recurved or circinate at the apex (DTO 333-E6, Fig. 9), olivaceous brown, smooth, 4.5–7.5 µm diam near the base, up to about 3 mm long. *Lateral hairs* seta-like, shorter. *Asci* fasciculate, fusiform, sometimes clavate, spore-bearing portion 27–45 × 12.5–19 µm, stalks 12–36 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* olivaceous brown when mature, ellipsoidal-fusiform, (12–)12.5–15(–16.5) × (7–)7.5–8.5 µm, with an apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with a lobate or crenated edge, about 32–39 mm diam in 7 d at 25 °C, with sparse smoke grey aerial hyphae mixed with pale olivaceous grey ascomata, with vinaceous buff to livid purple or livid violet exudates diffusing into the medium, reverse pale purplish grey to fuscous black. Colonies on PCA showing an entire or slightly crenated edge with aerial hyphae olivaceous buff (DTO 324-G9, Fig. 8), or showing a irregularly or radially striated with lobate edge without aerial hyphae (DTO 333-E6, Fig. 9), with a few concentric and lobate rings on it, about 24–34 mm diam in 7 d at 25 °C, without coloured exudates; reverse olivaceous buff to honey. Colonies on MEA with a slightly undulate or lobate edge, about 30–37 mm diam in 7 d at 25 °C, possessing white and floccose with radial furrows (DTO 324-G9, Fig. 8) or pale olivaceous grey to white and floccose mycelium with concentric and floral or irregular rings on it (DTO 333-E6, Fig. 9), non-sporulating, without coloured exudates; reverse uncoloured at the beginning, then ochraceous, umber to cinnamon. Colonies on DG18 with an irregularly crenated edge, about 9–17 mm diam in 7 d at 25 °C, pale buff to buff, wrinkled on the surface, without aerial hyphae, non-sporulating, without coloured exudates; reverse uncoloured to pale luteous.

Specimens examined: **China**, isolated from air by A.J. Chen, culture DTO 324-G9. **Denmark**, isolated from ceiling tile by B. Andersen, culture DTO 333-E6 (= IBT 42175).

Notes: Isolates DTO 324-G9 and DTO 333-E6 have different colony morphologies and ascomatal hairs. The ascospores of DTO 324-G9 are also slightly bigger than those of DTO 333-E6. However, the phylogenetic analysis did not show any sequence differences between them, suggesting that the differences mentioned above represent the morphological diversity within the species.

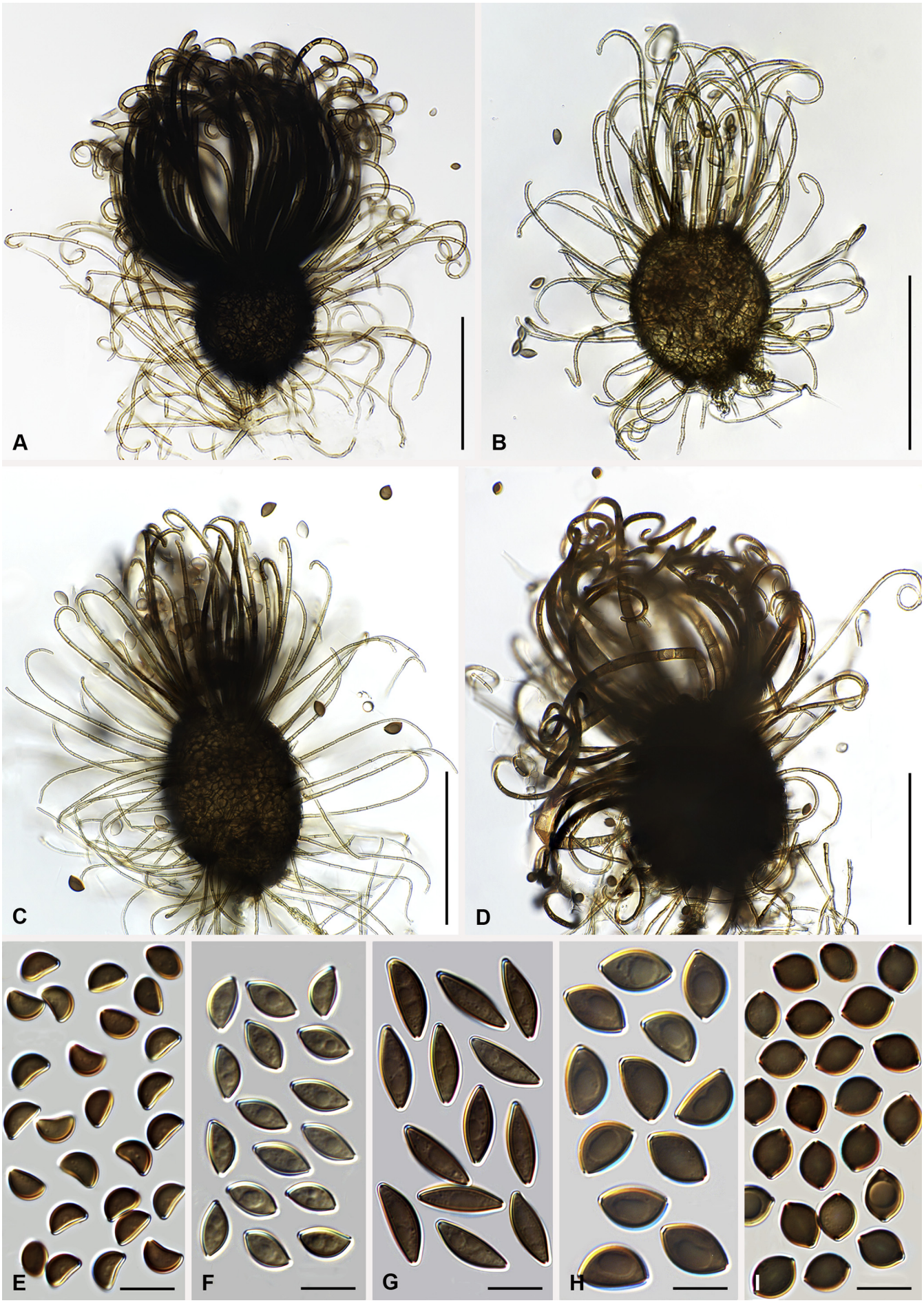


Fig. 6. Morphological diversity in the genus *Arcopilus*. Ascoma: A. *Ar. cupreus* (CBS 560.80). B. *Ar. aureus* (CBS 153.52). C. *Ar. flavigenus* (CBS 337.67^{T}). D. *Ar. turgidopilosus* (CBS 169.52^{T}). Ascospores: E. *Ar. cupreus* (CBS 560.80). F. *Ar. aureus* (CBS 153.52). G. *Ar. fusiformis* (CBS 484.85). H. *Ar. flavigenus* (CBS 337.67^{T}). I. *Ar. turgidopilosus* (CBS 169.52^{T}). Scale bars: A–D = 100 µm; E–I = 10 µm.

Fig. 7. *Arcopilus turgidopilosus* (CBS 169.52^{T}). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. An terminal ascomatal hair fading and tapering towards the tips. I. An terminal ascomatal hair with the widest lower middle portion. J. Asci. K. Ascospores. Scale bars: D = 100 µm; E–F = 20 µm; G–K = 10 µm.

Botryotrichum peruvianum Matsush., Icon. Microfung. Matsush. Lect. (Kobe): 17. 1975. Fig. 10.

Sexual morph unknown. *Sterile setae* often solitary, sometimes clustered with conidiophores, brown, verrucose, erect, flexuous or undulate, unbranched, 2.5–4.5 µm diam near the base, up to 2 200 µm long. *Conidiophores* descrete or clustered with a tuft of setae, hyaline, occasionally ochraceous, 2–4.5 µm near the base, up to 60 µm long, usually sympodially branched to produce several conidiogenous cells. *Conidiogenous cells* terminal or intercalary, monoblastic or sympodially polyblastic, cylindrical to degenerated form like a broad denticle, 0–14.5 × 2–3.5 µm, sometimes swollen beneath the conidium. *Conidia* single, occasionally two to three in chains, globose to subglobose, hyaline when young, then becoming pale luteous to ochraceous, conspicuously roughtened, (10–)12–16(–17.5) µm diam.

Culture characteristics: Colonies on OA with an entire edge, 36–41 mm diam in 7 d at 25 °C, with sparse white aerial hyphae, and then becoming ochraceous to pale mouse grey because of the formation of groups of conidia and setae, without coloured exudates; reverse uncoloured. Colonies on PCA with an undulate to lobate edge, about 22–28 mm diam in 7 d at 25 °C, with sparse white aerial hyphae, pale luteous in the centre, without coloured exudates; reverse honey in the centre. Colonies on MEA with a slightly lobate edge, about 21–28 mm diam in 7 d at 25 °C, with floccose, buff to pale ochraceous aerial hyphae, greyish sepia in the centre; without coloured exudates; reverse ochraceous to umber. Colonies on DG18 buff to honey, with a slightly crenated edge, about 9–15 mm diam in 7 d at 25 °C, slightly winkled without aerial hyphae; without coloured exudates; reverse buff.

Specimen examined: **Cuba**, isolated from air by R. Castañeda, culture CBS 421.93.

Note: This species can be distinguished from *B. piluliferum* by conspicuously roughened and pigmented conidia and by longer setae.

Botryotrichum piluliferum Sacc. & Marchal, *Bull. Soc. R. Bot. Belg.* 24(1): 66. 1885. Fig. 11.
Synonym: *Chaetomium piluliferum* Daniels, Trans. Br. Mycol. Soc. 44: 84. 1961.

Sexual morph absence in the examined specimens. *Sterile setae* solitary or in group from the hyaline hypha, brown, verrucose, erect or flexuous, unbranched or branched near the base, 3.5–7.5 µm diam near the base, usually less than 300 µm long, occasionally up to 690 µm long. *Conidiophores* usually produced together with a tuft of setae, or descreate, hyaline, occasionally ochraceous, 3–5 µm near the base, up to 40 µm long, usually sympodially branched to produce several conidiogenous cells. *Conidiogenous cells* terminal or intercalary, monoblastic or sympodially polyblastic, cylindrical to broad denticle, more or less constricted at the base, 0–13 × 2–4.5 µm. *Conidia* usually single, globose to subglobose, hyaline, occasionally ochraceous to umber, smooth to slightly roughtened, (9–)11–17.5(–18.5) µm diam.

Culture characteristics: Colonies on OA with an irregularly fimbriate edge, 22–28 mm diam in 7 d at 25 °C, with white and sparsely floccose aerial hyphae and then partially becoming pale mouse grey because of the formation of groups of setae, without coloured exudates; reverse uncoloured. Colonies on PCA with entire or slightly undulate edge, about 18–24 mm diam in 7 d at 25 °C, with white to buff, floccose aerial hyphae, without coloured exudates; reverse honey to pale luteous. Colonies on MEA with an entire edge, about 25–31 mm diam in 7 d at 25 °C, with floccose, white to rosy buff aerial hyphae; without coloured exudates; reverse ochraceous. Colonies on DG18 buff to honey, with an entire or lobate edge, about 7–13 mm diam in 7 d at 25 °C, winkled without aerial hyphae; without coloured exudates; reverse luteous.

Specimens examined: **Netherlands**, isolated from a wall, cultures DTO 194-F7, DTO 254-B8, DTO 254-B9.

Notes: The indoor isolates match the original description of *B. piluliferum* (Saccardo 1886). According to the observation of Daniels (1961), aside from the ascomata, the asexual morph of *Ch. piluliferum* produced two different types of asexual structures: one (text and fig. 1 in Daniels 1961) was similar to the description above, another was acremonium-like with hyaline conidia forming in chains on simple and hyaline phialides (text and fig. 2 in Daniels 1961). In our study, neither ascomata nor an acremonium-like morph was observed in the cultures of the indoor isolates.

Chaetomium Kunze, Mykol. Hefte 1: 16. 1817.

Ascomata globose, ellipsoid to ovate or obovate, ostiolate or non-ostiolate in a few species, with walls usually composed of *textura intricata* or *epidermoidea* in surface view, or of *textura angularis* in a few species. *Ascomatal hairs* hypha-like, flexuous, undulate, coiled to simply or dichotomously branched, with verrucose surface, or smooth in a few species. *Asci* clavate or fusiform with 8 biseriate or irregularly arranged ascospores, evanescent. *Ascospores* limoniform to globose, or irregular in a few species, bilaterally flattened, usually more than 7 µm in length. *Asexual morphs*, if present, acremonium-like.

Type species: *Chaetomium globosum* Kunze.

Notes: Since Saccardo (1882) separated *Chaetomidium* from *Chaetomium* as a distinct genus, *Chaetomium* had been defined to be a genus possessing typical ostiolate ascomata for over 100 years. Robust phylogenetic evidence (Wang *et al.* 2016) indicated that three species of *Chaetomidium*, including its type species *Ch. fimeti*, clustered in the *Chaetomium globosum* species complex. The data generated in this study further proved that the traditional morphologically-defined *Chaetomium* (Ames 1963, von Arx *et al.* 1986) has been divided into several different lineages which are intermingled with several other genera in the *Chaetomiaceae*. On the other hand, the monophyly of the *Chaetomium globosum* species complex was confirmed by the phylogenetic analysis based on the expanded dataset in this study (Fig. 1), thus the genus *Chaetomium* is restricted to the *Chaetomium globosum* species complex.

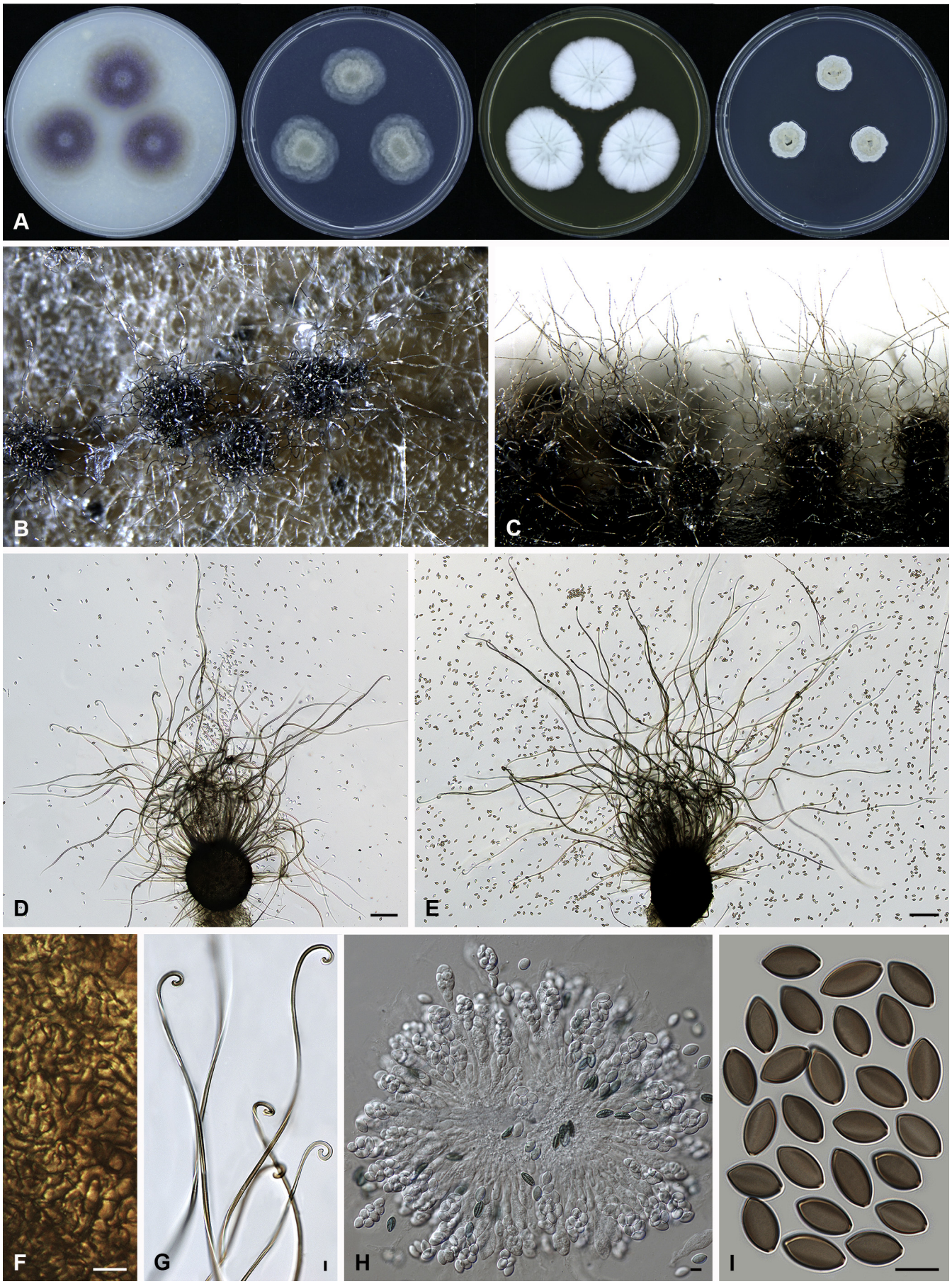


Fig. 8. *Botryotrichum murorum* (DTO 324-G9). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Structure of ascomatal wall in surface view. G. Upper part of a terminal ascomatal hair. H. Asci. I. Ascospores. Scale bars: D–E = 100 µm; F–I = 10 µm.

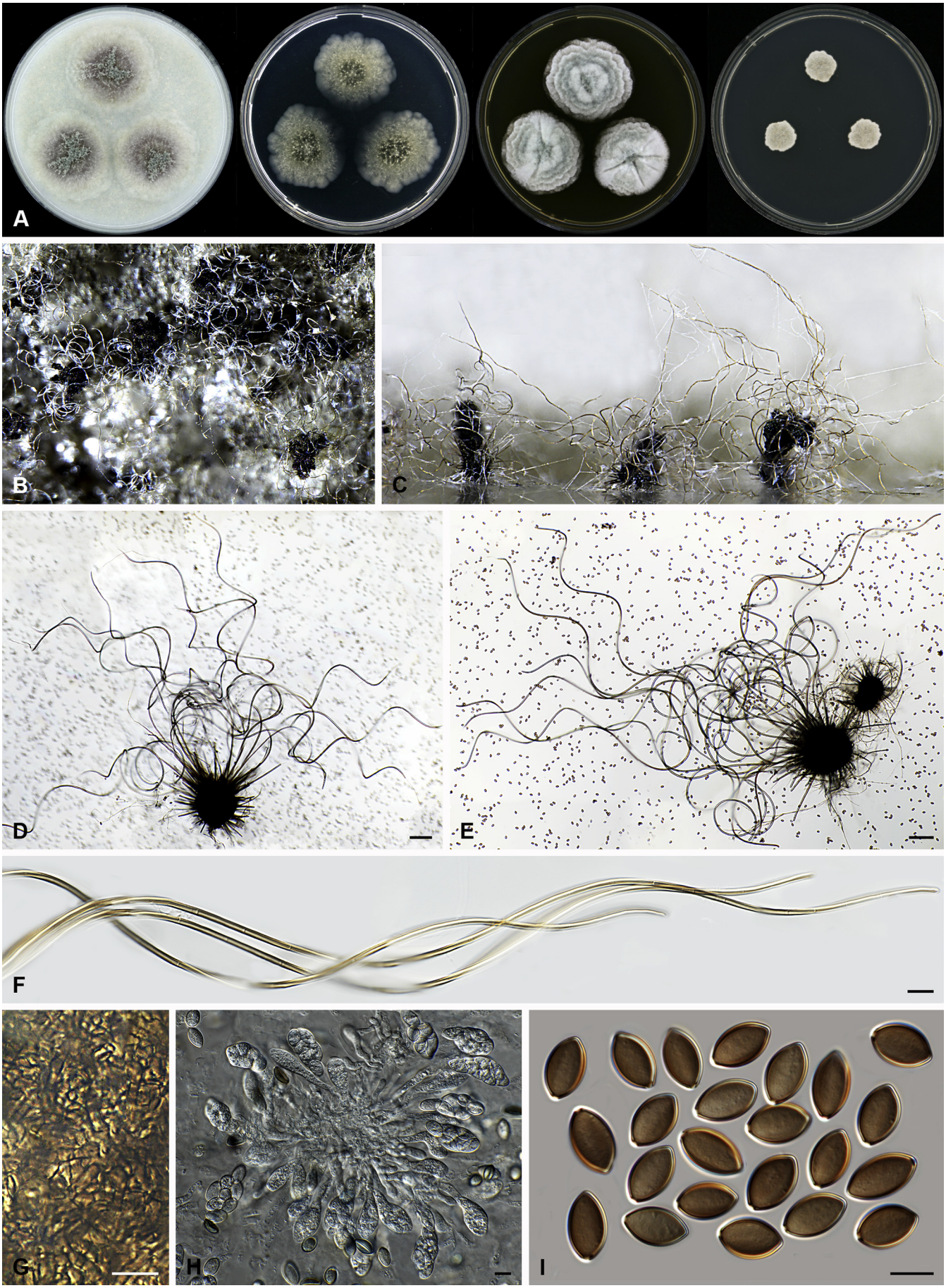


Fig. 9. *Botryotrichum murorum* (DTO 333-E6). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Upper part of terminal ascomatal hairs. G. Structure of ascomatal wall in surface view. H. Asci. I. Ascospores. Scale bars: D–E = 100 µm; F–I = 10 µm.

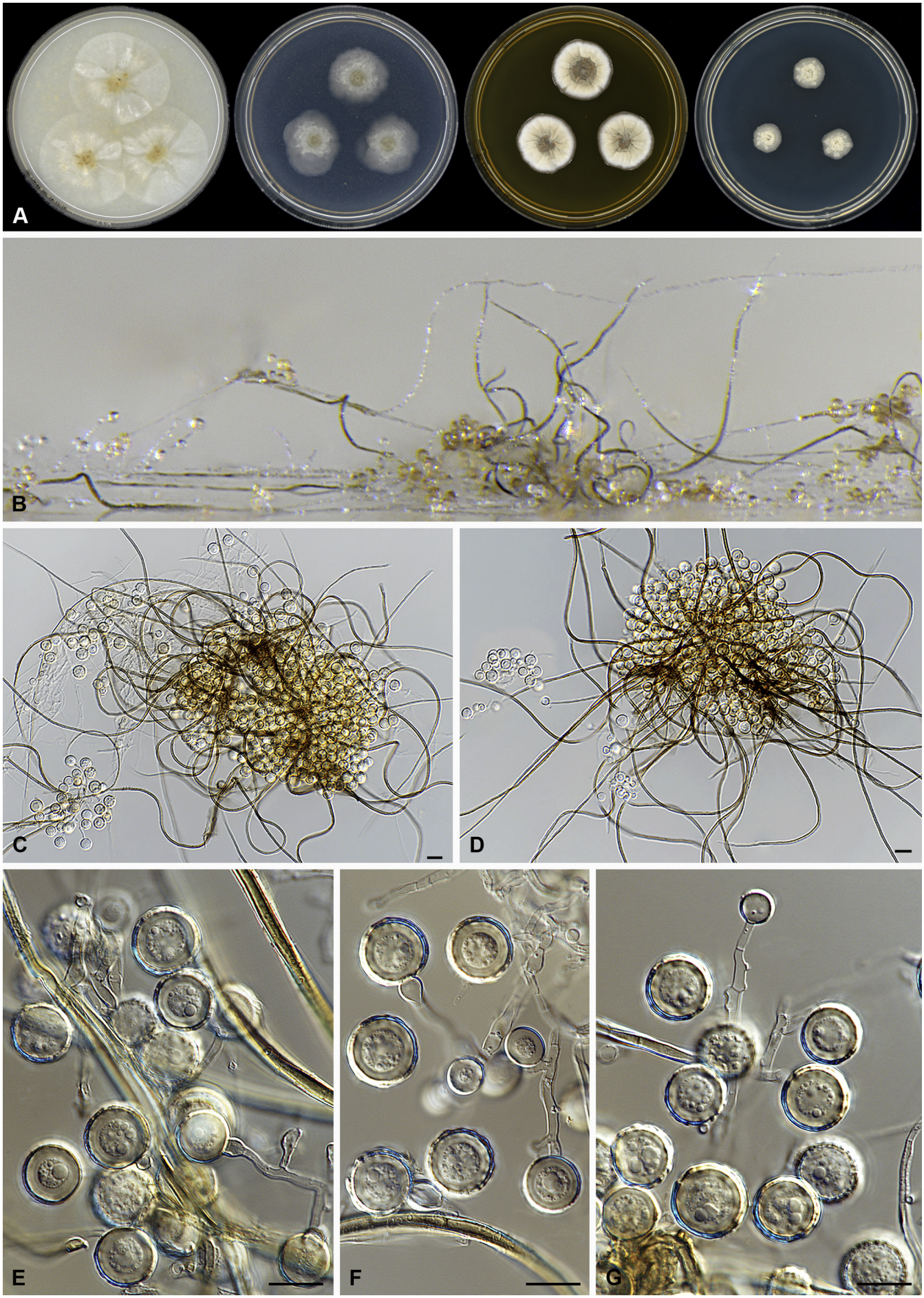


Fig. 10. *Botryotrichum peruvianum* (CBS 421.93). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Conidia on conidiophores together with setae on SNA, top view. C–D. Conidia on conidiophores together with setae mounted in lactic acid. E–G. Conidiophores with conidia. Scale bars: C–D = 20 µm; E–G = 10 µm.

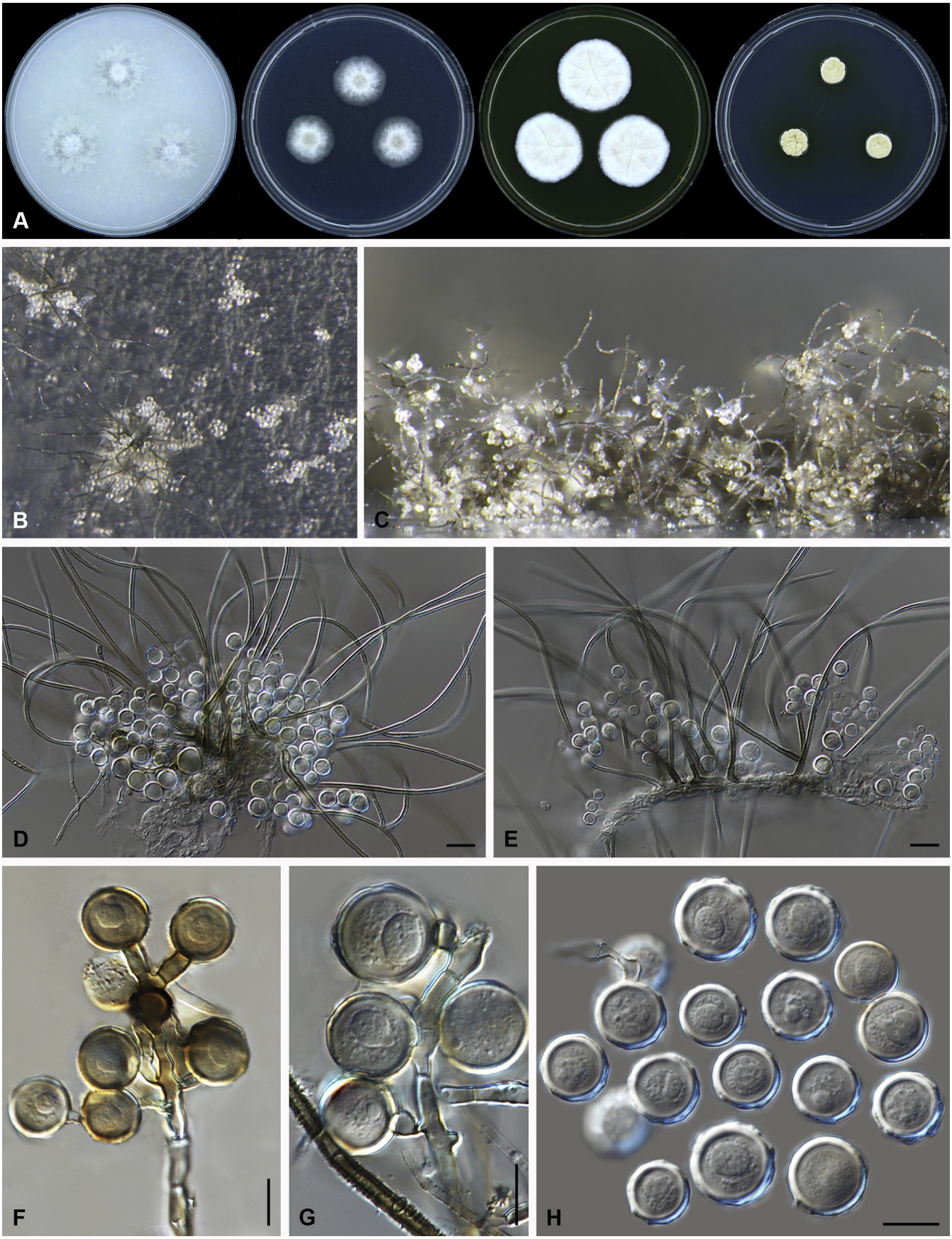


Fig. 11. *Botryotrichum piluliferum* (DTO 254-B8). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Conidia on conidiophores together with setae on SNA, top view; C. Conidia on conidiophores together with setae on SNA, side view. D–E. Conidia on conidiophores together with setae mounted in lactic acid. F–G. Conidiophores with conidia. H. Conidia. Scale bars: D–E = 20 µm; F–H = 10 µm.

Six indoor species were recognised in this genus.

Chaetomium cervicicola X. Wei Wang *et al.,* Persoonia 36: 93. 2016.

Culture sterile.

Specimen examined: **Mexico**, isolated from dust, culture DTO 318-G6.

Notes: This isolate phylogenetically clustered in the *Ch. cervicicola* clade. The ex-type culture CBS 128492 was also sterile. See phylogenetic description in Wang *et al.* (2016).

Chaetomium coarctatum Sergejeva, Not. Syst. sect. Crypt. Inst. Bot. Acad. Sci. U.S.S.R. 14: 146. 1961. Fig. 12.

Ascomata superficial, ostiolate, greyish white to olivaceous buff in reflected light owing to ascomatal hairs, subglobose, 320–480 µm high, 250–390 µm diam. *Ascomatal wall* brown, *textura epidermoidea* or *intricata* in surface view. *Terminal hairs* conspicuously rough, brown, undulate, 3–4 µm near the base and tapering towards the tips. *Lateral hairs* erect or flexuous, tapering towards the tips. *Asci* fasciculate, fusiform or clavate, spore-bearing part 31–43 × 14–21 µm, stalks 20–38 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* olivaceous brown when mature, broad limoniform to nearly globose, biapiculate, bilaterally flattened, (9–)10–12 × 9.5–11(–11.5) × (6–)6.5–7.5(–8) µm, with an apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge, spreading rapidly, over 70 mm diam in 7 d at 25 °C, with sparse white to buff aerial hyphae and pale greenish olivaceous to greenish olivaceous or citrine exudates diffusing into the medium; reverse ochraceous to citrine. Colonies on PCA honey to yellow with an irregular, fimbriate or rhizoid edge, about 42–48 mm diam in 7 d at 25 °C, with spare and pale luteous aerial hyphae, with amber exudates diffusing into the medium; reverse amber to luteous. Colonies on MEA buff with an entire edge, spreading rapidly, over 70 mm diam in 7 d at 25 °C, with floccose, greyish white aerial hyphae; reverse pale luteous to luteous owing to exudates diffusing into the medium. Colonies on DG18 buff or honey, with a thinner and irregular lobate or petaloid perisphere, about 17–23 mm diam in 7 d at 25 °C, with sparse white aerial hyphae; reverse scarlet owing to exudates diffusing into the medium.

Specimen examined: **China**, Beijing, isolated from air by A.J. Chen, culture DTO 324-H2.

Note: The morphology of the indoor isolates studied here fits with that of the ex-type culture, CBS 162.62 (fig. 8 in Wang *et al.* 2016), indicating that this species has a relatively stable morphology.

Chaetomium cochliodes Palliser, North Amer. Flora 3:61. 1910. Fig. 13.

