

Families of Dothideomycetes

In loving memory of Majorie Phyllis Hyde (affectionately known as Mum or Marj), 29 August 1921–18 January 2013—without mum's determination, a character passed on to children, this treatise would never have been completed—K.D. Hyde

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Abstract Dothideomycetes comprise a highly diverse range of fungi characterized mainly by asci with two wall layers (bitunicate asci) and often with fissitunicate dehiscence. Many species are saprobes, with many asexual states comprising important plant pathogens. They are also endophytes, epiphytes, fungicolous, lichenized, or lichenicolous fungi. They occur in terrestrial, freshwater and marine habitats in almost every part of the world. We accept 105 families in Dothideomycetes with the new families *Anteagloniaceae*, *Bambusicolaceae*, *Biatrisporaceae*, *Lichenocooniaceae*, *Muyocopronaceae*, *Paranectriellaceae*, *Roussoellaceae*, *Salsuginaceae*, *Synesiopeltidaceae* and *Thyridariaceae* introduced in this paper. Each family is provided with a description and notes, including asexual and asexual states, and if more than one genus is included, the type genus is also characterized. Each family is

provided with at least one figure-plate, usually illustrating the type genus, a list of accepted genera, including asexual genera, and a key to these genera. A phylogenetic tree based on four gene combined analysis add support for 64 of the families and 22 orders, including the novel orders, *Dyfrulomycetales*, *Lichenocooniales*, *Lichenotheliales*, *Monoblastiales*, *Natipusillales*, *Phaeotrichales* and *Strigulales*. The paper is expected to provide a working document on Dothideomycetes which can be modified as new data comes to light. It is hoped that by illustrating types we provide stimulation and interest so that more work is carried out in this remarkable group of fungi.

Keywords *Acrospermales* · *Asterinales* · *Botryosphaeriales* · *Capnodiales* · *Dothideales* · *Dyfrulomycetales* · *Hysteriales* · *Jahnulales* · *Lichenocooniales* · *Lichenotheliales* · *Microthyriales* · *Monoblastiales* · *Myriangiales* · *Mytilinidiales* · *Natipusillales* · *Patellariales* · *Phaeotrichales* · *Phylogeny* · *Pleosporales* · *Strigulales* · *Taxonomy* · *Trypetheliales* · *Tubeufiales* · *Type species* · *Venturiales*

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Introduction

Dothideomycetes is the largest class of Ascomycota, with an estimated number of 19,000 species (Kirk et al. 2008). This class largely corresponds to what has historically been called the Loculoascomycetes (Nannfeldt 1932; Luttrell 1955; Janex-Favre 1971; Barr 1979a, b, 1983a, b, 2001; Eriksson 1981; Reynolds 1971; Tehler 1990, 1995; Letrouit-Galinou et al. 1994; Barr and Huhndorf 2001; Liu and Hall 2004), although several lineages previously assigned to that group, such as the *Pyrenulales* and *Verrucariales*, are now classified in subclass Chaetothyriomycetidae, class Eurotiomycetes (Lutzoni et al. 2004; Schmitt et al. 2005; Hibbett et al.

2007; Schoch et al. 2009a, b). On the other hand, Arthoniomycetes, which were usually considered to feature an intermediate type of ascoma development between ascolocular ascohymenial fungi (Choisy 1955; Henssen and Jahns 1973; Eriksson 1994; Henssen and Thor 1994; Tehler 1990, 1995), have been shown to be a sister group to Dothideomycetes and the two classes are united in superclass Dothideomyceta (Schoch et al. 2009a).

Dothideomycetes are mostly characterized by ascolocular ascoma development and bitunicate (fissitunicate) asci (Nannfeldt 1932; Luttrell 1955; Eriksson 1981; Barr and Huhndorf 2001). However these characters are partially shared by other classes, such as Arthoniomycetes and

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Eurotiomycetes and ascoma development has not been thoroughly studied for the large majority of Ascomycota, including Dothideomycetes. Therefore, it is unclear whether Dothideomycetes feature distinct phenotypic apomorphies based on which the class could be characterized. Also, while the class itself receives good support and hence lineages can be assigned to it with confidence once molecular data is available, the subdivision of Dothideomycetes remains unclear, since backbone support is low (Schoch et al. 2009b). An example for the problem of internal classification are the lichenized families *Monoblastiaceae*, *Strigulaceae* and *Trypetheliaceae*, which all have certain morphological and anatomical features in common but are apparently unrelated and have, with few exceptions, no close non-lichenized relative in the class (Nelsen et al. 2009, 2011a). Therefore, all could be treated as separate orders, as already suggested for *Trypetheliaceae* (Aptroot et al. 2008).

There has been considerable research interest in the phylogeny of the Dothideomycetes in the last 3 years (Schoch et al. 2009b; Nelsen et al. 2009, 2011a). Much of this research has concentrated on the phylogenetic placement of genera based on single and multigene analysis of rDNA sequence data, however, there has been less attention paid to morphology. In particular there have been few attempts to link morphological characters of the morphs into a taxonomic framework, so much so that it is often not clear which characters should be used to define taxa at the order, family, and genus level. This problem has stemmed from the fact the arrangements are based mainly on results of molecular phylogenetic analysis combined with historical placements based on morphological arrangements. Because neither provides a complete assessment of taxa at various levels, the situation for the classification of Dothideomycetes remains confused. In this paper we deal with the families of Dothideomycetes as currently recognized and bring together recent published data and attempt to link morphological data to the findings resulting from molecular analysis. We presently accept 105 families and suggest which genera should be placed in these families, which genera can questionably be placed in these families, and which families and genera should be excluded. We also illustrate 138 dothideomycete genera, with full descriptions and notes and discuss their taxonomic placement.

The recent Outline of the Ascomycota (Lumbsch and Huhndorf 2010) provided the most recent arrangement of Dothideomycetes which included 41 families comprising 249 genera (13 families and 74 in subclass Dothideomycetidae, 28 and 175 in Pleosporomycetidae) and a further 116 genera which were placed in Dothideomycetes, genera *incertae sedis*. In the *Pleosporales* there were 28 families and 175 genera,

with 12 genera listed under *Pleosporales*, genera *incertae sedis*. Recent research, particularly dealing with the *Pleosporales*, has provided further data on the class. The study by Zhang et al. (2012a) in particular dealt with 105 genera of *Pleosporales*, in 28 families and emended the suborder *Pleosporineae* (Zhang et al. 2009a, b). These studies were mostly based on molecular phylogenetic analysis and did not correlate morphology at the family level with the new phylogenetic arrangements. In this paper we therefore attempt to add some structure to the arrangement of the *Pleosporales* by discussing the characters of familial arrangements determined at the phylogenetic level.

Orders of Dothideomycetes

The Dothideomycetes comprise 22 accepted orders based on molecular phylogenetic studies (Lumbsch and Huhndorf 2010). Each order is briefly discussed. Six families *Ascoporiaceae*, *Coccoideaceae*, *Cookellaceae*, *Perisporiopsidaceae*, *Protoscyphaceae* and *Pseudoperisporiaceae* are included under families *incertae sedis* because they lack molecular data that can resolve their position in Dothideomycetes. The *Meliolales* was recently included in Dothideomycetes but produce unitunicate asci (Hosagoudar 2003, 2006, 2013). In addition, molecular analyses revealed that isolates of *Meliola* (*Meliolaceae*, *Meliolales*) clustered with members of Sordariomycetes with strong support, and were unrelated to Dothideomycetes (Saenz and Taylor 1999; Zhuang and Liu 2012).

Presently accepted orders of Dothideomycetes

Acrospermales Minter et al., Boln Soc. argent. Bot. 42(1–2): 112 (2007)

The family *Acrospermaceae* has been placed in various orders at various times (Brandriff 1936; Eriksson 1982; Barr 1990a, b, c, d; Sherwood 1977; Eriksson and Hawksworth 1991; Hawksworth et al. 1995; Kirk et al. 2001). Minter et al. (2007) introduced the order *Acrospermales* to accommodate the family *Acrospermaceae*, which is typified by *Acrospermum compressum* Tode. Lumbsch and Huhndorf (2010) placed the *Acrospermales* in Dothideomycetes, order *incertae sedis*. Stenroos et al. (2010) showed that *Acrospermales* should be placed in Dothideomycetes, although they clustered with strains of Arthoniomycetes, whereas Pang et al. (2013) clearly show the order belongs in Dothideomycetes.

Asterinales M.E. Barr ex D. Hawksw. & O.E. Erikss., Syst. Ascom. 5(1): 177 (1986)

The order *Asterinales* was invalidly introduced by Barr (1976) because of lack of Latin diagnosis, but subsequently validated in Hawksworth and Eriksson (1986). The *Asterinales* is based on the type family *Asterinaceae* and is characterized by superficial, thyriothecial, dimidiate, black ascomata, with radial mycelium and often hyphopodiate, appressed hyphae, globose-subglobose asci and 1-septate, brown ascospores (Barr 1987a; Hosagoudar 2012). Molecular analyses confirmed that *Asterinales* can be included in Dothideomycetes with good support (Hofmann et al. 2010; Wu et al. 2011a). Wu et al. (2011a) also suggested the families *Aulographaceae* and *Parmulariaceae* should be included in this order. Therefore, the *Asterinales* presently include three families *Asterinaceae*, *Aulographaceae* and *Parmulariaceae*.

Botryosphaeriales C.L. Schoch et al., in Schoch et al., *Mycologia* 98(6): 1050 (2007) [2006]

Synonym: *Phyllostictales* Seaver, *North American Flora* 6(1): 1(1922)

The order *Botryosphaeriales* was introduced by Schoch et al. (2006) based on phylogenetic data and this has been verified in several recent papers (Schoch et al. 2006, 2009a). The order comprises three families: *Botryosphaeriaceae*, *Planistromellaceae* and *Phyllostictaceae* (Liu et al. 2012a; Monkai et al. 2013; Wikee et al. 2013). The order is defined by relatively thick-walled, dark-celled ascostromata, with one to several locules, bitunicate and fissitunicate asci and 1–2-celled ascospores, which are hyaline when immature and become brown in some genera at maturity. Cut ascostromata of dried specimens usually reveal distinct white contents. The asexual states are coelomycetous and produce hyaline to brown conidia from phialidic conidiogenous cells in conidiomata that usually form initially in the ascostromata.

Capnodiales Woron., *Annls mycol.* 23(1/2): 177 (1925)

The order *Capnodiales* was introduced by Woronichin (1925), and accepted in Dothideomycetes based on phylogenetic studies (Crous et al. 2009a; Schoch et al. 2006, 2009a; Chomnunti et al. 2011). Lumbsch and Huhndorf (2010) list the order as comprising eight families: *Antennulariellaceae*, *Capnodiaceae*, *Coccodiniaceae*, *Davidiellaceae*, *Dissoconiaceae*, *Metacapnodiaceae*, *Mycosphaerellaceae* and *Piedraiaceae*. The *Capnodiales* are mainly defined by their shared ecological niche as leaf epiphytes associated with the honey dew produced by insects, and saprobes or leaf pathogens and are an ascostromatal order without Pseudoparaphyses (Hughes 1976; Crous et al. 2009a; Chomnunti et al. 2011).

Dothideales Lindau, in Engler & Prantl, *Nat. Pflanzenfam., Teil. I* (Leipzig) 1: 373 (1897)

The order *Dothideales* was introduced by Lindau (1897) and typified by *Dothidea sambuci* (Pers.) Fr. Molecular phylogenetic studies indicate that the order *Dothideales* belongs

in Dothideomycetes with high bootstrap support (Boehm et al. 2009a; Schoch et al. 2009a, b; Shearer et al. 2009; Suetrong et al. 2009). Lumbsch and Huhndorf (2010) list the order as comprising three families: *Dothideaceae*, *Dothioraceae* and *Teratosphaeriaceae*. However, *Dothioraceae* is shown to be a synonym of *Dothideaceae* in this study, while Crous et al. (2007a) placed *Teratosphaeriaceae* in *Capnodiales*. The order is characterised by immersed, erumpent or superficial, uniloculate or multiloculate ascostromata, with or without a papillate apex, bitunicate asci and usually septate, symmetrical or longitudinally asymmetrical, sometimes muriform, hyaline or pigmented ascospores. The asexual states are coelomycetous and hyphomycetous.

Dyfrulomycetales K.L. Pang, K.D. Hyde & E.B.G. Jones, **ordo novus**, Mycobank: MB 805281

An order of marine fungi within the class Dothideomycetes. Characterized by perithicoid, coriaceous, immersed ascomata, clypeate, ostiole, papillate; bitunicate, fissitunicate, cylindrical asci, with a short pedicel and distinct ocular chamber with ring-like subapical apparatus; hyphae-like pseudoparaphyses in a gelatinous matrix and overlapping uniseriate, broadly fusiform, symmetrical, hyaline, multiseptate with wide septa, and smooth-walled ascospores. Differing from *Monoblastiales* in its nonlichenized ascomata, hyphae-like pseudoparaphyses, and hyaline, multiseptate ascospores. Differing from *Kirschsteiniotheliaceae* in lacking brown, 1-septate ascospores, and an asexual state in *Dendryophiopsis*.

Typus: *Dyfrulomyces* K.D. Hyde et al.

Hysteriales Lindau, in Engler & Prantl, *Nat. Pflanzenfam., Teil. I* (Leipzig) 1: 265 (1896)

The order *Hysteriales* was introduced by Lindau (1896) and has been placed among the pyrenomycetes and the discomycetes at different times (Rehm 1896). Molecular data now places *Hysteriales* in the Dothideomycetes (Boehm et al. 2009a, b; Shearer et al. 2009; Suetrong et al. 2009). This order consists of a single family, *Hysteriaceae*, characterized by a hysterothecium (a carbonaceous navicular ascoma with a longitudinal dehiscence slit). Ascospores are typically dark and vary in septation. The family has been extensively revised based on DNA and amino acid sequence analysis (Boehm et al. 2009a, b).

Jahnulales K.L. Pang et al., in Pang et al., *Mycol. Res.* 106(9): 1033 (2002)

Pang et al. (2002) introduced the order *Jahnulales* for species with ascomata with well-developed long hyphal stalks or pedicels. The placement of *Jahnulales* in Dothideomycetes was confirmed by molecular analysis (Pang et al. 2002; Campbell et al. 2007; Schoch et al. 2009b; Shearer et al. 2009; Suetrong et al. 2009, 2011a). *Jahnulales* comprises two families: *Aliquandostipitaceae* and *Manglicolaceae* (Suetrong et al. 2011a). Members of *Jahnulales* are aquatic species which are

lignicolous, saprobic, and occur on rotting or submerged woody debris and palms (Inderbitzin et al. 2001; Pang et al. 2002; Raja and Shearer 2006; Campbell et al. 2007; Suetrong et al. 2011a). The order is characterized by ca. 40 µm wide, septate, brown, thick-walled mycelial hyphae, that often bear ascomata, hypha-like or trabeculate, septate, unbranched pseudoparaphyses up to 4 µm wide; bitunicate asci with an ocular chamber; and ascospores that are 1-septate, pale to dark brown, with bipolar apical appendages or surrounded by a thin or elaborate wide gelatinous sheath (Suetrong et al. 2011a).

Lichenoconiales Diederich, Lawrey & K.D. Hyde, **ordo novus**, MycoBank: MB 805297

An order of lichenicolous fungi within class Dothideomycetes. Characterized by a lichenicolous habit, commensalistic to parasitic on crustose, foliose or fruticose lichens; sexual state unknown; conidiomata pycnidial, black, with an irregular pore-like opening; pseudoparenchymatic pycnidial wall composed of 2–4 layers of rounded to polyhedral, flattened cells, dark brown in outer and paler in inner layers, K+ olivaceous; conidiophores lacking; conidiogenous cells covering the entire wall of the inner pycnidial cavity, phialidic, often percurrently proliferating, hyaline and smooth-walled, rarely apically brown and verrucose, elongate ampulliform to subcylindrical; conidia arising singly or indistinctly catenate, subspherical, ellipsoid, obpyriform or elongate-clavate, basally usually truncate, aseptate, not visibly guttulate, surface verruculose to verrucose or echinulate, medium to dark brown, becoming more olivaceous in 10 % KOH. Differing from most pycnidial fungi by the combination of more or less hyaline, elongate ampulliform to subcylindrical, phialides, often percurrently proliferating conidiogenous cells, and ellipsoid, basally truncate, brown conidia with an ornamented wall.

Typus: *Lichenonium* Petr. & Syd.

Lichenotheliales K. Knudsen, Muggia & K.D. Hyde, **ordo novus**, MycoBank: MB 805298

An order of non-lichenized fungi within the class Dothideomycetes. Characterized by a saprobic or lichenicolous lifestyle, epiphytic or endolithic on rock, endokapalic or episubstratic on lichens; thallus black of scattered stroma, connected or not by superficial hyphae, or of areoles scattered to continuous; either with ascomata, perithecioid and ostiolate, with interascal filaments, or stromata non-ostiolate with asci forming in pseudoparenchymatous locules; asci bitunicate, globose to clavate, sometimes with outer layers or apex of ascus K/I+ blue, ascospores hyaline to brown, 1-septate to muriform; macroconidia present or not, black, originating from thallus surface; conidiomata immersed in stromata, present or not, conidia rod-shaped or unknown. Differing from the lichenicolous genus *Lichenostigma* in *Lichenostigmales* in the Arthoniomycetes (Ertz et al. 2013) in their ascus type and the presence of a

hamathecium, as well as in comprising many non-lichenicolous species occurring on rock.

Typus: *Lichenothelia* D. Hawksw.

Microthyriales G. Arnaud, *Les Astérinées*: 85 (1918)

The order *Microthyriales* was introduced by Arnaud (1918) with the family type *Microthyriaceae*. Schoch et al. (2009b) provided molecular evidence based on a strain of *Microthyrium microscopicum* Desm. (the type species of *Microthyriaceae*) and *Stomiopeltis betulae* J.P. Ellis (*Micropeltidaceae*) to represent the *Microthyriales* and showed that the order can be placed in Dothideomycetes. However, the molecular data based on these limited sequences did not provide enough clarity to support the order. Lumbsch and Huhndorf (2010) placed *Microthyriaceae* and *Micropeltidaceae* in Dothideomycetes as family *incertae sedis*, and *Microthyriales* was not listed. In this study we accept the *Microthyriales* based on morphological data and include the families *Microthyriaceae* and *Micropeltidaceae*. The *Microthyriales* are characterized by dark, circular, thyriothelial ascomata with poorly developed bases and central rounded ostioles (Wu et al. 2011a). The bitunicate asci are inclined from the base and outer rim towards the central ostiole and pseudoparaphyses may be present or lacking. Ascospores are hyaline or brown, mostly 2-celled or with a few to several transverse septa. Species are foliar epiphytes, biotrophs, saprobes or epiphytes on dead or living leaves and stems of plants. This group of fungi are relatively poorly studied (Wu et al. 2011a), and thus molecular data is needed to confirm the relationships of these families and their genera, which are generally poorly known. Asexual states are coelomycetous (*Asterostomula*, *?Cyclopeltella*, *Leptothyrium*, *?Sirothyriella*) or hyphomycetous (*Hansfordiella*, *Holubovaniella*, *Isthmospora*, *Zalerion*) (Kirk et al. 2008; Seifert et al. 2011; Wu et al. 2011a; Wijayawardene et al. 2012).

Monoblastiales Lücking, M.P. Nelsen & K.D. Hyde, **ordo novus**, MycoBank: MB 805299

An order of lichenized fungi within class Dothideomycetes. Characterized by crustose, mostly epiphytic habit on tree bark; endo- to epi-peridermal, ecorticate to corticate thallus; trentepohlioid photobiont; perithecioid ascomata with distinct or reduced involucrellum and psoroplectenchymatous excipulum; branched and anastomosing, thin, net-like physes; fissitunicate asci with ocular chamber and fluorescent ring- or cap-structures; mostly ellipsoid-fusiform, 1-septate (rarely non-septate or 3-septate), euseptate, hyaline to rarely brownish ascospores; conidia produced in conspicuous conidiomata, with the macroconidia typically clustered in groups or masses in a distinct gelatinous matrix; and generally lack secondary substances except lichexanthone and anthraquinones in a few taxa. Differing from *Strigulales* in the net-like physes and from most *Trypetheliales* in the euseptate ascospores with few septa and the poor secondary

chemistry, and from both in the macroconidia arranged in a gelatinous matrix.

Typus: *Monoblastia* Riddle

Myriangiales Starbäck, Bih. K. svenska Vetensk. Akad. Handl., Afd. 3 25(no. 1): 37 (1899)

Starbäck (1899) introduced the order *Myriangiales* for the species characterised by crustose ascostromata and muriform ascospores, similar to the type species, *Myriangium duriae* Mont. & Berk. (Berkeley 1845; Miller 1938). Phylogenetic studies based on a multi-gene analysis have indicated that *Myriangiales* always cluster with Dothideomycetes (Boehm et al. 2009b; Phillips et al. 2008; Schoch et al. 2009b; Zhang et al. 2011a). Kirk et al. (2008) included three families, *Cookellaceae*, *Elsinoaceae* and *Myriangiaceae* in *Myriangiales*, while Lumbsch and Huhndorf (2010) accepted only *Elsinoaceae* and *Myriangiaceae* in the order based on phylogenetic results, while *Cookellaceae* was treated in Dothideomycetes as family *incertae sedis*. The order is characterized by pulvinate, irregular ascostromata in which the asci are irregularly arranged in one or more layers in locules. Locules contain single or multiple asci. Asci have minute pedicels and indistinct ocular chambers. Ascospores which are irregularly arranged are liberated only by the breakup of the stromatal layers above them. Asexual states are coelomycetous.

Mytilinidiales Boehm et al., Mycol. Res. 113(4): 468 (2009)

The family *Mytiliniaceae* was separated from the order *Pleosporales* and elevated to a higher taxonomic rank, *Mytilinidiales* by Boehm et al. (2009a) supported by molecular data. The order comprises *Gloniaceae* and *Mytiliniaceae* (Boehm et al. 2009b; Lumbsch and Huhndorf 2010). Morphologically, the order is characterized by rigid, brittle, hysterothecial, carbonaceous ascomata with the appearance of bivalve shells or are wedge-shaped, and ascospores are of various septate types: didymosporous, phragmosporous and/or dictyosporous (Sivanesan 1984; Alexopoulos et al. 1996; Boehm et al. 2009a, b). Most are pantropical species, saprobic on wood, bark, stem, twigs, gymnosperms and some species are parasitic on leaves (Barr 1975, 1987a, b; Pereira and Barreto 2003; Boehm et al. 2009a).

Natipusillales Raja, Shearer, A.N. Mill. & K.D. Hyde, **ordo novus**, MycoBank: MB 805300

An order of freshwater fungi within the class Dothideomycetes characterized by small, globose to subglobose Ascomata on submerged wood, erumpent to superficial, hyaline to light brown. Peridial wall membranous, composed of pseudoparenchyma cells forming a *textura angularis* in surface view. Pseudoparaphyses septate, sparse. Asci 8-spored, bitunicate, fissionate, globose, subglobose or obclavate. Ascospores fusiform to cylindrical, one to several septate, multiguttulate or not, hyaline becoming brown

with age, with or without a gelatinous sheath and/or appendages. Included family: **Natipusillaceae** Raja, Shearer & A.N. Mill. Members of *Natipusillales* differ from other aquatic orders in the Dothideomycetes in having very small, globose, hyaline ascomata, globose asci and appendaged, hyaline ascospores. The establishment of *Natipusillales* is supported by both morphological characters as well as combined 18S and 28S nrDNA sequence data (Raja et al. 2013a, b, this study).

Typus: *Natipusilla* A. Ferrer et al.

Patellariales D. Hawksw. & O.E. Erikss., Syst. Ascom. 5(1): 181 (1986)

The order *Patellariales* was introduced by Hawksworth and Eriksson (1986) based on morphological data to accommodate *Patellariaceae*, *Arthrorhaphidaceae* and *Phillipsiellaceae*, while Barr (1987a) only accepted *Patellariaceae* in *Patellariales*. Luttrell (1951) had considered *Hysteriaceae* and *Patellariaceae* to be Discomycetes with bitunicate asci and placed them in the bitunicate group. Kutorga and Hawksworth (1997) later monographed several genera of *Patellariaceae* and 17 genera were accepted. Morphological features of the *Patellariales* are apothecial or hysterothecial, cup-shaped ascomata, bitunicate asci and hyaline, septate ascospores (Kutorga and Hawksworth 1997). Boehm et al. (2009a) and Schoch et al. (2009b) showed the *Patellariales* to belong in Dothideomycetes based on molecular data.

Phaeotrichales Ariyawansa, J.K. Liu & K.D. Hyde, **ordo novus**, MycoBank: MB 805301

An order of coprophilous fungi within the class Dothideomycetes. Characterized by a terrestrial or saprobic habitat. *Ascomata* solitary, or in small groups, superficial, unilocular, stromatic, globose, black, perithecial or cleistothecial setose. *Peridium* thin, carbonaceous, membranous. *Hamathecium* tissue absent or of evanescent cellular pseudoparaphyses *Asci* 8-spored, bitunicate, fissionate, in irregular or arranged in little groups or bundles and evanescent at maturity and sometimes with an apical ring. *Ascospores* uniseriate or partially overlapping, dark brown to reddish brown, sometimes fragmenting, composed of terminal germ pores, with or without a sheath. *Asexual state*: Unknown.

Typus: *Phaeotrichum* Cain & M.E. Barr

Pleosporales Luttr. ex M.E. Barr, Prodr. Cl. Loculoasc. (Amherst): 67 (1987)

The order *Pleosporales* was invalidly introduced by Luttrell (1955), and later validated by Barr (1987a), and is based on the family *Pleosporaceae* with the type species *Pleospora herbarum* (Pers.) Rabenh. (Barr 1987b). It is the largest order of Dothideomycetes (Kirk et al. 2008). Molecular studies indicated that *Pleosporales* should comprise 20 accepted families (Boehm et al. 2009a, b; Mugambi and Huhndorf 2009a; Schoch et al. 2009b; Shearer et al. 2009; Suetrong et al. 2009; Tanaka

et al. 2009; Zhang et al. 2009a, b), however, more recently Zhang et al. (2012a) included 25 families. The order *Pleosporales* presently comprises 28 families (Boonmee et al. 2012; Zhang et al. 2012a), while *Venturiaceae* was excluded from the *Pleosporales* by Zhang et al. (2011a) and placed in *Venturiales*. In this study we place 41 families in *Pleosporales*. Members of *Pleosporales* are saprobic on dead plant material in fresh water, marine, or terrestrial environments, and a large number, especially asexual states are pathogens on living plants (Zhang et al. 2009c; Boonmee et al. 2012). *Pleosporales* comprises the suborders *Pleosporineae* and *Massarineae*. Zhang et al. (2009a) emended the *Pleosporineae*, which is a phylogenetically well-supported suborder of *Pleosporales* and includes seven families: *Cucurbitariaceae*, *Didymellaceae*, *Didymosphaeriaceae*, *Dothidothiaceae*, *Leptosphaeriaceae*, *Phaeosphaeriaceae* and *Pleosporaceae*, while Ariyawansa et al. (2013a) and Liu et al. (2013) included two new families, *Halojulellaceae* and *Shiraiaceae*. *Pleosporineae* contains economically important plant pathogens (de Gruyter et al. 2010; Zhang et al. 2009a) and is characterized by broadly to narrowly oblong ascomata, downwardly growing pseudoparaphyses, with 1-multiseptate ascospores. Recent studies using multigene phylogeny of *Phoma* and its closely related genera, indicated that their representative species cluster in different subclades of *Pleosporineae* (de Gruyter et al. 2009, 2010). *Massarineae* is characterized by immersed or superficial ascomata, cylindrical asci with a short pedicel and 1-multiseptate ascospores. Zhang et al. (2012a) included five families in *Massarineae* viz. *Lentitheciaceae*, *Massarinaceae*, *Montagnulaceae*, *Morosphaeriaceae* and *Trematosphaeriaceae*, with most species saprobic in terrestrial or aquatic environments, and we introduce a new family *Bambusicolaceae* to this suborder.

Strigulales Lücking, M.P. Nelsen & K.D. Hyde, **ordo novus**, MycoBank: MB 805302

An order of lichenized fungi within class Dothideomycetes. Characterized by crustose, mostly epiphytic habit on leaves, tree bark, and rocks; sub or supracucicular (leaves) or endo to epiperidermal (bark), ecorticate to corticate thallus; trentepohlioid photobiont; perithecioid ascomata with distinct or rarely reduced involucrellum and psoroplectenchymatous excipulum; unbranched to more rarely branched and sometimes anastomosing, but not net-like physes; fissitunicate asci with ocular chamber; mostly fusiform to oblong, 1-septate (rarely 3–7-septate to muriform), euseptate, hyaline ascospores; conidia produced in pycnidia, with the macroconidia typically being septate to muriform and having terminal, gelatinous appendages; and general lack of secondary substances. Differing from most *Trypetheliales* in the euseptate ascospores with few septa and the lack of secondary chemistry, and from both *Monoblastiales* and *Trypetheliales* in the mostly unbranched physes and the macroconidia producing gelatinous appendages.

Typus: *Strigula* Fr.

Trypetheliales Lücking et al., in Aptroot et al., *Bibliotheca Lichenol.* 97: 13 (2008)

The order *Trypetheliales* was introduced in Aptroot et al. (2008) to accommodate a single family *Trypetheliaceae* of lichenized fungi. This order was accepted in the Dothideomycetes based on molecular phylogenetic results (Del Prado et al. 2006; Schoch et al. 2009a, b; Nelsen et al. 2009, 2011b). The order includes mostly lichenized species characterized by a branched and anastomosing hamathecium embedded in a distinct gelatinous matrix, and by usually hyaline ascospores that feature a combination of eusepta and angular distosepta, giving the lumina a diamond-shaped appearance. These characters are not constant, however, as some lineages produce ascospores with eusepta only and in some lineages they are dark brown. Also the degree of anastomosing of the hamathecium can vary, especially in basal lineages.

Tubeufiales S. Boonmee et al., *Fungal Divers.* (in prep.)

The order *Tubeufiales* will be introduced by Boonmee et al. (2013, in prep) based mainly on a distinct habit, most being saprobes on decaying lignocellulosic material, sexual characters, helicosporous asexual morphs, and strongly supported by molecular data. The ascomata are characterized by superficial, light brown, dark brown to black, uniloculate pseudothecia, and asexual states are hyphomycetous helicospores or chlamydospores (Barr 1979a, 1980; Sivanesan 1984; Kodsueb et al. 2006a; Tsui and Berbee 2006; Tsui et al. 2006; Boonmee et al. 2011).

Typus: *Tubeufia* Penz. & Sacc.

Venturiales Ying Zhang & K.D. Hyde, *Fungal Divers.* 51(1): 252 (2011)

The order *Venturiales* was introduced by Zhang et al. (2011a), based on morphological and ecological characteristics, as well as strong support from multigene phylogenetic analyses. This order presently includes *Sympoventuriaceae* and *Venturiaceae* (Zhang et al. 2011a). Some species are plant pathogens and others are saprobic, mostly on leaves or stems of dicotyledons. Important characters are small to medium-sized ascomata, with or without setae, a mostly evanescent hamathecium, 8-spored, broadly or usually obclavate asci, usually lacking a pedicel, hyaline, light greenish olivaceous to brown, 1-septate, symmetrical, asymmetrical or apiosporous ascospores and hyphomycetous asexual states.

Material and methods

Layout of the paper

Each family is treated with a family description, notes on its history and presence of any asexual morphs, an account of the genera and including phylogenetic data where applicable. The

type is listed along with a description of the type genus except in cases where there is only a single genus in the family. Notes on the type genus are provided along with full citations for the type species. This is followed by accepted genera and their type species; important synonyms and occasional notes are given. Synonymies follow the basis of one name for a biological genus or species (see Hawksworth et al. 2011; Hawksworth 2012) and follow published papers (e.g. Crous et al. 2006; Wingfield et al. 2012) or Wijayawardene et al. (in prep.) or Index Fungorum (2013). A key to the genera included in the family is provided unless the number of genera is small. The type genus is illustrated with a representative plate of its key morphological features. For consistency, authorities and their abbreviations for all taxa and citations of place of publication and abbreviations follow Index Fungorum (2013), even those these are not always entirely consistent.

Arrangement of dothideomycetes

The circumscription of the Dothideomycetes is based on the previous arrangements given in Lumbsch and Huhndorf (2010) which is then updated based on consideration of recent publications and interpretation of genera from the literature. We consider this a working circumscription which will be further refined as more genera are studied both at the morphological and molecular levels. Basionyms and synonyms are listed for the type genus and species of each family, unless there are more than three. Other synonyms are only listed where we have either made changes or examined material. All other possible synonyms can be found in Index Fungorum.

Molecular phylogeny

Sequences were obtained from GenBank following mostly previous publications (e.g. Schoch et al. 2006, 2009a; Suetrong et al. 2009; Zhang et al. 2012a; Li et al. 2012; Liu et al. 2012a) and are listed in Supplementary Table 1.

Sequences for each DNA region were initially aligned using Bioedit (Hall 2004) and ClustalW v. 1.6 (Thompson et al. 1997). Alignments were checked and manually optimized. The dataset was refined visually in BioEdit v. 7.0.1 (Hall 2004). By doing this we were able to make sure the data included in our tree were reliable. Following the recommendation of Wiens (2006), we included taxa in our multi-locus matrix even if they did not have all genes present. All absent genes were coded as missing data. *Schismatomma decolorans* (Turner & Borrer ex Sm.) Clauzade & Vezda (Arthoniomycetes) was chosen as the outgroup sequence based on its placement as sister clade to the Dothideomycetes (Schoch et al. 2006, 2009b). Four genes small subunits ribosomal RNA (SSU), large subunits ribosomal RNA (LSU), the translation elongation factor-1 alpha (*TEF1*) and the second largest subunit of RNA polymerase II (*RPB2*) were applied in this study.

Phylogenetic trees based on individual LSU, individual SSU, combined LSU and SSU and combined LSU, SSU and *TEF1* datasets (data not shown) were congruent with the combined LSU, SSU, *TEF1* and *RPB2* data sets. However, the position of the families *Kirschsteinioteliaceae*, *Lichenconiaceae* and *Monoblastiaceae* were not constant. The phylogenetic analyses of the combined LSU, SSU, *TEF1* and *RPB2* data were performed using maximum parsimony, Bayesian and maximum likelihood algorithms.

Maximum-parsimony analyses were performed by PAUP v. 4.0b10 (Swofford 2002) using the heuristic search option with 1,000 random taxa addition and tree bisection and reconnection (TBR) as the branch swapping algorithm. All characters were unordered and of equal weight and gaps were treated as missing data. The Tree Length (TL), Consistency Indices (CI), Retention Indices (RI), Rescaled Consistency Indices (RC) and Homoplasy Index (HI) were calculated for each tree generated. Maxtrees were unlimited, branches of zero length were collapsed and all multiple, equally parsimonious trees were saved. Clade stability was assessed using a bootstrap (BT) analysis with 1,000 replicates, each with 10 replicates of random stepwise addition of taxa (Hillis and Bull 1993). Maximum parsimony bootstrap values (MPBP) equal or greater than 50 % are given above each node (Fig. 2).

Maximum likelihood (ML) analysis was performed at the CIPRES webportal (Miller et al. 2010) using RAxML v. 7.2.8 as part of the “RAxML-HPC2 on TG” tool (Stamatakis 2006; Stamatakis et al. 2008). A general time reversible model (GTR) was applied with a discrete gamma distribution and four rate classes. Fifty thorough maximum likelihood (ML) tree searches were done in RAxML v. 7.2.7 under the same model, with each one starting from a sepa-rate randomised tree and the best scoring tree selected with a final ln value of -13,974.356237. One thousand non para-metric bootstrap iterations were run with the GTR model and a discrete gamma distribution. The resulting replicates were plotted on to the best scoring tree obtained previously. Maximum Likelihood bootstrap values (MLBP) equal or greater than 50 % are given above each node (Fig. 2).

Bayesian analyses (Larget and Simon 1999): The model of evolution was estimated by using MrModeltest 2.2 (Nylander 2004). Independent Bayesian phylogenetic analyses were performed in MrBayes v. 3.1.2 (Huelsenbeck and Ronquist 2001) using a uniform [GTR+I+G] model, lsetnst=6 rates=invgamma; prsetstatefreqpr=dirichlet (1,1,1,1). Posterior probabilities (PP) (Rannala and Yang 1996; Zhaxybayeva and Gogarten 2002) were determined by Markov Chain Monte Carlo sampling (BMCMC) in MrBayes v. 3.0b4 (Huelsenbeck and Ronquist 2001). Six simultaneous Markov chains were run for 5,000,000 generations and trees were sampled every 100th generation (resulting in 10,000 total trees). The first 5,000 trees were discarded as burn-in prior to convergence of the four chains. The remaining trees were used to construct a 50 % majority rule consensus tree and to calculate

Bayesian Posterior Probabilities (BYPP) with those equal or greater than 0.90 given below each node (Fig. 2).

Phylogenetic trees were drawn using Treeview v. 1.6.6 (Page 1996) and MEGA 5 (Tamura et al. 2011). The alignments were deposited in TreeBASE (www.treebase.org).

Definitions of previously inconsistently defined terms used in the study

We tried to be consistent in the terminology we have used. However, it was not always possible, especially because some terms are not commonly accepted and some have been interpreted differently by different authors. This applies especially to the denominations of the different types of interascal hyphae, for which we have defined the terminology used in this work as follows (Eriksson 1981; Ryan et al. 2005; Kirk et al. 2008).

Paraphyses: originating from only the bottom of the ascumatal cavity.

Paraphysoids: originating from both the bottom and top of the ascumatal cavity.

Pseudoparaphyses: originating from only the top but eventually attaching to the bottom and becoming free apically, in mature stages often not distinguishable from paraphysoids or paraphyses.

If the ontogeny and hence the type was unknown or unclear, we used as far as possible the neutral terms **physes** or **interascal hyphae**. Also, instead of distinguishing between ascolocular **pseudothecia** and ascohymental **perithecia**, we used the neutral terms perithecioid ascumata or else the term perithecia in a broad sense, since by definition all ascumata in the higher Ascomycota (Pezizomycotina) are homologous and thus a differential terminology using the term pseudothecia for ascolocular perithecioid ascumata does not reflect phylogenetic relationships.

The numbers cited for taxonomic entries up to 489999 had originally been assigned by Index Fungorum and have been adopted by MycoBank, and we cite them in this paper as MycoBank numbers.

Results and discussion

The combined LSU, SSU, *TEF1* and *RPB2* gene data set consists of 414 taxa, with *Schismatomma decolorans* as the outgroup taxon. The dataset consists of 4,584 characters after alignment, 1,615 characters were constant, and 2,303 characters were parsimony informative, while 666 variable characters are parsimony-uninformative. A heuristic search with random addition of taxa (1,000 replicates) and treating gaps as missing characters generated six equally parsimonious trees. The best scoring RAxML trees are shown in Figs. 1 and 2. Bootstrap support (BS) values of MP and ML (equal to or above 50 %) are shown on the upper branches. Values of

the Bayesian posterior probabilities (PP) (equal to or above 90 %) from MCMC analyses are shown under the branches (TL=39,381, CI=0.140, RI=0.617, RC=0.086, HI=0.860).

In the phylogenetic trees (Figs. 1 and 2), the 414 strains of Dothideomycetes included in the analysis cluster into the two Dothideomycete subclasses as previously described based on presence or absence of pseudoparaphyses (Schoch et al. 2006). Subclass Pleosporomycetidae includes *Pleosporales*, *Mytilinidiales*, and *Hysteriales* and is the same as in previous publications (Schoch et al. 2009b; Boehm et al. 2009b; Shearer et al. 2009; Suetrong et al. 2011a). However, the position of *Jahnulales* was not consistent and clustered together with two newly introduced orders *Dyfrulomycetales* and *Strigulales*; and *Acrospermales* in this study. The second subclass Dothideomycetidae representing *Capnodiales*, *Dothideales* and *Myriangiales* is confirmed as well-supported.

Twenty-two orders (*Pleosporales*, *Mytilinidiales*, *Hysteriales*, *Acrospermales*, *Dyfrulomycetales*, *Strigulales*, *Jahnulales*, *Tubeufiales*, *Patellariales*, *Botryosphaerales*, *Dothideales*, *Myriangiales*, *Capnodiales*, *Lichenocoriales*, *Phaeotrichales*, *Microthyriales*, *Natipusillales*, *Venturiales*, *Asterinales*, *Lichenotheliales*, *Monoblastiales* and *Trypetheliales*) within the class *Dothideomycetes* are supported in Figs. 1 and 2. The order *Venturiales* was recently proposed (Zhang et al. 2011a) with two families *Venturiaceae* and *Symptoventuriaceae* to accommodate the groups which have a parasitic or saprobic lifestyle, occurring on leaves or stems of dicotyledons; small to medium-sized ascumata, often with setae; deliquescent pseudoparaphyses; 8-spored, broadly cylindrical to obclavate asci; 1-septate, yellowish, greenish or pale brown to brown ascospores; and hyphomycetous asexual morphs (Zhang et al. 2011a). The family *Tubeufiaceae* which was not placed in an order by Schoch et al. (2006), is now accommodated in *Tubeufiales* (Boonmee et al. 2013, in press). The order *Tubeufiales* includes taxa with uni-loculate, superficial and pigmented (e.g. pale brown, brown, and dark brown to black) ascumata, and mostly multi-celled and hyaline relatively long ascospores and mostly produce helicosporeous asexual states. Both *Venturiaceae* and *Tubeufiaceae* were traditionally assigned to *Pleosporales*, although they have diagnostic characters which readily distinguish them from other pleosporalean families. Phylogenetically, the core genera of *Venturiaceae* and *Tubeufiaceae* form monophyletic clades within Dothideomycetes, and represent separate sister lineages from the current orders. The nearest relatives of the *Tubeufiales* are *Botryosphaerales*. The species-rich order *Botryosphaerales* included the single family *Botryosphaeriaceae* in Schoch et al. (2006). With more extensive taxa sampling of diversity in this order, the *Planistromellaceae* was shown to cluster adjacent to the *Botryosphaeriaceae* (Minnis et al. 2012; Monkai et al. 2013), and *Phyllostictaceae* reinstated (Wikee et al. 2013). Three well-supported clades are representative of these families in *Botryosphaerales* (Figs. 1 and 2). *Saccharata*

Taxonomy

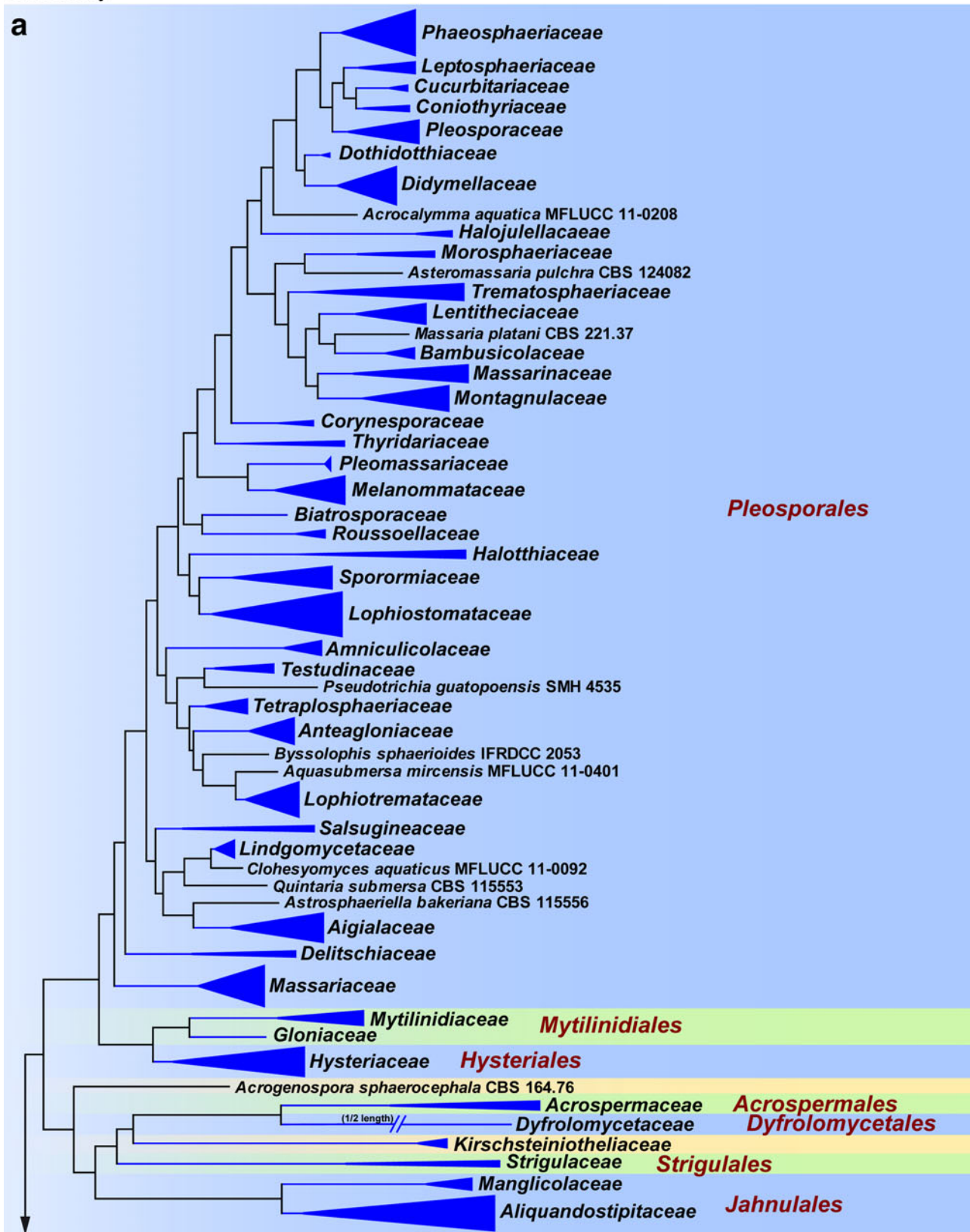


Fig. 1 The best scoring RAxML Dothideomycetes tree (compress overview tree) from 414 taxa based on a combined dataset of LSU, SSU, *TEF1* and *RPB2* sequences with all lineages collapsed to family level where possible. The tree was rooted with *Schizatomma decolorans*

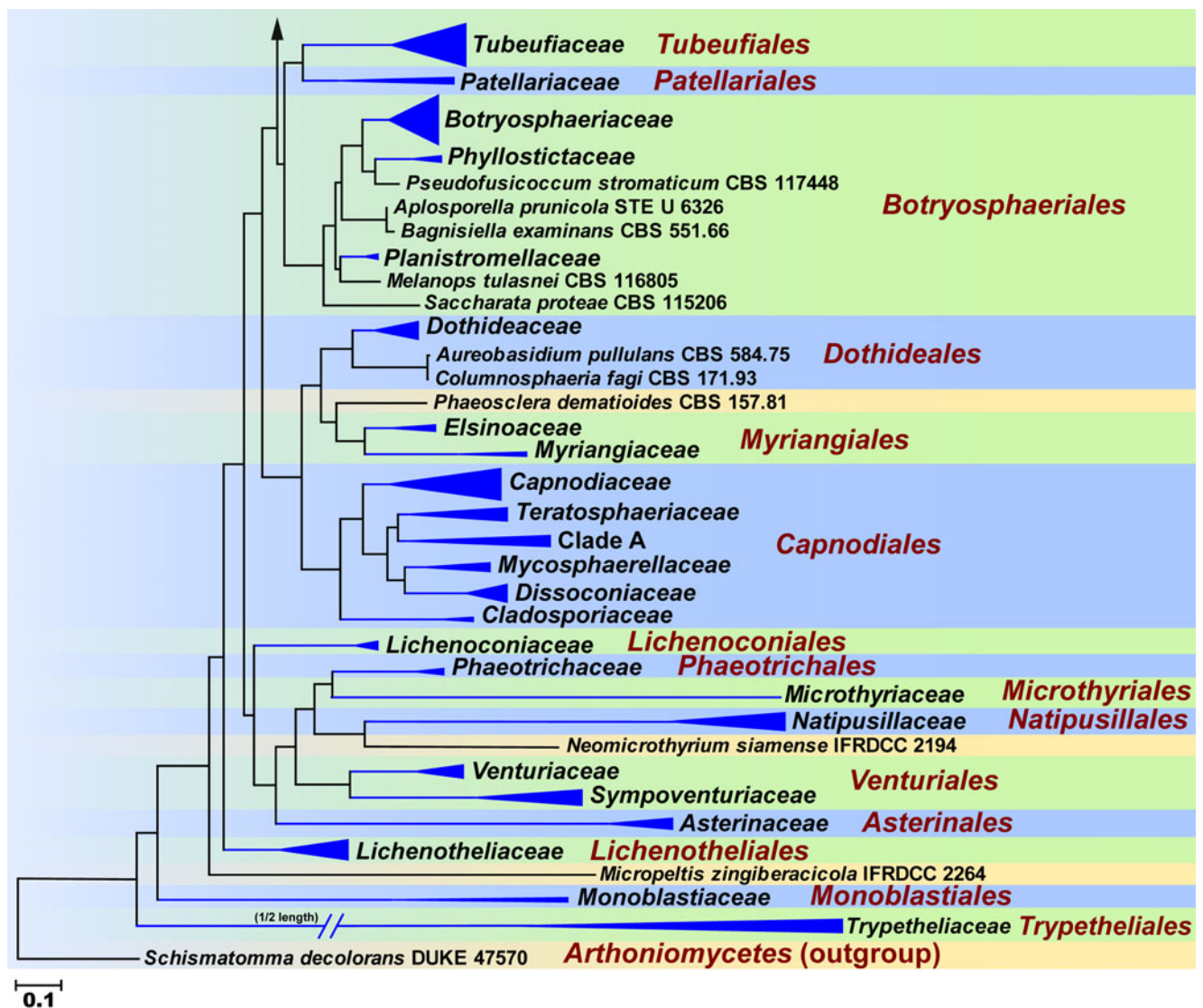


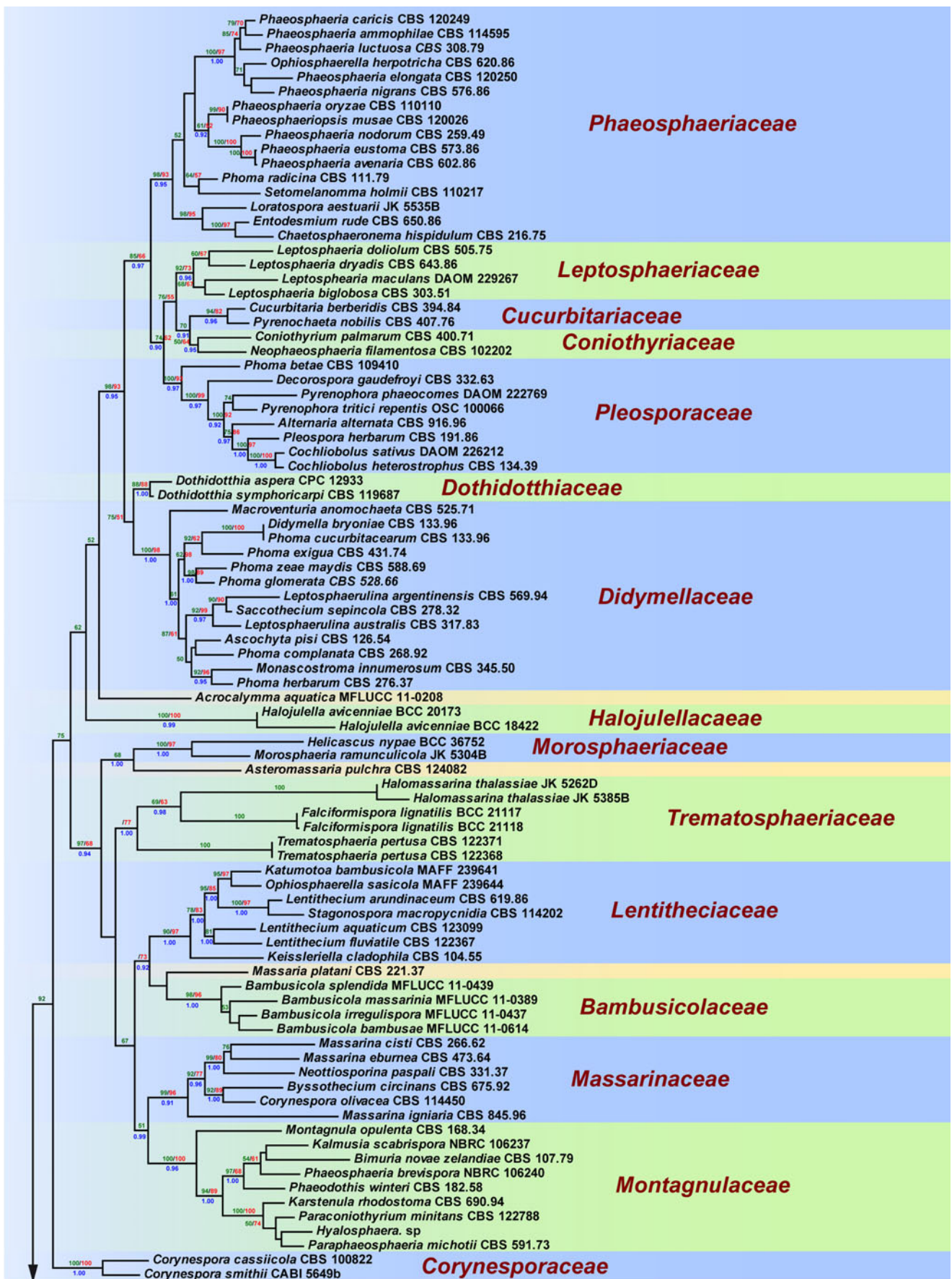
Fig. 1 (continued)

protea *Saccharata proteae* (Wakef.) Denman & Crous does not reside in any of the above clades, and is placed on early diverging branches of the order, representing an underscribed family (*Saccharataceae*; Slippers et al. 2013, in press). The monotypic genus *Melanops* (type=*Melanops tulasnei* Fuckel) clustered together with *Planistromellaceae*, but without strong support, and is placed in the *Melanopsaceae* by Slippers et al. (2013, in press). Their somewhat similar morphological characters however, may show that *Melanops* belongs in *Planistromellaceae*. In addition, the two asexual genera *Aplosporella* and *Pseudofusicoccum* did not cluster in any clade in this analysis. *Aplosporella* is placed in the *Aplosporellaceae* by Slippers et al. (2013, in press).

Families with good support but not clustering in any known orders include *Kirschsteinietheliaceae*, *Lichenoniconiaceae*, *Lichenotheliaceae*, *Monoblastiaceae*, *Natipusillaceae*, *Phaeotrichaceae*, and *Strigulaceae* (Figs. 1 and 2).