Ascomata superficial, ostiolate, greenish olivaceous to dark citrine in reflected light owing to ascomatal hairs, ellipsoid or subglobose, 200–440 µm high, 140–420 µm diam. *Ascomatal wall* brown, *textura intricata* in surface view. *Terminal hairs* conspicuously rough, dark brown, erect in the lower part, 3.5–6 µm near the base, tapering and fading towards the tips, spirally coiled in the upper part, usually with coils regularly tapering in diameter towards the tips, occasionally with coiled branches. *Lateral hairs* brown, flexuous, undulate or loosely coiled, tapering and fading towards the tips. *Asci* fasciculate, fusiform or clavate, spore-bearing part 30–45 × 13.5–21 µm, stalks 28–56 µm long, with 8 biseriate ascospores, evanescent. *Ascospores* brown when mature, limoniform, usually biapiculate at both ends, bilaterally flattened, (8.5–)9–10.5(–11) × (7–)7.5–9(–9.5) × 5.5–6.5 µm, with an apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge and spreading rapidly, over 70 mm diam in 7 d at 25 °C, usually with sparse buff and floccose aerial hyphae, then without aerial hyphae when ascomata manure, with pale luteous or pale amber to citrine exudates diffusing into the medium, reverse pale amber to pale citrine. Colonies on PCA with a fimbriate to rhizoid edge, about 52–58 mm diam in 7 d at 25 °C, appearing olivaceous buff to greenish olivaceous texture owing to ascomata mixed with sparse aerial hyphae, with pale greenish olivaceous to pale luteous exudates diffusing into the medium; reverse honey to olivaceous buff. Colonies on MEA with an entire edge and spreading rapidly, over 70 mm diam in 7 d at 25 °C, with sparse white or greyish white and floccose aerial hyphae, with citrine exudates diffusing into the medium, reverse sienna with pale perisphere. Colony growth on DG18 with a slightly undulate edge, about 19–25 mm diam in 7 d at 25 °C, buffish white and floccose with white edge, without coloured exudates; reverse uncoloured.

Specimens examined: **Netherlands**, Maastricht, isolated from air, culture DTO 013-C2; Eindhoven, isolated from air, culture DTO 089-E2. **South Africa**, isolated from dust, cultures DTO 319-B5 and DTO 319-B6. **USA**, isolated from dust, cultures DTO 318-H2, DTO 318-H4, DTO 318-H5, DTO 318-H7, DTO 318-H8, DTO 318-I1, 318-I3, DTO 318-I5, DTO 318-I6, DTO 318-I8, DTO 318-I9 and DTO 319-A1. The description above is based on the isolate DTO 318-I1.

Notes: This is a common indoor species, especially in the USA. The indoor isolates showed consistent morphology, fitting with that of *Ch. cochliodes* (ex-epitype CBS 155.52, fig. 9 in Wang *et al.* 2016).

Chaetomium elatum Kunze, Deutsche Schwämme 8: 3, No. 184. 1818. Figs 14, 15.

Ascomata superficial, ostiolate often covered by sparse white or buff aerial hyphae, grey olivaceous to isabelline in reflected light, globose or obovate, 280–440 µm high, 255–380 µm diam. *Ascomatal wall* brown, composed of hypha-like or amorphous cells, *textura intricata* or *textura epidermoidea* in surface view. *Terminal hairs* verrucose or warty, dark brown, tapering and fading towards the tips, erect or flexuous in the lower part, 3–5 µm diam near the base, repeatedly and dichotomously branched at right to nearly straight angles in the upper part, with erect to flexuous (DTO 319-B3) or undulate (DTO 318-H9) terminal branches taping and fading towards the tips. *Lateral hairs* brown, erect or flexuous, occasionally undulate, tapering towards the tips. *Asci* fasciculate, clavate or

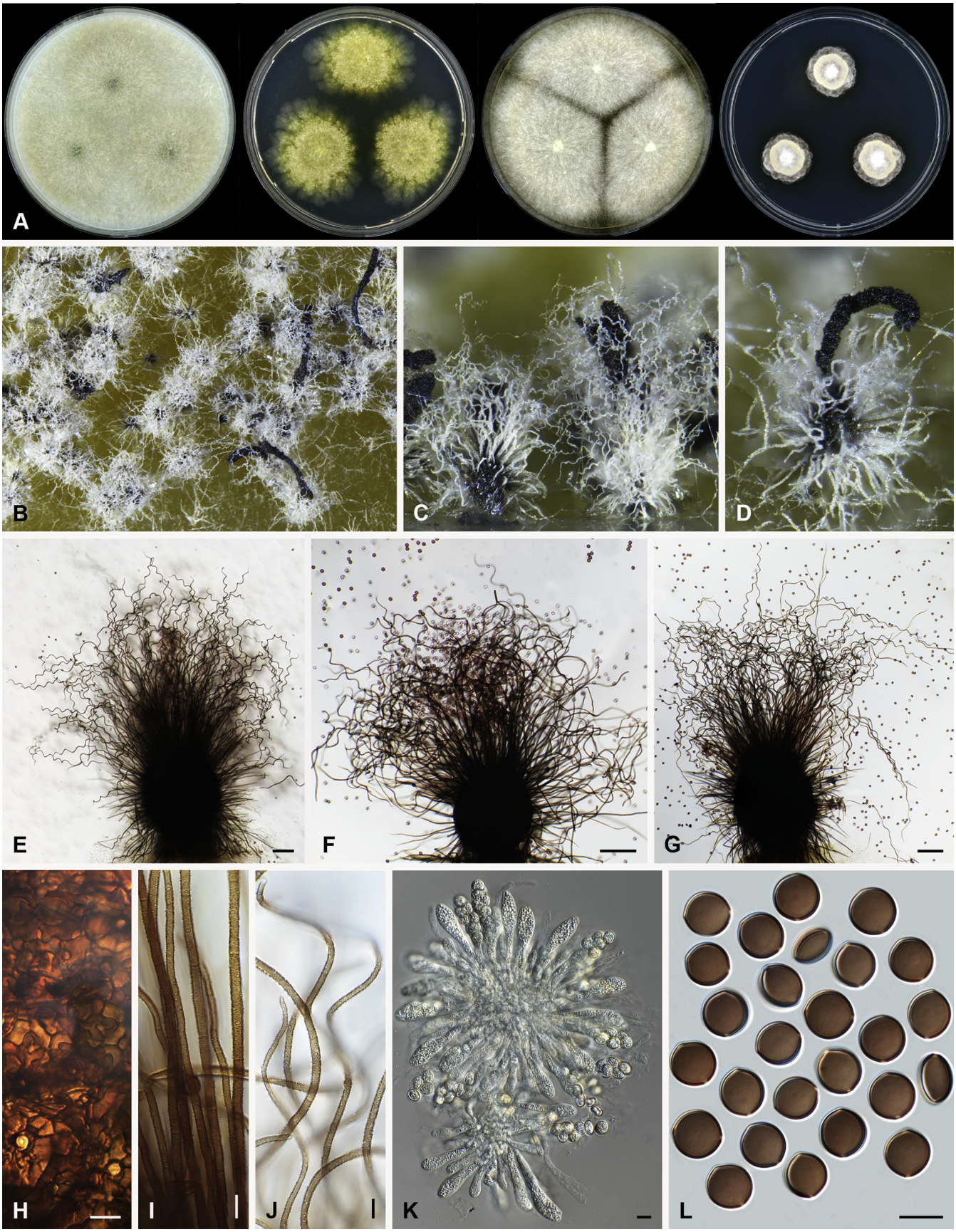
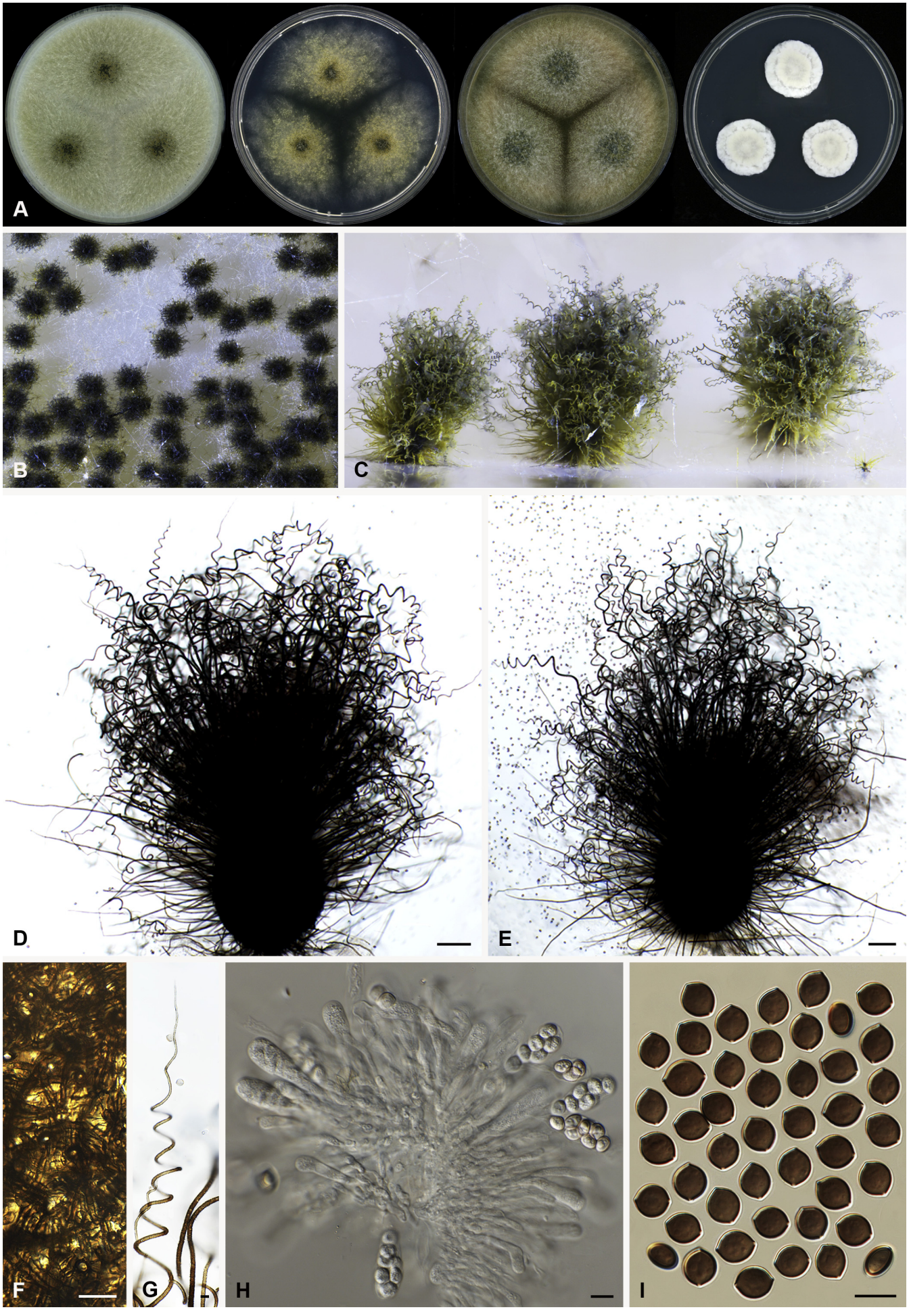


Fig. 12. *Chaetomium coactatum* (DTO 324-H2). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of ascomatal wall in surface view. I. Basal parts of terminal ascomatal hairs. J. Upper parts of terminal ascomatal hairs. K. Asci. L. Ascospores. Scale bars: E–G = 100 µm; H–L = 10 µm.

fusiform, spore-bearing part 36–49 × 12.5–16.5 µm, stalks 24–55 µm long, with 8 biseriate ascospores, evanescent. *Ascospores* brown when mature, limoniform, biapiculate or umbonate, bilaterally flattened, (10–)11.5–13.5(–16) × (8–)8.5–10(–11) × (6.5–)7–8 µm, with an apical germ pore. *Asexual morph* acremonium-like. *Conidiophores* phialidic, formed laterally from aerial hyphae, simple, 6–24.5 µm long, 1.5–3.5 µm diam at the base. *Conidia* formed basipetally in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chains, hyaline, aseptate, smooth, ovate, often with a truncated base and a rounded apex, (2–)2.5–4(–5.5) × 1.5–2(–2.5) µm.

Culture characteristics: Colonies on OA with entire edge and spreading rapidly, over 70 mm diam in 7 d at 25 °C, with sparse, honey to greenish olivaceous aerial hyphae (DTO 319-B3), or forming sparse or radially sectorial, white to buff and floccose aerial hyphae (DTO 318-H9), without coloured exudates when young, or with greyish yellow-green, olivaceous buff to honey exudates diffusing into the medium, reverse honey to greenish olivaceous. Colonies on PCA pale luteous to luteous, with irregularly deep lobate edge, about 52–61 mm diam in 7 d at 25 °C, aerial hyphae sparse and honey, with luteous exudates diffusing into the medium; reverse pale luteous to amber. Colonies on MEA forming pale honey, citrine green to citrine and floccose mycelium with entire edge, about 58–66 mm diam in 7 d at 25 °C, reverse citrine green to citrine. Colony growth on DG18 forming white to buff aerial hyphae, with slightly lobate or rhizoid edge, 18–23 mm diam in 7 d at 25 °C, non-sporulating, without coloured exudates; reverse buff.

Specimens examined: **Australia**, isolated from dust, culture DTO 319-B3. **Denmark**, isolated from cardboard by B. Andersen, **neotype designated here,** herbarium CBS H-22851, MBT 373430, culture ex-neotype CBS 142034 = DTO 333-E9 (= IBT 42179); from dust, culture DTO 333-E5 (= IBT 41944); from gypsum, culture DTO 333-F8 (= IBT 42329). **USA**, isolated from dust, cultures DTO 318-G7; DTO 318-H9.

Notes: Chaetomium elatum was originally described based on an isolate collected from dead leaves in Germany. Our attempt to find the holotype of *Ch. elatum* housed in B (Botanischer Garten und Botanisches Museum Berlin-Dahlem, Zentraleinrichtung der Freien Universität Berlin) was unsuccessful because the ascomycete collection was partly destroyed by a fire in 1943, in which the holotype of *Ch. globosum* might have been included. Therefore, a dried culture, CBS H-22851 from DTO 333-E9, is designated here as neotype of *Ch. elatum*, which was collected in Denmark geographically close to the collection location of the holotype.

As in our previous study (Wang *et al.* 2016), the phylogenetically defined *Ch. elatum* showed a diverse morphology in terminal ascomatal hairs. For example, CBS 910.70 (ex-type cultue of *Ch. ramipilosum*) exhibits relatively slender and flexible terminal hairs (2.5–4.5 µm diam near the base, fig. 10 in Wang *et al.* 2016), while DTO 319-B3, DTO 318-H9 and DTO 333-E9 exhibit relatively rigid terminal hairs which are more similar to *Ch. rectangulare*. Also DTO 319-B3 has erect to flexuous terminal branches of the hairs (Fig. 14), while DTO 318-H9 and DTO 333-E9 have undulate terminal branches of the hairs (Fig. 15). However, *Ch. rectangulare* can be distinguished from *Ch. elatum* by smaller ascospores (10–11 × 7–9 × 6–7.5 µm) and thicker terminal hairs (4.5–7 µm diam near the base fig. 28 in Wang *et al.* 2016).

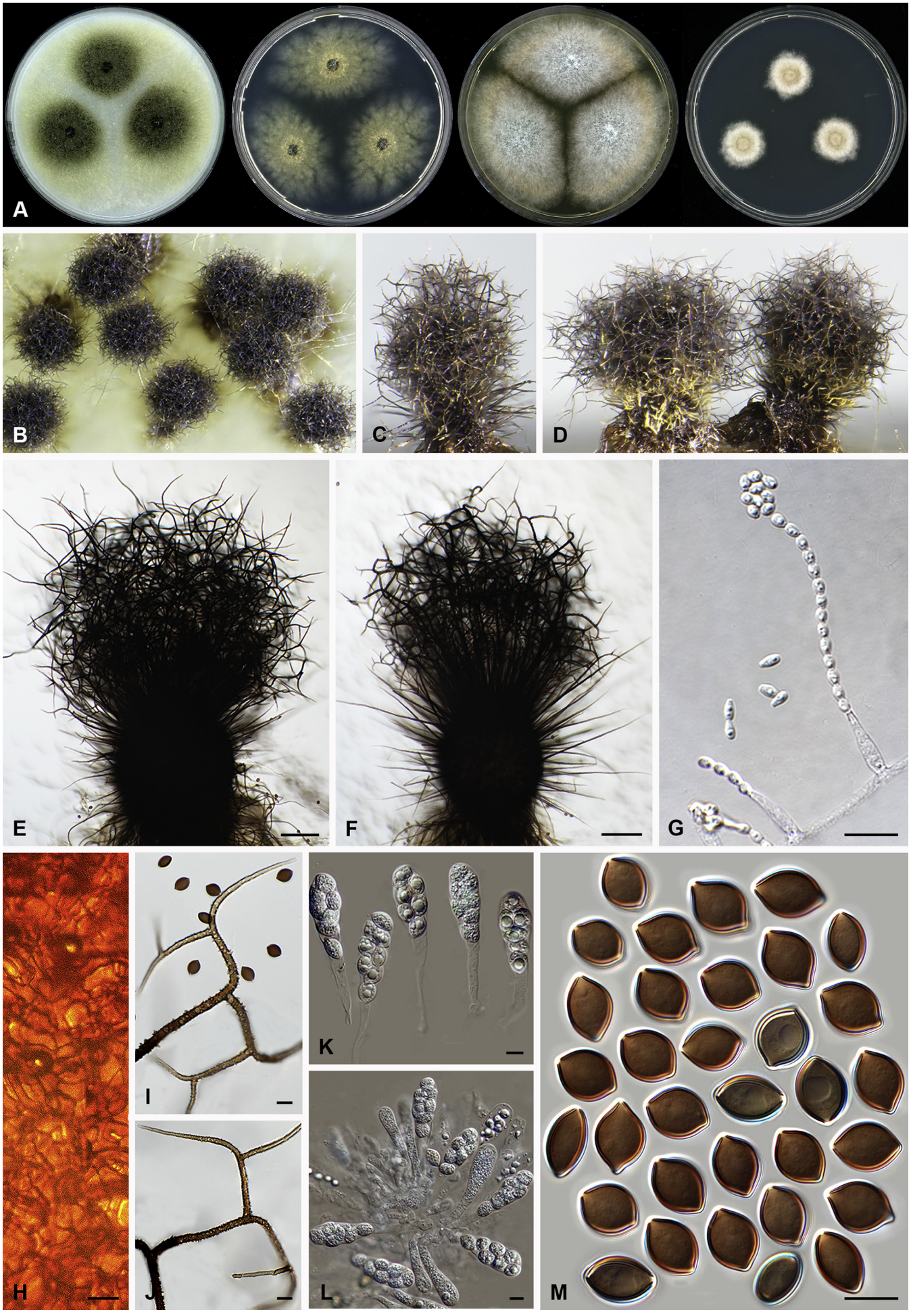
Chaetomium globosum Kunze, Mykol. Hefte 1: 16. 1817. Figs 16–18.

Ascomata superficial, ostiolate, greenish olivaceous (DTO 319-B2), or slightly dark olivaceous buff to grey (DTO 333-E3), or dull green (CBS 666.82) in reflected light owing to ascomatal hairs which can possess sulphur yellow lower parts (DTO 319-B2) or appear sulphur yellow to yellow (CBS 666.82), subglobose, ovate or obovate, 140–270 µm high, 100–240 µm diam. *Ascomatal wall* brown, *textura intricata* in surface view. *Terminal hairs* finely warty, brown, erect (more often in CBS 666.82) or flexuous (more often in DTO 333-E3) or undulate to loosely coiled (most of the indoor isolates, see DTO 319-B2, Fig. 16) with erect or flexuous lower part, tapering and fading towards the tips, 2–5 µm diam near the base. *Lateral hairs* brown, flexuous, fading and tapering towards the tips. *Asci* fasciculate, fusiform or clavate, spore-bearing part 19–38 × 12–17 µm, stalks 22–48 µm long (most of the indoor isolates, Figs 16, 17), or 10–19 µm long (CBS 666.82) with 8 irregularly-arranged ascospores, evanescent. *Ascospores* brown when mature, limoniform, usually biapiculate, bilaterally flattened, 8.5–11(–12) × 7–8.5(–9.5) × 5.5–7 µm, with an apical germ pore. *Asexual morph* absent.

Culture characteristics: Colonies on OA with an entire edge, spreading rapidly, over 70 mm diam in 7 d at 25 °C, with sparse white to olivaceous buff aerial hyphae when young, then without aerial hyphae and becoming citrine green, yellow, greenish olivaceous to grey olivaceous (most of the indoor isolates, Figs 16, 17) or dull green (CBS 666.82) owing to the aggregation of ascomata, with fulvous, apricot to sienna exudates (DTO 319-B2), or olivaceous to olivaceous grey exudates (DTO 333-E3) or ochraceous to greenish olivaceous exudates (CBS 666.82) diffusing into the medium; reverse apricot, orange or sienna (DTO 319-B2), grey olivaceous to olivaceous (DTO 333-E3) or umber to dark brick (CBS 666.82). Colonies on PCA translucent, usually with a more or less lobate edge, about 39–48 mm diam in 7 d at 25 °C, without or with very sparse and floccose, pale yellow aerial hyphae, without coloured exudates; reverse uncoloured. Colonies on MEA with an entire (DTO 319-B2 and CBS 666.82) or a fimbriate to rhizoid (DTO 333-E3) edge, spreading rapidly, over 70 mm diam in 7 d at 25 °C, honey to olivaceous buff (DTO 319-B2 and DTO 333-E3), or malachite green to dull green (CBS 666.82) owing to the aggregation of ascomata mixed with floccose aerial hyphae, reverse fulvous, orange to sienna (DTO 319-B2 and DTO 333-E3) or scarlet to rust (CBS 666.82) owing to exudates diffusing into the medium. Colonies on DG18 with a lobate or slightly crenated edge, about 10–17 mm diam in 7 d at 25 °C, buff to pale luteous, with sparse white to greyish white aerial hyphae; reverse orange, rust to bay (DTO 319-B2), ochraceous (DTO 333-E3) or scarlet (CBS 666.82) owing to exudates diffusing into the medium.

Specimens examined: **Algeria**, isolated from air, cultures DTO 134-D9; DTO 134-E1; DTO 134-E2; DTO 134-E3; DTO 134-E4; DTO 134-E5. **Canada**, isolated from dust, cultures DTO 318-G3; DTO 318-G4; DTO 318-G5. **China**, isolated from chili powder, culture CBS 666.82; isolated from air by A.J. Chen in Beijing, cultures DTO 324-D7; DTO 324-G8; DTO 324-H1; DTO 324-H4; DTO 324-H5; DTO 324-I1; DTO 324-I2; DTO 324-I3; DTO 324-I4; DTO 324-I5; DTO 324-I6; DTO 324-I7; DTO 324-I8; DTO 324-I9; DTO 325-A1; DTO 325-A2; DTO 325-A3;

Fig. 13. *Chaetomium cochliodes* (DTO 318-I1). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Structure of ascomatal wall in surface view. G. Terminal ascomatal hairs. H. Asci. I. Ascospores. Scale bars: D–E = 100 µm; F–I = 10 µm.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DTO 325-A4. **Denmark**, isolated from carpet by B. Andersen, culture DTO 333-E4 (= IBT 41801); from linoleum by B. Andersen, culture DTO 333-E3 (= IBT 41800); from gypsum by B. Andersen, cultures DTO 333-D7 (= IBT 42328); DTO 333-D8 (= IBT 42326); DTO 333-D9 (= IBT 42327); DTO 333-F4 (= IBT 42297); DTO 333-F5 (= IBT 42299); DTO 333-F6 (= IBT 42301); DTO 333-F7 (= IBT 42325); DTO 333-F9; from plywood by B. Andersen, cultures DTO 333-E1 (= IBT 41766); DTO 333-E8 (= IBT 42177); from oriented strand board by B. Andersen, culture DTO 333-E7 (= IBT 42176). **Germany**, isolated from air, cultures CBS 112386; DTO 340-I2; DTO 012-F3; DTO 012-D2. **Indonesia**, isolated from air, culture DTO 237-D4. **Mexico**, isolated from dust, cultures DTO 319-A3; DTO 319-A4; DTO 319-A5; DTO 319-A6; DTO 319-A7; DTO 319-A8; DTO 319-A9; DTO 319-B1; DTO 319-B2. **Netherlands**, isolated from air, cultures DTO 085-E8; DTO 085-F5; DTO 085-F6; from indoor materials, cultures DTO 264-C1; DTO 272-I1; from swap, cultures DTO 086-D6; DTO 126-B6; from wall paper, cultures DTO 011-F7; DTO 012-F2. **South Africa**, isolated from dust, culture DTO 319-B4. **Thailand**, isolated from dust, culture DTO 319-C3. **Uruguay**, isolated from dust, culture DTO 319-C9. **USA**, isolated from dust, cultures DTO 318-H3; DTO 318-H6; DTO 318-I4; DTO 319-C5; DTO 319-C6; from stored cotton, culture CBS 148.51. The description above is based on the isolates DTO 319-B2 from dust in Mexico, DTO DTO 333-E3 from Linoleum in Denmark and CBS 666.82 from chili powder in China.

Notes: The general description and morphological diversity of *Ch. globosum* has been discussed by Wang *et al.* (2016). The information presented here gave more insight in the morphological diversity of this species, especially its colony morphology.

Chaetomium tectifimeti X. Wei Wang & Samson, *sp. nov.* MycoBank MB818838. Fig. 19.
Etymology: Name refers to an indoor species similar to *Ch. fimeti*.

Ascomata superficial, non-ostiolate, olivaceous grey to olivaceous black, with numerous short, pale olivaceous to olivaceous grey ascomatal hairs, and several long dark olivaceous hairs in reflected light, spherical or oblate, 210–340 µm diam. *Ascomata walls* composed of two layers separating easily from each other when old: the external wall thick, dark brown, composed of thick-walled, angular or irregular cells, *textura angularis* in surface view; the inner layer thin, luteous to pale brown, composed of amorphous cells, *textura epidermoidea* in surface view. *Ascomatal hairs* of two types: shorter type covering the whole ascomata, conspicuously rough, dark brown at the lower part, fading towards the tips, 3–4.5 µm near the base, up to 400 µm long; longer type arising from the bases of the ascomata, sometimes absent on OA, smooth, dark brown, 4.5–7 µm near the base, 400–2000 µm long. *Asci* fasciculate, fusiform or clavate, with 8 biseriate ascospores, spore-bearing part 26–40 × 16–20 µm, stalks 20–40 µm long, evanescent. *Ascospores* olivaceous brown to brown when mature, limoniform, bilaterally flattened, (12–)12.5–15(–16) × 10–11.5(–12) × (8–)8.5–10 µm, with an apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge, about 30–36 mm diam in 7 d at 25 °C, with olivaceous buff aerial hyphae, producing green yellow to ochraceous exudates diffusing into the medium, reverse pale luteous to pale amber. Colonies on PCA with a slightly crenated edge, about 19–25 mm diam in 7 d at 25 °C, with buff and floccose aerial hyphae and translucent perisphere; without coloured exudates; reverse buff to honey. Colonies on MEA with a slightly undulate edge, about 29–35 mm diam in 7 d at 25 °C, with floccose mycelium appearing pale olivaceous grey centre and vinaceous buff in perisphere, reverse fulvous to sienna with a pale edge. Colony growth on DG18 with a slightly crenated edge, about 13–19 mm diam in 7 d at 25 °C, with white aerial hyphae, without coloured exudates; reverse uncoloured.

Specimen examined: **USA**, isolated from dust by Whitfield & K. Mwange in 2009 (**holotype** CBS H-22844, culture ex-type CBS 142032 = DTO 318-G8).

Notes: Phylogenetic inference indicated that *Ch. tectifimeti* clustered close to but separate from *Ch. fimeti* (ex-epitype culture DSM 62108). This species can be distinguished by its smaller ascomata (210–340 µm diam) than those of *Ch. fimeti* (320–500 µm diam), and broader ascospores (8.5–10 µm wide in front view) than those of *Ch. fimeti* (7–8 µm wide in front view).

Collariella X. Wei Wang, Samson & Crous, **gen. nov.** MycoBank MB818839. Figs 20, 21.
Etymology: Name refers to a dark collar-like apex around the ostiolar pore of the ascomata in most of the species in this genus.

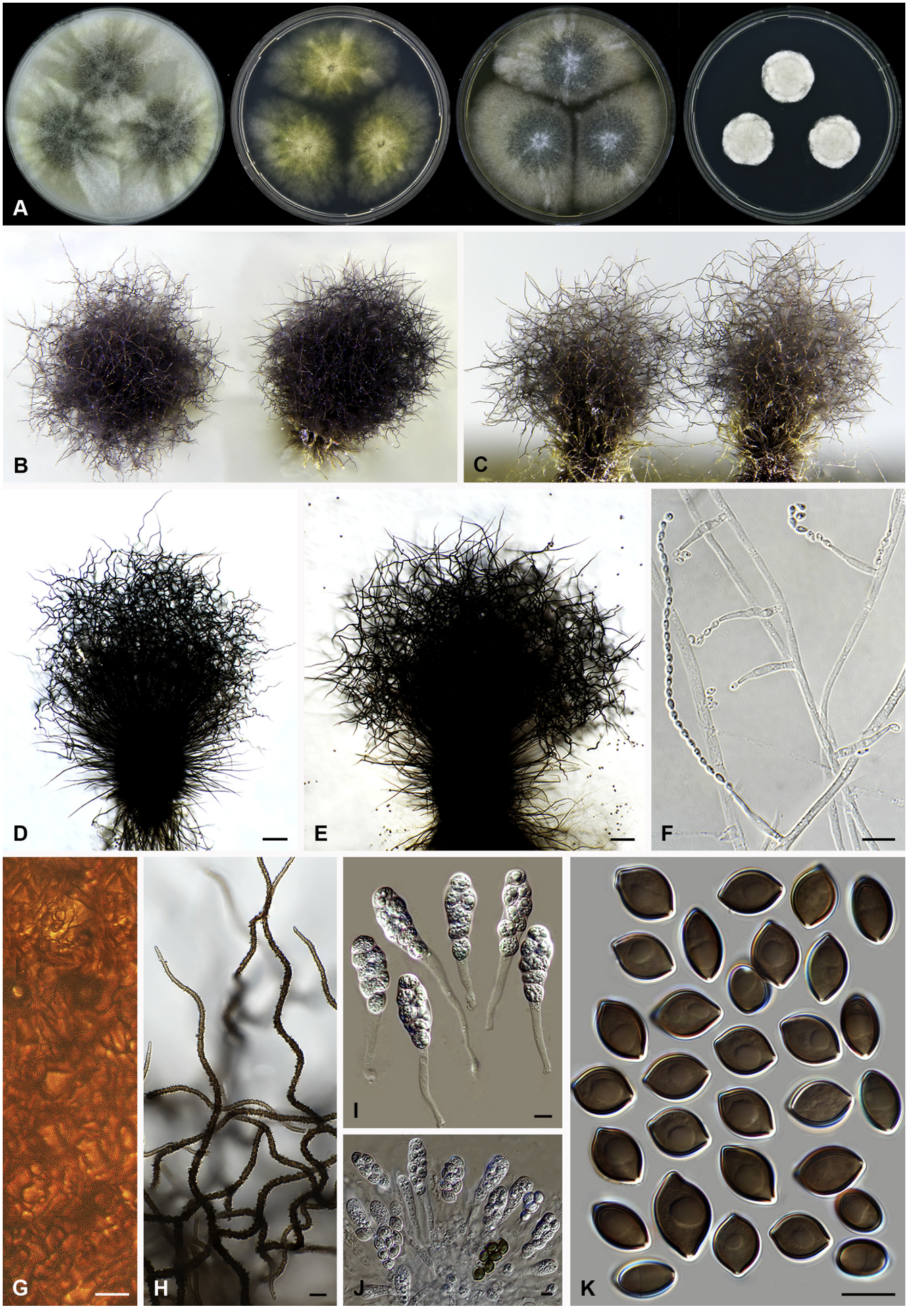
Type species: *Collariella bostrychodes* (Zopf) X. Wei Wang & Samson (= *Ch. bostrychodes*)

This genus is divided into two subclades by both phylogenetic and morphological evidence. The two subclades are closely related to each other with high statistical support (Fig. 1), indicating that they share a recent common ancestor. We therefore decided to keep them in the same genus. Different descriptions are provided here for each subclade:

Subclade 1: *Ascomata* superficial, ostiolate, ovate, obovate, ampulliform or cylindrical with brown walls of *textura angularis* in surface view. Apices of ascomata truncated, usually with a darkened collar around the ostiolar pore, and easy to rupture and to be dispersed together with ascomatal hairs as a whole. *Terminal hairs* highly diverse, straight, flexuous, undulate or spirally coiled or presenting two different types. *Lateral hairs* straight, flexuous. *Asci* fasciculate, fusiform or clavate, stalked, with 8 biseriate or irregularly arranged ascospores, evanescent. *Ascospores* olivaceous brown at maturity, broadly limoniform to quadrangular, bilaterally flattened, with an apical germ pore, usually less than 7.5 µm in length. *Asexual morph* unknown.

Subclade 2: *Ascomata* superficial, ostiolate, subglobose or ovate, with brown walls of *textura angularis* in surface view. *Terminal hairs* straight, flexuous, undulate or arcuate. *Lateral hairs* straight, flexuous. *Asci* fasciculate, clavate, fusiform or obovate, spore-bearing portion 18–26 × 11–14.5 µm, stalks 7–13 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* brown when mature, ellipsoidal or fusiform, never bilaterally flattened, with one or two apical or sometimes slightly sub-apical germ pores, usually more than 9 µm in length. *Asexual morph* unknown.