Dyfrlomycetaceae clustered together with *Acrospermaceae*, *Kirschsteinietheliaceae* and *Strigulaceae* and formed a sister group with *Jahmulales*. *Monoblastiaceae* (lichenized fungi) formed a separate lineage comprising two species, *Megalotremis verrucosa* and *Anisomeridium ubianum* (Vain.) R.C. Harris with 100 % bootstrap support and is closest to the lichen family *Trypetheliaceae* Zenker (1827). The recently introduced family *Kirschsteinietheliaceae* (Boonmee et al. 2012) is also related to *Dyfrlomycetaceae* and

Fig. 2 The best scoring RAxML Dothideomycetes tree from 414 taxa based on a combined dataset of LSU, SSU, *TEF1* and *RPB2* sequences with all lineages collapsed to family level where possible. The tree is the same as Fig. 1. Bootstrap support values for maximum likelihood (ML, green) and maximum parsimony (MP, red) greater than 50 % are given above the nodes; Bayesian posterior probabilities (BYPP, blue) above 0.90 are given below the nodes. The original isolate numbers are given after the species names. The tree was rooted with *Schimatomma decolorans*



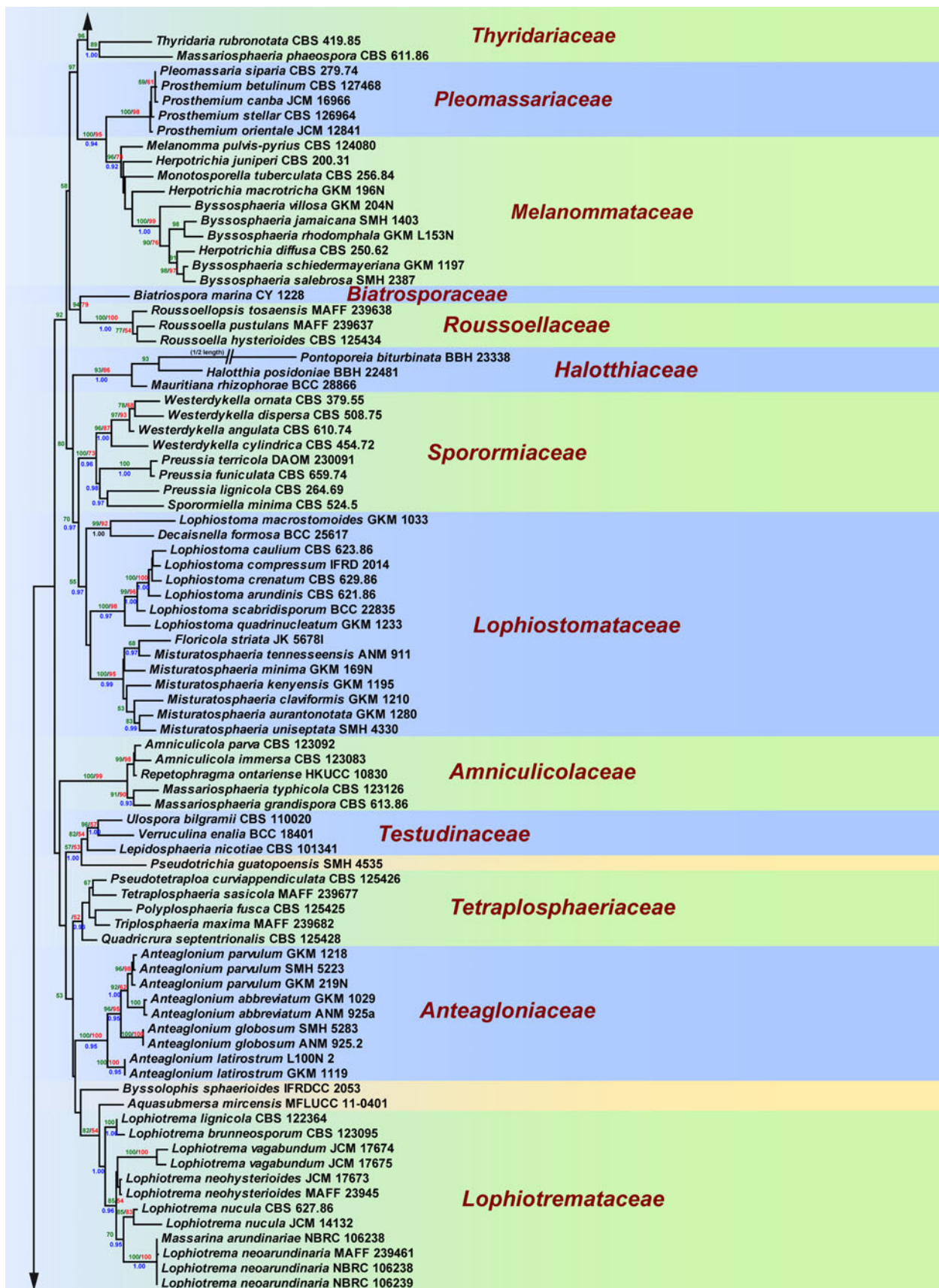


Fig. 2 (continued)

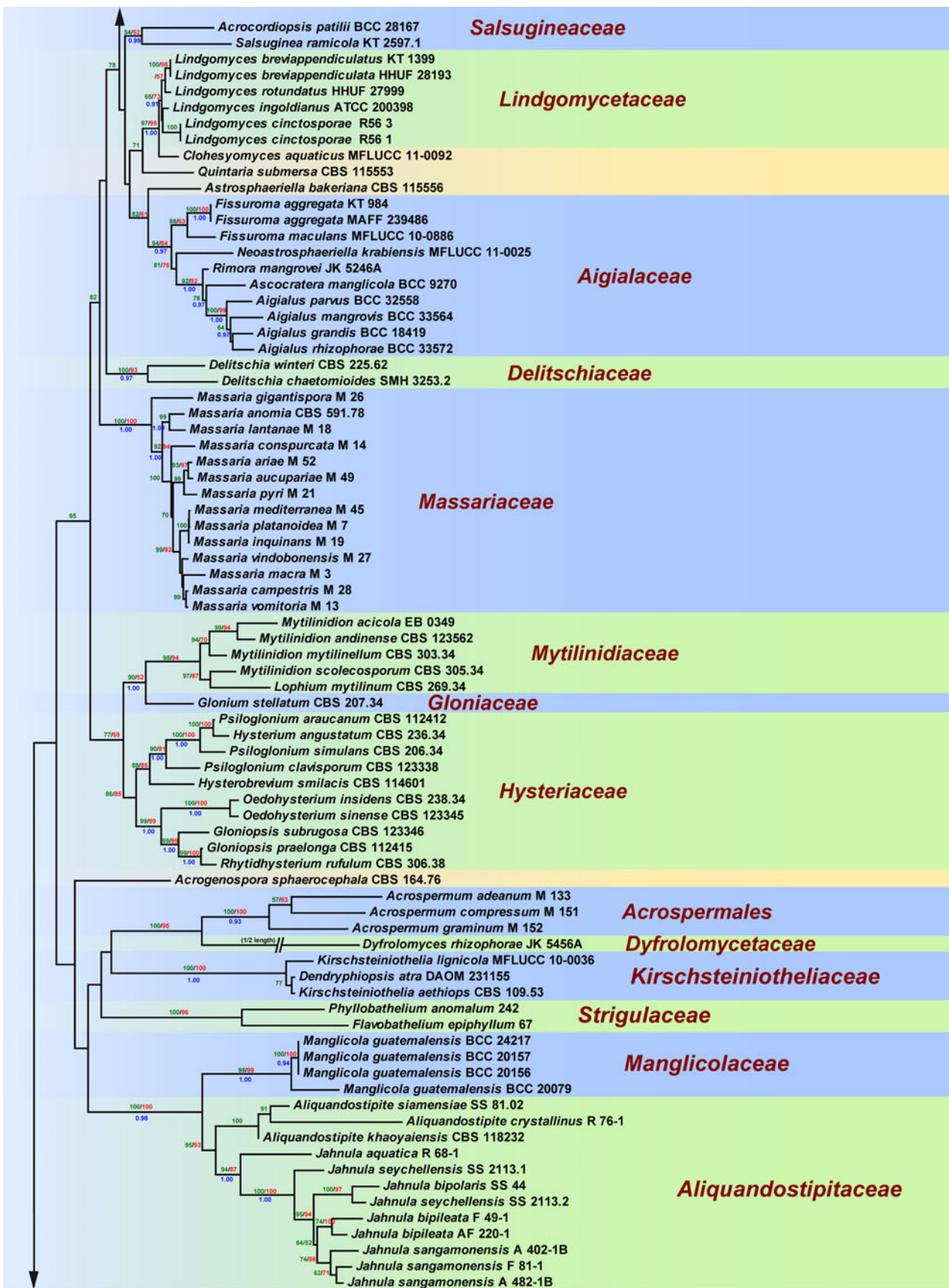


Fig. 2 (continued)

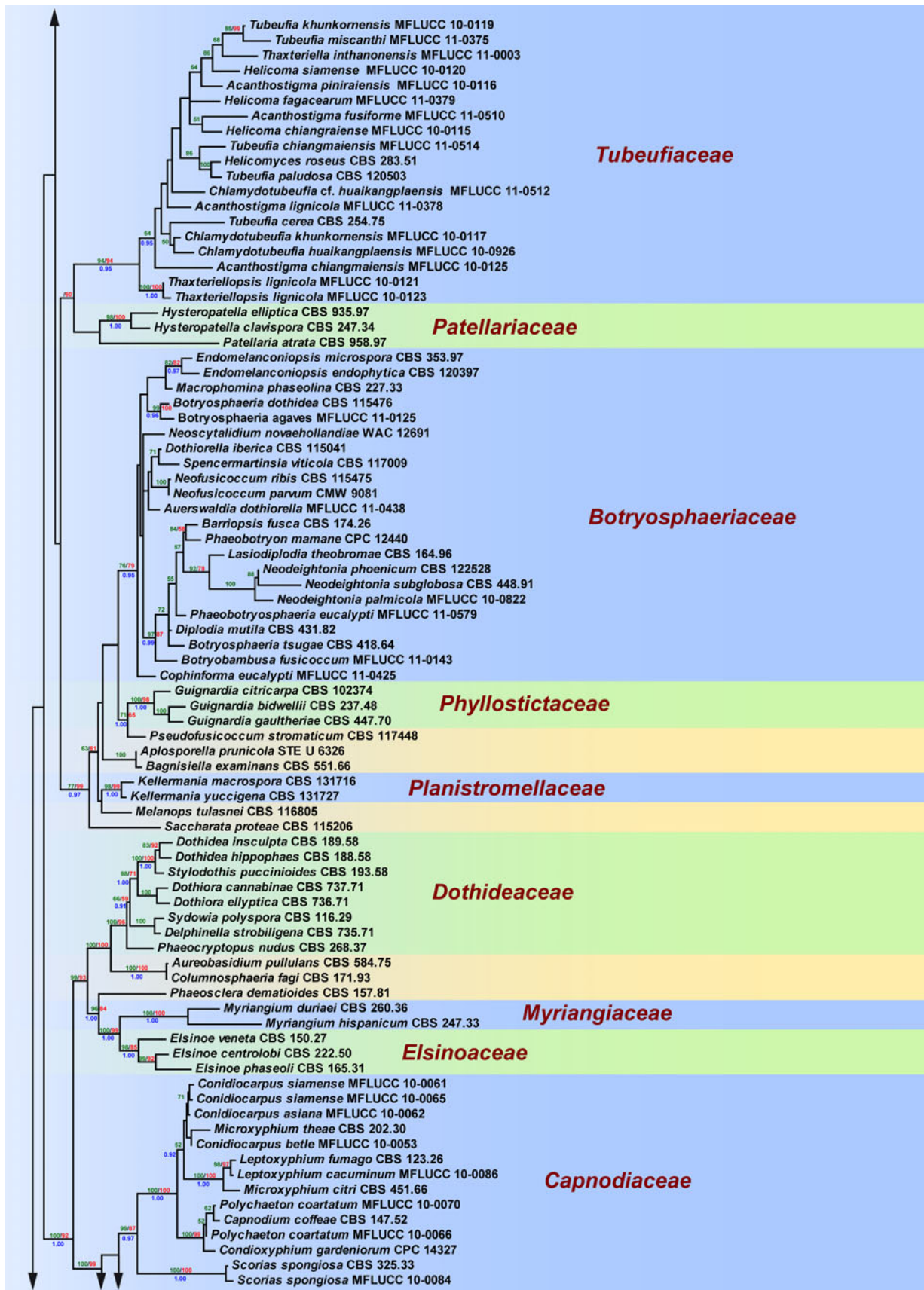


Fig. 2 (continued)

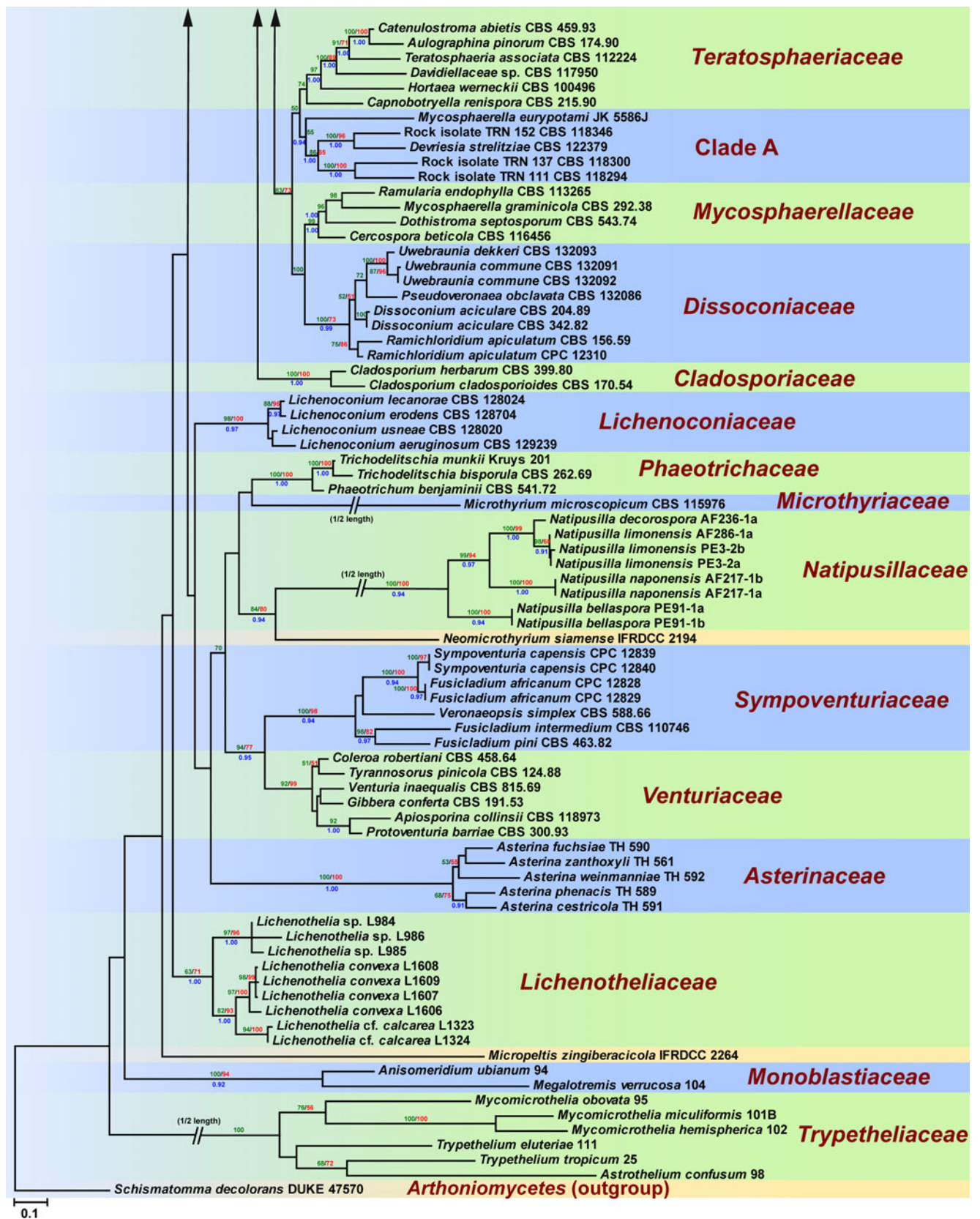


Fig. 2 (continued)

Acrospermaceae, however its placement is not stable in all phylogenetic analyses (Schoch et al. 2009b; Suetrong et al. 2009; Boonmee et al. 2012) and this will require further study. *Licheniconiaceae*, a lichenicolous group of coelomycetous asexual morphs, is introduced as a new family in this paper. *Natipusillaceae*, introduced by Raja et al. (2011) comprises freshwater species with unique characters (e.g. thin-walled, light-coloured, ascomata, subglobose asci and two-celled appendaged ascospores), and forms a distinct lineage (100 % and 100 % BS and 94 % PP) in a clade with *Phaeotrichaceae*, *Microthyriaceae* and *Venturiales*. The poorly studied *Phaeotrichaceae* is a distinct lineage (100 % and 100 % BS and 100 % PP) that clusters in a clade with *Asterinales*, *Microthyriales* and *Venturiales* (Figs. 1 and 2). The *Lichenotheliaceae* are lichenicolous or loosely associated with algae and form a separate clade without any close relatives. Based on their distinct morphological characters and habitat, and phylogenetic analysis (of available sequence data) we therefore introduce seven orders, namely ***Dyfrulomycetales*** K.L. Pang, K.D. Hyde & E.B.G. Jones, ordo novus, ***Licheniconiales*** Diederich, Lawrey & K.D. Hyde, ordo novus, ***Lichenotheliales*** K. Knudsen, Muggia & K.D. Hyde, ordo novus, ***Monoblastiales*** Lücking, M.P. Nelsen & K.D. Hyde, ordo novus, ***Natipusillales***, Raja, Shearer, A.N. Mill. & K.D. Hyde, ordo novus, ***Phaeotrichales*** Ariyawansa, J.K. Liu & K.D. Hyde, ordo novus and ***Strigulales*** Lücking, M.P. Nelsen & K.D. Hyde, ordo novus (Table 1).

Phylogeny of orders of dothideomycetes

Pleosporomycetidae C.L. Schoch et al., *Mycologia* 98(6): 1048 (2007) [2006]

Pleosporomycetidae was introduced as a subclass by Schoch et al. (2006) and included the single order *Pleosporales*. Subsequently, Schoch et al. (2009a) included the two other orders *Mytilinidiales* and *Hysteriales* within this subclass, and suggested that the order *Jahnulales* can be tentatively included within *Pleosporomycetidae*. Our phylogenetic analysis showed similar results, however the newly introduced order *Dyfrulomycetales* and *Strigulales*, and *Acrospermales* clustered together with *Jahnulales*. Because the lack of strong phylogenetic evidence, we only accept *Pleosporales*, *Mytilinidiales* and *Hysteriales* representing the subclass *Pleosporomycetidae*.

Pleosporales

The 23 or 27 families included in *Pleosporales* by Kirk et al. (2008) and Lumbsch and Huhndorf (2010) respectively, were previously grouped based on morphological characters. These families were recently resolved at molecular level, for example Schoch et al. (2006) found reasonable support for 7 to 23 families in a phylogeny generated from four genes.

Table 1 Dothideomycetes orders and included families

Order	Family
<i>Acrospermales</i>	<i>Acrospermaceae</i>
<i>Asterinales</i>	<i>Asterinaceae</i>
	<i>Aulographaceae</i>
	<i>Parmulariaceae</i>
<i>Botryosphaeriales</i>	<i>Botryosphaeriaceae</i>
	<i>Phyllostictaceae</i>
	<i>Planistromellaceae</i>
<i>Capnodiales</i>	<i>Antennulariellaceae</i>
	<i>Capnodiaceae</i>
	<i>Cladosporiaceae</i>
	<i>Coccoideaceae</i>
	<i>Dissoconiaceae</i>
	<i>Metacapnodiaceae</i>
	<i>Mycosphaerellaceae</i>
	<i>Piedriaceae</i>
	<i>Teratosphaeriaceae</i>
<i>Dothideales</i>	<i>Dothideaceae</i>
<i>Dyfrulomycetales</i>	<i>Dyfrulomycetaceae</i>
<i>Hysteriales</i>	<i>Hysteriaceae</i>
<i>Jahnulales</i>	<i>Aliquandostipitaceae</i>
	<i>Manglicolaceae</i>
	<i>Licheniconiaceae</i>
<i>Licheniconiales</i>	<i>Lichenotheliaceae</i>
<i>Lichenotheliales</i>	<i>Micropeltidaceae</i>
<i>Microthyriales</i>	<i>Microthyriaceae</i>
<i>Monoblastiales</i>	<i>Monoblastiaceae</i>
<i>Myriangiiales</i>	<i>Elsinoaceae</i>
	<i>Myriangiaceae</i>
<i>Mytilinidiales</i>	<i>Gloniaceae</i>
	<i>Mytiliniaceae</i>
<i>Natipusillales</i>	<i>Natipusillaceae</i>
<i>Patellariales</i>	<i>Patellariaceae</i>
<i>Phaeotrichales</i>	<i>Phaeotrichaceae</i>
<i>Pleosporales</i>	<i>Aigialaceae</i>
	<i>Anniculicolaceae</i>
	<i>Anteagloniaceae</i>
	<i>Bambusicolaceae</i>
	<i>Biatriosporaceae</i>
	<i>Coniothyriaceae</i>
	<i>Corynesporascaceae</i>
	<i>Cucurbitariaceae</i>
	<i>Delitschiaceae</i>
	<i>Diademaceae</i>
	<i>Didymellaceae</i>
	? <i>Didymosphaeriaceae</i>
	<i>Dothidotthiaceae</i>
	<i>Halojulellaceae</i>
	<i>Halothiaceae</i>
	<i>Hypsostromataceae</i>

Table 1 (continued)

Order	Family
	<i>Lentitheciaceae</i>
	<i>Leptosphaeriaceae</i>
	<i>Lindgomycetaceae</i>
	<i>Lophiostomataceae</i>
	<i>Lophiotremataceae</i>
	<i>Massariaceae</i>
	<i>Massarinaceae</i>
	<i>Melanommataceae</i>
	<i>Montagnulaceae</i>
	<i>Morosphaeriaceae</i>
	<i>Phaeosphaeriaceae</i>
	<i>Platystomaceae</i>
	<i>Pleomassariaceae</i>
	<i>Pleosporaceae</i>
	<i>Roussoellaceae</i>
	<i>Salsuginaceae</i>
	<i>Shiraiaceae</i>
	<i>Sporormiaceae</i>
	<i>Teichosporaceae</i>
	<i>Testudinaceae</i>
	<i>Tetraplophaeriaceae</i>
	<i>Thyridariaceae</i>
	<i>Trematosphaeriaceae</i>
	<i>Zopfiaceae</i>
Strigulales	<i>Strigulaceae</i>
Tubeufiales	<i>Tubeufiaceae</i>
Trypetheliales	<i>Trypetheliaceae</i>
Venturiales	<i>Venturiaceae</i>
	<i>Sympoventuriaceae</i>
<i>Dothideomycetes, families incertae sedis</i>	<i>Argynnaceae</i>
	<i>Ascoporiaceae</i>
	<i>Brefeldiellaceae</i>
	<i>Coccoideaceae</i>
	<i>Cookellaceae</i>
	<i>Dacampiaceae</i>
	<i>Englerulaceae</i>
	<i>Eremomycetaceae</i>
	<i>Euantennariaceae</i>
	<i>Fenestellaceae</i>
	<i>Kirschsteiniiotheliaceae</i>
	<i>Leptopeltidaceae</i>
	<i>Mesnieraceae</i>
	<i>Muyocopronaceae</i>
	<i>Mycoporaceae</i>
	<i>Naetrocymbaceae</i>
	<i>Paranectriellaceae</i>
	<i>Parodiellaceae</i>
	<i>Perisporiopsidaceae</i>
	<i>Polystomellaceae</i>

Table 1 (continued)

Order	Family
	<i>Protoscyphaceae</i>
	<i>Pseudoperisporiaceae</i>
	<i>Schizothyriaceae</i>
	<i>Seynesiopeltidaceae</i>
	<i>Trichothyriaceae</i>
	<i>Vizellaceae</i>

Text in bold indicate family placement is supported by molecular data

Subsequently, Zhang et al. (2012a) accepted 28 families in this order based on both morphology and phylogeny (four genes). Our analysis in Figs. 1 and 2 provide support for 33 family clades, which correspond to the suborders *Pleosporineae* with seven families and *Massarianae* with six families. The other seven newly introduced families are *Anteagloniaceae*, *Bambusicolaceae*, *Biatrisporaceae*, *Halojulellaceae*, *Roussoellaceae*, *Salsugineaceae* and *Thyridariaceae*, belong in *Pleosporales*, while the newly introduced family *Bambusicolaceae* forms a clade within the suborder *Massarianae*. *Lophiostomataceae* comprise two distinct clades *Lophiostoma*-clade (100 %, 100 % BS and 0.97 PP) and *Misturarosphaeria*-clade (100 %, 95 % BS and 0.99 PP) which may represent distinct families, however, we refrain from introducing a new family until more species are sequenced. *Roussoellaceae* (100 %, 100 % BS and 1.00 PP) and *Biatrisporaceae* are newly introduced families in this paper. They form distinct clades (94 % and 79 % BS) which comprise morphologically and phylogenetically distinct families. The *Anteagloniaceae* (100 %, 100 % BS and 0.95 PP) is also introduced as a new family and is related to *Lophiotremataceae*. *Salsuginaceae* (54 %, 52 % BS and 0.99 PP) is also a distinct family introduced in this paper, close to *Aigialaceae* and *Lindgomycetaceae*.

Mytilinidiales

No new data are available for this order which appears to be well-supported (Boehm et al. 2009a, b, c; Schoch et al. 2009b).

Hysteriales

Phylogenetic analyses indicate that the *Hysteriales* are closely related to the *Pleosporales* (Schoch et al. 2006, 2009a, b, c; Boehm et al. 2009a). In addition, the shared morphological characters, such as the similar centrum confirms their close relationship. However, there is still strong branch support for its separation from *Pleosporales* (Boehm et al. 2009a, b).

Luttrell (1955) retained the *Hysteriales* based on the elongated hysteriaceous locule, capable of relatively indeterminate linear growth which is distinct from the strict Pleospora-type centrum, defined as it is by constrained concentric growth. In contrast to the close association between the *Hysteriales* and the *Pleosporales*, the *Mytilinidiales* is a distant clade which is close to *Pleosporales* within the *Pleosporomycetidae* (Boehm et al. 2009a, b).

Acrospermales

The order *Acrospermales* was established by Minter et al. (2007) to accommodate *Acrospermaceae* which the asci and ascospores more than 1,000 μm . The phylogenetic studies of Stenroos et al. (2010) used five-gene analysis to show that this order belongs in Dothideomycetes. In our phylogenetic study, it is close to the other two newly introduced order *Dyfrulomycetales* and *Strigulales*. However, whether a subclass is required to accommodate this order requires further research.

Dyfrulomycetales

The order *Dyfrulomycetales* is introduced in this study.

Strigulales

The order *Strigulales* is introduced in this study.

Jahmulales

The order *Jahmulales* was introduced in Dothideomycetes based on molecular analysis of SSU nrDNA sequence data from *Aliquandostipite*, *Jahmula* and *Patescospora* (Pang et al. 2002). Most taxa of *Aliquandostipitaceae* are freshwater fungi occurring on woody substrata. Suetrong et al. (2011a) introduced a new family *Manglicolaceae* for the marine ascomycete *Manglicola guatemalensis* Kohlm. & E. Kohlm. In this study, taxa of *Aliquandostipitaceae* and *Manglicolaceae* from *Jahmulales* formed a well-supported clade related to the newly introduced orders *Dyfrulomycetales* and *Strigulales*, and *Acrospermales*, and is close to *Hysteriales*, as was indicated in earlier studies (Schoch et al. 2009a, b; Boehm et al. 2009a, Shearer et al. 2009). Although in our trees (Figs. 1 and 2) these orders form a distinct clade, the results are not stable, and therefore we do not treat these orders as members of *Pleosporomycetidae*, nor do we introduce a new subclass.

Tubeufiales

This strongly supported order, with a distinct habitat, being mostly saprobes on decaying lignocellulosic

material with helicosporous asexual morphs is introduced in Boonmee et al. (2013) and is not discussed further here.

Patellariales

The *Patellariales* is a poorly known order with discomycetous ascomata. A more extensive taxon sampling is required to address the diversity in this order and determine its phylogenetic relationships.

Botryosphaerales

The order *Botryosphaerales* was introduced by Schoch et al. (2006), following molecular analysis, and comprised a single family *Botryosphaeriaceae*. Subsequent studies suggested that *Botryosphaerales* most likely should accommodate additional families (Schoch et al. 2009a; Liu et al. 2012a, b; Minnis et al. 2012; Monkai et al. 2013). Based on morphology and phylogeny (four genes), Liu et al. (2012a) presented a classification of *Botryosphaerales*, and two major clades representing *Botryosphaeriaceae* and *Phyllostictaceae* resulted from their analysis. Minnis et al. (2012) also included *Planistromellaceae* as a distinct family, in an unresolved position relative to other genera within *Botryosphaerales*. In our phylogenetic analysis, these three families formed well-supported clades (Figs. 1 and 2). The placement of the monotypic genera *Saccharata* and *Melanops* were unresolved, *Saccharata proteae* being basal in the order and *Melanops tulasnei* clustering together with *Planistromellaceae* with low bootstrap support. Slippers et al. (2013, in press) introduce the *Saccharataceae* and *Melanopsaceae* to accommodate these taxa. A strongly supported clade which included *Aplosporella prunicola* Damm & Crous and a putative strain of *Bagnisiella examinans* was formed between *Planistromellaceae* and *Phyllostictaceae*, for which Slippers et al. (2013, in press) introduce the *Aplosporellaceae*. The asexual genus *Pseudofusicoccum* clustered together with *Phyllostictaceae* with good support, however, the position of the strain was not stable; we therefore do not include this genus in *Phyllostictaceae* in our study. The family *Botryosphaeriaceae*, typified by *Botryosphaeria dothidea* (Moug. ex Fr.) Ces. & De Not and related genera formed a well-supported clade and includes most sexual and asexual genera presently placed in the family. An extensive taxon sampling is required to address the diversity in this order and there is still much research to be carried out with resolution of families and genera, linkage of sexual and asexual morphs and differentiation of cryptic species (Liu et al. 2012a, b).

Dothideomycetidae P.M. Kirk et al., ex C.L. Schoch et al., Mycologia 98(6): 1048 (2007) [2006]

This subclass always comprises *Capnodiales*, *Dothideales* and *Myriangiales* (Schoch et al. 2006, 2009b; Zhang et al. 2009a, b, c; Boehm et al. 2009a, b, c; Figs. 1 and 2)

Dothideales

The order *Dothideales* was introduced by Lindau (1897) to accommodate a single family *Dothideaceae* and the families of the *Dothideales* varied from author to author. The *Dothideales* previously comprised *Dothideaceae*, *Dothioraceae* and *Teratosphaeriaceae* (Lumbsch and Huhndorf 2010). Morphological examination and multi-gene phylogenetic analysis indicate that the *Dothioraceae* should be combined under *Dothideaceae*, while *Aureobasidium*, *Selenophoma*, *Kabatiella* and *Columnosphaeria* may need a new family (Thambugala et al. in prep., Figs. 1 and 2).

Myriangiales

This order comprises *Myriangiaceae* and *Elsinoaceae* which are separated by 100 % BS. Further collections and sequence data of species in this order are needed to establish if these families can be maintained.

Capnodiales

The order *Capnodiales* comprises six clades (Figs. 1 and 2) representing *Capnodiaceae*, *Cladosporiaceae*, *Dissoconiaceae*, *Mycosphaerellaceae* and *Teratosphaeriaceae* plus one unnamed clade comprising mostly rock inhabiting species. The *Teratosphaeriaceae* is recently included (Crous et al. 2009c), while the *Capnodiaceae* has been redefined (Chomnunti et al. 2011). The family *Dissoconiaceae* comprises several asexual genera of plant pathogens and has been studied by Li et al. (2012).

Lichenoconiales

The order *Lichenoconiales* is introduced in this study.

Phaeotrichales

The order *Phaeotrichales* is introduced in this study.

Microthyriales

The *Microthyriales* is a poorly known order with thyrothelial ascomata and it is represented by only a single taxon, *Microthyrium microscopicum* (type species) in our phylogenetic analysis. This result requires additional molecular data.

Natipusillales

The order *Natipusillales* is introduced in this study.

Venturiales

The order *Venturiales* has been detailed by Zhang et al. (2011a) and no new data are available.

Asterinales

The order *Asterinales* is represented by *Asterinaceae* in our phylogenetic analysis. Few molecular studies have been carried out on this group, which mostly focused on morphology. Hofmann et al. (2010) presented the first molecular hypothesis of the *Asterinaceae* within Dothideomycetes based on the LSU and SSU sequences. In our phylogenetic analysis, it is close to *Venturiales* and the newly introduced orders *Natipusillales* and *Phaeotrichales*.

Lichenotheliales

The order *Lichenotheliales* is introduced in this study.

Monoblastiales

The order *Monoblastiales* is introduced in this study.

Trypetheliales

The order *Trypetheliales* was recently introduced by Aptroot et al. (2008) and represents the largest lichen forming clade in Dothideomycetes.

Taxonomy

Acrospermaceae Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 92 (1870) [1869–70], MycoBank: MB 80430

Saprobic, *epiphytic* or *symbiotic* on herbaceous plants. Sexual state: *Ascomata* solitary or in groups, superficial or immersed in stromata, often long, yellowish white to brown, black when dry, club-shaped to conoid, with a short stipe, flattened when dry, swelling when moist, ostiole large. *Peridium* in horizontal section comprising three layers, an outer layer composed of dark brown cells of *textura angularis*, a central layer, composed of pale brown tissue of elongated cells, and an inner layer composed of dense tissue of small, light brown cells. *Hamathecium* of narrow long, pseudoparaphyses or pseudoparaphyses lacking. *Asci* 8-spored, bitunicate, narrowly cylindrical, pedicellate, apically rounded with an ocular chamber. *Ascospores* fasciculate, filiform, hyaline, multi-septate, almost as long as the asci, smooth-walled. Asexual

state: hyphomycetous. *Conidiophores* micronematous, pale brown, septate, branched or unbranched. *Conidiogenous cells* holoblastic, sympodial with denticles, pale brown, smooth-walled. *Conidia* cylindrical, long ellipsoid, pale yellow, 1–3-septate, smooth-walled.

Notes: The family *Acrospermaceae* presently includes two genera *Acrospermum* and *Oomyces* (Lumbsch and Huhndorf 2010). *Acrospermum* has club-shaped, brown, uni-locular ascospores. However, *Oomyces* has conoid, yellowish white, multi-locular stromata and lacks pseudoparaphyses (Eriksson 1981). The asexual states of this family include members of *Dactylaria* and *Gonatophragmium* which are linked to asexual *Acrospermum* (Wijayawardene et al. 2012). However, *Dactylaria* was shown to be polyphyletic by Bussaban et al. (2005) and Seifert et al. (2011) also stated that *Dactylaria* is heterogenous, hence the phylogeny needs clarification. Kirk et al. (2008) mentioned *Gonatophragmium* is an asexual state of *Acrospermum*, but Seifert et al. (2011) did not assign any taxonomic affiliation. Whether *Gonatophragmium* is polyphyletic is not clear. No asexual state has been reported for *Oomyces*. Minter et al. (2007) established the order *Acrospermales* to accommodate this family, and Stenroos et al. (2010) confirmed this unique order belonging to Dothideomycetes by using five-gene.

Type: *Acrospermum* Tode, Fung. mecklenb. sel. (Lüneburg) 1: 8 (1790), MycoBank: MB 54 Fig. 3

Possible synonyms:

Scleroglossum Pers., J. Colorado-Wyoming Acad. Sci.: no. 671 (1820)

Xyloglossum Pers., Traité sur les Champignons Comestibles (Paris): 140,144 (1818)

Saprobic or *epiphytic* on herbaceous plants. Sexual state: *Ascomata* solitary or in groups, superficial, club-shaped to conoid, erect, uni-locular, brown to blackish when dry, with a short stipe or sessile, flattened when dry, swelling when moist, ostiole large, apex rounded. *Peridium* in horizontal section comprising three layers, an outer layer comprising dark brown cells of *textura angularis*, a central thick layer, comprising pale brown tissue of gelatinized hyphae with elongated cells, and an inner layer comprising dense tissue of small, light brown cells. *Hamathecium* of narrow, long, pseudoparaphyses. *Asci* 8-spored, bitunicate, narrowly cylindrical, pedicellate, with an ocular chamber. *Ascospores* fasciculate, filiform, hyaline, multi-septate, almost as long as the asci, smooth-walled. Asexual state: Hyphomycetous. *Conidiophores* micronematous, pale brown, septate, branched or un-branched. *Conidiogenous cells* holoblastic, sympodial with denticles, long cylindrical, pale brown, smooth-walled. *Conidia* cylindrical, long ellipsoid, pale yellow, 1–3-septate, apically rounded, smooth-walled (Webster 1956).

Notes: *Acrospermum* includes 66 species epithets (Index Fungorum 2013). The genus was established by Tode (1790)

and has superficial, club-like ascomata, narrowly cylindrical, bitunicate asci and filiform, multi-septate, hyaline ascospores (Riddle 1920). Eriksson (1981) redescribed the type species *A. compressum* and another similar species *A. graminum*. Molecular data showed that these two species can be clearly separated (Stenroos 2010). Webster (1956) also concluded after studying the asexual morphs in culture.

Type species: *Acrospermum compressum* Tode, Fung. mecklenb. sel. (Lüneburg) 1: 8 (1790), MycoBank: MB 140891

Other genera included

Gonatophragmium Deighton, in Cejp & Deighton, Mycol. Pap. 117: 13 (1969)

Type species: *Gonatophragmium mori* (Sawada) Deighton, in Cejp & Deighton, Mycol. Pap. 117: 13 (1969)

Oomyces Berk. & Broome, Ann. Mag. nat. Hist., Ser. 2 7: 185 (1851)

Type species: *Oomyces carneoalbus* (Lib.) Berk. & Broome, Ann. Mag. Nat. Hist., Ser. 2 7: 185 (1851)

Key to sexual genera of *Acrospermaceae*

1. Fruiting bodies ascomata club-shaped, brown, paraphyses long *Acrospermum*

1. Fruiting bodies stomata conoid, yellowish white, paraphyses lacking *Oomyces*

Aigialaceae Suetrong et al., in Suetrong et al., Stud. Mycol. 64: 166 (2009), MycoBank: MB 515957

Saprobic on submerged wood in mangroves and terrestrial habitats. Sexual state: *Ascomata* scattered or rarely clustered, immersed, erumpent to superficial, black, globose or conical, coriaceous to carbonaceous, ostiolate, with rounded or slit-like ostiole, apapillate. *Peridium* 50–130 μm wide, composed of dark brown thick-walled cells. *Hamathecium* comprising 1.5–2 μm wide, hyaline, anastomosing, trabeculate pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, obclavate to cylindrical, long-pedicellate, with a non-amyloid ocular chamber. *Ascospores* bi-seriate, fusiform, hyaline to brown, septate to muriform, smooth-walled, slightly constricted at the septa, surrounded by an evanescent mucilaginous sheath or with caps at the ends. Asexual state: Unknown.

Notes: The family *Aigialaceae* was introduced by Suetrong et al. (2009) for taxa with carbonaceous ascomata without papilla, trabeculate pseudoparaphyses, cylindrical asci and ascospores with a sheath or gelatinous appendages around the apical cells. Three genera, *Aigialus*, *Ascocratera* and *Rimora*, all marine taxa, were included. These genera were previously referred to *Massarinaceae* (Lumbsch and Huhndorf 2010). Zhang et al. (2012a) commented on the wide range of morphological variation between members of *Aigialaceae*, with taxa sharing very few features in common.



Fig. 3 *AcrospERMUM* cf. *compressum* (Material examined: VANU-ATU, Santo Island, South Santo, on decaying leaves of *Pandanus* sp., 31 October 1996, E.H.C. McKenzie HKU (M) 5005, IFRD 210–003). **a**, **b** Dry black ascomata on host surface. **c** Ascomata with short stipe. **d**

Ascomata with large ostiole. **e** Ascoma in horizontal section. **f**, **g** Three layers of peridium. **h–j** Narrowly cylindrical asci. **k**, **l** Filiform ascospores. Scale bars: **a–d** = 200 μ m, **e–j** = 50 μ m, **h–l** = 10 μ m

Aigialus grandis, the type species of *Aigialaceae* has flattened, brown, muriform ascospores, with mucilage surrounding their apices (Jones et al. 2009a). The asci are cylindrical and the hamathecium comprises narrow anastomosing pseudoparaphyses (trabeculae), while the ascomata are mostly immersed in wood and asymmetrical, forming in the same

plane as the wood fibres and have an apical slit-like opening. This is quite different from the second genus presently included in *Aigialaceae*, *Ascocratera* (Suetrong et al. 2009). This monotypic genus represented by *Ascocratera manglicola* Kohlm., has raised superficial carbonaceous ascomata, lacking a papilla, and 1(–3)-septate hyaline ascospores surrounded

by a mucilaginous sheath (Kohlmeyer 1986). The third genus, shown by molecular data to belong in the family, *Rimora* (= *Lophiostoma mangrovei* Kohlm. & Vittal), is similar to *Ascocratera*, with raised apapillate ascomata and septate hyaline ascospores. Despite these morphological similarities *Ascocratera* and *Rimora* are not congeneric as shown by the sequence data (Fig. 1) (Suetrong et al. 2009; Zhang et al. 2012a).

The introduction of the family *Aigialaceae* is strongly supported (100/100 support) by phylogenetic analyses of five nuclear genes (LSU, SSU, rRNA, RPB2 and TEF1) in *Pleosporales* as shown in Fig. 1. Subsequently two additional genera, from terrestrial habitats, have been included in the family: *Fissuroma* and *Neoastrisphaeriella* (Liu et al. 2011). These two genera form a well-supported subclade in the *Aigialaceae*, and share morphological features with *Ascocratera* and *Rimora*, i.e. carbonaceous apapillate ascomata, trabeculate pseudoparaphyses, cylindrical asci and septate ascospores with a sheath. The genus *Fissuroma* was introduced to accommodate species previously assigned to *Astrisphaeriella* with slit-like ostioles. Further *Astrisphaeriella*, *Lophiostoma* and *Massarina* species should be sequenced to determine their phylogenetic relationships.

The family includes five genera and eleven species, of which three genera with marine/mangrove affinities and two only from terrestrial habitats. The family type, *Aigialus*, and *Fissuroma* are illustrated below.

Type: Aigialus Kohlm. & S. Schatz, Trans. Br. mycol. Soc. 85(4): 699 (1985), MycoBank: MB 6002 Fig. 4

Saprobic on mangrove wood, marine and with a tropical distribution. Sexual state: *Ascomata* gregarious, completely immersed, subglobose, laterally compressed, black, ostiolate, with a slit-like opening, apapillate. *Peridium* coriaceous to carbonaceous, two-layered, outer layer 50–100 μm , composed of elongate cells, inner layer 30–50 μm , of smaller hyaline cells. *Hamathecium* comprising 1.5–2 μm wide, trabeculate pseudoparaphyses, unbranched at the base, anastomosing above the asci, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, long-pedicellate, with a refractive non-amyloid, apical ring. *Ascospores* biserial, ellipsoidal to broadly fusiform, muriform, dark brown except for hyaline to pale brown apical cells, glabrous, with a gelatinous cap or a mucilaginous sheath. Asexual state: Unknown.

Notes: A tropical to subtropical marine Ascomycete genus found on mangrove wood, frequent in occurrence. The genus *Aigialus* was initially classified in the *Melanommatales* (Kohlmeyer and Schatz 1985) sensu Barr (1979a) because of the trabeculate pseudoparaphyses, but it was not assigned to any family in the *Dothideomycetes*. Hawksworth et al. (1995) assigned the genus to *Massariaceae* in the order *Pyrenulales*, based on the possession of a refractive apical

ring in the ascus that is J–. Subsequently, Tam et al. (2003), based on a single gene sequence analysis, referred it to the *Pleosporales*, a proposal accepted by Kirk et al. (2008). *Aigialus* can now be classified with confidence in the *Pleosporales*, family *Aigialaceae* based on a wider taxon sampling (five species) and four gene sequence analysis. Thus the classification of this genus is resolved within a wider study of taxa in the *Dothideomycetes* (Schoch et al. 2009b; Suetrong et al. 2009; Zhang et al. 2012a). Five species are accepted in the genus: *A. grandis*, *A. mangrovei* Borse, *A. parvus* S. Schatz & Kohlm., *A. rhizophorae* Borse and *A. striatispora* K.D. Hyde (Jones et al. 2009a).

Type species: Aigialus grandis Kohlm. & S. Schatz, Trans. Br. mycol. Soc. 85(4): 699 (1985), MycoBank: MB 103973

Other genera included

Ascocratera Kohlm., Can. J. Bot. 64: 3036 (1986)

Type species: Ascocratera manglicola Kohlm., Can. J. Bot. 64: 3036 (1986)

Fissuroma J.K. Liu et al., Fungal Divers. 51: 145 (2011)

Type species: Fissuroma maculans (Rehm) J.K. Liu et al., Fungal Divers. 51: 145 (2011)

Neoastrisphaeriella J.K. Liu et al., Fungal Divers. 51: 148 (2011) MycoBank: MB 563462

Figure 5

Saprobic on woody palm tissue, tropical in distribution. Sexual state: *Ascomata* scattered, usually immersed to semi-immersed beneath host tissue, or erumpent, black, carbonaceous, with a slit-like ostiole. *Peridium* composed of dark brown thick-walled cells. *Hamathecium* comprising 1–1.5 μm wide, anastomosing, trabeculate pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, obclavate to cylindrical, short-pedicellate, with a small ocular chamber. *Ascospores* 2–3-seriate, fusiform, hyaline when young, becoming brown to dark brown, 1-septate, constricted at the septum, spore wall verrucose when mature, surrounded by a mucilaginous sheath. Asexual state: Unknown.

Notes: A monotypic tropical terrestrial ascomycete genus found on palm petioles and forming a sister group (Fig. 1) with four other genera in the *Aigialaceae* (Liu et al. 2011). The genus is characterized by its semi-immersed ascomata with slit-like ostioles, obclavate asci and brown, verrucose ascospores. The genus differs from *Fissuroma* in having smaller obclavate asci and brown verrucose ascospores, while *Fissuroma* has cylindro-clavate asci and hyaline ascospores. Molecular analyses based on a combined dataset of 18S and 28S nrDNA sequences place *Neoastrisphaeriella* in subclade to the genera *Fissuroma*, *Aigialus*, *Rimora* and *Ascocratera*. *Neoastrisphaeriella* shares features with *Astrisphaeriella*, a genus which is basal to *Aigialaceae* in the *Pleosporales* (Schoch et al. 2009b).

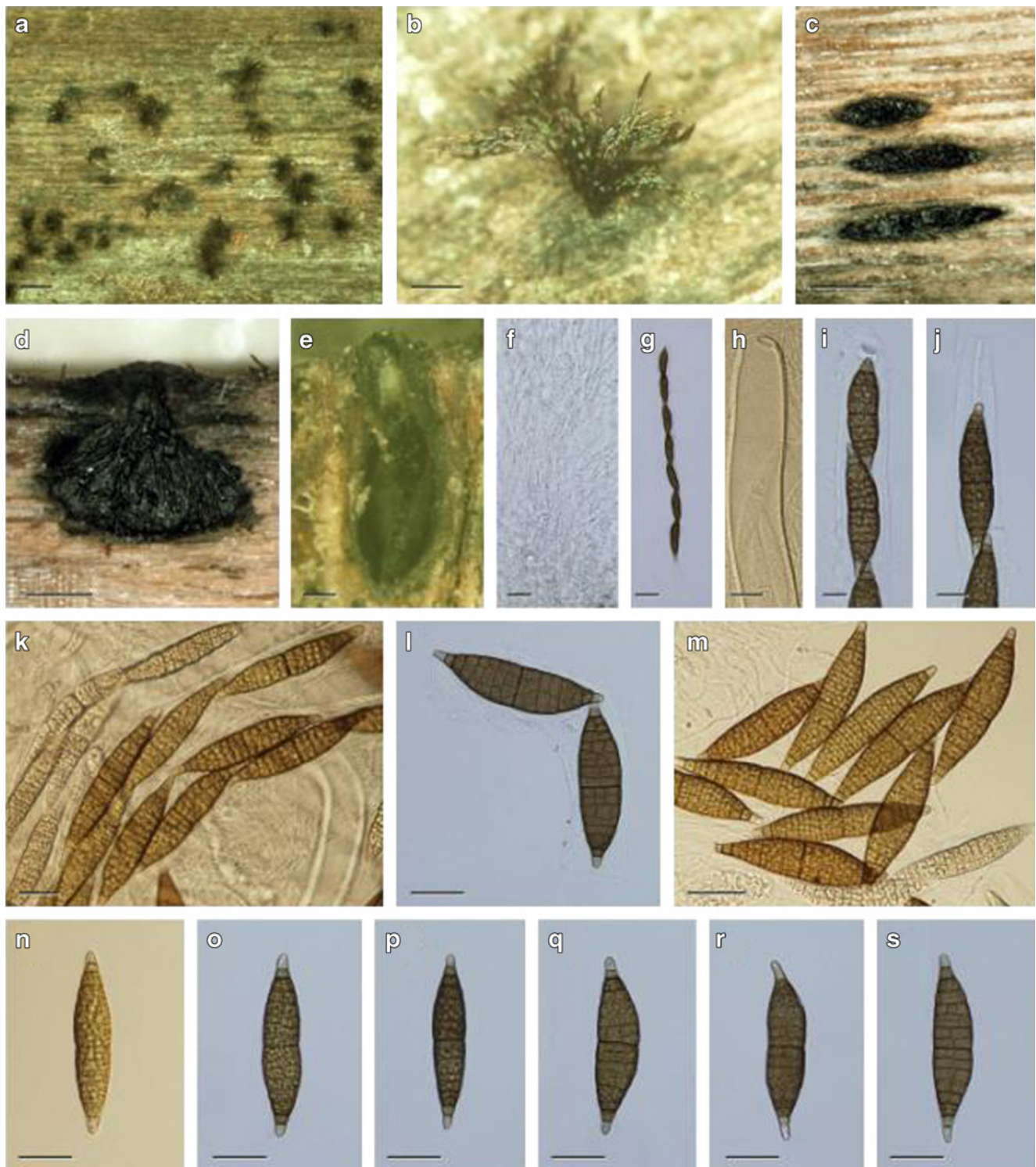


Fig. 4 *Aigialus grandis* (Material examined: THAILAND, Chanthaburi Province, Tha Mai, Khung Kraben Bay Royal Development Study Center, on mangrove wood, 28 June 2008, S Suetrong et al. (BBH 23439 with isolates BCC 32284, 32285, 32286, 32287). **a** Surface view of mature ascomata of *A. grandis* on mangrove wood. **b** Released ascospores from the ostiole. **c** Surface of wood cut to show immersed ascomata with thick-

walled peridium. **d** Longitudinal section through mature ascoma. **e** Sagittal section of ascus. **f** Trabeculate pseudoparaphyses. **g** Cylindrical ascus. **h–j** Ascus with refractive apical ring. Apex of endoascus with some ascospores already released. **k–l** Ascospores in asci. **m–s** Ascospores. Scale bars: **a** = 1 mm, **b–d** = 500 μ m, **e** = 100 μ m, **f**, **k–s** = 25 μ m, **g** = 50 μ m, **h–j** = 15 μ m

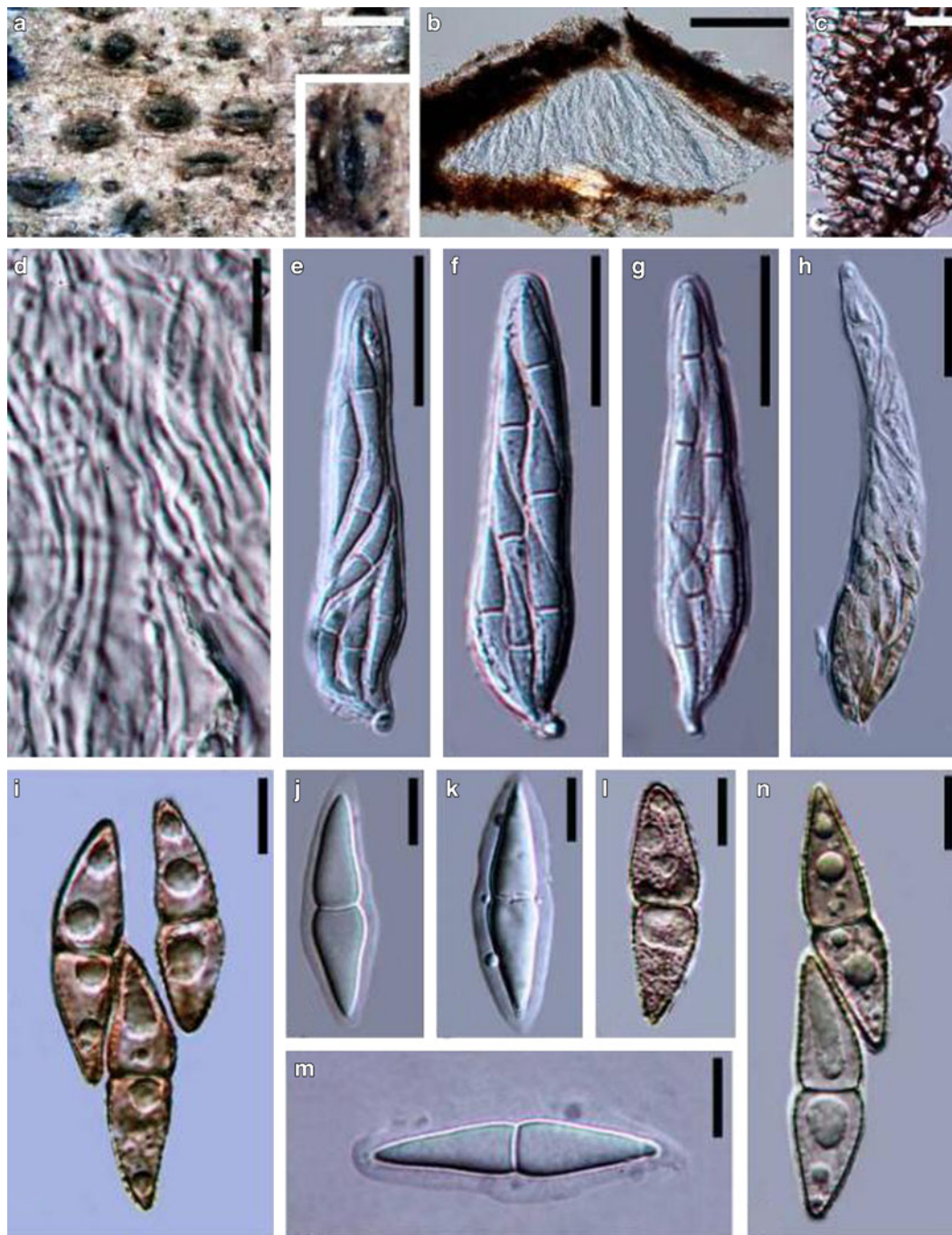


Fig. 5 *Neoastrophaeriella krabiensis* (THAILAND, Krabi Prov., Krabi College of Agriculture and Technology, on petiole of *Metroxylon sagu*, 26 September 2010, J.K. Liu, JKA0050, MFLU11-1151, holotype). **a** Appearance of ascomata on host surface. **b** Section of an ascoma.

c Structure of peridium. **d** Pseudoparaphyses. **e–h** Asci. **i–n** Ascospores. Note the sheath in young ascospores. Scale bars: **a** = 1 mm, **b** = 100 μ m, **c**, **d** = 10 μ m, **e–h** = 30 μ m, **i–n** = 10 μ m

Type species: Neoastrophaeriella krabiensis Jian K. Liu et al., in Liu et al., Fungal Divers. 51(1): 148 (2011), MycoBank: MB 563463

Rimora Kohlm. et al., in Suetrong et al., Stud. Mycol. 64: 166 (2009)

Type species: Rimora mangrovei (Kohlm. & Vittal) Kohlm et al., in Suetrong et al., Stud. Mycol. 64: 166 (2009)

Key to genera of Aigialaceae

1. Ascomata immersed or conical and crater-like, with rounded often papillate ostioles2
1. Ascomata elongate with flat tops, opening with a slit-like ostiole3
2. Ascomata immersed in a stroma, asci with a refractive apical plate in the ectoascus and a refractive ring in endoascus,

- ascospores dark brown, muriform with hyaline to light brown apical cells *Aigialus*
2. Ascomata conical and crater-like, on a black stroma, asci with refractive apical apparatus, ascospores hyaline, 1-septate *Ascocratera*
3. Ascomata forming on black stromatic crust, superficial, asci without apical apparatus, ascospores fusiform, 3-septate *Rimora*
3. Ascomata immersed to semi-immersed, ascospores 1-septate 4
4. Asci cylindro-clavate, ascospores elongate-fusiform, hyaline, smooth *Fissuroma*
4. Asci obclavate, ascospore fusiform, brown to dark brown, verrucose when mature *Neoastrisphaeriella*

Aliquandostipitaceae Inderb., in Inderbitzin et al., Am. J. Bot. 88(1): 54 (2001), MycoBank: MB 82130

Saprobic on submerged or trapped decorticated wood in freshwater streams, peat swamps and marine habitats. Sexual state: *Ascomata* scattered or rarely in small groups, immersed-erumpent or superficial, if superficial often attached to substrate by repent or pendant thick brown hyphal strands, hyaline, pale brown to black, coriaceous, ostiolate, short papillate. *Peridium* variable, 3–7 cell layers thick, comprising *textura globulosa* to *angularis* of very large, light brown to brown, thin-walled, cells. *Hamathecium* comprising 2–7 μm wide, hyaline, septate, sparsely branched, filamentous pseudoparaphyses, anastomosing above the asci. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cylindrical, pedicel absent or very short, with or without an ocular chamber. *Ascospores* bi-seriate to multi-seriate, 1-septate, ellipsoid to fusiform, hyaline to pale brown, guttulate, with or without various types of appendages and/or sheaths. Asexual states: hyphomycetous *Brachiosphaera*, *Xylomyces*. *Conidiophores* reduced or un-branched or sparingly branched, hyaline. *Conidiogenous cells* monoblastic, thallic or sympodial or percurrent, moniloid, hyaline or brown. *Conidia* phragmosporous or staurosporous, with globose central cell, with 4-several, radiating septate arms, hyaline or brown, single or branched or un-branched chains (Seifert et al. 2011) or tetradiate with 4–8 appendages.

Notes: The family *Aliquandostipitaceae* (*Jahnulales*) was introduced by Inderbitzin et al. (2001) for taxa with mycelium five times wider than those of normal ascomycetes. *Ascomata*, borne either on these thick hyphae or on hyphal stalks, are membranous, have a hamathecium of persistent pseudoparaphyses, bitunicate asci and hyaline to pale brown, 1-septate ascospores with or without a sheath or with appendages. Two new species were described, *Aliquandostipite khaoyaiensis* Inderb. and *A. sunyatsenii* Inderb. from wood collected in Thailand and China, respectively, and assigned to the family *Aliquandostipitaceae* based on 18S rDNA data (Inderbitzin et al. 2001). Inderbitzin et al. (2001) were unable

to assign the family to any order, e.g., *Dothideales* or *Pleosporales*. Based primarily on analyses of 18S rDNA sequence data, Pang et al. (2002) subsequently established *Jahnulales* Pang et al. (Dothideomycetes, Ascomycota) for *Aliquandostipitaceae* that was monophyletic and distinct from other clades of bitunicate fungi, such as the *Pleosporales* and *Dothideales*. More recently, based on a review of the *Jahnulales*, Suetrong et al. (2011a) accepted the family *Aliquandostipitaceae* and included *Aliquandostipite*, *Jahnula* and *Megalohypha* and the asexual genera *Brachiosphaera*, *Speiropsis* and *Xylomyces* (Fig. 1). Molecular data also supported the inclusion of *Manglicola* in *Jahnulales*, but its familial placement was distinct from *Aliquandostipitaceae* (Suetrong et al. 2011a). Within the *Jahnulales*, generic limits are not well-delineated, and *Jahnula* was shown to be polyphyletic in a multi-gene study by Suetrong et al. (2011a). *Jahnula* species grouped in three clades, Clade I, *Jahnula* sensu stricto, included *J. aquatica* (Plöttner & Kirschst.) Kirschst., (type species), *J. granulosa* K.D. Hyde & S.W. Wong, *J. rostrata* Raja & Shearer, *J. potamophila* K.D. Hyde & S.W. Wong and *Megalohypha aqua-dulces* A. Ferrer & hearer. Clade II comprised seven *Jahnula* species, while *J. australiensis* K.D. Hyde, *Brachiosphaera tropicalis* Nawawi & Descals and *Speiropsis pedatospora* Tubaki group in Clade III. Species grouping in Clade II (*Jahnula* sensu lato) may comprise more than one genus, for example, *J. bipolaris* (K.D. Hyde) K.D. Hyde, *J. seychellensis* K.D. Hyde & S.W. Wong and *J. sunyatsenii* (Inderb.) L.L. Pang & E.B.G. Jones all have ascospores with apical gelatinous pads and could be referred to the genus *Ascagilis* (Hyde 1992b). However, no taxonomical changes were proposed for *Jahnula* species not grouping in the *Jahnula* sensu stricto clade, until further species are collected and sequenced (Suetrong et al. 2011a). All *Aliquandostipite* species have well developed ascospore sheaths, with the exception of *A. siamensis*. (Sivichai & E.B.G. Joes J.) Campbell et al. 2007).

Type: *Aliquandostipite* Inderb., Am. J. Bot. 88(1): 54 (2001), MycoBank: MB 483979

Figure 6

Saprobic on woody material in freshwater habitats. Sexual state: *Ascomata* immersed to superficial, globose to subglobose, hyaline, becoming brown to dark brown, coriaceous, papillate, developing on hyphal strands, or long or short hyphal stalks, often dimorphic. *Peridium* membranous, 1–4-layered, of cells of *textura angularis* to *globosa*. *Hamathecium* consisting of septate, hyaline, sparsely branched, hypha-like pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cymbiform, short-pedicellate, with thickened apical region, and ocular chamber. *Ascospores* bi-seriate to multi-seriate, oval to fusiform, 1-septate, constricted at the septum, hyaline becoming pale-brown with well-developed sheath, smooth-walled. Asexual state: Unknown.

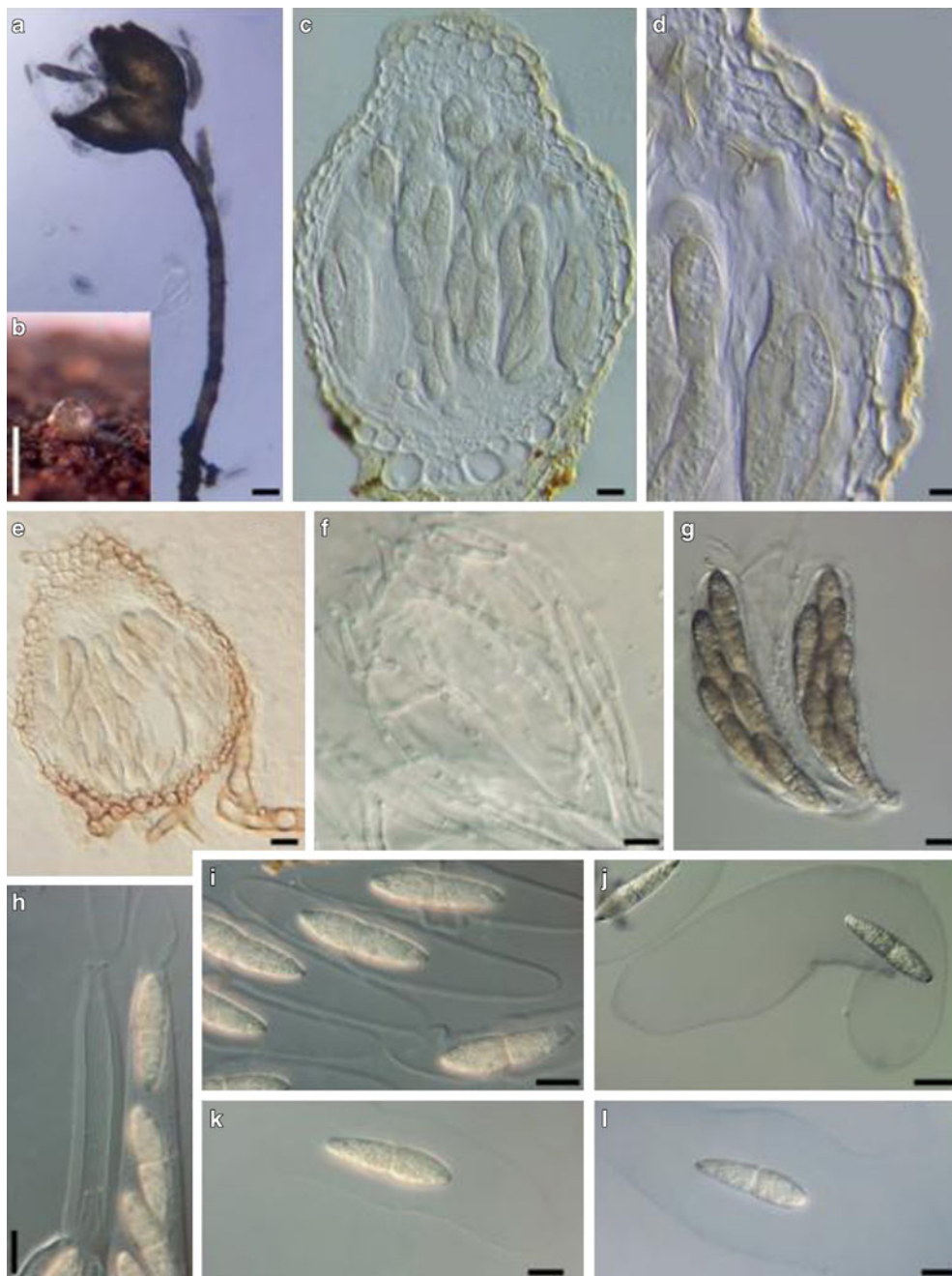


Fig. 6 *Aliquandostipite khaoyaiensis* (Material examined: **a, c, d, g, j**=ILLS A441-1; A441-2; **b, e, f, h, i, k, l**=F89-1). **a** Ascoma with a stalk. **b** Sessile ascoma on wood. **c** Longitudinal section of ascoma. **d** Peridial wall. **e** Longitudinal section of sessile ascoma. **f**

Pseudoparaphyses. **g** Asci. **h** Dehiscent asci. **i-l** Ascospores with gelatinous sheath; stained with Indian ink in figure **j** and in aqueous nigrosin in figure **l**. Scale bars: **a**=40 μ m; **b**=500 μ m; **c-l**=20 μ m

Type species: Aliquandostipite khaoyaiensis Inderb., Am. J. Bot. 88(1): 54 (2001)

Notes: The genus was introduced by Inderbitzin et al. (2001) for two freshwater lignicolous ascomycetes collected in Thailand and China: *A. khaoyaiensis* Inderb., and *A. sunyatsenii* Inderb. (= *Jahnula sunyatsenii*). The genus is characterized by sessile and/or stalked ascomata (dimorphic), wide mycelium, bitunicate asci, the presence of pseudoparaphyses and 1-septate ascospores with or without a

sheath (Inderbitzin et al. 2001). Currently, five species are accepted in the genus: *A. crystallinus* Raja et al., *A. khaoyaiensis*, *A. minuta* Raja & Shearer, *A. separans* (Abdel-Wahab & El Sharouney) J. Campb. et al., and *A. siamensis* (Suetrong et al. 2011a). Shearer et al. (2009) showed that four *Aliquandostipite* species form a well-supported monophyletic group. Strains of *A. khaoyaiensis* and *A. siamensis* group together, with ascospore measurements in the same range. They differ in that the sheath in *A.*

khaoyaiensis balloons out, while in *A. siamensis* it is narrow and ascospores in the latter are dimorphic: small and brown ($33\text{--}45 \times 10\text{--}13 \mu\text{m}$) or large ($58\text{--}73 \times 15\text{--}25 \mu\text{m}$) and hyaline to pale brown (Pang et al. 2002). Both types of ascospores, small and brown and large and hyaline to pale brown were observed in the same ascus in *A. siamensis* (Campbell et al. 2007). A combined analysis (SSU rDNA, LSU rDNA) of taxa in the *Jahnulales* showed that *Aliquandostipite* species formed a well-supported clade (Campbell et al. 2007), which is also supported in a larger study by Suetrong et al. (2011a).

Other genera included

Brachiosphaera Nawawi, in Descals et al., Trans. Br. mycol. Soc. 67: 213 (1976)

Type species: Brachiosphaera jamaicensis (J.L. Crane & Dumont) Nawawi, in Descals et al., Trans. Br. mycol. Soc. 67: 216 (1976)

Jahnula Kirschst., Ann. mycol. 34(3): 196 (1936), MycoBank MB 2526 Fig. 7

Saprobic on soft, decorticated woody material, predominately a freshwater genus, but also marine. Sexual state: *Ascomata* immersed, semi-immersed or erumpent, sessile or attached to a long stalk, globose to subglobose, black, coriaceous, ostiolate, short-papillate, easily detached from the substratum, solitary or gregarious. *Peridium* comprising 3–5 layers of relatively large, thin-walled, brown or hyaline, angular cells, arranged in a *textura angularis*. *Hamathecium* comprising 2–4 μm wide, hypha-like, filamentous, septate pseudoparaphyses, unbranched between the asci, branching and anastomosing above the asci. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical or obclavate, pedicellate, thick-walled, with an ocular chamber and faint ring. *Ascospores* 1–3-seriate, ellipsoid-fusiform, pale brown to dark brown, 1-septate, constricted at the septum, guttulate, smooth or verruculose, some with mucilaginous appendages, pads or sheaths. Asexual state: Unknown.

Notes: Jahnula comprises saprobic species on woody material (generally decorticated wood) in streams, with the exception of *J. appendiculata* Pinruan et al. found on the trunk of the palm *Licuala longecalycata* in a peat swamp (Pinruan et al. 2002) and *Xylomyces chlamydosporus* Goos et al. and *X. rhizophorae* Kohlm. & Volkm.-Kohlm. which occur in marine habitats (Kohlmeyer and Volkmann-Kohlmeyer 1998a, b). In a molecular study by Campbell et al. (2007) the genus would appear to be paraphyletic, while in a the combined analysis of SSU and LSU rDNA, *Jahnula* species grouped into three clades, hence Suetrong et al. (2011a) concluded that it is polyphyletic. Suetrong et al. (2011a) refrained from introducing new genera for species assigned to Clades II and III, and suggested further taxon sampling in order to resolve the phylogenetic relationships and delineation of *Jahnula* species. *Xylomyces* is therefore regarded as a

synonym of *Jahnula* based on the one name rule (McNeill et al. 2011). Likewise, *Brachiosphaera tropicalis* and *Speiropsis pedatospora* group with *Jahnula* species in Clade III, but these cannot be synonymized until the phylogenetic relationships of *Jahnula* species are resolved further. Moreover, the genera *Brachiosphaera*, *Speiropsis* and *Xylomyces* have been shown to be polyphyletic and not all belong in the *Jahnulales*.

Type species: Jahnula aquatica (Plöttner & Kirschst.) Kirschst., Ann. Mycol. 34: 196 (1936), MycoBank: MB 257114

The species illustrated in Fig. 2 is *Jahnula seychellensis* from material collected in Thailand, S. Sivichai (SS1536.2) on submerged wood.

Megalohypha A. Ferrer & Shearer, in Ferrer et al., Mycologia 99: 458 (2007)

Type species: Megalohypha aqua-dulces A. Ferrer & Shearer, in Ferrer et al., Mycologia 99(3): 456 (2007)

Speiropsis Tubaki, J. Hattori bot Lab. 20: 171 (1958)

Type species: Speiropsis pedatospora Tubaki, J. Hattori Bot Lab. 20: 171 (1958)

Xylomyces Goos et al., Mycologia 69(2): 282 (1977)

Type species: Xylomyces chlamydosporus Goos et al. [as ‘chlamydosporis’], Mycologia 69(2): 282 (1977)

Key to sexual genera of Aliquandostipitaceae

3. Ascospores with a thin or broad gelatinous sheath, lacking appendages *Aliquandostipite*
3. Ascospores with apical caps, appendages, or lacking such structures 3
4. Ascospores with longitudinal sulcate striations, lacking appendages or a gelatinous sheath *Megalohypha*
4. Ascospores lacking longitudinal sulcate striations, with or without apical pads *Jahnula*

Key to asexual genera of Aliquandostipitaceae

1. Asexual morph hypha-like, filamentous, septate, conidia and conidiophores absent 2
1. Sexual morphs 3
2. Conidiophores and conidia lacking, chlamydosporous intercalary, multi-septate *Xylomyces*
2. Conidia tetra- or poly-radial with 4–8 appendages (arms) *Brachiosphaera*

Amniculicolaceae Y. Zhang et al., in Zhang et al., Stud. Mycol. 64: 95 (2009), MycoBank: MB 515469

Saprobic in freshwater habitats. Sexual state: *Ascomata* solitary, scattered or in small groups, erumpent, immersed or nearly superficial, globose, subglobose to lenticular, with rough black surface, usually staining the woody substrate shades of purple, ostiolate. *Ostirole* with elongate apex and ostiolar canal filled with hyaline cells. *Peridium* two-layered, outer layer of small heavily pigmented thick-walled cells of

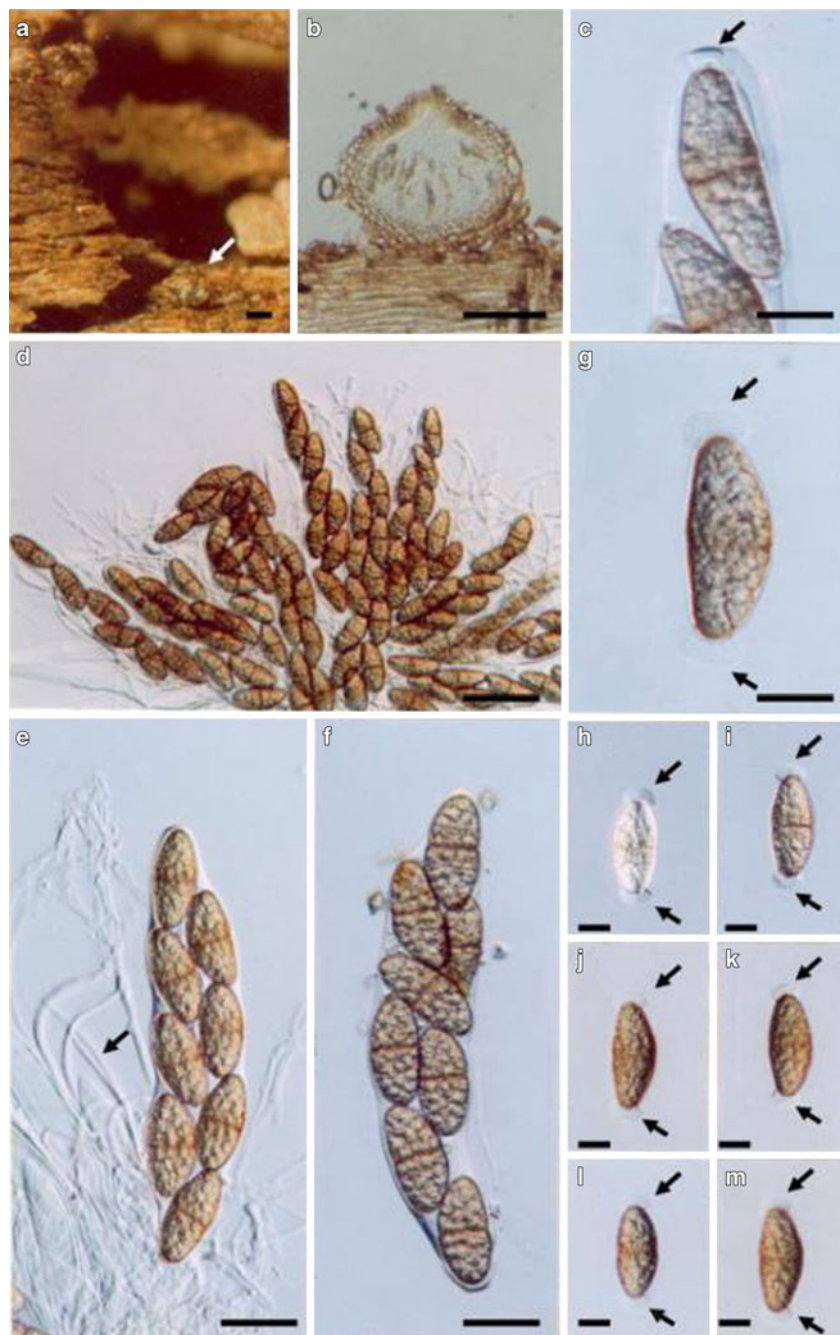


Fig. 7 *Jahnula seychellensis* (Material examined: THAILAND, Nakorn Ratchassima Province, Tad Tha Phu, KhaoYaiNational Park, on *Sindora siamensis* in freshwater, 2 May 2001, S. Sivichai, BCC SS1536.2). **a** Ascomata with short stalk (arrowed). **b** Section of ascoma. **c** Ascus apical

pore (arrowed). **d** Asci and pseudoparaphyses. **e, f** Asci. **g–m** Ascospores with bipolar pads (arrowed). Scale bars: **a, b** = 100 μm , **c, g** = 10 μm , **d** = 40 μm , **e–f** = 20 μm , **h–m** = 10 μm

textura angularis, inner layer of hyaline thin-walled cells *textura angularis*. *Hamathecium* comprising numerous, hyaline, septate, narrow, trabeculate, pseudoparaphyses, embedded in a gel matrix. *Asci* 8-spored, bitunicate, fissionitic, long cylindrical to clavate, short-pedicellate, apically truncate, with an ocular chamber. *Ascospores* 1–2-seriate, fusiform or narrowly fusiform, hyaline, reddish-brown or pale, one to

multi-septate, or muriform, constricted at the median septum, generally surrounded by an irregular, hyaline, gelatinous sheath. Asexual states: closely related to *Anguillospora longissima* (Sacc. & P. Syd.) Ingold, *Spirosphaera cupreorufescens* Voglmayr and *Repetophragma ontariense* (Matsush.) W.P. Wu (Zhang et al. 2008b, 2012a; Shearer et al. 2009).

Notes: The family *Amniculicolaceae* was formally introduced by Zhang et al. (2009b) to accommodate various fresh water fungi collected from Europe in the order *Pleosporales* and accepted by Shearer et al. (2009). The family is characterized by ascomata with a rough black surface, usually staining the woody substrate purple, trabeculate pseudoparaphyses and short-pedicellate asci bearing hyaline, reddish-brown or pale, 1-multi-septate or muriform ascospores, generally with hyaline gelatinous sheath (Zhang et al. 2009b). Currently the family comprises three genera, *Amniculicola* (type), *Murispora* and *Neomassariosphaeria* that form a well supported clade in the *Pleosporales* (Zhang et al. 2009a). Seifert et al. (2011) also confirmed the placement of *Anguillospora* in *Amniculicolaceae* but the placement of *Repetophragma* and *Spirosphaera* is confused as it has some lineages in *Sordariomycetes*. Hence we conclude that *Amniculicolaceae* have *Anguillospora*, “*Spirosphaera*”-like and “*Repetophragma*”-like hyphomycetous asexual morphs.

Type: *Amniculicola* Y. Zhang & K.D. Hyde, Mycol. Res. 112(10): 1189 (2008), MycoBank: MB 511328 Fig. 8

Saprobic on wood in freshwater habitats. Sexual state: *Ascomata* scattered, solitary, or in small groups, initially immersed, becoming erumpent, to nearly superficial, with basal wall remaining immersed in host tissue, laterally flattened and base not easy to remove from the host, with black wall, rough and often consisting of remnants of the host, usually staining the woody substrate purple, globose to subglobose, broadly or narrowly conical, ostiolate. *Ostiole* slit-like, with apex well-differentiated into two tuberculate flared lips, long, ostiolar canal filled with periphyses. *Peridium* thick laterally and at the apex, thinner at the base, coriaceous, two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Hamathecium* comprising numerous, hyaline, septate, narrow, trabeculate, branched pseudoparaphyses, anastomosing between and above the asci, and embedded in gel matrix. *Asci* 8-spored, bitunicate, fissitunicate, long cylindrical to narrowly fusiform, with a short, twisted, narrow, furcate pedicel, truncate to rounded at the apex with a minute ocular chamber, inconspicuous when observed in water. *Ascospores* obliquely uni-seriate, partially overlapping, or bi-seriate, broadly fusiform to fusiform with broadly to narrowly rounded ends, hyaline, 1-septate, deeply constricted at the median septum, smooth-walled, containing four refractive oil globules, surrounded by an irregular, hyaline, gelatinous sheath, observed only when mounted in Indian ink. Asexual state: Unknown.

Notes: Based on ascomata with slit-like ostioles, thin, branching and anastomosing pseudoparaphyses and 1-septate, deeply constricted, fusiform ascospores, with a wide gelatinous sheath, Zhang et al. (2008b) introduced this new freshwater genus and referred it to the *Pleosporales* (Zhang et al. 2009a, 2012a). Initially treated as monotypic, the genus

Amniculicola is represented by *A. lignicola* Y. Zhang ter & K.D. Hyde, but subsequently two other species were described, *A. immersa* Y. Zhang ter. et al. and *A. parva* Y. Zhang ter. et al. (Zhang et al. 2009b). All three *Amniculicola* species were collected from submerged wood in freshwater (Zhang et al. 2008b, 2009b). Shearer et al. (2009) showed that *Amniculicola parva*, *Anguillospora longissima* and *Amniculicola immersa* formed well-supported sister group to *Amniculicola lignicola*, with *Massariosphaeria typhicola* (P. Karst.) Leuchtm. (mistakenly designated as *Semimassariosphaeria typhicola* in Shearer et al. 2009) in a sister clade. In a four gene analysis *Repetophragma ontariense*, *A. immersa*, *A. parva* formed a sister group to *Massariosphaeria* (current name *Neomassariosphaeria*) *typhicola* and *M. grandispora* (Sacc.) Leuchtm. in a well-supported clade (Zhang et al. 2012a). However, the type species *A. lignicola* was not included in their analysis. The sexual state of *Anguillospora longissima*, has been reported as an undescribed species of ‘*Massarina*’ (Willoughby and Archer 1973; Webster 1992), which possesses superficial ascomata with a dark peridium, cylindrical, 8-spored asci and fusiform 1-septate ascospores, characters compatible with the morphological characters similar to *Amniculicola lignicola*. Therefore the sexual state of *Anguillospora longissima* may be *Amniculicola parva*, or a new species of *Amniculicola*, however this cannot currently be resolved as no asexual state has been reported for *Amniculicola lignicola*.

Type species: *Amniculicola lignicola* Y. Zhang ter & K.D. Hyde, Mycol. Res. 112(10): 1189 (2008), MycoBank MB 511330

Other genera included

Murispora Y. Zhang bis et al., in Zhang et al., Stud. Mycol. 64: 95 (2009)

Type species: *Murispora rubicunda* (Niessl) Y. Zhang ter et al., in Zhang et al., Stud. Mycol. 64: 96 (2009)

Neomassariosphaeria Y. Zhang bis et al., in Zhang et al., Stud. Mycol. 64: 96 (2009)

Type species: *Neomassariosphaeria typhicola* (P. Karst.) Y. Zhang ter et al., in Zhang, et al., Stud. Mycol. 64: 96 (2009)

Key to genera of *Amniculicolaceae*

1. Ascospores two-celled *Amniculicola*
1. Ascospores with more than two septa 2
2. Ascospores muriform, pale or reddish-brown *Murispora*
2. Ascospores with trans-septa only, hyaline to reddish-brown *Neomassariosphaeria*

Anteaglioniaceae K.D. Hyde, J.K. Liu & A. Mapook, **fam. nov.** MycoBank: MB 804658

Saprobic on dead wood. Sexual state: *Ascomata* hysterothecial, superficial or sunken in substrate, oval to

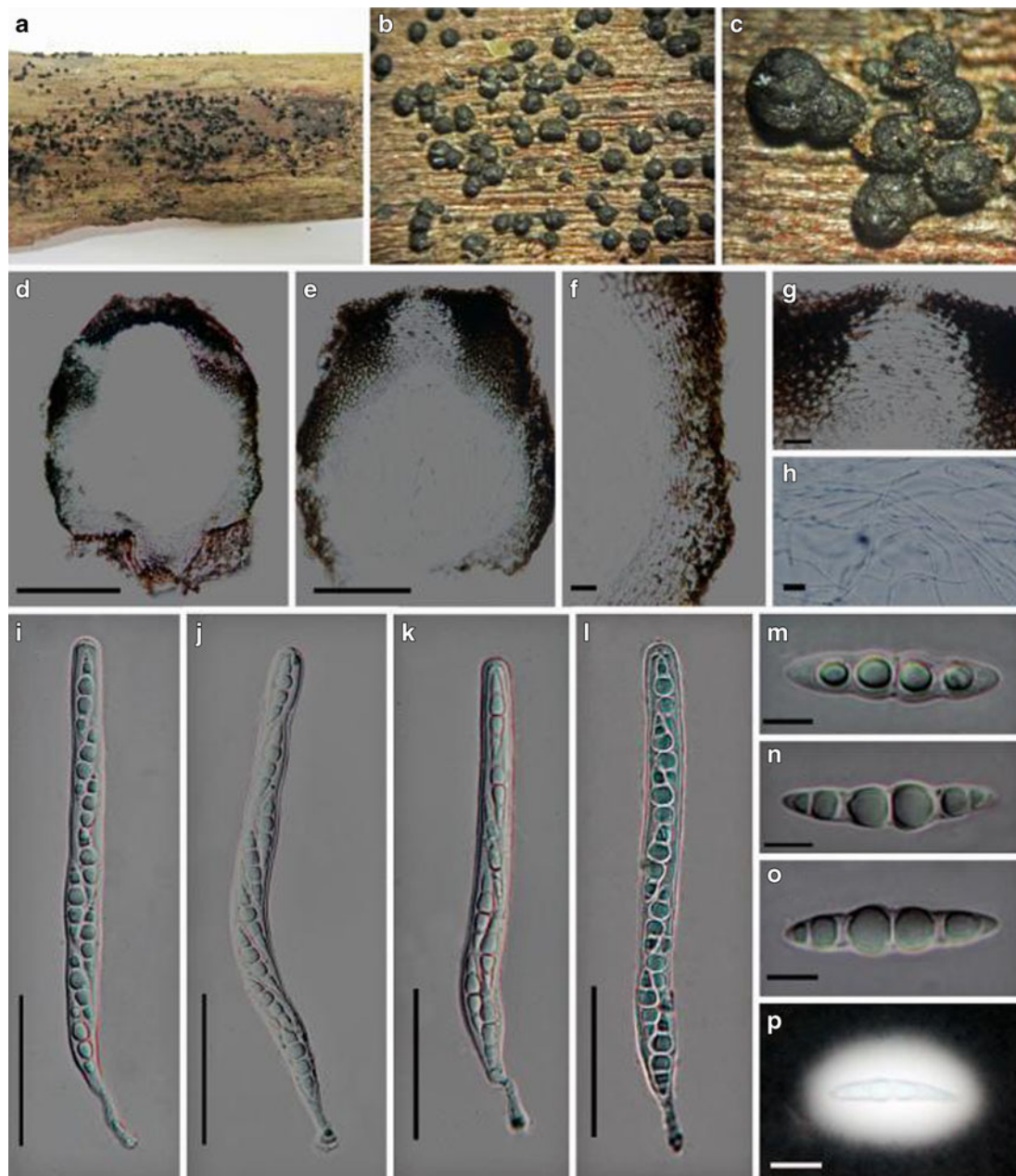


Fig. 8 *Amniculicola lignicola* (Material examined: FRANCE, Rimont, Ruisseau de Peyrau on driftwood of *Alnus glutinosa*, 23 July 2006, J. Fournier, HKU (M) 17515, **holotype**). **a, b** Placement of the ascomata on host surface. **c** Close up of ascomata with slit like opening. **d, e** Section of ascoma (TS) with purple basal consisting of remnants of the host. **f** Close up of the peridium. **g** Slot-like ostiole, apex well-differentiated into two

tuberculate flared lips. **h** Septate, long, hyaline, anastomosing and branched pseudoparaphyses placing between and above the asci. **i-l** Eight-spored asci with short, furcate pedicel. **m-o** Hyaline ascospores, with deeply constricted median septa. **p** Ascospores surrounded by an irregular hyaline gelatinous sheath in Indian ink. Scale bars: **d–e** = 150 μm , **f** = 25 μm , **g** = 40 μm , **h** = 5 μm , **i–l** = 50 μm , **m–p** = 10 μm

elongate, or globose to subglobose, black, carbonaceous, straight or curved, rarely branched, without subiculum. *Ostiole* central, slit-like. *Peridium* thick, dark brown, comprising a single stratum of dark brown cells of *textura epidermoidea*. *Hamathecium* comprising 1.4–1.5 μm wide, cylindrical to filiform pseudoparaphyses in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, elongate cylindrical-clavate, straight or slightly curved, short-pedicellate, apically rounded, with an ocular chamber. *Ascospores*

uniseriate, 2-celled, very small, ellipsoidal, hyaline, 1-septate, constricted at septa, widest at the middle and tapering towards the narrow ends, straight, smooth-walled. Asexual state: Unknown.

Typus: *Anteaglonium* Mugambi & Huhndorf

Notes: Although the ascomata of *Anteaglonium* are hysteriothecial and characteristic of *Hysteriaceae*, the genus was shown to cluster as a distinct lineage in *Pleosporales* (Mugambi and Huhndorf 2009a, b) showing a parallel evolution

of hysterothecial ascomata in *Dothideomycetes*. A similar topology was shown in the study of Schoch et al. (2009a), Zhang et al. (2012a), Mugambi and Huhndorf (2009b) and is confirmed in our analysis (Figs. 1 and 2). We therefore introduce a new family to accommodate this distinct lineage. *Anteaglonium* comprises four species in Index Fungorum (2013).

Type: Anteaglonium Mugambi & Huhndorf, Syst. Biodiv. 7(4): 460 (2009) Fig. 9

Type species: Anteaglonium abbreviatum (Schwein.) Mugambi & Huhndorf, Syst. Biodiv. 7(4): 460 (2009)

≡ *Hysterium abbreviatum* Schwein., Trans. Am. phil. Soc., Ser. 2 4(2): no. 2094 (1832)

Antennulariaceae Woron., Anns mycol. 23 (1/2): 178 (1925), MycoBank: MB 80461

Foliar epiphytes as sooty moulds living on insect exudates. *Subiculum* dark brown to black, effuse, densely velutinous, somewhat dense or velvety, forming on the surface of leaves and twigs. *Hyphae* deeply pigmented at the margin, cylindrical to moniliform, or regular, septate hyphae with smooth or roughened walls. Erect hyphae dark, broad and irregularly anastomosing in a network, forming a brown to black, dense or scant covering. Sexual state: *Ascomata* developing from repeated divisions of hyphae, brown to dark brown, subglobose, obovoid to broadly ellipsoidal, or ovoid, sessile, or with a robust stalk, with or without appendages, ostiolate at maturity, arising from terminal or intercalary cells on aerial hyphae. *Peridium* thin-walled, pseudoparenchymatous. *Asci* 8-spored, bitunicate, fissitunicate, small, pyriform to ellipsoidal, or clavate. *Ascospores* minute, not numerous, irregularly

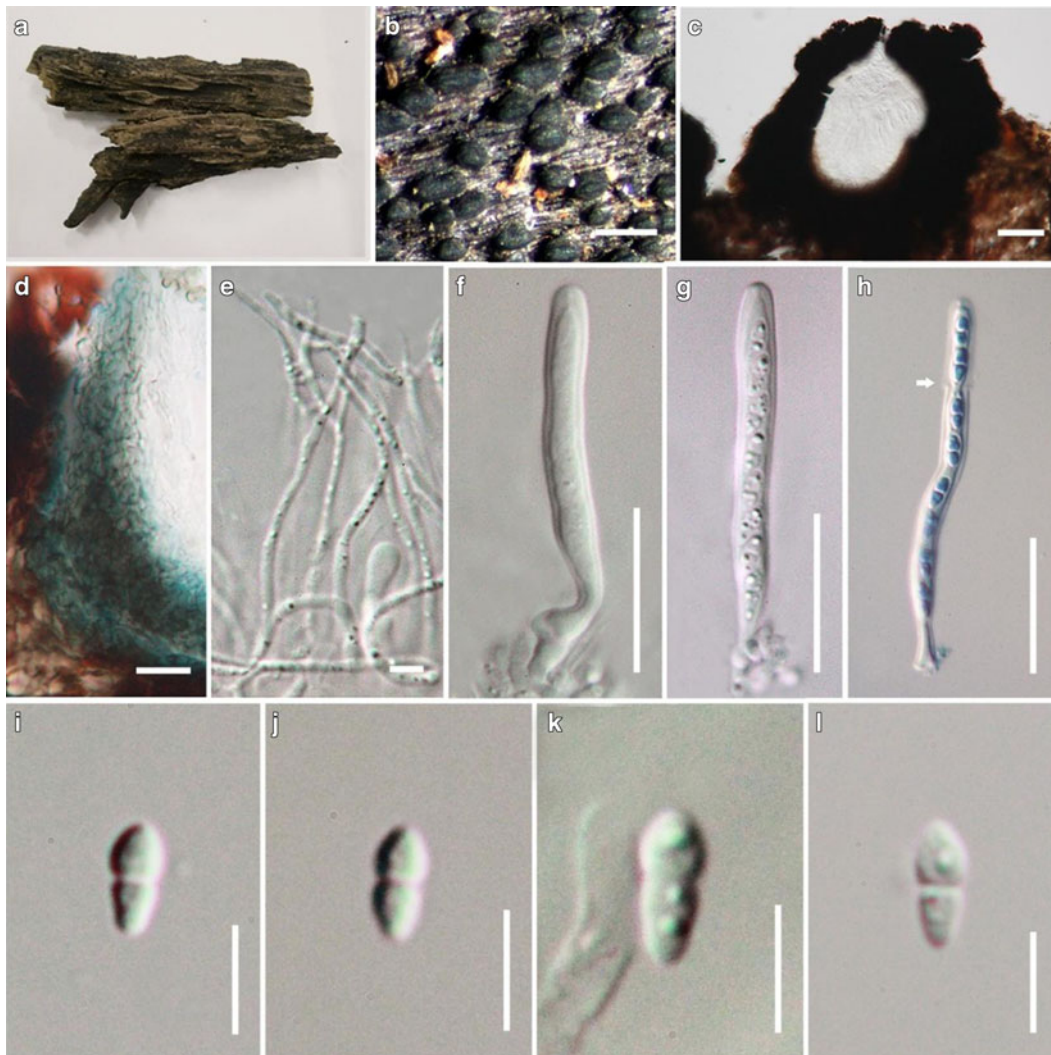


Fig. 9 *Anteaglonium abbreviatum* (Material examined: USA, Tennessee, Sevier County, Great Smoky Mountains National Park, Cherokee Orchard, vic. of Gatlinburg, Trillium trail, 35° 40' 30.88" W, 780 m elev., on wood, branch, on ground, 1" diam., A.N. Miller et al., 12 July 2004, ANM 37). **a** Herbarium specimen. **b** Ascomata on host surface. **c**

Section through ascoma. **d** Peridium. **e** Pseudoparaphyses. **f-h** Immature and mature asci. Note fissitunicate ascus and stained by lactophenol cotton blue (see in **h**). **i-l** Ascospores. Scale bars: **b** = 500 μ m, **c** = 50 μ m, **f-h** = 20 μ m, **d** = 10, **i-l** = 5 μ m

arranged, ovoid, more or less oblong, hyaline, 1–3-septate, slightly constricted at the septum, with the upper half slightly shorter and broader than the lower one, rounded at both ends. Asexual state: coelomycetous or hyphomycetous (see under notes).

Notes: *Antennulariaceae*, a family of sooty moulds, was described by Woronichin (1925) in *Capnodiales*, including six genera with 27 species (Kirk et al. 2008), while Lumbsch and Huhndorf (2010) listed only two genera. Species in the family have a widespread distribution, and are found in warm temperate to tropical locations, where they grow as black sooty molds on plants (Cannon and Kirk 2007). The asexual states of *Antennulariaceae* have been recorded as pycnidial (*Antennariella*, Batista and Ciferri 1963) and hyphomycetous (*Capnodendron*, Hughes 1976, 2000). In *Antennariella* pycnidia are reported to be small and dark brown, with a smooth or roughened pseudoparenchymatous wall, subglobose to obovoid, terminal on a short stalk or intercalary, somewhat lateral on conidiophores, with a short neck and ostioles at maturity. Conidiogenous cells are rare and not reported by Hughes (2000). Conidia are minute, hyaline, more or less ellipsoidal and 1-celled (Hughes 1976). In *Capnodendron* hyphae are dark brown, cylindrical or irregular, septate, smooth or roughened. *Conidiophores* are scattered, or gregarious, and velutinous, straight or irregularly bent, barely different from aerial hyphae, arising as upright branches of repent hyphae or as modified upturned ends of hyphae and very variable in length, brown to dark brown, more or less cylindrical, smooth to coarsely roughened, with lateral branches terminating in a characteristic conidiogenous cell (Hughes 1976, 2000). The terminal conidiogenous cell is very characteristic and more or less ovoid with a flat terminal scar left by the fallen conidium, sessile. *Conidia* are brown to dark brown, somewhat pale brown to brown, holoblastic, narrowly clavate to ellipsoidal or fusiform, straight or curved or irregularly curved, slightly constricted at the septa, smooth or coarsely roughened, sometimes with longitudinal striations, gently or abruptly tapered at the base to a flattened or denticulate scar, rounded at the apex or scarred at both ends of conidia in chains. Conidia and conidiophores can anastomose with each other; the asexual state has been found attached to ascostromata, with flexuous hyphal appendages in *Antennulariella* (Hughes 1976, 2000).

Woronichin (1925) referred this family along with *Capnodiaceae* and *Coccodiniaceae* to *Capnodiales*. *Antennulariaceae* may differ from these two families in having completely closed ascomata with irregular hyphae and in its conidial states. Woronichin (1925) mentions that the *Antennulariaceae* were the most representative family in the order, the two families (*Capnodiaceae* and *Coccodiniaceae*) with ostiolate ascomata, being the most advanced. Hughes (1976) however, reported that the ascomata of *Antennulariella* are ostiolate at maturity. Woronichin (1926)

added *Achaetobotrys* as a second genus in *Antennulariaceae* with two species, both referred to *Limacinia* by Barr (1961) and to *Euantennaria* by Hughes (1974). Hughes (2003) introduced the hyphomycetous sooty mould genus, *Capnofrasera* from New Zealand, Chile, Venezuela, Brazil, Canada and USA in the *Antennulariaceae*, and compared the genus with *Tomenticola*, *Paratomenticola*, *Sporidesmiopsis* and *Capnodendron*. The family needs a detailed study of both sexual and asexual states to establish the relationships among the various genera. We tentatively include all names mentioned in *Antennulariaceae* pending further studies.

Type: *Antennulariella* Woron., Trudy Byuro Prikl. Bot. 8(6): 771 (1915), MycoBank: MB 221 Fig. 10

Foliar epiphytes as sooty moulds living on insect exudates. *Mycelium* brown to dark brown, thin to dense, cylindrical, irregular, septate, slightly constricted at the septa, smooth-walled. Sexual state: *Ascomata* developing from repeated divisions of hyphae, dark brown, sessile, with a pseudoparenchymatous wall, subglobose to globose, with a robust stalk, with long, cylindrical, hyphal appendages, wide at the base, tapering to the apex, ostiolate at maturity, terminally or laterally on hyphae. *Peridium* thin-walled, cells brown to pale brown, of *textura angularis*. *Hamathecium* paraphysate. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, clavate to ellipsoidal. *Ascospores* overlapping, hyaline, 1-septate, with the upper cell slightly shorter and broader than the lower one, rounded end at both apices. Asexual state: coelomycetous, *Antennariella* pycnidial, terminal on long stalk, or lateral or intercalary, dark brown with pseudoparenchymatous walls, subglobose to ovoid, with ostioles. *Conidia* ellipsoidal, hyaline, one-celled; hyphomycetous asexual state, *Capnodendron* Hughes, mycelium superficial, scattered to dense, pale brown to dark brown, smooth-walled, cylindrical, branched, upright hyphae, straight or branched, septate, long, tapering to the apex. Some upright hyphae and their branches may become conidiogenous cells. *Conidia* in simple chains, subglobose, or ellipsoidal to cylindrical, brown to dark brown, with or without septa, slightly constricted at the septa, various lengths in multi-septate conidia, with a rounded or slight scar at one or both ends.

Notes: *Antennulariella* was introduced by Woronichin (1915) and now includes five species (Kirk et al. 2008, Index Fungorum 2013). Hughes (1976) has seen many collections which have characteristics similar to those of the type species as illustrated by Woronichin (1915). Phylogenetic estimates of *Capnodiaceae* and distribution of characters and classifications using character compatibility analysis show that *Antennulariella* and *Acrogenotheca* form one group; this group produces ascospores which have only one septum at maturity in the ascus, the spore dispersal strategy incorporates delayed states of hyphal initial germination and growth so that septation and pigmentation develop in steps, usually outside the ascus (Reynolds 1986).



Fig. 10 *Antennulariella fuliginosa* (Material examined: RUSSIA, Sochi, Kraevskij Mountain, on living leaf of *Ilex*, 14 May 1913, Woronichin, **holotype**). **a** Herbarium specimen. **b–d, h** Hypha with ascomata. **e, f** Ascomata with long cylindrical appendage. **g** Hyphae. **i**

Vertical section through ascoma. **j** Ascoma with ostiole. **k** Ascoma with a robust stalk. **l** Asci and ascospores (redrawn from Woronichin, 1915). Scale bars: **b–d** = 50 μm , **e, f, h, i, k** = 20 μm , **g, j** = 10 μm

Antennulariella batistae S Hughes (2000) was described as a new species with a hyphomycetous synanamorph *Capnodendron trichomericola*, which is the type of the genus *Capnodendron*. We therefore synonymize *Capnodendron* under *Antennulariella* above. *Antennulariella batistae* is a sooty mold which occurs alongside *Metacapnodium moniliforme* (L.R. Fraser) S. Hughes (Fraser) Hughes (1981), *Euantennaria mucronata* (Mont.) S Hughes (1974) and *Trichopelthea asiatica* Batista et al. (Hughes 1965) and has been reported on more than 80 hosts, including ferns, conifers, monocotyledons and dicotyledons. *Capnodendron trichomericola* (Cif., Bat. & Nascim.) S. Hughes is also a synonym of *Antennulariella batistae*.

Antennulariella unedonis (Maire & Sacc.) Bat. & Cif., is regarded as a synonym of *Capnodium* = *Polychaeton* (*Capnodiaceae*), while *Microxiphium footii* var. *ciliolatum* Sacc. is also listed as a synonym of *Capnodium* (= *Polychaeton*) (Index Fungorum 2013). Hughes (2000) lists *Capnodendron* and *Antennulariella* as synanamorphs of

Achaetobotrys batistae while Hughes (1976) links *Achaetobotrys* with *Antennulariella*. *Antennulariella concinnata* (Fraser) S Hughes (1976) is neotypified, illustrated and described by Hughes (2007) who also mentions that *Heteroconium* is a synanamorph. It is therefore synonymized above. There is, however, considerable confusion in such linkages, as many different sooty mold species may occur on a single host. Linkage by association alone is not good enough evidence and in future studies individual spores should be isolated and subjected to sequence analysis to establish which sexual and asexual states are the same biological species.

Type species: Antennulariella fuliginosa Woron., Trudy Byuro Prikl. Bot. 8: 769–807 (1915), MycoBank: MB 224166

Other genera included

Achaetobotrys Bat. & Cif., Saccardo 2: 49 (1963)

Type species: Achaetobotrys affinis (L.R. Fraser) Bat. & Cif., Saccardo 2: 49 (1963)

Capnofrasera S. Hughes, N.Z. J Bot. 41(1): 139 (2003)

Type species: Capnofrasera dendryphioides S. Hughes, N.Z. J Bot. 41(1): 141 (2003)

Key to sexual genera of *Antennulariaceae*

1. Ascstromata subglobose to globose, with hyphal appendages *Antennulariella*

1. Ascstromata obovoid to broadly ellipsoidal, lacking hyphal appendages *Achaetobotrys*

Argynnaceae Shearer & J.L. Crane, Trans. Br. mycol. Soc. 75(2): 193 (1980), MycoBank: MB 80470

Saprobic on plant stems or wood and in fresh water and terrestrial habitats. Sexual state: *Ascomata* apothecial or perithecial, solitary, superficial to slightly immersed, discal, dark brown to black, coriaceous, non-ostiolate, lacking a stipe. *Excipulum* thick, ectal excipulum composed of brown to dark brown tissues mixed with host cells, medullary excipulum composed of hyaline cells of *textura porrecta*. *Hymenium* composed of wide, septate, branching, hyaline pseudoparaphyses. *Epithecium* lacking. *Asci* 8-spored, bitunicate, fissitunicate, clavate, globose to subglobose, pedicellate, thick-walled, lacking an ocular chamber, exposed or not. *Ascospores* 2–3-seriate, or multi-seriate, papilionaceous to broadly reniform, 1-septate, light brown, orange to light orange brown, smooth-walled, bi- to multi-guttulate, with a dark band at the septum. Asexual states: Unknown.

Notes: The family *Argynnaceae* is characterized by taxa with apothecia and perithecia and papilionaceous, 1-septate, ascospores (Shearer and Crane 1980). *Argynna* has superficial, discal apothecia, with light brown ascospores, with a dark band at the septum (Shearer and Crane 1980). *Lepidopterella* has superficial to slightly immersed, globose to subglobose ascomata, and papilionaceous to broadly reniform, brown to orange-brown ascospores (Shearer and Crane 1980; Raja and Shearer 2008). *Lepidopterella* is therefore quite dissimilar to *Argynna*, however, *Lepidopterella* is included in this family because of the butterfly-shaped ascospores. Lumbsch and Huhndorf (2010) also include *Argynna* and *Lepidopterella* in *Argynnaceae* and we retain both genera in the family until molecular data become available. Shearer and Crane (1980) misinterpreted the asci of this family as being unitunicate when they introduced this family. However, our studies on herbarium material of *Argynna polyhedron* (Schwein.) and Morgan also indicate that this species has bitunicate asci.

Type: Argynna Morgan, J. Cincinnati Soc. Nat. Hist. 18: 41 (1895), MycoBank: MB 306

Figure 11

Saprobic on plant stems of maize and in terrestrial habitats. Sexual state: *Mycelium* branched, septate, finely roughened, yellowish-brown, growing around apothecium. *Apothecia* thin, solitary, superficial, discal, dark brown to black, non-ostiolate, with flat apex. *Excipulum* thick, formed on the host

surface, lacking side layers, basal layer thin, ectal excipulum composed of brown to dark brown tissues, mixed with host cells, medullary excipulum composed of hyaline cells of *textura porrecta*. *Hymenium* composed of wide, septate, branching, hyaline pseudoparaphyses. *Epithecium* lacking. *Asci* 8-spored, bitunicate, clavate, pedicellate, thick-walled, lacking an evident ocular chamber. *Ascospores* 2–3-seriate, multi-seriate, papilionaceous, 1-septate, light brown, smooth-walled, with a dark band at the septum. Asexual states: Unknown.

Notes: *Argynna* includes one species according to Shearer and Crane (1980). This genus is characterized by solitary, superficial apothecia and 1-septate papilionaceous, light brown, smooth-walled ascospores with a dark band at the septum. The genus *Argynna* is similar to members of the discomycetes based on the apothecium-like fruiting bodies.

Type species: Argynna polyhedron (Schwein.) Morgan [as ‘polyedron’], J. Cincinnati Soc. Nat. Hist. 18: 41 (1895), MycoBank: MB 140004

≡ *Physarum polyhedron* Schwein. [as ‘polyaedron’], Trans. Am. phil. Soc., Ser. 2 4(2): 257 (1832)

Other genus included

Lepidopterella Shearer & J.L. Crane, Trans. Br. mycol. Soc. 75(2): 194 (1980)

Type species: Lepidopterella palustris Shearer & J.L. Crane, Trans. Br. mycol. Soc. 75(2): 194 (1980)

Key to genera of *Argynnaceae*

1. *Asci* clavate, ascospores light brown, with a dark band at the septum *Argynna*

1. *Asci* globose to subglobose, ascospores brown to orange brown, without a dark band at the septum *Lepidopterella*

Arthopyreniaceae Walt. Watson, New Phytol. 28: 107 (1929), MycoBank: MB 80473

Non-lichenized on bark in terrestrial, temperate forest habitats. *Thallus* reduced and ecorticate, whitish or indistinct. Sexual state: *Ascomata* scattered, prominent, brown-black, hemisphaerical, carbonaceous, ostiolate, ostiole round. *Involucrellum* not distinctly separated from excipulum, dark brown to carbonized. *Excipulum* dense, proso- to paraplectenchymatous in thin sections, brown. *Hamathecium* comprising 0.5–0.7 μm wide, densely packed paraphysoids connected to both the base and the top of the centrum, hyaline, straight to irregularly bent, branched and anastomosing. *Asci* forming in locules between the paraphysoids, 8-spored, bitunicate, fissitunicate, broadly clavate, short-pedicellate, with rather broad, non-amyloid ocular chamber. *Ascospores* irregularly arranged to bi-seriate, oblong with the proximal end slightly tapering, hyaline, (1–3)-septate, with thin eusepta and rectangular lumina, smooth-walled, not or very slightly constricted at the septa, the upper cells often slightly larger

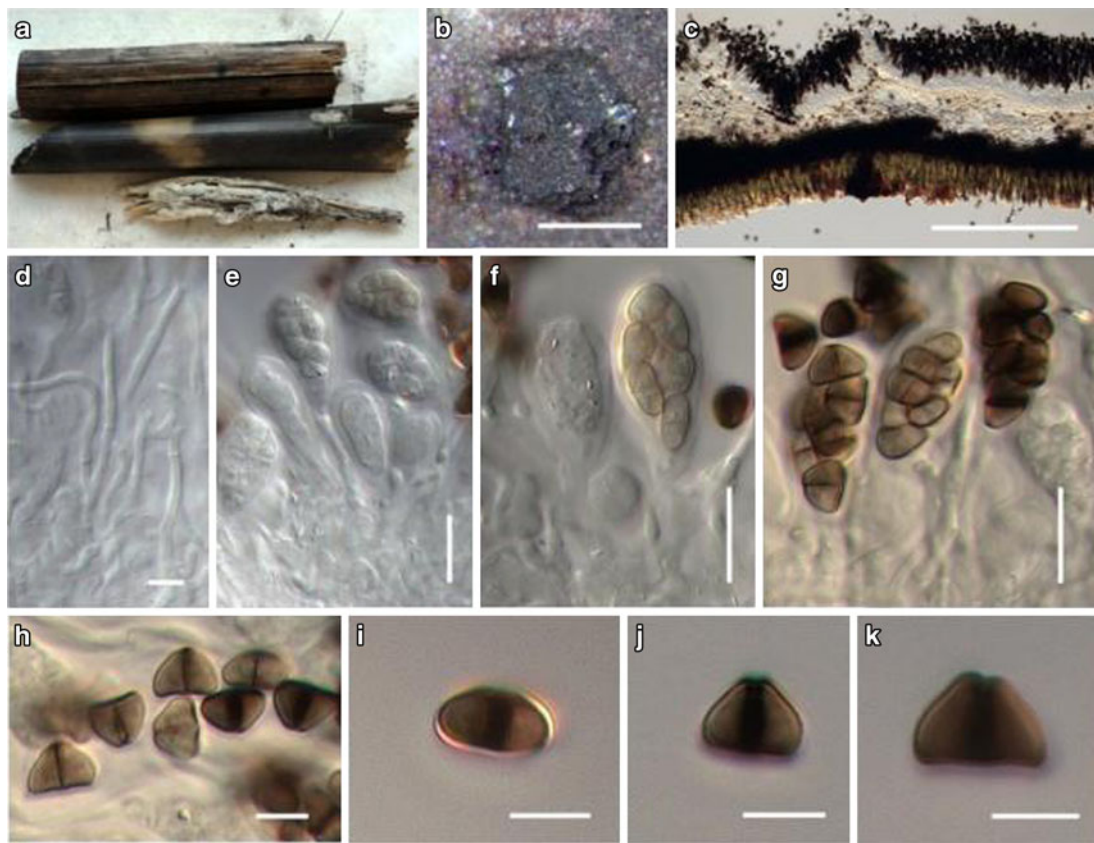


Fig. 11 *Argynna polyhedron* (Material examined: USA, Missouri, Big Spring, on stalks of *Zea mays*, 15 April 1939, G.W. Martin (3922), BPI 618534). **a** Herbarium material. **b** Black ascoma on host surface. **c** Section through ascoma and peridium. **d** Septate and branched

pseudoparaphyses. **e–g** Immature and mature asci. **h–k** Papilionaceous ascospores, with a dark band at the septum. Scale bars: **b** = 500 μm , **c** = 200 μm , **d** = 5 μm , **e–g** = 10 μm , **h–k** = 5 μm

than the lower cells. Asexual state: *Pycnidia* erumpent to prominent, visible as brown-black dots. *Conidia* acrogenous, either macro- or microconidia; macroconidia non-septate, bacillar, hyaline, 10–13 \times 2–2.5 μm ; microconidia non-septate, acicular, hyaline, 7–14 \times 0.8–1 μm . *Chemistry*: Unidentified perithecial wall pigment reacting K⁺ green.

Notes: The family *Arthopyreniaceae* was originally established by Watson (1929) to include a large number of presumably lichenized fungi with perithecioid ascomata: *Acrocordia*, *Athrismidium*, *Arthopyrenia*, *Bottaria*, *Celothelium*, *Laurera*, *Leptorhaphis*, *Microthelia*, *Microtheliopsis*, *Polyblastiopsis*, *Pseudosagedia*, *Raciborskiella*, and *Tomasellia*. Watson (1929) united this amalgam of genera as a result of their shared trentepohlioid photobiont and branched, anastomosing paraphyses; however, Watson's (1929) concept of *Arthopyreniaceae* included taxa now assigned to three different classes, at least six different orders, and eight different families (Harris 1975, 1995; Aptroot et al. 2008; Nelsen et al. 2009, 2011b). Thus, *Acrocordia* forms part of *Monoblastiaceae* (*Dothideomycetes*) and *Microthelia* is a synonym of *Anisomeridium* in the same family; *Athrismidium* is a synonym of *Tomasellia* which is currently classified in *Naetrocymbaceae* (*Dothideomycetes*), as well as

Leptorhaphis; *Bottaria* is a synonym of *Mycoporum* in *Mycoporaceae* (*Dothideomycetes*); *Celothelium* belongs in *Celotheliaceae* (*Chaetothyriomycetidae*: *Pyrenulales*) and *Microtheliopsis* in *Microtheliopsidaceae* in the same subclass (*Chaetothyriomycetidae*: *Chaetothyriales*); *Laurera* is a synonym of *Astrothelium* in *Trypetheliaceae* (*Dothideomycetes*: *Trypetheliales*); *Polyblastiopsis* is a synonym of *Julella* (*Dothideomycetes*); *Pseudosagedia* belongs in *Porinaceae* (*Lecanoromycetes*: *Ostropales*); and *Raciborskiella* is a synonym of *Strigula* in *Strigulaceae* (*Dothideomycetes*).

Overall, Watson's (1929) definition of *Arthopyreniaceae* encompassed several lichenized and some non-lichenized lineages currently classified in *Dothideomycetes* but unrelated to each other (Nelsen et al. 2009, 2011b). The family circumscription was eventually refined, but at the same time, some authors subsumed *Arthopyreniaceae* under *Mycoporaceae* (Riedl 1961; von Arx and Müller 1975) or *Pleosporaceae* (Poelt 1974; Harris 1975). The family was later reinstated by Barr (1979a), but Eriksson (1981) considered it a synonym of *Xanthopyreniaceae*; this stems from the author's observations on *Arthopyrenia rhyponota* (Ach.) A. Massal., a species now included in *Naetrocymbe* (Harris 1995).

Following a broad revision of *Arthopyrenia* sensu lato (Harris 1975), *Arthopyreniaceae* was redefined to include only the genera *Arthopyrenia*, *Julella*, and *Mycomicrothelia*, distinguished from each other by their ascospore septation and pigmentation (Harris 1995). According to Harris (1995), the main characters uniting these genera are clypeate ascomata (i.e. with distinct involucrellum), presence of cellular pseudoparaphyses (i.e. developing from the top of the centrum; see Eriksson 1981), and fissitunicate asci with an ocular chamber. While two of these characters are rather universal among many perithecial fungi, the type of interascal hyphae actually varies within *Arthopyrenia* sensu Harris (1975, 1995), with different types found in the *Arthopyrenia cerasi* (Schrad.) A. Massal. group, *A. cinchonae* (Ach.) Müll. Arg. and relatives, and *A. salicis* A. Massal. (Foucard 1992). *Arthopyrenia cerasi* and the closely related *A. lapponina* Anzi, which represent *Arthopyrenia* sensu stricto (see below), have persistent, very densely arranged paraphysoids that develop from both the top and the base of the centrum and form locules for the asci (see below); these two species also share the K+ sordid-green perithecial wall. In *A. cinchonae* and relatives, the persistent physes develop from the bottom of the centrum, as correctly stated by Harris (1995), and taper towards the top. These species phylogenetically nest in *Trypetheliaceae* and are unrelated to *Arthopyrenia* sensu stricto (Nelsen et al. 2009, 2011a). The hitherto sequenced species of *Julella* and *Mycomicrothelia*, with a similar type of paraphyses, also cluster in *Trypetheliaceae* (Nelsen et al. 2009, 2011a). Finally, *Arthopyrenia salicis* forms periphysoids, whereas the paraphyses become gelatinous at maturity; it is the only other species of *Arthopyrenia* sensu lato sequenced besides the tropical group centered around *A. cinchonae* and occupies a position within *Pleosporales* (Nelsen et al. 2009, 2011a).

Thus, with *Arthopyreniaceae* and *Arthopyrenia* itself being obviously heterogeneous, the exact definition of the family hinges on its typification. Massalongo (1852) included 13 species in its original circumscription of *Arthopyrenia*, but did not define a holotype. Of these, five belong in *Naetrocymbaceae*, three in *Monoblastiaceae*, and one in *Porinaceae*, while a further one is a non-lichenized member of *Dothideomycetes* in the genus *Cyrtidula*. The remaining three species are *A. analepta* (Ach.) A. Massal., *A. cerasi*, and *A. salicis*, all temperate in their distribution. *Arthopyrenia* was first lectotypified by Fink (1910) with *A. analepta*; however, this name is illegitimate since Acharius (1798) cited *Verrucaria olivacea* Pers., a synonym of *Porina borrieri* (Trevis.) D. Hawks. & P. James, as synonym of *Lichen analeptus* Ach., and hence, as already noted by Riedl (1961), *A. analepta* is automatically typified by the type of *Verrucaria olivacea* and thus a synonym of *P. borrieri*. Riedl (1961) selected a different lectotype, *A. rhyponia*, which, however, is a member of *Naetrocymbe* (Harris 1995) and

would make *Arthopyrenia* the valid name for that group of species. The problem was eventually solved by Jørgensen's request (following suggestion by Harris) to reconsider the proposal of Hawksworth and David (1989), which ultimately lead to the conservation of *Arthopyrenia* with a conserved type, *A. cerasi* (Gams 1999). This conservation turned out to be quite fortunate, since based on phylogenetic and anatomical evidence, this is the only way to conserve *Arthopyrenia* and *Arthopyreniaceae* as a separate entity in a sense closest to what Harris (1995) had envisioned, albeit with only a single genus and few species belonging here. Thus, with *Arthopyrenia* forming four separate groups based on molecular and anatomical data, one including the largely tropical species now assigned to *Trypetheliaceae* (Nelsen et al. 2011a), one comprising the species now classified as *Naetrocymbe* (Harris 1995), and the two remaining groups representing the unusual *A. salicis* and the anatomically unique *A. cerasi* and relatives, the selection of the latter as the type defines *Arthopyrenia* and *Arthopyreniaceae* through the presence of densely arranged paraphysoids with the asci formed in locules, and by the peculiar, K+sordid-green reaction of the perithecial wall.

Type: *Arthopyrenia* A. Massal., Ric. auton. lich. crost. (Verona): 165 (1852), MycoBank: MB 325 Fig. 12

Non-lichenized on bark in terrestrial, temperate forest habitats. *Thallus* reduced and immersed in the substrate, whitish or indistinct, often forming dark brown hyphae over the substrate. Sexual state: *Ascomata* scattered, prominent, brown-black, hemisphaerical, carbonaceous, ostiolate, ostiole round. *Involucrellum* not distinctly separated from excipulum, dark brown to carbonized, K+ sordid-green in section. *Excipulum* dense, proso- to paraplectenchymatous in thin sections, brown. *Hamathecium* comprising 0.5–0.7 µm wide, densely packed paraphysoids connected to both the base and the top of the centrum, hyaline, straight to irregularly bent, branched and anastomosing. *Asci* forming in locules between the paraphysoids, 8-spored, bitunicate, fissitunicate, broadly clavate, short-pedicellate, with rather broad, non-amyloid ocular chamber. *Ascospores* irregularly arranged to bi-seriate, oblong with the proximal end slightly tapering, hyaline, (1–)3-septate, with thin eusepta and rectangular lumina, smooth-walled, not or very slightly constricted at the septa, the upper cells often slightly larger than the lower cells. Asexual state: *Pycnidia* erumpent to prominent, visible as brown-black dots. *Conidia* acrogenous, either macro- or microconidia; macroconidia non-septate, bacillar, hyaline; microconidia non-septate, acicular, hyaline. **Chemistry:** Unidentified perithecial wall pigment reacting K+ green.

Notes: *Arthopyrenia*, once a large collective genus including over hundred accepted species, and with over 600 epithets associated with that name (Harris 1975), is now reduced to less than a handful of species which are essentially northern temperate in their distribution and not lichenized. The unique

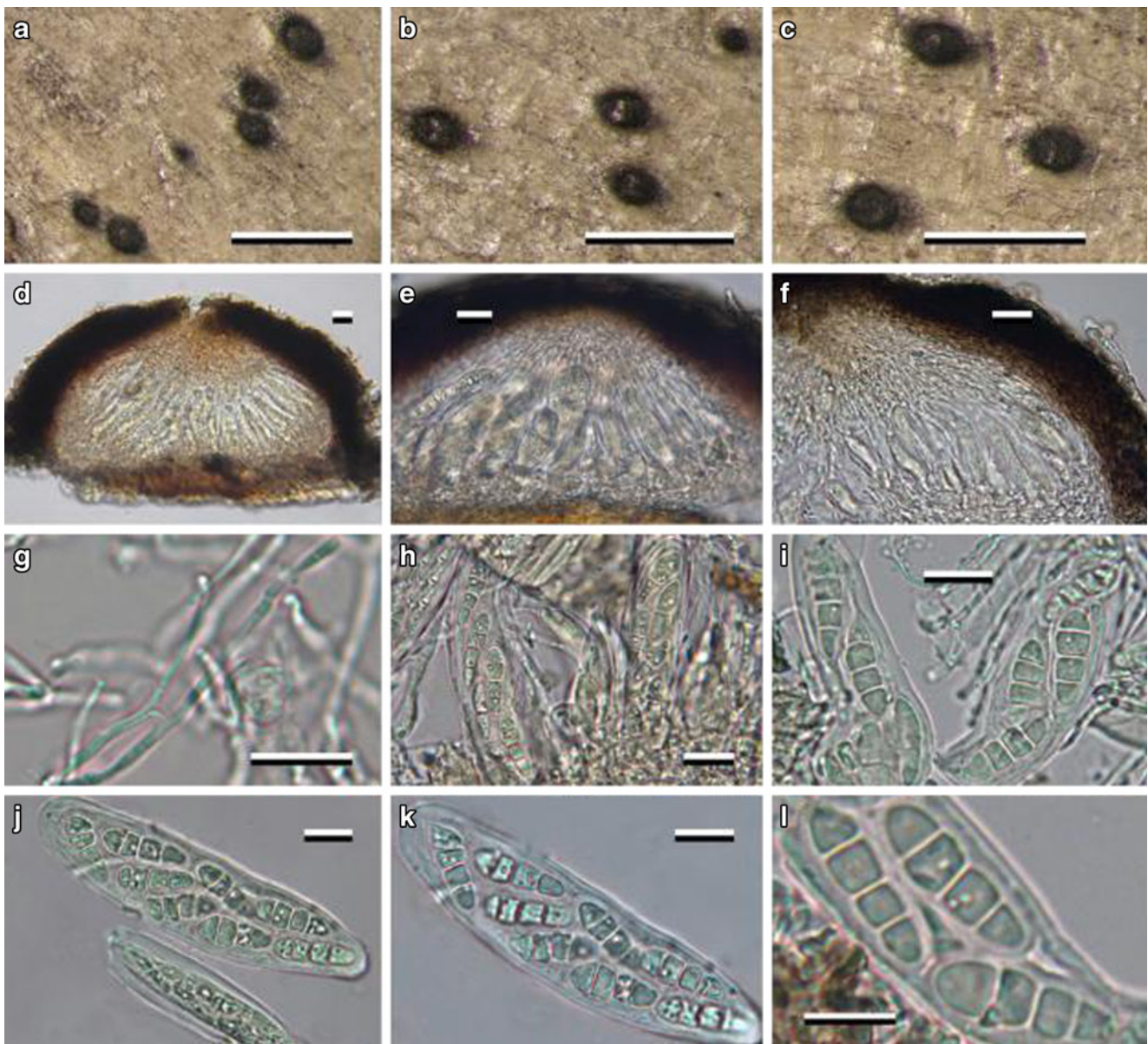


Fig. 12 *Arthopyrenia cerasi* (Material examined: Rabenhorst, Lichenes Europaei 145) **a–c** Surface view of thallus and perithecial ascomata, showing dark brown hyphae. **d–f** Section through perithecium showing centrum, paraphysoids, and asci. **g** Branched and anastomosing

paraphysoids. **h, i** Asci with ascospores embedded in hamathecium. **j, k** Individual asci with ascospores. **l** Ascus enlarged showing ascospores. Scale bars: **a–c**=1 mm, **d–l**=10 μ m

features of these species are the densely arranged paraphysoids developing from both the top and base of the centrum, and the K⁺ sordid-green perithecial wall (Foucard 1992; Harris 1995; Smith et al. 2009). While Harris (1975) transferred a large number of species to genera unrelated to *Arthopyrenia*, he suggested that *Arthopyrenia* could still be further reduced and might contain groups of unrelated taxa. Harris (1995) continued his refinement of *Arthopyrenia* by transferring a number of species from the *A. rhyponota*-*A. saxicola* group to *Naetrocymbe* and again noted the genus may contain further aberrant taxa. Not all agreed with Harris'

transfer of these species to *Naetrocymbe* and have continued to recognize species from this group as *Arthopyrenia* (Aptroot 1998, 2002a; Coppins 2002).

A number of molecular studies have demonstrated the placement of *Arthopyrenia salicis* and an unidentified *Arthopyrenia* species in *Pleosporales* (Lumbsch et al. 2005; Mugambi and Huhndorf 2009a; Schoch et al. 2009b; Tanaka et al. 2009; Zhang et al. 2009a, 2012a). *Arthopyrenia salicis* has been considered an unusual *Arthopyrenia* species, as it forms short paraphysoids and produces gelatinizing physes at maturity (Harris 1973; Coppins 1988; Foucard 1992), both of

which are aberrant characters for *Arthopyrenia* sensu lato. Harris (1995) ultimately retained this taxon in *Arthopyrenia*, but noted his uncertainty about this decision. Molecular data have demonstrated that *A. salicis* is related to *Roussoella* and *Roussoellopsis* (Tanaka et al. 2009; Schoch et al. 2009b; Nelsen et al. 2011a, b), two genera of bambusicolous fungi. *Arthopyrenia salicis* forms periphysoids produced in a gelatinized matrix, while these two genera, differ from *A. salicis* by the formation of paraphysoids and oblong to fusiform, hyaline spores lacking striation (Hino and Katumoto 1965; Hyde 1997). In contrast, *A. cinchonae* and related species were found to cluster in *Trypetheliales* (Nelsen et al. 2011b). Notably, neither the *A. cinchonae* nor the *A. salicis* group have names available at generic level. In contrast, *Arthopyrenia* sensu stricto has at least two generic synonyms in *Ciferriolichen* and *Mycociferria*, both based on *A. lapponina* (Tomaselli and Ciferri 1952, Ciferri and Tomaselli 1953). Further anatomical and phylogenetic revision of many additional species is required to adequately place all species currently assigned to *Arthopyrenia* sensu lato in one of these clades.

The other names tentatively listed as synonyms of *Arthopyrenia* require further taxonomic studies. Thus, *Giacominia* was described as the ‘fungal’ element of *Arthonia parolinii* Beltram. and the status of that species is unclear; it is not included in the current checklist of Italian lichens. The same applies to *Arthopyrenia maroccana* (M. Choisy) Zahlbr. the type of *Mesopyrenia*, and *Mycarthopyrenia sorbi* Keissl., the type of *Mycarthopyrenia*. Other genera commonly listed as synonyms of *Arthopyrenia* belong elsewhere: *Leiophloea* (Ach.) Gray, based on *Verrucaria* subgen. *Leiophloea* Ach. [the name *Leiophloea* Trevis. does not exist and is a lapsus for (Ach.) Gray], was lectotypified with *Lichen analeptus* Ach. by Riedl (1961) and hence is a synonym of *Porina* s.lat. (see above). The same applies to *Mycarthopyrenia* Cif. & Tomas., which is also based on *Lichen analeptus*. *Magmopsis* Nyl. appears to be a synonym of *Pyrenopsis* in *Lichinaceae*. The names *Jattaolichen* and *Jattaemyces* are both based on *Verrucaria epidermidis* var. *pyrenastrella* Nyl., which is a synonym of *Naetrocymbe punctiformis*, and hence these names are synonyms of *Naetrocymbe*.

Type species: Arthopyrenia cerasi (Schrad.) A. Massal., Ric. auton. lich. crost. (Verona): 167 (1852), MycoBank: MB 377023

≡ *Verrucaria cerasi* Schrad., Nov. gen. pl. (Lipsiae) 22: 86 (1797)

Ascoporiaceae Kutorga & D. Hawksw., Syst Ascom 15(1–2): 25 (1997), MycoBank: MB 81923

Saprobic on decorticated wood in terrestrial habitats. Sexual state: *Ascostromata* relatively large, superficial, circular or cupulate, slightly raised, stipitate, solitary, exterior

surrounded by brown mycelium, orange to red-brown at the margin or edge, dark brown to black in the centre, cells of ascostromata comprising a maze-like arrangement of mixed, brown-walled cells of *textura angularis* to *subglobosa* or *epidermoidea*, multi-loculate. *Locules* in a single layer at the periphery of the ascostromata, subcylindric-elongate, obpyriform to ovoid, crowded, opening by small, narrow, vertical ostiole. *Hamathecium* comprising numerous filiform, branched, septate pseudoparaphyses embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, narrowly cylindrical-clavate, pedicellate, apically rounded with a small ocular chamber, staining pinkish to purplish in 3 % KOH. *Ascospores* bi-seriate, fusiform, 1-septate, constricted at the septum, hyaline to yellowish when immature, olive-brown to dark brown when mature. Asexual state: see notes under genus.