Fig. 14. *Chaetomium elatum* (DTO 319-B3). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–F. Ascomata mounted in lactic acid. G. Asexual morph (Conidiophores and conidia). H. Structure of ascomatal wall in surface view. I–J. Upper part of terminal ascomatal hairs. K–L. Asci. M. Ascospores. Scale bars: E–F = 100 µm; G–M = 10 µm.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Collariella bostrychodes (Zopf) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818862. Fig. 22.
Basionym: *Chaetomium bostrychodes* Zopf, Abh. Bot. Ver. Prov. Brandenburg 19:173. 1877.

Ascomata superficial, pale greenish grey or pale purplish grey in reflected light owing to ascomatal hairs, subglobose, ovate or obovate, ostiolate, 210–300 µm high (including the collar), 160–240 µm diam. Wide, apically black due to a darkened collar in 25–55 µm high and 75–170 µm wide around the ostiolar pore with the area near the apical collar often in paler colour than the lower part of the ascoma. *Ascomatal wall* brown, *textura angularis* in surface view. *Terminal hairs* arising from the apical collar, conspicuously rough, dark brown, septate, erect in the lower part, 4–7 µm near the base, spirally coiled in the upper part, often with coiled branches. *Lateral hairs* seta-like, tapering and fading towards the tips. *Asci* fasciculate, fusiform or clavate, spore-bearing part 22–33 × 7–11 µm, stalks 9–20 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* olivaceous when mature, limoniform, bilaterally flattened, 6–7(–7.5) × (5–)5.5–6.5 × (4–)4.5–5.5 µm, with an apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire edge, about 34–40 mm diam in 7 d at 25 °C, usually without or with sparse white aerial hyphae, without coloured exudates, reverse uncoloured. Colonies on PCA translucent, with entire edge, about 33–39 mm diam in 7 d at 25 °C, without aerial hyphae, without coloured exudates; reverse uncoloured. Colonies on MEA translucent and membranous, with entire edge, about 29–35 mm diam in 7 d at 25 °C, forming radiating and luteous or fulvous furrows, non-sporulating, often with sparse and concentric white aerial hyphae; reverse uncoloured. Colonies on DG18 with entire edge, about 14–20 mm diam in 7 d at 25 °C, with white floccose aerial hyphae especially at the edge, non-sporulating, reverse uncoloured.

Specimens examined: **Indonesia**, isolated from dust, DTO 319-C3. **China**, Beijing, isolated from air by A.J. Chen, cultures DTO 324-H3; DTO 324-H6. The description above is based on the isolate DTO 324-H6.

Notes: This species was originally described with ellipsoid ascomata (Saccardo 1882), and later Ames (1963) described the species with subglobose to ovoid ascomata. von Arx *et al.* (1986) placed several species in synonymy with *Col. bostrychodes* (= *Ch. bostrychodes*), and their description covered a high morphological diversity in the shape of ascomata. Our description based on the indoor isolates fitted with that of Ames. Examination on more isolates of related species is required to delimit this species more accurately.

Collariella carteri X. Wei Wang, Houbraken & Samson, **sp. nov.** MycoBank MB818863. Fig. 23.
Etymology: Named after Dr Adrian Carter, who recognised this species as new in his PhD thesis.
Synonym: *Chaetomium intricatum* A. Carter, *A Taxonomic Study of the Ascomycete genus Chaetomium Kunze*, unpublished PhD thesis of the University of Toronto. 1982. nom. inval.

Ascomata superficial, often covered by sparse white aerial hyphae, easily falling down rather than erect when mature, dark brick to sepia in reflected light, globose or subglobose, ostiolate, occasionally pyriform owing to a short ostiolar beak, 175–320 µm high (including the collar), 110–220 µm diam, apically black due to a darkened collar in 20–60 µm high and 40–120 µm wide around the ostiolar pore. *Ascomatal wall* brown, *textura intricata* mixed *with angularis* or *epidermoidea* in surface view. *Terminal hairs* arising from the apical collar, seta-like or flexuous, 30–180 µm long, usually shorter than the height of an ascoma, smooth, dark brown, distinctly septate, 4–8.5 µm near the base, tapering and fading towards the nearly hyaline tips. *Lateral hairs* similar but quite sparse. *Asci* fasciculate, clavate or slightly fusiform, spore-bearing part 17–26 × 8.5–11.5 µm, stalks 10–18 µm long, with 8 biseriate or irregularly arranged ascospores, evanescent. *Ascospores* olivaceous when mature, limoniform, usually biapiculate at both ends, bilaterally flattened, (6–)6.5–7.5(–8.5) × (4.5–)5–6(–7.5) × 4–5.5 µm, with an apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire edge, about 24–30 mm diam in 7 d at 25 °C, with white aerial hyphae and citrine green or greenish yellow to citrine exudates diffusing into the medium, reverse greenish yellow to greenish olivaceous. Colonies on PCA translucent, with entire edge, about 28–34 mm diam in 7 d at 25 °C, without aerial hyphae, without coloured exudates; reverse uncoloured. Colonies on MEA translucent and membranous, with entire edge, about 29–33 mm diam in 7 d at 25 °C, forming radiated and luteous or ochraceous furrows; non-sporulating, reverse uncoloured. Colony growth on DG18 very limited, less 3 mm diam after 7 d, without coloured exudates; reverse uncoloured.

Specimen examined: **Canada**, Vancouver, isolated from air of Bacteriology Lab in the University of British Columbia by R.J. Bandoni on 14 Feb. 1966 (**holotype** CBS H-22845, culture ex-type CBS 128.85).

Notes: *Collariella carteri* is easily recognised by its short and seta-like terminal ascomatal hairs. Carter (1982) noted that the ascomatal wall of this species consists of *textura intricata* in surface view. Our observation showed that the wall structure of CBS 128.85 consisted of *textura intricate*, *angularis* and *epidermoidea* (Fig. 23E–I). This species formed a sister lineage to *Col. bostrychodes*.

Collariella causiiformis (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818864. Fig. 24.
Basionym: *Chaetomium causiiforme* Mycologia 41: 644. 1949.

Ascomata superficial, usually forming a layer on the surface of OA medium owing to adjacent long ascomatal hairs intermingling with each other, hazel to olivaceous in reflected light due to ascomatal hairs, globose or subglobose, ostiolate, 70–140 µm high (including the darkened collar), 60–120 µm diam, apically black due to a darkened collar in 10–24 µm high and 32–65 µm wide around the ostiolar pore. *Ascomatal wall* translucent, ochraceous, *textura angularis* in surface view. *Terminal hairs* arising from the apical collar, a few type I: up to 2 600 µm long, undulate,

Fig. 15. *Chaetomium elatum* (DTO 318-H9). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Asexual morph (Conidiophores and conidia). G. Structure of ascomatal wall in surface view. H. Upper part of terminal ascomatal hairs. I–J. Asci. K. Ascospores. Scale bars: D–E = 100 µm; F–K = 10 µm.

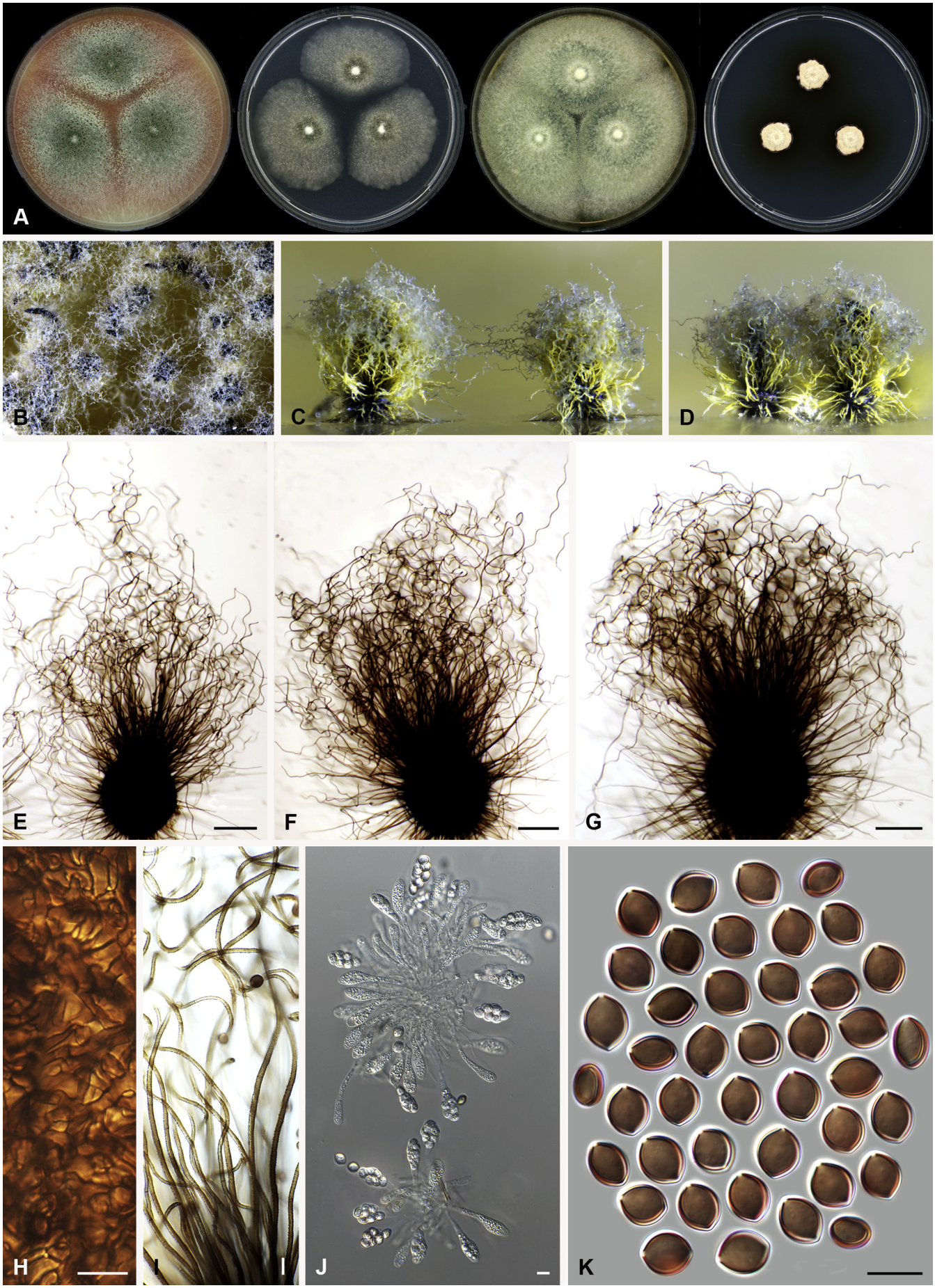


Fig. 16. *Chaetomium globosum* (DTO 319-B2). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of ascomatal wall in surface view. I. Terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–G = 100 µm; H–K = 10 µm.

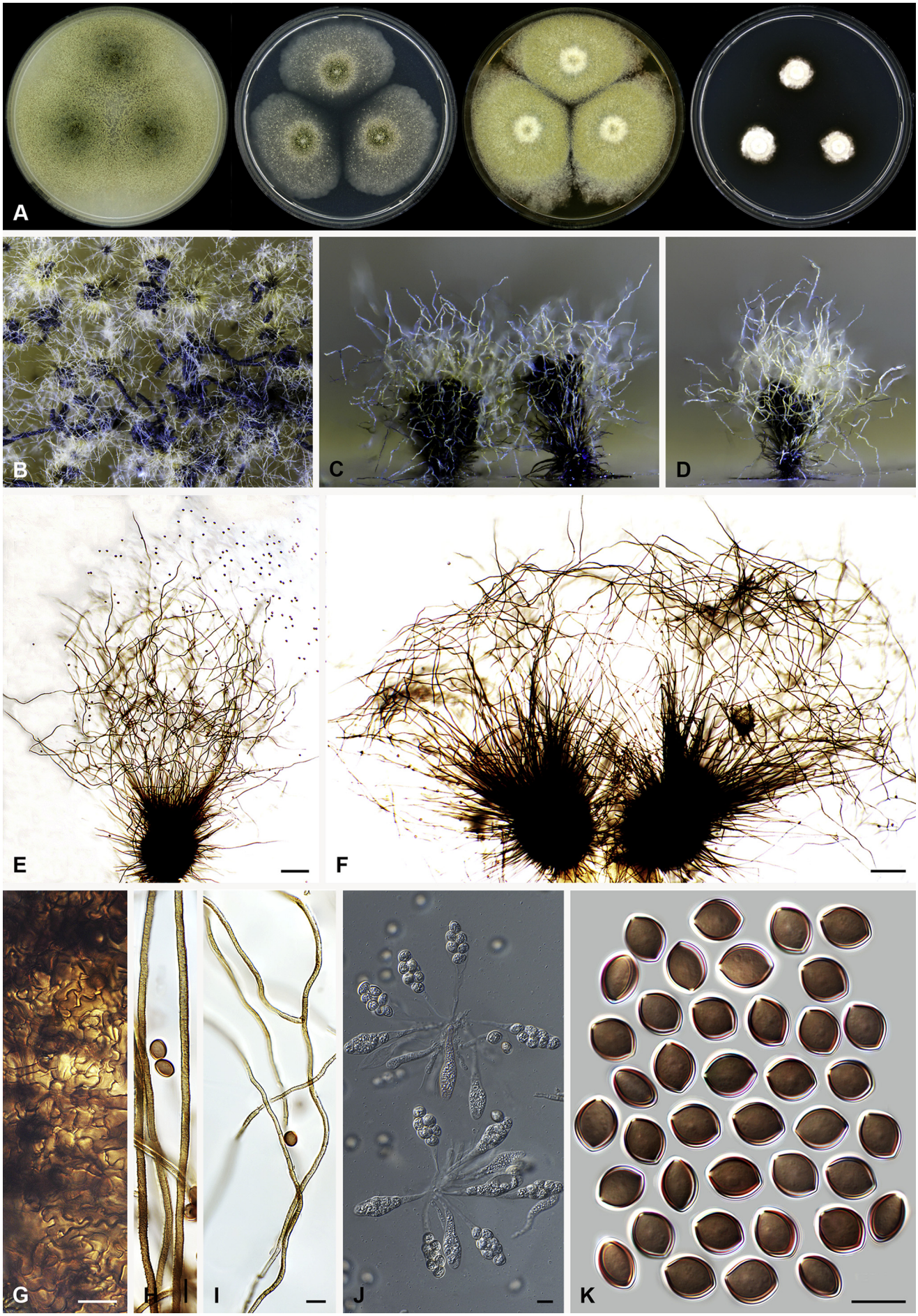


Fig. 17. *Chaetomium globosum* (DTO 333-E3). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Basal parts of terminal ascomatal hairs. I. Upper parts of terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–F = 100 µm; G–K = 10 µm.

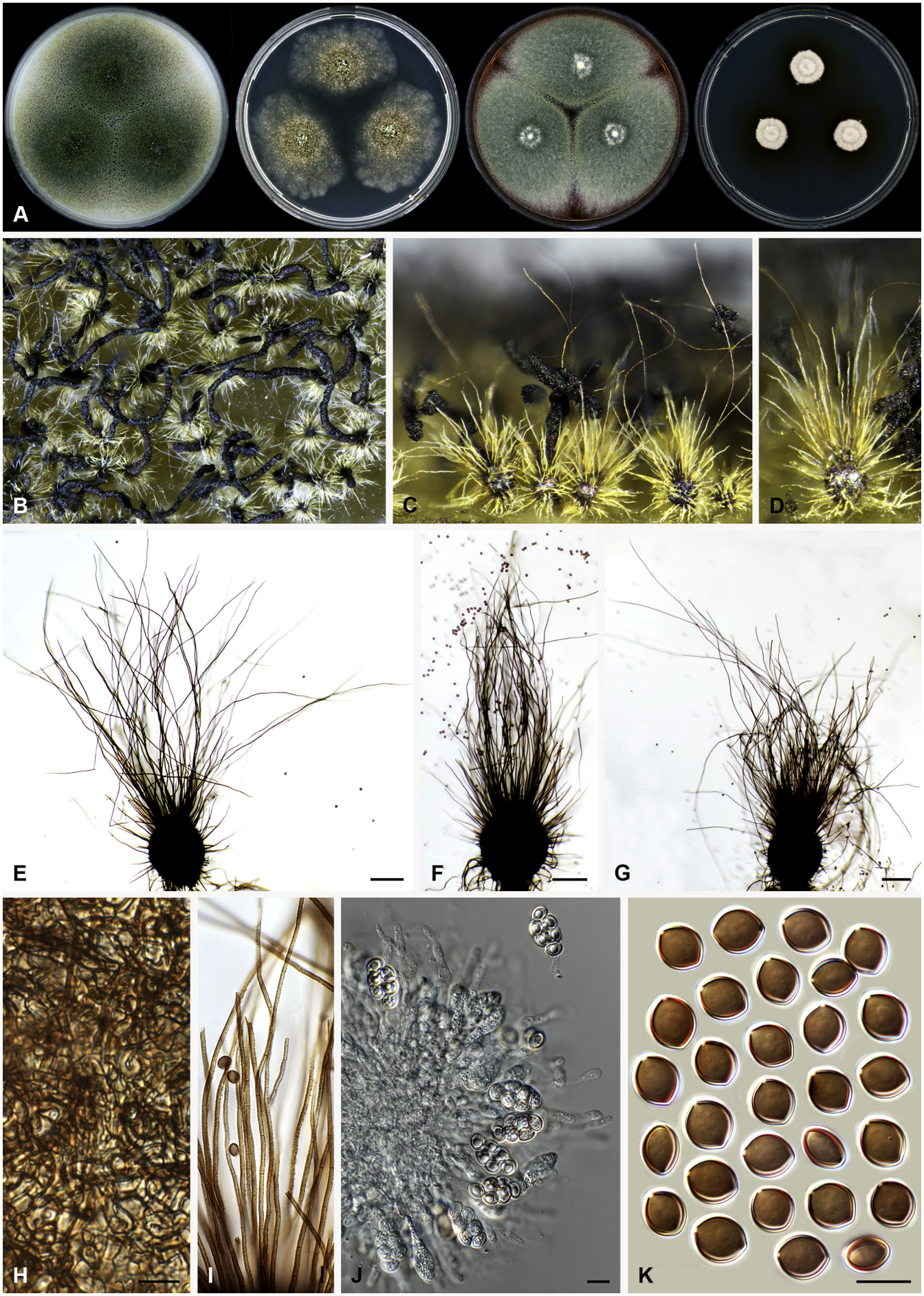


Fig. 18. *Chaetomium globosum* (CBS 666.82). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of ascomatal wall in surface view. I. Terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–G = 100 µm; H–K = 10 µm.

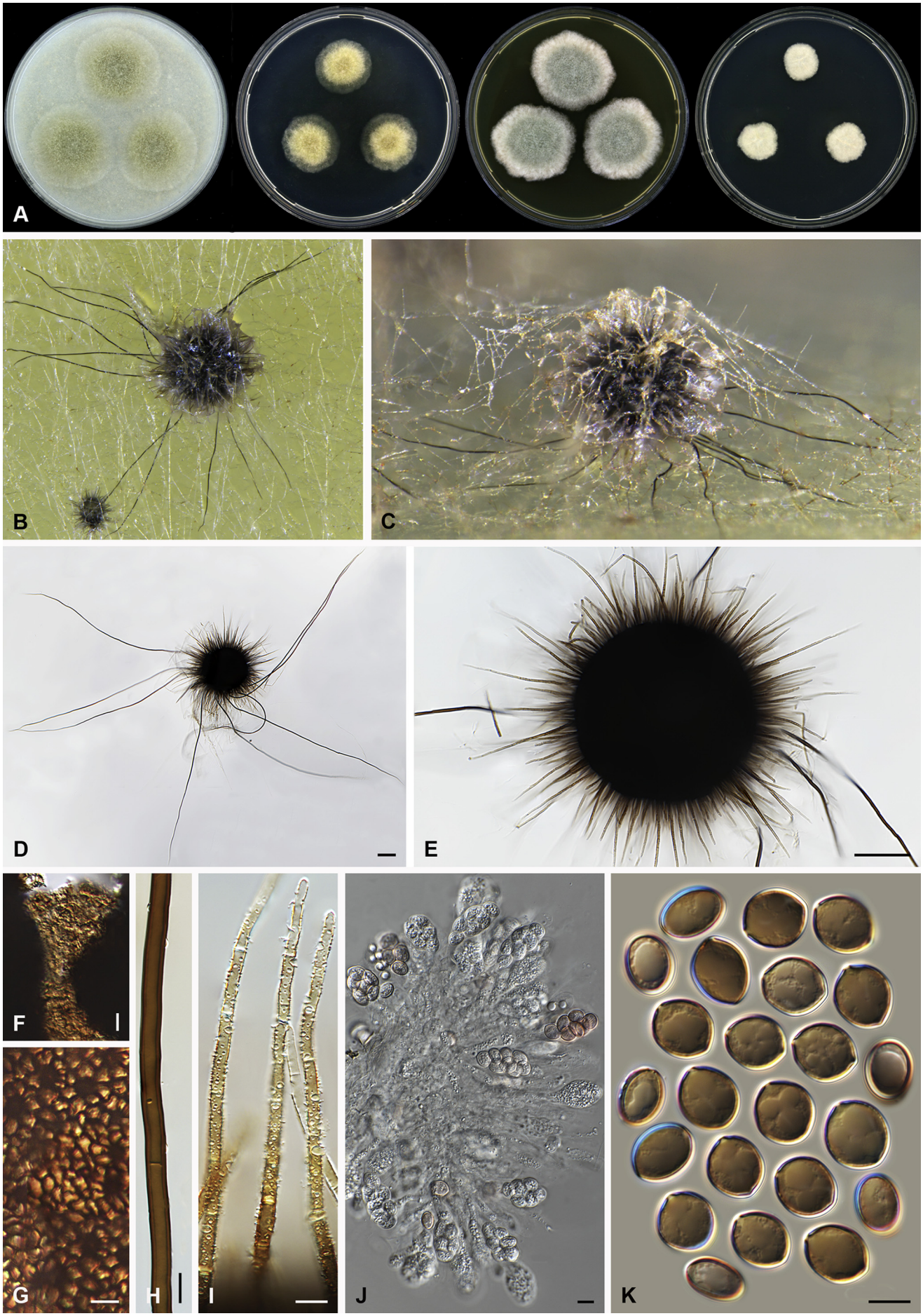


Fig. 19. *Chaetomium tectifimeti* (CBS 142032 = DTO 318-G8, ex-type culture). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Inner and external layers of ascomatal wall in surface view. G. Structure of external layer of ascomatal wall in surface view. H. Part of a terminal ascomatal hair, longer type. I. Terminal ascomatal hairs, shorter type J. Asci. K. Ascospores. Scale bars: D–E = 100 µm; F–K = 10 µm.

Fig. 20. Morphological diversity of ascomata in the genus *Collariella*. A. *Col. bostrychodes* (DTO 326-H6). B. *Col. robusta* (CBS 551.83^{T}). C. *Col. quandrangulata* (CBS 152.59). D. *Col. causiiformis* (CBS 792.83^{T}). E. *Col. intricata* (CBS 128.85^{T}). F. *Col. virescens* (CBS 148.68^{T}). G. *Col. gracilis* (CBS 249.75). Scale bars: A–G = 100 µm.

olivaceous, smooth, septate, 3.5–5 µm diam near the base; most type II: usually less than 700 µm long, olivaceous, smooth, septate, flexous or geniculate, often branched, sometimes spically recurved or circinate, 2–3 µm diam near the base. *Lateral hairs* seta-like, sparse. *Asci* fasciculate, fusiform, sometimes clavate, spore-bearing portion 15–22 × 8–13 µm, stalks 6–13 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* olivaceous when mature, broad limoniform or ovate, bilaterally flattened, (5–)5.5–6.5 × (4.5–)5–5.5(–6) × (3.5–)4–5 µm, with an apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA translucent at the beginning, with entire edge, 27–33 mm diam in 7 d at 25 °C, without aerial hyphae, without coloured exudates, reverse uncoloured. Colonies on PCA translucent, with entire edge and lobate and relatively thicker texture in the centre, about 24–30 mm diam in 7 d at 25 °C, without aerial hyphae, without coloured exudates; reverse uncoloured. Colonies on MEA translucent and membranous, with entire edge, about 20–26 mm diam in 7 d at 25 °C, forming radiating and luteous or fulvous furrows, non-sporulating; reverse uncoloured. No visible growth of colonies on DG18 after 7 d at 25 °C.

Specimen examined: **Solomon Islands**, isolated from sweatband of helmet liner by G.W. Martin, ex-type culture CBS 792.83.

Notes: *Collariella causiiformis* forms two types of terminal ascomatal hairs and this feature is not observed in the other known *Collariella* species. This species formed a sister lineage to the clade in which both *Col. carteri* and *Col. bostrychodes* are included.

Collariella gracilis (Udagawa) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818865. Fig. 25.
Basionym: *Chaetomium gracile* Udagawa, J. Gen. Appl. Microbiol. 6: 235. 1960.

Ascomata superficial, often covered by white aerial hyphae, ostiolate, olivaceous in reflected light due to ascomatal hairs and with black ascospores aggregating on the top, subglobose or ovate, 120–200 µm high, 100–180 µm diam, often with truncated and darkened apices, but not easy to rupture and to be dispersed. *Ascomatal wall* brown, *textura angularis*. *Terminal hairs* numerous, arcuate, partly apically flexuous, incurved or circinate, fine rough, brown, septate, 3.5–5.5 µm diam near the base. *Lateral hairs* relatively sparse, seta-like or flexuous. *Asci* fasciculate, clavate, fusiform or obovate, spore-bearing portion 18–26 × 11–14.5 µm, stalks 7–13 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* brown when mature, ellipsoidal or broadly fusiform, (9.5–)10–12.5(–13) × 6–7.5(–8) µm, with an apical or sometimes slightly sub-apical germ pore. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with white aerial hyphae, translucent at the beginning, with an entire or slightly undulate edge, about 32–38 mm diam in 7 d at 25 °C, irregularly producing white aerial hyphae later, with citrine green or amber to citrine exudates diffusing into the medium, reverse yellow to amber. Colonies on PCA citrine, with or slightly crenated edge, about 23–29 mm diam in 7 d at 25 °C, with sparse white to straw aerial hyphae, reverse citrine. Colonies on MEA with entire edge, about 29–35 mm diam in 7 d at 25 °C, with white to yellowish buff and floccose aerial mycelium, reverse saffron due to exudates diffusing into the medium. Colony growth on DG18 with entire edge, about 11–17 mm diam in 7 d at 25 °C, pale rosy buff with white aerial hyphae, without coloured exudates; reverse uncoloured.

Specimen examined: **India**, Uttar Pradesh, isolated from air by Kamal, culture CBS 249.75.

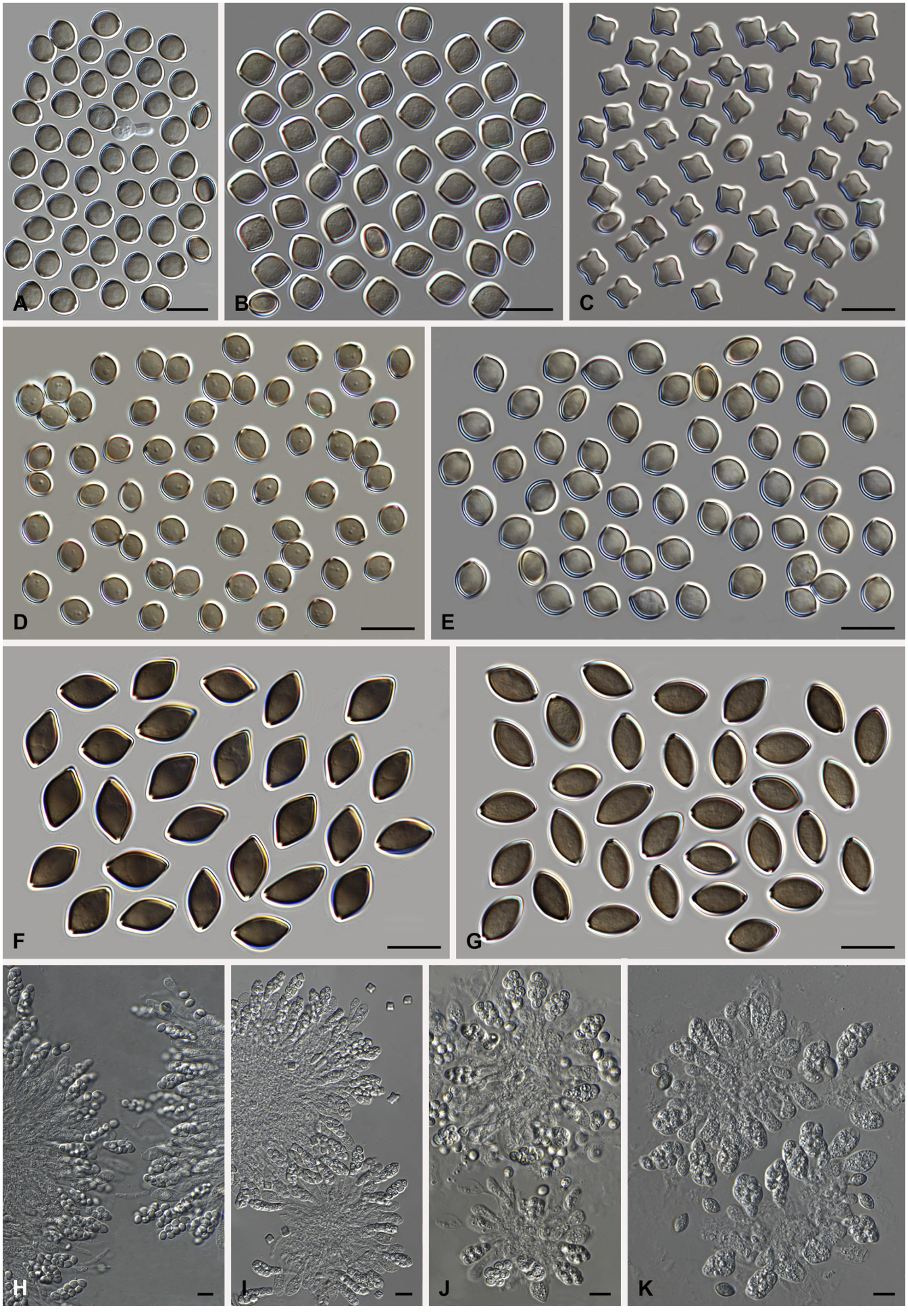
Notes: von Arx *et al.* (1986) suggested that this species was closely related to *Col. virescens*. Our phylogenetic analysis confirmed their close relationship. The two species differ in ascomata and ascospores (Figs 20, 21).

Dichotomopilus X. Wei Wang, Samson & Crous, **gen. nov.** MycoBank MB818840. Figs 26, 27.
Etymology: Name refers to the shape of terminal ascomatal hairs which are usually dichotomously branched.

Ascomata superficial, ostiolate, spherical, ellipsoid or ovate with walls of *textura intricata* or *epidermoidea* in surface view, or of *textura angularis* in a few species. *Terminal hairs* seta-like and the beginning, then the majority developing into dichotomously or irregularly branched to form a net structure to hold ascospores, sometimes branched and seta-like together, occasional stayinging seta-like, usually punctulate or verrucose, with the exception of those of *D. dolichotrichus* (= *Ch. dolichotrichum*) presenting smooth. *Lateral hairs* unbranched, seta-like, tapering towards tips. *Asci* fasciculate, clavate, broadly clavate or ovate, stalked, with 8 biseriate or irregularly arranged ascospores, evanescent quickly. *Ascospores* brown at maturity, narrowly ovate, ovate or broad ovate, bilaterally flattened, attenuate at one or both ends, with an apical or slightly sub-apical germ pore at the most attenuated end, the opposite end more or less apiculate if not attenuate, usually less than 7.5 µm long, with the exception of *D. fusus* (= *Ch. fusum*) possessing cylindrical ascospores without visible germ pores. *Asexual morph* unknown.