Notes: Ascoporia was introduced by Samuels and Romero (1991) and placed in *Patellariaceae*. There is considerable variation in ascostroma structures, ascus shape and ascospore colour of *A. lateritia* Samuels & A.I. Romero. Typically the ascostromata are darkly pigmented in section, although bright coloured features may be seen on the substrate as well; asci are obviously bitunicate with a small ocular chamber; ascospores are typically fusiform, 1-septate and dark brown at maturity (Samuels and Romero 1991). Kutorga and Hawksworth (1997) investigated the isotype of *A. lateritia* and found that overall morphologies distinguish it from the type species of *Patellariaceae* (*Patellaria* Fr. 1882). Therefore, they separated *Ascoporia* from *Patellariaceae* and introduced the family *Ascoporiaceae* (Kutorga and Hawksworth 1997) comprising a single genus *Ascoporia*.

An earlier name for *Ascoporia* was found in *Pseudosolidum* by Rossman et al. (1999) when they examined a portion of the type specimen of *Pseudosolidum* at K.

Type: Ascoporia Samuels & A.I. Romero, Bolm Mus. paraense ‘Emilio Goeldi’, sér. bot.7(2): 264 (1993) [1991]

Synonym:

Pseudosolidum Lloyd (as McGinty), Mycol. Writ. 7: 1206 (1923), MycoBank: MB 26458 Fig. 13

Notes: Pseudosolidum (= *Ascoporia*) is a unique genus with locules lying in a peripheral layer around the cushion-like ascostromata, but is typical of *Dothideomycetes* in its hamathecium characters (Fig. 13). The most similar genus may be *Shiraia* which also has large orange ascostromata; however the habit (an endophyte on bamboo) and ascospores (muriform) are distinct (Hennings 1900; Liu et al. 2012a). *Pseudosolidum* contains a single species *P. solidum* (Berk. & M.A. Curtis) Lloyd (Fig. 13). Rossman et al. (1999) noted that *Ascoporia lateritia* Samuels & A.I. Romero, which is illustrated here, is a synonym of *Pseudosolidum solidum*. Kutorga and Hawksworth (1997), in their examination of the isotype specimen of *A. lateritia*, found a coelomycete similar to *Plectrophomella*, which they considered as a possible asexual



Fig. 13 *Pseudosolidum solidum* (Material examined: BRAZIL, Belem, Iha do Combu, Estacao Experimental Combu, Para. 01d30's, 48d27'w, on decorticated wood, January 1989, G.J. Samuels; K.F. Rodrigues (6207), BPI1109903, **isotype** of *Ascoporia lateritia*). **a** Ascostroma on substrate in surface view. **b** Crowded brown mycelium surrounding

ascostroma. **c, d** Section through ascostroma showing arrangement of locules. **e** Cells of ascostroma. **f** Hamathecium. **g–i** Immature and mature asci in 3% KOH. Note colour changes. **j–l** Ascospores. Note remnants of mucilage in j and k. Scale bars: **a**=5 mm, **b**=1 mm, **c–d**=200 μ m, **e**=10 μ m, **f**=5 μ m, **g–i**=50 μ m, **j–l**=20 μ m

state. This coelomycetous asexual morph has cylindrical, hyaline, smooth, phialidic conidiogenous cells and ellipsoid to ovate, 1-celled, hyaline conidia and was described by Kutorga and Hawksworth (1997). There are no molecular data to support this link.

Type species: Ascoporia lateritia Samuels & A.I. Romero, Bolm Mus paraense 'Emilio Goeldi', sér bot 7(2): 264 (1993) [1991], MycoBank: MB 360813

= *Pseudosolidum solidum* (Berk. & M.A. Curtis) Lloyd (as McGinty), Mycol. Writ. 7: 1206 (1923)

= *Hypoxylon solidum* Berk. & M.A. Curtis, J. Acad. nat. Sci. Philad., N.S. 2(6): 286 (1854) [1853]

Asterinaceae Hansf., Mycol. Pap. 15: 188 (1946), MycoBank: MB 80492

Possible synonyms:

Leveillellaceae Theiss. & Syd., Annl. mycol. 16(1/2): 33 (1918)

Lembosiaceae Hosag., in Hosagoudar, Abraham & Biju, J. Mycopathol. Res. 39(1): 61 (2001)

Foliar epiphytes obligately biotrophic on the upper or lower surface of leaves, rarely on stalks or shoots of plants, often forming web-like circular structures containing superficial black ascomata. Sexual state: *Mycelium* superficial, usually hyphopodiate. *Ascomata* superficial, forming below blackened mycelia, flattened, roundish in outline, elongate or linear, opening by radiating star-like or longitudinal splits, interascal tissue absent. *Upper wall* comprising rows of cells, radiating from the central ostiole to the periphery, base poorly developed. *Asci* 8-spored, bitunicate, fissitunicate, globose or broadly saccate, with short indistinct pedicel, lacking a distinct ocular chamber, occasionally with J+ (blue) gel remnants. *Ascospores* 2–5-seriate or fasciculate or conglobate, ellipsoidal, occasionally cylindrical, hyaline or brown, mostly 2-septate, mostly brown when mature, wall smooth or roughened. Asexual state: coelomycetous states with pycnidia or pycnothyria. *Conidiophores* branched or unbranched, hyaline or brown. *Conidiogenous cell* monoblastic or percurrent, hyaline or brown. *Conidia* brown, phragmosporous, single; hyphomycetous states without conidiomata or sporodochia then gelatinous, pale, mycelium hyaline or darkly pigmented. *Conidia* forming on stalked conidiophores, non-septate or 1-septate, variable in shape, e.g. globose to ellipsoidal, clavate, mostly brown to dark brown at maturity, mostly with hyaline areas or germ pores.

Notes: Eriksson (1981) suggested *Asterinaceae* should be restricted to certain tropical *Melastomataceae* and a remarkable common feature was the J+ granular coating on the surface of the asci. We have studied many genera of *Asterinaceae* and the J+ coating on the surface of the asci seems rare, while species have been recorded from a wide range of non *melastomataceous* hosts. Eriksson (1981) also compared the *Asterinaceae* with *Englerulaceae*; ascomata forming beneath the superficial mycelium in the former and on the mycelium in the latter.

The important features of *Asterinaceae* are the superficial, web-like, black colonies that form on the upper and lower surface of leaves and are typical of *Asterinaceae* (see Fig. 14). The mycelium is usually hyphopodiate. The thyriothecia form below the mycelium and comprise radiating cells and have a concentrically ridged surface – albeit hard to observe under the light microscope. The thyriothecia open by gelatinization of the shield cells and are usually stellate but may be longitudinal. Asci are saccate and ascospores are mostly conglobate and hyaline when young and becoming brown at maturity. The significance of the J+ ascocal coating as mentioned by Eriksson (1981) is unclear.

Sivanesan (1984) stated that *Asterostomella*, *Clasterosporium*, *Mitteriella*, *Sarcinella*, *Sporidesmium*, *Triposporium* and *Septothyrella* are the asexual states of *Asterinaceae*. In addition to these, Wijayawardene et al. (2012) listed *Acarella*, *Asterostromina*, *Asterostomula*, *Clasterosporium*, *Clasterosporium*, *Elachopeltis*,

Eriothyrium, *Leprieurina*, *Mahanteshamomyces*, *Peltasterella*, *Pirozynskia*, *Septoidium*, *Septothyrella*, *Shivamyces*, *Sirothyriella*, *Thyrinula* and *Triposporium* as also belonging to *Asterinaceae*. However the placement of *Septoidium* in *Asterinaceae* is confused as Ellis (1971) and Sivanesan (1984) stated that *Septoidium* is the asexual state of *Perisporiopsis* (*Parodiopsidaceae*). Chaverri and Gazis (2010) also confirmed this link. Seifert et al. (2011) also concluded that *Septoidium* belonged to *Parodiopsidaceae* and *Parodiellaceae*, hence we exclude *Septoidium* from *Asterinaceae*. Hosagoudar (2004) showed that *Shivamyces* is the asexual state of *Alina* (*Parodiopsidaceae*) hence we remove *Shivamyces* also from *Asterinaceae*. Most of these placements are based on morphological characters and presence on the same host. Hofmann et al. (2010) showed that this family clustered together with *Venturiaceae* within Dothideomycetes based on LSU and SSU data. Our phylogenetic results (Figs. 1 and 2) showed that it belongs to *Asterinales* and is close to *Venturiales*.

Type: *Asterina* Lév., Anns Sci. Nat., Bot., sér. 3 3: 59 (1845), MycoBank: MB 409

Figures 14 and 15

Foliar epiphytes obligately biotrophic on leaves, forming blackened, circular, elongate or X- or Y-shaped areas. *Mycelium* spreading over the leaf surface, with hyphopodia and scattered with superficial ascomata. *Hyphopodia* circular, lateral, alternating, sparsely septate, penetrating the host cells with haustoria. *Thyriothecia* solitary, gregarious, superficial, easily removed from the host surface, rounded, black, dehiscing to open by slit-like, star-like, or X or Y-shaped fissures when mature. *Upper wall* comprising a thin layer of mostly neatly arranged dark cells, which are branched at the outer rim, from which mycelium strands develop, basal wall layer poorly developed. *Hamathecium* usually lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate dehiscence not observed, oblong to subglobose, lacking a pedicel, ocular chamber not observed, not staining blue in IKI, asci arranged vertically in the thyriothecium. *Ascospores* overlapping, conglobate, hyaline when immature, brown when mature, 1-septate, strongly constricted at the septum. Asexual states “*Asterostomella*”, “*Clasterosporium*”-like, “*Mahanteshamyces*”. *Mycelium* brown, superficial, with appressoria. *Conidiomata* pycnothyria flattened, dimidiate, radiate, orbicular, stellately dehiscent at the centre. *Conidia* pycnothyriospores, brown, ovate, pyriform, angular, or wall straight to sinuate.

Type species: *Asterina melastomatis* Lév., Anns Sci. Nat., Bot., sér. 3 3: 59 (1845), MycoBank: MB 218181

Other genera included

Aphanopeltis Syd., Anns mycol. 25(1/2): 82 (1927)

Type species: *Aphanopeltis phoebes* Syd., Anns mycol. 25(1/2): 82 (1927)

Asterotexis Arx, Fungus, Wageningen 28: 6 (1958)

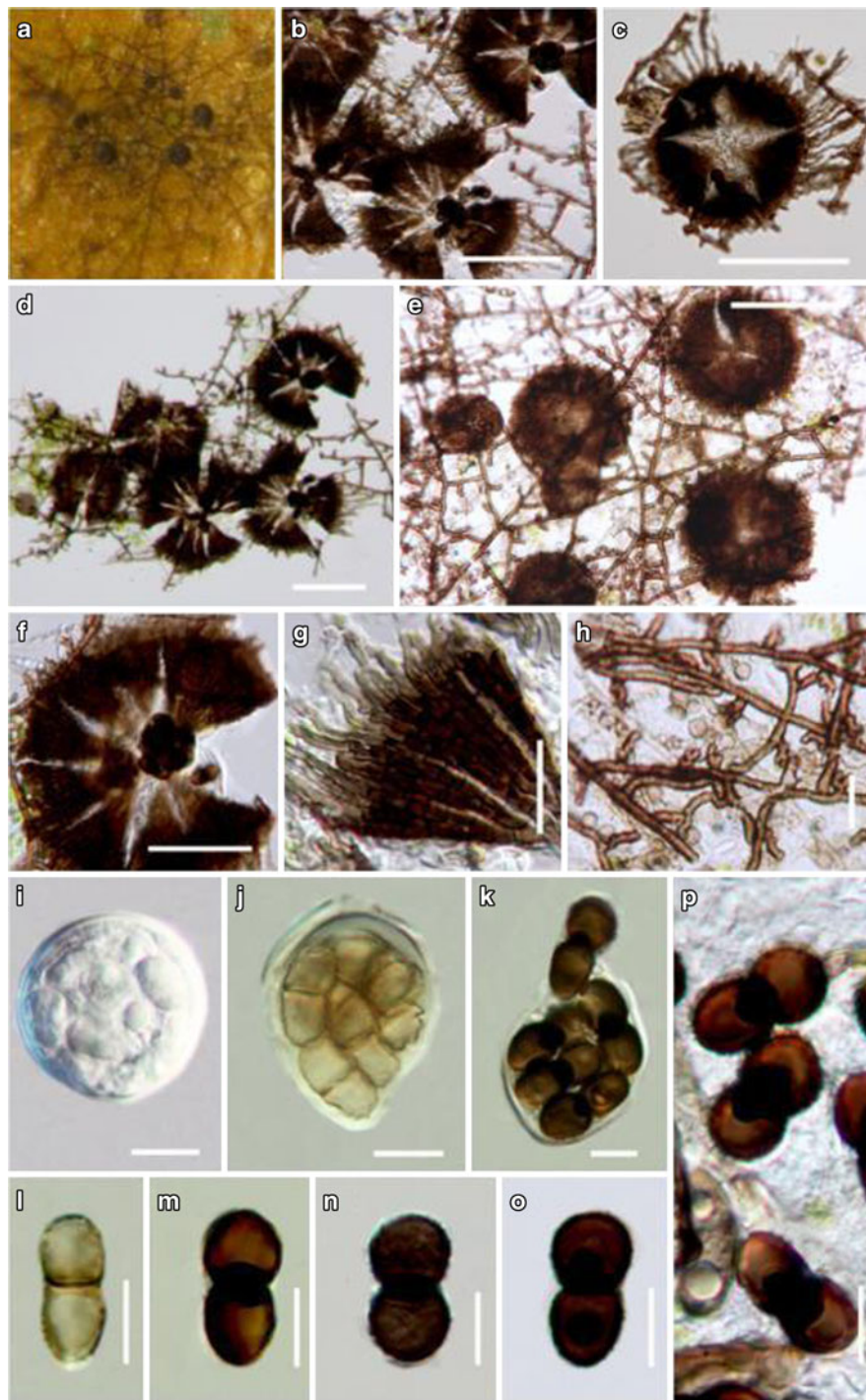


Fig. 14 *Asterina milletiae* Sexual state. (Material examined: PHILIPPINES, Luzon, Laguna Province, Mount Makiling, on living leaves of *Cynometra ramiflora*, February 2012, KD Hyde, MFLU 13–0087). **a** Ascomata superficial on host substrate. **b, c** Star-shaped opening. **d, e** Superficial mycelium. **f, g** Ascoma wall cells radially arranged. **h** My-

celium with hyphopodia. **i** Immature ascus. **j** Immature ascus in Melzer's reagent. **k** Ascus at maturity. **l** Immature ascospore in Melzer's reagent. **m** Ascospore at maturity in Melzer's reagent. **n–p** Ascospores at maturity. Scale bars: **b–e** = 100 μm , **f** = 50 μm , **g, h** = 20 μm , **i–p** = 10 μm

Type species: Asterotexis cucurbitacearum (Rehm) Arx, Fungus, Wageningen 28: 6 (1958)

Batistinula Arx, Publicações Inst. Micol. Recife 287: 4 (1960)

Type species: Batistinula gallesiae Arx, Publicações Inst. Micol. Recife 287: 6 (1960)

Cirsosia G. Arnaud, Annals d'École National d'Agric. de Montpellier, Série 2 16(1–4): 127 (1918) [1917]



Fig. 15 *Asterina phlogacanthi* Asexual state (Material examined: THAILAND, Chiang Rai, Tasud, on living leaves of *Clinacanthus nutans*, May 2012, Saowanee Wikee, MFLU 13–0088). **a** Pycnothyrium superficial on host substrate. **b** Star-shaped opening. **c** Conidia arranged

in pycnothyrium. **d** Conidioma wall cells radially arranged. **e** Conidioma when immature. **f** Thin basal layer of the pycnothyrium wall. **g** Mycelium bearing hyphopodia. **h–i** Conidia. **j** Conidiogenous cells producing conidia. Scale bars: **e, g, h, i, j** = 20 μm , **b, d, f** = 50 μm , **c** = 100 μm

Type species: Cirrosia manaoensis (Henn.) G. Arnaud [as ‘manaoensis’], *Annals d’École National d’Agric. de Montpellier, Série 2* 16(1–4): 127 (1918) [1917]

Halbania Racib., *Crypt. Par. Java*: no. 89 (1889)

Type species: Halbania cyathearum Racib., *Crypt. Par. Java*: 89 (1889)

Lembosia Lév., *Annl. Sci. Nat., Bot., sér. 3* 3: 58 (1845). MycoBank: MB2724

Type species: Lembosia tenella Lév., *Annl. Sci. Nat., Bot., sér. 3* 3: 58 (1845)

Meliolaster Höhn., *Ber. dt. bot. Ges.* 35: 701 (1918)

Type species: Meliolaster clavisporea (Pat.) Höhn., *Ber. dt. bot. Ges.* 35: 701 (1918)

Prillieuxina G. Arnaud, *Annals d'École National d'Agric. de Montpellier*, Série 2 16(1–4): 161 (1918) [1917], MycoBank: MB4365

Type species: Prillieuxina winteriana (Pazschke) G. Arnaud, *Annals d'École National d'Agric. de Montpellier*, Série 2 16(1–4): 162 (1918) [1917], MycoBank: MB160955

Schenckiella Henn., *Bot. Jb.* 17: 523 (1893)

Type species: Schenckiella marcgraviae Henn., *Bot. Jb.* 17: 523 (1893)

Trichasterina G. Arnaud, *Annals d'École National d'Agric. de Montpellier*, Série 2 16(1–4): 172 (1918) [1917]

Type species: Trichasterina styracis (Theiss.) G. Arnaud, *Annales de l'École Nationale d'Agriculture de Montpellier*, N.S. 16(1–4): 172 (1918)

Uleothyrium Petr., *Annls mycol.* 27(5/6): 388 (1929)

Type species: Uleothyrium amazonicum Petr., *Annls mycol.* 27(5/6): 388 (1929)

Key to sexual genera of Asterinaceae

1. Ascospores with more than two cells2
1. Ascospores 2-celled6
2. Ascospores hyaline**Uleothyrium**
2. Ascospores brown3
3. Ascospores cylindrical, 4-septate, light brown**Schenckiella**
3. Ascospores not cylindrical, with less than 4 septa4
4. Ascospores clavate, reddish brown**Meliolaster**
4. Ascospores ellipsoidal-fusiform, 3-septate, dark brown,5
5. On dicotyledon leaves**Batistinula**
5. On fern leaves**Halbania**
6. Ascospores clavate, apical cell large and rounded, asci cylindrical to clavate, on *Cucurbitaceae***Asterotexis**
6. Ascospores conglobose, ellipsoidal, mostly on other hosts7
7. Thyriothecium mostly elongate, opening by a stellate fissure, ascospores oblong to obovoid, hyaline to brown **Lembosia**
7. Thyriothecium mostly rounded, opening by a stellate fissure, ascospores conglobate, brown8
8. Ascospores hyaline at maturity, hyphopodia arrow-like, lateral and alternative, asexual state Elachopeltis-like **Aphanopeltis**
8. Ascospores brown at maturity, not with the above combination of characters9
9. Superficial mycelia without spines**Trichasterina**
9. Superficial mycelia with spines10
10. Ascospores ellipsoidal, lower cell longer and narrower**Prillieuxina**
10. Ascospores conglobose11
11. Hyphopodia lateral and alternating, composed of three cells, with the middle cell swelling, ascospores 2-celled, clearly ornamented**Cirsosia**

11. Hyphopodia circular, lateral and alternating, sparsely septate, some ascospores ornamented**Asterina**

Aulographaceae Luttrell ex P.M. Kirk et al., in Kirk et al., *Ainsworth & Bisby's Dictionary of the Fungi*, Edn 9 (Wallingford): ix (2001), MycoBank: MB 82122

Possible synonyms:

Aulographaceae Luttr., in Ainsworth, Sparrow & Sussman, *The Fungi* (London) 4A: 154 (1973)

Lembosiaceae Hosag., in Hosagoudar, Abraham & Biju, *J. Mycopathol. Res.* 39(1): 61 (2001)

Lembosiaceae Höhn., *Annls mycol.* 16(1/2): 146 (1918)

Saprobic on dead leaves. Sexual state: *Ascomata* superficial, a thyriothecium, solitary, some fused, scattered, usually elongate, slightly convex or shield-like, mostly linear, some furcate or branched, anastomosed, triangular in shape, dehiscing by a slit, dark brown to black, red-brown at the margin, mycelium appressed towards the base. *Peridium* composed of very thin, tightly packed *textura epidermoidea*, somewhat brittle, easily broken. *Hamathecium* of asci and lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, broadly ellipsoid or subclavate-oblong, or globose to subglobose, apex thickened, pedicel stumpy or lacking, ocular chamber not distinct. *Ascospores* 2–3-seriate, narrowly obovoid to clavate, 1-septate, not constricted at the septum, upper cell wider, hyaline, guttulate, smooth-walled. Asexual state: Unknown.

Notes: The family *Aulographaceae* was introduced by Luttrell (1973) and based on the tribe Aulographées (Arnaud 1930) which is an invalid name (Index Fungorum 2013). Luttrell (1973) did not provide a Latin diagnosis and thus his family was also invalid, however this was later validated with a Latin diagnosis in Kirk et al. (2001). Subsequently, it was accommodated in *Microthyriales* based on the flattened thyriothecial ascomata (Kirk et al. 2008), but treated as a distinct family due to the opening by a longitudinal slit at maturity to expose the asci (George 1895; Luttrell 1973; Sierra 2006). Presently, the family comprises *Aulographum* and *Polychypeolina* (Lumbsch and Huhndorf 2010). These genera occur on the surface of leaves (Fig. 16). In *Polychypeolina* ascomata form irregularly, are clustered and fused, without a longitudinal slit, and asci and ascospores differ from *Aulographum* (Hansford 1945; Batista 1959, Fig. 3). Based on morphological characters this genus can be excluded and placed in Ascomycetes, genera *incertae sedis*. Molecular data is needed to confirm its correct placement. Wu et al. (2011a) added *Lembosiella* to *Aulographaceae* based on ascomatal structures resembling those of *Aulographum*. The ascomata are typically dimidiate, superficial thyriothecia and similar to *Asterinaceae* (Batista 1960; Ellis 1980). Ascomatal structures of *Asterinaceae* are generally but not always circular with outwardly radiating mycelium which dehisces by irregular fissures

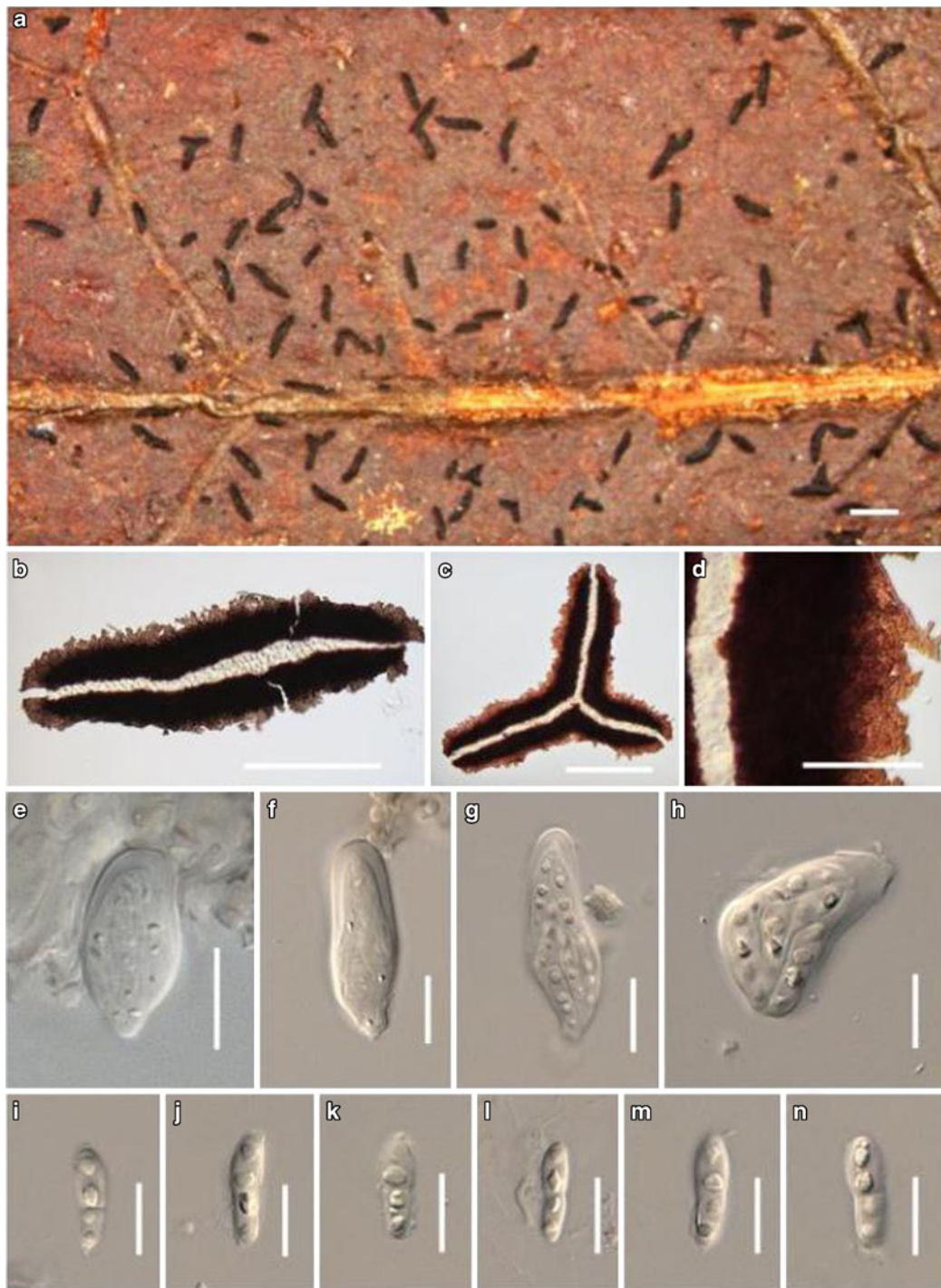


Fig. 16 *Aulographum hederae* (Material examined: on leaves of *Hedera* sp., BPI1108478) **a** Thyriothecia. **b-d** Squash mount of thyriothecia. **e-h** Immature and mature asci. **i-n** Ascospores. Scale bars: **a**=500 μ m, **d**=50 μ m, **e-n**=10 μ m

(Hansford 1946; Batista et al. 1958). In addition, they produce appressoria (Hofmann et al. 2010; Hosagoudar 2012), a character which may distinguish these families. *Aulographum* is similar to *Aulographina* and *Lembosia* in *Asterinaceae* and these genera may be synonyms. *Aulographum* may also be placed in *Asterinaceae*. For

the proper placement of these taxa, molecular data is needed.

Type: *Aulographum* Lib., Pl. crypt. Arduenna, fasc. (Liège) 3: no. 272 (1834), MycoBank: MB 461 Fig. 16

Saprobic on dead leaves. Sexual state: *Ascomata* superficial, a thyriothecium, solitary, some fused, scattered, usually

elongate, slightly convex or shield-like, mostly linear, some furcate or branched, or anastomosed and triangular in shape, dark brown to black, red brown at the margin, dehiscing by a longitudinal slit, mycelium appressed outwards from the base. *Peridium* composed of very tightly packed *textura epidermoidea*, somewhat brittle, easily broken. *Hamathecium* of asci, pseudoparaphyses lacking. *Asci* 8-spored, bitunicate, fissitunicate, broadly ellipsoid, subclavate-oblong, apex thickened, pedicel stumpy or lacking, ocular chamber not distinct. *Ascospores* 2–3-seriate, narrowly obovoid, clavate, 1-septate, not constricted at the septum, upper cell wider, hyaline, guttulate, smooth-walled. Asexual state: Unknown.

Notes: *Aulographum* was introduced by Libert (1834), and is typified by *Aulographum hederæ* Lib.. The type specimen of *Aulographum hederæ* was not available for study, therefore the illustration is derived from BPI 1108478 which appears to be an authentic specimen (Fig. 16). In the protologue by Libert (1834), thyriothecia are slightly linear, longitudinally splitting and produce oval-oblong, 1-septate, hyaline ascospores (Masse 1895). This genus comprises 75 epithets (Index Fungorum 2013). Several of the species however, were transferred to other families, such as *Asterinaceae*, *Elsinoaceae*, *Leptopeltidaceae*, or *Lophiostomataceae*. *Aulographum hederæ* is characterized by longitudinally splitting ascomata and a peridial wall appressed by mycelium with bright-colours at the margin (Fig. 16a–d). These are different from *Polyclypeolina*, presently included in the same family (Hansford 1945; Batista 1959).

Type species: *Aulographum hederæ* Lib., Pl. crypt. Arduenna, fasc. (Liège) 3: no. 272 (1834), MycoBank: MB 161393

=*Aulographum vagum* Desm. Anns Sci. Nat., Bot., sér. 2 19: 362 (1843)

Other genera included

Echidnodella Theiss. & Syd., Anns mycol. 15(6): 422 (1918) [1917]

Type species: *Echidnodella linearis* (Syd. & P. Syd.) Syd., Anns mycol. 15(6): 422 (1918) [1917]

Echidnodes Theiss. & Syd., Anns. Mycol. 15(6): 422 (1918) [1917]

Type species: *Echidnodes lituræ* (Cooke) Theiss. & Syd. [as 'litsuræ'], Anns. Mycol. 15(6): 422 (1918) [1917]

Lembosina Theiss., Anns mycol. 11(5): 437 (1913)

Type species: *Lembosina aulographoides* (E. Bommer et al.) Theiss., Anns mycol. 11(5): 437 (1913)

Morenoina Theiss., Anns mycol. 11(5): 434 (1913)

Type species: *Morenoina antarctica* (Speg.) Theiss., Anns mycol. 11(5): 434 (1913).

Thyriopsis Theiss. & Syd.. Anns mycol. 13(3/4): 369 (1915).

Type species: *Thyriopsis halepensis* (Cooke) Theiss. & Syd., Anns mycol. 13(3/4): 369 (1915)

Key to genera of *Aulographaceae*

1. Ascospores hyaline or yellowish-brown at maturity2
1. Ascospores brown at maturity4
2. Thyriothecia star-like, with thin upper layer of brick-like cells, opening with stellate fissures, on grasses*Morenoina*
2. Thyriothecia linear, or occasionally with three arms, cells of upper layer less distinct3
3. Ascospores conglobose, strongly constricted at the septum*Thyriopsis*
3. Ascospores ellipsoidal or subclavate, slightly constricted at the septum4
4. Thyriothecia very long, always linear*Echidnodes*
4. Thyriothecia relatively short, linear, or occasionally with three arms*Aulographum*
5. Ascospores with protrusion at the base, light brown*Lembosina*
5. Ascospores conglobose, brown*Echidnodella*

Bambusicolaceae D.Q. Dai & K.D. Hyde, **fam. nov.**, MycoBank: MB 804293

Saprobic on decaying bamboo culms. Sexual state: *Ascomata* small, solitary, scattered, immersed, conical, ostiolate, coriaceous. *Peridium* thin, composed of brown and thick-walled cells of *textura angularis*, with the basal part composed of thinner, hyaline, smaller cells. *Hamathecium* of relatively thin, dense, anastomosing and branching interascal filaments. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, with a short furcate pedicel, apically rounded, with a shallow ocular chamber. *Ascospores* 2–3-seriate, slightly broad fusiform, 1-septate, narrowly rounded at both ends, hyaline, surrounded by a gelatinous sheath. Asexual state: *Conidiomata* small, pycnothyrial, acerous or subglobose, solitary, scattered, immersed to semi-immersed. *Conidiophores* indistinct. *Conidiogenous cells* holoblastic, annelidic, discrete, cylindrical, and smooth. *Conidia* pale brown to dark brown, 1–3-septate, cylindrical, straight or slightly curved, obtuse at the apex, with many guttules.

Typus: *Bambusicola* D.Q. Dai & K.D. Hyde

Notes: The family *Bambusicolaceae* is established to accommodate the genus *Bambusicola* which comprises three species. Morphologically, *Bambusicolaceae* species are similar to genera in *Tetraplospheariaceae* i.e. *Tetraplosphearia*, *Triplosphearia* and *Polyplosphearia* (Tanaka et al. 2009), but Dai et al. (2012) phylogenetically showed *Bambusicola* species to belong in a different lineage. All the members in *Tetraplospheariaceae* have immersed to superficial, globose to subglobose ascomata, cylindrical to clavate asci and hyaline, fusiform ascospores surrounded by a mucilaginous sheath (Tanaka et al. 2009). Both *Triplosphearia* and *Bambusicola massarinia* D.Q. Dai & K.D. Hyde have similar

rim-like side walls (Tanaka et al. 2009; Dai et al. 2012). All genera in *Tetraplophaeriaceae* have been linked to “Tetraploa”-like hyphomycetous states (Tanaka et al. 2009), however, coelomycetous states were observed in all species of *Bambusicolaceae* in culture or on host culms. Molecular data show this family to belong in *Pleosporales*, related to *Massarinaceae* and *Montagnulaceae* (Fig. 1)

Type: Bambusicola D. Q. Dai & K.D. Hyde, Cryptog. Mycol. 33(3): 367 (2012), MycoBank: MB 801041 Fig. 17

Notes: Bambusicola includes four species (Dai et al. 2012), all from bamboo.

Type species: Bambusicola massarinia D.Q. Dai & K.D. Hyde, Cryptog. Mycol. 33(3): 370 (2012), MycoBank: MB 801045

Biatrisporaceae K.D. Hyde, **fam. nov.**, MycoBank: MB 803357

Saprobic on decaying submerged intertidal mangrove wood. Sexual state: *Ascomata* relatively large, solitary to gregarious, pyreniform, immersed, lying horizontal to the host surface, ostiolate, periphysate, black, coriaceous, with ostiole recurving upwards to pierce the host surface. *Peridium* thin, composed of brown pseudoparenchymatous cells. *Hamathecium* of dense, thin (ca 1 μ m diam) anastomosing, branching, trabeculate pseudoparaphyses embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, with a relatively long pedicel, with a large, distinct ocular chamber. *Ascospores* overlapping uni-seriate, fusiform, dark brown, with hyaline swollen rounded ends, with 1–4 septa towards the ends, lacking septa in the centre part, smooth-walled, releasing mucilage from the ends. Asexual state: Unknown.

Typus: Biatrispora K.D. Hyde & Borse

Notes: This remarkable genus was introduced by Hyde and Borse (1986) for a mangrove inhabiting species and has since been collected many times and shown to have a wide ranging distribution and to occur on a wide range of hosts. The dark brown ascospores are unusual in that they are fusiform with hyaline, rounded swollen ends which release mucilage (Hyde and Jones 1989) and 1–4 septa are situated near the ends. In previous classifications this genus would have sat nicely in *Melanommataceae*, as it has trabeculate pseudoparaphyses. However, Liew et al. (2000) show this character to be unreliable in predicting family placement of genera in Dothideomycetes. In the phylogenetic tree (Figs. 1 and 2) this genus sits independently with *Rousoella* and *Rousoellopsis* strains with strong support (92 %). A new family, *Biatrisporaceae* in the *Pleosporales* is therefore introduced to accommodate this monotypic genus.

Type: Biatrispora K.D. Hyde & Borse, Mycotaxon 26: 263 (1986), MycoBank: MB 801041 Fig. 18

Type species: Biatrispora marina K.D. Hyde & Borse, Mycotaxon 26: 264 (1986), MycoBank: MB 801045

Notes: The genus is monotypic.

Botryosphaeriaceae Theiss. & Syd. [as ‘*Botryosphaeriaceae*’], *Annls mycol.* 16(1/2): 16 (1918), MycoBank MB 80530

Biotrophic, necrotrophic and *saprobic* especially on wood in terrestrial habitats. Sexual state: *Ascostromata* uni- to multi-locular, with multi-layered walls, single or in clusters, with or without basal stroma, fully or partially erumpent at maturity. *Hamathecium* of hypha-like, branched or unbranched, septate pseudoparaphyses, which are constricted at the septum, frequently disappearing at maturity. *Asci* mostly 8-spored, bitunicate, fissitunicate, with thick endotunica, clavate to cylindro-clavate, short or long-pedicellate, apically rounded with an ocular chamber. *Ascospores* 2–3-seriate, hyaline to brown, smooth to verruculose, thin-walled, aseptate to septate, fusoid to ellipsoid or ovoid, with or without a mucoid sheath or rarely with appendages. Asexual states: with uni- to multi-locular pycnidial conidiomata, frequently embedded in stromatic tissue, with hyaline, phialidic conidiogenous cells. *Conidia* hyaline to pigmented, thin- to thick-walled, sometimes with mucoid appendages or sheaths, smooth to verruculose, sometimes striate, with or without germ slits.

Notes: The family *Botryosphaeriaceae* was introduced by Theissen and Sydow (1918) in *Botryosphaeriales* (Schoch et al. 2006). Hibbett et al. (2007) did not assign the *Botryosphaeriales* to any subclass, but Schoch et al. (2009a) accepted its position in the *Pleosporomycetidae*. Previously the family had been referred to various orders: *Myrangiiales* (Theissen 1916), *Dothideales* (Miller 1928; Kirk et al. 2001), and *Pseudosphaeriales/Pleosporales* (Luttrell 1955). The family is well-defined morphologically and supported by molecular data, with a number of lineages strongly corresponding to asexual morphological genera, e.g. *Diplodia*, *Fusicoccum*, and *Lasiodiplodia* (Schoch et al. 2009a; Liu et al. 2012a). Species are widespread in the tropics and temperate zones, some are forest pathogens, and some may be host-specific, while generally they are saprobic or endophytic. They also cause important diseases in forestry and agriculture (e.g. on grape-vines, van Niekerk et al. 2004). Liu et al. (2012a) accepted 29 genera in the *Botryosphaeriales* and molecular data showed the clade for the family *Botryosphaeriaceae* comprising eight sub-clades corresponding to: A1 *Diplodia*, *Neodeightonia* and *Lasiodiplodia*; A2 *Phaeobotryosphaeria*, *Phaeobotryon* and *Barriopsis*; A3 *Dothiorella*, *Spencermartinsia* and *Auerswaldia*; A4 *Botryobambusa*; A5 *Neofusicoccum*; A6 *Botryosphaeria* including the type species of the genus, *Neoscytalidium* and *Cophinforma* (a new genus); A7 *Pseudofusicoccum*; and A8 *Aplosporella* (Liu et al. 2012a).

Type: Botryosphaeria Botryosphaeria Ces. & De Not., *Comm. Soc. crittog. Ital.* 1(4): 211 (1863), MycoBank MB 635 Fig. 19

Hemibiotrophic or *saprobic* on leaves and wood in terrestrial habitats. Sexual state: *Ascstromata* erumpent through the bark, often forming a botryose aggregate, sometimes solitary, globose, brown to black, individual locules with a central ostiole, papillate or not. *Peridium* two-layered, outer layer composed of dark brown or brown, thick-walled cells of *textura angularis*, inner layer composed of hyaline, thin-walled cells of *textura angularis*, lining the locule. *Hamathecium* comprising numerous, 2–4 µm wide, septate, hypha-like pseudoparaphyses, rarely branched at the apex. *Asci* 8-spored, bitunicate, fissitunicate, clavate, short-pedicellate, apically rounded with a small ocular chamber. *Ascospores* bi-seriate, hyaline, aseptate, fusoid to ovoid, sometimes with tapered ends, giving a spindle-shaped appearance, smooth with granular contents, with or without a mucilaginous sheath. Asexual states: *Conidiomata* pycnidial in nature. *Conidiogenous cells* holoblastic, hyaline, subcylindrical, proliferating percurrently with 1–2 proliferations and periclinal thickening. *Conidia* hyaline, aseptate, narrowly fusiform, or irregularly fusiform, base subtruncate to bluntly rounded, rarely forming a septum before germination, smooth with granular contents (asexual morph description follows Slippers et al. 2004).

Notes: The genus *Botryosphaeria* was introduced in 1863 and emended by Saccardo (1877) and is based on the type species *B. dothidea* (Moug.: Fr.) Ces. & de Not. However, as the type material was immature, Slippers et al. (2004) epitypified the type species *Botryosphaeria dothidea* based on morphology and phylogenetic data. Species of *Botryosphaeriaceae* occur on woody branches, herbaceous leaves, stems, and twigs of a wide range of plants (monocotyledons, dicotyledons and gymnosperms) and have a cosmopolitan distribution (Crous et al. 2006). Species are frequently associated with dieback and cankers of woody tissues and other plant diseases.

Botryosphaeria is characterized by ascstromata, bitunicate asci with a thick endotunica, stalked or sessile, clavate with a well-developed apical chamber, with hyaline pseudoparaphyses, constricted at the septa, and aseptate, hyaline ascospores, fusoid to ellipsoid or ovoid, generally lacking mucoid sheaths or appendages. *Botryosphaeria* asexual morphs have been assigned to some 18 coelomycete genera based on molecular data (Crous et al. 2006; Liu et al. 2012a; Wijayawardene et al. 2012).

Type species: *Botryosphaeria dothidea* (Moug: Fr.) Ces. & de Not., Comment Soc. crittog. Ital. 1: 212 (1863)

≡ *Sphaeria dothidea* Moug., in Fries, Syst. mycol. (Lundae) 2(2): 423 (1823)

Other genera included

Aplosporella Speg., Anal. Soc. cient. argent. 10(5–6): 157 (1880)

Type species: *Aplosporella chlorostroma* Speg., Anal. Soc. cient. argent. 10(5–6): 158 [no. 117, reprint page 35] (1880)

Auerswaldia Sacc., Syll. Fung. (Abellini) 2: 626 (1883)

Type species: *Auerswaldia examinans* (Mont. & Berk.) Sacc., Syll. Fung. 2: 266 (1883)

Auerswaldiella Theiss. & Syd., Ann. mycol. 12(3): 278 (1914)

Type species: *Auerswaldiella puccinioides* (Speg.) Theiss. & Syd., Ann. mycol. 12(3): 278 (1914)

Barriopsis A.J.L. Phillips et al., Persoonia 21: 39 (2008)

Type species: *Barriopsis fusca* (N.E. Stevens) A.J.L. Phillips et al., Persoonia 21: 39 (2008)

Botryobambusa R. Phookamsak et al., Fungal Divers. 57: 166 (2012)

Type species: *Botryobambusa fusicoccum* R. Phookamsak et al., Fungal Divers. 57: 166 (2012)

Cophinforma Doilom, J.K. Liu & K.D. Hyde, in Liu et al. Fungal Divers. 57: 174 (2012)

Type species: *Cophinforma eucalyptus* Doilom, J.K. Liu & K.D. Hyde, in Liu et al. Fungal Divers. 57: 174 (2012)

Dichomera Cooke, Nuovo G. bot. ital. 10: 24 (1878)

Type species: *Dichomera saubinetii* (Mont.) Cooke, Nuovo G. bot. ital. 10: 24 (1878)

Diplodia Fr., in Montagne, Anns Sci. Nat., Bot., sér. 2 1: 302 (1834)

Type species: *Diplodia mutila* (Fr.) Mon., Anns Sci. Nat., Bot., sér. 2 1: 302 (1834)

Dothiorella Sacc., Michelia 2 (no. 6): 5 (1880)

Type species: *Dothiorella pyrenophora* Berk. ex Sacc., Michelia 2 (no. 6): 5 (1880)

Endomelanconiopsis E.I. Rojas & Samuels, in Rojas et al., Mycologia 100 (5): 770 (2008)

Type species: *Endomelanconiopsis endophytica* E.I. Rojas & Samuels, in Rojas et al., Mycologia 100 (5): 770 (2008)

Lasiodiplodia Ellis & Everh., Bot. Gaz. 21: 92 (1896)

Type species: *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl., Bull. Soc. mycol. Fr. 25: 57(1909)

Macrophomina Petr., Anns. mycol. 21(3/4): 314 (1923)

Type species: *Macrophomina phaselina* (Tassi) Gorf., Annali Sper. agr.n.s. 1: 457 (1947)

Microdiplodia Allesch., Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1(7): 78 (1901) [1903]

Type species: *Microdiplodia conigena* Allesch., Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1(7): 79 (1901) [1903]

Macrovalsaria Petr., Sydowia 15: 298 (1962) [1961]

Type species: *Macrovalsaria leonensis* (Deighton) Petr., Sydowia 15(1–6): 298 (1962) [1961]

Neodeightonia C. Booth, in Punithalingam, Mycol. Pap. 119: 17 (1970) [1969], MycoBank MB 3450 Figs. 20 and 21

Saprobic on dead wood and leaves of monocotyledons. Sexual state: *Ascstromata* brown to dark brown, uni-

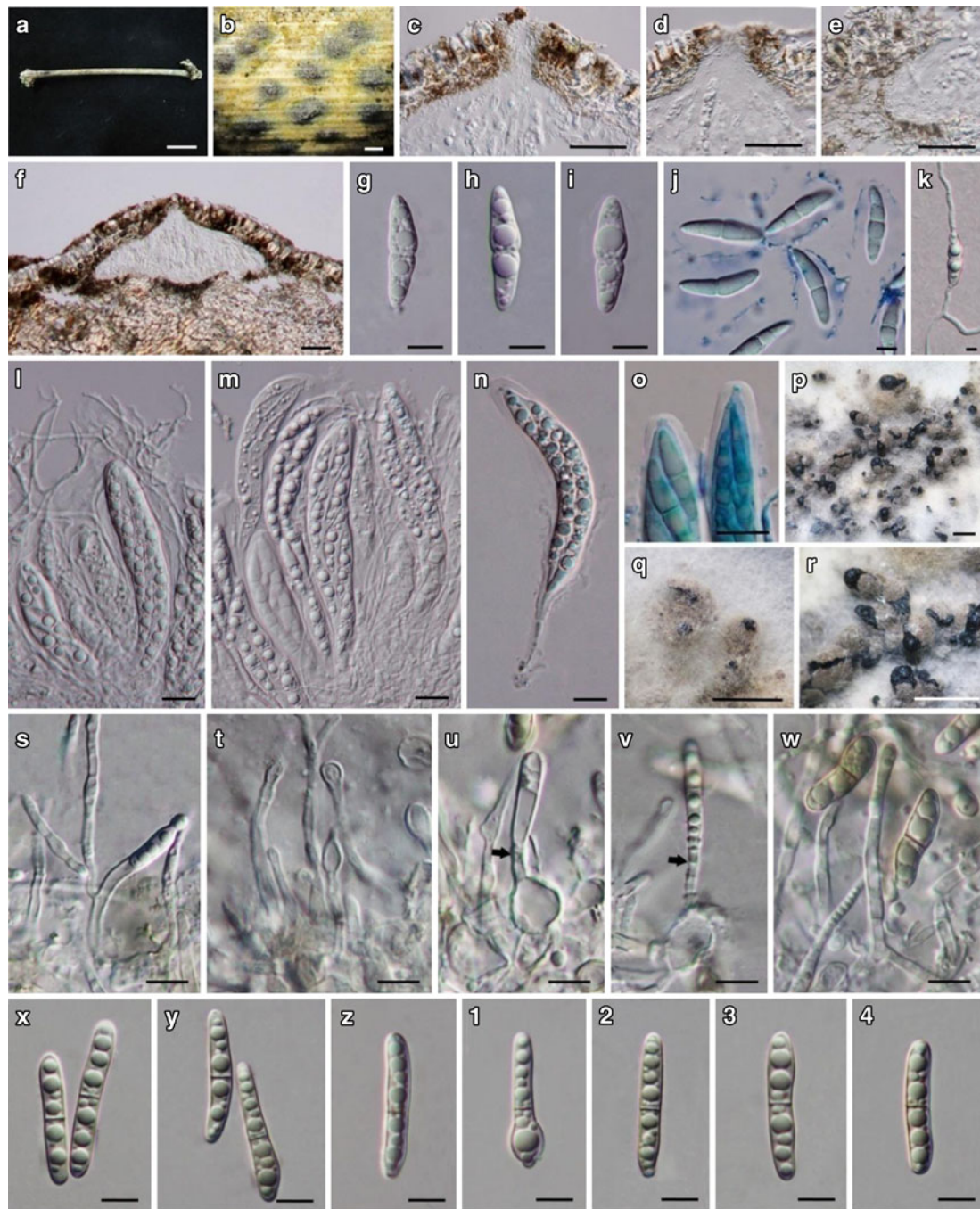


Fig. 17 *Bambusicola massarinia* (Material examined: THAILAND, Chiang Rai Province, Doi Fung, on decaying culm of bamboo, 4 May 2011, Dong-Qin Dai DDQ0003, MFLU12-0405, **holotype**). **a** Bamboo type specimen. **b** Habit of immersed ascomata on host. **c, d** Section through ostiole with periphyses. **e** Section of peridium. **f** Section of ascoma. **g–i** Hyaline and 1-septate ascospores. **j** Ascospore

with gelatinous sheath. **k** Germinating ascospore. **l** Pseudoparaphyses above asci. **m** Asci with ascospores. **n** Fissitunicate ascus. **o** Apices of asci. **p–r** Conidiomata surrounded by mycelium. **s, t, w** Conidiophores and conidiogenous cells producing conidia., **u, v** Conidiogenous cells with 1–5 annellations. **x–4** One septate conidia. Scale bars: **a** = 50 mm, **b, p–r** = 100 μ m, **c–f** = 50 μ m, **g–k, s–4** = 5 μ m, **l–o** = 10 μ m

loculate, immersed to erumpent, globose to subglobose. *Ostiole* circular, central. *Peridium* of dark, brown walled cells of *textura angularis*. *Hamathecium* of hypha-like, branched or unbranched, septate pseudoparaphyses constricted at the

septa. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cylindrical-clavate, apically rounded with an ocular chamber. *Ascospores* uni-seriate or irregularly bi-seriate, hyaline, aseptate, ellipsoidal-fusiform, or fusiform, surrounded or not

surrounded by a complex sheath. Asexual state: *Pycnidia* uni-loculate or multi-locular, semi-immersed, solitary, globose, covered by mycelium, wall composed of dark brown thick-walled *textura angularis*, becoming thin-walled and hyaline towards the inner region. *Paraphyses* hyaline, cylindrical. *Conidiogenous cells* holoblastic, hyaline, aseptate, cylindrical to subcylindrical. *Conidia* initially hyaline, aseptate, ellipsoid to obovoid, thick-walled with granular content, rounded at apex, occasionally truncate at base. Aged conidia becoming cinnamon to sepia, and 1-septate, brown to dark brown.

Notes: *Neodeightonia* was introduced by Booth (in Punithalingam 1969). However, von Arx and Müller (1975) transferred the type of the genus, *N. subglobosa* C. Booth., to *Botryosphaeria*, reducing *Neodeightonia* to synonymy. Phillips et al. (2008) reinstated this genus which is distinguishable from *Botryosphaeria* morphologically (based on the dark, 1-septate conidiospores) and phylogenetically (Phillips et al. 2008; Abdollahzadeh et al. 2009) and described a new species *N. phoenicum* A.J.L. Phillips & Crous. Liu et al. (2010) added the fourth species; *N. palmicola* based on morphological studies of the sexual and asexual morphs and phylogenetic data, which is illustrated here (Fig. 3).

Type species: Neodeightonia subglobosa C. Booth, in Punithalingam, Mycol. Pap. 119: 19 (1970) [1969]

Neofusicoccum Crous et al., Stud. Mycol. 55: 247 (2006)

Type species: Neofusicoccum parvum (Pennycook & Samuels) Crous et al., Stud. Mycol. 55: 248 (2006)

Neoscytalidium Crous & Slippers, Stud. Mycol. 55: 244 (2006)

Type species: Neoscytalidium dimidiatum Crous & Slippers, Stud. Mycol. 55: 244 (2006)

Phaeobotryon Theiss. & Syd., Ann. Mycol. 13 (5/6): 664 (1915)

Type species: Phaeobotryon cercidis (Cooke) Theiss. & Syd., Annl. mycol. 13: 664. 1915

Phaeobotryosphaeria Speg., Anal. Mus. nac. B. Aires, Ser. 3 17(10): 120 (1908)

Type species: Phaeobotryosphaeria yerbae Speg., Anal. Mus. nac. B. Aires, Ser. 317(10): 120(1908)

Phyllachorella Syd., Annl. mycol. 12: 489 (1914)

Type species: Phyllachorella micheliae Syd., Annl. mycol. 12(5): 489 (1914)

Pseudofusicoccum Mohali et al., Stud. Mycol. 55: 249 (2006)

Type species: Pseudofusicoccum stromaticum (Mohali et al.) Mohali et al., Stud. Mycol. 55: 249 (2006)

Pyrenostigma Syd., Annl. mycol. 24: 370 (1926)

Type species: Pyrenostigma siparunae Syd., Annl. mycol. 24: 370 (1926)

Sivanesia W.H. Hsieh & Chi Y. Chen, Mycol. Res. 98 (1): 44 (1994)

Type species: Sivanesia rubi W.H. Hsieh & Chi Y. Chen, Mycol. Res. 100(9): 1106 (1996)

Spencermartinsia A.J.L. Phillips et al., Persoonia 21: 51 (2008)

Type species: Spencermartinsia viticola (A.J.L. Phillips & J. Luque) A.J.L. Phillips et al., Persoonia 21: 51 (2008)

Tiarosporella Höhn., in Weese, Mitt. bot. Inst. tech. Hochsch. Wien 1 (3): 82 (1924)

Type species: Tiarosporella paludosa (Sacc. & Fiori ex P. Syd.) Höhn., in Weese, Mitt. bot. Inst. tech. Hochsch. Wien 1 (3): 82 (1924)

Thyrostroma Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 120: 472 [94 repr.] (1911)

Type species: Thyrostroma compactum (Sacc.) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 120: 472 [94 repr.] (1911)

Vestergrenia Rehm, Hedwigia 40: 100 (1901)

Type species: Vestergrenia nervisequia Rehm, Hedwigia 40: 101 (1901)

Key to sexual genera of *Botryosphaeriaceae*

1. Ascostromata unilocular2
1. Ascostromata multi-locular4
2. Ascostromata superficial3
2. Ascostromata immersed to erumpent*Cophinforma*
3. Asci cylindrical to clavate with a small ocular chamber*Phyllachorella*
3. Asci clavate to ovoid with a long pedicel, apically rounded with an ocular chamber*Vestergrenia*
4. Ascostromata superficial, immersed with a foot-like hypostroma5
4. Ascostromata immersed, covered by cuticle or epidermis7
5. Asci cylindro-clavate, with a short pedicel, apically rounded with a small ocular chamber6
5. Asci broadly clavate with short narrow furcate pedicel and large ocular chamber*Pyrenostigma*
6. Ascostromata superficial on upper surface of the leaf, four to numerous locules*Auerswaldia*
6. Ascostromata superficial on lower surface of the leaf, subglobose to globose*Auerswaldiella*
7. Ascostromata globose to ovoid8
7. Ascostromata flask shaped, ascospores with hyaline apiculus*Phaeobotryosphaeria*
8. Ascospores septate9
8. Ascospores aseptate11
9. Ascospores 1-septate10
9. Ascospores 2-septate*Phaeobotryon*
10. Ascospores uni-seriate, elliptical fusoid, slightly constricted at septum, skull cap-like germ apparatus at the lower end*Macrovalsaria*
10. Ascospores uniseptate with an apiculus at each end, hyaline to brown*Spencermartinsia*

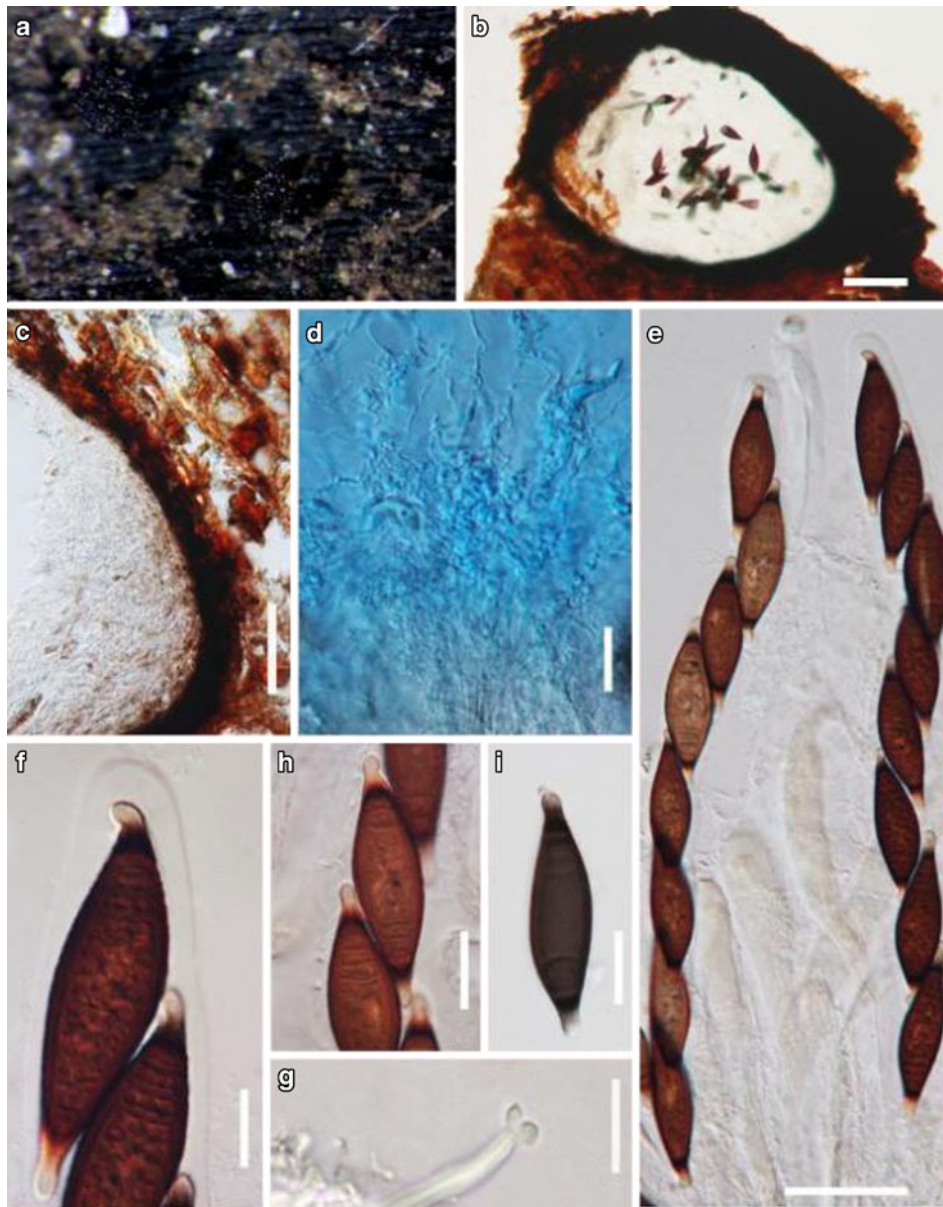


Fig. 18 *Biatriospora marina* (Material examined: SEYCHELLES, on submerged wood of *Rhizophora*, 2 January 1985, K.D. Hyde, IMI 297768, **holotype**). **a** Ascomata semi-immersed on host. **b** Vertical

section of ascoma. **c** Peridium. **d** Pseudoparaphyses stained with lactophenol cotton blue. **e–f** Bitunicate asci. **h–i** Ascospores. **g** Pedicle. Scale bars: **b, c**=100 μ m. **e**=50 μ m. **d, f–i**=20 μ m

- 11. Ascospores brown when mature12
- 11. Ascospores hyaline when mature13
- 12. Ascostromata immersed, discoid to pulvinate or hemisphaerical*Barriopsis*
- 12. Ascostromata immersed to erumpent, subglobose to ovoid, ascospores filiform, with simple appendage.....*Sivanesia*
- 13. Ascostromata erumpent, subglobose.....*Botryobambusa*
- 13. Ascostromata immersed, globose14
- 14. Ascospores spindle shape*Botryosphaeria*
- 14. Ascospores ellipsoidal to fusiform15
- 15. Ascospores with prominent sheath*Neodeightonia*

- 15. Ascospores without mucilaginous sheath.....*Neofusicoccum*

Key to asexual genera of Botryosphaeriaceae

- 1. Conidiomata superficial2
- 1. Conidiomata immersed5
- 2. Conidiophores reduced to conidiogenous cells, holoblastic, cylindrical3
- 2. Conidia occurring in arthric chains in aerial mycelium*Neoscytalidium*
- 3. Paraphyses hyaline, thin walled, usually aseptate*Barriopsis*
- 3. Paraphyses absent4

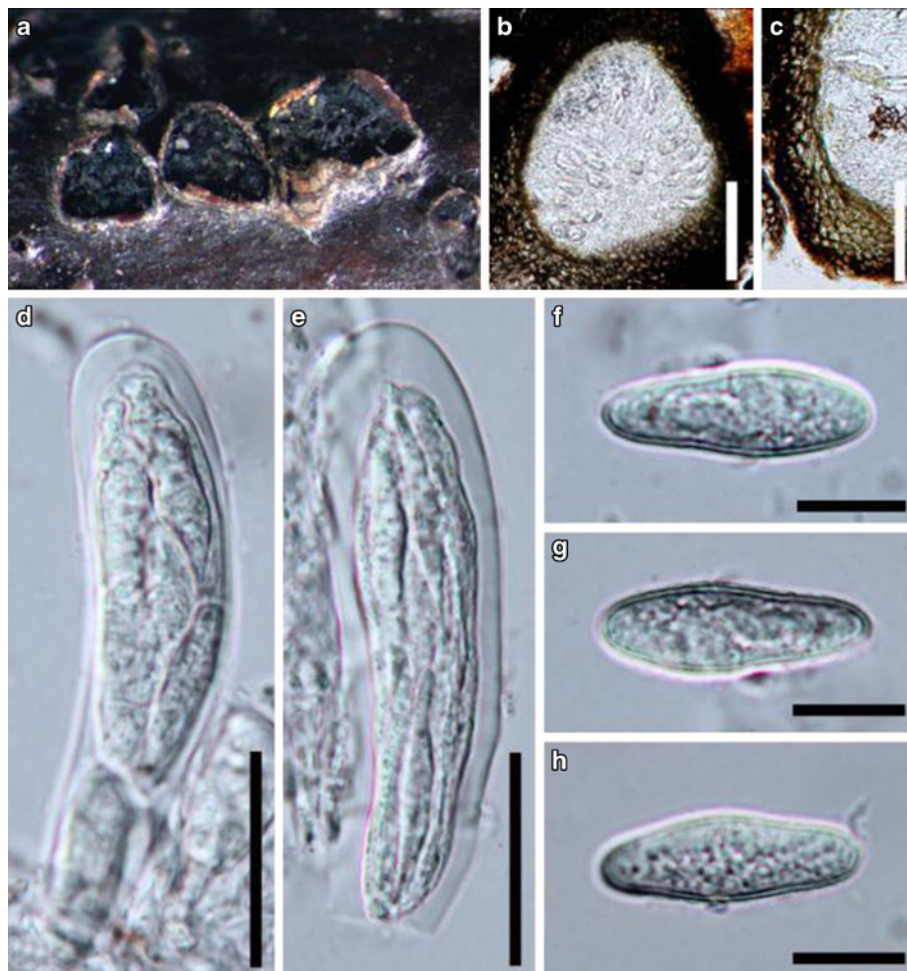


Fig. 19 *Botryosphaeria dothidea* (PREM 57372, epitype) **a** Ascostromata on host substrate. **b** Section through ascostroma. **c** Peridium. **d–e** Asci. **f–h** Ascospores. Scale bars: **b–c**=100 μ m, **d–e**=30 μ m, **f–h**=10 μ m

- | | |
|---|----------------------------|
| 4. Conidia hyaline, fusiform to ellipsoidal..... | <i>Botryobambusa</i> |
| 4. Conidia brown, broadly ellipsoidal to subcylindrical..... | <i>Endomelanconiopsis</i> |
| 5. Conidiomata uni-locular..... | 8 |
| 5. Conidiomata multi-locular..... | 6 |
| 6. Paraphyses septate, Conidiogenous cells holoblastic, smooth walled..... | <i>Aplosporella</i> |
| 6. Paraphyses aseptate..... | 7 |
| 7. Conidia aseptate..... | <i>Neodeightonia</i> |
| 7. Conidia septate..... | <i>Phaeobotryon</i> |
| 8. Conidia septate..... | 11 |
| 8. Conidia aseptate..... | 13 |
| 11. Conidia brown when attached to conidiophores..... | 12 |
| 11. Conidia hyaline when attached to conidiophores, becoming brown when mature..... | <i>Diplodia</i> |
| 12. Mycelium immersed or superficial, branched, septate, melanised..... | <i>Dothiorella</i> |
| 12. Conidiogenous cells lining inner surface of conidiomata..... | <i>Spencermartinsia</i> |
| 13. Matured conidia hyaline..... | <i>Botryosphaeria</i> |
| 13. Matured conidia brown..... | 14 |
| 14. Conidia with undulating striations on the surface..... | 15 |
| 14. Conidia without undulating striations on the surface..... | 16 |
| 15. Conidia with granular content..... | <i>Lasiodiplodia</i> |
| 15. Conidia without granular content..... | <i>Auerswaldia</i> |
| 16. Conidia enclosed in a mucous sheath..... | |
| | <i>Macrophomina</i> |
| 16. Conidia not enclosed in a mucous sheath..... | 17 |
| 17. Conidia apex round, base flat..... | <i>Neofusicoccum</i> |
| 17. Conidia clavate, straight, thick-walled..... | |
| | <i>Phaeobotryosphaeria</i> |
- Brefeldiaceae** E. Müll. & Arx, in Müller & von Arx, Beitr. Kryptfl. Schweiz 11(no. 2): 148 (1962), MycoBank: MB 80534
- Foliar epiphytes* or *parasites* on leaves of various hosts worldwide. Sexual state: *Thallus* relatively large, circular or irregular, or spreading as root-like structures across the leaf

surface, brown to black, extremely thin, covering thyriothecia, and covering host tissue with a skin-like layer; cells of thallus consisting of a single layer of somewhat radially arranged cylindrical to cuboid cells, each cell distinct. *Thyriothecia* circular in outline, flattened, thin-walled, developing under thallus, with numerous asci. *Ostioles* central. *Hamathecium* comprising asci, pseudoparaphyses not observed. *Asci* 8-spored, bitunicate, fissitunicate, saccate, short-pedicellate or sessile, ocular chamber not obvious. *Ascospores* 2–3-seriate, oblong-ellipsoidal or clavate, hyaline, 1-septate, trans-septate or muriform, smooth-walled. Asexual state: see in notes.

Notes: According to Cooke and Hawksworth (1970) the name *Brefeldiaceae* is illegitimate. Eriksson (1981) however, mentioned that Müller and von Arx (1962) referred to a legitimate description by Theissen (of subfam. *Brefeldiineae*) and suggested the name is therefore legitimate. Eriksson (1981) also mentioned the status of the family is uncertain. In this study we accept *Brefeldiaceae* and add several genera. The characters of *Brefeldiaceae* are rather confusing and fresh material and molecular data is needed to establish the taxonomic placement of this family and the various genera that we accommodate in this family. The spreading thallus which covers ascomata with a parallel arrangement of cells is typical of the arrangement of cells in the thyriothecia found in *Asterinaceae* and *Microthyriaceae*. The asci are however, different to those in *Asterinaceae*, saccate to cylindro-clavate in *Brefeldiaceae* and globose in *Asterinaceae*. The *Brefeldiaceae* may therefore be a sister family to *Microthyriaceae*. In this monograph we include *Acrogenotheca*, *Saccardinula*, *Trichopeltina* and *Trichopeltum* in the family mainly because of thallus characteristics and saccate to cylindro-clavate asci. *Acrogenotheca* (type *A. pulcherrima* Bat. & Cif.) was described from undetermined leaves collected in Cuba. Unfortunately more than one taxon is represented on the type material. *Saccardinula* (type *S. guaranitica* Speg.) is a less convincing member of the family as it has globose asci and muriform spores, while the thallus is less developed. *Trichopeltella* (type *T. montana* (Racib.) Höhn.) was described on leaves from Java, Indonesia and although we were only able to find asexual structures, the thallus is typical of *Brefeldiella*. The conidia are produced on small conidiogenous cells that line the conidiomata wall and conidia are cylindrical, hyaline and unicellular. *Trichopeltella* may be a synonym of *Brefeldiella*. *Trichopeltum* (type *T. hawaiiense* Bat. & C.A.A. Costa) was described on leaves of *Smilax* from Hawaii. This species has a spreading root-like thallus which superficially look similar to those in *Teratosphaeriaceae* but are made up of cells typical of *Brefeldiaceae*.

The arrangement of *Brefeldiaceae* as treated here is certainly polyphyletic. Reynolds and Gilbert (2005) also

treated this family with similar wide ranging ascal and thallus characters and the genera certainly need recollecting and sequencing to establish a better phylogeny.

Type: *Brefeldiella* Speg., Boln Acad. nac. Cienc. Córdoba 11(4): 558 (1889), MycoBank: MB 648 Figs. 22, 23 and 24

Foliar epiphytes or *parasites* on leaves of various hosts. Sexual state: *Thallus* relatively large, circular or irregular, or spreading as root-like structures across leaf surface, brown to black, extremely thin, covering some ascomata, and covering host tissue with a skin-like layer; cells of thallus consisting of a single layer of somewhat radially arranged cylindrical to cuboid cells, each cell distinct. *Thyriothecia* circular in outline, flattened, thin-walled, developing under thallus, with numerous asci. *Ostioles* central. *Hamathecium* comprising of asci, pseudoparaphyses not observed. *Asci* 8-spored, bitunicate, fissitunicate, cylindric-clavate, short-pedicellate, apically rounded with small ocular chamber. *Ascospores* 2–3-seriate, hyaline, oblong-ellipsoidal, 1-septate, upper cell wider, shorter, and more rounded than thinner and longer lower cell, thin-walled, smooth-walled. Asexual state: Unknown.

Notes: The genus comprises four species (Index Fungorum 2013). Eriksson (1981) examined the type collection of *B. brasiliensis* Speg. (LPS) which contained numerous ascomata, but which are immature. This genus may have been described on more than one occasion and needs recollecting.

Type species: *Brefeldiella brasiliensis* Speg., Boln Acad. nac. Cienc. Córdoba 11(4): 558 [no. 344] (1889), MycoBank: MB 230084

Other genera included

Acrogenotheca Cif. & Bat., in Batista & Ciferri, Saccardo 2: 51 (1963)

Type species: *Acrogenotheca pulcherrima* Bat. & Cif., Saccardo 2: 52 (1963)

Pycnoderma Syd. & P. Syd., Anns. mycol 12(6): 563 (1914)

Type species: *Pycnoderma bambusinum* Syd. & P. Syd. Anns. mycol 12(6): 563 (1914)

Saccardinula Speg., Anal. Soc. cient. argent. 19(6): 257 (1885)

Type species: *Saccardinula guaranitica* Speg., Anal. Soc. cient. argent. 19(6): 258 (1885)

Trichopeltella Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 458 [66 repr.] (1910)

Type species: *Trichopeltella montana* (Racib.) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 458 [66 repr.] (1910)

Trichopeltina Theiss., Beih. bot. Zbl., Abt. 2 32: 3 (1914)

Type species: *Trichopeltina labecula* (Mont.) Theiss., Zentbl. Bakt. ParasitKde, Abt. II 39: 630 (1914)

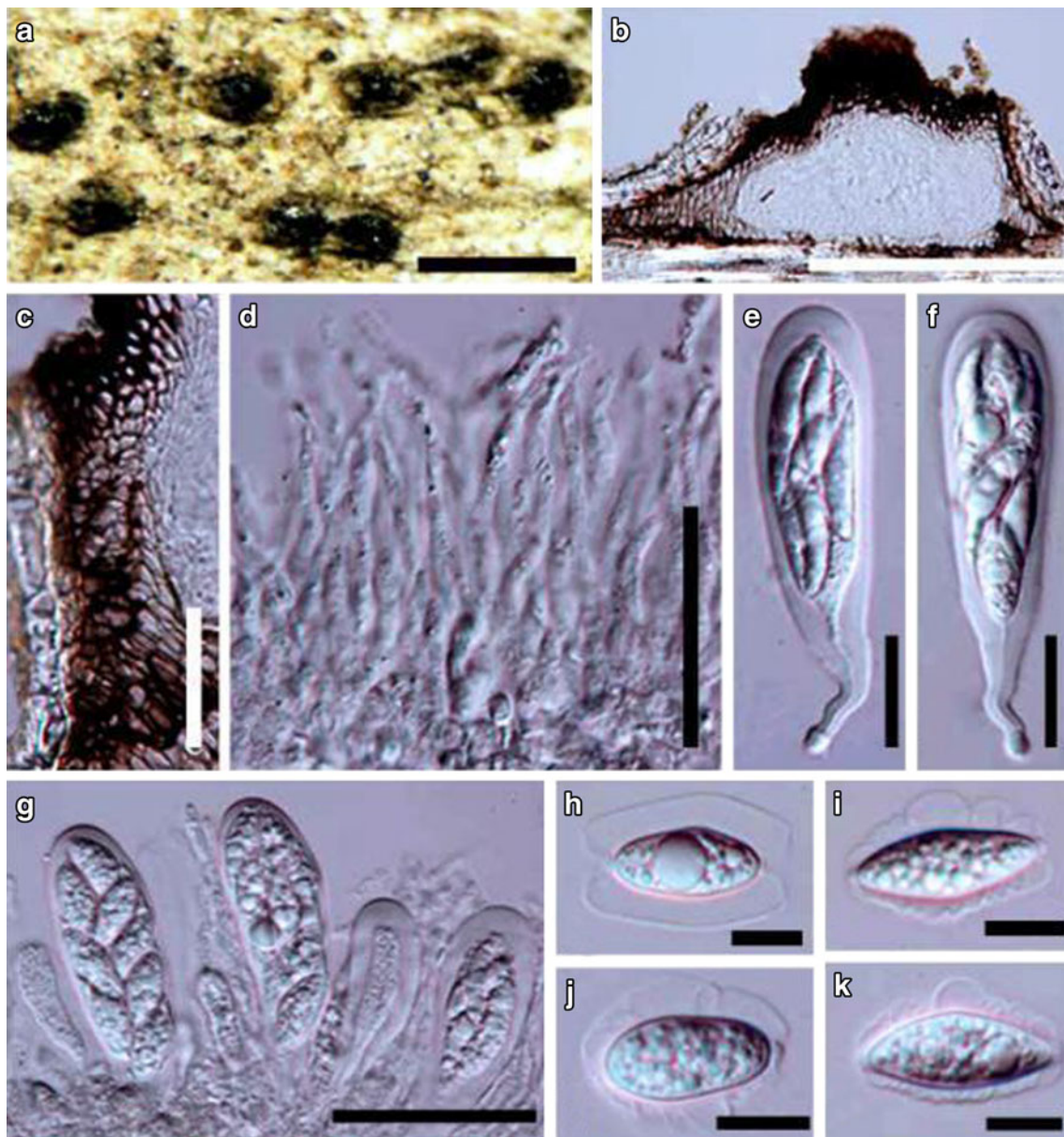


Fig. 20 *Neodeightonia subglobosa* (Material examined: MFLU 11–0199); THAILAND, Lampang Province., Jae Hom District, Mae Yuag Forestry Plantation, on dead culms of *Bambusa* sp., 19 August 2010, R. Phookamsak, RP0079, MFLU 11–0199). **a** Ascomata on host tissue. **b**

Section through uni-loculate ascoma. **c** Section through peridium. **d** Pseudoparaphyses. **e, f** Asci **g** Asci with pseudoparaphyses. **h–k** Ascospores with a prominent sheath. Scale bars: **a** = 500 μ m, **b** = 200 μ m, **c, d, g** = 50 μ m, **e, f** = 20 μ m, **h–k** = 10 μ m

Trichopeltum Bat. et al., in Batista et al., Publções Inst. Micol. Recife 90: 20 (1957)

Type species: *Trichopeltum hawaiiense* Bat. & C.A.A. Costa [as ‘hawaiiensis’], in Batista et al., Publções Inst. Micol. Recife 90: 21 (1957)

Key to genera of Brefeldiaceae

- 1. Thallus appearing as root-like structures growing on the host surface*Trichopeltum*
- 1. Thallus spreading as a regular outgrowths, often rounded or sheet-like on host surface2
- 2. Ascospores muriform3

- 2. Ascospores with transverse septa only4
- 3. Ascospores with slightly constricted at septate, pale brown, gelatinous sheath*Pycnoderma*
- 3. Ascospores with hardly constricted at septate, hyaline*Saccardinula*
- 4. Ascospores 2-celled5
- 4. Ascospores 3-celled*Acrogenotheca*
- 5. Ascospores pale brown*Trichopeltina*
- 5. Ascospores hyaline*Brefeldiella*

Capnodiaceae Höhn. ex Theiss., Verh. zool.-bot. Ges. Wien 66: 363 (1916), MycoBank: MB 82008



Fig. 21 *Neodeightonia palmicola* - asexual state (Material examined: THAILAND, Chiang Rai Province., Muang District, Khun Korn Waterfall, on dead leaves of *Arenga westerhoutii*, 18 Dec 2009, J.K. Liu, JKA0022, MFLU 10-0407, holotype); Chiang Rai Prov., Muang District, Khun Korn Waterfall, on living leaves of *Caryota urens*., 22 Jul 2009, R.

Phookamsak, RP0004 (MFLU 100409 **a, b** Conidiomata on pine needles. **c** Section of conidioma. **d, e** Conidiogenous cells. **f, g** Young conidia. **h, i** Mature conidia with septa. Scale bars: **a, b**=500 μm , **c**=100 μm , **d, e**=30 μm , **g–j**=10 μm

Saprobic on honey dew excretions from insects, usually forming blackened sooty-like regions on green healthy leaves, stems, bark and even rocks and often in association with numerous other species and fungicolous taxa. *Thallus* comprising mycelium with black sooty growth on the host surface, producing superficial colonies with septate, cylindrical, brown hyphae. Sexual state: *Ascomata* arise from the mycelial mass, subglobose to globose, coriaceous, with or without setae, dark

brown, with a central ostiole. *Peridium* brown, relatively thin, comprising cells of *textura angularis*. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, saccate, with a short pedicel, lacking an ocular chamber. *Ascospores* overlapping bi-seriate, multi-septate or muriform, hyaline to brown. Asexual states: pycnidial, mostly elongated, with short or long narrow necks, and with or without a swelling where the conidia are produced. *Ostiole* prominent at the apex of the

pycnidial neck. *Conidia* occur on typical capnodiaceous hyphae within the pycnidia, small, one-celled, ellipsoidal, hyaline.

Notes: The family *Capnodiaceae* was introduced by von Höhnel (1909a) and validated by Theissen (1916) according to von Arx and Müller (1975) and Hughes (1976), and is circumscribed as dothideomycetous sooty moulds with mostly pycnidial asexual states (Reynolds 1982). Kirk et al. (2008) stated the *Capnodiaceae* include 26 genera and 117 species, while Lumbsch and Huhndorf (2010) mentioned 13 genera. Chomnunti et al. (2011) revisited the *Capnodiaceae* and removed many genera to other families based on morphological characters of type specimens, thus only five genera are now accepted in *Capnodiaceae*.

The taxa of this family can be recognized by black mycelial growth spreading on the host surface which produces superficial colonies with septate, cylindrical, dark-brown hyphae. Ascomata arise from the mycelial mass and are subglobose to globose (Sivanesan 1984; Barr 1987a). Their asexual states form elongated pycnidia that develop from a superficial mycelium on living plant surfaces. Pycnidia have short or long narrow necks with a conspicuous oval swelling which produce minute, unicellular and hyaline conidia from near the base, middle or apex (Chomnunti et al. 2011).

In the past some members of the family had been known only from asexual states, and these pycnidia had been assigned to one or other sexual state genera and families depending on whether the researchers gave more emphasis to Saccardoan generic concepts such as spore morphology and colour, or colony hyphal development, hyphal morphology and ascomatal and pycnidial formation (as with Hughes 1976). The use of molecular techniques has now enabled us to confirm their relationships in the *Capnodiaceae*. Crous et al. (2009b) used molecular methods to evaluate the monophyly of the order *Capnodiales*, yet they did not discuss the family in detail, although concluding that it probably contained diverse lineages. Chomnunti et al. (2011) used a RAxML maximum likelihood tree based on combined LSU and SSU genes to show that *Capnodium*, *Leptoxyphium*, *Phragmocapnias* and *Scorias* are resolved genera in *Capnodiaceae*.

Type: *Capnodium* Mont. Anns Sci. Nat., Bot., sér. 311: 233 (1849), MycoBank: MB 809 Figs. 25 and 26

Saprobic on sugary exudates from insects growing on the surface of leaves, fruits, stems and other non plant objects. *Thallus* a loose or dense network of pale brown, superficial hyphae or a thick pseudoparenchymatous stroma, with sexual and asexual states often growing together. Sexual state: *Ascomata* superficial on mycelium of thallus, brown to dark brown or black, globose to ellipsoidal, short-stalked or sessile, ostiolate at maturity, scattered or in groups, without setae. *Peridium*

comprising dark brown to pale brown, thick-walled cells forming a *textura angularis*. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, clavate, ovoid or saccate, apedicellate, lacking an ocular chamber. *Ascospores* overlapping bi-seriate, brown, oblong or ovoid and some reniform, transversely septate with one or more vertical septa or without vertical septa. Asexual state: “*Polychaeton*” spp. *Pycnidia* elongate, often with long stalks, dark brown. *Ostiole* at apex of pycnidia with hyphae continued upwards to the tapered neck, terminating in an ostiole which is surrounded by dull hyphal round ends. *Conidia* hyaline, 1-celled.

Notes: Chomnunti et al. (2011) revisited the sooty mould genera in *Capnodiaceae* based on examination of types and a RAxML maximum likelihood tree based on combined LSU and SSU genes, using 15 specimens of sooty moulds from Thailand; *Phragmocapnias* and *Scorias* were also epitypified (Chomnunti et al. 2011). In addition, it was suggested that *Capnodium* should be used rather than *Polychaeton*, because it is better known, has widespread use and is the sexual state and type of the family and order. Hawksworth (2012) gave *Capnodium* as the example for widely used names of fungi that could be proposed for use, against the older lesser used asexual name (*Polychaeton*). It is expected that *Capnodium* will be defined for future use in the lists of accepted names to be approved by the General Committee under Art. 14.13. The sexual state of *Capnodium* is illustrated here based on *Capnodium tiliae* Berk. & Desm., and the asexual state is illustrated based on a recent collection of *Capnodium coartatum* Chomnunti & K.D. Hyde., *Acanthorus* Bat. & Cavalc. was reported in *Abolisiaceae* which is pycnidial (Batista and Cavalcante 1967) and an invalid family. Kirk et al. (2008) mention that *Acanthorus* is the asexual state of *Capnodiaceae*, but this has not been followed by other researchers.

Type species: *Capnodium citri* Berk. & Desm., in Berkeley, Journal of the Royal Horticultural Society 4: 11 (1849), MycoBank: MB 164508

Other genera included

Leptoxyphium Speg., Physis, B. Aires 4: 294 (1918)

Type species: *Leptoxyphium graminum* (Pat) Speg., Physis, B. Aires 4: 294 (1918)

Phragmocapnias Theiss. & Syd., Anns mycol. 15(6): 480 (1918) [1917]

Type species: *Phragmocapnias betle* (Syd., P. Syd & E.J. Butler) Theiss. & Syd., Anns mycol. 15(6): 480 (1918) [1917]

Scorias Fr. Syst. mycol. 3(2): 269, 290 (1832)

Type species: *Scorias spongiosa* (Schwein.) Fr., Syst. mycol. 3(2): 291 (1832)

Scoriadopsis J.M. Mend., in Stevens, Anns mycol. 28 (5/6): 365 (1930)

Type species: Scoriadopsis miconiae J.M. Mend., in Stevens, *Annls mycol.* 28 (5/6): 365 (1930)

Key to genera of *Capnodiaceae*

1. Pycnidia with a black stalk, and an upper brown swollen region producing conidia; ascospores hyaline *Phragmocapnias*
1. Pycnidia without a black stalk or an upper brown swollen region producing conidia; ascospores brown or hyaline **2**
2. Pycnidia lacking a basal bulbous part; ascospores brown *Capnodium*
2. Pycnidia with basal bulbous part; ascospores other than above **3**
3. Ascomycetous state unknown, pycnidia with narrow bulbous base, apex cup-like which produces conidia *Leptoxyphium*
3. Pycnidia with swollen bulbous base; ascomata present, gregarious on blacked mycelial mat **4**
4. Ascospores mostly 3-septate *Scorias*
4. Ascospores mostly 1-septate *Scoriadopsis*

Cladosporiaceae Nann., *Repert. mic. uomo*: 404 (1934), MycoBank: MB 80600

Synonym:

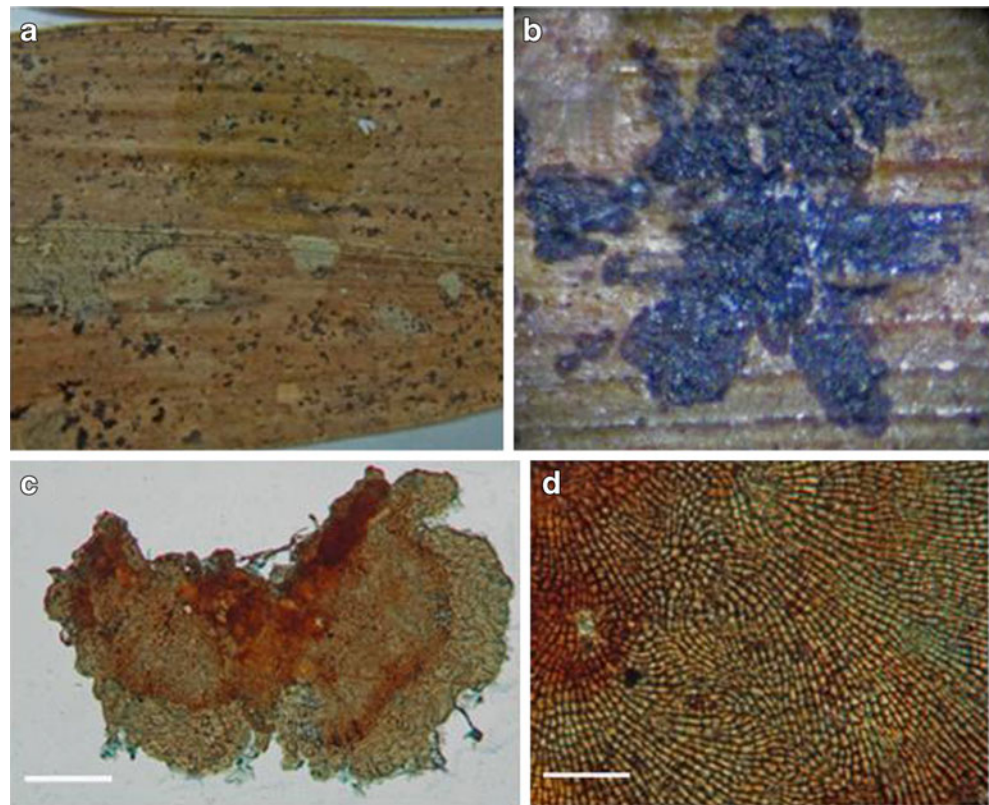
Davidiellaceae C.L. Schoch, Spatafora, Crous & Shoemaker, in Schoch, Shoemaker, Seifert, Hambleton, Spatafora & Crous, *Mycologia* 98(6): 1048 (2007) [2006], MycoBank: MB 504453

Saprobic or *phytopathogenic*, also endophytic and involved in diseases of humans and animals. Sexual state: *Ascomata* pseudothecial, gregarious or scattered, inconspicuous, black to red-brown, globose to subglobose, uniloculate, inconspicuous and immersed in the substratum to superficial, in plant pathogenic species beneath stromata, situated on a reduced stroma, with 1(–3) short, periphysate ostiolar necks; periphysoids frequently growing down into cavity. *Ostiole* necks, with numerous periphysoids. *Peridium* consisting of 3–6 layers of dark brown cells, usually *textura angularis*. *Hamathecium* of hyaline, septate, subcylindrical pseudoparaphyses, present in mature ascomata. *Asci* 8-spored, bitunicate, fissitunicate, sessile to short-stalked, obovoid to broadly ellipsoid or subcylindrical, straight to slightly curved. *Ascospores* bi- to multi-seriate, or overlapping, hyaline, obovoid to ellipsoid-fusiform, with irregular luminal inclusions, mostly thick-walled, straight to slightly curved; with age frequently becoming brown and verruculose in asci, 1-septate, not or somewhat constricted at the septum, at times covered by a mucilaginous sheath. Asexual state: hyphomycetous. *Conidiophores* macronematous, mononematous, simple or branched, brown. *Conidiogenous cells* integrated, terminal and intercalary, sympodial or synchronous,

holoblastic, mostly polyblastic, conidiogenous loci conspicuous, mostly protuberant, darkened-refractive, coronate, i.e. composed of a convex central dome (which is the slightly bulging half of the original septum, delimiting the conidium and the conidiogenous cell, after being cleft) and a raised periclinal rim. *Conidia* solitary or mostly in branched or unbranched acropetal chains, amero-, didymo- to phragmosporous, subhyaline to brown, smooth to verrucose or echinulate, sometimes forming ramoconidia, dry, conidium secession schizolytic (Schoch et al. 2006; Seifert et al. 2011; Bensch et al. 2012).

Notes: Schoch et al. (2006) introduced the new family *Davidiellaceae* in *Capnodiales* to accommodate *Davidiella* with its *Cladosporium* asexual morphs (type species *Davidiella tassiana* (De Not.) Crous & U. Braun, asexual state *Cladosporium herbarum* (Pers.: Fr.) Link.). Previously, Ellis (1971, 1976) and Sivanesan (1984) had reported *Cladosporium* as the asexual states of *Mycosphaerella* and placed the genus in *Mycosphaerellaceae*. Braun et al. (2003) clearly showed that *Mycosphaerella sensu stricto* and *Cladosporium herbarum*, the type of *Cladosporium*, belong to different phylogenetic lineages. At the same time they showed several “*Mycosphaerella*”-like sexual states grouped with *C. herbarum* that possessed ascomata which were very similar to *Mycosphaerella* sect. *Tassiana*. Hence they introduced the new genus *Davidiella* for “*Mycosphaerella*”-like sexual morphs connected to *Cladosporium* asexual morphs. This was confirmed by Schoch et al. (2006) who introduced the family *Davidiellaceae*. Previous concepts of *Cladosporium* had been very broad, covering a wide range of dematiaceous hyphomycetes with conidia formed in acropetal chains (Dugan et al. 2004). Braun et al. (2003) and Crous et al. (2007b) treated *Cladosporium sensu stricto* along with *Davidiella*, and discussed the circumscription of this genus and its delimitation from morphologically similar, often confused genera. Crous et al. (2007b) provided a key to cladosporioid genera, which is in slightly modified form also included in Seifert et al. (2011). Numerous “*Cladosporium*”-like species, previously referred to as *Cladosporium sensu lato* but not congeneric, belong elsewhere and have been reallocated to different genera. For example, *C. malorum* Rühle (*Pleosporales*) was first moved to *Alternaria* (Braun et al. 2003) and later to *Chalastospora* (Crous et al. 2009b). Other cladosporioid fungi with unthickened, non-coronate conidiogenous loci, belonging to the *Venturiaceae*, represent *Fusicladium* asexual states of *Venturia* (Schubert et al. 2003; Crous et al. 2007b). Species of the genera *Graphiopsis*, *Rachicladosporium*, *Toxicocladosporium* and *Verrucocladosporium* are morphologically cladosporioid, except for lacking coronate conidiogenous loci, but phylogenetically distinct. They cluster in adjacent position but do not belong to the *Cladosporiaceae* clade *sensu stricto* (Crous et al. 2007b: 36, Fig. 1). Based on

Fig. 22 *Brefeldiella brasiliensis* (Material examined: BRAZIL, Apiahy, on leaves of Bambusaceae, J. Puiggari, no 2356, 1888, **holotype**). **a, b** Appearance of thallus on substrate **c** Squash of thallus. **d** Arrangement of cells of thallus. Scale bars: **c–d** = 100 μ m



the new ICN, Hawksworth (2012) proposed to use *Cladosporium* as holomorph genus as it is the oldest and most widely used name. Bensch et al. (2012), who published a comprehensive monograph of *Cladosporium*, also used the latter name in this sense and reintroduced the old family name *Cladosporiaceae* instead of *Davidiellaceae*. We also suggest using *Cladosporiaceae* hereafter, as it is older than *Davidiellaceae* and reflects the current use of *Cladosporium* as holomorph name. This family is homotypic, i.e. it comprises only the genus *Cladosporium*, including

holomorphs with asexual hyphomycetous and their sexual “*Davidiella*” states and “*Davidiella*” teleo-holomorphs, without any asexual states and asexual states which may be ana-holomorphs.

Type: Cladosporium Link, Mag. Gesell. naturf. Freunde, Berlin7: 37. 1816 [1815], MycoBank: MB 7681

Figure 27

Acrosporella Riedl & Ershad, Sydowia 29(1–6): 166 (1977) [1976] *Davidiella* Crous & U. Braun, in Braun et al., Mycol. Progr. 2(1): 8 (2003) *Notes*: The genus *Cladosporium* was introduced by Link (1816) [1815] and it is considered as one of the largest and most heterogeneous genera of hyphomycetes (Dugan et al. 2004), currently comprising 773 epithets (Index Fungorum 2013). Bensch et al. (2012) however, included 139 names of “*Heterosporium*” (reduced “*Heterosporium*” under *Cladosporium*) in their monograph of *Cladosporium sensu lato*. Hence the total number of epithets in *Cladosporium sensu lato* is 993 (854 in *Cladosporium* and 139 in “*Heterosporium*”) (Bensch et al. 2012). *Cladosporium sensu stricto* (asexual state of ‘*Davidiella*’) is characterised by having coronate conidiogenous loci and conidial hila, i.e., with a convex central dome surrounded by a raised periclinal rim (Bensch et al. 2012).

Type species: Cladosporium herbarum (Pers.) Link, in Willdenow, Willd., Sp. pl., Edn 4 6(1): 556 (1816), MycoBank: MB 231458

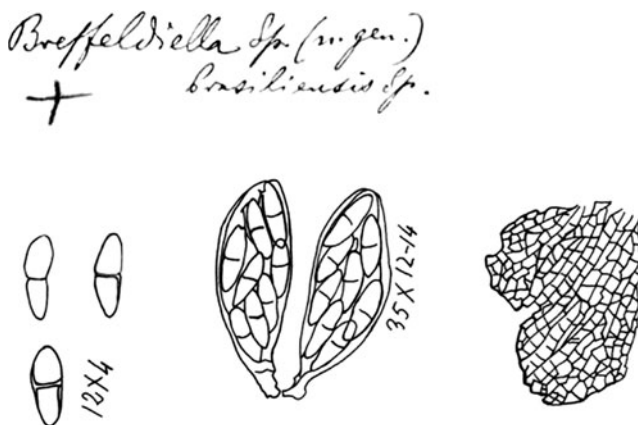


Fig. 23 *Brefeldiella brasiliensis* ascospores, asci and structure of thallus (redrawn from Spegazzini’s drawing on the herbarium packet (http://www.cybertruffle.org.uk/spegazzini/eng/001400a_.htm))



Fig. 24 *Trichopeltina labecula* (Material examined: FRENCH GUYANA, Gabaret River, on coriaceous leaf, September 1835, Coll. no. 664, PC0084645, **syntype**). **a** Herbarium specimens. **b** Thallus on host substrate. **c** Thyrtothecia within thin superficial thallus in 70 % lactic acid. **d** Cells of thallus and thyrtothecium ostiole. **e** Cells of thallus. **f**

Hamathecium in Melzer's reagent. **g** Ascus when immature in Melzer's reagent. **h** Ascus in Melzer's reagent. **i** Ascus in lactophenol cotton blue reagent. **j** Ascospore in 70 % lactic acid. **k** Ascospore in Melzer's reagent. **l** Ascospore in Lactophenol cotton blue reagent. Scale bars: **c** = 100 μ m. **e–i** = 20 μ m. **j–l** = 10 μ m

Other genera included

Acroconidiella J.C. Lindq. & Alippi, Darwiniana 13(2–4): 612 (1964)

Type species: Acroconidiella tropaeoli (T.E.T. Bond) J.C. Lindq. & Alippi, Darwiniana 13(2–4): 613 (1964)

Graphiopsis Trail, Scott., N.S. 4 ('10'): 75 (1889)



Fig. 25 *Capnodium tiliae* (Material examined: GERMANY, Biebrich, on branch of *Tilia parviflora*, Herbarium Fuckel no. 899 1894, G, Herbarium Barbey Boissier, exsiccata of *Fumago tiliae*). **a** Label data and specimen. **b** Vertical section through ascoma. **c** Dark brown mycelium. **d** Peridium.

e, f. Peridium with cells of *textura angularis*. **g–i** Cylindrical to cylindrical-clavate asci. **j.** Ascospores 3–4-septate. Scale bars: **f**=200 μ m, **b–d**=100 μ m, **e, g–i**=20 μ m, **j**=10 μ m

Type species: Phaeoisaria clematidis (Fuckel) S. Hughes, Can. J. Bot. 36: 794 (1958)

Hoornsmania Crous, in Crous et al., Fungal Planet 11: [2] (2007)

Type species: Hoornsmania pyrina Crous, Fungal Planet 11–21: 11: [2] (2007)

Rachicladosporium Crous, U. Braun & C.F. Hill, in Crous et al., Stud. Mycol. 58: 38 (2007)

Type species: Rachicladosporium luculiae Crous, U. Braun & C.F. Hill, in Crous, Braun, Schubert & Groenewald, Stud. Mycol. 58: 39 (2007)

Toxicocladosporium Crous & U. Braun, in Crous, Braun, Schubert & Groenewald, Stud. Mycol. 58: 39 (2007)

Type species: Toxicocladosporium irritans Crous & U. Braun, in Crous, Braun, Schubert & Groenewald, Stud. Mycol. 58: 39 (2007)

Verrucocladosporium K. Schub., Aptroot & Crous, in Crous, Braun, Schubert & Groenewald, Stud. Mycol. 58: 41 (2007)

Type species: Verrucocladosporium dirinae K. Schub., Aptroot & Crous, in Crous, Braun, Schubert & Groenewald, Stud. Mycol. 58: 41 (2007)



Fig. 26 *Capnodium coartatum* (Material examined: THAILAND, Chiang Rai, on living leaf of *Bischofia javanica*, 27 April 2011, Putarak Chomnunti 001, MFLU11–1155, **holotype**) **a–c** Appearance of sooty

moulds on host. **d–g** Elongate pycnidia. **e** Globose, septate mycelium. **h** Conical pycnidium. **i** Ostiole surrounded by hyaline hyphae. **j** Conidia. Scale bars: **d, e, g** = 50 μm , **f, h** = 20 μm , **i, j** = 10 μm

Key to the asexual genera of *Cladosporiaceae*

1. Setae unbranched, brown *Acroconidiella*
1. Setae absent 2
2. Conidiophores compact, dense *Graphiopsis*
2. Conidiophores solitary 3
3. Conidiogenous cell cylindrical *Cladosporium*
3. Conidiogenous cell elongate-ellipsoid to fusoid *Hoornsmania*

Coccoideaceae Henn. ex Sacc. & D. Sacc., Syll. fung. (Abellini) 17: 860 (1905), MycoBank: MB 80616

Parasitic on living leaves. Sexual state: *Ascstromata* large, up to 2 mm diam, single to solitary, or scattered, mostly superficial, slightly immersed in host tissue, circular to subcircular, discoid, cushion-like, semicircular in section, edge entire, slightly convex at the top, raised from the base, black, thickened at the base, soft, with numerous locules, in a layer in the upper part the ascostromata. *Cells of ascostromata* comprising heavily, pigmented cells of *textura angularis*. *Locules* completely immersed in ascostromata, globose, subglobose or obpyriform, with apical ostiole. *Hamathecium* of filiform, anastomosing, branched, septate, hyaline,

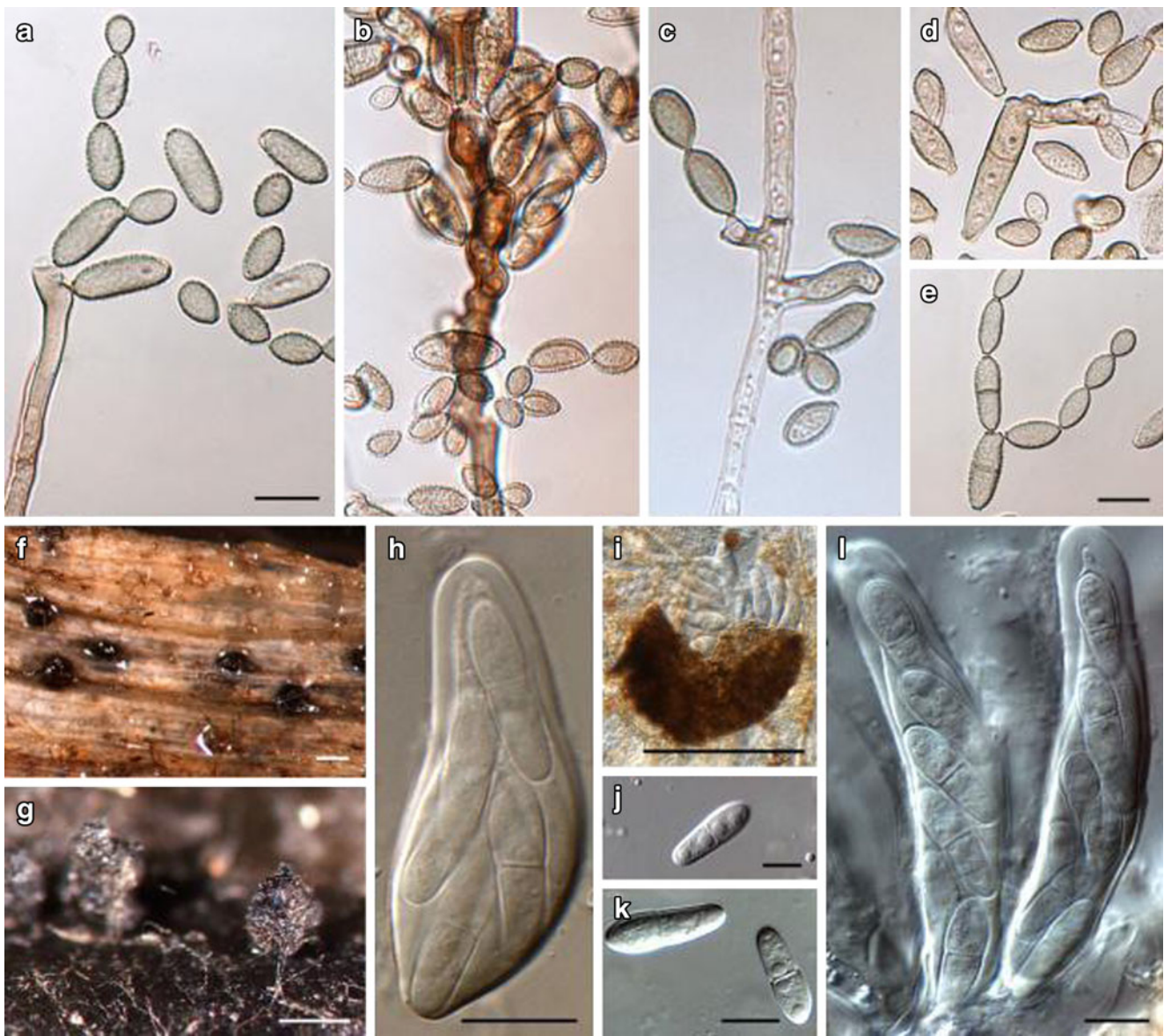


Fig. 27 *Cladosporium herbarum* (CPC 11600), asexual and sexual morphs (from the host and CPC 12181). **a, b** Macronematous conidiophores. **c** Micronematous conidiophores. **d** Microcyclic conidiogenesis.

e Conidial chain. **f** Ascomata on the leaf. **g** Ascomata formed in culture on nettle stems. **h–i** Asci on the host. **j–k** Ascospores in culture. **l** Asci in culture. Scale bars: **a, e, h, j–l** = 10 μm **f–g, l** = 200 μm

relatively wide pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to subclavate, pedicellate, apically rounded, with a distinct, wide, ocular chamber. *Ascospores* 2-seriate, apiosporous, ellipsoidal-obovoid, slightly oval, subglobose, yellowish to light brown, tapering towards the narrow, lower end, 1-septate at the lower end, not constricted at the septum, darkened at the septa, smooth-walled. Asexual state: Unknown.

Notes: The family *Coccoideaceae* was invalidly introduced by Hennings (1904a) and was subsequently validly published in Saccardo and Saccardo (1905). These are mainly parasites on the lower surface of living leaves and have superficial, circular or discoid and darkly pigmented, ascostromata (Saccardo and Saccardo 1905). The family

Coccoideaceae now includes three genera and is placed under *Dothideales* in Kirk et al. (2008). Lumbsch and Huhndorf (2010) however, list two genera, i.e. *Coccoidea* and *Cocoidella* placed in *Dothideomycetes incertae sedis*. There is no molecular data to confirm these placements. The family is based on the type species *C. quercicola* Henn. & Shirai from Japan, which we have not been able to locate. von Höhnelt (1909b) added a second genus *Cocoidella*, having circular and flattened ascostromata and bitunicate, oblong asci (Berkeley 1876). We have examined this which mainly differs in having 2-celled ascospores. Both genera are placed in the same family based on only morphological classification and the genera need to be re-studied.

Type: *Coccoidea* Henn., Bot. Jb. 28: 275 (1900),
Mycobank: MB 1144 Fig. 28

Possible synonyms:

Apiodothina Petr. & Cif., Annl. mycol. 30(3/4): 153
(1932)

Coccodiscus Henn., Hedwigia 43: 144 (1904)

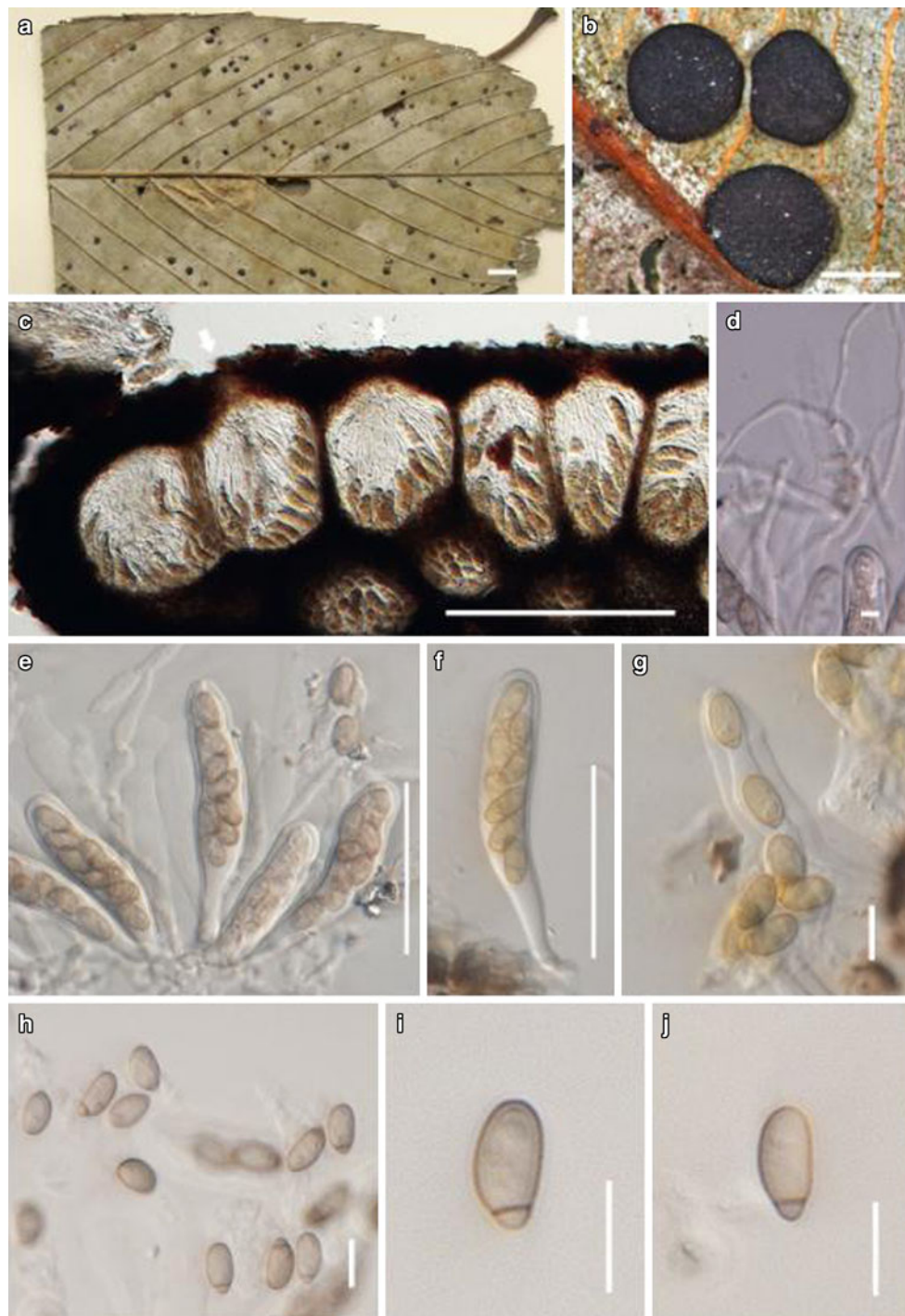


Fig. 28 *Coccoidea quercicola* (Material examined: INDIA, Sukliapokhari, Alt. 7,000 ft., on living leaves of *Quercus lamellosa* Sm., 11 May 1967, M.K. Maity PCC 1252, BPI 643971). **a, b** Ascostromata. **c** Section of ascostroma (Note ostioles - arrowed). **d**

Pseudoparaphyses. **e–g** Immature and mature asci, with a wide ocular chamber. Note: Fissitunicate ascus when releasing ascospores. **h–j** Ascospores. Scale bars: **a** = 5 mm, **b** = 1 mm, **c** = 200 μ m, **d, f–g** = 50 μ m, **h–j** = 10 μ m

Parasitic on living leaves of *Quercus lamellosa*. Sexual state: *Ascstromata* large, up to 2 mm diam, single to solitary, or scattered, mostly superficial, slightly immersed in host tissue, circular to subcircular, discoid, cushion-like, semicircular in section, edge entire, slightly convex at the top, raised from the base, black, thickened at the base, soft, with numerous locules, in a layer in the upper part the ascstromata. *Cells of ascstromata* comprising heavily pigmented cells of *textura angularis*. *Locules* of ascstromata completely immersed in ascstromata, globose to subglobose or obpyriform, with upper ostiole. *Hamathecium* of filiform, anastomosing, branched, septate, hyaline, relatively wide pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical-clavate, with short to long pedicels, apically rounded, with a wide ocular chamber. *Ascospores* 1–2-seriate, ellipsoidal-obovoid, slightly oval, subglobose, tapering towards narrow, nipple-like base, hyaline and 1-celled when immature, at maturity, 1-septate near the lower end, not constricted and dark brown at the septum, yellowish to light brown, smooth-walled. Asexual state: Unknown.

Notes: *Coccoidea* was introduced by Hennings (1900), for species with superficial, circular-shaped and black ascstromata. The locules are reported to be in a layer at the top of the ascstromata. Besides the type species it contains three other epithets (Müller and Sanwal 1954; Sawada 1959; Müller and von Arx 1962; Kobayashi et al. 1992; Kishi 1998), one being the type of *Coccoidella*. Both genera have been placed in *Venturiaceae*, *Pseudosphaeriales* (Müller and von Arx 1962). The specimen illustrated here is from India (Kar and Maity 1971) and is different to the Japanese species in having many locules scattered throughout the larger ascstromata. The genus and family need to be restudied.

Type species: *Coccoidea quercicola* Henn. & Shirai, in Hennings, Bot. Jb. 28: 275 (1900) MycoBank: MB 167300

Other genera included

Coccoidella Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 847 [35 repr.] (1909)

Type species: *Coccoidella scutula* (Berk. & M.A. Curtis) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 847 [35 repr.] (1909)

Key to genera of *Coccoideaceae*

1. Asci slightly oval, septate at the lower end, yellowish-brown to light brown *Coccoidea*
1. Asci ellipsoidal-oblong to clavate, septate at the centre, hyaline-pale brown *Coccoidella*

Coniothyriaceae W.B. Cooke, Revta Biol., Lisb. 12: 289 (1983), MycoBank: MB: 80635

Sexual state: Unknown. *Pathogens* of leaves or bark. Asexual state: *Conidiomata* pycnidial, separate, globose, dark or pale brown, immersed, uni-ocular, thin-walled; wall of brown, thick-walled cells of *textura angularis* or *globulosa*.

Ostiole circular, central, sometimes papillate. *Conidiophores* absent. *Conidiogenous cells* holoblastic, annellidic, indeterminate, discrete, doliiform to cylindrical, hyaline or pale brown, smooth, with 1- close or widely separated annellations, formed from the inner cells of the pycnidial wall. *Conidia* hyaline to brown, thick-walled, 0–1-euseptate, verruculose, apex obtuse, base truncate (sometimes with a marginal frill), cylindrical, sphaerical, elliptical or broadly clavate.

Notes: Cooke (1983) introduced this family to accommodate *Coniothyrium* spp. However, Kirk et al. (2008) synonymized *Coniothyriaceae* with *Leptosphaeriaceae*. This was followed by several researchers (de Gruyter et al. 2009; Schoch et al. 2009a, b; Aveskamp et al. 2010). However, de Gruyter et al. (2012) showed that *C. palmarum* Corda has distinct phylogenetic relationships with *Leptosphaeriaceae*. Therefore they reinstated the family *Coniothyriaceae* in *Pleosporales*. In their study they transferred some *Phoma* spp. to *Coniothyrium* as they group in clade *Coniothyriaceae*. Although *C. palmarum* is placed in *Coniothyriaceae*, *C. minitans* W.A. Campb. and *C. sporulosum* (W. Gams & Domsch) Aa grouped in *Montagnulaceae* hence they were moved to a new genus, *Paraconiothyrium* (Verkley et al. 2004). *Coniothyrium zuluense* M.J. Wingf. was shown to be accommodated in *Mycosphaerellaceae* (Cortinas et al. 2004), but Cortinas et al. (2006) and Crous et al. (2009c) transferred *C. zuluense* to *Colletogloeopsis* and showed it best accommodated in *Teratosphaeriaceae*. However, *C. concentricum* (Desm.) Sacc. belongs in *Phaeosphaeriaceae*.

Type: *Coniothyrium* Corda, Icon. fung. (Prague) 4: 38 (1840), MycoBank: MB 7765

Figure 29

Type species: *Coniothyrium palmarum* Corda, Icon. fung. (Prague) 4: 38 (1840), MycoBank: MB 170942

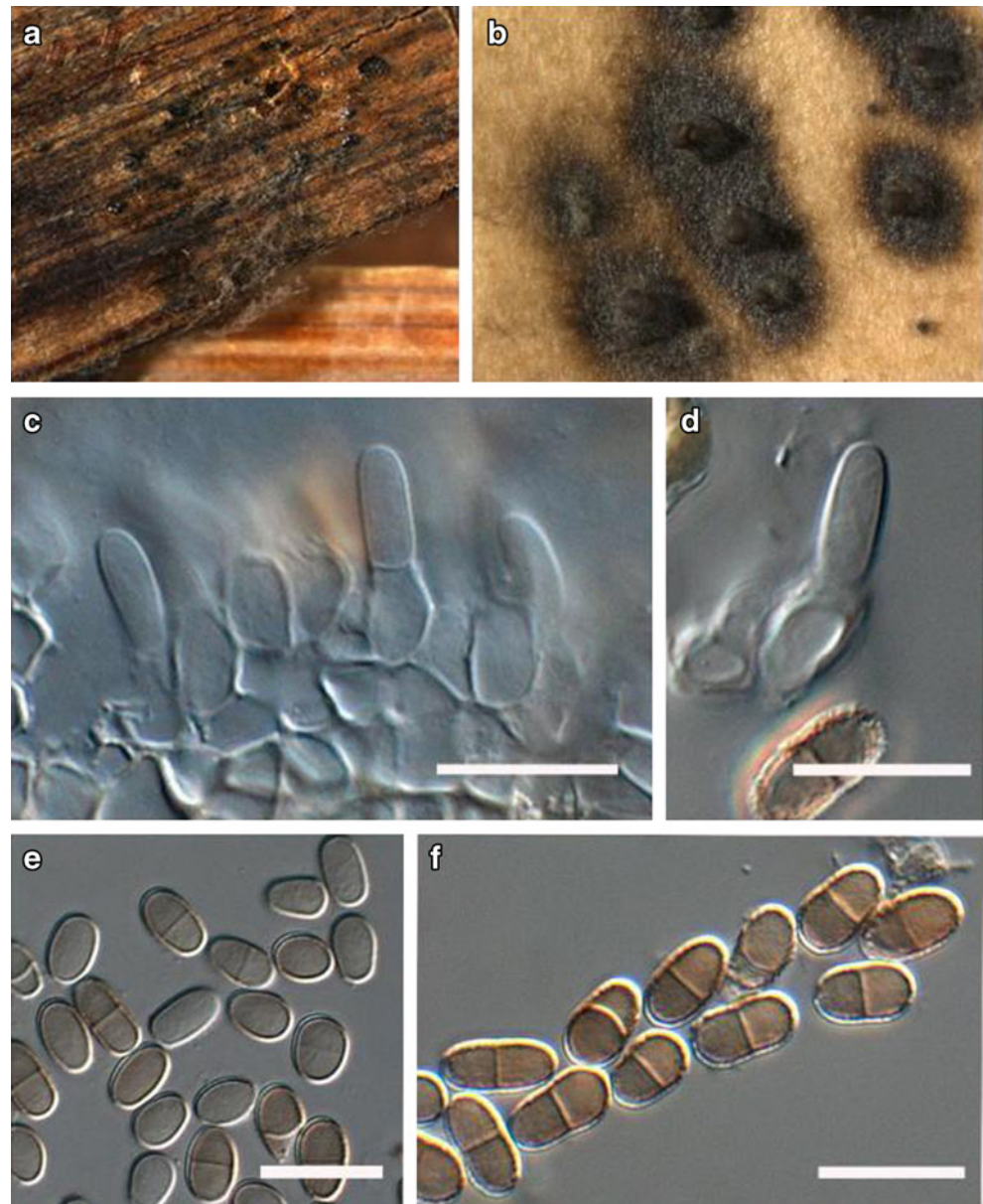
Cookellaceae Höhn. ex Saccardo & Trotter, in Saccardo, Syll. Fung. (Abellini) 22: 585 (1913), MycoBank: MB 80637

Possible synonym:

Uleomycetaceae Moreau [as ‘Uléomycétacées’], Les Champignons 2: 1384 (1954)

Parasitic on leaves in terrestrial habitats, some possibly fungicolous. Sexual state: *Ascstromata* superficial, subglobose or irregular, pulvinate to effuse, cushion-shaped, surface rough, flat or applanate at the base, scattered, pigmented, containing locules with individual asci, non-papillate, opening by breaks in the upper surface; soft-textured, cells of ascstromata comprising *textura angularis* to *subglobulosa*, with a basal hypostroma, developing in the host tissue, appearing as stromal blocks and swollen cells, of compressed packages of *textura angularis* to *prismatica*. *Locules* scattered throughout ascstromata, small, globose-subglobose, containing single asci, wall not obvious. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, globose to subglobose or saccate,

Fig. 29 *Coniothyrium palmarum* (Material examined: CBS 400–71). **a, b** Conidiomata on *Chamaerops humilis* (Palmae). **c, d** Developing conidia attach to conidiogenous cells. **e** Immature conidia with 0–1 septa. **f** Mature conidia with one septum. Scale bars. **c–f** = 10 μ m



apedicellate, lacking an ocular chamber. *Ascospores* scattered in 3–5-seriate overlapping rows, muriform, ellipsoid to oblong, hyaline when immature, becoming brown at maturity, straight to slightly curved, ends rounded, with 3-transverse septa and 1-longitudinal septum in each cell, constricted at the septa, smooth-walled. Asexual state: (see notes under genus).

Notes: The family *Cookellaceae* was introduced by von Höhnelt (1909b) as *Cookellaceen*, and formally published by Saccardo and Trotter (1913). The family is characterized by superficial pulvinate to effuse, cushion-shaped, pigmented ascostromata, without pseudoparaphyses, forming hypostroma in the host tissues. Asci are arranged in individual locules, irregular and mostly globose to subglobose. Ascospores are hyaline to brown, septate and muriform, and forcible discharge of ascospores occurs at maturity (von

Höhnelt 1909b; von Arx 1963; von Arx and Müller 1975; Barr 1979a, 1987a). von Höhnelt (1909a) initially placed *Cookella* in *Myriangiaceae*, based on the superficial, disk-like ascostromata with flattened bases, and asci produced in locules in a hyphal tissue. von Höhnelt (1909b, 1911) later considered that ascostromata with a flattened base, and bright thin-walled peridium, were characteristics that differed from the *Myriangiaceae* and therefore introduced the family *Cookellaceae*. von Arx (1963) placed *Cookellaceae* in *Myriangiales* based on the superficial, stromatic ascostromata and parasitic life form on leaves or other fungi. Later, the family was excluded from *Myriangiales* and placed in *Dothideomycetes* of uncertain order (Eriksson 2005). The *Cookellaceae* presently comprise three genera, *Cookella*, *Pycnoderma* and *Uleomyces* (Lumbsch and Huhndorf 2010;

Kirk et al. 2008). *Uleomyces* is a very poorly known genus that may be similar to *Cookella* and has pulvinate ascostromata, globose asci and hyaline to brown ascospores (Inácio and Cannon 2008) and also occurs on oak leaves. *Uleomyces* is said to be fungicolous (Hennings 1895). *Pycnoderma* is more like a member of *Brefeldiaceae*. No molecular data is available for any of these taxa and their placement in the *Myriangiiales* cannot be confirmed.

Type: Cookella Sacc., *Michelia* 1(no. 4): 407 (1878), MycoBank: MB 1225 Fig. 30

Possible synonyms:

Ascomycetella Peck, *Bull. Torrey bot. Club* 8: 50 (1881)

Phaneroascus Baudyš, *Glasnik zemalyste Muzy Basni Hercegu*. 30: 320 (1919)

Parasitic on leaves in terrestrial habitats. Sexual state: *Ascostromata* superficial, subglobose, cushion-shaped, surface rough, flat or applanate at the base, scattered, pigmented, containing locules with individual asci, non-papillate, opening

by breaks in the upper surface; cells of ascostromata comprising *textura angularis* to *subglobulosa*, with a basal hypostroma, developing in the host tissue, appearing as stromal blocks with swollen cells, compressed packages of *textura angularis* to *prismatica*. *Locules* scattered throughout ascostromata, small, globose to subglobose, peridial wall composed of *textura angularis* to *subglobulosa*. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, globose to subglobose or saccate, apedicellate, lacking an ocular chamber. *Ascospores* scattered in 3–5-seriate overlapping rows, muriform, ellipsoid to oblong, hyaline when immature, becoming brown at maturity, straight to slightly curved, ends rounded, with 3-transverse septa and 1-longitudinal septum in each cell, constricted at the septa, smooth-walled. Asexual state: see notes.