Type species: *Dichotomopilus indicus* (Corda) X. Wei Wang & Samson = (*Ch. indicum*)

Notes: Skolko & Groves (1948) provided the first overview of this group of fungi. Based on the presence or absence of unbranched terminal hairs and the characteristics of the branched hairs, they circumscribed and accepted six species. Their classification was followed by Ames (1963), Mazzucchetti (1965) and Seth (1970). However, von Arx *et al.* (1986) only accepted two species: *Ch. indicum* and *Ch. funicola*. *Chaetomium indicum* was described to show typical dichotomously branched terminal ascomatal hairs, while *Ch. funicola* was described to produce both unbranched seta-like and dichotomously branched terminal hairs. Based on these definitions, *Ch. dolichotrichum* was treated as a synonym of *Ch. funicola*, and the rest of the species accepted by Skolko & Groves (1948) were questioned. Wang *et al.* (2014) re-assessed all these species based on a five-locus phylogenetic analysis. The results indicated that all these species clustered in a monophyletic clade. Five of the six species of Skolko & Groves (1948) were recognised with the exception of *Ch. cancroideum*, which clustered in the *Ch. funicola* clade. At the same time, three more species: *Ch. subfunicola*, *Ch. ramosissimum* and *Ch. pratense* were discovered,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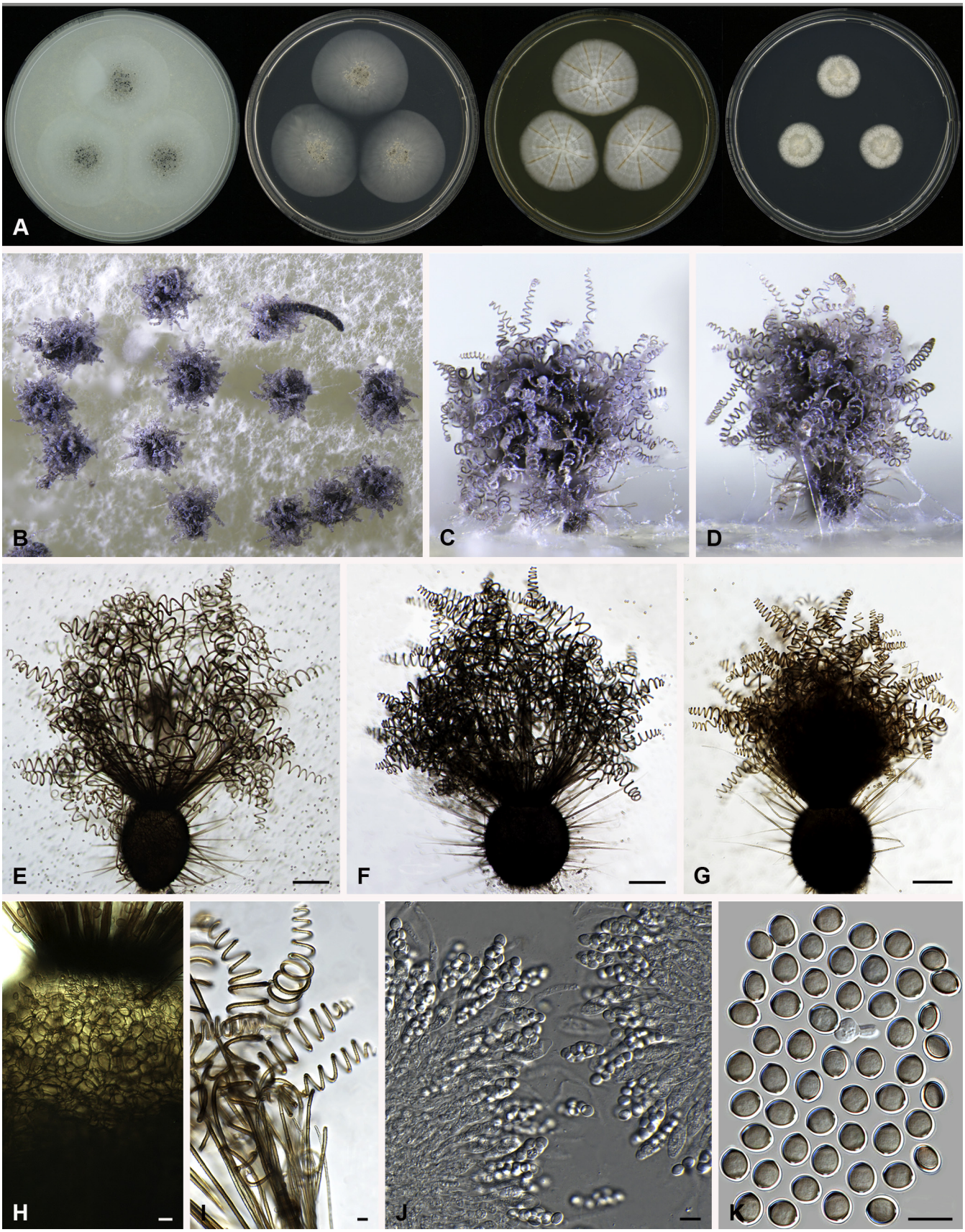


Fig. 22. *Collariella bostrychodes* (DTO 324-H6). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of upper part of ascomatal wall in surface view. I. Terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–G = 100 µm; H–K = 10 µm.

Fig. 21. Morphological diversity of ascospores and asci in genus *Collariella*. Ascospores: *Col. bostrychodes* (DTO 326-H6). B. *Col. robusta* (CBS 551.83^{T}). C. *Col. quandrangulata* (CBS 152.59). D. *Col. causiiformis* (CBS 792.83^{T}). E. *Col. intricata* (CBS 128.85^{T}). F. *Col. virescens* (CBS 148.68^{T}). G. *Col. gracilis* (CBS 249.75). Asci: H. *Col. bostrychodes* (DTO 326-H6). I. *Col. quandrangulata* (CBS 152.59). J. *Col. causiiformis* (CBS 792.83^{T}). K. *Col. gracilis* (CBS 249.75). Scale bars: A–K = 10 µm.

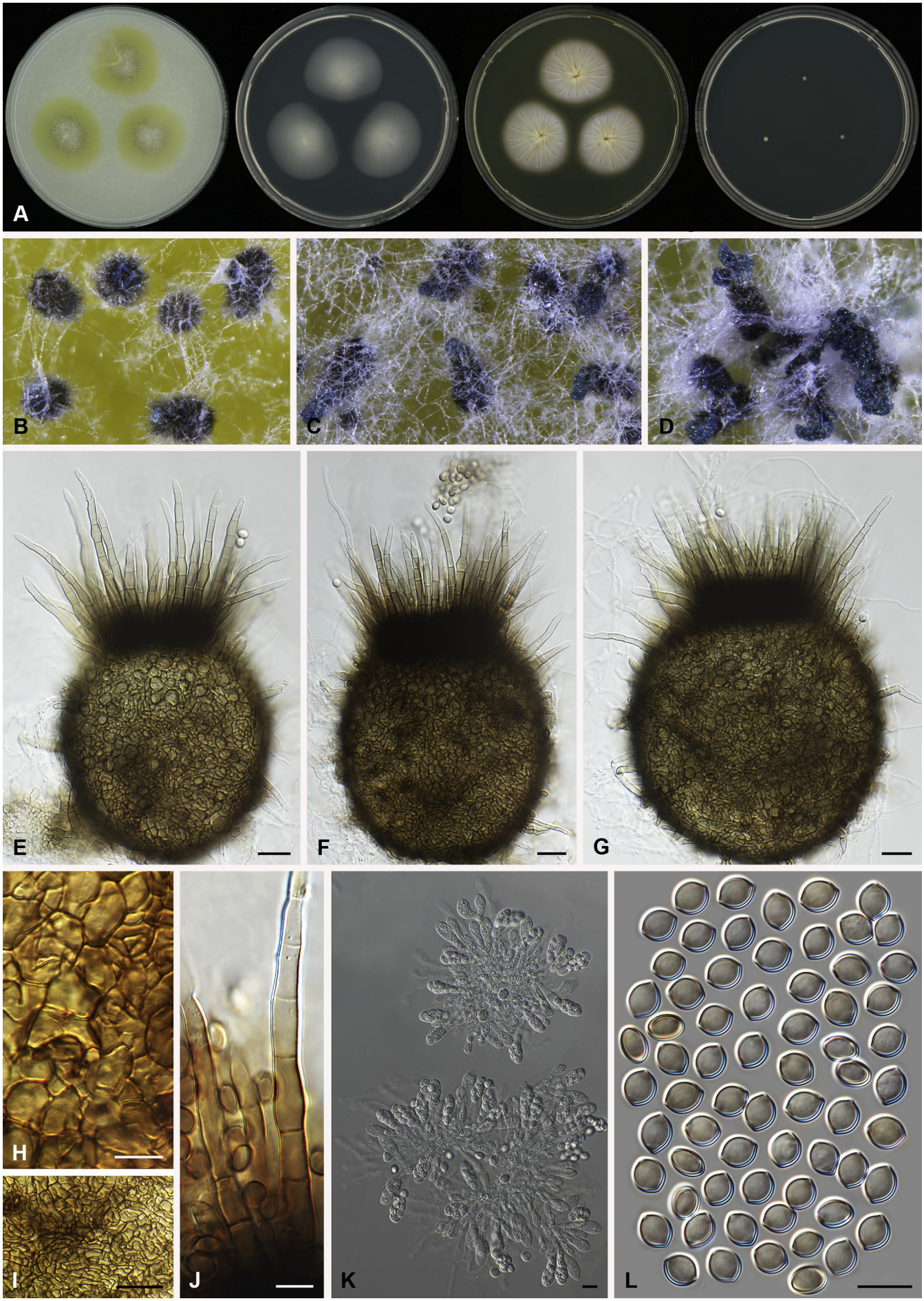


Fig. 23. *Collariella carteri* (CBS 128.85, ex-type culture). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H–I. Structure of ascomatal wall in surface view. J. Terminal ascomatal hairs. K. Asci. L. Ascospores. Scale bars: E–G = 20 µm; H–L = 10 µm.

which were phylogenetically close to but separated from *Ch. funicola*, *Ch. erectum* and *Ch. indicum*, respectively (Wang *et al.* 2014).

In the present study, a new genus *Dichotomopilus* is proposed to accommodate this monophyletic lineage. Within the genus, two more species *D. pseudofunicla* and *D. pseudoerectus* were described as new. Two other species, *D. variostiolatus* (= *Ch. variostiolatum*) and *D. fusus* (*Ch. fusum*), also clustered in this genus. The former was originally described to possess unbranched seta-like terminal hairs (Fig. 26A), and the latter produces dichotomously-branched terminal hairs (Fig. 26L), and quite distinct ascospores (Fig. 27L).

Seven indoor species were recognised in *Dichotomopilus*. A high morphological diversity in ascomatal hairs, asci and ascospores was observed within indoor isolates of *D. funicola*, *D. indicus*, *D. subfunicola* and *D. variostiolatus*. Our morphological examination indicated extremely high intra-/ inter-species diversity and also overlap occurs between the indoor isolates of the four species. In contrast, the species *D. pratensis* (Figs 26G, 27G), *D. dolichotrichus* (Figs 26J, 27J), *D. reflexus* (Figs 26K, 27K) and *D. fusus* (Figs 26L, 27L) from different substrates and different locations are morphologically stable, and easy to be recognised on the basis of morphology. It is a challenge to identify *D. funicola*, *D. indicus*, *D. subfunicola* and *D. variostiolatus* only based on morphology. We highly recommend the use of sequence data to recognise these species in the genus *Dichotomopilus*.

Dichotomopilus funicola (Cooke) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818841. Fig. 28.
Basionym: *Chaetomium funicola* Cooke, Grevillea 1: 176. 1873.
Synonym: *Chaetomium cancroideum* Tschudy, Am. J. Bot. 24: 478. 1937.

Ascomata superficial, ostiolate, greenish olivaceous to grey olivaceous in reflected light, subglobose to ellipsoid or ovate, 195–255 µm high, 180–240 µm diam. *Ascomatal wall* composed of brown, irregular or elongate cells (*textura intricata* or *epidermoidea*). *Terminal hairs* composed of two types: (1) wider, dark brown and erect, 4–5.5 µm diam near the base, tapering and fading towards tips, dichotomously branched profusely at acute angles starting from the upper half part, punctulate; (2) thinner, luteous to brown, 2–3.5 µm diam near the base, dichotomously branched at wide to acute angles starting near the base; the terminal branches relatively short, erect, incurved or reflexed, often in dense clusters. *Lateral hairs* simply branched or seta-like, tapering and fading towards tips. *Asci* fasciculate, with 8 irregularly-arranged ascospores, clavate, pyriform to ovate, spore-bearing portion 11–18 × 7–11.5 µm, stalks 6–10 µm long, evanescent quickly. *Ascospores* olivaceous when mature, ovate to slightly elongate ovate, bilaterally flattened, 5–6 × 3.5–4.8 × 3–3.8 µm, with an apical germ pore at the more attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge, spreading rapidly, over 70 mm diam in 7 d at 25 °C, with pale yellow, sparse and floccose aerial hyphae, producing greenish olivaceous to citrine exudates diffusing into the medium; reverse ochraceous to cinnamon. Colonies on PCA olivaceous buff to greenish olivaceous because of the sparse aerial hyphae and ascomata, with irregularly crenated edge, spreading rapidly, over 70 mm diam in 7 d at 25 °C, without coloured exudates; reverse olivaceous buff to greenish olivaceous. Colonies on MEA with entire edge, about 57–63 mm diam in 7 d at 25 °C, forming profuse and pale yellow mycelium and then greenish olivaceous because of the formation of ascomata, without coloured exudates, reverse ochraceous. Colonies on DG18 buff with slightly lobate or crenated edge, about 10–16 mm diam in 7 d at 25 °C, without aerial hyphae, without coloured exudates; reverse pale buff.

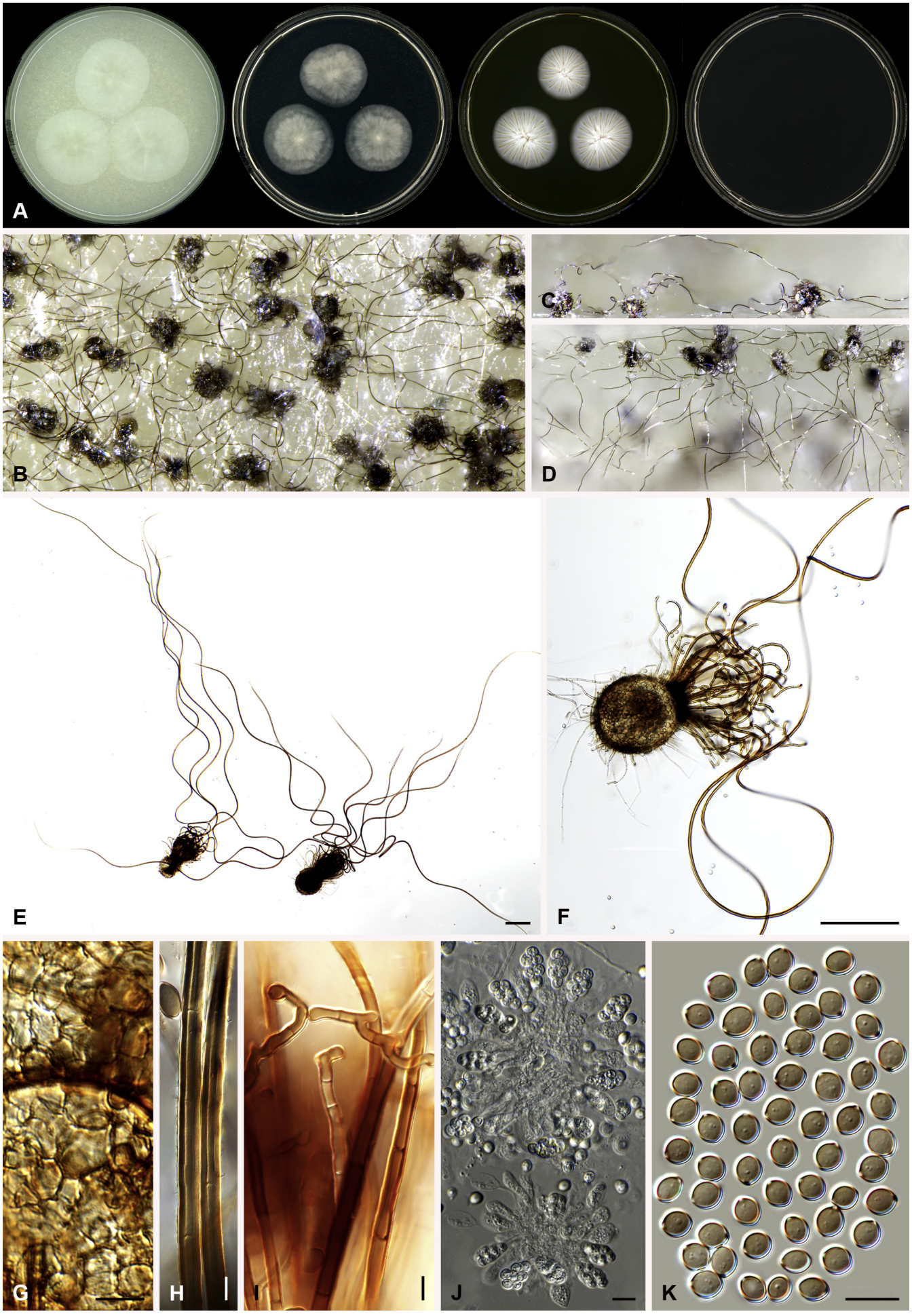
Specimens examined: **Denmark**, isolated from dust by B. Andersen, cultures DTO 333-F1 (=IBT 42276); DTO 333-F2 (= IBT 42277). **USA**, isolated from dust, culture DTO 318-I2.

Notes: The terminal hairs of the indoor isolate examined above look like intermediates between the ex-epitype culture of *D. funicola* (fig. 3i–o in Wang *et al.* 2014) and the authentic culture of *Ch. cancroideum* (Fig. 26E in this study), especially in the terminal branches. This implied intra-species variation within this species, and encouraged us to synonymise *Ch. cancroideum* into *D. funicola*. This treatment is consistent with the phylogenetic data (Fig. 1).

Dichotomopilus indicus (Corda) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818842. Figs 29–31.
Basionym: *Chaetomium indicum* Corda, Icon. Fung. 4: 38. 1840.

Ascomata superficial, ostiolate, greenish olivaceous to grey olivaceous in reflected light, subglobose or ovate, 160–310 µm high, 140–275 µm diam. *Ascomatal wall* composed of brown, irregular or elongate cells (*textura intricata* or *epidermoidea*). *Terminal hairs* composed of two types: (1) wider, dark brown and erect, 4–5 µm diam near the base, tapering and fading towards tips, dichotomously branched at acute angles starting from the upper half part, punctulate; (2) thinner, luteous to brown, 2–3.5 µm diam near the base, dichotomously branched at wide to acute angles starting near the base (DTO 333-F3), or only composed of one type: dark brown and erect, 3–5.5 µm diam near the base, dichotomously branched at acute to wide angles starting from the upper half part, verrucose, tapering and fading towards tips (DTO 319-B3) or partly shorter and dichotomously branched 1–4 times at acute angles starting from the upper half part, partly longer, unbranched and seta-like (DTO 333-E2). *Lateral hairs* unbranched, seta-like, tapering and fading towards tips. *Asci* fasciculate, with 8 irregularly-arranged ascospores visible, clavate, broadly clavate, fusiform to pyriform, spore-bearing portion 11–25.5 × 6.5–13.5 µm, stalks 6–15 µm long, evanescent quickly. *Ascospores* olivaceous when mature, ovate to slightly elongate ovate, bilaterally flattened, 5.5–6.5 × 3.5–4.5 × 2.5–3 µm (DTO 333-F3), or 5.5–6.5 × 4–5 × 3–4 µm (DTO 319-B3), or (6–) 6.5–7.5(–8) × 4.5–5.5 × 3.5–4.5 µm (DTO 333-E2), with an apical germ pore at the more attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire edge, about 20–48 mm diam in 7 d at 25 °C, with sparse buff, pale yellow to pale primrose aerial hyphae, without coloured exudates at the beginning, and then producing pale luteous, amber, ochraceous to cinnamon exudates diffusing into the medium, reverse buff, pale luteous, luteous, ochraceous to cinnamon. Colonies on PCA usually with entire, slightly undulate, or irregularly crenated edge, about 25–54 mm diam in 7 d at 25 °C, olivaceous buff, pale yellow to greenish olivaceous because of the sparse aerial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hyphae together with ascomata and ascospores, without coloured exudates; reverse olivaceous buff, pale yellow to greenish olivaceous. Colonies on MEA with entire or slightly lobate edge, about 36–53 mm diam in 7 d at 25 °C, forming thick yellowish white to pale yellow mycelium, sometimes with radiating furrows, reverse pale luteous to ochraceous. Isolate DTO 333E2 showed distinct colony morphology: white and a little bit wrinkled with entire edge, about 12–18 mm diam in 7 d at 25 °C, forming a relatively thin layer of aerial hyphae, reverse pale luteous. Colonies on DG18 white with entire to crenated edge, about 8–15 mm diam in 7 d at 25 °C, with sparse white aerial hyphae, reverse pale yellow, pale luteous or rust. DTO 333E2 showed distinct colony morphology: buff and wrinkled with crenated edge, about 3–9 mm diam in 7 d at 25 °C, without aerial hyphae, reverse buff.

Specimens examined: **Denmark**, isolated from feather by B. Andersen, cultures DTO 333-F3 (IBT 42278); DTO 333-E2 (IBT 41796). **South Africa**, isolated from dust, culture DTO 319-B8.

Notes: Three isolates phylogenetically recognised as *D. indicus* were examined critically. Each of them showed distinct morphology. Isolate DTO 319-B8 presented relatively sparse terminal hairs with the branched part not significantly thinner than the basal part of the hairs (Fig. 29). DTO 333-E2 showed seta-like terminal hairs, and only parts of them were branched near the top (Fig. 30). DTO 333-F3 presented relatively numerous terminal hairs dichotomously branched in two different types, the thicker ones with the branched part conspicuously thinner than the basal parts (Fig. 31). The examined isolates also showed difference to some extent in ascospores. DTO 333-E2 produced the largest ascospores (6.5–7.5 × 4.5–5.5 × 3.5–4.5 µm) compared to those of the two other isolates, while DTO 333-F3 produced narrower ascospores (5.5–6.5 × 3.5–4.5 × 2.5–3 µm) than DTO 319-B8 (5.5–6.5 × 4–5 × 3–4 µm).

Dichotomopilus pratensis (X.W. Wang & L. Cai) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818843. Fig. 32.
Basionym: *Chaetomium pratense* X.W. Wang & L. Cai, Mycol. Prog. 13: 723. 2014.

Ascomata superficial, ostiolate, greenish olivaceous to olivaceous in reflected light, subglobose or ovate, 135–230 µm high, 120–200 µm diam. *Ascomatal wall* composed of brown, irregular or elongate cells (*textura intricata* or *epidermoidea*). *Terminal hairs* dark brown and often attached by yellow but soluble crystals which would soon dissolve in the mounting solution, 4–6 µm diam near the base, erect, dichotomously branched at wide (nearly straight) to right angles primarily starting from the upper half part, verrucose. *Lateral hairs* unbranched, seta-like, tapering and fading towards tips. *Asci* fasciculate, clavate, sometimes fusiform or pyriform, with 8 irregularly-arranged ascospores, spore-bearing portion 14–22 × 8–11.5 µm, stalks 5–10 µm long, evanescent quickly. *Ascospores* olivaceous when mature, broad ovate to nearly globose, bilaterally flattened, 5–6.5 × 4.5–5.5 × 3.5–4.5 µm, with an apical germ pore at the more attenuated end, and slight apiculate at the other end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA pale luteous to amber with entire or slightly undulate edge, about 34–40 mm diam in 7 d at 25 °C, with sparse aerial hyphae, with amber exudates diffusing into the medium, reverse amber to luteous. Colonies on PCA translucent with entire edge, about 43–49 mm diam in 7 d at 25 °C, pale luteous to greenish olivaceous because of the formation of ascomatal, without aerial hyphae, without coloured exudates; reverse buff to pale luteous under the clusters of ascomata. Colonies on MEA amber, with irregularly lobate edge, about 29–35 mm diam in 7 d at 25 °C, with sparse yellow aerial hyphae, reverse luteous to ochraceous. Colonies on DG18 with entire edge, about 28–34 mm diam in 7 d at 25 °C, with yellow to amber aerial hyphae, reverse amber to luteous.

Specimen examined: **Germany**, Kiel-Kitzeberg, isolated from air by K.H. Domsch, culture CBS 860.68.

Notes: Comparing several isolates of *D. pratensis* indicated a stable morphology. This species can be easily distinguished by its yellow to amber colony, broad ovate to nearly globose ascospores and the terminal hairs usually branched at wide (straight to right) angle. Prevously, a mistake in sequencing gave a wrong identification for the indoor isolate CBS 860.68 (was wrongly identified as *Ch. indicum* in Wang *et al.* 2014). We corrected this mistake in the present study.

Dichotomopilus pseudoerectus X. Wei Wang & Samson, **sp. nov.** MycoBank MB818844. Fig. 33.
Etymology: Name refers to its similarity to *D. erectus* (= *Ch. erectum*).

Ascomata superficial, ostiolate, greenish olivaceous to olivaceous grey in reflected light, subglobose or ovate, 135–220 µm high, 125–195 µm diam. *Ascomatal wall* composed of brown, angular or elongate hypha-like cells (*textura angularis* mixed with *textura intricata*). *Terminal hairs* dark brown, irregular in length and often attached by amber but soluble crystals which would soon dissolve in the mounting solution, 3–4.5 µm diam near the base, dichotomously branched at wide to acute angles starting near the bases, verrucose. *Lateral hairs* similar to the terminal ones but shorter, or seta-like. *Asci* fasciculate, with 8 irregularly-arranged ascospores visible, clavate, broadly clavate, pyriform to ovate, spore-bearing portion 10–15 × 7.5–10.5 µm, stalks 4.5–10.5 µm long, evanescent quickly. *Ascospores* olivaceous when mature, ovate to broad ovate, bilaterally flattened, 5.5–6.5(–7) × 5–5.5 × 3.5–4 µm, with an apical germ pore at the more attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire edge and spreading rapidly, over 70 mm diam in 7 d at 25 °C, with luteous to ochraceous and floccose aerial hyphae, with amber to ochraceous exudates diffusing into the medium, reverse ochraceous. Colonies on PCA olivaceous with entire edge, about 45–51 mm diam in 7 d at 25 °C, with pale yellow to pale luteous, sparse and floccose aerial hyphae, without coloured exudates; reverse honey. Colonies on MEA white to pale yellow, with irregularly fimbriate edge, wrinkled with irregularly radiating furrows, about 22–26 mm diam in 7 d at 25 °C, with sparse aerial

Fig. 24. *Collariella causiiformis* (CBS 792.82). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Basal parts of terminal ascomatal hairs. I. Upper parts of terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–F = 100 µm; G–K = 10 µm.

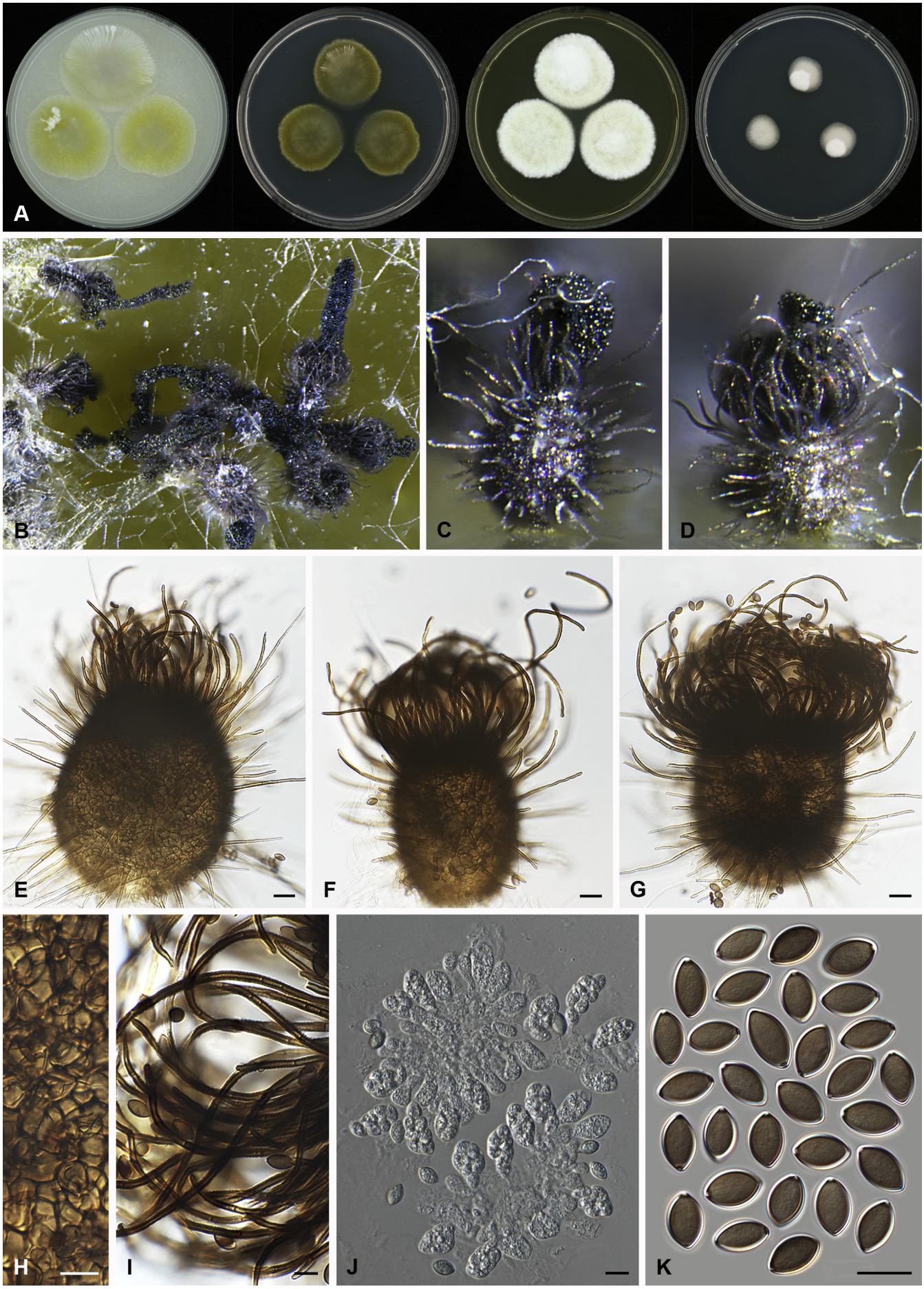


Fig. 25. *Collariella gracilis* (CBS 249.75). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–G. Ascomata mounted in lactic acid. H. Structure of ascomatal wall in surface view. I. Terminal ascomatal hairs. J. Asci. K. Ascospores. Scale bars: E–G = 20 µm; H–K = 10 µm.

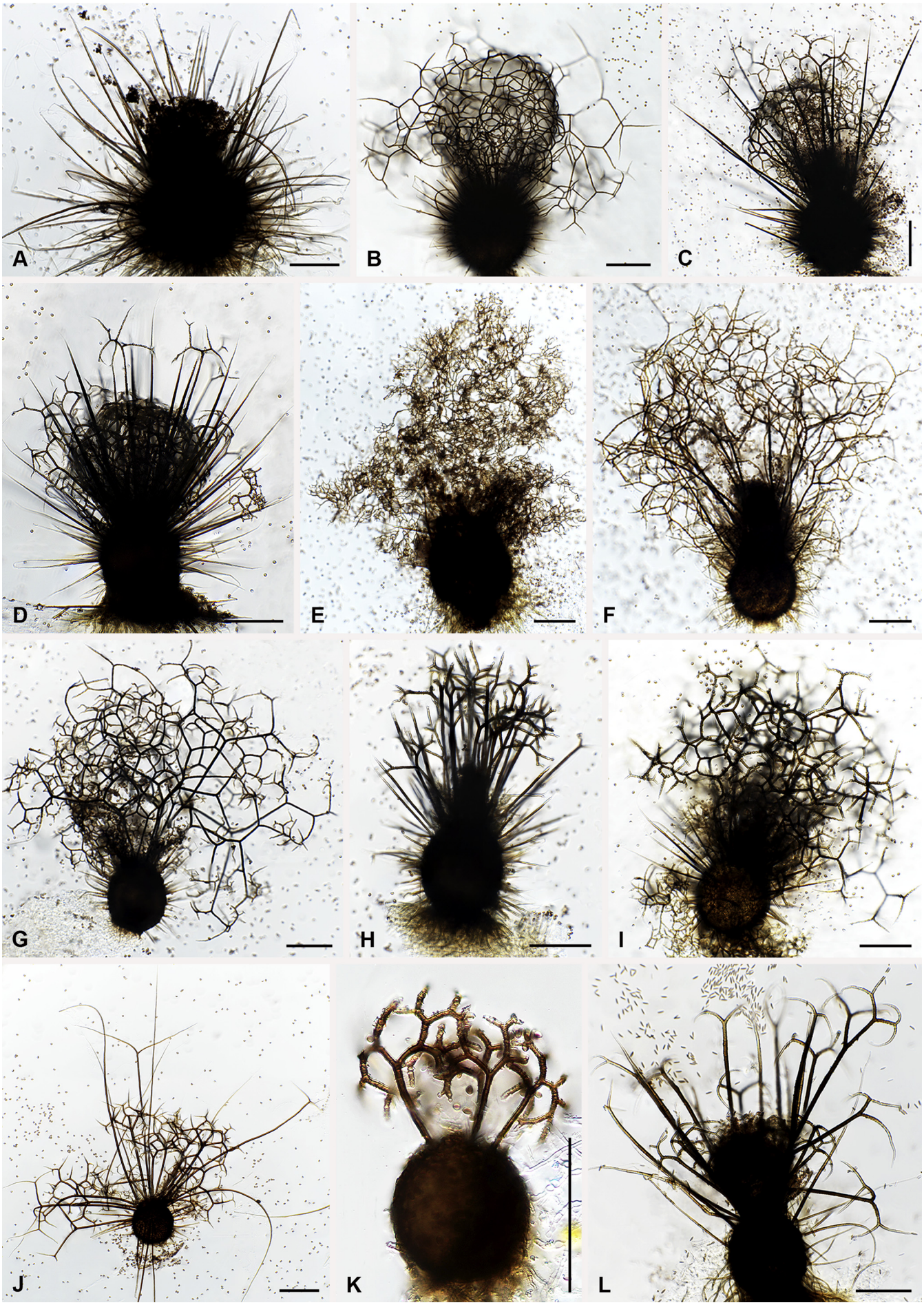
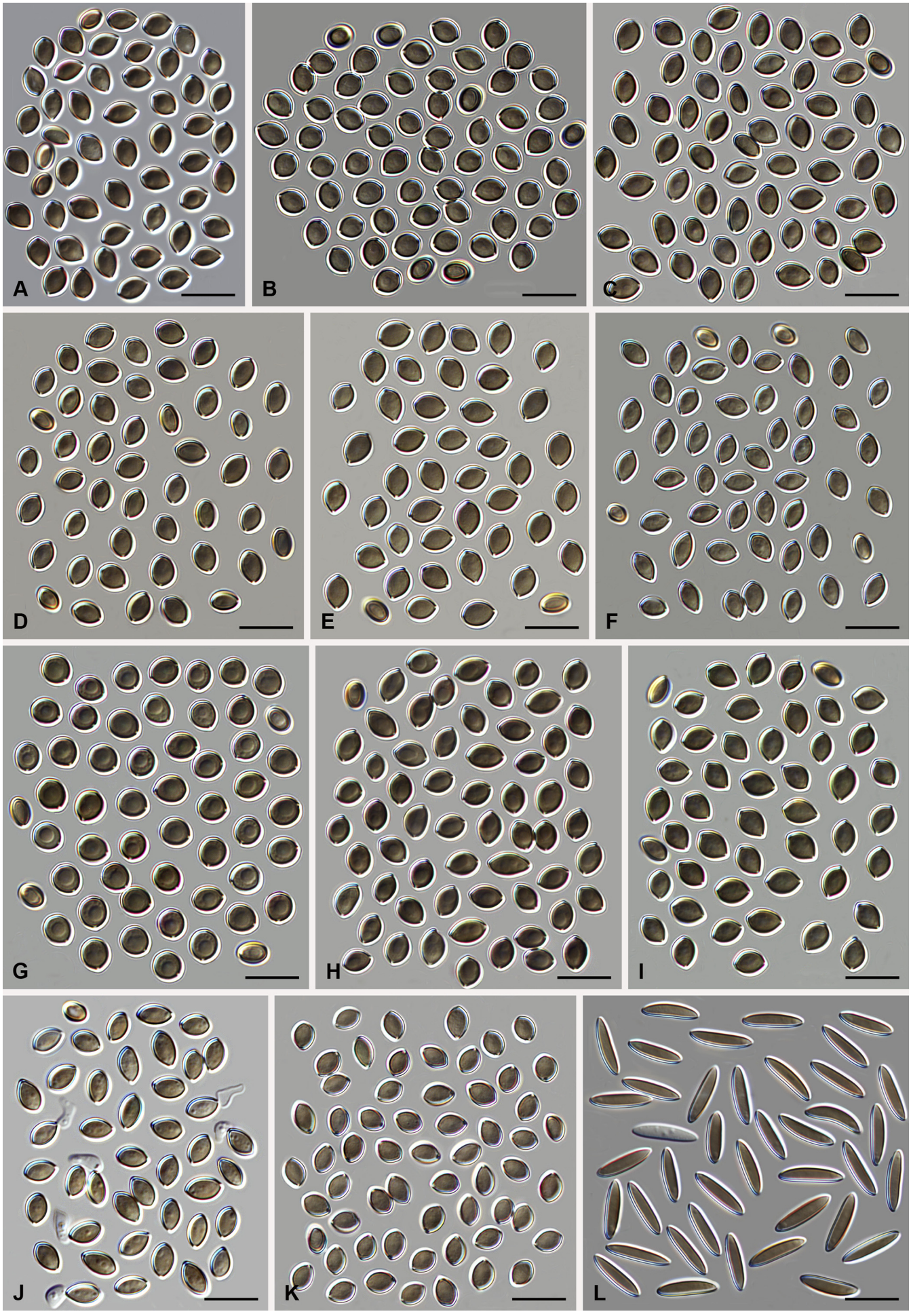


Fig. 26. Morphological diversity of ascomata in the genus *Dichotomopilus*. A. *D. variostiolatus* (CBS 179.84^{T}). B. *D. variostiolatus* (DTO 319-A2). C. *D. subfunicola* (CBS 812.73). D. *D. pseudofunicola* (DTO 318-I7). E. *D. funicola* (CBS 136.38 = *C. cancroideum*). F. *D. indicus* (DTO 319-B8). G. *D. pratensis* (CBS 860.68). H. *D. erectus* (CGMCC 3.12900). I. *D. ramosissimus* (CGMCC 3.14183^{T}). J. *D. dolichotrichus* (CBS 162.48^{T}). K. *D. reflexus* (CBS 157.49^{T}). L. *D. fusus* (CBS 114.83). Scale bars: A–L = 100 µm.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hyphae, reverse luteous to fulvous. Colonies on DG18 pale ochraceous with entire edge, about 7–13 mm diam in 7 d at 25 °C, without aerial hyphae, reverse pale luteous.

Specimen examined: **India**, Uttar Pradesh, isolated from air by Kamal (**holotype** CBS H-22846, culture ex-type CBS 252.75).

Notes: the ex-type culture CBS 252.75 is deposited in the CBS collection as *Ch. erectum*. This species is indeed morphologically similar to *D. erectus* (= *Ch. erectum*). However, the phylogenetic analysis (Fig. 1) indicated that it is closer to *D. ramosissimus* than to *D. erectus*. *Dichotomophilus pseudoerectus* can be differentiated from *D. ramosissimus* by relatively sparse terminal ascomatal hairs which are often different in length.

Dichotomopilus pseudofunicola X. Wei Wang & Samson, **sp. nov.** MycoBank MB818845. Fig. 34.
Etymology: Name refers to its similarity to *D. funicola*.

Ascomata superficial, ostiolate, grey olivaceous to dark grey olivaceous in reflected light, subglobose or ovate, 140–260 µm high, 130–235 µm diam. *Ascomatal wall* composed of brown, hypha-like or irregular cells (*textura intricata*). *Terminal hairs* olivaceous brown, 4–7 µm diam near the base, punctulate, partly longer and erect, seta-like, unbranched or dichotomously branched 1–3 times at wide to acute angles usually only at the top part; partly shorter, dichotomously branched profusely starting near the base and forming a globose net to enfold ascospores. *Lateral hairs* unbranched, seta-like, tapering and fading towards tips. *Asci* fasciculate, clavate, broadly clavate to pyriform or ovate, with 8 irregularly-arranged ascospores, spore-bearing portion 12–18 × 7–10.5 µm, stalks 6–11 µm long, evanescent quickly. *Ascospores* olivaceous when mature, ovate to limoniform, biapiculate, bilaterally flattened, 5.5–6(–6.5) × 4–5 × 3.5–4 µm, with an apical germ pore at the more attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge, about 55–61 mm diam in 7 d at 25 °C, with yellowish white to pale yellow, producing honey to pale luteous exudates diffusing into the medium; reverse pale luteous. Colonies on PCA with entire edge, about 54–60 mm diam in 7 d at 25 °C, olivaceous buff, greenish olivaceous in the centre because of the formation of ascomata, without coloured exudates; reverse olivaceous buff. Colonies on MEA white to pale yellow with an entire and pale olivaceous buff edge, about 45–51 mm diam in 7 d at 25 °C, forming floccose aerial hyphae, without coloured exudates, reverse ochraceous. Colonies on DG18 white to buff with an entire edge, about 11–17 mm diam in 7 d at 25 °C, without aerial hyphae, without coloured exudates; reverse pale buff.

Specimen examined: **USA**, isolated from dust by Whitfield & K. Mwange in 2009 (**holotype** CBS H-22847, culture ex-type CBS 142033 = DTO 318-I7).

Notes: Based on the examined isolate, this species seems to be the best example to reflect the description of *D. funicola* (= *Ch. funicola*) given by von Arx *et al.* (1986), showing seta-like together with repeatedly dichotomously branched terminal hairs. The isolate of *D. pseudofunicola* grew slower than the isolates of *D. funicola*. As this species is only known by the type, more isolates are waited for a better delimitation of this species.

Dichotomopilus subfunicola (X.W. Wang & L. Cai) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818846. Figs 35, 36.
Basionym: *Chaetomium subfunicola* X.W. Wang & L. Cai, Mycol. Prog. 13: 723. 2014.

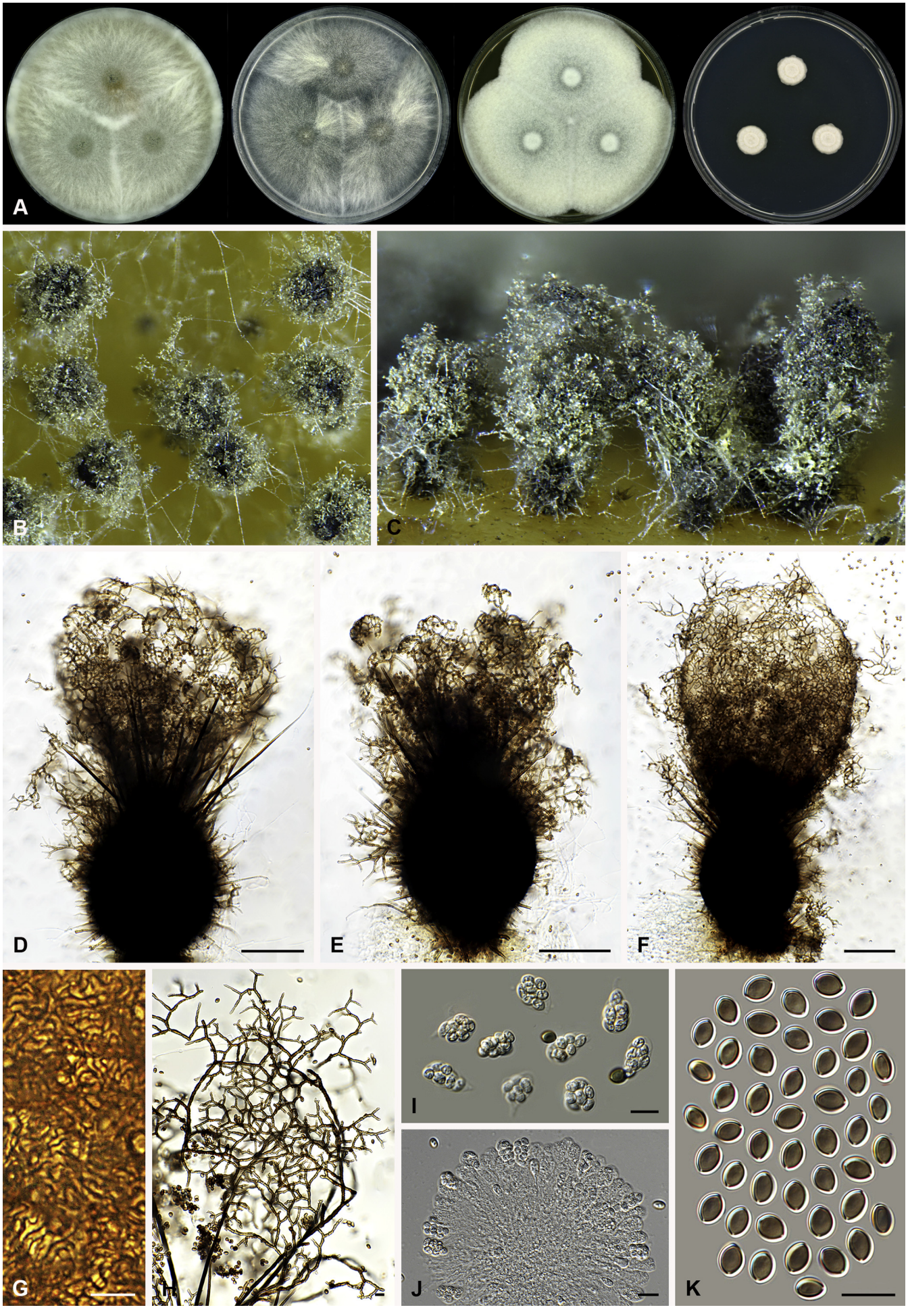
Ascomata superficial, ostiolate, greenish olivaceous to citrine olivaceous in reflected light, subglobose to ellipsoid, 145–270 µm high, 120–250 µm diam. *Ascomatal wall* composed of brown, irregular or elongate cells (*textura intricata* or *epidermoidea*). *Terminal hairs* composed of two types: (1) wider, dark brown and erect, 3.5–6 µm diam near the base, tapering and fading towards tips, seta-like or dichotomously branched at wide to acute angles starting near the base, verrucose; (2) thinner, umber to brown, 2.5–4.5 µm diam near the base, dichotomously branched profusely at wide to acute angles starting near the base and often forming a loose net to enfold ascospores (CBS 812.73), or only composed of the thinner type ones (CBS 794.83). *Lateral hairs* simply branched or seta-like, tapering and fading towards tips. *Asci* fasciculate, with 8 irregularly-arranged ascospores, clavate, ovate to broadly ovate or pyriform, spore-bearing portion 12.5–18.5 × 7.5–12 µm, stalks 4.5–9 µm long, evanescent quickly. *Ascospores* olivaceous when mature, ovate, bilaterally flattened, 5.5–6.5(–7.5) × 4–5 × 3.5–4(–4.5) µm, with an apical germ pore at the more attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with an entire edge, about 46–54 mm diam in 7 d at 25 °C, with pale yellow, floccose aerial hyphae, producing pale luteous, pale citrine, citrine green to greenish olivaceous exudates diffusing into the medium; reverse pale luteous, citrine, greyish yellow-green to citrine green. Colonies on PCA pale yellow to greenish olivaceous because of the sparse aerial hyphae and ascomata, with entire or slightly lobate edge, about 55–62 mm diam in 7 d at 25 °C, without coloured exudates; reverse uncoloured. Colonies on MEA with lobate edge, about 41–47 mm diam in 7 d at 25 °C, forming profuse and pale yellow mycelium, greenish olivaceous because of the formation of ascomata (CBS 812.73), or with white to pale yellow aerial hyphae forming a few crenated concentric circles near the edge (CBS 794.83), without coloured exudates, reverse pale luteous to ochraceous. Colonies on DG18 pale luteous, with slightly lobate or crenated edge, about 7–16 mm diam in 7 d at 25 °C, with white aerial hyphae, without coloured exudates; reverse pale luteous.

Specimens examined: **New Guinea**, isolated from pistol belt by E.T. Reese, culture CBS 812.73. **Switzerland**, Engadin, isolated from paper by M. Dreyfuss, culture CBS 794.83.

Notes: *Dichotomopilus subfunicola* is another species close to *D. funicola*. There is phylogenetic variation within the species, but no strong evidence allowed us to segregate it into two different species. This species also showed high morphological intra-species variation, especially in terminal ascomatal hairs.

Fig. 27. Morphological diversity of ascospores in the genus *Dichotomopilus*. A. *D. variostiolatus* (CBS 179.84^T). B. *D. variostiolatus* (DTO 319-A2). C. *D. subfunicola* (CBS 812.73). D. *D. funicola* (DTO 333-F1). E. *D. indicus* (DTO 319-B8). F. *D. indicus* (DTO 333-F3). G. *D. pratensis* (CBS 860.68). H. *D. erectus* (CGMCC 3.12900). I. *D. ramosissimus* (CGMCC 3.14183^T). J. *D. dolichotrichus* (CBS 162.48^T). K. *D. reflexus* (CBS 157.49^T). L. *D. fusus* (CBS 114.83). Scale bars: A–L = 10 µm.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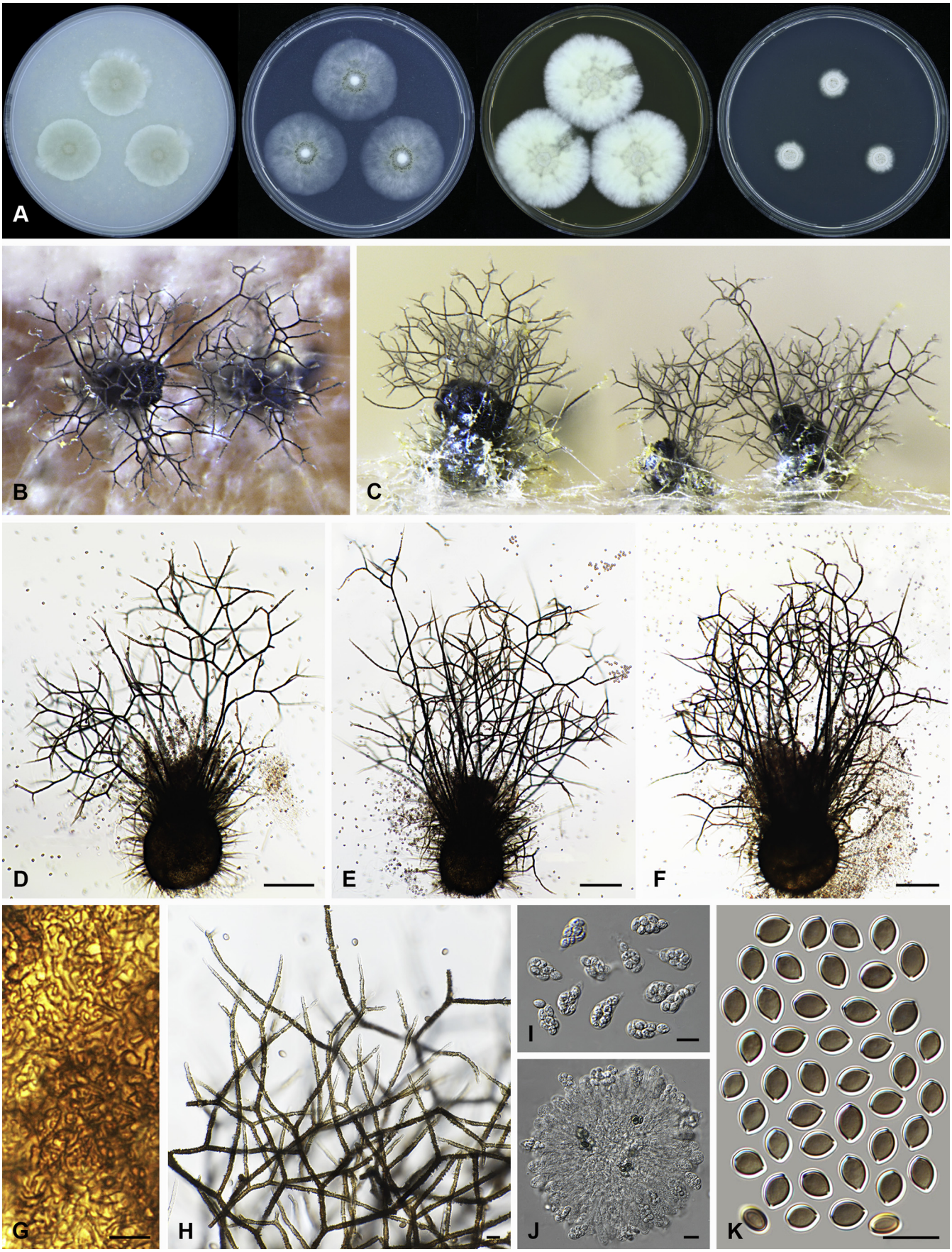


Fig. 29. *Dichotomopilus indicus* (DTO 319-B8). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper part of a terminal ascomatal hair. I–J. Asci. K. Ascospores. Scale bars: D–F = 100 µm; G–K = 10 µm.

Fig. 28. *Dichotomopilus funicola* (DTO 333-F1). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper part of a terminal ascomatal hair. I–J. Asci. K. Ascospores. Scale bars: D–F = 100 µm; G–K = 10 µm.

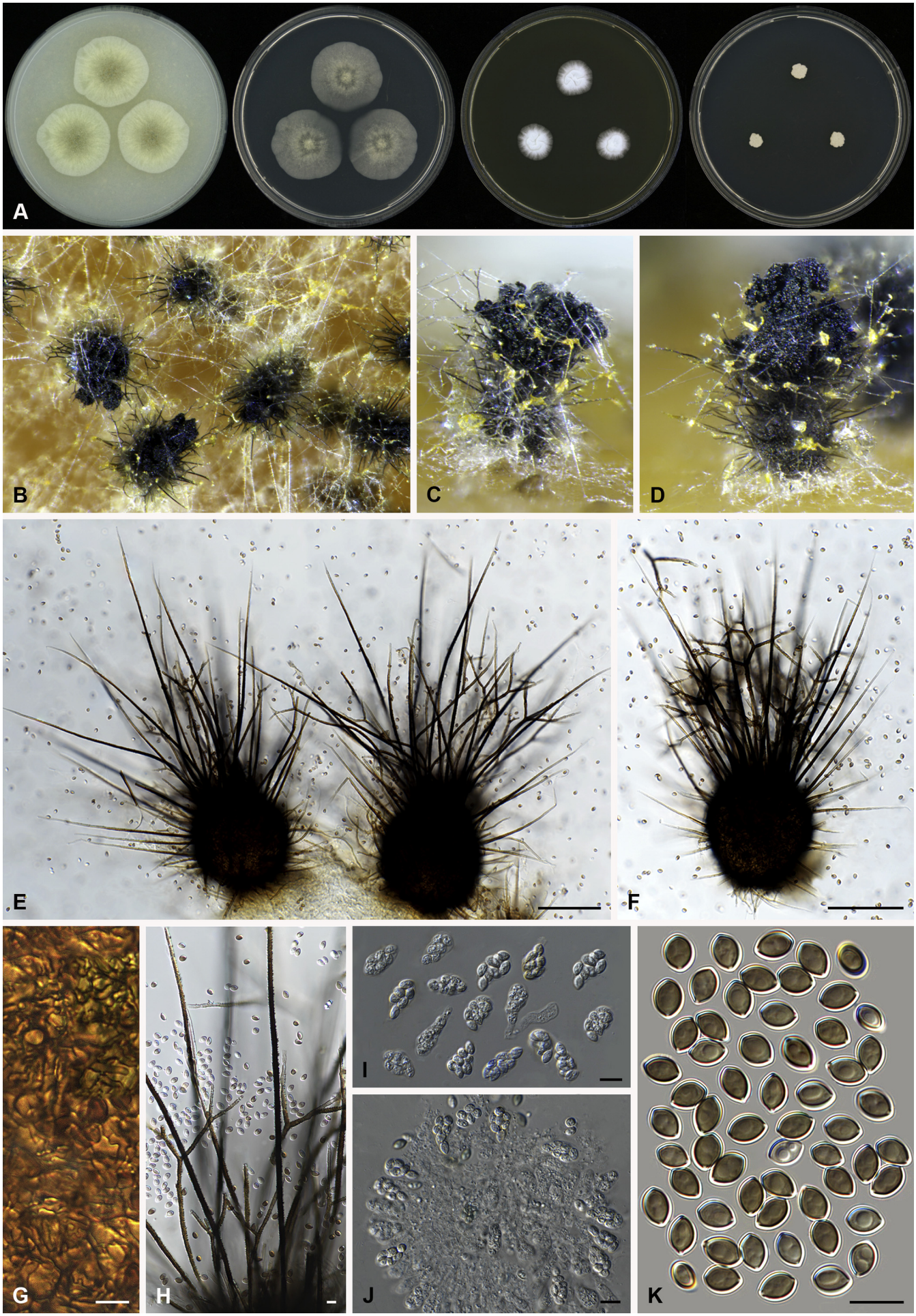


Fig. 30. *Dichotomopilus indicus* (DTO 333-E2). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper part of a terminal ascomatal hair. I–J. Asci. K. Ascospores. Scale bars: E–F = 100 µm; G–K = 10 µm.

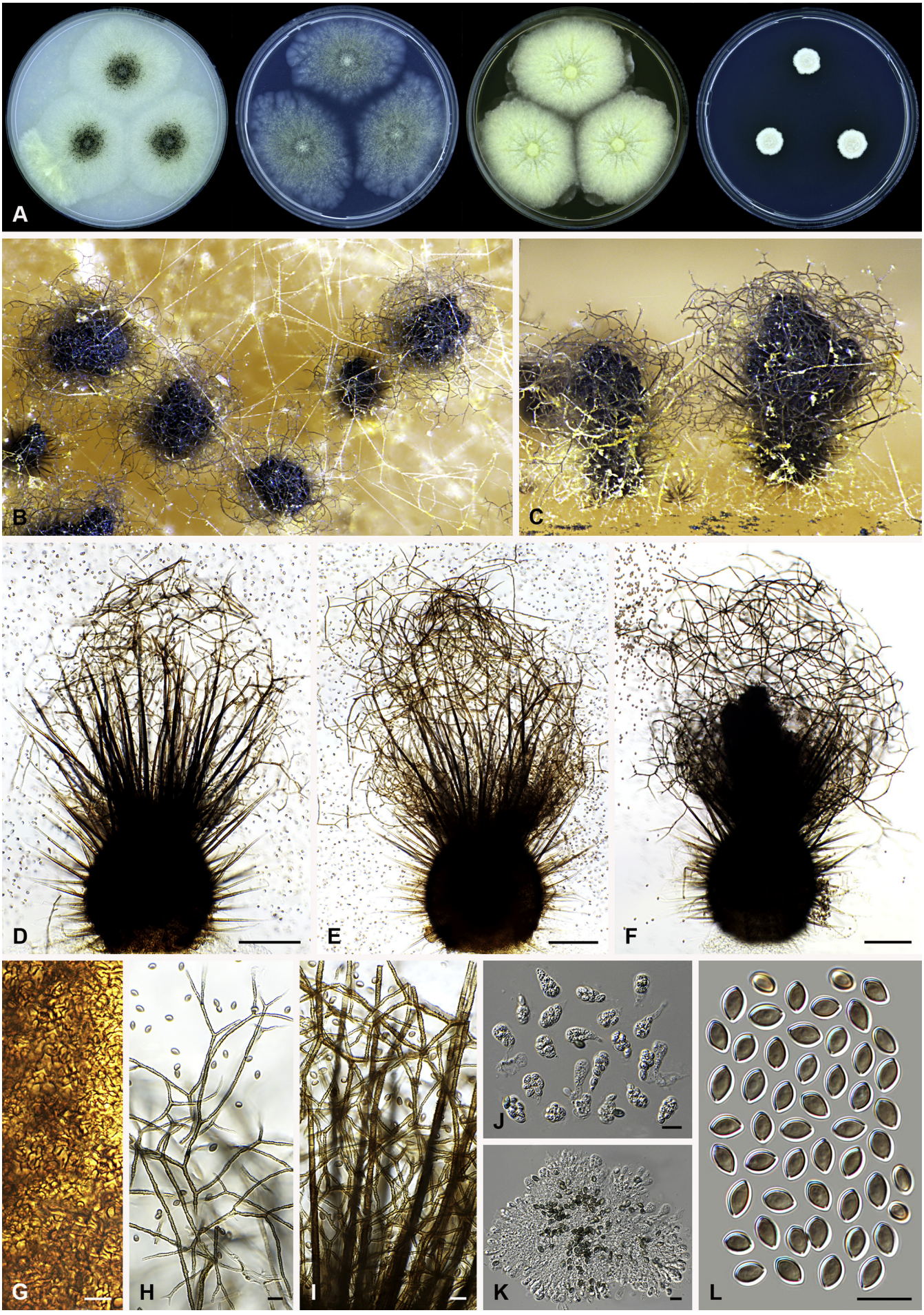


Fig. 31. *Dichotomopilus indicus* (DTO 333-F3). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper parts of terminal ascomatal hairs. I. Basal parts of terminal ascomatal hairs. J–K. Asci. L. Ascospores. Scale bars: D–F = 100 µm; G–L = 10 µm.

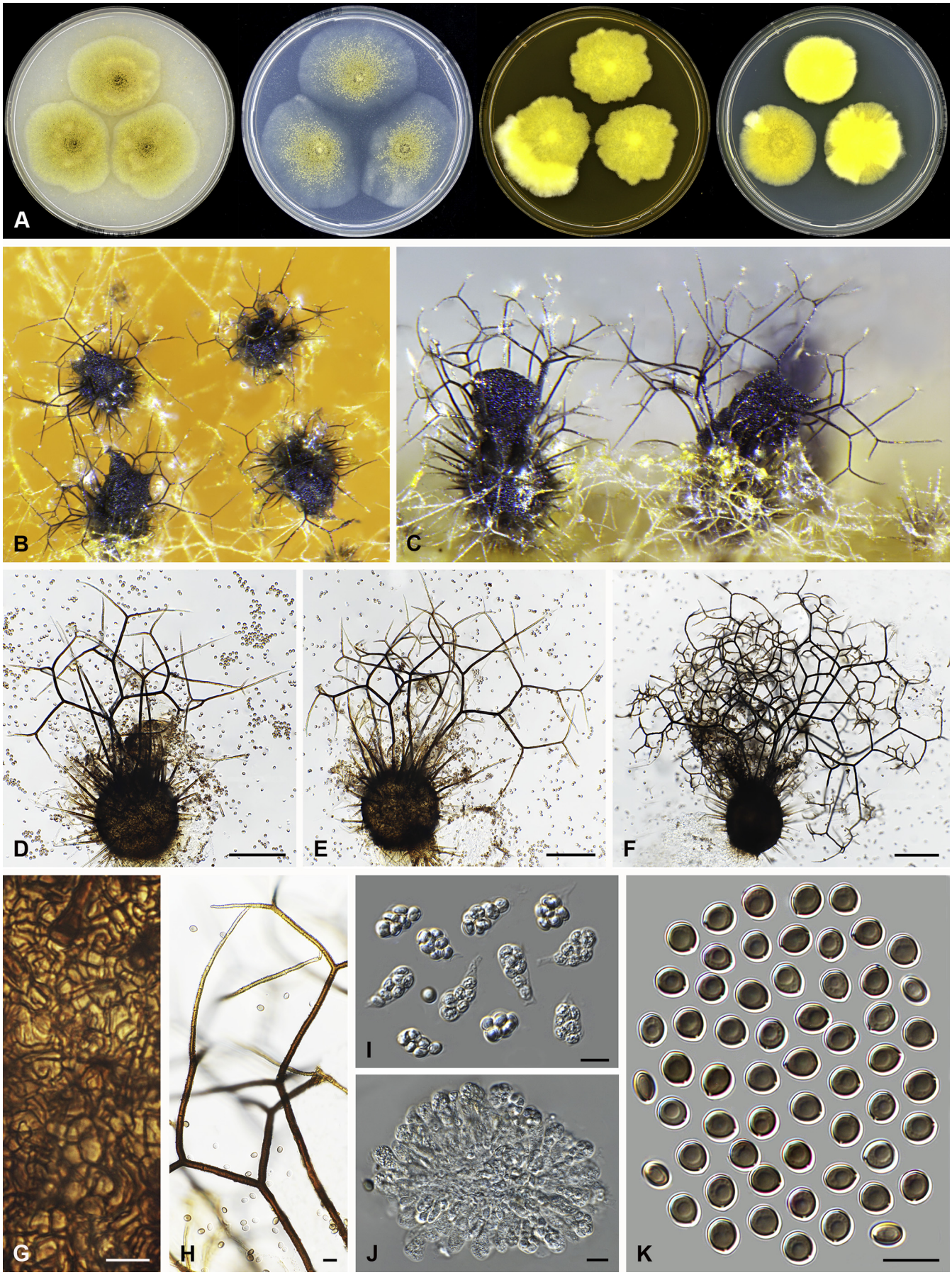


Fig. 32. *Dichotomopilus pratensis* (CBS 860.68). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper parts of terminal ascomatal hairs. I–J. Asci. K. Ascospores. Scale bars: D–F = 100 µm; G–K = 10 µm.