Type species: Cookella microscopica Sacc., *Michelia* 1(no. 4): 407 (1878), MycoBank: MB 218808

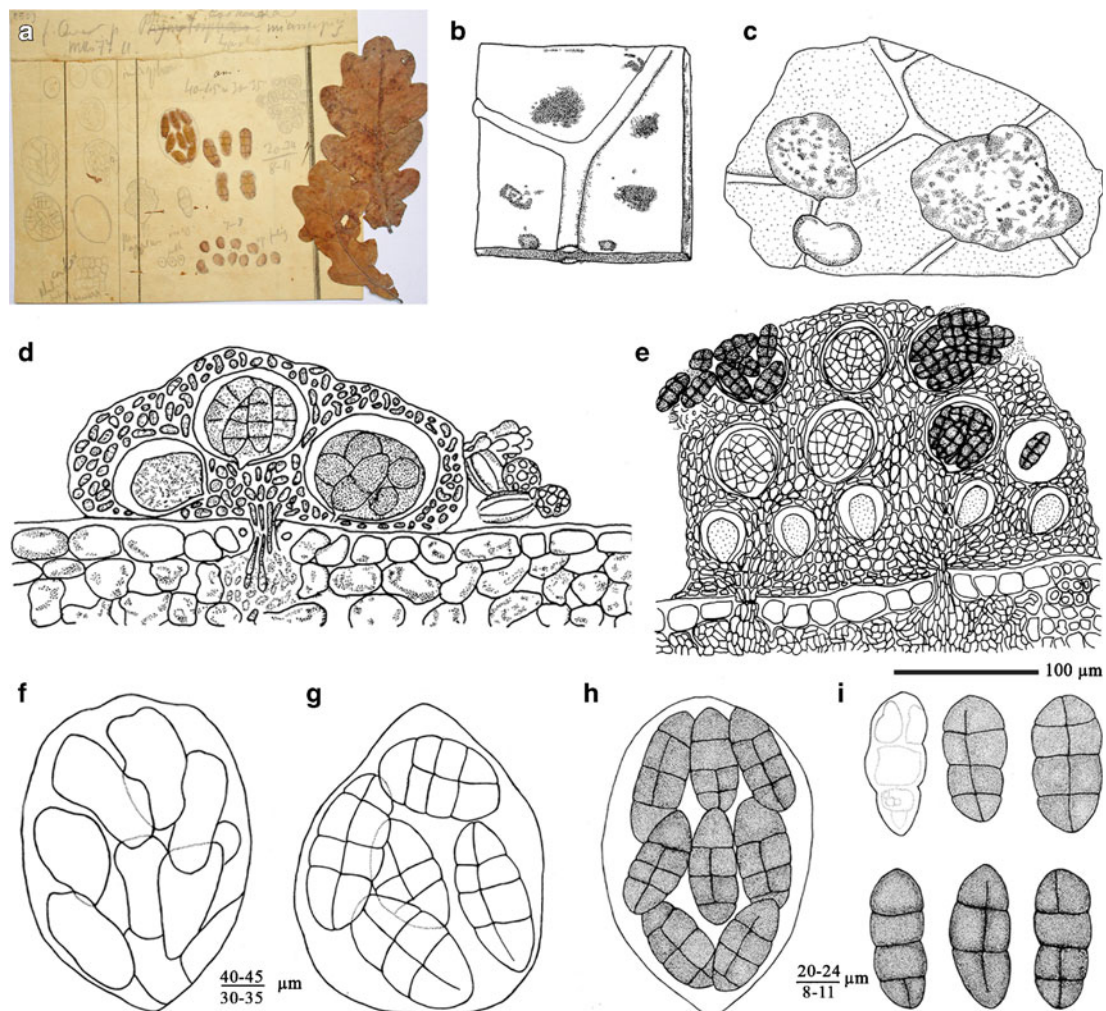


Fig. 30 *Cookella microscopica* (a–i redrawn from PAD: no. 2509; b–d redrawn from Arnaud 1925; e redrawn from von Arx 1963). a Reproduction of notes on herbarium envelope of *Cookella microscopica*. b, c

Ascostromata on substrate. d, e Section through ascostroma to show distribution of locules. f, h Immature and mature asci. i Immature and mature ascospores

Notes: The type specimen obtained from PAD on oak leaves lacking ascostromata. Therefore, we provide an account of *Cookella* based on the protologue and drawings in Arnaud (1925) and von Arx (1963) and from the drawing with the PAD type material. *Cookella* was established by Saccardo (1878) based on a description of *Cookella microscopica*. Five species of *Cookella* are listed in Index Fungorum (2013) and are typically parasites on leaves (von Höhnelt 1909b; Barr 1987a). Saccardo (1878) found a coelomycetous taxon with muriform conidia, named *Stigmella* on leaves around ascostromata of *C. microscopica*, and considered that this might be the asexual state. The fruiting bodies of the two taxa are however dissimilar (ascostromata versus immersed individual conidiomata). The relationship of these two morphs, which are based on being found on the same material, must be treated with caution.

Other genera included

Pycnoderma Syd. & P. Syd., Annl. mycol. 12(6): 563 (1914)

Type species: *Pycnoderma bambusinum* Syd. & P. Syd. Annl. mycol. 12(6): 563 (1914)

Uleomyces Henn., Hedwigia 34: 107 (1895)

Type species: *Uleomyces parasiticus* Henn., Hedwigia 34: 107 (1895)

Key to genera of *Cookellaceae*

1. Ascostromata superficial, cushion or disk-shaped2
1. Thyriothecia superficial, disk-shaped,*Pycnoderma*
2. Ascospores brown*Cookella*
2. Ascospores hyaline*Uleomyces*

Corynesporascaceae Sivan., Mycol. Res. 100(7): 786 (1996), MycoBank: MB 81981

Pathogenic and saprobic on leaves. Sexual state: **Ascomata** cleistothecial with conidiophores arising from cleistothecial walls, sphaerical, solitary to aggregated, superficial on mycelia, or immersed when grown in agar. **Peridium** thin, composed of pale brown, compressed cells, forming a *textura globosa* or *angularis*, covered by mycelia and conidiophores. **Hamathecium** comprising paraphysoids, with branched, septate, apically free, cylindrical hyphae, which break up when asci mature. **Asci** 8-spored, thick-walled, bitunicate, obovoid, deliquescent, short-stalked, fasciculate and arising to form a hymenium among deliquescent paraphysoids. **Ascospores** 2–3-seriate, oblong, pale to dark brown, 1-euseptate at the centre and indistinctly 1-distoseptate in the upper and lower cell, constricted at the median septum, smooth, with a somewhat slightly longer basal cell, which possesses an indistinct, hyaline area, at or near its centre, with three lenticular to globose, granular lumina, the central lumen occupying both the central cells. Asexual state: **Conidiophores** formed on the superficial, floccose mycelium

and cleistothecial wall, macronematous, mononematous, single or caespitose, erect, simple, straight or flexuous, subhyaline to pale brown, none to few septate, smooth, cylindrical. **Conidiogenous cells** monotretic, integrated, terminal, percurrently proliferating, subhyaline to pale brown, smooth, cylindrical, becoming spatulate towards the apex. **Conidia** solitary, obclavate, wide at the truncate base, tapering towards the apex, subhyaline to pale brown, acrogenous, unbranched, smooth-walled, straight to curved, multi to distoseptate, germinating from the apical end of the terminal cell by means of 1–4 germ tubes (Sivanesan 1996).

Notes: The family *Corynesporascaceae* was introduced by Sivanesan (1996) with *Corynesporasca caryotae* Sivan. as the type species, isolated from a decaying leaf of *Caryota urens* collected in Sri Lanka. Sivanesan (1996) linked the sexual (*Corynesporasca caryotae*) and asexual (*Corynespora*) state in culture. The *Corynesporascaceae* differ from *Testudinaceae* by its cephalothecoid peridium and hamathecium with cellular pseudoparaphyses (Hawksworth and Booth 1974; Hawksworth 1979). *Didymosphaeria* resembles *Corynesporasca* in having brown, 1-septate ascospores, but are rather small, smooth to echinulate and uni-seriately arranged inside the persistent, usually cylindrical asci, which are provided with a narrow, ocular chamber. The ascomata are immersed and clypeate unlike those in *Corynesporasca*. *Corynesporasca* has asci with a wide ocular chamber and lacks a refractive ring. Immature ascospores are 1-septate almost in the middle and appear to be faintly distoseptate in each cell. The ascospore cells have lenticular to globose lumina. The ascospores lack a mucilaginous sheath. While *Massariaceae* have asci with a wide ocular chamber but often surrounded by refractive, non-amyloid ring; the ascospores are usually distoseptate in some state of their development, often with lenticular to globose lumina and surrounded by a mucilaginous sheath.

Pyrenulaceae and *Requienellaceae* are similar with *Corynesporasca* in having distoseptate and euseptate ascospores with lumina, but are distinguishable from *Corynesporasca* by their lichenized habit and peridium comprised of *textura intricata* in *Pyrenulaceae*, or cellular pseudoparaphyses in *Requienellaceae* (Aptroot 1991a, b). The *Trypetheliaceae* differ from *Corynesporasca* in having lichenized ascomata, which may be aggregated in a pseudostroma, a peridium of *textura intricata* and a pycnidial asexual state (Aptroot 1991a, b). *Tubeufiaceae* differ from *Corynesporasca* in having a hamathecium with cellular pseudoparaphyses and submedianly 1-septate, hyaline to yellowish brown, sheathed ascospores (Rodrigues and Samuels 1994).

Type: *Corynesporasca* Sivan. Mycol. Res. 100(7): 786 (1996), MycoBank: MB 27579

Figure 31

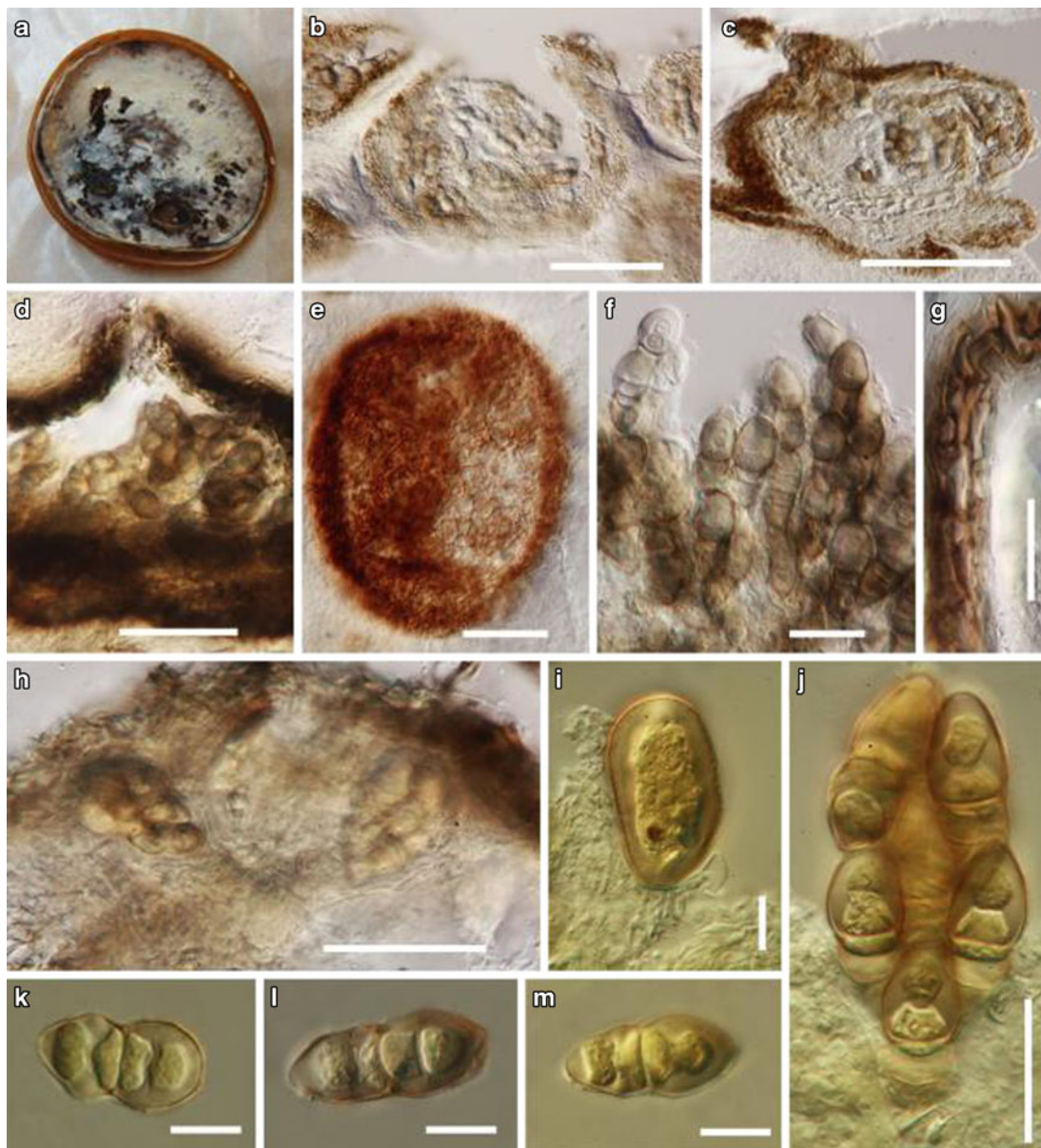


Fig. 31 *Corynesporasca caryotae* (Material examined: SRI LANKA, Kandy, isolate from living leaf of *Caryota urens*, 18 March 1994, J.M. Waller 4058d, IMI362840a, **holotype**). **a** Dried culture of herbarium specimen. **b–d** Vertical section through cleistothecium. **e** Surface view

of cleistothecium wall. **f** Wall with conidiophores. **g, h** Peridium. **i, j** Asci. **k–m** Ascospores. Scale bars: **b, c** = 100 μm , **d, e, h** = 50 μm , **f, g, j** = 20 μm , **i, k, l, m** = 10 μm

Notes: *Corynespora* includes 89 species and the genus has a widespread distribution (Kirk et al. 2008), or 173 species epithets (Index Fungorum 2013) and are saprobes, pathogens, and endophytes on woody and herbaceous plants, other fungi, nematodes, and human skin (Dixon et al. 2009). The type of *Corynespora* is *Corynespora maezi* Güssow (current name *C. cassiicola* (Berk. & M.A. Curtis) C.T. Wei). *Corynespora cassiicola* is an important fungus causing target-spot on a wide host range in tropical and subtropical countries, especially *Hevea brasiliensis* (rubber) in Sri Lanka and other countries (de Liyanage et al. 1986). In Schoch et al. (2009b, Fig. 2a) *C.*

cassiicola and *C. smithii* (Berk. & Broome) M.B. Ellis cluster in Clade K in *Pleosporales* which is basal to *Morosphaeriaceae*, while *C. olivacea* (Wallr.) M.B. Ellis clustered with *Massarinaceae*. *Corynespora* is obviously polyphyletic and requires detailed molecular analysis. We cannot therefore synonymize *Corynesporasca* under *Corynespora* (the older name) at this time, as the types of the two genera may be unrelated. Germination of ascospores occurs with the germ tube arising from the end of the basal cell. A single germ tube may emerge from the base, but single or multiple germ tubes may be produced from any surface area of the upper cell (Sivanesan 1996).

Type species: Corynesporasca caryotae Sivan., Mycol. Res. 100(7): 786 (1996), MycoBank: MB 415571

Cucurbitariaceae G. Winter [as ‘Cucurbitarieae’], Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1.2: 308 (1885), MycoBank: MB 80667

Necrotrophic or *saprobic* on woody plants. Sexual state: *Ascomata* immersed, semi-immersed, becoming erumpent, to nearly superficial, scattered, or clustered on basal hypostroma, base not easy to remove from the substrate, usually containing host particles, globose to subglobose, black, ostiolate. *Ostiole* black, papillate, ostiolar canal filled with hyaline cells. *Peridium* composed of several cell layers of *textura angularis*, light brown to reddish-brown, smooth to rough, or hairy. *Hamathecium* of dense, filiform, hyaline, filamentous, septate pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to clavate, with furcate pedicel and minute ocular chamber. *Ascospores* uni-seriate, or partially overlapping, ellipsoidal, golden brown to dark brown, multi-septate, muriform, constricted at the septum. Asexual state: “Coniothyrium”-like, “Phaeoseptoria”-like, *Pyrenochaeta* and *Pyrenochaetopsis* coelomycetous states are included in *Cucurbitariaceae*.

Notes: The family *Cucurbitariaceae* was introduced by Winter (1885) with *Cucurbitaria berberidis* (Pers.) Gray, as the type species, based on aggregated ostiolate, ascomata on a basal stromatic structure, fissitunicate and cylindrical asci and pigmented, phragmosporous or muriform ascospores. Barr (1987a) included *Cucurbitariaceae* in the order *Pleosporales*, with *Cucurbitaria*, *Cucurbitodithis*, *Othia*, *Rhytidiella* and *Syncarpella*. Schoch et al. (2009b), based on molecular data, have shown that *Othia* groups in the *Botryosphaeriaceae*, although this may have not been a good representative strain. Little molecular data is available for taxa assigned to the family (Schoch et al. 2006; Kruys and Wedin 2009). In the dataset by Zhang et al. (2012a), based on sequences of four genes, the clade including the type species is poorly supported and labeled *Cucurbitariaceae/Didymosphaeriaceae?* Thus indicating that further taxon sampling is required to resolve its position in the *Pleosporales*. Based on the multi-gene analysis *Pyrenochaeta*, and *Pyrenochaetopsis* were shown to be accommodated in *Cucurbitariaceae* (de Gruyter et al. 2010, 2012). Wijayawardene et al. (2012) listed “Camarosporium”-like, “Coniothyrium”-like and “Phaeoseptoria”-like asexual states in *Cucurbitariaceae*. The type species of *Cucurbitaria* (*C. berberidis*) is linked to *Pyrenochaeta berberidis* (Sacc.) Brunaud (Sivanesan 1984; Farr et al. 1989; de Gruyter et al. 2010) hence we accept that *Cucurbitaria* has “Pyrenochaeta”-like asexual states. However, Doilom et al. (2013) show that *Pyrenochaeta nobilis* De Not. which is the type of *Pyrenochaeta*, groups away from *Cucurbitaria berberidis*, thus we do not synonymize *Pyrenochaeta* under

Cucurbitaria (Doilom et al. 2013) and that this is a well-supported family.

Type: Cucurbitaria Gray, Nat. Arr. Brit. Pl. (London) 1: 508, 519 (1821), MycoBank: MB 1348 Fig. 32

Saprobic on woody branches. Sexual state: *Ascomata* black, semi-immersed, scattered or clustered on a basal hypostroma beneath the host periderm or on decorticated wood, fully or partly erumpent, globose, smooth to rough or hairy, with a papillate ostiole. *Hypostroma* cells brown, angular to globose, thickened at the base. *Peridium* comprising 5–6 cell layers of light brown to reddish-brown cells of *textura angularis*. *Hamathecium* of 2–3 μm wide, numerous, filiform, hyaline pseudoparaphyses. *Asci* 8-spored, bitunicate, thick-walled, cylindrical, short-pedicellate, clusters arising from the base. *Ascospores* uni-seriate, initially hyaline, becoming golden brown to dark brown, ellipsoidal to broadly muriform, constricted at the septum, with obtuse or acute ends. Asexual state: “Pyrenochaeta”-like, *Pycnidia* superficial on wood in bark fissures, scattered or aggregated, (sub)globose or obpyriform, unilocular, dark brown to black, thick-walled, with setae, pseudoparenchymatous walled. *Setae* dark brown, thick-walled, sometimes light-brown and thin-walled, ends narrowly rounded and broadly at the base, septate, numerous, crowded. *Conidiogenous cells* enteroblastic, phialidic, hyaline, smooth. *Conidia* agglutinated in masses, oblong to ellipsoid, hyaline, aseptate, guttulate, smooth-walled (Sutton 1980).

Notes: *Cucurbitaria* is one of the oldest pyrenomycete genera separated from *Sphaeria* Haller in the sense of Tode (1790) and Persoon (1801), while Fries (1823) considered it under Pyrenomycetes along with the genus *Sphaeria*. *Cucurbitaria* was described by Gray (1821) and *C. berberidis* is considered the type of the genus. The original generic diagnosis of *Cucurbitaria* was “Thallus spreading irregular, thecae in tufts, placed on the thallus.” but the scope of the genus was unlimited. Therefore, Greville (1824, 1825a, b), Tulasne and Tulasne (1863) Saccardo (1883), Winter (1887), Ellis and Everhart (1892) and Berlese (1900), have described the genus in more detail but still the delimitation of the genus remains inconclusive. Winter (1887) placed *Cucurbitaria* in the family *Cucurbitariaceae* with other taxa having aggregated fruiting bodies. The subsequent monographic study by Welch (1926) had a narrow concept for the genus, and accepted only *C. berberidis*, *C. caraganae* P. Karst., *C. laburni* (Pers.) De Not., *C. elongata* (Fr.) Grev. and *C. arizonica* Ellis & Everh. Other species were regarded as doubtful species, or excluded species.

Type species: Cucurbitaria berberidis (Pers.) Gray, Nat. Arr. Brit. Pl. (London) 1: 508, 519 (1821), MycoBank MB 239072 \equiv *Sphaeria berberidis* Pers., *Neues Mag. Bot.* 1: 83 (1794)

Other genera included

Curreya Sacc., Syll. fung. (Abellini) 2: 651 (1883)

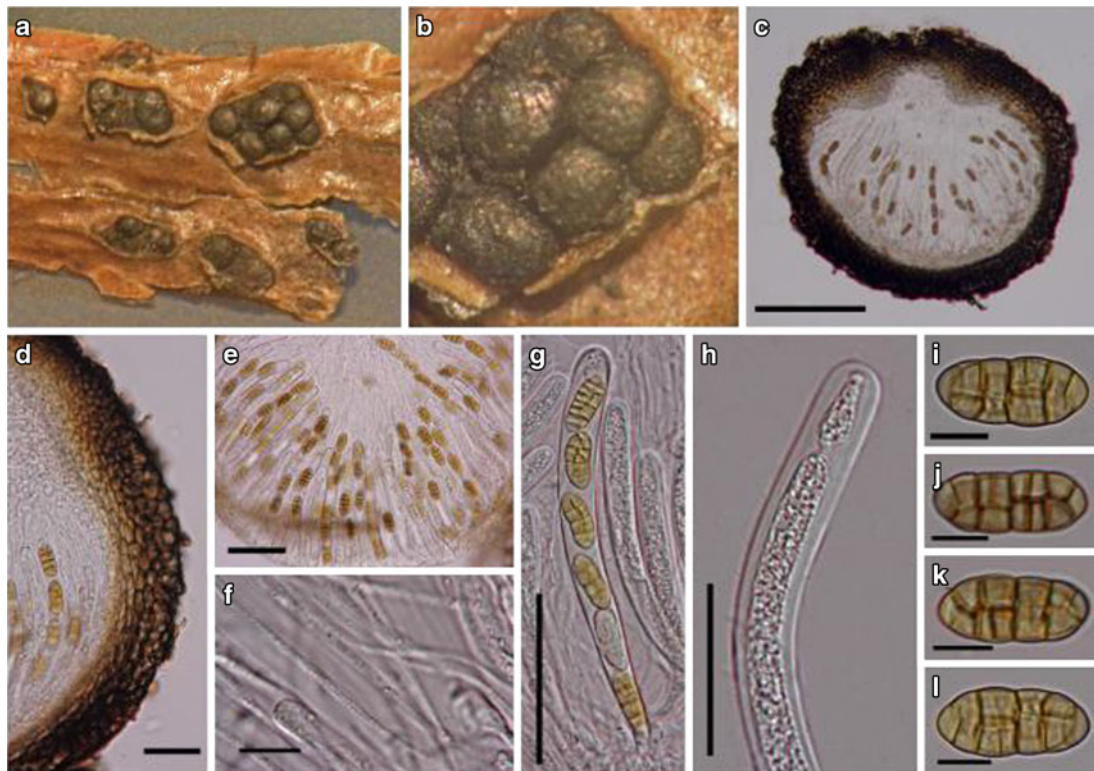


Fig. 32 *Cucurbitaria elongata* (Fr.) Grev. (Material examined: ITALY, Forli-Cesena, Corniolo, on dead wood of *Cytisus scoparius*, 06 December 2011, E Campestri, MFLU13-0085). **a** Ascomata on the host stems, partly erumpent. **b** Close up of the ascomata. **c** Section of an ascoma. **d** Close up of the peridium. **e** Hamathecium comprising asci and

filamentous pseudoparaphyses. **f** Hyaline, filamentous pseudoparaphyses. **g** 8-spored asci with short pedicels. **h** Ascus tip showing apical apparatus. **i-l** Golden brown to dark brown, ellipsoidal to broadly, muriform ascospores. Scale bars: **c**=200 μ m, **d**=20 μ m, **e**=10 μ m, **f-h**=30 μ m, **i-l**=10 μ m

Type species: Curreya conorum (Fuckel) Sacc., Syll. fung. (Abellini) 2: 651 (1883)

Pyrenochaeta De Not., Mem. R. Accad. Sci. Torino, Ser. 2 10: 348 (1849)

Type species: Pyrenochaeta nobilis De Not., Mem. R. Accad. Sci. Torino, Ser. 2 10: 347 (1849)

Pyrenochaetopsis Gruyter et al., Mycologia 102(5): 1076 (2010)

Type species: Pyrenochaetopsis leptospora (Sacc. & Briard) Gruyter et al., Mycologia 102(5): 1076 (2010)

Rhytidiella Zalasky, Can. J. Bot. 46(11): 1383 (1968)

Type species: Rhytidiella moriformis Zalasky, Can. J. Bot. 46(11): 1383 (1968)

Syncarpella Theiss. & Syd., Anns mycol. 13(5/6): 631 (1915)

Type species: Syncarpella tumefaciens (Ellis & Harkn.) Theiss. & Syd., Anns mycol. 13(5/6): 633 (1915)

Key to sexual genera of Cucurbitariaceae

- 1. Ascospores muriform2
- 1. Ascospores filiform3
- 2. Asci 183×17 μ m, cylindrical*Cucurbitaria*
- 2. Asci 77×28 μ m, cylindrical-clavate to broadly clavate*Curreya*

- 3. Ascospores with 3 transverse septa, slightly constrict at the septa*Syncarpella*
- 3. Ascospores with more than 7 transverse septa, sigmoid to curved*Rhytidiella*

Key to asexual genera of Cucurbitariaceae

- 1. Conidiomata with setae (in most cases), conidia wider than 2 μ m*Pyrenochaeta*
- 1. Conidiomata lack of setae, conidia narrower than 2 μ m*Pyrenochaetopsis*

Dacampiaceae Krb. [as ‘*Dacampieae*’], Syst. Lich. Germ.: 322 (1855), MycoBank: MB 80680

Possible synonym:

Pyrenidiaceae Zahlbr., in Engler, Syllabus, Edn 2 (Berlin): 46 (1898)

Lichenicolous, lichenized or saprobic. Sexual state: *Ascomata* perithecioid, mostly uni-locular, with a central ostiole, some genera forming a clypeus around the ostiole, lacking setae, black, immersed to superficial, mostly subglobose to obpyriform, rarely elongate or irregularly-shaped, solitary and scattered over the substratum, or grouped. *Peridium* composed of several layers of angular pseudoparenchymatous, radially compressed, thick-walled cells of

textura angularis, reddish to dark brown, or pale brown to colorless, surrounded by a dark brown involucrellum. *Hamathecium* of numerous, usually branched and anastomosing, trabeculate or cellular pseudoparaphyses, I-, more rarely K/I+bluish. *Asci* up to 8-spored, bitunicate, fissitunicate, elongate-clavate to short-cylindrical, short-pedicellate, with a thick-walled apex and a small, sometimes indistinct ocular chamber, I-, more rarely K/I+bluish. *Ascospores* 1–2-seriate, 1- or more septate to muriform, in most species brown to dark brown, more rarely hyaline to pale brown, ellipsoid to fusiform, often constricted at the septa, smooth to verrucose, perispore present in some species. Asexual state: pycnidial states reported in a few genera, e.g. in *Eopyrenula* (colourless, simple microconidia and brown, 1- or more septate macroconidia), *Munkovalsaria* (“*Lecythophora*”-like asexual state), *Polycoccum* (“*Cyclothyrium*”-like asexual state of *P. peltigerae*, “*Phoma*”-like asexual state of *P. rubellianae*).

Notes: The family *Dacampiaceae*, as currently understood, is certainly heterogeneous, and the inclusion of several genera is tentative, as the lack of molecular data does not support or reject their inclusion. The core of the family, as suggested by Crivelli (1983) and Hawksworth and Diederich (1988) comprises the type, *Dacampia*, and several other lichenicolous genera, such as *Clypeococcum*, *Polycoccum*, *Pyrenidium* and *Weddellomyces*. Most species included in these genera share blackish, perithecioid ascomata, bitunicate, fissitunicate asci, similar pseudoparaphyses and medium to dark brown, thick-walled ascospores. However, there have been few ontogenetic studies concerning the nature of the hamathecium, and such studies would probably have an influence on the circumscription of the family. Very few asexual morphs have been reported within these genera, and almost no species have been isolated in pure culture. No molecular data is available yet for the genus *Dacampia*, and very few sequences have been published from other genera currently referred to the *Dacampiaceae*. *Munkovalsaria appendiculata* Aptroot was included in a phylogenetic analysis by Wang et al. (2007) and the species referred to the *Dacampiaceae*, but as no *Dacampia* species has been sequenced, interpretations of the phylogenetic position of the family are speculative.

Most species of the *Dacampiaceae* are lichenicolous, and almost all seem to be host-specific. *Pyrenidium actinellum* Nyl. was often considered as an exception, being found on unrelated hosts, but in reality represents an assemblage of many distinct, mostly undescribed species. The type of *Dacampia* is remarkable in being lichenized, and a further genus often included in the *Dacampiaceae*, *Eopyrenula*, is a facultative lichen. Several poorly known genera, some with aberrant characters, such as hyaline ascospores and unbranched hamathecial filaments, mainly growing on plants, have provisionally been included in the *Dacampiaceae* and are listed and keyed out below. The family includes ten genera and 110 species. *Aaosphaeria* is a monotypic, non-

lichenicolous genus with a *Microsphaeropsis* anamorph that “could be close to *Polycoccum* in the *Dacampiaceae*” (Aptroot 1995a). *Clypeococcum* includes nine lichenicolous species. Species of *Eopyrenula* are bark-inhabiting, facultatively lichenized with a *Trentepohlia* photobiont; six species were keyed out by Aptroot (2012) who treated *Eopyrenula* as part of *Pyrenulaceae* (Eurotiomycetes); further studies are needed to clarify the position of this genus. *Leptocurthis* is a monotypic, non-lichenicolous genus included in *Dacampiaceae* by Aptroot and van Iperen (1998), but differing by unbranched pseudoparaphyses. *Munkovalsaria* is a non-lichenicolous genus with an anamorph resembling *Lecythophora* “best accommodated in the *Dacampiaceae*” (Aptroot 1995a), with two species. *Polycoccum* includes 56 lichenicolous species. *Pseudoniitschkia* is a poorly known, monotypic lichenicolous genus “sharing certain features with the *Dacampiaceae*” (Coppins and Kondratyuk 1995). *Pyrenidium* includes nine species, while *Weddellomyces* includes 12 lichenicolous species, of which eight are keyed out by Calatayud and Navarro-Rosinés (1998).

The conidial taxa of *Dacampiaceae* need to be resolved. Halici and Hawksworth (2008) speculated whether *Dacampia muralicola* Halici & D. Hawksw. has asexual states in *Phoma* as *D. muralicola* is associated with *Phoma* spp. However this link has not been proven by any physical connection (Halici and Hawksworth 2008). Most of these associated lichenicolous “*Phoma*”-like spp. (*Phoma* sensu stricto restricted to *Didymellaceae*) must be grouped in *Phaeosphaeriaceae* (Lawrey et al. 2012); however, it is not yet possible to reject with certainty any link between *Dacampia* and associated *Phoma* spp. Wijayawardene et al. (2012) listed *Cyclothyrium* as an asexual state of *Polycoccum*, but Sutton (1980) stated that *Cyclothyrium juglandis* (Schumach.) B. Sutton, the type of the genus *Cyclothyrium*, is the asexual state of *Thyridaria rubronotata* (Berk. & Broome) Sacc. This link was proven by Verkley et al. (2004) using molecular phylogeny. However *Thyridaria* was not placed in *Dacampiaceae* (Schoch et al. 2009b; Zhang et al. 2012a); hence the link between *Cyclothyrium* sensu stricto and *Polycoccum* is questionable.

Type: *Dacampia* A. Massal., Sulla Lec. hook. Schaer.: 7 (1853), MycoBank: MB 1401

Figures 33 and 34

Possible synonyms:

Decampia Mudd, (1861)

Xenosphaeria Trevis., Conspect. Verruc.: 18 (1860)

Lichenicolous or with a lichenized thallus. Sexual state: *Ascomata* perithecioid, with a central ostiole, lacking setae, black, immersed to semi-immersed, subglobose to obpyriform, solitary, sometimes clustered, scattered over the host thallus or apothecia. *Peridium* composed of several layers of angular pseudoparenchymatous, radially compressed, thick-walled cells of *textura angularis*, reddish to dark brown.

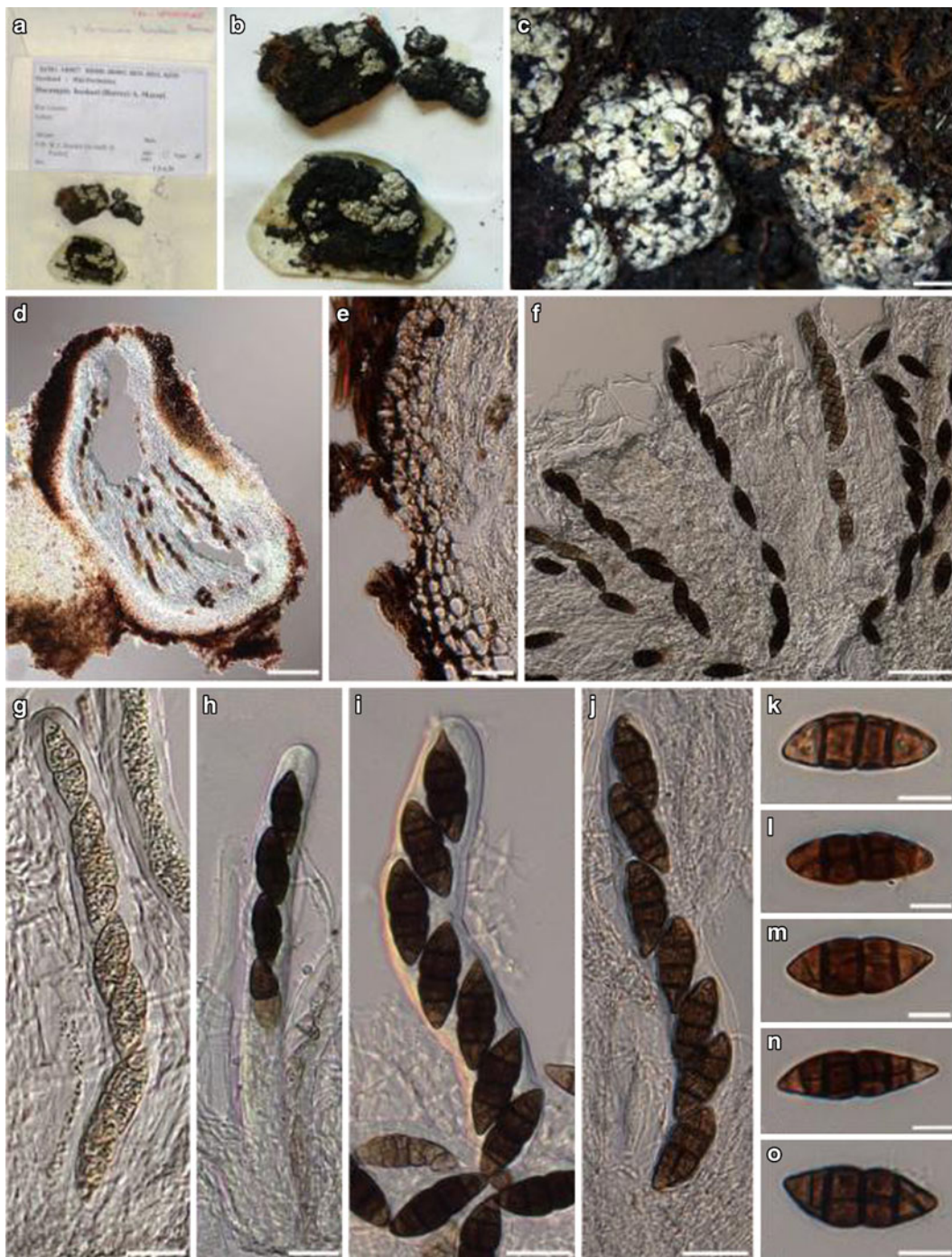


Fig. 33 *Dacampia hookeri* (Material examined: UK, Scotland, Mid Perthshire, on dead mosses on the micaceous soil of Ben Lawers, on thallus of lichen, W.J. Hooker, K(M) 140027, **isotype?**). **a** Herbarium label **b** Specimen of *Dacampia hookeri*. **c** Ascomata on white thallus. **d**

Section through ascoma. **e** Section through peridium. **f** Asci with pseudoparaphyses. **g** Young ascus with pale brown, immature ascospores. **h–j** Mature asci. **k–o** Ascospores stained by Lactoglycerol. Scale bars: **c** = 1 mm, **d** = 100 μm , **f** = 50 μm , **e**, **g**, **h**, **i**, **j** = 20 μm , **k–o** = 10 μm

Hamathecium of numerous, branched and anastomosing, cellular pseudoparaphyses, I-. Asci 8-spored, bitunicate, elongate-clavate to short-cylindrical, short-pedicellate, with a thick-walled apex and a small, sometimes indistinct, ocular chamber. Ascospores 1–2-seriate, muriform (but transverse septa may be missing when immature), initially pale yellowish to pale

brown, becoming brown to dark brown, ellipsoid to fusiform, often constricted at the septa, smooth, without visible perispore. Asexual state: Unknown.

Notes: Unlike all other known species of the genus, which are lichenicolous and non-lichenized, the type *Dacampia hookeri* (Borrer) A. Massal., shows an unusual and for a long

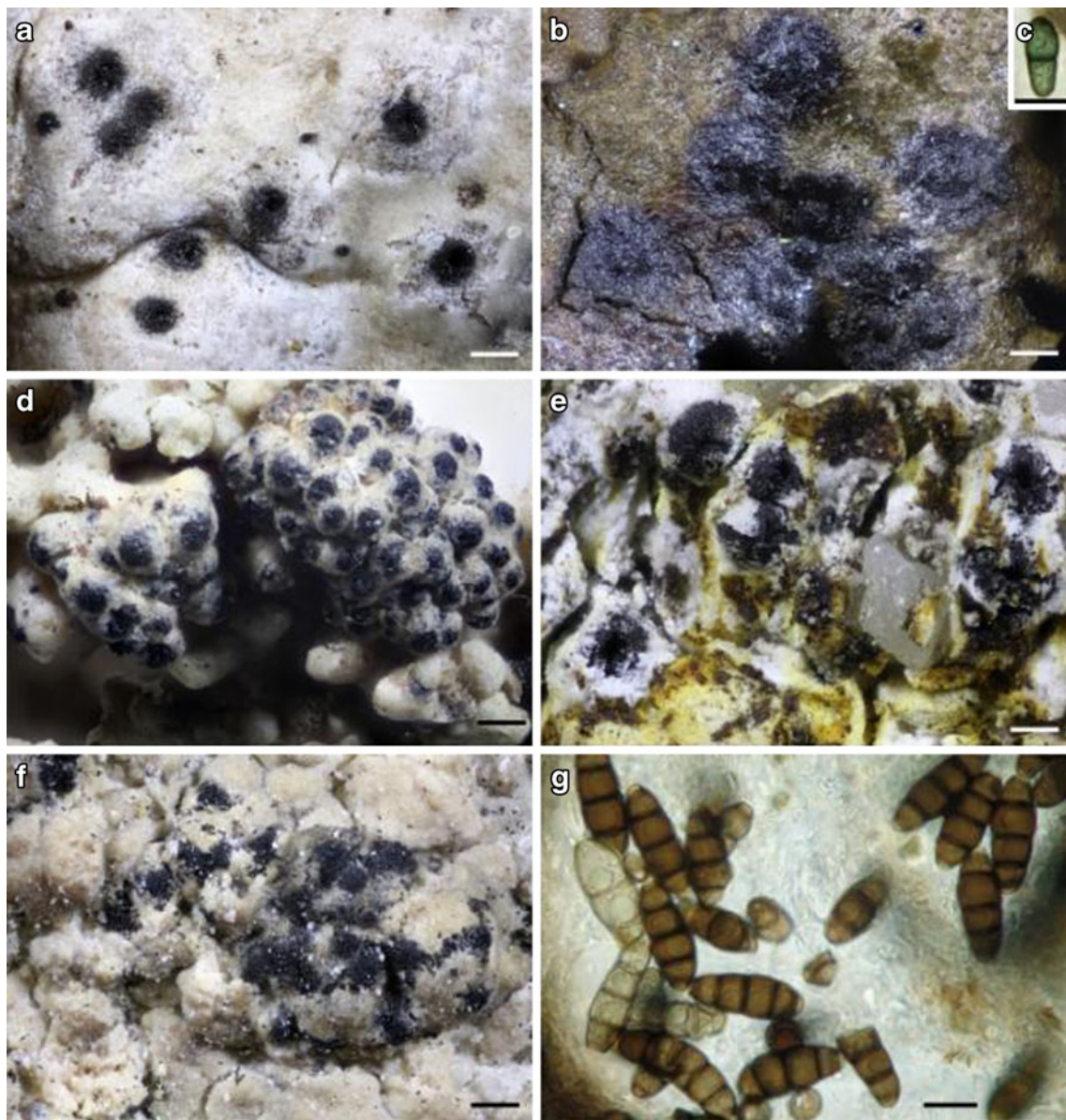


Fig. 34 Lichenicolous members of *Dacampiaceae*. **a** *Dacampia engeliana* (Material examined: GERMANY, Bayern, Bad Tölz-Wolfratshausen, 1978, Feuerer), black perithecia immersed in a thallus of *Solorina saccata*. **b** *Clypeococcum cladonema* (Material examined: BELGIUM, Houffalize, 2010, Diederich 17134), black clypei with immersed perithecia on a thallus of *Xanthoparmelia pulla*. **c** Ascospore of same specimen. **d** *Polycoccum tryptelioides* (Material examined: CANADA, British Columbia, Kispiox, 1995, Goward 95–282), black perithecia inducing galls on *Stereocaulon tomentosum*. **e** *Weddellomyces*

epicallopisma (Material examined: FRANCE, Vaucluse, Gordes, 1995, Diederich 12327), black perithecia immersed in a partly decolorized thallus of *Caloplaca aurantia*. **f** *Pyrenidium baeomycearium* (Material examined: Santesson, *Fungi Lich. Exs.* 331, sub *P. actinellum*), black perithecia inducing galls on *Baeomyces rufus*. **g** *Pyrenidium* sp. (Material examined: LUXEMBOURG, Baschleiden, on *Verrucaria*, 2007, Kuborn), 3-septate ascospores with an apically paler wall. Scale bars: **a–b, d–f**=200 μ m, **c, g**=10 μ m

time misunderstood biology. Ascomata of *D. hookeri*, develop over a white, terricolous, lichenized thallus, often associated when young with *Solorina* thalli. Henssen (1995) demonstrated that this white thallus belongs to *D. hookeri*, which is therefore the only known lichenized member of the genus. Other species are parasitic and form necrotic patches on the host thallus or tend to be commensalistic. A total of 13 species

are currently known and a key to seven of them is given by Halici and Hawksworth (2008).

Type species: Dacampia hookeri (Borrer) A. Massal., Sulla Lec. hook. Schaer.: 7 (1853)

Mycobank: MB 119080

≡ *Verrucaria hookeri* Borrer, in Smith & Sowerby, Engl. Bot., Suppl. 1: pl. 2622, Fig. 1 (1831)

Other genera included

Aaosphaeria Aptroot, Nova Hedwigia 60(3–4): 329 (1995)
Type species: Aaosphaeria arxii (Aa) Aptroot, Nova Hedwigia 60(3–4): 329 (1995)

Clypeococcum D. Hawksw., J. Linn. Soc., Bot. 75: 196 (1977)
Type species: Clypeococcum cladonema (Wedd.) D. Hawksw., J. Linn. Soc., Bot. 75(2): 197 (1977)

Eopyrenula R.C. Harris, Michigan Bot. 12(1): 19 (1973)
Type species: Eopyrenula leucoplaca (Wallr.) R.C. Harris, Michigan Bot. 12(1): 19 (1973)

Leptocurthis Aptroot, in Aptroot & Iperen, Nova Hedwigia 67: 485 (1998)

Type species: Leptocurthis quadrata Aptroot, in Aptroot & Iperen, Nova Hedwigia 67: 485 (1998)

Munkovalsaria Aptroot, Nova Hedwigia 60(3–4): 346 (1995)

Type species: Munkovalsaria donacina (Niessl) Aptroot, Nova Hedwigia 60(3–4): 346 (1995)

Polycoccum Saut. ex Körb., Parerga lichenol. (Breslau): 470 (1865)

Type species: Polycoccum sauteri Körb., Parerga lichenol. (Breslau): 470 (1865)

Pseudonitschkia Coppins & S. Y. Kondr., Arch. Protistenk. 52(2): 232 (1995)

Type species: Pseudonitschkia parmotrematis Coppins & S.Y. Kondr., Edinb. J. Bot. 52: 232 (1995)

Pyrenidium Nyl., Flora, Jena 48: 210 (1865)

Type species: Pyrenidium actinellum Nyl., Flora, Jena 48: 210 (1865)

Weddellomyces D. Hawksw., Notes R. bot. Gdn Edinb. 43(3): 511 (1986)

Type species: Weddellomyces epicallopisma (Wedd.) D. Hawksw. [as ‘epicallopismum’], Notes R. bot. Gdn Edinb. 43(3): 512 (1986)

Key to genera of Dacampiaceae

1. Pseudoparaphyses unbranched, ostiole slit-like to stellate, with 3–6 radiate splits, ascospores hyaline, elongate fusiform to subcylindrical, 1-septate**Leptocurthis**
1. Pseudoparaphyses branched, ostiole punctiform2
2. Ascromatal surface deeply cracked and rugulose with 10–17 μm warts, ascospores hyaline, becoming brownish when over mature, fusiform, 1(–3)-septate, 40–49 \times 6.5–7.5 μm **Pseudonitschkia**
2. Ascromatal surface smooth, not distinctly cracked or rugulose, ascospores pale to dark brown, length/breadth ratio usually smaller3
3. Ascospores 1-septate4
3. Ascospores 3–7-septate to muriform7
4. Ascromata discrete, not united in a clypeus5
4. Ascromata united in groups by a common black clypeus6

5. Ascromata on lichens**Polycoccum**

5. Ascromata on plants**Aaosphaeria**

6. Ascromata on lichens**Clypeococcum**

6. Ascromata on stems and bark of various plants**Munkovalsaria**

7. Peridium in upper part made of cephalothecoid plates, breaking up irregularly, ascospores 3-septate to muriform**Weddellomyces**

7. Peridium not cephalothecoid8

8. Ascromata non-lichenicolous, usually with an immersed, inconspicuous or whitish corticolous thallus that may be lichenized with a *Trentepohlia* photobiont, often with a dark brown involucrellum, frequently accompanied by a micro- or macroconidial pycnidial asexual morph, ascospores 3–7-septate, apices often paler**Eopyrenula**

8. Ascromata lichenicolous, more rarely lichenized with a thick, white thallus with a *Coccomyxa* photobiont and external cephalodia with *Nostoc*9

9. Ascospores 3-septate, wall at both apices paler and thinner, ascromata lichenicolous**Pyrenidium**

9. Ascospores muriform, wall uniformly thickened and pigmented, ascromata lichenicolous or lichenized with a thick, white thallus with a *Coccomyxa* photobiont and external cephalodia with *Nostoc***Dacampia**

Delitschiaceae M.E. Barr, Mycotaxon. 76: 109 (2000), MycoBank: MB 82092

Terrestrial, hyper-saprobic on herbivore dung, or rarely on aged wood or plants. Sexual state: *Ascromata* uni-locular pseudothecia, solitary or scattered, sometimes gregarious, immersed to erumpent, brown or black, globose to subglobose, or pyriform, membranous to coriaceous, with a papilla or a well differentiated ostiole, outer wall smooth or hairy, periphysate. *Peridium* pseudoparenchymatous exostratum, consists with *textura angularis* cells. *Hamathecium* of dense, long, branching, anastomosing, cellular pseudoparaphyses. *Asci* 8-spored, sometimes 4 or poly-spored, bitunicate, fissitunicate, cylindrical to cylindric-clavate, pedicellate, with a non-amyloid, refractive apical apparatus. *Ascospores* uni- or bi-seriate, rarely tri-seriate, ovoid or ellipsoid, pale to dark brown, unicellular or bi- to multi-cellular, often constricted at the septum, resulting in fragmenting cells, wall smooth, with a full length germ slit in each cell, surrounded by a gel coat. Asexual state: not reported.

Notes: The family *Delitschiaceae* (*Pleosporales*) was introduced to accommodate three genera of the family *Sporormiaceae*, that were clearly different from that family in having a periphysate ostiolium and asci with a well-developed and refractive apical chamber (Barr 2000a). *Delitschia*, the type genus of this family, was introduced by Auerswald (1866) and assigned to *Sphaeriaceae*. It was considered to be closely related to *Sordariaceae* and

Amphisphaeriaceae. Winter (1887) assigned *Delitschia* under *Sordariaceae* and this placement is followed in several subsequent studies (Griffiths 1901; Kirschstein 1911). Cain (1934) suggested that *Delitschia* might belong in *Pleosporaceae* and this proposal was supported by Moreau (1953) and Dennis (1968). In his key to coprophilous *Sphaeriales*, Cain (1934) separated the fissitunicate bitunicate fungi in to three genera, *Sporormia*, *Delitschia*, and *Pleophragmia* on the basis of ascospore septation. Munk (1957) established *Sporormiaceae* and *Delitschia* was assigned therein together with other coprophilous genera, i.e. *Sporormia* (inclusive of *Sporormiella*), *Perisporium* (= *Preussia*), and *Trichodelitschia*. Barr (1987b) included the *Sporormiaceae* in *Phaeotrichaceae*, but later (Barr 1990b) regarded them as independent families, misinterpreting *Phaeotrichaceae* as having unitunicate asci and accommodating them in *Sordariales*. Finally (Barr 2000a) subdivided coprophilous bitunicate fungi in three families, assigning those with ascospores with germ pores to *Phaeotrichaceae*, those with germ slits or no germinal mechanism to *Delitschiaceae* or *Sporormiaceae*, the latter aperiophysate and with a narrow ascus endotunica lacking a refractive apical apparatus. Phylogenetic molecular studies (Kruys et al. 2006; Schoch et al. 2009b) showed *Phaeotrichaceae*, *Sporormiaceae* and *Delitschiaceae* to form separate monophyletic groups.

Type: Delitschia Auersw., Hedwigia 5: 49 (1866), MycoBank: MB 1443 Fig. 35

Possible synonyms:

Delitschiella Sacc. & D. Sacc., in Saccardo & Saccardo, Syll. fung. (Abellini) 17: 688 (1905)

Pachyspora Kirschst., Verh. bot. Ver. Prov. Brandenb. 48: 48 (1907) [1906]

Habitat terrestrial. *Saprobic* on old herbivore dung. Sexual state: *Ascomata* solitary or scattered, immersed to semi-immersed, subglobose to subpyriform, brown or black, membranous, relatively large, often covered with dense, hyphoid hairs, neck blackish, central, usually coriaceous, with a wide opening and a smooth or tuberculate to hairy surface. *Peridium* thick at the apex, thinner at the base, well differentiated with an outer layer of thick-walled, dark pigmented cells, and an inner layer of larger, thin-walled, lightly pigmented cells. *Hamathecium* of dense, very long, anastomosing and branching, filiform pseudoparaphyses. *Asci* 8-spored, cylindrical to cylindro-clavate, short, narrow pedicellate, which are rounded at the base, apex with a wide ocular chamber. *Ascospores* obliquely uni-seriate and partially overlapping, ellipsoid, reddish brown, 1-septate, slightly constricted at the septum, smooth-walled, cells often easily separable from each other, each cell with a full length germ slit. Asexual state: Unknown.

Notes: Luck-Allen and Cain (1975) reviewed the genus *Delitschia*, which they definitively regarded as usually fimicolous, with bitunicate asci, and pigmented, 1-septate

ascospores, with an elongated germ slit in each cell and surrounded by a gelatinous sheath. They described several new taxa and accepted 46 species. Since then about 15 new *Delitschia* species have been described, some as wood-inhabiting (Eaton and Jones 1971; Romero and Samuels 1991; Hyde and Steinke 1996). Kirk et al. (2008) recognized 51 species, whereas 81 taxa are mentioned in Index Fungorum (2013).

Type species: Delitschia didyma Auersw., Hedwigia 5: 49 (1866), MycoBank: MB 177056

Other genera included

Ohleriella Earle, Bulletin of the New York Botanical Garden 2: 349 (1902)

Type species: Ohleriella neomexicana Earle, Bulletin of the New York Botanical Garden 2: 349 (1902)

Semidelitschia Cain & Luck-Allen, Mycologia 61: 581 (1969)

Type species: Semidelitschia agasmatica Cain & Luck-Allen, Mycologia 61: 581 (1969)

Key to genera in *Delitschiaceae*

1. Ascospores 1-celled, fimicolous*Semidelitschia*
1. Ascospores septate, also on other substrata2
2. Ascospores 2-celled, fimicolous, rarely lignicolous*Delitschia*
2. Ascospores more than 2-celled, on woody material*Ohleriella*

Diademaceae Shoemaker & C.E. Babcock, Can. J. Bot. 70(8): 1618 (1992), MycoBank: MB 81955

Parasitic or *saprobic* in stems and leaves. Sexual state: *Ascomata* subepidermal or subcuticular and later become superficial, dark brown to black, globose, opening via a flat, circular lid. *Peridium* thin, consisting of small, pigmented, thick-walled cells of *textura angularis*. *Hamathecium* of dense, cellular pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, clavate or ellipsoidal, with short, broad, furcate pedicel, apically rounded with an ocular chamber. *Ascospores* bi-seriate, partially overlapping, fusiform, brown, with 3 or more transverse septa, with or without longitudinal septa, applanate or rarely terete, with a thick sheath most of the time. Asexual state: Unknown.

Notes: Shoemaker and Babcock (1992) introduced *Diademaceae* which they considered to be a unique family based on the ascomata opening by a flat, circular lid and comprising *Clathrospora*, *Comoclathris*, *Diadema*, *Diademosia* and *Macrospora* Shoemaker and Babcock (1992). *Macrospora* was excluded by Lumbsch and Huhndorf (2010) and included in the family *Pleosporaceae*, as it was considered to be a synonym for *Pyrenophora*. Other than the main feature of ascoma opening via a flat, circular lid, as an adaptation to the alpine habitat (Shoemaker and Babcock 1989), ascomata are superficial, globose to



Fig. 35 *Delitschia didyma* (Material examined: ITALY, F. Doveri, MFLU 12–2217). **a, b** Ascomata on natural substrate. **c** Cross section of ascoma. **d** Ostiole. **e** Peridium **f** Pseudoparaphyses. **g, h** Asci in water.

i Apical chamber. **j, k** Ascospores in water. Scale bars: **a**=1 mm, **b**=500 μ m, **c, d**=100 μ m, **e–h**=50 μ m, **i–k**=20 μ m

subglobose, brown to dark brown, with 8-spored, clavate or ellipsoidal, bitunicate asci. Ascospores are fusiform, brown, with 3 or more transverse septa with or without longitudinal septa, applanate or rarely circular in section, but narrowing to one end (*Diademosa*) with a thick sheath most of the time (Shoemaker and Babcock 1992; Zhang et al. 2011b). *Platyspora* has been added to this family by various authors (Zhang et al. 2011b), or was considered a synonym of *Graphyllum* (Zhang et al. 2011b) or as a synonym of *Comoclathris* (Index Fungorum 2013). Lumbsch and Huhndorf (2010) included *Graphyllum* in the family *Diademaceae*, but Zhang et al. (2011b) referred it the *Hysteriaceae* due to its hysterothecium-like ascomata, forming a longitudinal opening. The final placement of *Graphyllum*

will rely on molecular data (Zhang et al. 2011b). No asexual state has been linked to most of the members of this family, but an “*Alternaria*”-like asexual morph has been linked to *Clathrospora* and *Comoclathris* (Zhang et al. 2011a, b). No new genera have been included in the family since *Diademaceae* was introduced by Shoemaker and Babcock (1992). Molecular data is only available in GenBank for putative strains of *Clathrospora elyanae* Rabenh. (CBS 196.54) and *C. diplospora* (Ellis & Everh.) Wehm. (IMI 68086), which clustered within the family *Pleosporaceae*.

Species of the order *Pleosporales* with applanate ascospores can be separated into three families (*Diademaceae*, *Hysteriaceae*, *Pleosporaceae*) and differ in the way the ascomata open. Ascomata opening by a flat, circular lid are

characteristic of the family *Diademaceae*, while species of *Hysteriaceae* open via a long, narrow slit and species of *Pleosporaceae* open by a central pore (Shoemaker and Babcock 1992). The placement of *Diademaceae* is not supported by molecular data and studies are required to resolve its phylogenetic relationship in the *Pleosporales*.

Type: Diadema Shoemaker & C.E. Babcock, Can. J. Bot. 67(5): 1349 (1989), MycoBank:

MB25293 Fig. 36

Saprobic on culms of grasses (*Poaceae*). Sexual state: *Ascomata* scattered, immersed, intra-epidermal,

globose to subglobose, black to brown, smooth-walled and opening via a flat circular lid. *Peridium* 1-layered, composed of small, pigmented, thick walled, compressed cells, base consisting of small, pigmented, thick-walled cells of *textura angularis*. *Hamathecium* of dense, numerous, septate, hyaline, cellular pseudoparaphyses. *Asci* 8-spored, numerous, bitunicate, fissitunicate, broadly-clavate, with a short, orbicular pedicel, rounded at apex, without an ocular chamber. *Ascospores* obliquely bi-seriate, broadly fusiform, 3-trans-septate, without longitudinal septa, brown to



Fig. 36 *Diadema tetramerum* (Material examined: USA, California, Mt. Shasta, ridge south of Horse Camp, elevation 8,250 ft, on culms of *Trisetum spicatum* (L.) Richter, 2 July 1947 W.B. Cooke 20223, DAOM, **holotype**). **a** Ascomata on substrate opening via a flat circular lid. **b**

Vertical section of ascoma. **c** Close up of the peridium. **d** Hyaline, cellular, pseudoparaphyses. **e–i** Asci with short orbicular pedicel. **j–l** Reddish-brown ascospores with very broad sheath. Scale bars: **b** = 100 μ m, **c** = 10 μ m, **d–g** = 60 μ m, **h–j** = 30 μ m

reddish-brown with guttules, smooth-walled, finely punctate, with wide mucilaginous sheath. Asexual state: Unknown.

Notes: *Diadema* is characterized by having large ascospores, without longitudinal septa and ascomata with a circular, lid-like opening (Shoemaker and Babcock 1989). Eight species of *Diadema* are listed in Index Fungorum (2013). Six species were included when the genus was introduced and another two species (*Diadema ahmadii*, Kaz. Tanaka & S.H. Iqbal, *Diadema sieversiae* (Peck) Huhndorf) were later added (Shoemaker and Babcock 1989; Zhang et al. 2011b).

Type species: ***Diadema tetramerum*** Shoemaker & C.E. Babc. [as ‘tetramera’], Can. J. Bot. 67(5): 1354 (1989), MycoBank: MB 136222

Other genera included

Comoclathris Clem., Gen. fung. (Minneapolis), 37: 173 (1909)

Type species: ***Comoclathris lanata*** Clem. [as ‘Comochlathris’], Gen. fung. (Minneapolis): 1–227 (1909)

Diademosia Shoemaker & C.E. Babc., Can. J. Bot. 70(8): 1641 (1992)

Type species: ***Diademosia californiana*** (M.E. Barr) Shoemaker & C.E. Babc. [as ‘californianum’], Can. J. Bot. 70(8): 1641 (1992)

Key to genera of *Diademaceae*

1. Ascospores with transverse septa, without longitudinal septa ***Diadema***
1. Ascospores with transverse septa, with longitudinal septa 2
2. Ascospores cylindrical ***Diademosia***
2. Ascospores flattened ***Comoclathris***

Didymellaceae Gruyter, Aveskamp & Verkley, Mycol. Res. 113(4): 516 (2009), MycoBank: MB 508292

Parasites or *saprobies* on wood and dead herbaceous stems or leaves. Sexual state: *Ascomata* pseudothecia, separate or gregarious, or scattered, immersed, erumpent, or rarely superficial, brown to black, ostiole central. *Peridium* relatively thin, composed of 2–3 cell layers of *textura angularis*. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindric-clavate to clavate, short-pedicellate or apedicellate, with an ocular chamber. *Ascospores* overlapping uni-seriate or bi-seriate, upper cell wider than lower cell, hyaline 1-septate, constricted at the septum, smooth-walled, asymmetrical. Asexual states: coelomycetous. *Conidiomata* pycnidial, immersed, or semi-immersed, sometimes becoming erumpent, uni-locular, pale to medium brown, globose, thin or thick-walled, peridium with cells of *textura angularis*. *Ostiole* central, circular, papillate or not. *Conidiophores* mostly absent, only present in *Phoma cava* Schulzer and *P. tracheiphila* (Petri) L.A.

Kantsch. & Gikaschvili and then either filiform, septate, and branched, or short, irregularly branched, and ramified respectively. *Conidiogenous cells* enteroblastic, phialidic, doliform to lageniform, ampulliform or cylindrical, hyaline, thin walled, smooth-walled. *Conidia* hyaline or pale brown, septate or aseptate, thin-walled, guttulate, ellipsoid, cylindrical, fusiform, pyriform or globose.

Notes: The family *Didymellaceae* was introduced by de Gruyter et al. (2009) in order to accommodate the type species *Didymella exigua*, together with some *Phoma* or *Phoma*-like genera which formed a robust familial clade in the phylogenetic tree. Zhang et al. (2009a) included the family in the order *Pleosporales* within the suborder *Pleosporineae*. De Gruyter et al. (2009) included the sexual morphs of *Didymella* and *Leptosphaerulina* in *Didymellaceae*. Wijayawardene et al. (2012) and Zhang et al. (2012a) listed the asexual states of *Didymellaceae* as *Ampelomyces*, *Ascochyta*, *Boeremia*, *Chaetasbolisia*, *Dactuliochaeta*, *Epicoccum*, *Microsphaeropsis*, *Peyronellaea*, *Phoma*, *Piggotia* and *Pithoascus*. Among them *Ascochyta* and *Phoma* are well known pathogens that are significantly important in quarantine (Kaiser et al. 2008; Aveskamp et al. 2010; de Gruyter et al. 2012, in press). Much research has been carried out since Saccardoan times to distinguish *Ascochyta* and *Phoma* according to their morphological characters, such as their habitat or substrate and morphological characters, such as presence or absence of septa (Van der Aa et al. 1990). However molecular evidence shows that there are significant differences between *Ascochyta* and *Phoma* (de Gruyter et al. 2009). Previously *Ascochyta* was considered to be the asexual state of *Mycosphaerella* (Stone 1912; van Warmelo 1966). Peever et al. (2007) and Chilvers et al. (2009) showed that *Didymella pinodes* (Berk. & A. Bloxam) Petr. is the sexual state of *Ascochyta pinodes* L.K. Jones, and *D. pisi* Chilvers et al. (2009) is the sexual state of *A. pisi* Lib. The latter species of *Ascochyta* is the type species; hence *Ascochyta* is confirmed as *Didymellaceae*. Recently, Su et al. (2012) showed *A. anemones* Lib. to have a *Didymella* sexual state and named as *Didymella anemones*. Since, *Ascochyta pisi* is the type species of *Ascochyta* it is confirmed as *Didymellaceae*. However, some *Phoma* species are also linked with *Didymella* species (Aveskamp et al. 2008; Woudenberg et al. 2013). Therefore the *Ascochyta-Didymella-Phoma* complex needs to be resolved.

Boerema (1997) and Boerema et al. (2004) proposed nine sections for *Phoma* based on morphological and physiological characters; i.e., *Phoma*, *Heterospora*, *Paraphoma*, *Peyronellaea*, *Phyllostictoides*, *Sclerophomella*, *Plenodomus*, *Macrospora* and *Pilosa*. de Gruyter et al. (2009) discussed the confusion regarding this classification system, and de Gruyter et al. (2009, 2010) proposed that *Phoma* must be restricted only to *Didymellaceae*. Therefore they proposed new names for all other species which group outside

Didymellaceae (i.e. in *Cucurbitariaceae*, *Coniothyriaceae*, *Leptosphaeriaceae* and *Montagnulaceae*) and accepted the entire *Phoma* spp. group inside *Didymellaceae* along with *P. herbarum*, the type species. *Ampelomyces quisqualis* the type species of *Ampelomyces* was shown to belong in *Phaeosphaeriaceae* (de Gruyter et al. 2009; Wijayawardene et al. 2013, in press) and at the same time *A. quercinus* grouped in *Didymellaceae* (de Gruyter et al. 2009). This contradiction was discussed by Aveskamp et al. (2010) and they moved all *Ampelomyces* spp. grouped in *Didymellaceae* to *Phoma*. Herein we do not accept *Ampelomyces* as *Didymellaceae*. Aveskamp et al. (2010) showed that *Phoma exigua* is a separate clade, for which they established the new genus *Boeremia*. *Chaetabolisia*, *Epicoccum*, *Microsphaeropsis* and *Peyronellaea* (*Phoma glomerata*) was shown to belong in *Didymellaceae* (de Gruyter et al. 2009; Aveskamp et al. 2010). *Epicoccum* was confirmed to be a dimorphic genus which includes species with either hyphomycetous or “Phoma”-like synanamorphs (Aveskamp et al. 2010; Seifert et al. 2011). *Peyronellaea* is one of the sections of *Phoma*, so it is better to exclude it from the list of asexual genera of *Didymellaceae*. However, the taxonomic placements of *Dactuliochaeta*, *Piggotia* and *Pithoascus* need to be confirmed by a molecular study. Currently six genera are accepted in the family (Zhang et al. 2012a) and here we accept 13 genera. Even though this family is recognized as a separate family in *Pleosporales*, further studies on morphology (sexual morphs as well as their asexual morphs combined with evolutionary linkages) and molecular analysis are needed to confirm relationships.

Type: *Didymella* Sacc., *Michelia* 2(no. 6): 57 (1880), MycoBank MB1548 Fig. 37

Possible synonyms:

Arcangelia Sacc., *Bull. Soc. mycol. Fr.* 5: 115 (1890)

Haplotheciella Höhn., *Ber. dt. bot. Ges.* 36: 314 (1918)

Mycosphaerellopsis Höhn., *Annl. mycol.* 16(1/2): 157 (1918)

Pathogens of many important crops, cortex of stems or in bracts of dead inflorescences, some putatively named species are marine fungi. Sexual state: *Ascomata* pseudothecia, separate or gregarious, or scattered, immersed, erumpent, or rarely superficial, brown to black, ostiole central. *Peridium* comprising two layers, out layer composed of 4–5 layers of blackened, thick-walled cells of *textura angularis*, inner layer hyaline, thin-walled. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindric-clavate to clavate, short-pedicellate or apedicellate, apically rounded, with an ocular chamber. *Ascospores* overlapping uni-seriate or bi-seriate, hyaline, ovoid to ellipsoidal, asymmetrical, upper cell wider than lower cell, 1-septate, constricted at the septum, smooth-walled. Asexual states: coelomycetous. *Conidiomata* pycnidial, amphigenous, separate, globose, brown, immersed,

uni-locular, of thin-walled cells of *textura angularis*. *Ostiole* central, circular, slightly papillate. *Conidiophores* absent. *Conidiogenous cells* enteroblastic, phialidic, determinate, discrete, doliiiform to lageniform, hyaline, smooth-walled, formed from the inner cells of the pycnidial wall. *Conidia* hyaline, medianly 1-septate, continuous or constricted, thin-walled, smooth-walled, ± guttulate, cylindrical to irregular (Sutton 1980).

Notes: *Didymella exigua* (Niessl) Sacc. is the type of the genus *Didymella* (Corlett 1981). *Didymella* contains some very important and serious plant pathogenic species, as well as species that are endophytic and saprobic on a wide range of crops (Aveskamp et al. 2010). Sivanesan (1984) mentioned that *Didymella* and *Mycosphaerella* were originally described in the *Mycosphaerellaceae*. Later, *Didymella* was placed in the *Pleosporales* (*Pleosporaceae*), *Phaeosphaeriaceae* (Barr 1979a; Silva-Hanlin and Hanlin 1999), *Venturiaceae* (Reddy et al. 1998), or considered as a genus *incertae sedis* (Lumbsch and Huhndorf 2010). More recently the *Didymellaceae* was introduced to accommodate this genus (de Gruyter et al. 2009). The herbarium material of the holotype of *D. exigua* was not present in M or BRNU, where the main original collections of Niessl von Mayendorf are preserved, and appears to have been lost. A neotype was designated for *Didymella exigua* de Gruyter et al. 2009 and is a dried culture CBS H-20123 isolated from this taxon on *Rumex arifolius* (*Polygonaceae*) France, with a living ex-neotype culture (CBS 183.55).

Type species: *Didymella exigua* (Niessl) Sacc., *Syll. fung.* (Abellini) 1: 553 (1882)

MycoBank: MB 218525

≡ *Didymosphaeria exigua* Niessl, *Öst. bot. Z.* 25(4): 165 (1875)

Other genera included

Ascochyta Lib., *Pl. crypt. Arduenna*, fasc. (Liège) 1(Praef.): 8 (1830)

Type species: *Ascochyta pisi* Lib., *Pl. crypt. Arduenna*, fasc. (Liège) 1: no. 59 (1830)

Boeremia Aveskamp et al., in Aveskamp et al., *Stud. Mycol.* 65: 36 (2010)

Type species: *Boeremia exigua* (Desm.) Aveskamp et al., in Aveskamp et al., *Stud. Mycol.* 65: 37 (2010)

Chaetabolisia Speg., *Physis*, B. Aires 4: 293 (1918)

Type species: *Chaetabolisia erysiphoides* Griffon & Maubl., *Physis*, *Rev. Soc. Arg. Cienc. Nat.* 4: 293 (1918)

Dactuliochaeta G.L. Hartm. & J.B. Sinclair, *Mycologia* 80(5): 697 (1988)

Type species: *Dactuliochaeta glycines* (R.B. Stewart) G.L. Hartm. & J.B. Sinclair, *Mycologia* 80(5): 699 (1988)

Epicoccum Link, *Mag. Gesell. naturf. Freunde*, Berlin 7: 32 (1816) [1815]

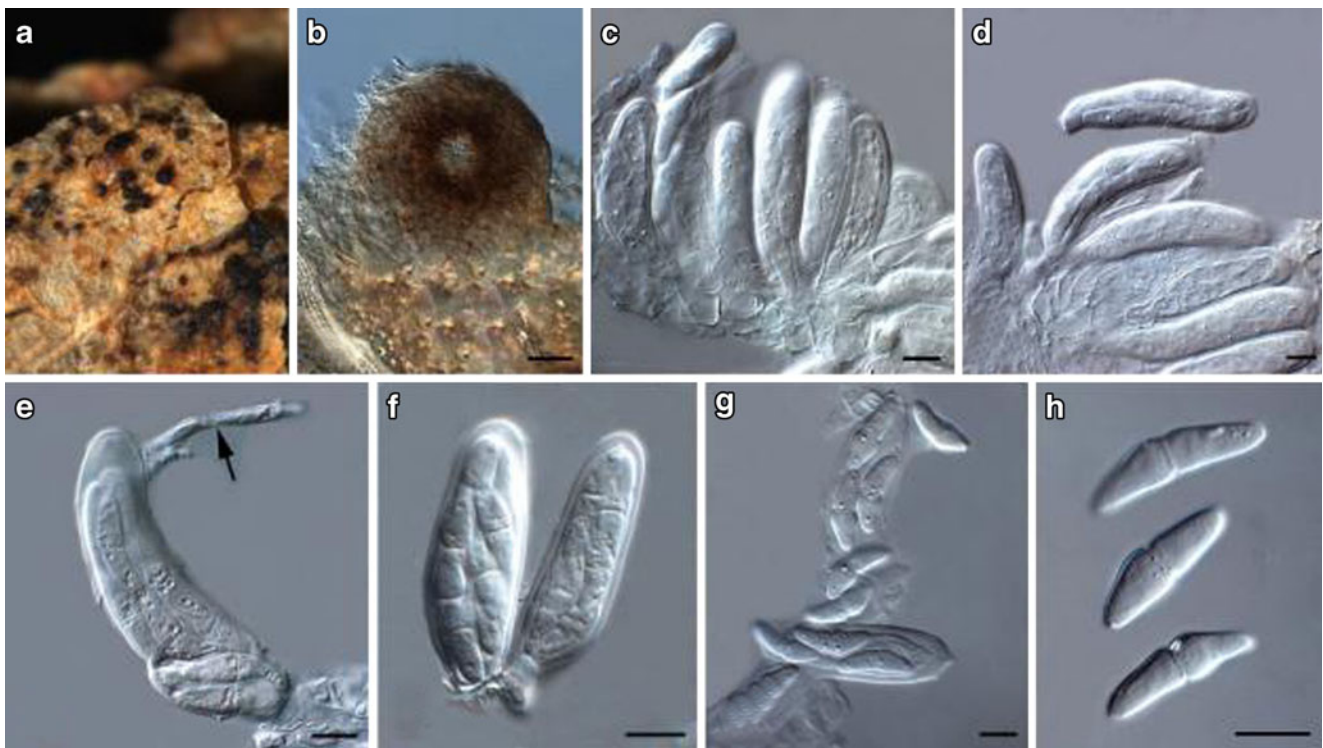


Fig. 37 *Didymella exigua* (Material examined: FRANCE, Memise sur Thollon, on *Rumex arifolius* (*Polygonaceae*), isolated by E. Müller, 2 Nov 1953, deposited by E. Müller, May 1955, CBS H-20123, culture ex-

neotype CBS 183.55. Notes: the CBS Culture is sterile, but the original specimen is in Zurich) **a** Ascomata on host. **b** Surface view of ascoma. **c–g** Asci with ascospores. **h** Hyaline, ascospores. Scale bars: **a–h** = 10 μ m

Type species: Epicoccum nigrum Link, Mag. Gesell. naturf. Freunde, Berlin 7: 32 (1816) [1815]

Leptosphaerulina McAlpine, Fungus Diseases of stone-fruit trees in Australia: 103 (1902).

Type species: Leptosphaerulina australis McAlpine, Fungus Diseases of stone-fruit trees in Australia: 103 (1902)

Macroventuria Aa, Persoonia 6(3): 359 (1971)

Type species: Macroventuria anomochaeta Aa, Persoonia 6(3): 362 (1971)

Microsphaeropsis Höhn., Hedwigia 59: 267 (1917)

Type species: Microsphaeropsis olivacea (Bonord.) Höhn. [as ‘olivaceus’], Hedwigia 59: 267 (1917)

Monascostroma Höhn., Anns mycol. 16(1/2): 160 (1918)

Type species: Monascostroma innumerosum (Desm.) Höhn. [as ‘innumerosa’], Anns mycol. 16(1/2): 160 (1918)

Phoma Sacc., Michelia 2(no. 6): 4 (1880)

Type species: Phoma herbarum Westend., Bull. Acad. R. Sci. Belg., Cl. Sci., sér. 2 19(3): 118 (1852)

Piggotia Berk. & Broome, Ann. Mag. nat. Hist., Ser. 2 7: 95 (1851)

Type species: Piggotia astroidea Berk. & Broome, Ann. Mag. nat. Hist., Ser. 2 7: no. 503 (1851)

Pithomyces Berk. & Broome, J. Linn. Soc., Bot. 14(no. 74): 100 (1873) [1875]

Type species: Pithomyces flavus Berk. & Broome, J. Linn. Soc., Bot. 14(no. 74): 100 (1873) [1875]

Key to sexual genera of Didymellaceae

- 1. Ascospores muriform*Leptosphaerulina*
- 1. Ascospores 2-celled, rarely 3- to 4-celled2
- 2. Ascospores constricted at the central septum3
- 2. Ascospores septate near the lower end*Platychora*
- 3. Ascospores narrowly inequilateral*Monascostroma*
- 3. Ascospores ovoid to ellipsoidal4
- 4. Ascomata with hairs or setae*Macroventuria*
- 4. Ascomata without hairs or setae*Didymella*

Key to asexual genera of Didymellaceae

- 1. Coelomycetous asexual states2
- 1. Hyphomycetous asexual states8
- 2. Pycnidia having dark brown setae, verrucose, conidia ellipsoid3
- 2. Pycnidia lacking setae4
- 3. Conidiophores hyaline to sub hyaline, ampulliform to lageniform*Dactuliochaeta*
- 3. Conidiophores hyaline, doliiform to ampulliform*Chaetasbolisia*
- 4. Conidiophores present*Piggotia*
- 4. Conidiophores absent5

5. Conidia brown, globose, pyriform, cylindrical or ellipsoid ***Microsphaeropsis***
 5. Conidia hyaline **6**
 6. Conidiogenous cells doliform to lageniform, hyaline, conidia hyaline, cylindrical to irregular ***Ascochyta***
 6. Conidiogenous cells ampulliform to doliform **7**
 7. Conidia ellipsoid, cylindrical fusiform, pyriform or globose, often guttulate ***Phoma***
 7. Conidia irregular shape, large conidia (15×5 μm), 1(–2)-septate ***Boeremia***
 8. Dark sporodochia, with branched (sub) hyaline conidiophores ***Epicoccum***
 8. Conidiophores brown, denticles ***Pithomyces***

Didymosphaeriaceae Munk, Dansk bot. Ark. 15(no. 2): 128 (1953), MycoBank: MB 80702

Terrestrial, saprobic or parasitic on woody branches and herbaceous stems and leaves, also parasitic on other fungi. Sexual state: *Ascomata* solitary, scattered, or in small groups, immersed to erumpent or superficial, globose to ovoid, ostiolate. *Ostiole* papillate, ostiolar canal filled with hyaline cells (periphyses). *Peridium* thin, composed of brown, thick-walled pseudoparenchymatous cells. *Hamathecium* of narrow, dense, trabeculate pseudoparaphyses, anastomosing above the asci, in a gelatinous matrix. *Asci* 2–4-spored or 8-spored, bitunicate, fissitunicate, cylindrical, pedicellate, with a small ocular chamber. *Ascospores* uni-seriate or partially overlapping, ellipsoid or oblong, brown, 1-septate. Asexual states: “Fusicladium”-like and “Phoma”-like

Notes: Based on the distoseptate ascospores and trabeculate pseudoparaphyses, mainly anastomosing above the asci, Munk (1953) introduced a new family *Didymosphaeriaceae*, typified by the genus *Didymosphaeria*, in the order *Pleosporales*. Barr (1990c) included this family in the order *Melanommatales* based on its trabeculate pseudoparaphyses. Familial placement of the *Didymosphaeriaceae* is still uncertain because several authors refer the family to different higher taxa; i.e., von Arx and Müller (1975) treated *Didymosphaeriaceae* as a synonym of the *Pleosporaceae*, Lumbsch and Huhndorf (2007) assigned it to the *Montagnulaceae*, while Zhang et al. (2012a) tentatively included *Didymosphaeriaceae* as a separate family in the *Pleosporales* under the suborder *Pleosporineae*. In the same study it was shown that *Didymosphaeria futilis* (Berk. & Broome) Rehm is closely related to the *Cucurbitariaceae* (Zhang et al. 2012a, b). Barr (1990c) included *Neotestudina* under this family by considering the morphology of ascospores. Kohlmeyer and Volkmann-Kohlmeyer (1990) assigned *Coronopapilla* under *Didymosphaeriaceae*, while *Lojkania enalia* (Kohlm.) M.E. Barr (= *Didymosphaeria enalia* Kohlm.) was also included in the family, due to the same character. Zhang et al. (2012a) accepted *Appendispora*,

Didymosphaeria and *Phaeodothis* in the family. Correct placement of this family depends on further molecular and morphological data based with correctly identified and verified strains.

Sivanesan (1984) stated that *Didymosphaeria* has *Ascochyta* and *Periconia* asexual states, while *Keissleriella* has *Dendrophoma* asexual states. However, Schoch et al. (2009b) and Zhang et al. (2012a) showed that *Keissleriella* belongs to *Lentitheciaceae*. Crous et al. (2013) showed that *Dendrophoma cytisporoides* Sacc., the type of *Dendrophoma* groups with *Chaetosphaeria hebetiseta* Réblová & W. Gams and *C. callimorpha* (Mont.) Sacc., hence we exclude *Dendrophoma* from *Didymosphaeriaceae*. Ellis (1971) also reported that *Didymosphaeria* has asexual states in *Periconia*, but according to Seifert et al. (2011), this record was a misidentification of *Lophiostoma* as *Didymosphaeria*. Placing *Ascochyta* in *Didymosphaeriaceae* also met with some contradictions, as *Ascochyta pisi* Lib., the type was shown to belong in *Didymellaceae* (de Gruyter et al. 2009). Wijayawardene et al. (2012) stated that *Rousoëlla* has a *Cytoplea* asexual state and this was phylogenetically linked by Kang et al. (1998) and in culture (Hyde et al. 1996). However the phylogenetic placement of *Rousoëlla* is also uncertain (Zhang et al. 2012a) as in their study it grouped in *Arthopyreniaceae* while in this study is groups near *Bioatriosporaceae* and is accommodated in a new family *Rousoellaceae* (Liu et al. 2013).

Type: Didymosphaeria Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 140 (1870) [1869–70], MycoBank: MB 1562 Fig. 38

Terrestrial, saprobic or parasitic on woody branches and herbaceous stems and leaves, also parasitic on other fungi. Sexual state: *Ascomata* solitary, scattered, or in small groups, immersed to erumpent, globose to ovoid, ostiolate. *Ostiole* papillate with a pore-like opening, ostiolar canal filled with hyaline cells (periphyses). *Peridium* 1-layered, thin, composed of brown pseudoparenchymatous cells of *textura angularis*. *Hamathecium* of dense, trabeculate, pseudoparaphyses, anastomosing mostly above the asci. *Asci* 2–4-spored, or 8-spored, bitunicate, fissitunicate, cylindrical, with a furcated pedicel, apically rounded with an indistinct ocular chamber. *Ascospores* uni-seriate, ellipsoid, brown, 1-septate, wall smooth or roughed. Asexual state: see notes below.

Notes: *Didymosphaeria* was introduced by Fuckel (1870) for three species with two-celled ascospores. This genus now comprises species having a wide distribution and a broad host range. Saccardo (1882) restricted species only with brown spores to the genus (Aptroot 1995a). More than 100 species have also been excluded from this genus (Barr 1989a, b, 1990b, 1992a, b, 1993a, b; Hawksworth 1985a, b; Hawksworth and Boise 1985; Hawksworth and Diederich 1988; Scheinpflug 1958), while Aptroot (1995b) included over 400 epithets of *Didymosphaeria* in his monograph of the genus after examining over 3,000 species. Hawksworth and David (1989) proposed to conserve the genus with a



Fig. 38 *Didymosphaeria futilis* (Material examined: ITALY, Forlì-Cesena, Ravaldino, on dead cane of *Rubus ulmifolius*, 14 January 2012, E. Camporesi, MFLU12-2215). **a** Immersed ascomata on the host surface. **b** Close up of the ascomata. **c** Section of an ascoma. **d** Peridium. **e**

Trabeculate, anastomosing and branching pseudoparaphyses. **f** Eight spored asci with pedicels which are rounded at their bases. **g** Brown, 1-septate ascospores with spinulose ornamentation. Scale bars: **c**=200 μ m, **d**=20 μ m, **e**=10 μ m, **f–h**=30 μ m, **i–l**=10 μ m

lectotype specimen, in Fungi Rhenani 1770 which we follow here, while *Didymosphaeria epidermidis* (Fr.) Fuckel was chosen as the lectotype species by Aptroot (1995b). In his monograph Aptroot (1995b) listed seven species which were closely related with the type of *Didymosphaeria* without considering differences of host or country of origin. Many taxa were excluded from the *Didymosphaeriaceae*: *Aaosphaeria*, *Amphisphaeria*, *Astrosphaeriella*, *Dothidothia*, *Flagellophaeria*, *Kirschsteiniethelia*, *Megalotremis*, *Montagnula*, *Munkovalsaria*, *Mycomicrothelia*, *Parapyrenis* or *Phaeodothis*. Aptroot (1995a) concluded that *Didymosphaeria* belonged in the family *Didymosphaeriaceae* (*Pleosporales*) based on a peridium consisting of flattened or irregular cells, a hamathecium consisting of narrow, trabeculate pseudoparaphyses, richly anastomosing above the asci; and brown, thinly distoseptate ascospores. Currently there are around 500 species epithets listed in Index Fungorum (2013), while GenBank has 21 hits for the genus including putative strains of *Didymosphaeria futilis* (HKUCC 5834) and

Verruculina enalia (Kohlm.) Kohlm. & Volkm.-Kohlm (AFTOL-ID 1601) (a genus now referred to the *Testudinaceae*, Schoch et al. 2006). *Didymosphaeria* has been accepted as a well-established genus represented by *D. futilis*. However few molecular investigations of *Didymosphaeria* have been undertaken when compared to the morphological studies.

Type species: Didymosphaeria futilis (Berk. & Broome) Rehm, Hedwigia 18: 167 (1879), MycoBank: MB 223613
 ≡ *Sphaeria futilis* Berk. & Broome, Ann. Mag. nat. Hist., Ser. 2 9: 326 (1852)

Other genera included

Appendispora K.D. Hyde, Anal. Soc. cient. argent. 46(1): 29 (1994)

Type: Appendispora frondicola K.D. Hyde, Sydowia 46(1): 30 (1994)

Phaeodothis Syd. & P. Syd., Anns mycol. 2(2): 166 (1904)

Type: Phaeodothis tricuspis Syd. & P. Syd., Anns mycol. 2(2): 166 (1904)

Key to genera of *Didymosphaeriaceae*

1. Hamathecium consisting of narrow, trabeculate pseudoparaphyses2
 1. Hamathecium consisting of thin filaments, often sparse pseudoparaphyses *Phaeodothis*
 2. Asci with faint ring and short pedicels *Appendispora*
 2. Cylindrical asci with a furcate pedicel *Didymosphaeria*

Dissoconiaceae Crous & de Hoog, in Crous et al., Stud. Mycol. 64: 36 (2009), MycoBank: MB 514699

Mycoparasitic on powdery mildew, pathogens on Eucalyptus species. Sexual state: *Ascomata* pseudothecial, immersed, globose, uni-locular, papillate, ostiolate, canal periphysate. *Peridium* consisting of 3–4 layers of brown *textura angularis*; inner layer of fattened, hyaline cells. *Pseudoparaphyses* absent. *Asci* 8-spored, bitunicate. *Ascospores* fasciculate, ellipsoid-fusoid, 1-septate, hyaline, with or without mucoid sheath. Asexual state: *Mycelium* internal and external, consisting of branched, septate, smooth-walled, hyaline to pale brown hyphae. *Conidiophores* separate, arising from hyphae, subcylindrical, subulate or lageniform to cylindrical, tapering to a bluntly rounded or truncate apex, straight to once geniculate, smooth-walled, medium brown to brown, multi-septate; loci terminal and lateral, visible as slightly thickened, darkened scars on a rachis. *Conidiogenous cells* terminal or lateral, integrated, tapering towards an acutely rounded apex, pale to brown, subcylindrical, proliferating sympodially, forming a rachis with slightly thickened and darkened, circular. *Conidia* solitary, pale olivaceous-brown, smooth-walled, ellipsoid to obclavate or globose, 0–1-septate; hila somewhat darkened. *Secondary conidia* present or absent; developing adjacent to primary conidia, pale olivaceous to subhyaline, aseptate, pyriform; conidium discharge active or passive. *Dissoconium* has secondary conidia but *Ramichloridium* does not produce secondary conidia (Crous et al. 2009b; Li et al. 2012).

Notes: The asexual typified family *Dissoconiaceae* (*Capnodiales*), was introduced by Crous et al. (2009b). The type is *Dissoconium aciculare* de Hoog et al. and species of *Dissoconium* have “*Mycosphaerella*”-like asexual states (Crous et al. 2004). Crous et al. (2004) showed that *Dissoconium aciculare* clusters with *Mycosphaerella communis* Crous & Mansilla, indicating *Mycosphaerella* as the sexual state. However, Crous et al. (2009b) and Li et al. (2012) clearly showed that *Dissoconium aciculare*, *D. australiensis* Crous & Summerell, *D. commune* Crous & Mansilla, *Ramichloridium apiculatum* (J.H. Mill. et al.) de Hoog, *Uwebraunia commune* (J.H. Mill. et al.) de Hoog and *U. dekkeri* (de Hoog & Hijwegen) Crous group together, but separately as the sister clade of *Mycosphaerellaceae*. The characteristic feature of the genus is conidia which are formed in pairs that are forcefully discharged, which

is quite unique in the *Capnodiales* (de Hoog et al. 1983). Li et al. (2012) accepted *Dissoconium*, *Pseudoveronaea*, *Ramichloridium* and *Uwebraunia* in *Dissoconiaceae*. There is evidence that some species such as *U. dekkeri* (= *D. dekkeri* de Hoog & Hijwegen) could be plant pathogenic (Jackson et al. 2004), while some species occur as commensalists, associated with pathogenic species of *Capnodiales*. The type species of *Ramichloridium*, *R. apiculatum* (J.H. Mill. et al.) de Hoog, is placed in *Dissoconiaceae*, while *R. musae* Stahel (EU041857), *R. australiense* Arzanlou & Crous (EU041852), *R. strelitziae* Arzanlou et al. (EU041860) and *R. cerophilum* (Tubaki) de Hoog (GU214485) group in *Mycosphaerellaceae*.

Type: Dissoconium de Hoog et al., Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci. 86(2): 198 (1983) Fig. 39

Notes: Li et al. (2012) showed that *D. commune* and *D. dekkeri* are well accommodated with *Uwebraunia* hence these species were transferred to *Uwebraunia*. Currently three species are accepted in *Dissoconium* i.e. *D. aciculare*, *D. eucalypti* Crous & Carnegie and *D. protea* Crous (Index Fungorum 2013).

Type species: Dissoconium aciculare de Hoog et al., Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci. 86(2): 198. 1983, MycoBank: MB 107937

Dothideaceae Chevall. [as ‘Dothideae’], Fl. gén. env. Paris (Paris) 1: 446 (1826), MycoBank: MB 80715

Possible synonyms:

Dothioraceae Theiss. & Syd., Anns mycol. 15(6): 444 (1918) [1917]

Pringsheimiaceae Chadeff., Traité bot. syst. 1: 584 (1960)

Biotrophic, necrotrophic or saprobic on twigs and other parts of plants, rarely on leaves. Sexual state: *Ascostromata* uni-loculate or multi-loculate, immersed or erumpent, usually pulvinate, or crustose, black, thick-walled, non-ostiolate, opening by an apical, usually lysigenous pore or dehiscence, interascal tissue lacking. *Peridium* generally 1–2-layers of lightly pigmented, dark brown to black, thick-walled cells of *textura angularis*. *Hamathecium* comprising pseudoparaphyses generally absent in well-developed ascomata. *Asci* 8- or many-spored, bitunicate, fissitunicate, saccate or clavate, short-pedicellate, inner membrane apically thickened, apically rounded with an ocular chamber, asci borne at the base of the loculus. *Ascospores* uni-seriate or bi-seriate, partially overlapping, hyaline or brown, transversely septate, or muriform, small, often guttulate. Asexual states: mostly coelomycetous rarely hyphomycetous mostly species of *Endoconidioma*, *Hormonema*, *Kabatina* and *Podoplaconema*.

Notes: The family *Dothideaceae* was introduced by Chevallier (1826) and is the type family in the order *Dothideales* (Orton 1924). Based on locules embedded in

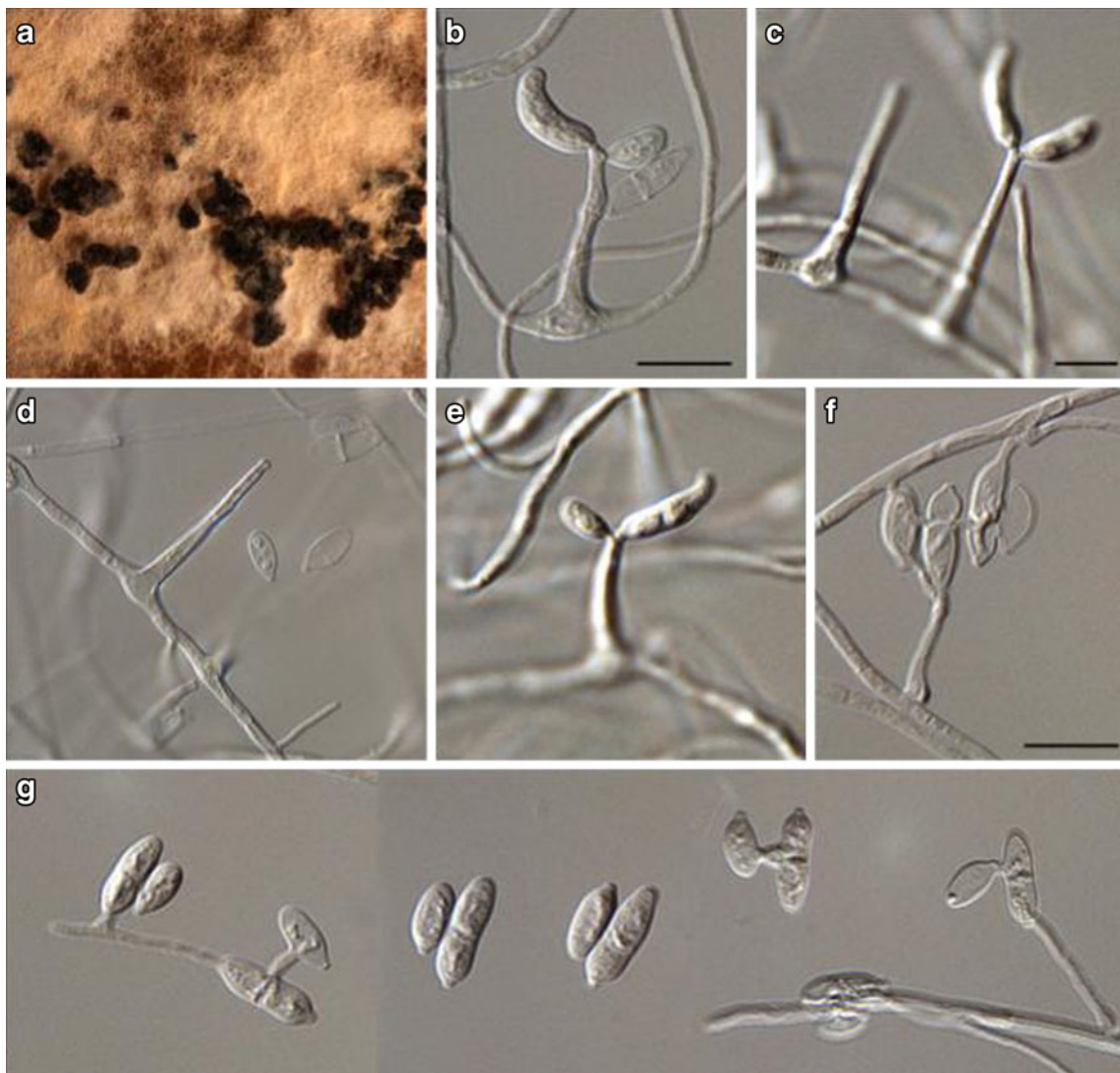


Fig. 39 *Dissoconium proteae* **a** Colony characteristics in culture. **b, c, e, f** Different stages of conidial development, with conidia attached to conidiogenous cells. **c** Conidiophores arising from the mycelium. **g** Conidia. Scale bars: **b–g** = 10 μ m

ascostromata without a definite perithecium, Fuckel (1870) assigned *Dothideaceae* to *Dothideales* and typified the family with *Dothidea*, and assigned *D. gibberulosa* (Fr.) Fr. as the type species (Orton 1924). Winter (1887) separated *Dothideaceae* from *Hypocreaceae* and *Sphaeriaceae* based on the characters of the ascostromata (always present, fleshy, black or blackish brown, lack of perithecium most of the time) and included nine genera with 38 species (Orton 1924). Theissen (1915) include three genera under *Dothideaceae*, i.e. *Coccoideae*, *Leveillelleae* and *Dothidea*, while Luttrell (1973) extended the genera to 22 genera using innate or erumpent pseudothecia on or immersed in a crustose to pulvinate, superficial, erumpent, or innate stroma. von Arx and Müller (1975) included 11 genera in *Dothideaceae*. Currently 20 genera are listed in Index Fungorum (2013). Combined gene analysis of nrSSU, nrLSU rDNA, TEF, RPB1 and RPB2 supported the familial placement

of *Dothideaceae* in order *Dothideales*, in the class Dothideomycetes (Schoch et al. 2009b). The *Dothioraceae* clustered together in the same clade as *Dothideaceae* with a high bootstrap support when some genera and type species i.e. *Delphinella*, *Sydowia* and *Dothiora cannabinae* Froid. and *Dothiora elliptica* Fuckel were included in the analysis (Schoch et al. 2009b). Both of these families share a common morphology such as uni-loculate or multi-loculate, immersed or erumpent, usually pulvinate or crustose ascostromata, along with oblong to short clavate asci with a small, ocular chamber, and asci arising from the basal cushion and dissolving the locule tissue (Blain 1927; Luttrell 1955; Miller 1928; Miller and Burton 1943). Thambugala et al. (in prep), based on molecular data and morphology of generic types, suggested that these two families can be treated as one family, *Dothideaceae*, in the order *Dothideales*.

The asexual genus *Kabatina* was shown to be grouped as a sister clade with *Dothidea hippophaës* (Pass.) Fuckel by Tsuneda et al. (2004). Sutton (1980) concluded that *Asteromellopsis* must be the spermatial or microconidial state of *Dothidella insculpta* (Wallr.) Theiss. & Syd. (later referred to *Dothidea insculpta* Wallr. by Müller and von Arx 1962). Sivanesan (1984) also mentioned this is the spermatial stage of *Scirrha*. Hence we do not consider this state as a different genus, but a spermatial state of *Dothidea insculpta*. *Didymochora* is stated as belonging to *Dothioraceae* (Index Fungorum 2013). However, Sivanesan (1984) stated that *D. betulina* Höhn., the generic type, is the asexual state of *Atopospora*, which belongs in *Venturiaceae* (*Venturiales*). This has not been proven by molecular data, although Zhang et al. (2012a) accepted *Didymochora* under *Venturiaceae*.

Type: Dothidea Fr., *Observ. mycol. (Havniae)* 2: 347 (1818), MycoBank: MB 1693

Figure 40

Possible synonyms:

Phragmodothis Theiss. & Syd., *Annl. mycol.* 12(2): 179 (1914)

Systemma Theiss. & Syd., *Annl. mycol.* 13(3/4): 330 (1915)

Sexual state: *Ascostromata* solitary or scattered, erumpent through the outer layer of the host tissue, to near superficial, multi-loculate, with 8–10 locules with individual ostioles, dark brown to black, globose to subglobose, broadly or narrowly conical, coriaceous. *Peridium* comprising 1–2 layers of thick-walled, lightly pigmented, small cells of *textura angularis*. *Asci* 8-spored, bitunicate, fissitunicate, clavate to sub-cylindrical, with a short, broad pedicel, thickened and rounded at the apex, with a ocular chamber. *Ascospores* uni-seriate, partially overlapping, ellipsoidal with broadly, rounded ends, 1-septate, constricted at the septum, hyaline to light brown when immature, becoming brown to chestnut brown when mature, smooth-walled, thick-walled, without a sheath., Asexual state: Unknown.

Notes: The genus *Dothidea* was erected by Fries (1818) and Fuckel (1870) typified the *Dothideaceae* with *Dothidea*, and assigned *D. gibberulosa* as the type species. *Auerswaldia* was mistakenly categorized under this genus, but Miller and Burton (1943) treated it as separate genus. *Dothidea* was later typified with *D. sambuci*. The formal proposal for this solution was finally brought forward by Shoemaker et al. (2003) who also designated a lecto- and epitype of this species. Fr., focusing mainly on the presence or absence of pseudoparaphyses, Luttrell (1955) differentiated *Pleospora* from *Dothidea*.

Type species: Dothidea sambuci (Pers.) Fr., *Syst. mycol. (Lundae)* 2(2): 551 (1823)

≡ *Sphaeria sambuci* Pers., *Syn. meth. fung. (Göttingen)* 1: 14 (1801)

Other genera included

Coccostromella Petr., *Sydowia* 21: 267 (1968) [1967]

Type species: Coccostromella puttemansii (Henn.) Petr., *Sydowia* 21: 267 (1968) [1967]

Delphinella (Sacc.) Kuntze, *Revis. gen. pl. (Leipzig)* 3(2): 74 (1898)

Type species: Delphinella strobiligena (Desm.) Sacc. ex E. Müll. & Arx, in Müller & von Arx, *Beitr. Kryptfl. Schweiz* 11(no. 2): 25 (1962)

Dictyodothis Theiss. & Syd., *Annl. mycol.* 13(3/4): 346 (1915)

Type species: Dictyodothis berberidis (Rehm) Theiss. & Syd., *Annl. mycol.* 13(3/4): 346 (1915)

Dothiora Fr., *Summa veg. Scand., Section Post. (Stockholm)*: 418 (1849)

Type species: Dothiora pyrenophora (Fr.) Fr., *Summa veg. Scand., Section Post. (Stockholm)*: 418 (1849)

Endoconidioma Tsuneda et al., *Mycologia* 96(5): 1129 (2004)

Type species: Endoconidioma populi Tsuneda et al., *Mycologia* 96(5): 1129 (2004)

Endodothiora Petr., *Annl. mycol.* 27(5/6): 345 (1929)

Type species: Endodothiora sydowiana Petr., *Annl. mycol.* 27(5/6): 345 (1929)

Kabatina R. Schneid. & Arx, *Phytopath. Z.* 57: 179 (1966)

Type species: Kabatina thujae R. Schneid. & Arx, *Phytopath. Z.* 57: 180 (1966)

Omphalospora Theiss. & Syd., *Annl. mycol.* 13(3/4): 361 (1915)

Type species: Omphalospora stellariae (Lib.) Theiss. & Syd., *Annl. mycol.* 13(3/4): 361 (1915)

Phaeocryptopus Naumov, *Bull. Soc. mycol. Fr.* 30(1): 424 (1915)

Type species: Phaeocryptopus abietis Naumov, *Bull. Soc. mycol. Fr.* 30: 424 (1914)

Plowrightia Sacc., *Syll. fung. (Abellini)* 2: 635 (1883)

Type species: Plowrightia ribesia (Pers.) Sacc., *Syll. fung. (Abellini)* 2: 635 (1883)

Podoplaconema Petr., *Annl. mycol.* 19(1/2): 83 (1921)

Type species: Podoplaconema melaenum (Fr.) Petr., *Annl. mycol.* 19(1/2): 84 (1921)

Pringsheimia Schulzer, *Verh. zool.-bot. Ges. Wien* 16: 57 (1866)

Type species: Pringsheimia rosarum Schulzer, *Verh. zool.-bot. Ges. Wien* 16: 57 (1866)

Stylodothis Arx & E. Müll., *Stud. Mycol.* 9: 11 (1975)

Type species: Stylodothis puccinioides (DC.) Arx & E. Müll., *Stud. Mycol.* 9: 11 (1975)

Sydowia Bres., *Hedwigia* 34(Beibl.): (66) (1895)

Possible synonym:

Hormonema Lagerb. & Melin, in Lagerberg, Lundberg & Melin, *Svensk Skogsvårdsförening Tidskr.* 25: 233 (1927) (See Wijayawardene et al. 2013)

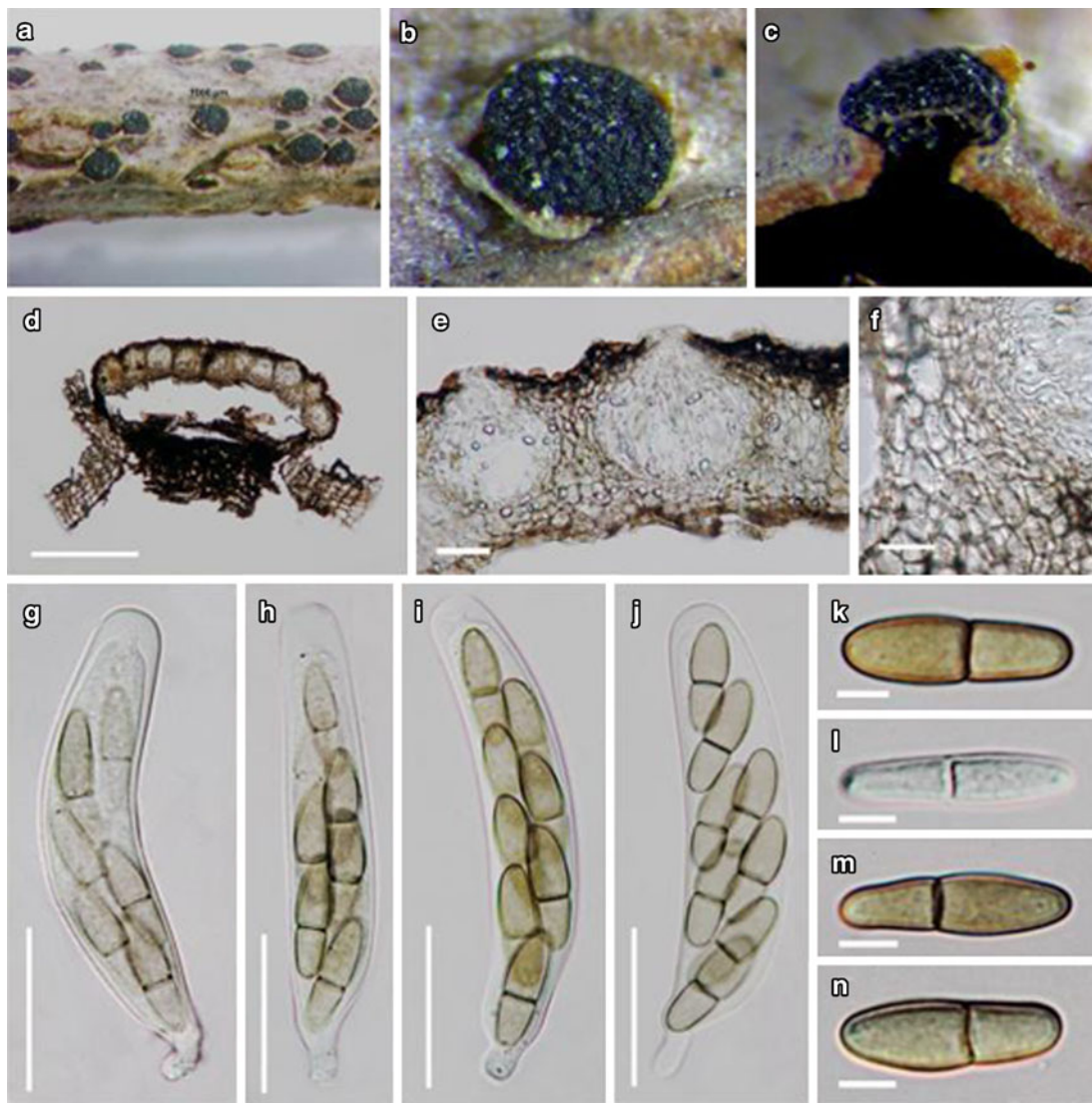


Fig. 40 *Dothidea sambuci* (Material examined: AUSTRIA, Steiermark, on *Sambucus nigra*, 19 March 2000, A. Draxler & W. Maurer, S F21693, **nontype**). **a** Ascostromata on host substrate. **b** Close up of ascostromata. **c** Front view of ascostromata. **d**, **e** Section of an ascostroma. **f** Close up

of the peridium. **g-j** Asci with short, broad pedicel bearing 8-ascospores. **k-n** Mature and immature ascospores with smooth walls. Scale bars: **d** = 500 μ m, **e** = 50 μ m, **f** = 10 μ m, **g-j** = 10 μ m, **k-n** = 5 μ m

Type species: Sydowia gregaria Bres., Hedwigia 34(Beibl.): (66) (1895)

Key to sexual genera of Dothideaceae

- 1. Ascostromata superficial, gregarious, globose to globose-depressed, black, develop on conifer needles *Phaeocryptopus*
- 1. Ascostromata immersed, becoming erumpent, clustered, gregarious, or scattered, pulvinate or crustose, locules subglobose to globose, dark brown to black, develop on twigs, woody branches or leaves 2
- 2. Ascostromata uni-loculate, loculi usually broad 3
- 2. Ascostromata usually multi-loculate, loculi often spherical 5

- 3. Asci with many ascospores 4
- 3. Asci with 8, multi-septate ascospores, constricted at the primary septum *Pringsheimia*
- 4. Ascospores 1-septate, constricted at the septum *Delphinella*
- 4. Ascospores multi-septate or muriform, constricted at the primary septum *Sydowia*
- 5. Ascospores hyaline to brown, 1-many septate or muriform 6
- 5. Ascospores hyaline, ellipsoidal to obovoid, aseptate *Coccostromella*
- 6. Asci with 4–8, ellipsoid to fusiform, 1-septate ascospores *Stylodothis*
- 6. Asci with 8 or more ascospores 7

7. Asci with 8 ascospores8
 7. Asci with 8 or more, 1-many septate ascospores***Dothiora***
 8. Ascospores 1-septate9
 8. Ascospores multi-septate or muriform10
 9. Ascospores usually hyaline, more or less constricted at the septum11
 9. Ascospores hyaline to brown, constricted at the septum***Dothidea***
 10. Ascospores hyaline, consist with 5–7 transverse septa***Endoarthia***
 10. Ascospores brown, muriform, consist with longitudinal and transverse septa***Dictyodopsis***
 11. Ascospores septate near the base, slightly constricted at the septum, upper cell broader than the lower cell***Omphalospora***
 11. Ascospores septate at the middle, strongly constricted at the septum***Plowrightia***

Key to asexual genera of *Dothideaceae*

1. Coelomycetous asexual states2
 1. Hyphomycetous asexual states with slimy conidia***Hormonema***
 2. Two types of conidia, endoconidia hyaline, unicellular, blastic conidia mostly two-celled, light to dark brown***Endoconidioma***
 2. Only one type of conidia3
 3. Conidiophores absent***Podoplaconema***
 3. Conidiophores present, rarely branched***Kabatina***

Dothidotthiaceae Crous & A.J.L. Phillips, in Phillips et al., *Persoonia* 21: 35 (2008), MycoBank MB 511706

Saprobic on wood and branches in terrestrial habitats. Sexual state: *Ascomata* solitary, clustered or somewhat gregarious, erumpent, subglobose, medium-sized, dark brown to black, ostiolate. *Ostirole* apex somewhat papillate to depressed, coriaceous. *Peridium* consisting of a few layers (3–6) of dark brown cells of *textura angularis*, basal region giving rise to dark brown, thick-walled hyphae, that extend from the based of the ascomata into the substrate. *Hamathecium* of dense, hyaline, broad, septate pseudoparaphyses, generally not constricted at the septa, branched in upper part above asci, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, clavate, straight to curved, with a short broad pedicel, rounded at apex with an ocular chamber. *Ascospores* bi-seriate or obliquely uni-seriate, partially overlapping, ellipsoid, 1-septate, slightly constricted at the septum, rounded at the ends, smooth-walled, thin-walled without or occasionally with a gelatinous sheath, brown to chestnut or pale brown. Asexual state: *Colonies* punctiform, brown to black. *Mycelium* immersed. *Conidiomata* immersed, erumpent or nearly superficial, hyaline to dark brown. *Conidiophores* macronematous, mononematous, usually short and packed

closely together forming pulvinate sporodochia, mostly unbranched, straight or flexuous, subhyaline to brown, or olivaceous brown, smooth or verrucose. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent, cylindrical, doliiform or lageniform. *Conidia* clavate, cylindrical, ellipsoidal or obclavate, subhyaline to dark brown, with smooth, verrucose or echinulate spore wall, one or multi-septate (Phillips et al. 2008; Ramaley 2005).

Type Dothidotthia Höhn., Ber. dt. Bot. Ges. 36: 312 (1918), MycoBank MB 1699 Fig. 41

Notes: The family *Dothidotthiaceae* was introduced by Phillips et al. (2008) in order to accommodate the single genus *Dothidotthia*. Barr (1987a) originally classified *Dothidotthia* as a member of the *Botryosphaeriaceae*. A multi-gene analysis of SSU, ITS, LSU, EF1- α and β -tubulin showed that *Dothidotthiaceae* form a separate clade from the other families of order *Pleosporales* (Zhang et al. 2012a), and is closely related to *Didymellaceae*.

Type species: Dothidotthia symphoricarpi (Rehm) Höhn., Ber. dt. bot. Ges. 36: 312 (1918), MycoBank: MB 218661
 \equiv *Pseudothia symphoricarpi* Rehm, *Annl. mycol.* 11(2): 169 (1913)

Notes: *Dothidotthia* was initially established by von Höhnell (1918a, b) to accommodate *Pseudothia symphoricarpi*. *Dothidotthia* had been treated as a synonym of *Gibbera* by von Arx and Muller (1954) and Müller and von Arx (1962) and this was followed by Shoemaker (1963) and Eriksson and Hawksworth (1987). von Arx and Muller (1954) and Müller and von Arx (1962) showed *Dothidotthia* to be closely related to a *Dibotryon*, a genus in the *Venturiaceae*. Barr (1989b) introduced the combination *Dothidotthia aspera*, but incorrectly listed *D. symphoricarpi* as synonym and included it in *Botryosphaeriaceae* (Ellis & Everh.) M.E. Barr, based on the coelomycetous asexual morph and peridium structure, shape of asci, as well as morphology of pseudoparaphyses. A multi-gene analysis of SSU, ITS, LSU, EF1- α and β -tubulin was undertaken which included *Dothidotthia* as a genus in the *Dothidotthiaceae* (order *Pleosporales*) and typified by *Dothidotthia symphoricarpi* (Phillips et al. 2008). Initially it was believed that the asexual state of this genus was coelomycetous, but later it was proven that it produces a hyphomycetous state (Phillips et al. 2008; Ramaley 2005). Currently there are around eleven species epithets listed in the Index Fungorum (2013).

Dyfrlolomycetaceae K.D. Hyde et al., *Crypt. Mycol.* 34:223–232 (2013), MycoBank: MB 804662

Saprobic on wood in aquatic or terrestrial environments. Sexual state: *Ascomata* relatively large, solitary to gregarious, immersed, globose or subglobose, coriaceous, clypeate, ostirole rounded, papillate. *Peridium* broadest at the sides, comprising two layers, an outer layer composed of host cells, interdispersed with fungi hyphae, forming a *textura intricata*

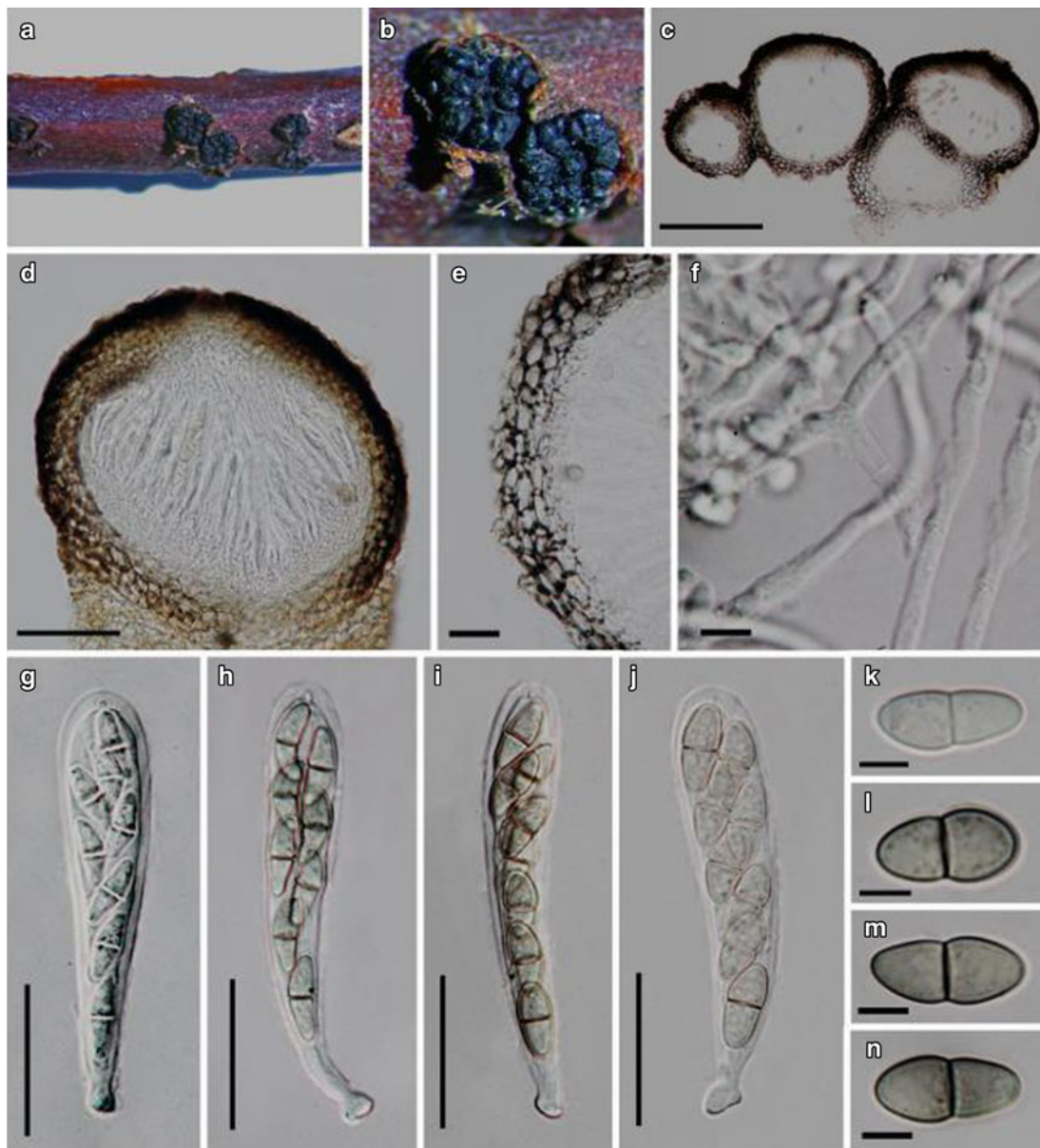


Fig. 41 *Dothidothia symphoricarpi* (Material examined: USA, North Dakota, on branches of *Symphoricarpi occidentalis*, 10 May 1914, J.F. Brenckle, S F102883) **a** Ascomata on host substrate. **b** Close up of the ascoma. **c–d** Section of ascoma. **e** Peridium **f** Long branched cellular

pseudoparaphyses **g–j** Asci with short broad pedicel, bearing 8-ascospores. **k–n** Smooth-walled immature and mature ascospores without a sheath. Scale bars: **c**=250 μm , **d**=100 μm , **e**=40 μm , **f**=5 μm , **g–j**=45 μm , **k–n**=5 μm

and an inner layer of thick-walled cells of *textura angularis*. *Hamathecium* comprising numerous, relatively narrow (up to 2 μm wide), septate, narrow pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, with a relatively short pedicel, apically rounded or flattened with a distinct ocular chamber and ring-like subapical apparatus. *Ascospores* overlapping uni-seriate, broadly fusiform, symmetrical, hyaline, multi-septate with wide septa (distoseptate?), smooth-walled. Asexual state: Unknown.

Notes: *Saccardoella* was introduced by Spegazzini (1879) and presently has 22 species epithets (Index Fungorum). The genus is typified by *Saccardoella montellica* Speg., which

was described from *Quercus* in Italy. There has been confusion over the nature of the asci as they are neither typically unitunicate or bitunicate, thus the placement of the genus has been unsettled (Mathiassen 1989; Hyde 1992c). Ascumata are immersed in wood, asci are 4-spored, long cylindrical and “iodine fluorescent” and ascospores are 100–130 μm long and 20–30 septate, with apical spines (Spegazzini’s drawing in Cybertruffle 2013). The iodine positive reaction of the asci was not mentioned in the protologue (Spegazzini 1879) or subsequent papers (Petrak 1962; Barr 1990a; Hyde 1992c; Tsui et al. 2006) and this has caused considerable confusion. The iodine positive ring indicates that *Saccardoella*

montellica belongs in *Xylariales*. We cannot confirm this, as LPS will no longer loan Spegazzini's type material, but follow the drawing provided by the author. The asci and ascospores in the aquatic species of *Saccardoella* are also considerably different to those of *Saccardoella montellica*. Therefore, any Dothideomycetous elements in *Saccardoella* should be transferred to one or more new genera.

Saccardoella has been variously assigned to the *Clypeosphaeriaceae* (Barr 1990a), and unitunicate *Ascomycetes incertae sedis* (Jones et al. 2009a). Suetrong et al. (2009) sequenced a strain of *Saccardoella rhizophorae* isolated by Kohlmeyer from collections made in Hawaii. This sequence did not group with any known taxon in the *Dothideomycetes*, but formed a unique clade that could not be referred to any family or order. Pang et al. (2013) described a new fungus with close morphological affinity with the marine *Saccardoella* spp. Phylogenetically, it grouped with the two isolates of *S. rhizophorae* and consequently, a new genus *Dyfrulomyces* was introduced to accommodate the new fungus and all marine species of *Saccardoella*. Pang et al. (2013) described a new family to accommodate this genus. In our phylogenetic results (Figs. 1 and 2), it forms a unique clade which is same with Pang et al. (2013) and we therefore introduce a new order for this family. *Discostroma corticola* (Fuckel) Brockmann may have similarities with this family (Wehmeyer 1957).

Type: *Dyfrulomyces* K.D. Hyde et al., *Crypt, Mycol.* 34:223–232 (2013) Fig. 42

Notes: Currently, only *Dyfrulomyces* is included in the family with four species and therefore a genus description is not provided. *Dyfrulomyces tiomanensis* is a new species while *D. mangrovei* K.D. Hyde, *D. marinospora* K.D. Hyde and *D. rhizophorae* were transferred from *Saccardoella* (Pang et al. 2013). Whether the freshwater species of *Saccardoella* belongs to *Dyfrulomyces* will require further studies on these species at the molecular level.

Type species: *Dyfrulomyces tiomanensis* K.L. Pang et al., *Crypto, Mycol.* 34: xxx (2013)

Elsinoaceae Höhn. ex Sacc. & Trotter, *Syll. fung.* (Abellini) 22: 584 (1913), MycoBank: MB 82022

Possible synonyms:

Myxomyangiaceae (Theiss.) Theiss.