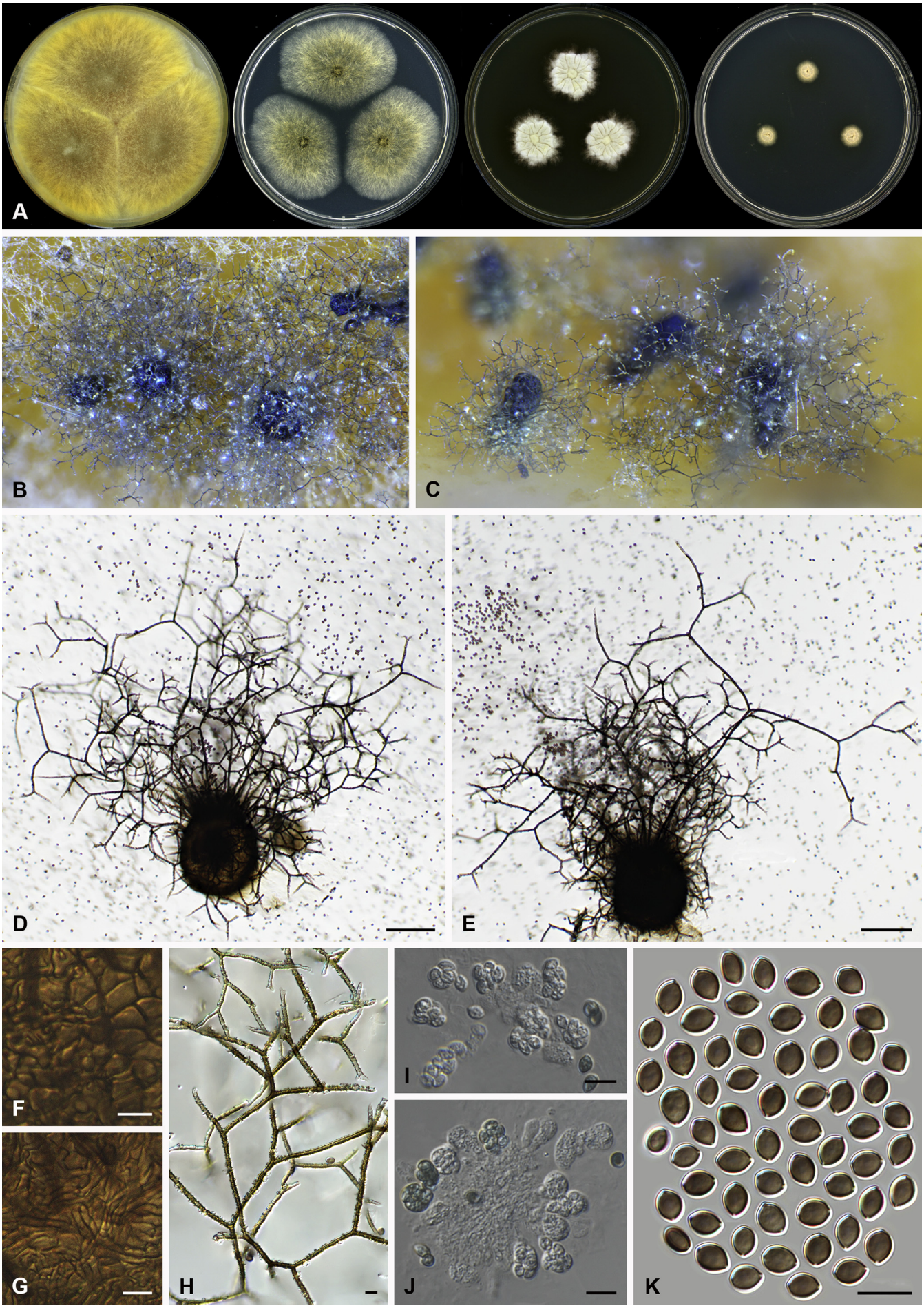


Fig. 33. *Dichotomopilus pseudoerectus* (CBS 252.75, ex-type culture). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. *Textura angularis* structure of ascomatal wall in surface view. G. *Textura intricata* structure of ascomatal wall in surface view. H. Terminal ascomatal hairs. I–J. Asci. K. Ascospores. Scale bars: D–E = 100 µm; F–K = 10 µm.

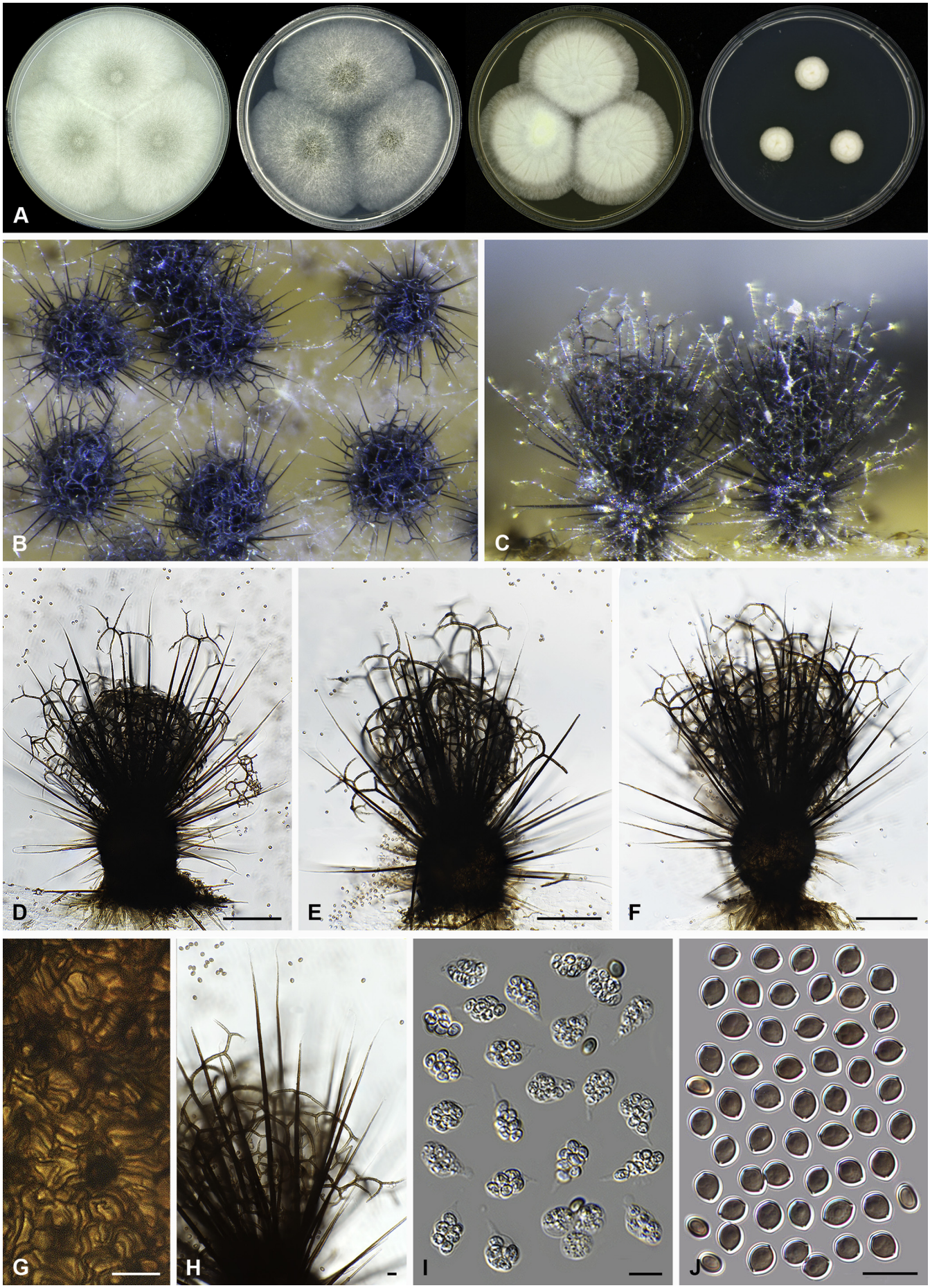


Fig. 34. *Dichotomopilus pseudofunicola* (CBS 142033 = DTO 318-I7, ex-type culture). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Terminal ascomatal hairs. I. Asci. J. Ascospores. Scale bars: D–F = 100 µm; G–J = 10 µm.

Isolates of the species often form two types of ascomatal hairs, but some isolates produce only one type (CBS 794.83, Fig. 36). Wang *et al.* (2014) differentiated *D. subfunicola* from *D. funicola* by broader (ovate) asci. Examination of more isolates showed a morphological diversity in the shape of the asci, and this indicates that this character is not suitable for differentiation between those two species.

Dichotomopilus variostiolatus (Carter) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818847. Figs 37–39.
Basionym: *Chaetomium variostiolatum* Carter, Canad. J. Bot. 61: 2603. 1983.

Ascomata superficial, or covered by white to pale yellow aerial hyphae, ostiolate, olivaceous grey dark brick to brown vinaceous in reflected light due to ascomatal hairs, globose or subglobose, 150–250 µm diam. *Ascomatal wall* brown, *textura intricata* or *epidermoidea* in surface view. *Ascomatal hairs* seta-like or flexuous, smooth to finely verrucose, brown, 4–6.5 µm diam near the base, fading and tapering towards the tips (CBS 179.84), or olivaceous to brown, 2–3.5 µm diam near the base, dichotomously branched profusely at wide angles starting near the base and forming a nearly globose net to enfold ascospores, and often with several longer hairs out of the net (DTO 319-A2), or composed of both types: (1) thinner, olivaceous to brown, 1.6–3.5 µm diam near the base, dichotomously branched profusely at acute to wide angles starting near the base, often constricted at septa, verrucose; (2) wider, dark brown and erect, 3–5 µm diam near the base, tapering and fading towards tips, seta-like or branched near the top, the branches often constricted at septa, verrucose (DTO 319-B9). *Lateral hairs* simply branched or seta-like, tapering and fading towards tips, sometimes covered by pale yellow soluble crystals. *Asci* fasciculate, clavate, fusiform, pyriform or obovate, with 8 irregularly arranged ascospores, spore-bearing part 11–24 × 7–12.5 µm, stalks 7–20 µm long, evanescent quickly. *Ascospores* brown when mature, ovate, (5–)5.5–6.5(–7) × (3.5–)4–4.5(–5) × 3–4 µm, with an apical germ pore at the attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with lobate edge, about 34–46 mm diam (CBS 179.84 and DTO 319-B9) or spreading rapidly, over 70 mm diam (DTO 319-A2) in 7 d at 25 °C, with a relatively thick layer of white mycelium varying usually in thickness (CBS 179.84), or white to pale yellow at the beginning because of the aerial hyphae, gradually olivaceous grey because of the formation of ascomata (DTO 319-A2), or with sparse pale yellow aerial hyphae (DTO 319-B9), producing luteous, amber, citrine green to citrine exudates diffusing into the medium; reverse pale luteous, greyish olivaceous or greyish yellow-green. Colonies on PCA translucent, with an entire or crenated edge, about 29–47 mm diam (CBS 179.84 and DTO 319-B9) or over 70 mm diam (DTO 319-A2) in 7 d at 25 °C, with sparse and floccose aerial hyphae, without coloured exudates; reverse uncoloured. Colonies on MEA with an entire or lobate to irregularly crenated edge, about 34–40 mm diam(CBS 179.84 and DTO 319-B9), or about 54–60 mm diam (DTO 319-A2) in 7 d at 25 °C, with floccose and white aerial hyphae together with several radiated furrows and a dark ring around the central point because of the formation of ascomata (CBS 179.84 and DTO 319-B9), or white to greyish yellow-green because of the profuse aerial hyphae and ascomata below (DTO 319-A2) without coloured exudates; reverse luteous to ochraceous. Colonies on DG18 white to buff with an entire, a slightly crenated or lobate to edge, about 9–18 mm diam in 7 d at 25 °C, with a white floccose ring composed of aerial hyphae near the edge (CBS 179.84),or without aerial hyphae (DTO 319-A2 and DTO 319-B9), without coloured exudates, reverse uncoloured.

Specimens examined: **New Guinea**, collected from tarpaulin by E.T. Reese, ex-type culture CBS 179.84. **Thailand**, isolated from dust, cultures DTO 319-B9; DTO 319-C1. **USA**, isolated from dust, culture DTO 319-A2.

Notes: *Dichotomopilus variostiolatus* was originally described to possess unbranched seta-like terminal hairs on the basis of the ex-type culture CBS 179.84 (Carter 1983). This study confirmed the examination of Carter (Fig. 37), proving a stable morphology of the ex-type culture. At the same time, several indoor isolates were found to cluster with the ex-type. These isolates produce either dichotomously branched (Fig. 38) or together with seta-like (Fig. 39) terminal hairs, indicating a broad range of the species population.

Humicola Traaen, *Nytt Mag. Natur.* 52: 33. 1914.

Type species: *Humicola fuscoatra* Traaen

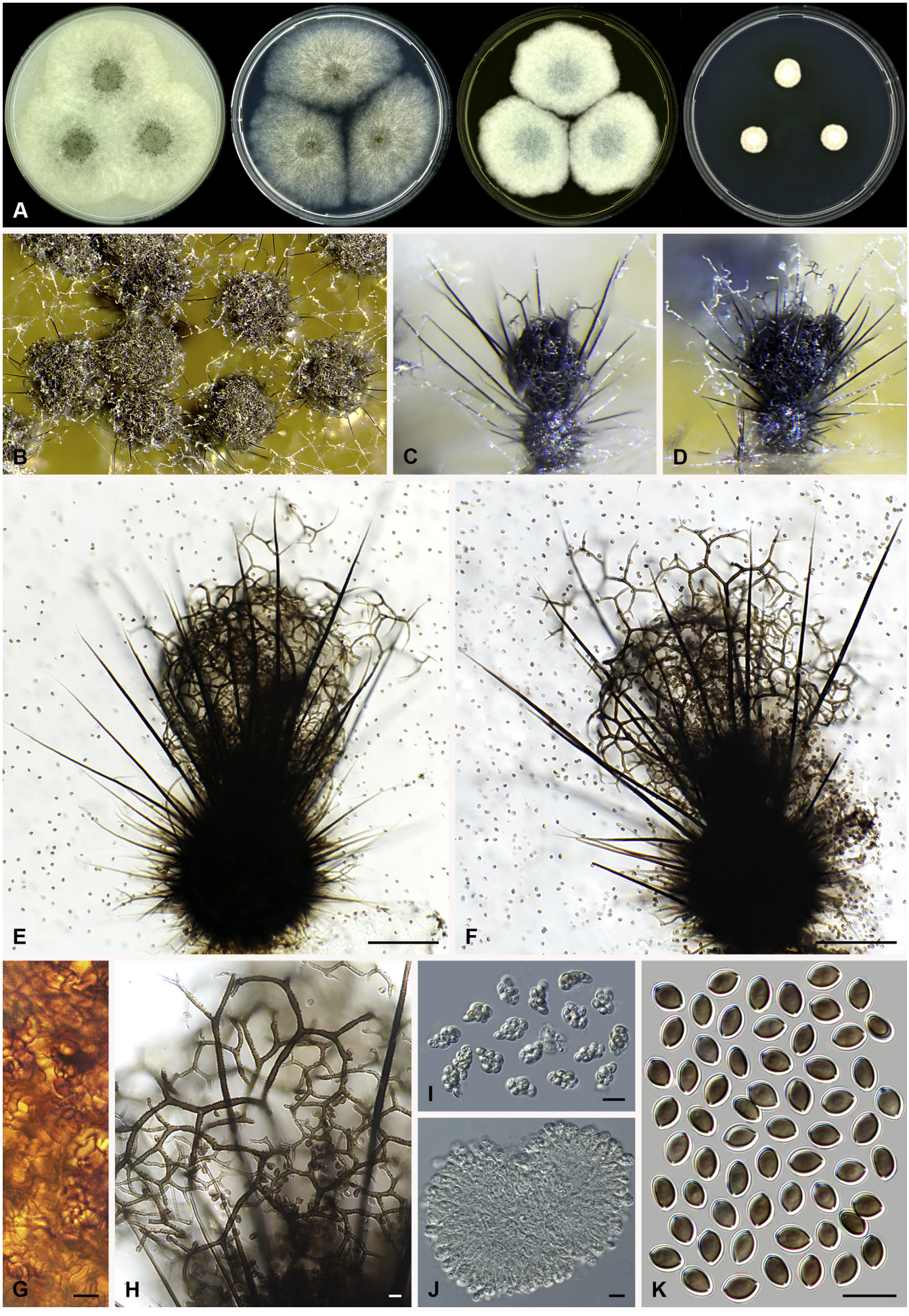
Two indoor taxa of this genus were recognised in this study. They are clustered closely with the type species of *Humicola*, *H. fuscoatra* (ex-type CBS 118.14) in a strongly supported monophyletic lineage (Fig. 1).

Humicola olivacea X. Wei Wang & Samson, **sp. nov.** MycoBank MB818848. Fig. 40.
Etymology: Name refers to the colony colour of this fungus.

Somatic hyphae hyaline to honey, 1–2.5 µm wide. *Aleurioconidia* usually produced singly or in chains on 2–8 µm long or very reduced lateral hyphae, olivaceous brown, subglobose to broad obovate, attenuated at the base, (7.5–)8–9.5(–11) × (7–)7.5–9(–10) µm. Description of the micromorphology was based on the culture on SNA.

Culture characteristics: Colonies on OA with an entire edge, about 49–55 mm diam in 7 d at 25 °C, greenish olivaceous because of the formation of a large number of conidia, with a thin layer of aerial hyphae; reverse black. Colonies on PCA greenish olivaceous to grey olivaceous, with an entire edge, about 37–43 mm diam in 7 d at 25 °C, with sparse white to grey aerial hyphae; reverse black with grey edge. Colonies on MEA white, with an entire edge, 47–53 mm diam in 7 d at 25 °C, forming radiating furrows, with white and relatively sparse floccose aerial hyphae; reverse olivaceous buff to greenish olivaceous. Colonies on DG18 olivaceous with an entire and buff edge, about 13–19 mm diam in 7 d at 25 °C, with olivaceous aerial hyphae; reverse hazel with buff edge. Colonies on SNA with an entire edge, about 41–47 mm diam in 7 d at 25 °C, translucent, without aerial hyphae, grey olivaceous in the centre; reverse olivaceous in the centre.

Specimen examined: **USA**, isolated from dust by K. Seifert (**holotype** CBS H-22848, culture ex-type CBS 142031 = DTO 319-C7).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Notes: This species is morphologically similar to *H. glauca*, *H. lutea* and *H. repens* (Bertoldi 1976), especially in shape and size of aleurioconidia, but can be distinguished by the colour of aleurioconidia, the colony morphology and the formation of aleurioconidia easily in chains. The ITS sequence data also supported the differences between this species and the three morphologically similar species (data not shown here).

Humicola sp. Fig. 41.

Somatic hyphae hyaline to subhyaline, 1–3 µm wide. *Aleurioconidia* produced terminally or laterally singly or two in chains on hyaline to pale brown hyphae which are very reduced till up to 16 µm long, smooth, globose, obovoid, pyriform to clavate, pale brown to brown, (7.5–)8.5–11.5(–13.5) × (5.5–)7.5–9(–11) µm.

Culture characteristics: Colonies on OA with an entire or irregularly undulated edge, about 52–58 mm diam in 7 d at 25 °C, partially with thick white and floccose aerial hyphae, immersed hyphae grey to black; reverse black. Colonies on PCA white to honey, with an entire edge, about 48–54 mm diam in 7 d at 25 °C, translucent, with thick white aerial hyphae in the centre; reverse white to smoke grey, black in the centre. Colonies on MEA with an entire edge, 51–57 mm diam in 7 d at 25 °C, with thick, white to honey floccose aerial hyphae; reverse black. Colonies on DG18 white, with an entire edge, about 18–24 mm diam in 7 d at 25 °C, with relatively thin white aerial hyphae; reverse pale luteous, black in the centre. Colonies on SNA white, with an entire edge, about 56–62 mm diam in 7 d at 25 °C, translucent with sparse and uneven white aerial hyphae; reverse partially black.

Specimens examined: **Mexico**, isolated from dust, cultures DTO 318-G9; DTO 318-H1. **South Africa**, isolated from dust, culture DTO 319-B7.

Notes: These isolates are morphologically similar to *H. piriformis* especially in the shape of their aleurioconidia. However, it differs in having larger aleurioconidia than *H. piriformis* (7.0–7.5 µm diam). The ITS sequences of *H. aurea*, *H. glauca*, *H. lutea*, *H. piriformis* and *H. repens* are identical and our indoor isolates differ only by one base pair. ITS sequences seemed not to be informative enough to distinguish the aleurioconidial fungi. For example, the ITS sequences of *H. grisea* and *Trichocladium asperum* were identical (data not shown here), but the morphology of these two species are distinct (Hambleton *et al.* 2005). Cultures of all the related species and more research are needed to re-evaluate these related species, and then to make an identification decision for this taxon.

Humicola is a well-known hyphomycetous genus possessing smooth-walled and usually aseptate aleurioconidia forming attached to lateral or terminal conidiogenous cells (Bertoldi 1976, Hambleton *et al.* 2005). Further study is strongly encouraged to clarify the relationships of the *Humicola* species included in this study to the other *Humicola* species as well as the members of *Farrowia* (Hawksworth 1975) and some traditional species of *Chaetomium* such as *C. homopilatum* which have humicola-like asexual morphs.

Melanocarpus Arx, Stud. Mycol. 8:17. 1975.

Type species: *Melanocarpus albomyces* (Cooney & R. Emers.) Arx

Melanocarpus tardus X. Wei Wang & Samson, **sp. nov.** MycoBank MB818849. Fig. 42.

Etymology: Name refers to the restricted growth of this fungus on the agar media.

Ascomata superficial, or embedded in white aerial mycelium, often aggregated, non-ostiolate, black in reflected light, glabrous or with a few hypha-like and hyaline hairs, globose, 50–170 µm diam. *Ascomatal wall* brown, ochraceous or fulvous when young, dark brown to black when mature, *textura epidermoidea* or *intricata* in surface view. *Asci* fasciculate, ovate to broadly ovate, spore-bearing portion 11–16.5 × 9–13.5 µm, stalks 4–9.5 µm long, with 8 irregularly-arranged ascospores, evanescent quickly before the ascospores mature. *Ascospores* brown when mature, ovate to broadly ovate, bilaterally flattened, 7–8(–8.5) × (6–)6.5–7.5 × 5–6 µm, with an apical germ pore at the attenuated end. *Asexual morph* unknown.

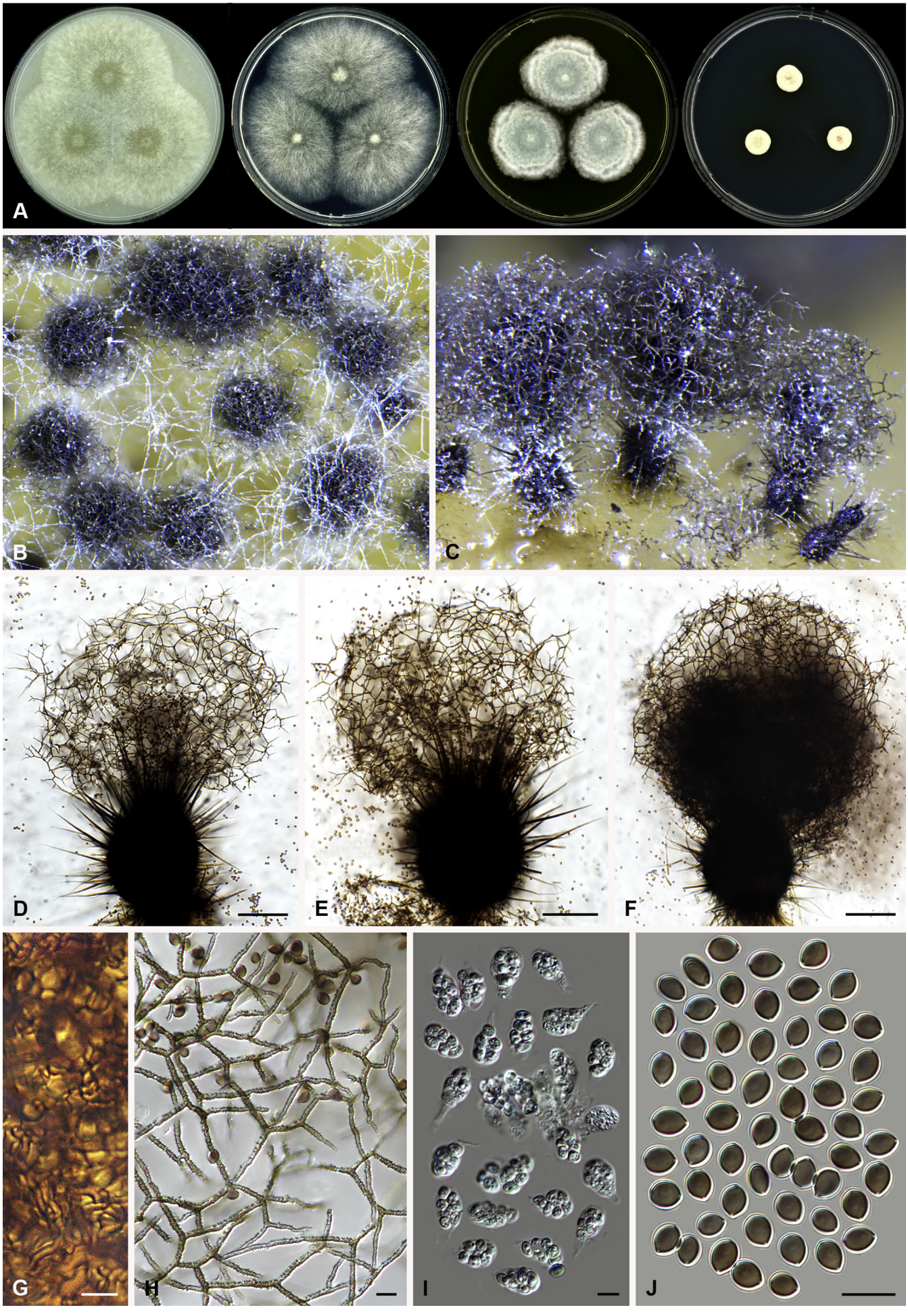
Culture characteristics: Colonies on OA growing slowly, about 2–7 mm diam in 7 d at 25 °C, with an entire edge, with white, floccose and compact aerial mycelium, without coloured exudates, or producing honey to greenish olivaceous exudates diffusing into the medium when becoming old; reverse uncoloured. Colonies on PCA with an entire edge, about 2–8 mm diam in 7 d at 25 °C, buff, slightly floccose, without coloured exudates; reverse uncoloured. Colonies on MEA with a lobate edge, about 3–8 mm diam in 7 d at 25 °C, with white and floccose mycelium, without coloured exudates; reverse uncoloured. The growth of colonies on DG18 was restricted, less than 2 mm after 7 d at 25 °C, without coloured exudates; reverse uncoloured.

Specimen examined: **Switzerland**, St. Gallen, isolated from cotton jacket by E. Müller in Sep. 1976 (**holotype** CBS H-22849, culture ex-type CBS 541.76).

Notes: The ex-type culture CBS 541.76 is deposited in the CBS collection as *T. minuta*. *Thielavia minuta* was originally described to have rapidly spreading colonies. Furthermore, the ascomata are covered by a dense layer of curved brown and curved hairs, and the ascospores are ovate shaped, measuring 6.5–8 × 5–5.5 µm (Cain 1961). CBS 541.76 exhibits very restricted growth on agar media, and the ascomata are glabrous or nearly so, and contain conspicuously bilaterally flattened ascospores. This combination of characteristics does not fit with that of *T. minuta* and therefore a new species was introduced for this isolate.

Although *Melanocarpus tardus* and the type species of the genus *Melanocarpus*, *Me. albomyces* are on two very long branches in the phylogenetic tree (Fig. 1), they clustered together with high statistic support. We prefer to keep this species as a member of *Melanocarpus* rather than introducing a novel monotypic genus to accommodate it.

Fig. 35. *Dichotomopilus subfunicola* (CBS 812.73). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper parts of terminal ascomatal hairs. I–J. Asci. K. Ascospores. Scale bars: E–F = 100 µm; G–K = 10 µm.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The genus *Melanocarpus* was considered to possess non-ostiolate ascomata, and differs from *Thielavia* in having spreading colonies; obovate, spherical or oblate ascospores and chrysonilia-like asexual morph (von Arx *et al.* 1988). The isolate CBS 541.76 does not produce spreading colonies and chrysonilia-like asexual morph. The addition of this species into *Melanocarpus* prompts the re-evaluation of this genus.

Ovatospora X. Wei Wang, Samson & Crous, **gen. nov.** MycoBank MB818850. Figs 43, 44.
Etymology: Name refers to ovate to broad ovate ascospores of all the known species in this genus.

Type species: *Ovatospora brasiliensis* (Batista & Pontual) (= *Ch. brasiliense*).

Ascomata superficial, ostiolate, subglobose or ovate with brown walls of *textura angularis* in surface view. *Terminal hairs* usually coiled, sometimes with coiled branches. *Lateral hairs* flexuous. *Asci* fasciculate, cylindrical with 8 uniseriate ascospores, or clavate with 8 biseriate or irregularly arranged ascospores, evanescent. *Ascospores* brown when mature, broadly ovate, bilaterally flattened, rounded at one end, with an apical germ pore at another attenuate or apiculate end. *Asexual morph* unknown.

Ovatospora brasiliensis (Batista & Pontual) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818851. Fig. 45.
Basionym: *Chaetomium brasiliense* Batista & Pontual, Bol. Agr. Com. Pernambuco 15: 70. 1948.

Ascomata superficial, pale olivaceous grey to mouse grey in reflected light due to ascomatal hairs, globose or subglobose, ostiolate, 85–135 µm high, 75–110 µm diam. *Ascomatal wall* brown, *textura angularis*, sometimes mixed with *textura intricata* in surface view. *Terminal hairs* undulate to loosely coiled with erect or flexuous lower part, conspicuously rough (granulate), greyish sepia to brown, septate, 2–3.5 µm diam in the undulate or coiled upper portion. *Lateral hairs* flexuous, tapering and fading towards the tips. *Asci* fasciculate, cylindrical, spore-bearing part 35–45 × 5–7.5 µm, stalks 8–18 µm long, with 8 uniseriate ascospores, evanescent before ascospores become mature. *Ascospores* olivaceous brown when mature, ovate, bilaterally flattened, (6.5–)7–7.5(–8) × (5.5–)6–6.5(–7) × (4.5–)5–5.5(–6) µm, with an apical germ pore at the attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire or slightly undulate edge, about 41–47 mm diam in 7 d at 25 °C, usually irregularly concentric because of the concentric formation of ascomata between the floccose rings consisting of pale grey to pale olivaceous grey or honey-coloured aerial mycelium, with pigmented hyphae immersed in medium, and with dark exudates diffusing into the medium, reverse black. Colonies on PCA translucent, with entire edge, about 36–42 mm diam in 7 d at 25 °C, with olivaceous buff and floccose aerial hyphae mixed with ascomata, without coloured exudates; reverse olivaceous or olivaceous grey. Colonies on MEA with slightly undulate edge, about 32–38 mm diam in 7 d at 25 °C, with floccose, concentric and buff to white aerial mycelium, with pigmented hyphae immersed in medium, without coloured exudates, reverse black with pale edge. Colony growth on DG18 with entire edge, about 16–22 mm diam in 7 d at 25 °C, with white aerial mycelium appearing irregularly petaloid texture, without coloured exudates; reverse uncoloured.

Specimen examined: **India**, Calcutta, isolated from moist jute cloth by S.N. Basu, culture CBS 140.50.

Notes: *Ovatospora brasiliensis* formed a sister lineage to *O. mollicella* and can be distinguished by producing zonate colonies and smaller ascospores (7–7.5 × 6–6.5 × 5–5.5 *vs.* 8–9.5 × 7–8 × 6–7 µm, von Arx *et al.* 1986). No ex-type culture is available. Typification of this species awaits obtaining a culture or isolate morphologically consistent with the holotype.

Ovatospora pseudomollicella X. Wei Wang & Samson, **sp. nov.** MycoBank MB818852. Fig. 46.
Etymology: Name refers to the similarity to *Ovatospora mollicella* (= *Ch. mollicellum*).

Ascomata superficial, pale smoke grey to pale olivaceous grey in reflected light due to ascomatal hairs, subglobose to ovate, ostiolate, 100–135 µm high, 80–120 µm diam. *Ascomatal wall* brown, *textura angularis* in surface view. *Terminal hairs* loosely coiled to regularly coiled with erect or flexuous lower part, conspicuously rough (granulate), greyish sepia to brown, septate, 1.5–2.5 µm diam in the undulate or coiled upper portion. *Lateral hairs* flexuous or undulate. *Asci* fasciculate, cylindrical, spore-bearing part 40–51 × 6.5–8.5 µm, stalks 7–20 µm long, with 8 uniseriate ascospores, evanescent before ascospores become mature. *Ascospores* olivaceous brown when mature, ovate, bilaterally flattened, (7–)7.5–8.5(–9) × (5.5–)6–7.5(–8) × 5–6(–7) µm, with an apical germ pore at the attenuated end. *Asexual morph* unknown.

Culture characteristics: Colonies on OA with entire edge, about 43–49 mm diam in 7 d at 25 °C, with a floccose, white to pale grey mycelium, often with one or a few irregular concentric rings, with pigmented hyphae immersed in medium, and with mouse grey to black exudates diffusing into the medium, reverse black. Colonies on PCA with entire edge, about 33–39 mm diam in 7 d at 25 °C, with floccose and white to olivaceous buff aerial hyphae mixed with ascomata, without coloured exudates; reverse hazel to olivaceous. Colonies on MEA with slightly undulate edge, about 41–37 mm diam in 7 d at 25 °C, with floccose, white and irregularly petaloid rather than concentric aerial mycelium, with pigmented hyphae immersed in medium, without coloured exudates, reverse black with pale edge. Colony growth on DG18 with slightly crenated edge, about 18–24 mm diam in 7 d at 25 °C, pale vinaceous to vinaceous buff with white aerial mycelium, without coloured exudates; reverse rosy vinaceous to flesh and saffron in the centre.

Specimen examined: **India**, Uttar Pradesh, isolated from air by Kamal (**holotype** CBS H-22850, culture ex-type CBS 251.75).

Fig. 36. *Dichotomopilus subfunicola* (CBS 794.83). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper parts of terminal ascomatal hairs. I. Asci. J. Ascospores. Scale bars: D–F = 100 µm; G–J = 10 µm.

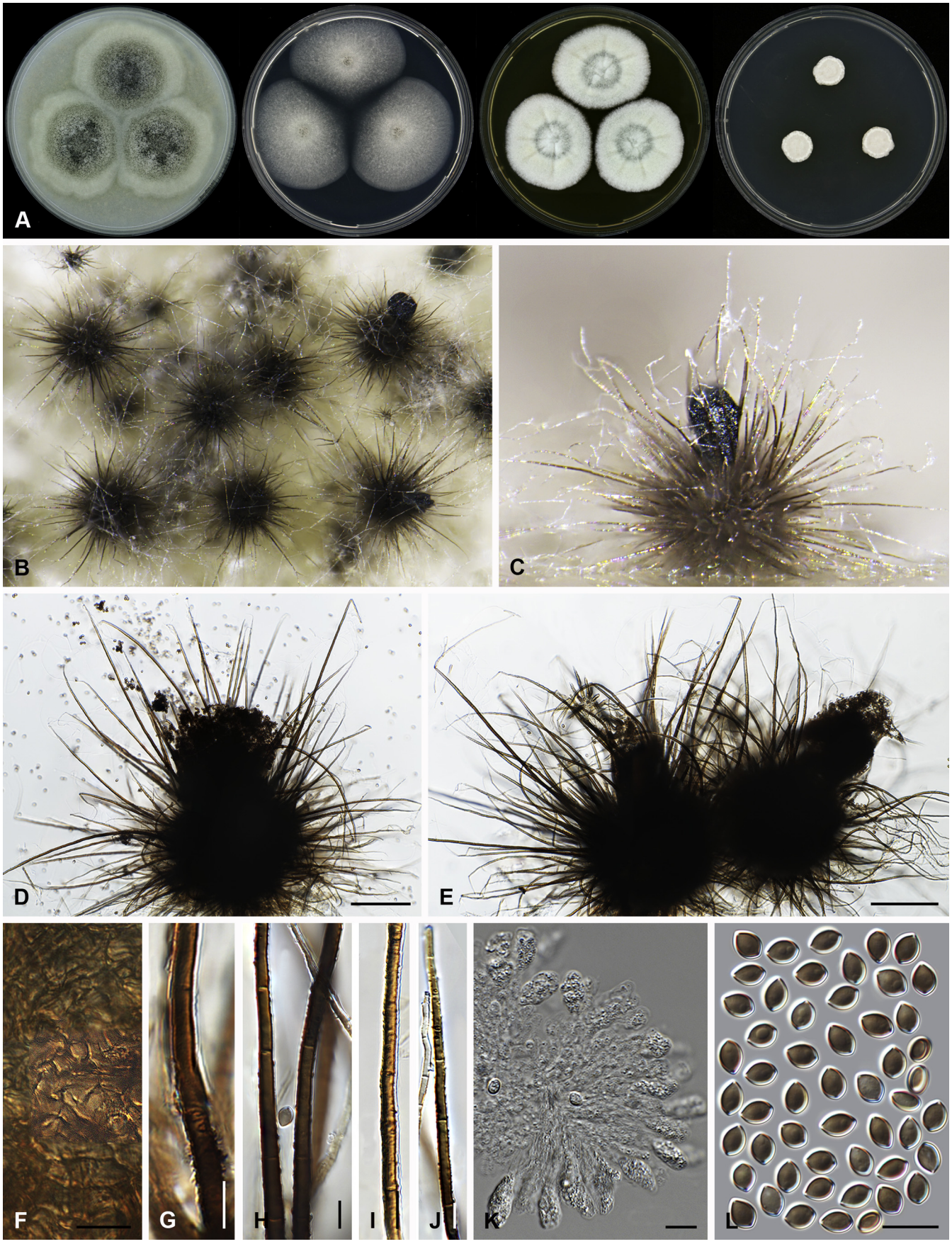


Fig. 37. *Dichotomopilus variostiolatus* (CBS 179.84^{T}). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Structure of ascomatal wall in surface view. G–J. Terminal ascomatal hairs from basal to upper parts. K. Asci. L. Ascospores. Scale bars: D–E = 100 µm; F–L = 10 µm.

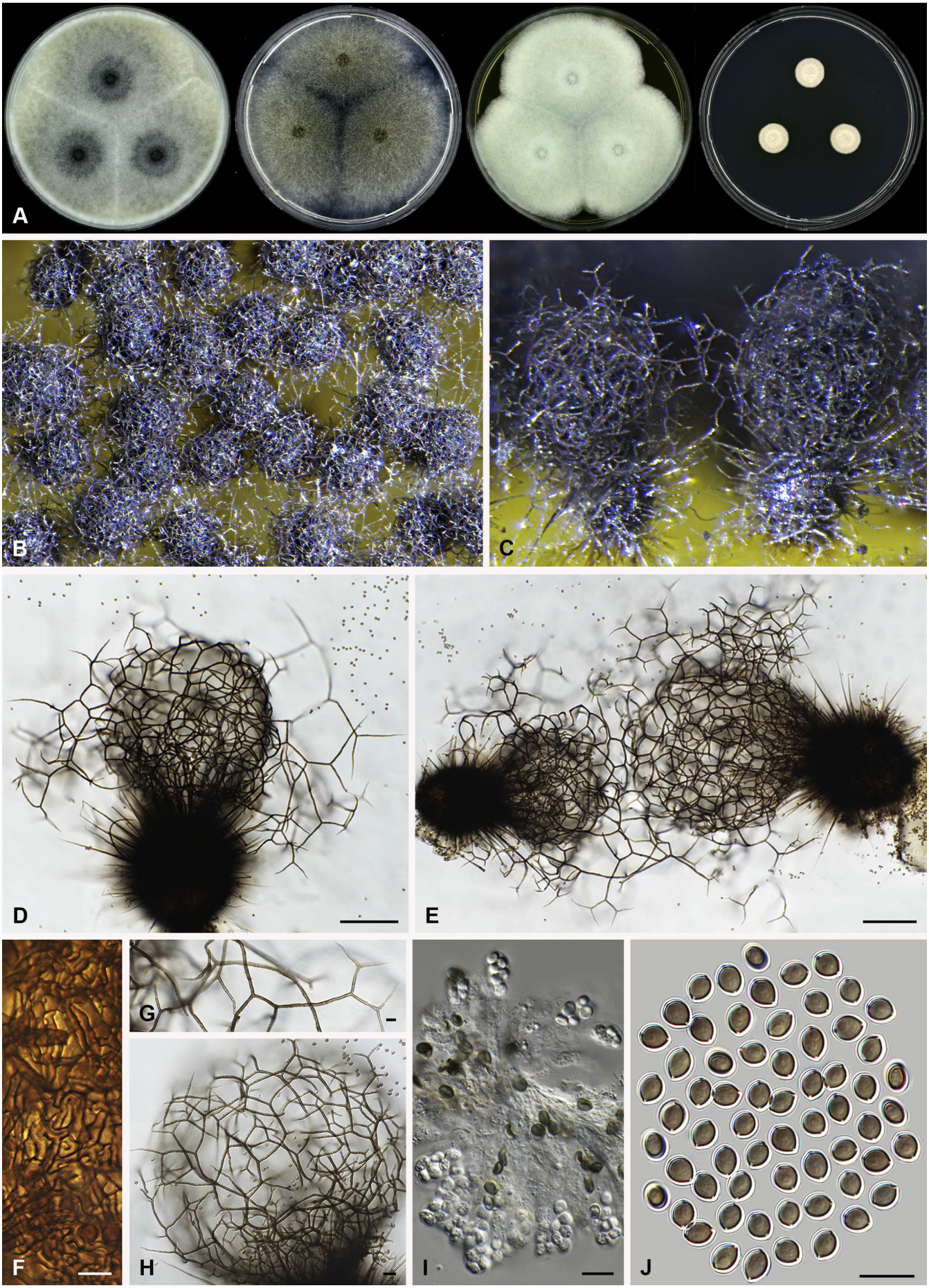


Fig. 38. *Dichotomopilus variostiolatus* (DTO 319-A2). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Structure of ascomatal wall in surface view. G. Upper part of a terminal ascomatal hair. H. Net structure formed by terminal ascomatal hairs. I. Asci. J. Ascospores. Scale bars: D–E = 100 µm; H= 20 µm; F–G, I–J = 10 µm.

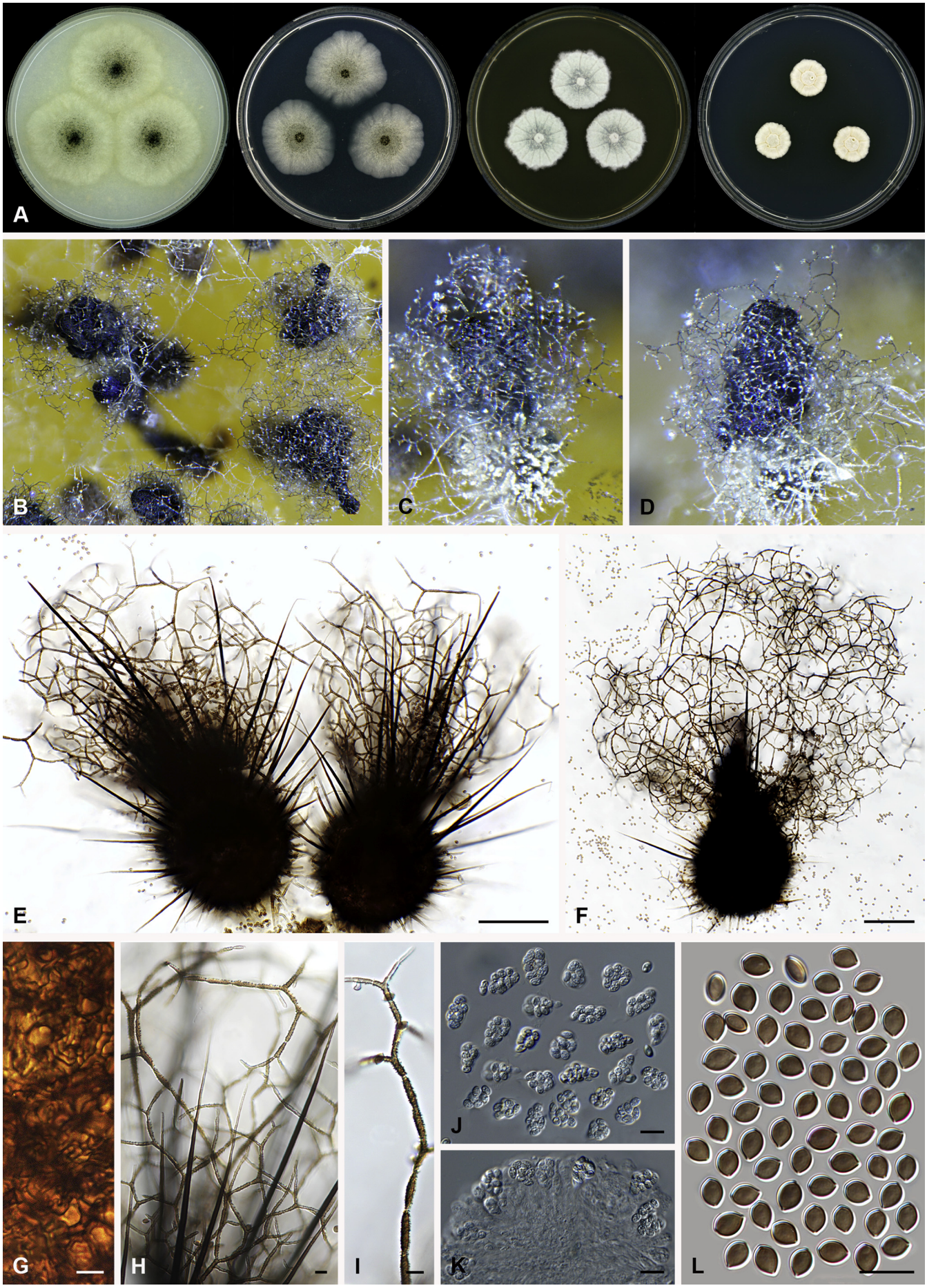


Fig. 39. *Dichotomopilus variostilatus* (DTO 319-B9). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–D. Mature ascomata on OA, side view. E–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Terminal ascomatal hair. I. Upper part of a branched terminal ascomatal hair. J–K. Asci. L. Ascospores. Scale bars: E–F = 100 µm; G–L = 10 µm.

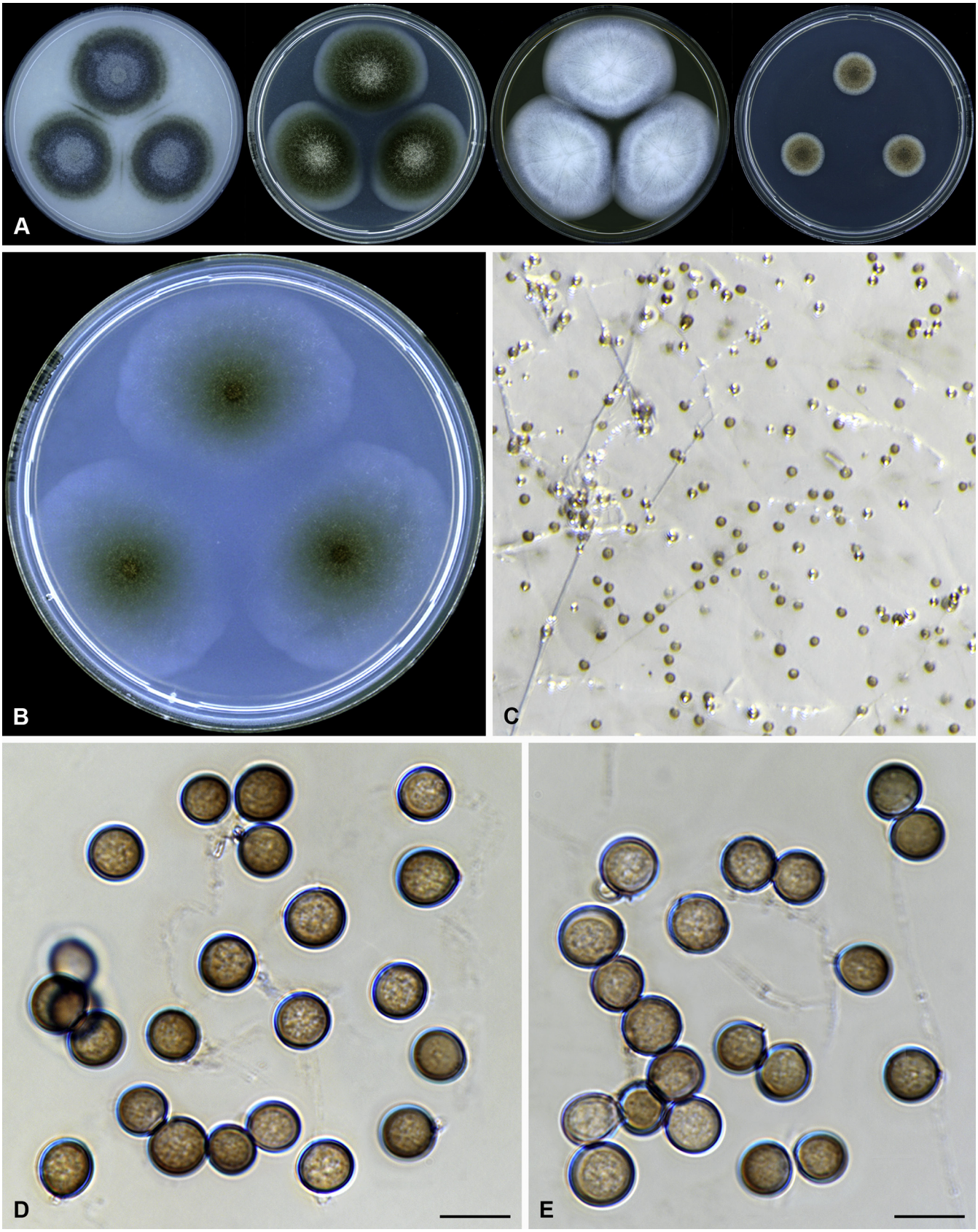


Fig. 40. *Humicola olivacea* (CBS 142031 = DTO 319-C7, ex-type culture). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Colonies on SNA. C. Conidia on the surface of medium SNA, top view; D–E. Conidia and conidiophores mounted in lactic acid. Scale bars: D–E = 10 µm.

Notes: Phylogenetic inference indicated that *O. pseudomollicella* clustered close to but separated from *O. mollicella* (CBS 583.83). This species can be distinguished by the size of its ascospores (7.5–8.5 × 6–7.5 × 5–6 µm), which are larger than those of *O. brasiliensis* (7–7.5 × 6–6.5 × 5–5.5 µm), and smaller than those of the ex-type of *O. mollicella* (8–9.5 × 7–8 × 6–7 µm; von Arx *et al.* 1986).

The previous study (Carter 1982) indicated that the species of this genus, together with the members of *Arcopilus* and *Farrowa* (Hawksworth 1975), had long stipitate ascogonial coils, while

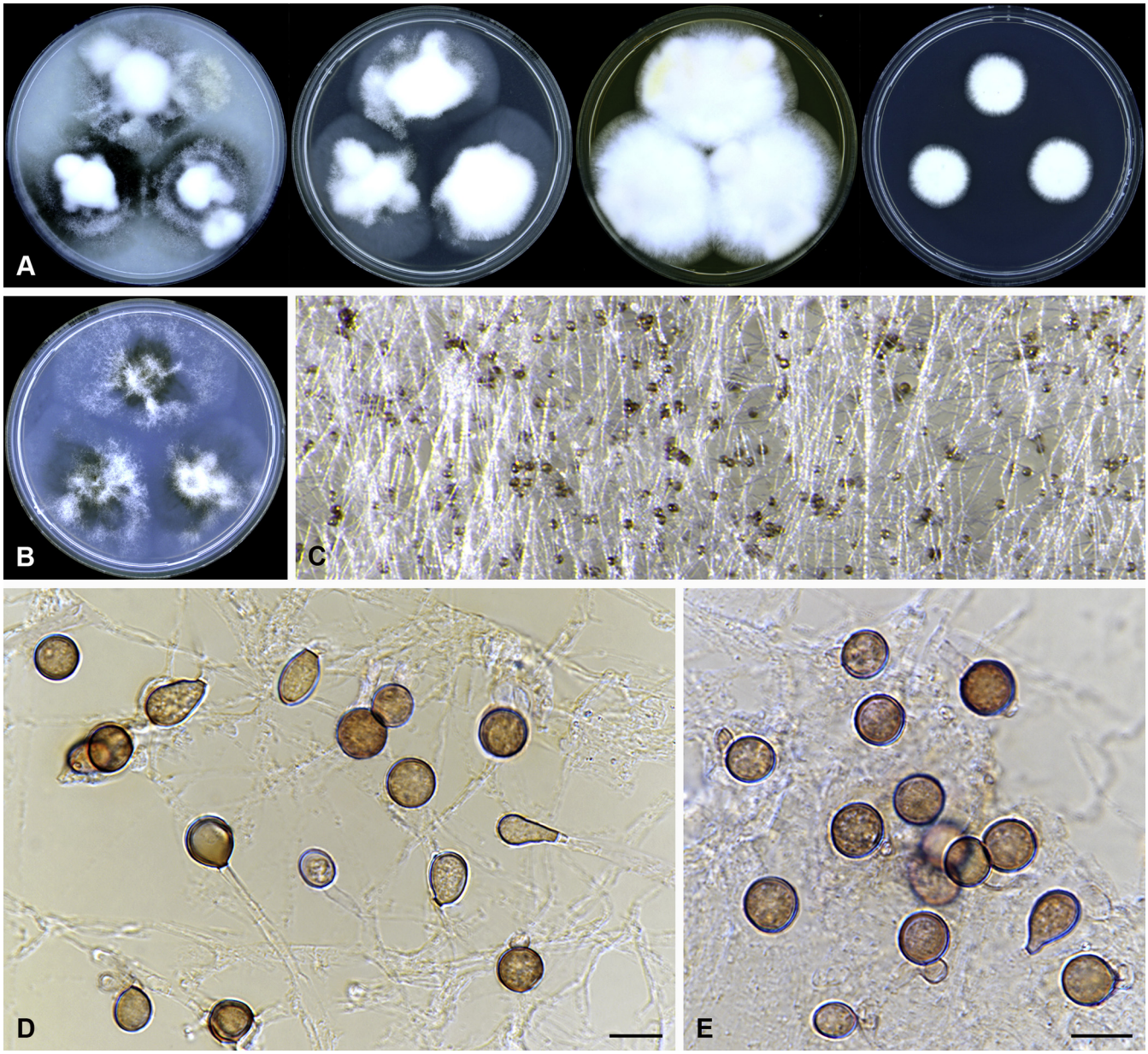


Fig. 41. *Humicola* sp. 2 (DTO 319-B7). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Colonies on SNA. C. Conidia on the surface of medium SNA, top view; D–E. Conidia and conidiophores mounted in lactic acid. Scale bars: D–E = 10 µm.

most of the other species in the *Chaetomiaceae* had irregular ascogonial coils. This might be worth noticing when observing the formation of young ascomata.

Subramaniula Arx, Proc. Indian Acad. Sci., Plant Sci. 94: 344. 1985.

Type species: *Subramaniula thielavioides* (Arx, Mukerji & N. Singh) Arx
Synonym: Achaetomium thielavioides Arx, Mukerji & N. Singh, Persoonia 10: 144. 1978.

Notes: The genus *Subramaniula* was originally proposed to accommodate species with urniform and nearly glabrous ascomata with a translucent wall and a wide ostiole surrounded by a hyaline collar (von Arx 1985b). A recent study (Ahmed *et al.* 2016) indicated the close relationships between *S. thielavioides* and several chaetomium-like species. The phylogenetic analyses in this study confirmed their results. These data greatly expanded the number of species in this genus. *Subramaniula* remains to be redescribed, and the description of one species from the indoor environment is given below.

Subramaniula cristata (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818853. Fig. 47.
Basionym: *Chaetomium cristatum* Ames, Mycologia 41: 639. 1949.

Ascomata superficial, ostiolate, pale olivaceous grey or pale mouse grey to mouse grey in reflected light owing to ascomatal hairs, subglobose or ovate, 240–390 µm high, 200–300 µm diam. *Ascomatal wall* brown, *textura angularis* in surface view. *Terminal hairs* erect, finely warty, dark brown, 4.5–5.5 µm diam near the base, apically irregularly-curved and branched repeatedly, forming a network consisting of thinner (1.5–2.3 µm diam), olivaceous or fawn, flexuous or undulate branches. *Lateral hairs* brown, seta-like, fading and tapering towards the tips. *Asci* fasciculate, fusiform or clavate, spore-bearing part 23–40 × 9–12 µm, stalks 12–30 µm long, with 8 irregularly-arranged ascospores, evanescent. *Ascospores* olivaceous brown when mature,

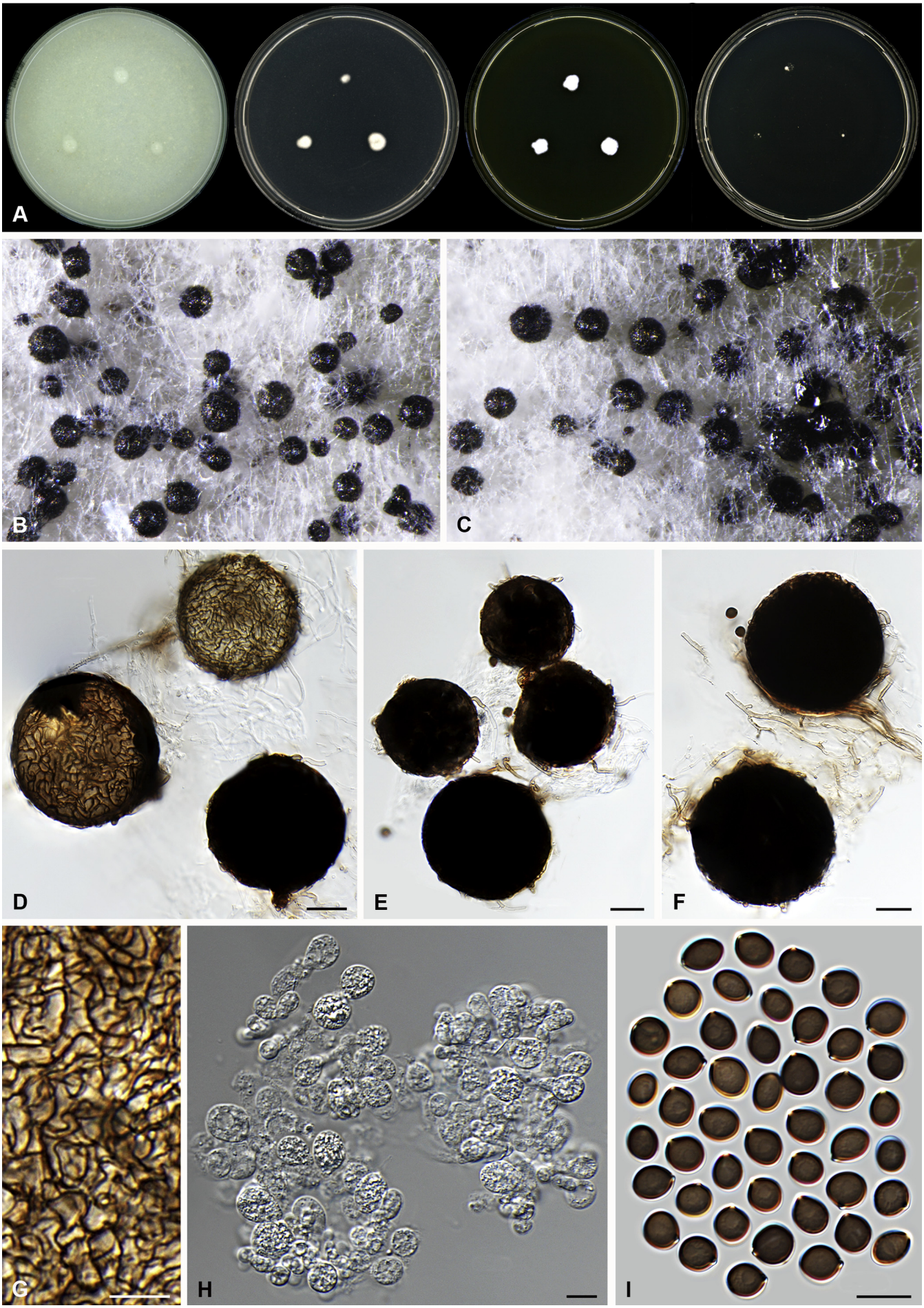


Fig. 42. *Melanocarpus tardus* (CBS 541.76, ex-type culture). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B–C. Mature ascomata on OA, top view; D–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Asci. I. Ascospores. Scale bars: D–F = 20 µm; G–I = 10 µm.

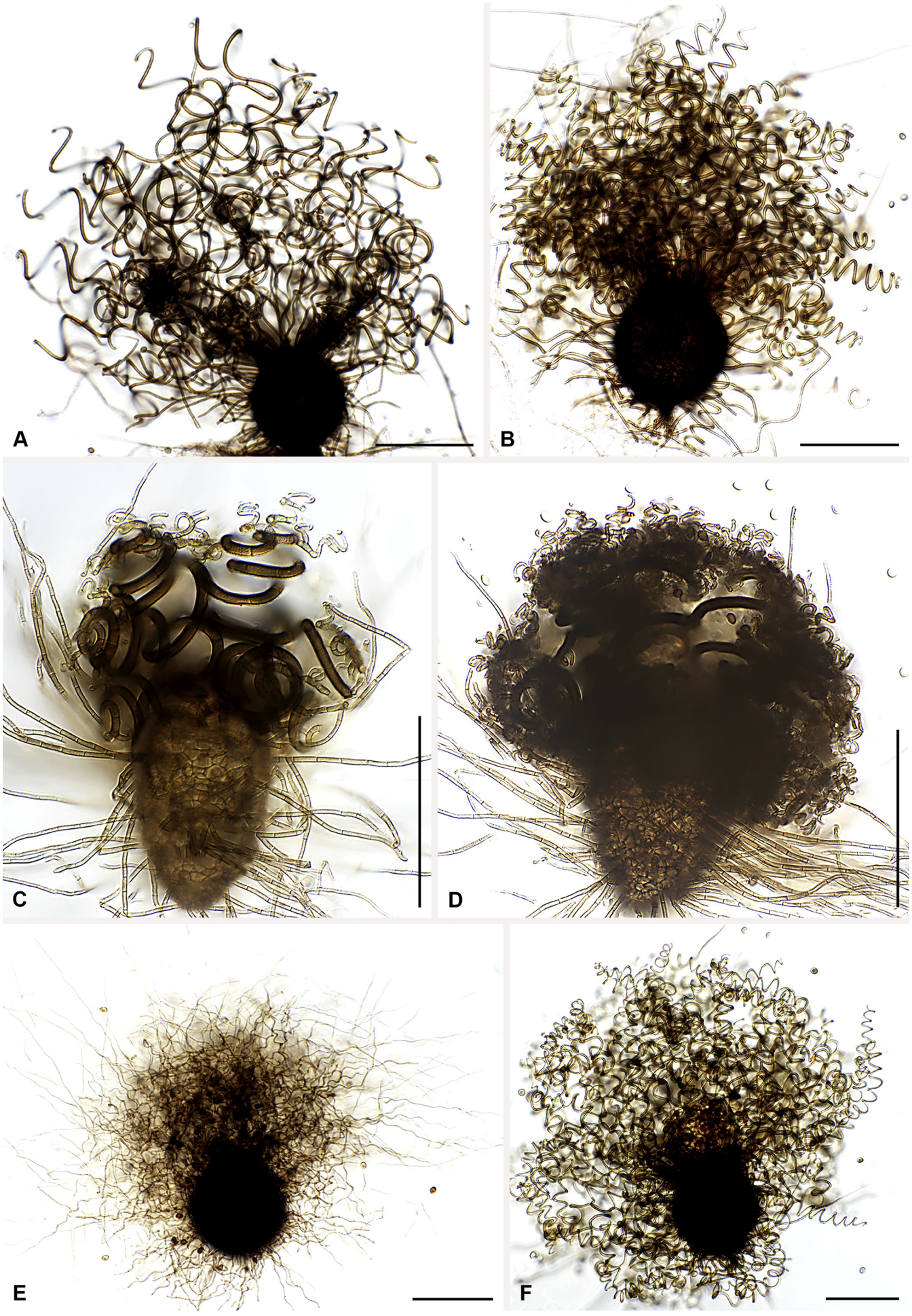


Fig. 43. Morphological diversity of Ascomata in the genus *Ovatospora*. A. *O. brasiliensis* (CBS 140.50). B. *O. pseudomollicella* (CBS 251.75^{T}). C. *O. medusarum* (CBS 148.67^{T}, young ascoma). D. *O. medusarum* (CBS 148.67^{T}, mature ascoma). E. *O. senegalensis* (CBS 728.84^{T}). F. *O. unipora* (CBS 109.83^{T}). Scale bars: A–F = 100 µm.

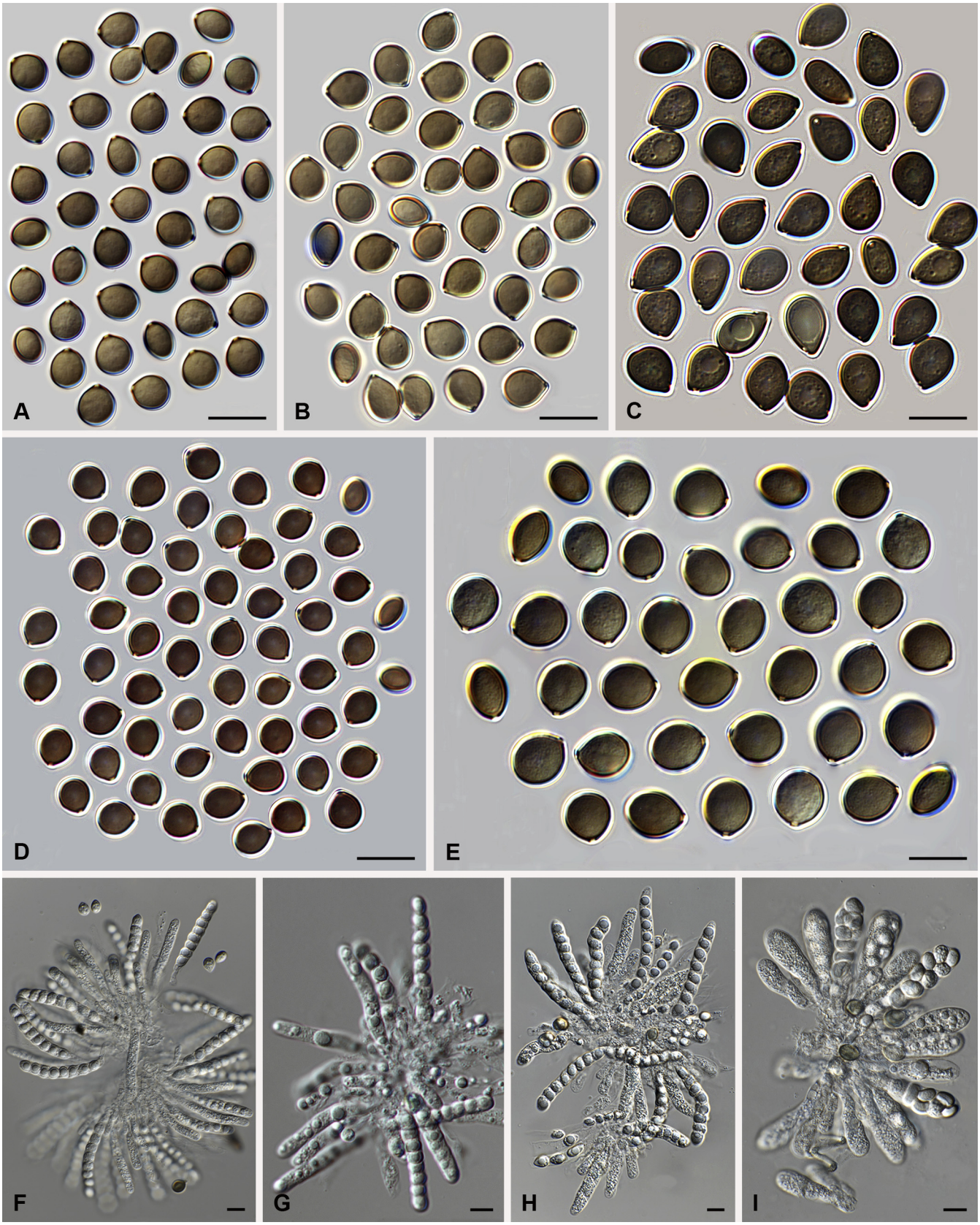
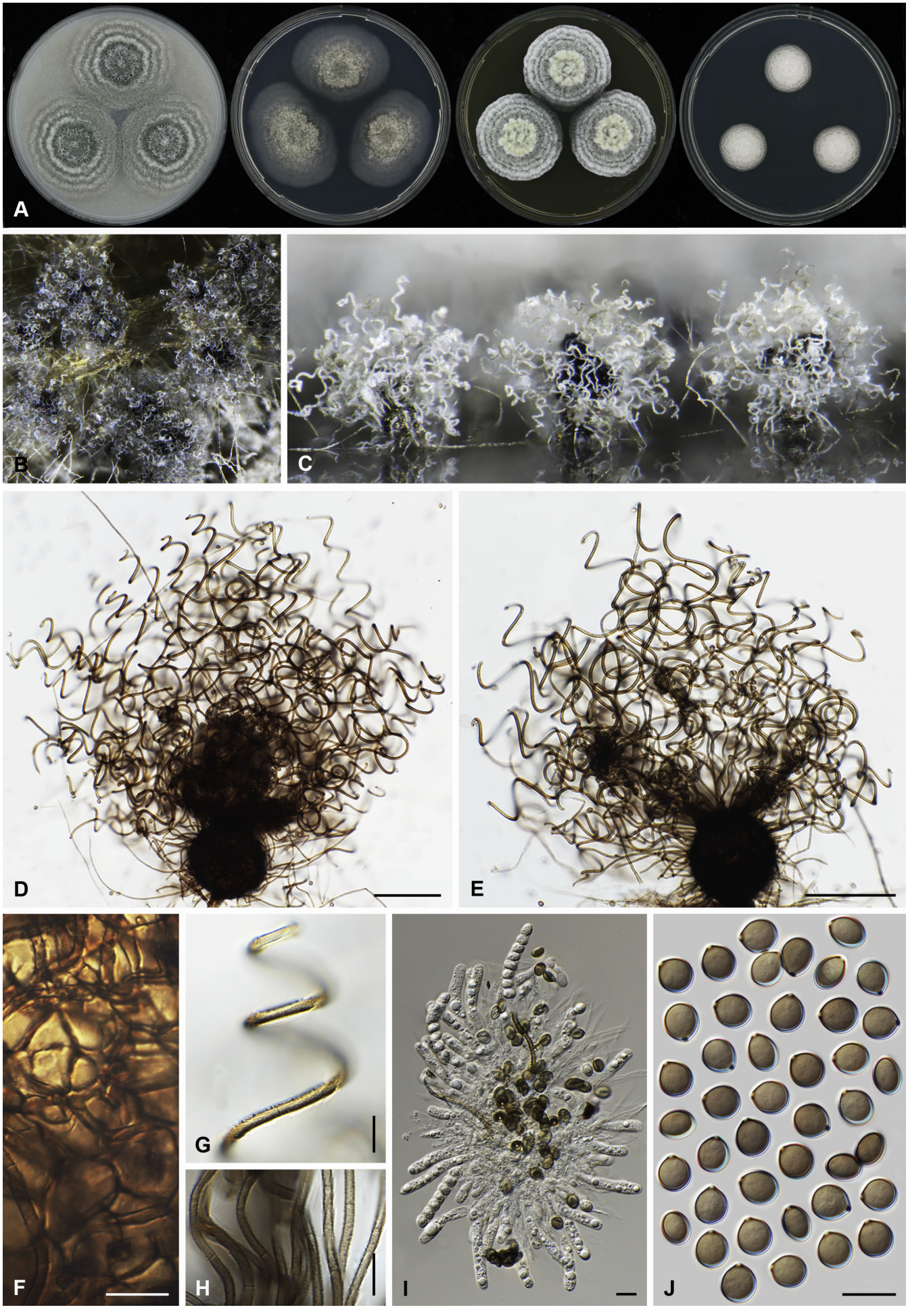


Fig. 44. Morphological diversity of ascospores and asci in the genus *Ovatospora*. Ascospores: A. *O. brasiliensis* (CBS 140.50). B. *O. pseudomollicella* (CBS 251.75^{T}). C. *O. senegalensis* (CBS 728.84^{T}). D. *O. medusarum* (CBS 148.67^{T}). E. *O. unipora* (CBS 109.83^{T}). Asci: F. *O. pseudomollicella* (CBS 251.75^{T}). G. *O. medusarum* (CBS 148.67^{T}). H. *O. senegalensis* (CBS 728.84^{T}). I. *O. unipora* (CBS 109.83^{T}). Scale bars: A–I = 10 µm.

ellipsoidal-fusiform, (9–)9.5–10.5(–11) × (5–)5.5–6.5(–7) µm, with a subapical germ pore. *Asexual morph* absent.

Culture characteristics: Colonies on OA with an entire edge, about 34–40 mm diam in 7 d at 25 °C, without aerial hyphae, with smoke grey to olivaceous grey exudates diffusing into the medium, reverse pale olivaceous grey to olivaceous. Colonies on PCA translucent, with numerous vinaceous buff ascomata in the central area and a slightly lobate edge, about 33–39 mm diam in 7 d at 25 °C, without aerial hyphae, without coloured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exudates; reverse uncoloured. Colonies on MEA pale vinaceous with brick perisphere, about 18–24 mm diam in 7 d at 25 °C, non-sporulating, reverse vinaceous with salmon edge. Colonies on DG18 with an entire or slightly undulate edge, about 3–9 mm diam in 7 d at 25 °C, buff and slightly floccose, non-sporulating, without coloured exudates; reverse uncoloured.

Specimens examined: **China**, Beijing, isolated from air by A.J. Chen, cultures DTO 324-H7 and DTO 324-H8.

Notes: *Subramaniula cristata* morphologically fits with *S. cuniculorum* (*Ch. cuniculorum*). Ames (1963) synonymised this species to *Ch. cuniculorum*. This decision was followed by von Arx *et al.* (1986). The phylogenetic analysis indicated that our indoor isolates clustered with the ex-type of *S. cristata*. They were close to but separated from the reference isolate of *S. cuniculorum*. *Subramaniula cuniculorum* was originally collected from Germany in 1869. No ex-type culture of *S. cuniculorum* is available now. The reference isolate CBS 800.83 was from Spain. Typification of *S. cuniculorum* and distinguishing this species from *S. cristata* await comparison with the holotype of *S. cuniculorum*.

Additional new combinations from non-indoor environments:

Amesia gelasinospora (Aue & Müller) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818854.
Basionym: *Chaetomium gelasinosporum* Aue & Müller, Ber Schweiz. Bot. Ges. 77:193. 1967.

Arcopilus aureus (Chivers) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818855.
Basionym: *Chaetomium aureum* Chivers, Proc. Am. Acad. Arts Sci. 48: 87. 1912

Arcopilus cupreus (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818856.
Basionym: *Chaetomium cupreum* Ames, Mycologia 41: 642. 1949.

Arcopilus fusiformis (Chivers) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818857.
Basionym: *Chaetomium fusiforme* Chivers, Proc. Am. Acad. Arts Sci. 48: 87. 1912.

Arcopilus flavigenus (van Warmelo) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818858.
Basionym: *Chaetomium flavigenum* van Warmelo, Mycologia 58: 847. 1966.

Botryotrichum spirotrichum (R.K. Benjamin) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818860.
Basionym: *Magnusia spirotricha* R.K. Benjamin, Aliso 3: 199. 1955.
Synonyms: *Kernia spirotricha* (R.K. Benjamin) Aliso 3: 344. 1956
Chaetomidium spirotricha (R.K. Benjamin) Malloch & Cain, Canad. J. Bot. 49: 867. 1971.
Thielavia spirotricha (R.K. Benjamin) Malloch & Cain, Mycologia 65: 1069. 1973.
Emilmuelleria spirotricha (R.K. Benjamin) Arx, Sydowia 38: 6. 1985.

Collariella quadrangulata (Chivers) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818861.
Basionym: *Chaetomium quadrangulatum* Chivers, Proc. Am. Acad. Arts Sci. 48: 85. 1912.

Collariella robusta (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818872.
Basionym: *Chaetomium robustum* Ames, Monograph of the Chaetomiaceae: 35. 1963.

Collariella virescens (Arx) X. Wei Wang & Samson, **comb. nov.** MycoBank MB819488.
Basionym: *Achaetomiella virescens* Arx, Genera of Fungi: 247. 1970.
Synonym: *Chaetomium virescens* (Arx) Udagawa, Trans. Mycol. Soc. Japan 21: 34. 1980.

Dichotomopilus dolichotrichus (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818866.
Basionym: *Chaetomium dolichotrichum* Ames, Mycologia 37: 145. 1945.

Dichotomopilus erectus (Skolko & J.W. Groves) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818867.
Basionym: *Chaetomium erectum* Skolko & J.W. Groves, Canad. J. Res., Section C 26: 277. 1948.

Dichotomopilus fusus (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818868.
Basionym: *Chaetomium fusum* Ames, Monograph of the Chaetomiaceae: 25. 1963.

Dichotomopilus ramosissimus (X.W. Wang & L. Cai) X. Wei Wang & Samson, comb. nov. MycoBank MB818869.
Basionym: Chaetomium ramosissimum X.W. Wang & L. Cai, Mycol. Prog. 13: 725. 2014.

Dichotomopilus reflexus (Skolko & J.W. Groves) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818870.
Basionym: *Chaetomium reflexum* Skolko & J.W. Groves, Canad. J. Res., Section C 26: 279. 1948.

Ovatospora medusarum (Meyer & Lanneau) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818871.
Basionym: *Chaetomium medusarum* Meyer & Lanneau, Bull. Soc. Mycol. Fr. 83: 318. 1967.

Ovatospora mollicella (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818873.
Basionym: *Chaetomium mollicellum* Ames, Monograph of the Chaetomiaceae: 30. 1963.

Ovatospora senegalensis (Ames) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818874.
Basionym: *Chaetomium senegalense* Ames, Monograph of the Chaetomiaceae: 36. 1963.

Ovatospora unipora (Aue & Müller) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818875.

Fig. 45. *Ovatospora brasiliensis* (CBS 140.50). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C. Mature ascomata on OA, side view. D–E. Ascomata mounted in lactic acid. F. Structure of ascomatal wall in surface view. G. Upper part of a terminal ascomatal hair. H. Basal part of terminal ascomatal hairs. I. Asci. J. Ascospores. Scale bars: D–E = 100 µm; F–J = 10 µm.

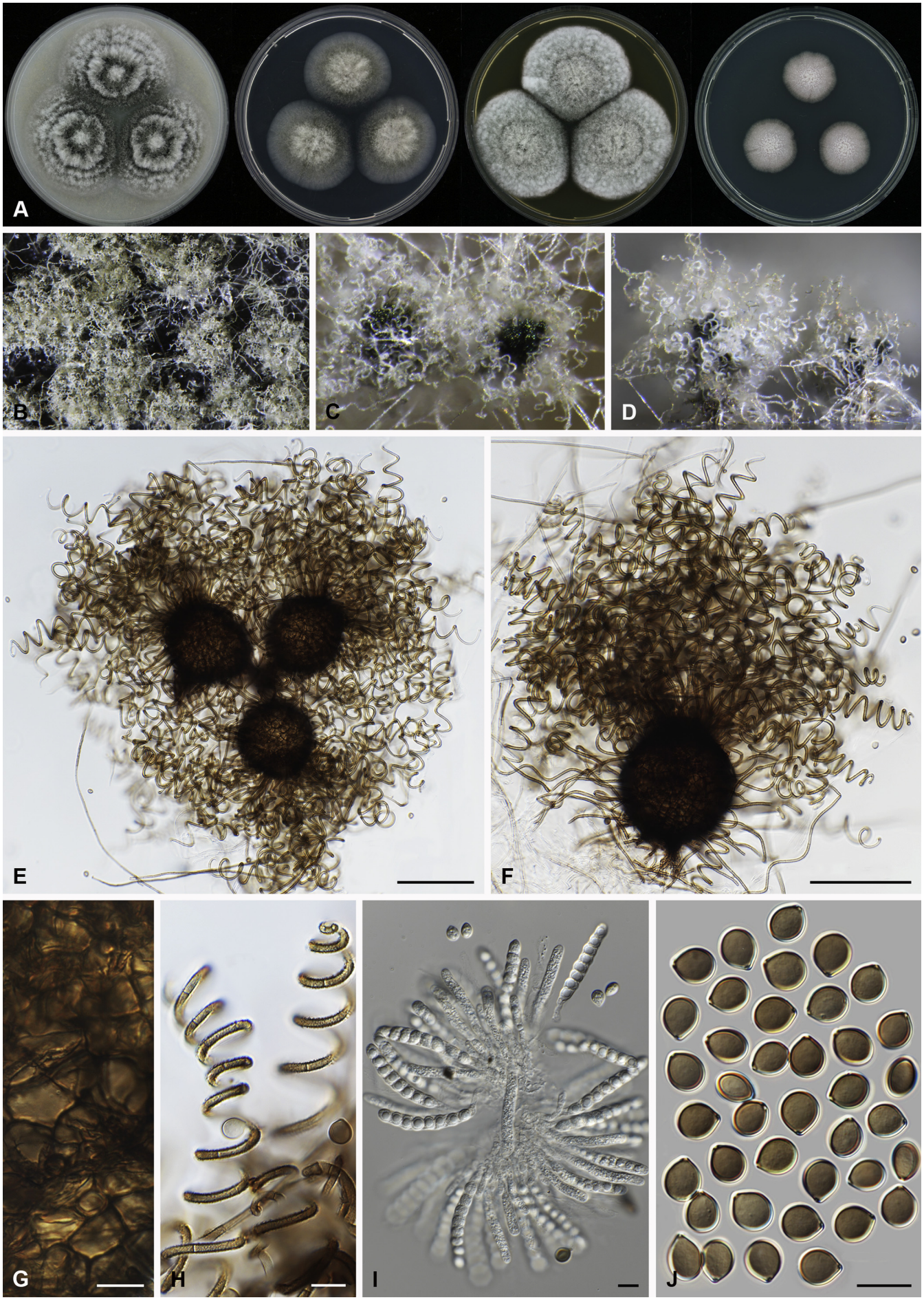

Fig. 46. *Ovatospora pseudomollicella* (CBS 251.75, ex-type culture). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B–C. Mature ascomata on OA, top view; D. Mature ascomata on OA, side view. E–F. Ascomata mounted in lactic acid. G. Structure of ascomatal wall in surface view. H. Upper parts of terminal ascomatal hairs. I. Asci. J. Ascospores. Scale bars: E–F = 100 µm; G–J = 10 µm.

Fig. 47. *Subramaniula cristata* (DTO 324-H8). A. Colonies from left to right on OA, PCA, MEA and DG18 after 7 d incubation. B. Mature ascomata on OA, top view; C–E. Mature ascomata on OA, side view. F–H. Ascomata mounted in lactic acid. I. Structure of ascomatal wall in surface view. J. Upper part of a terminal ascomatal hair. K. Asci. L. Ascospores. Scale bars: F–H = 100 µm; I–L = 10 µm.

Basionym: *Chaetomium uniporum* Aue & Müller, Ber Schweiz. Bot. Ges. 77: 187. 1967.

Subramaniula anamorphosa (S.A. Ahmed, *et al.*) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818876.
Basionym: *Chaetomium anamorphosum* S.A. Ahmed, *et al.*, Fungal Diversity 76: 18. 2016.

Subramaniula cuniculorum (Fuckel) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818877.
Basionym: *Chaetomium cuniculorum* Fuckel, *Symb. Mycol.*: 89. 1869.

Subramaniula flavipila X. Wei Wang & Samson, **nom. nov.** MycoBank MB818878.
Basionym: *Chaetomium irregulare* Sörgel, Nova Hedwigia 12: 386. 1966.
Etymology: Name refers to the yellow to luteous ascomatal hairs of this fungus.

Notes: Non *Subramaniula irregularis* P. Cannon & D. Hawksworth, Trans. Br. Mycol. Soc. 87: 56. 1986. The name *S. irregularis* already exists, therefore the new name is proposed.

Subramaniula fusispora (G. Smith) X. Wei Wang & Samson, **comb. nov.** MycoBank MB818879.
Basionym: *Chaetomium fusisporum* G. Smith, Trans. Br. Mycol. Soc. 44: 46. 1961.

KEY TO THE MOST COMMON *CHAETOMIACEAE* SPECIES (OR SPECIES COMPLEX) FROM THE INDOOR ENVIRONMENTS

1. Asexual morph present 2
1. Asexual morph absent 3
2. Ascomata absent or rare; *conidiophores* usually produced together with brown serile setae; *conidia* subglobose, usually hyaline, smooth to slightly roughened, 11–17.5 µm diam ..... ***Botryotrichum piluliferum***
2. Ascomata numerous, terminal ascomatal hairs repeatedly dichotomously branched, usually less than 5 µm diam near the base; *Ascospores* limoniform, bilaterally flattened, 11.5–14 × 8.5–10 × 7–8 µm, with an apical germ pore asexual morphs acremonium-like ..... ***Chaetomium elatum***
3. Terminal ascomatal hairs repeatedly dichotomously branched or seta-like, often composed of two types of hairs different in length; ascospores ovate to elongate ovate, bilaterally flattened, usually less than 7.5 µm long (***Dichotomopilus indicus*** or ***D. funicola*** **species complex** (including *D. funicola*, *D. pseudofunicola*, *D. subfunicola* and *D. variostiolatus*) 4
3. Terminal ascomatal hairs not repeatedly dichotomously branched, ascospores limoniform, bilaterally flattened, with an apical germ pore 5
4. Shorter terminal hairs, if present, usually forming a net structure to enfold ascospres ..... ***D. funicola*** **species complex**
4. Shorter terminal hairs, if present, inconspicuous due to the masses of ascospores, not easy to observe ..... ***Dichotomopilus indicus***
5. Ascomata subglobose to obovate with a dark collar-like apex around the ostiolar pore; terminal hairs spirally coiled, *ascospores* limoniform, bilaterally flattened, 6–7 × 5.5–6.5 × 4.5–5.5 µm, with an apical germ pore ..... ***Collariella bostrychodes***
5. Ascomata without a dark collar-like apex around the ostiolar pore; ascospores 8.5–11 × 7–9 × 5.5–7 µm 5
6. Terminal hairs flexuous, undulate to slightly coiled ..... ***Chaetomium cochliodes***
6. Terminal hairs spirally coiled, usually with coils regularly tapering in diameter ..... ***Chaetomium globosum***

DISCUSSION

Chaetomium spp., together with several other genera such as *Stachybotrys*, *Aspergillus* and *Penicillium*, are of concern because of their ability to grow in the indoor environment and their association with production of bioactive metabolites (Brasel *et al.* 2005, Samson *et al.* 2010, Andersen *et al.* in press, Došen *et al.* in press). Depending on the type of water damaged building material, *Chaetomium sensu lato* are found in 16–66 % of environmental samples (Flannigan & Miller 2011, Andersen *et al.* in press). Our survey shows a high species diversity of *Chaetomiaceae* in the indoor environments worldwide and based on phylogenetic analysis and morphological examination 30 indoor species lineages were recognised. These species were scattered throughout the *Chaetomiaceae* and this finding prompted us to re-evaluate the phylogeny of *Chaetomium* and related genera.

Traditionally, *Chaetomium* was defined to possess superficial and typically ostiolate ascomata covered by more or less developed hairs or setae and connected to the substrate by rhizoidal hyphae. The asci develop in basal fascicles, are stalked and have a thin and evanescent wall devoid of apical structures. The majority of species produce asci containing eight ascospores, which are single-celled, smooth and pigmented with germ pores and without sheaths (von Arx *et al.* 1986). This generic concept covers quite a high diversity of morphology. For example, ascomatal hairs can be straight (seta-like), flexuous, arcuate, undulate, circinate, spirally coiled or variously branched, the asci obovate, clavate, fusiform to cylindrical, and the ascospores oblate, ovate, limoniform, fusiform, lunate, triangular to irregular, laterally flattened or not, with one, two or more germ pores which can be apically, sub-apically or even laterally formed on ascospores. Most species do not produce an asexual morph, while some species have a humicola-like, botryotrichum-like, or acremonium-like asexual state. Contrary to the genus *Chaetomium*, the concepts of some other genera were quite narrow. For example, *Emilmuelleria* was characterised by its distinct tufts of spirally-coiled ascomatal appendages arranged usually at the opposite sides of non-ostiolate ascomata (von Arx 1985a); *Subramaniula* was distinguished from *Chaetomium* by its urniform and nearly glabrous ascomata with a translucent wall and a

wide ostiole surrounded by a hyaline collar (von Arx 1985b, von Arx *et al.* 1988). The ascospores of *Myceliophthora* (= *Corynascus*, with asexual morph) and *Corynascella* (asexual morph unknown) have more than one germ pore per ascospore, and other non-ostiolate genera usually produce ascospores with only one germ pore.

The concept of *Chaetomium* has been challenged in the study of the non-ostiolate genus *Chaetomidium* (Greif *et al.* 2009, Wang *et al.* 2016). Based on a six-locus analysis, three species of *Chaetomidium*, including its type *C. fimeti*, are closely related to the type species of *Chaetomium*, *C. globosum*. As these three *Chaetomidium* species are all within the *C. globosum* species complex, the genus *Chaetomidium* was rejected and the three non-ostiolate species were transferred into the genus *Chaetomium* (Wang *et al.* 2016).

The phylogenetic inference in this study clearly demonstrated that the traditionally defined *Chaetomium* as noted above was polyphyletic. The indoor members of *Chaetomium* were segregated into 10 monophyletic lineages by several other genera in the family (Fig. 1). Six indoor species fell into the *C. globosum* complex which was designated here as *Chaetomium sensu stricto*, including 36 species with limoniform to globose or irregular and bilaterally flattened ascospores as delimited in our previous study (Wang *et al.* 2016). *Chaetomium murorum* clustered with three asexual species of *Botryotrichum* and non-ostiolate *Emilmuelleria* in a strongly-supported monophyletic clade, which was designated here as the expanded genus *Botryotrichum*. This result also refuted the presence or absence of ascomatal ostioles to be a criterion for distinguishing genera in the *Chaetomiaceae*. Species of the traditional genus *Subramaniula* grouped with several species previously classified in *Chaetomium*, for example *S. cristata* (= *C. cristatum*), *S. cuniculorum* (= *C. cuniculorum*), *S. fusispora* (*C. fusisporum*) and *S. flavipila* (= *C. irregular*). Based on these data, the genus *Subramaniula* was expanded to include species with typical chaetomium-like ascomata and ascomatal hairs. More data are needed to determine the morphological delimitation of the genera *Botryotrichum* and *Subramaniula* supported by the molecular data in this study.

Two taxa obtained from the indoor environment produced humicola-like conidia. Based on a preliminary analysis of ITS sequences of asexual *Humicola* species, only a few species clustered together with *H. fuscoatra*, the type species of this genus. The other *Humicola* species available were placed in several different clades, indicating that the asexual genus *Humicola* is polyphyletic. More research is needed to clarify the relationship of *Humicola sensu stricto* to the other humicola-like species as well as those chaetomium-like species with humicola-like asexual morph. The indoor species *Me. tardus* was on a long branch within the highly supported *Melanocarpus* clade. Further research is required to determine the phylogenetic relationships of the species with in this genus.

Representatives of the genera *Achaetomium*, *Myceliophthora*, *Thielavia*, and *Corynascella* were included in our phylogenetic study. These data contributed to the delimitation of genera in *Chaetomiaceae* and the introduction of five new genera. The genera *Achaetomium* and *Myceliophthora* were strongly supported as monophyletic lineages in this study. *Thielavia* was known as the second largest genus in the family (von Arx *et al.* 1988, Kirk *et al.* 2008). Five species of *Thielavia* were included here in our analysis to represent this genus. The phylogeny confirmed the monophyly of this *Thielavia* clade. Further research with a larger sampling is required to re-evaluate this genus in more detail. *Corynascella* was represented only by its type species. Further data are required to determine the phylogenetic relationships between the type species and the other species of *Corynascella*.

Our results provided an insight in the phylogeny of the family, and in the diversity of indoor *Chaetomiaceae* (Table 2). Of the 145 isolates obtained in this survey, 30 species were recognised in 10 different genera, presenting a much higher species diversity of indoor *Chaetomiaceae* than previous studies. *Chaetomium globosum* was the predominant species in the indoor environments as also noted in the previous studies (Vesper *et al.* 2007, Ayanbimpe *et al.* 2010, Straus 2011, McMullin *et al.* 2013, Miller & McMullin 2014). This species accounted for 51 % of the total obtained isolates (74/145). *Chaetomium cochliodes* is the second predominant species (17/145), mainly because of its abundance in the indoor environments in the USA. In addition, *Ch. elatum* (6/145) and *B. piluliferum* (5/145) were also frequently encountered in samples obtained from indoor environments. At the genus level, members of *Chaetomium sensu stricto* accounted for 69 % of the total isolates obtained (100 isolates in six species). *Dichotomopilus* was found to be the second most common genus (15 isolates, seven species), followed by *Collariella* (seven isolates, four species), *Botryotrichum* (eight isolates, three species), *Amesia* (five isolates, three species) and *Humicola* (four isolates, two species). Members of the four other genera were found to be rare in the indoor environments.

Secondary metabolites have been used as valuable additional taxonomic features in several fungal genera such as *Penicillium*, *Aspergillus*, *Alternaria*, *Fusarium* (Frisvad *et al.* 2008). It has been known that, in order to adapt to diverse environments, the species of *Chaetomium sensu lato* are capable of producing various secondary metabolites, which display a wide range of biological activities (Udagawa *et al.* 1979, Sekita *et al.* 1981, Ding *et al.* 2006, Ge *et al.* 2008, Momesso *et al.* 2008, Phonkerd *et al.* 2008, Kharwar *et al.* 2011, Yamada *et al.* 2012, Zhang *et al.* 2012, Lu *et al.* 2013, Awad *et al.* 2014, Yan *et al.* 2014). Some of them are mycotoxins and can cause health hazards (Polizzi *et al.* 2009, Mason *et al.* 2010, Andersen *et al.* 2011, Miller & McMullin 2014, Wang *et al.* 2015). In this study profiles of metabolites were analysed in the majority of indoor chaetomium-like species using advanced analytical chemical methods to ensure correct identity of the secondary metabolites. The resulting metabolite profiling shows that it is possible to distinguish *Chaetomium sensu stricto* and *Dichotomopilus* from each other and from other genera based on secondary metabolites. It is even possible to discriminate between *C. globosum* and other species based on the pattern of metabolites. *Chaetomium globosum* seems to be the only species that produces the combination of chaetoviridin A, chaetoglobosin A, rotiorinol and cochliodones, however, chemical analyses of more isolates from the other closely related *Chaetomium* species are necessary to verify the result. Furthermore, chaetoviridin A, chaetoglobosin A and cochliodones are the major metabolites produced on building materials with *Chaetomium* growth (Došen *et al.* in press). Likewise, analyses of more

isolates of *C. cochloides* are needed to determine which metabolite pattern that is species specific in order to distinguish it from *C. pseudofimeti*. Production of sterigmatocystin, the precursor to aflatoxin, was only found in *H. olivacea* in this study. Another study by Rank *et al.* (2011) did detect sterigmatocystin in *B. piluliferum* (NRRL 38180), but it was not detected in the *B. piluliferum* isolate (DTO 254-B8) used in this study. Also in this case an extended analysis of isolates is needed. As only a limited number of isolates and species in the *Chaetomiaceae* were analysed for their metabolite profile in general, more research is encouraged in order to understand the correlation between the studied taxa, their metabolite profiles and the effects of these products on human health.

In this study we also showed the morphological diversity that exists in some species. Taken together with the morphological data from our earlier studies (Wang *et al.* 2014, 2016), we show that *Ch. globosum*, *Ch. elatum*, *B. murorum*, the *D. funicola* species complex (including *D. funicola*, *D. pseudofunicola*, *D. subfunicola* and *D. variostiolatus*) and *D. indicus* all exhibited intra-species morphological variation. For the *D. funicola* species complex, almost each of the examined isolates presented different morphology in the terminal ascomatal hairs. A similar problem in morphological identification also occurs in *D. indicus*. The examined isolates of this species showed morphological differences not only in the terminal ascomatal hairs, but sometimes even in the shape and size of ascospores. These results implied an active differentiation of morphology within these species lineages. This makes it very complicated to identify these species only based on morphology. A molecular based identification will help to solve this problem. Several *Chaetomiaceae* species share ITS sequences, and for routine identification, β-tubulin (*tub2*) is recommended. On the other hand, it needs to be noted that not all species are represented with *tub2* sequences in the public databases and future studies should aim to complete this omission.

It has been demonstrated that the presence of *C. globosum* in the indoor environment is one of the important contributors to the development of symptoms of rhinitis, asthma and other health problems (Vesper *et al.* 2007, Apetrei *et al.* 2009, Polizzi *et al.* 2009, Mason *et al.* 2010, Miller & McMullin 2014). This species is also the most common human pathogen mainly associated with onychomycosis (Naidu *et al.* 1991, Stiller *et al.* 1992, Aspiroz *et al.* 2007, Latha *et al.* 2010, Tullio *et al.* 2010, Hwang *et al.* 2012, Lagacé & Cellier 2012, Kim *et al.* 2013). In addition, some other indoor chaetomium-like species were also reported in clinical cases, such as *D. funicola* (= *C. funicola*, Koch & Haneke 1965), *O. brasiliensis* (= C. *brasiliense*, Hubka *et al.* 2011) and *Am. atrobrunnea* (= C. *atrobrunneum*, Guppy *et al.* 1998, de Hoog *et al.* 2013). These species, which grow in our living and working environment, deserve more attention in future.

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