Plectodiscellaceae Woron., *Mykol. Zentbl.* 4: 232 (1914)

Saccardinulaceae G. Arnaud, *Annl. Sci. Nat., Bot., sér.* 10 7: 647 (1925)

Stephanothecaceae Petr., *Annl. mycol.* 29(5/6): 345 (1931)

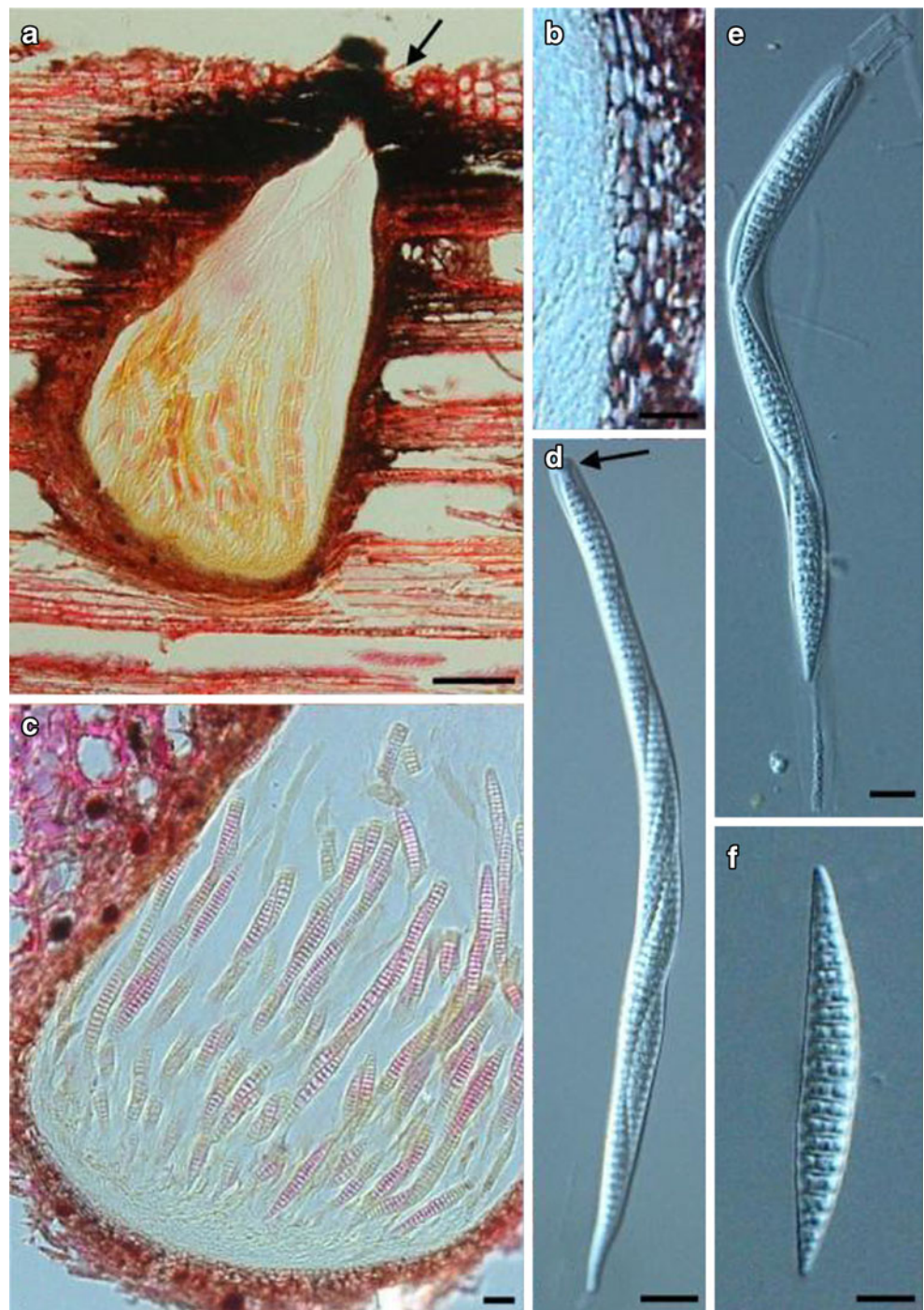
Parasitic on plant leaves causing scab and anthracnose. Sexual state: *Ascstromata* usually spread around host veins, solitary, aggregated, or gregarious, wart-like, or as small distinctively coloured elevations, or pulvinate, immersed to semi-immersed, globose to subglobose, white, pale yellow or brown, soft, multi-loculate, locules scattered in upper part of

ascstromata, cells of ascstromata comprising pseudoparenchymatous cells of *textura globulosa* to *angularis*. *Locules* with few to numerous asci inside each locule, ostiolate. *Ostiole* minute, periphyses absent. *Asci* 8-spored, bitunicate, fissitunicate, saccate to globose, with a minute pedicel, and indistinct ocular chamber. *Ascospores* irregularly arranged, oblong or fusiform with slightly acute ends, with 2–3 transverse septa, hyaline, smooth-walled, lacking a sheath. Asexual state: “*Sphaceloma*” *Acervuli* subepidermal, pseudoparenchymatous. *Conidiophores* hyaline to pale-brown, polyphialidic. *Conidiogenous cells* formed directly from the upper cells of the pseudoparenchyma, monopialidic to polyphialidic, integrated or discrete, determinate, hyaline to pale brown, lacking a thickened region around the phialide channel. *Conidia* hyaline, unicellular, ellipsoidal, aseptate, biguttulate.

Notes: *Elsinoaceae* is a family of plant pathogens that causes anthracnose and scab. Many classical treatments have placed *Elsinoaceae* in synonymy with *Myriangiaceae*; however von Höhnel (1909c) was convinced that the former constituted a separate family. Eriksson (1981) agreed and maintained two separate families with *Myriangiaceae* predominantly saprobic on branches and *Elsinoaceae* restricted to foliar pathogens. In *Elsinoaceae* the ascstromata form whitish, crust-like patches on leaves. Asci are subglobose and J- and form in locules mostly at the periphery of the ascstromata. Ascospores are hyaline or light brown, transversely septate or muriform. The asexual morphs are coelomycetous and acervular, and where known are in the genus *Sphaceloma*.

Lumbsch and Huhndorf (2010) included ten genera in *Elsinoaceae* and in this treatment we maintain *Butleria*, *Hemimyriangium*, *Micularia* and *Mollerella*, while the other genera included by Lumbsch and Huhndorf (2010) are placed in different families. Li et al. (2011) revised the familial positions of *Beelia*, *Hyalotheles* and *Saccardinula* and supported the separation of *Elsinoaceae* from the family *Myriangiaceae*. *Beelia* is a superficial biotroph on leaf surfaces, which is a character shared by the family *Chaetothyriaceae*. *Hyalotheles* was considered to be better placed in *Dothideomycetes incertae sedis*. Luttrell (1973) grouped *Saccardinula* under *Saccardinulaceae* based on its ascstromata grouping in a radiate, superficial, cellular membrane (Li et al. 2011). The ascromata in *Saccardinula* resemble thyrothecia which are found in *Brefeldiaceae* and *Microthyriaceae*. Formation of asci and ascromata are more similar to *Brefeldiella* that occur on leaves (Reynolds and Gilbert 2005). *Saccardinula* is placed under family *Brefeldiaceae* even though it is a less convincing member of the family as it has globose asci and muriform spores, while the thallus is less developed. *Stephanotheca* is characteristic of the family *Asterinaceae*. *Xenodium* Syd. was included in the family *Elsinoaceae* by Lumbsch and Huhndorf (2010), but has unitunicate asci and thus excluded from *Dothideomycetes*.

Fig. 42 *Dyfrlomyces tiomanensis*. (Material examined: MALAYSIA: Tioman Island, on a piece of unidentified mangrove wood, 13 July 2010, K.L. Pang, MFLU 13-00063, **holotype**, sections of the ascomata; MFLUCC13-0440) **a** Immersed ascoma with a clypeus (*arrow*). **b** Peridium comprising two layers, an outer layer of cells of *textura intricata* composed of host cells interspersed with fungal hyphae and an inner layer of thick-walled cells of *textura angularis*. **c** Asci forming at the base of ascoma. **d** Cylindrical ascus with a faint, ring-like subapical apparatus (*arrow*). **e** Dehiscence of the ascus. **f** Spindle-shaped ascospore with 20 septa. Scale bars: **a** = 100 μm ; **b**, **f** = 10 μm ; **c–e** = 20 μm



Type genus: *Elsinoë* Racib., Parasit. Alg. Pilze Java's (Jakarta) 1: 14 (1900) Figs. 43, 44 and 45

Synonyms:

Sphaceloma de Bary, Ann. Oenol. 4: 165–167 (1874)

For other possible synonyms see Index Fungorum, MycoBank: MB 1764

Parasitic on plant leaves causing scab and anthracnose. Sexual state: *Ascstromata* occurring on both surfaces of the leaves, especially on underside of the leaves, usually spread

around host veins, lower part fusing with host cells, solitary, aggregated, or gregarious, wart-like, or as small distinctively coloured elevations, or pulvinate, immersed to semi-immersed, globose to subglobose, white, pale yellow or brown, soft, multi-locular, locules scattered in upper part of ascostromata, cells of ascostromata comprising pseudoparenchymatous cells of *textura globulosa* to *angularis*. *Locules* with numerous asci inside each locule, ostiolate. *Ostiole* minute, periphyses absent. *Asci* 8-spored, bitunicate, fissionate,

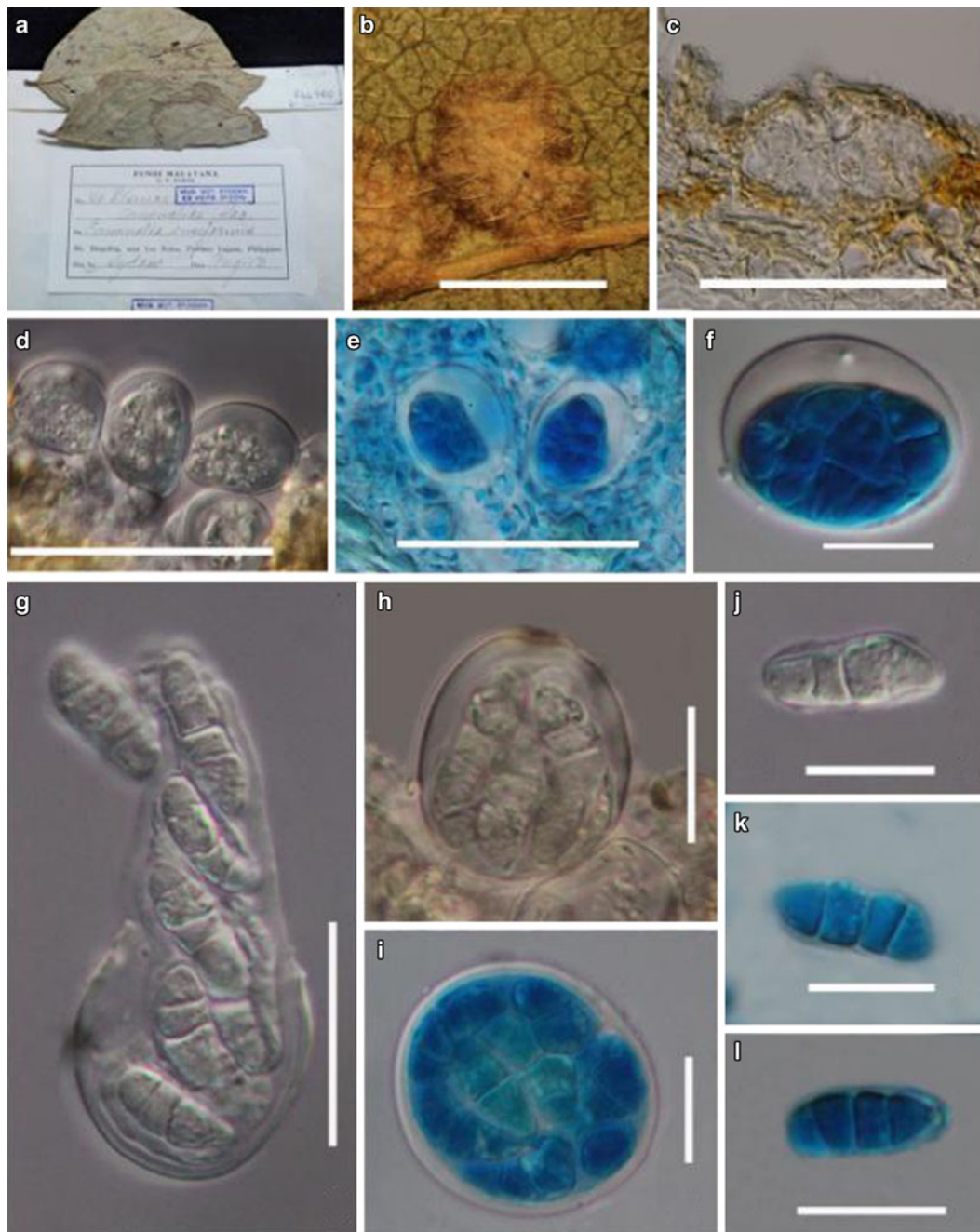


Fig. 43 *Elsinoë canavaliae* (Material examined: PHILIPPINES, Province Laguna, Mount Maquilang, near Los Baños, on *Canavalia ensiformis*, August 1913 (S F66900). **a** Herbarium specimen. **b** Ascostromata on host substrate. **c** Section of ascostromata. **d** Asci. **e-f**

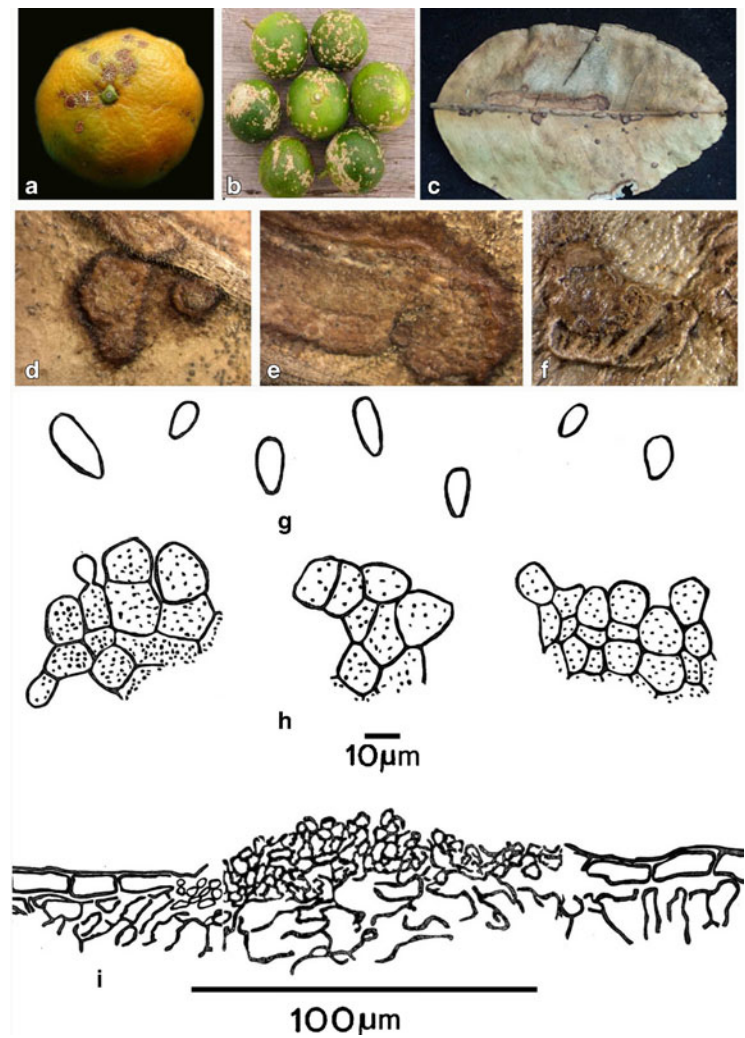
Asci stained with lactophenol cotton blue reagent. **g** Fissitunicate ascus. **h-i** Asci bearing eight irregularly arranged ascospores. **j** Smooth, hyaline ascospore. **k-l** Ascospores stained with lactophenol cotton blue reagent. Scale bars: **b** = 100 μm , **c-e** = 50 μm , **g** = 20 μm , **f, h-l** = 10 μm

saccate to globose, with a minute pedicel, and indistinct ocular chamber. *Ascospores* irregularly arranged, oblong or fusiform with slightly acute ends, with 2–3 transverse septa, hyaline, smooth-walled, lacking a sheath. Asexual state: “Sphaceloma” *Acervuli* subepidermal, pseudoparenchymatous. *Conidiophores* hyaline to pale-brown, polyphialidic. *Conidiogenous cells* formed directly from the upper cells of the pseudoparenchyma, monophialidic to polyphialidic, lacking a thickened region around the phialidic channel, terminal,

integrated, determinate, hyaline to pale brown. *Conidia* hyaline, unicellular, ellipsoidal, aseptate, biguttulate.

Notes: *Elsinoë* was established by Raciborski (1900) with descriptions of three species (*E. canavaliae* Racib., *E. antidesmae* Racib., *E. meninspermacearum* Racib.). von Arx and Müller (1975) placed *Elsinoë* in *Myriangiaceae* based on its immersed or erumpent, pulvinate or irregular ascomata and being parasitic on higher plants causing scab. Later, the genus was removed to the family *Elsinoaceae* (Barr

Fig. 44 *Elsinoë fawcettii*
(Material examined:
THAILAND, Chiang Rai, near
Phu chi Fa, on *Citrus* sp., 28
January 2013, MFLU 12–2214),
material redrawn from Sutton
and Pollok (1973). **a, b** Disease
symptoms on citrus fruit.
c–f Leaf spots. **g** Conidia. **h**
Conidiogenous cells. **i** Section
of conidioma. Scale bars:
l=100 μ m, **e–i**=50 μ m,
c–d=20 μ m, **k**=10 μ m



1979a; Lumbsch and Huhndorf 2010). Index Fungorum (2013) list 139 epithets under *Elsinoë*. Species of *Elsinoë* are phytopathogens of economically important plants, including *Citrus* and *Eucalyptus* (Cheewangkoon et al. 2010; Chung 2011). The asexual state of *Elsinoë* was reported in ‘Sphaceloma’ (Wijayawardene et al. 2012) and Cheewangkoon et al. (2010) has resolved this relationship by analysing rDNA sequence data. Hence, we propose *Elsinoë*, the widely used sexually typified name over ‘Sphaceloma’, although the latter genus is the older name.

Elsinoë is an important plant pathogenic genus causing scab and anthracnose of *Citrus*, *Malus*, *Rubus* and several other plants. *Elsinoë fawcettii* Bitanc. & Jenkins and *E. australis* Bitanc. & Jenkins cause scab disease of *Citrus* spp. (Hanlin 1989; Timmer et al. 1996; Hyun et al. 2001; Nelson 2008) and there are many other important pathogens in this genus. Examples include *Elsinoë* species causing scab disease of *Proteaceae* (Swart et al. 2001), mango scab caused by *E. mangiferae* Bitanc. & Jenkins (Conde et al. 1997) and

scab of goldenrot caused by *Elsinoë solidaginis* Jenkins & Ukkelberg (Jenkins and Ukkelberg 1935). *Elsinoë takoropuku* G.S. Ridl & Ramsfield is a recently introduced species (Ridley and Ramsfield 2006), but differs from *E. canavaliae* markedly as it forms ascostromata on twigs of *Pittosporum tenuifolium* instead of scabs on leaves. It contains locules each containing single ascus. The asci are however, thought to be more similar to the *Elsinoë* type even though it has many characters similar with *Myriangiaceae*. Molecular studies are required for this group.

There have been few molecular studies using strains of *Elsinoë*. Schoch et al. (2006) and Boehm et al. (2009a) showed that there is a distinct subclade among the species of *Myriangiaceae* (named *Elsinoaceae*). However, only four *Elsinoë* strains and one *Myriangium* strain were used in Schoch et al. (2006) and no *Elsinoë* strains were used in Schoch et al. (2009b). Thus, molecular data do not convincingly resolve the two separate families.



Fig. 45 *Elsinoë fawcettii* (Material examined: THAILAND, Chiang Rai, near Phu chi Fa, on *Citrus* sp., 28 January 2013, MFLU 12–2214) **a, b** Conidiomata on host substrate. **c, d** Section of conidioma. **e–g** Conidiogenous cells. **h–i** Conidia. Scale bars: **e–i** = 50 μ m, **c–d** = 20 μ m

Type species: Elsinoë canavaliae Racib. [as ‘canavalliae’], Parasit. Alg. Pilze Java’s (Jakarta) 1: 14 (1900), MycoBank: MB: 217658

Possible synonym:

Uleomyces canavaliae (Racib.) G. Arnaud, Anns Sci. Nat., Bot., sér. 10 5: 685 (1925)

Other genera included

Butleria Sacc., Anns mycol. 12(3): 302 (1914)

Type species: Butleria inaghatahani Sacc., Anns mycol. 12(3): 302 (1914)

Hemimyriangium J. Reid & Piroz., Can. J. Bot. 44: 650 (1966)

Type species: Hemimyriangium betulae J. Reid & Piroz., Can. J. Bot. 44: 651 (1966)

Micularia Boedijn, Persoonia 2(1): 67 (1961)

Type species: Micularia merremiae Boedijn, Persoonia 2(1): 67 (1961)

Mollerella G. Winter, Bolm Soc. broteriana, Coimbra, sér. 1 4: 199 (1886)

Type species: Mollerella mirabilis G. Winter, Bolm Soc. broteriana, Coimbra, sér. 1 4: 199 (1886)

Key to genera of Elsinoaceae

1. Ascstromata superficial2
1. Ascstromata immersed to erumpent, ascospores usually with more than 2-septa, with *Sphaceloma* asexual state and usually causing scabs on leaves.....*Elsinoë*
2. Ascstromata more or less kidney-shaped*Mollerella*
2. Ascstromata subglobose, globose and irregular3
3. Asci showing acropetal succession, ascospores 4-celled*Hemimyriangium*
3. Asci not showing acropetal succession, ascospores 2-celled4
4. Ascospores broadly clavate, hyaline*Micularia*
4. Ascospores conglobose, brown*Butleria*

Englerulaceae Henn., Hedwigia 43: 353 (1904), MycoBank: MB 80736

Synonym:

Schiffnerulaceae Hosag., Pl. Pathol. Quarant. 1(2): 132 (2011)

Saprobic or *epiphytic* on leaves, primarily tropical. *Colonies* superficial, thin to dense, brown to dark brown, confluent, velvety, with unicellular appressoria. *Hyphae* straight to flexuous, septate, irregularly to reticulately branched, brown. *Hyphopodia* globose, brown, thick-walled, irregular or absent. Sexual state: *Ascomata* relatively small, superficial on hyphae, scattered, ellipsoid to globose, cupulate, brown to black, or small circular thyriothecia, membranous, containing few asci, non-ostiolate, dissolving at centre to release asci. *Hamathecium* of brown, septate, pseudoparaphyses or pseudoparaphyses lacking. *Asci* 8-spored or rarely 2-spored, bitunicate, thick-walled, ovate, globose to subglobose, pedicellate, with an ocular chamber. *Ascospores* uni-seriate to multi-seriate, oblong to ellipsoid, ellipsoid to ovate, or fusiform, hyaline to dark brown, 1-septate, smooth-walled, constricted at the septum. Asexual state: *Conidiomata* pycnidial, similar to ascomata, superficial, globose, thin-walled. *Conidiogenous cells* holoblastic, phialidic, discrete, hyaline, smooth, 1-celled, nearly ampulliform, alternate or absent. *Conidia* 1-celled, oblong to ovate, globose or nearly globose, hyaline to brown.

Notes: The family *Englerulaceae* was introduced by Hennings (1904b) for taxa with brown to dark-brown colonies on host leaves, with superficial, scattered, ascomata lacking ostioles. Asci are 2–8-spored, bitunicate, ovate to globose and ascospores are multiseriate, oblong to ellipsoid, brown, 1-septate, and smooth-walled (Eriksson 1981). Lumbsch and Huhndorf (2010) included seven genera in the family, while Hyde et al. (2011) considered *Schiffnerulaceae* (Hosagoudar 2011) to be a synonym. *Schiffnerula* had been introduced by von Höhnelt (1909a) and placed in the family *Englerulaceae*, because of its globose ascomata and globose to ovate asci. Subsequently, Hosagoudar (2011) introduced a new family *Schiffnerulaceae* which is typified by *Schiffnerula* and characterized by thyriothecoid ascomata developing below the mycelium, and asci exposed in the central portion of the thyriothecium. Hosagoudar (2011) included four asexual genera in the family with more than one hundred species. *Schiffnerula* has black colonies on the leaf surface, with brown, superficial, septate mycelium, 8-spored, bitunicate, cylindrical to globose asci, and brown, 1-septate, ascospores which are constricted at the septa. With such characters *Schiffnerula* can be accommodated in *Englerulaceae*.

In *Englerulaceae*, the genera *Englerula* have hyphae without hyphopodia or appressoria, while *Goosia*, *Parenglerula*, *Rhytidenglerula*, *Schiffnerula* and *Thrauste* have hyphopodia (Bin 2003; Castlebury et al. 1995; Hosagoudar et al. 2011a, b; von Höhnelt 1909a, 1910a, b, 1918a, b; Theissen 1916). Whether this character is taxonomically important needs to be tested using molecular data; but for now we accept these

genera in the same family. In addition, *Parenglerula* has pseudoparaphyses which differentiate it from the other genera in the family. *Goosia* has 1-celled, nearly ampulliform and alternate phialides and 2-spored asci which distinguishes it from the other genera (Bin 2003). The type of *Goosia* is lost, and this needs recollecting and neotyping. In *Rhytidenglerula*, *Schiffnerula* and *Thrauste*, hyphopodia are brown, globose to subglobose and thick-walled. *Thrauste* has large perithecia. *Rhytidenglerula* and *Schiffnerula* have cylindrical and brown ascospores. *Rhytidenglerula* has superficial ascomata with shield-like, radiating hyphal tissue, while *Schiffnerula* differs from other genera by ascomata arising from short lateral branches. There appears to be two groups in this family.

Asexual states of this family are coelomyceteous and hyphomyceteous which are known in genera such as *Capnodiastrum*, *Digitosarcinella*, *Mitteriella*, *Questieriella* and *Sarcinella* (Wijayawardene et al. 2012). *Parenglerula* and *Thrauste*, are known to lack asexual stages, while *Schiffnerula* has four hyphomyceteous asexual states, namely *Digitosarcinella*, *Mitteriella*, *Questieriella* and *Sarcinella*, (Hosagoudar 2003). *Englerula* and *Rhytidenglerula* have asexual states with pycnidia which belong to *Capnodiastrum* (Wijayawardene et al. 2012). Hosagoudar (2003) proposed a new pycnidial genus *Krishnamyces* for the asexual stage of *Rhytidenglerula*. Bin (2003) described *Goosia* with 1-celled, brown conidia. *Rhizotaxis* has no known asexual state.

Type: **Englerula** Henn., Bot. Jb. 34: 49 (1904), MycoBank: MB 1820 Fig. 46

Possible synonym:

Anatexis Syd., Anns mycol. 26(1/2): 90 (1928)

Saprobic or *epiphytic* on leaves, primarily tropical. *Colonies* on both leaf sides, superficial, thin to dense, round to irregular, dark brown to black, confluent, velvety. *Hyphae* superficial, straight to curved, septate, irregular to reticulately branched, and acute to wide angles, brown. *Hyphopodia* absent. Sexual state: *Ascomata* perithecioid, superficial on hyphae, scattered, globose to subglobose, brown to black, non-ostiolate, containing few asci. *Peridium* thin, membranous. *Pseudoparaphyses* absent. *Asci* 8-spored, bitunicate, thick-walled, obovoid to subclavate, globose to subglobose, with a thick ocular chamber and apex. *Ascospores* multi-seriate, fusiform, broadly ellipsoid to subobovoid, yellowish-brown to dark brown, 1-septate, smooth-walled, constricted at the septum, ends rounded, surrounded by remnants of mucilage. Asexual states: in *Capnodiastrum*. *Conidiomata* pycnidial similar to perithecia, superficial, globose, thin-walled. *Conidiogenous cells* holoblastic, discrete, hyaline, smooth. *Conidia* 1-celled, oblong to ovate, brown.

Notes: *Englerula* includes 13 species according to Index Fungorum (2013). This genus is characterized by thin to dense, rounded to irregular, brown to black colonies, with superficial, branched, acute to wide angled hyphae, globose

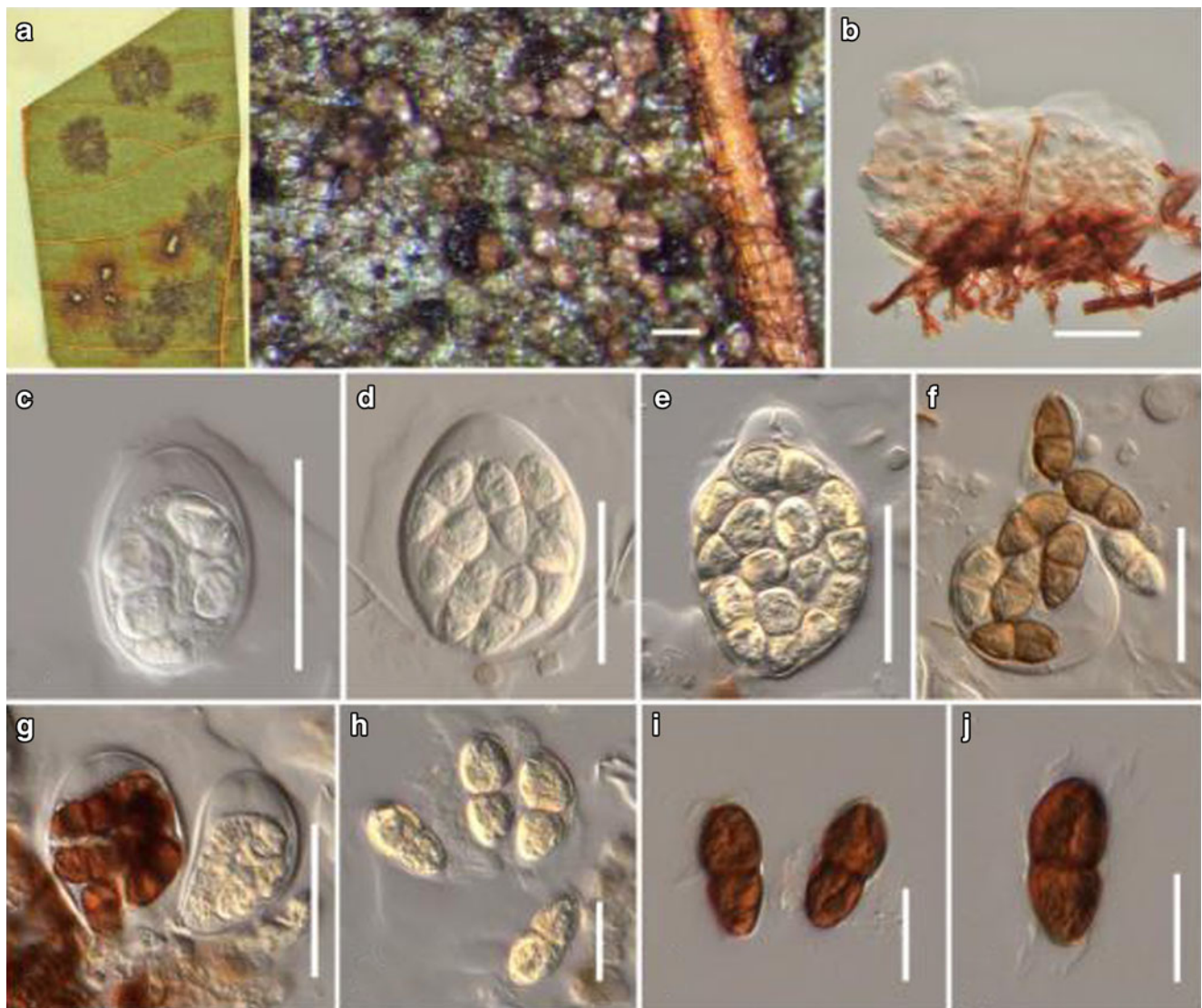


Fig. 46 *Englerula macarangae* (Material examined: TANZANIA, Usambara Mountains, on leaves of *Macaranga kilimandscharica*, Engler, Rehm Ascomyceten 1539 September 1902, BPI 566046, **syntype**). **a** Appearance of colonies on leaf surface, and close up of

ascomata on mycelium. **b** Squash mount of ascoma. **c–g** Asci with ascospores. **f** Dehisced ascus. **h** Immature ascospores. **i–j** Brown mature ascospores surrounded by mucilaginous material. Scale bars: **a** = 100 μ m, **b–g** = 50 μ m, **h–j** = 20 μ m

to subglobose ascomata with a thin peridium, obovoid to globose asci, and broadly ellipsoid to subobovoid, brown, 1-septate ascospores, constricted at the septum (Hosagoudar et al. 2011a).

Type species: Englerula macarangae Henn., Bot. Jb. 34: 49 (1904), MycoBank: MB 140464

Other genera included

Digitosarcinella S. Hughes, Can. J. Bot. 62(11): 2208 (1984)

Type species: Digitosarcinella caseariae S. Hughes, Can. J. Bot. 62(11): 2208 (1984)

Goosia B. Song, Mycotaxon 87: 413 (2003)

Type species: Goosia melastomatis B. Song, Mycotaxon 87: 413 (2003)

Note: the type material is missing and therefore the drawing has to act as the holotype.

Krishnamyces Hosag., Zoos' Print Journal 18(8): 1159 (2003)

Type species: Krishnamyces indica Hosag., Zoos' Print Journal 18(8): 1160 (2003)

Mitteriella Syd., in Sydow & Mitter, Annl. mycol. 31(1/2): 95 (1933)

Type species: Mitteriella ziziphina Syd. [as 'Mitteriella ziziphina'], (1933)

Parenglerula Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 465 [73 repr.] (1910)

Type species: Parenglerula macowaniana (Thüm.) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 465 [73 repr.] (1910)

Questieriella G. Arnaud ex S. Hughes, Can. J. Bot. 61(6): 1729 (1983)

Type species: *Questieriella pulchra* S. Hughes, Can. J. Bot. 61(6): 1730 (1983)

Rhizotexis Theiss. & Syd., Anns mycol. 15(1/2): 140 (1917)

Type species: *Rhizotexis bauhiniarum* (Henn.) Theiss. & Syd., Anns mycol. 15(1/2): 140 (1917)

Rhytidenglerula Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 127: 386 [58 repr.] (1918)

Type species: *Rhytidenglerula carnea* (Ellis & G. Martin) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 127: 386 [58 repr.] (1918)

Sarcinella Sacc., Michelia 2(no. 6): 31 (1880)

Type species: *Sarcinella heterospora* Sacc., Fungi italica autogr. del. 1–4: tab. 126 (1877)

Schiffnerula Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 867 [55 repr.] (1909), MycoBank: MB 4886 Fig. 47

Colonies foliicolous, formed on surface of leaves, thin to dense, round to irregular, black, confluent. Sexual state: *Hyphae* superficial, straight to curved, septate, irregular to reticulately branched, brown, appressoriate, outer surface smooth, tuberculate to crenulate. *Hyphopodia* alternate to unilateral, unicellular, elliptical, globose to subglobose, dark brown, formed laterally. *Thyriothecia* minute, orbicular, brown, cells on the upper surface radiating, dissolute at the centre at maturity, with few asci. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, broadly clavate, globose to ovate, exposed. *Ascospores* multi-seriate, broadly fusiform, ellipsoid to oblong, brown, 1-septate, smooth-walled, constricted at the septum, ends rounded to pointed. Asexual state: *Conidiophores* macronematous to micronematous, mononematous, lateral, 0–2-septate. *Conidiogenous cells* monoblastic to polyblastic, lateral or integrated, terminal, lateral, intercalary, determinate. *Conidia* solitary, acrogenous or acropleurogenous, 4-celled, narrowly ellipsoidal to obovoid, subglobose, sarciniform, dark brown to reddish brown, curved, falcate, sigmoid, truncate at the base, constricted at the septum (Hosagoudar 2011).

Notes: *Schiffnerula* includes more than hundred species (Index Fungorum 2013). Asexual states of this genus are reported to belong to *Mitteriella*, *Questieriella* and *Sarcinella* (Hosagoudar 2011).

Type species: *Schiffnerula mirabilis* Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 868 [56 repr.] (1909), MycoBank: MB 211121

Thrauste Theiss., Verh. zool.-bot. Ges. Wien 66: 337 (1916)

Type species: *Thrauste medinillae* (Racib.) Theiss., Verh. zool.-bot. Ges. Wien 66: 338 (1916)

Key to sexual genera of *Englerulaceae*

1. Colonies on host, superficial, brown to black2
1. Colonies on host lacking, comprising only ascomata*Rhizotexis*
2. Hyphopodia or appressoria brown3
2. Hyphopodia and appressoria absent*Englerula*
3. Pseudoparaphyses brown, septate, straight to curved*Parenglerula*
3. Pseudoparaphyses absent4
4. Phialides brown, 1-septate, nearly ampulliform, alternate*Goosia*
4. Phialides absent4
5. Perithecia, large, greenish-brown*Thrauste*
5. Perithecia, small, yellowish-brown6
6. Ascomata superficial on hyphae or radiating, shield-like plate..... *Rhytidenglerula*
6. Ascomata arise from the short lateral branches*Schiffnerula*

Key to asexual genera of *Englerulaceae*

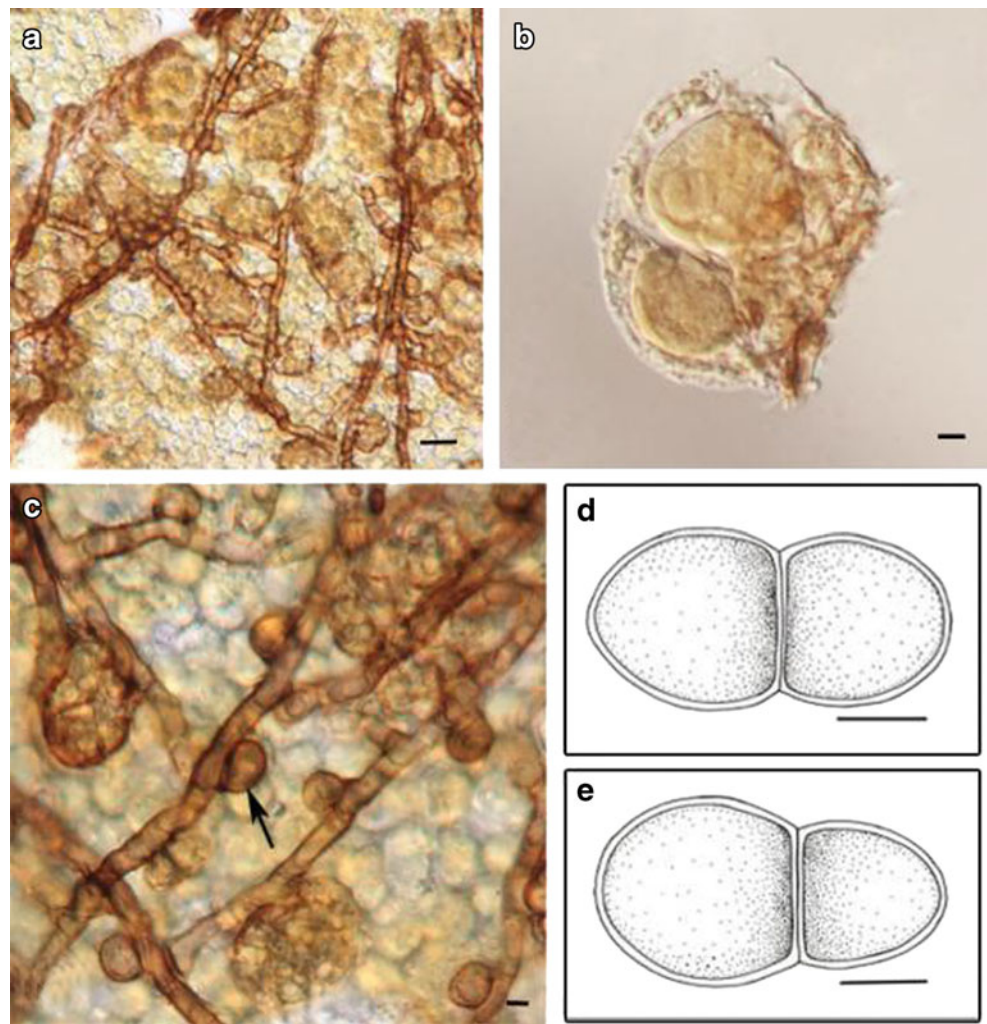
1. Coelomycetous state with superficial pycnidia and brown, oval to ellipsoidal conidia*Krishnamyces*
1. Hyphomycetous states2
2. Conidiophores reduced to conidiogenous cells*Digitosarcinella*
2. Reduced conidiophores (unbranched), conidiogenous cells with denticles3
3. Conidiogenous cell sympodial, denticles broad*Mitteriella*
3. Conidiogenous cell monoblastic, denticles long*Questieriella*

Eremomycetaceae Malloch & Cain, Can. J. Bot. 49: 847 (1971), MycoBank: MB 80751

Saprobic on animal dung or soil. Colonies flocculent, drift white, superficial, dense, growing slowly on agar media. *Hyphae* septate, branch, hyaline to brown. Sexual state: *Ascomata* solitary, scattered, superficial on hyphae, or submerged in the agar, globose to ellipsoid, dark brown to black, non-ostiolate, but tending to split open before maturity. *Peridium* thin, pseudoparenchymatous, composed of large, brown cells of *textura angularis*. *Pseudoparaphyses* lacking. *Asci* 8-spored, bitunicate, obovoid to clavate, thin-walled, pedicellate, evanescent. *Ascospores* multi-seriate, fabiform to broadly oblate, hyaline to pale brown, non-septate, smooth-walled to slightly verrucose. Asexual state: see below.

Notes: The family *Eremomycetaceae* was introduced for taxa occurring on dung with hyaline to brown mycelium, globose to ellipsoid, dark brown to black pseudoparenchymatous ascomata, which lack ostioles, 8-spored, obovoid to clavate, evanescent asci, and reniform to broadly oblate, hyaline to pale brown, 1-septate ascospores. Conidia in *Rhexothecium* are hyphomycetous, solitary to catenulate, lateral, ellipsoid to

Fig. 47 *Schiffnerula mirabilis* (Material examined: Slides FH 3372, 3375, **ex-holotype**). **a** Thyriothecia superficial on brown hyphae. **b** Globose to ovate asci surrounded by thin peridium. **c** Alternate to unilateral, subglobose, dark brown hyphopodia. **d, e** Ascospores (Drawings based on slides). Scale bars: **a, b**=10 μm , **c, e**=5 μm



ovoid, schizolytically dehiscent, hyaline, with a truncate base and borne on aerial hyphae (Malloch and Cain 1971; Malloch and Sigler 1988). The *Pseudeurotiaceae* are most similar to the *Eremomycetaceae* in morphology (Malloch and Sigler 1988). However, *Eremomycetaceae* have pseudoparenchymatous ascomata, which differ from *Pseudeurotiaceae* in having coiled ascomata. Lumbsch and Huhndorf (2010) included *Eremomyces* and *Rhexothecium* in the family; *Eremomyces* has fabiform and hyaline ascospores, while, *Rhexothecium* has broadly oblate and pale yellow to brown ascospores.

Asexual states in this family are reported to include members of *Arthrographis* and *Trichosporiella* (Wijayawardene et al. 2012), but they are not known for the type species. *Eremomyces* (as *Pithoascus langeronii* Arx) has subglobose to globose, hyaline conidia similar to *Trichosporiella* (*Helotiales*). Malloch and Sigler (1988) referred to *E. langeronii* or combined with *Pithoascus langeronii* (synonym: *Eremomyces langeronii* (Arx) Malloch & Sigler) which have chains of schizolytic arthroconidia and are similar to *Arthrographis*, but Kang et al. (2010) used molecular data based on SSU rDNA to show that *Pithoascus langeronii*

belongs to *Pezizales*. Thus, *Arthrographis* may not be a good name for the asexual state of *Eremomyces* as listed in Index Fungorum (2013). *Rhexothecium* also has solitary to catenulate, lateral, hyaline, basic truncate conidia, which are similar to *Trichosporiella* (*Helotiales*). The placement of *Eremomyces* is therefore still unclear and fresh collections with sequence data is needed. *Rhexothecium* has isolates in CBS 203.78 and these also need sequencing to establish if it is related to *Eremomyces*.

Type: Eremomyces Malloch & Cain, Can. J. Bot. 49(6): 847 (1971), MycoBank: MB 1880 Fig. 48

Possible synonym:

Pithoascina Valmaseda et al., Can. J. Bot. 65(9): 1905 (1987)

Saprobic on dung of the North American porcupine. Colonies flocculent, drift white, superficial, dense, growing slowly on agar media. *Hyphae* septate, branch, hyaline to brown. Sexual state: *Ascomata* solitary, scattered, superficial on hyphae, globose to ellipsoid, dark brown to black, non-ostiolate. *Peridium* thin, composed of large brown cells of *textura angularis*. *Pseudoparaphyses* lacking. *Asci* 8-spored,

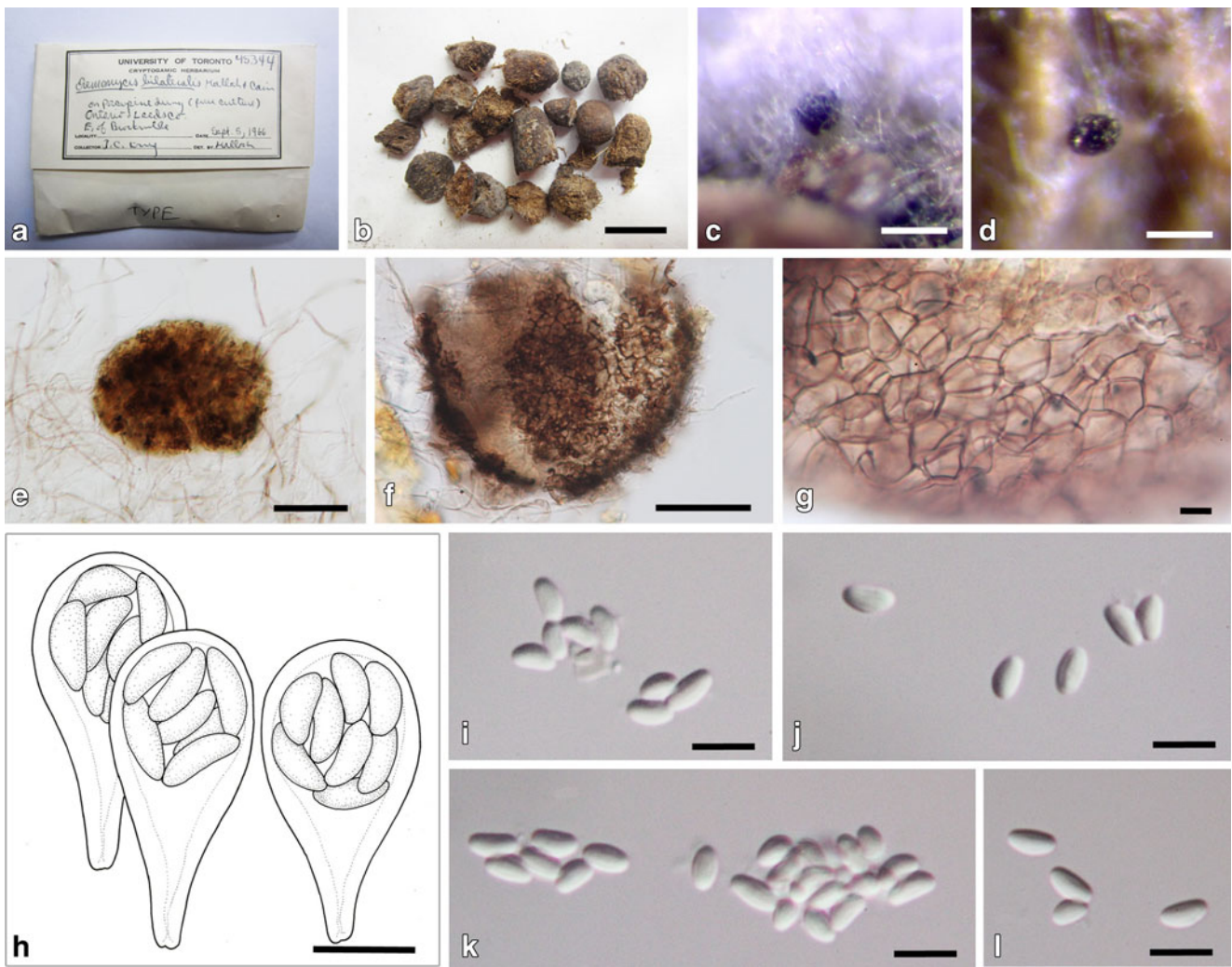


Fig. 48 *Eremomyces bilateralis* (Material examined: CANADA, Ontario, Leeds Co., E of Brockville, in dung of *Erethizon dorsatum*, 5 September 1966, J.C. Krug, TRTC 45344, **holotype**). **a, b** Herbarium packet and dung samples. **c, d** Ascomata on hyphae. **e, f** Brown ascoma. **g** Thin

peridium of ascoma. **h** Asci with ascospores (Redrawn from Malloch and Cain 1971). **i–l** Ascospores. Scale bars: **b** = 20 mm, **c, d** = 100 μ m, **e–f** = 50 μ m, **g–l** = 5 μ m

bitunicate, obovoid, thin-walled, pedicellate, evanescent. Ascospores multi-seriate, fabiform, hyaline, non-septate, smooth-walled. Asexual state: Unknown.

Notes: *Eremomyces* includes one species introduced by Malloch and Cain (1971), while Malloch and Sigler (1988) also placed *Pithoascus langeronii* in the genus, as this species is also characterized by taxa with colonies growing on dung with brown to black ascomata, having a pseudoparenchymatous peridium. Molecular data however, show that *Pithoascus langeronii* belongs to *Pezizales* (Kang et al. 2010).

Type species: *Eremomyces bilateralis* Malloch & Cain, *Can. J. Bot.* 49(6): 849 (1971)

Mycobank: MB 313945

Other genera included

Rhexothecium Samson & Mouch., *Can. J. Bot.* 53(16): 1637 (1975)

Type species: *Rhexothecium globosum* Samson & Mouch., *Can. J. Bot.* 53(16): 1637 (1975)

Key to genera of Eremomyces

- 1. Ascospores fabiform, hyaline*Eremomyces*
- 1. Ascospores broadly oblate, pale brown*Rhexothecium*

Euantennariaceae S. Hughes & Corlett ex S. Hughes, *N.Z. J. Bot.* 10: 238 (1972), MycoBank: MB 81674

Parasitic on pine needles or leaves of other plants. *Mycelium* superficial, dark, forming a flattened mat, but frequently with erect branches. *Hyphae* straight to irregularly curved, occasionally anastomosing, septate, finely or coarsely roughened, pale brown to brown, or hyphae of some species formed on one cell-thick plate. *Hyphal appendages* numerous, barrel-shaped, brown, obtuse, sometimes septate, verrucose. Sexual state: *Ascomata* perithecia, unilocular,

superficial on or immersed in hyphae, scattered, or in groups, subglobose, brown to dark brown, or black, membranous, ostiolate without periphysoids, containing few asci. *Peridium* thick, dark, composed of one layer of dark brown cells of *textura angularis*. *Hamathecium* of few pseudoparaphyses, or pseudoparaphyses lacking. *Asci* 4–8-spored, bitunicate, fasciculate, ellipsoidal to broadly ellipsoidal, thin walled, sessile, with an ocular chamber. *Ascospores* 2–3-seriate to irregularly arranged in asci, ellipsoidal to fusiform, sometimes wider above the middle, pale brown to dark brown, 3–7-multi-septate, or dictyoseptate, smooth and thick-walled, constricted at the septa.

Notes: The sooty mould family *Euantennariaceae* was introduced by Hughes (1972) for taxa with superficial, dark mycelium, superficial to immersed, dark ascromata, ellipsoidal to broadly ellipsoidal asci and ellipsoidal to fusiform, pale brown to dark brown, 3–7-multi-septate ascospores. *Euantennariaceae* and *Metacapnodiaceae* are similar in having ellipsoidal asci and ellipsoidal ascospores. The only difference is that *Euantennariaceae* lacks periphysoids (Eriksson 1981). *Trichopelthea* differs from *Euantennaria*, *Rasutoria* and *Strigopodia* in this family by having hyphae formed on one cell thick plates (Hughes 1968, 1972). In addition, *Rasutoria* has saccate asci which differentiate it from the other genera. *Euantennaria* has pale brown to brown ascospores. However, *Strigopodia* has brown to dark brown ascospores. *Racodium* is a “nom.cons.”; refer to Hawksworth et al. (IMA Fungus 2: 71–79, 2011) for discussion of the complex nomenclatural issues.

Wijayawardene et al. (2012) listed the asexual states as *Antennatula*, *Capnokyma*, *Hormisciomyces*, *Plokamidomyces*, *Racodium* and *Trichothallus*. Hughes (1972, 1974) stated *Antennatula* is an asexual state of *Euantennaria*, but according to Sivanesan (1984) *Antennatula* is the asexual state of *Strigopodia*. *Hormisciomyces* was also linked with *Euantennaria* by Hughes (1972) and Sivanesan (1984). However, Hughes (1976) also linked *Hormisciomyces* with *Trichopelthea*. Hughes (Hughes 1972, 1976) and Sivanesan (1984) stated that *Plokamidomyces* and *Trichothallus* are asexual states of *Trichopelthea*. However these links between sexual and asexual states are not supported by molecular taxonomy.

Type: *Euantennaria* Speg., Physis, B. Aires 4: 284 (1918), MycoBank: MB 1908 Fig. 49

Parasitic on pine needles. **Mycelium** superficial, dark, flattened. **Hyphae** cylindrical, straight to irregularly curved, occasionally anastomosing, septate, finely or coarsely roughened, pale brown to brown, lateral repent branches occur at right angles or at a wide angle and may be solitary or opposite. **Sexual state:** *Ascomata* perithecia, unilocular, superficial on hyphae, scattered, subglobose, brown to dark brown, membranous, ostiolate without periphysoids, surrounded by

cylindrical hypha appendages, containing few asci. *Peridium* thick, dark, composed of one layer of dark brown cells of *textura angularis*. *Pseudoparaphyses* lacking. *Asci* 4–8-spored, bitunicate, ellipsoidal, thin-walled, sessile, with an ocular chamber. *Ascospores* irregularly arranged in asci, ellipsoidal, pale brown to brown, 3–7-multi-septate, or dictyoseptate, with or without mucronate ends, rounded at the ends, slightly or not at all constricted at the septa.

Notes: *Euantennaria* includes nine species according to Index Fungorum (2013). Four euantennariaceous sooty moulds from New Zealand were illustrated with ascostromata, and asexual morphs as *Antennatula* and *Hormisciomyces* by Hughes (1974) with *E. tropicicola* as the type species of *Euantennaria*. It was suggested that *Hormisciella rubi* Bat. is a possible name of the *Antennatula* state and *Hormisciomyces prepusum* Bat. & Nasc. and *H. bellum* Bat. & Carn. are possible names for the *Hormisciomyces* state. Below we illustrate both asexual and sexual states of *Euantennaria mucronata* (Mont.) S. Hughes.

Type species: *Euantennaria tropicicola* Speg., Boln Acad. nac. Cienc. Córdoba 23(3–4): 549 [no. 448, reprint pages 187] (1919)

Other genera included

Antennatula Fr. ex F. Strauss, Flora, Jena 33(Beil.): 98, 99 (1850)

Type species: *Antennatula pinophila* Fr., Flora, Jena 33(Beil.): 99 (1850)

Capnokyma S. Hughes, N.Z. JI Bot. 13(4): 638 (1975)

Type species: *Capnokyma corticola* S. Hughes, N.Z. JI Bot. 13(4): 638 (1975)

Hormisciomyces Bat. & Nascim., Anais Soc. Biol. Pernambuco 15(2): 349 (1957)

Type species: *Hormisciomyces prepusum* Bat. & Nascim. [as ‘prepusum’], Anais Soc. Biol. Pernambuco 15(2): 350 (1957)

Plokamidomyces Bat. et al., Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5 15: 47 (1957)

Type species: *Plokamidomyces colensoi* Bat. et al., Publicões Inst. Micol. Recife 90: 15 (1958) [1957]

Racodium Fr., Syst. mycol. (Lundae) 3(1): 229 (1829)

Type species: *Racodium rupestre* Pers., Neues Mag. Bot. 1: 123 (1794)

Rasutoria M.E. Barr, Mycotaxon 29: 501 (1987)

Type species: *Rasutoria abietis* (Dearn.) M.E. Barr, Mycotaxon 29: 502 (1987)

Strigopodia Bat., in Batista et al., Anais Soc. Biol. Pernambuco 15(2): 440 (1957)

Type species: *Strigopodia piceae* Bat., in Batista et al., Anais Soc. Biol. Pernambuco 15(2): 440 (1957)

Trichopelthea Bat. et al., Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5 15: 44 (1958)

Type species: *Trichopelthea asiatica* Bat. et al. Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5 15: 44 (1958)

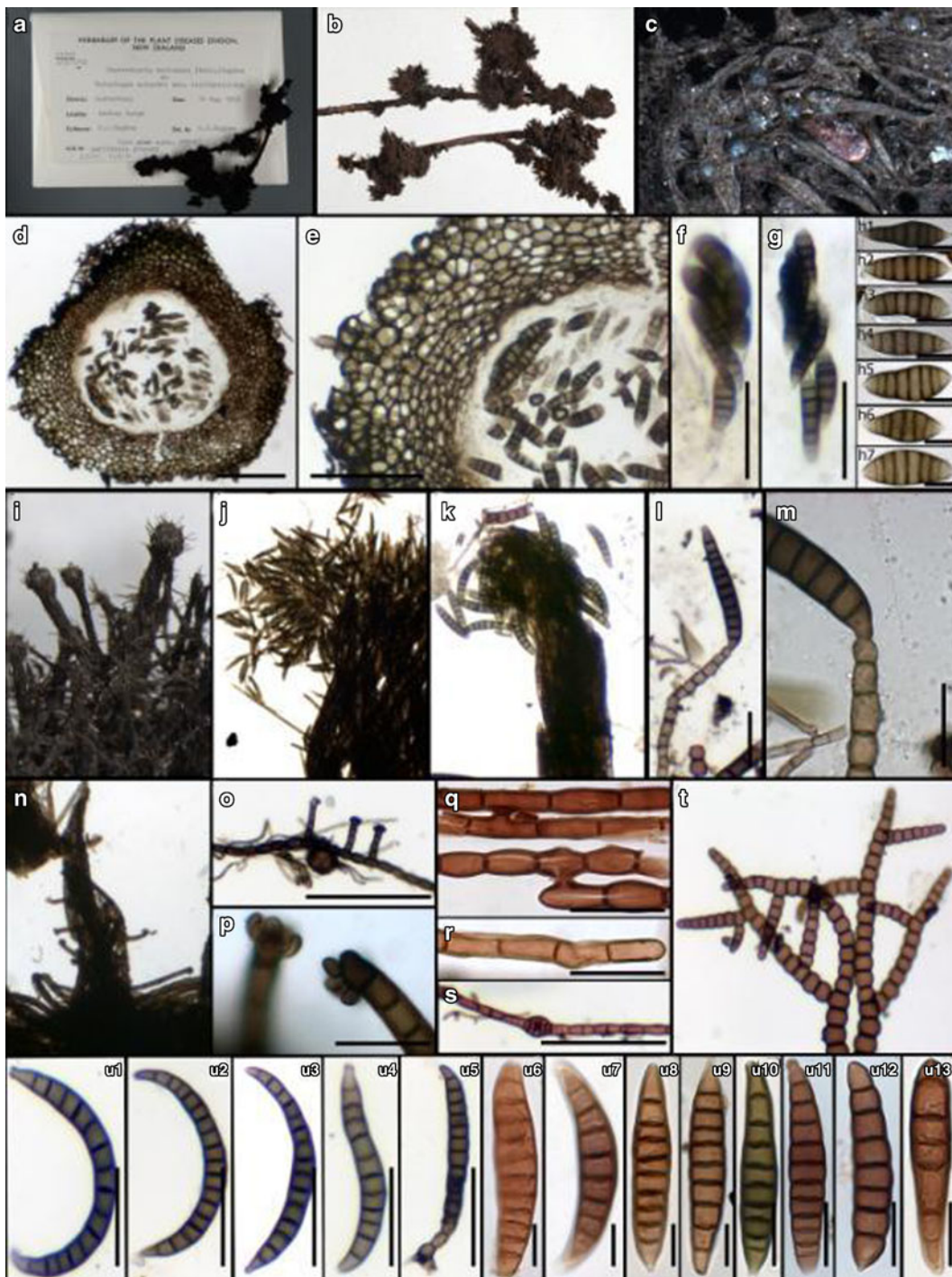


Fig 49 *Euantennaria mucronata* (Material examined: NEW ZEALAND, Canterbury, on *Nothofagus solandri* var. *cliffortioides*, 14 May 1963, S.J. Hughes, PDD 21317) **a** Type collection packet. **b** Type specimen. **c** Perithecia. **d, e** Cross section of ascostroma. **f, g** Asci. **h 1–7** Ascospores. **i** Synnemata. **j, k** Synnema with head of conidia. **l, m**

Hyphae from teased, mature synnema with conidia. **n–p** Cluster of terminal conidiogenous cells on erect hyphae. **q** Anastomosed hyphae. **r** Hyphal appendages on ascostroma. **s, t** Branching hyphae with septa. **u1–u13** Conidia. Scale bars: **f–g, h1–h7** = 20 μm, **d, e** = 100 μm. **n, q–r, u6–u13** = 20 μm, **s, u1–u5** = 50 μm, **o** = 200 μm

Trichothallus F. Stevens, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 85 (1925)

Type species: Trichothallus hawaiiensis F. Stevens, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 85 (1925)

Key to sexual genera of Euantennariaceae

1. Hyphae formed on one-cell-thick plate over the fungal host *Trichopeltheca*
1. Hyphae formed on the fungal host directly 2
2. Ascisaccate *Rasutoria*

2. Asci ellipsoidal3
 3. Ascospores pale brown to brown*Euantennaria*
 3. Ascospores brown to dark brown*Strigopodia*

Key for asexual genera of *Euantennariaceae*

1. Lichen-forming asexual state*Racodium*
 1. Non-lichenised hyphomycetes2
 2. Setae present3
 2. Setae absent4
 3. Stromata dark brown, setae unbranched, brown*Trichothallus*
 3. Conidiomata absent, setae branched*Capnokyma*
 4. Conidia hyaline, slimy*Hormiscomyces*
 4. Conidia brown5
 5. Conidia phragmosporous, single*Antennatula*
 5. Conidia amerosporous*Plokamidomyces*

Fenestellaceae M.E. Barr, Mycologia 71(5): 952 (1979), MycoBank: MB 81670

Saprobic or *hemibiotrophic* on woody plants. Sexual state: *Fruiting bodies* comprising immersed or semi-immersed ascomata in valsoid groups, in medium to large sized pseudostromata, which form beneath the host periderm, cells between ascomata of compressed hyphae and host cells, immersed, globose, ovoid, obovoid or obpyriform, brown to dark brown or black, membranous, minutely papillate, or with rounded plane apex. *Peridium* thin-walled, composed of a few layers of brown to dark brown or reddish brown, small pseudoparanchymatous cells, forming a *textura angularis*. *Hamathecium* comprising numerous, anastomosing, trabeculate pseudoparaphyses, embedded in gelatinous matrix. *Asci* bitunicate, fissitunicate, cylindrical to cylindrical-clavate, with a long pedicel, apically rounded, with a wide, indistinct ocular chamber. *Ascospores* uni-seriate, muriform, ellipsoidal, broadly fusiform, fusoid or nearly oblong, with obtuse or acute ends, pale yellowish, brown to dark brown, or reddish brown, almost hyaline at the extreme ends, usually constricted at the central septum, smooth-walled or verrucose. Asexual state: see notes under genus.

Notes: The family *Fenestellaceae* was introduced by Barr (1979a) for genera characterized by “globose, ovoid to obovoid, turbinate ascomata, with minute papillae, a peridium of sclerenchymatous cells, cylindrical, bitunicate asci, trabeculate pseudoparaphyses, and ellipsoidal, hyaline, brown to dark brown or reddish brown, uni to multi-septate ascospores”. Barr (1979a) included the type *Fenestella*, plus *Crotonocarpia*, *Curcubidothis*, *Melanopsamma* and *Othiella*. She accommodated *Fenestellaceae* in *Melanommatales* based on the centrum type (Sporormia-type centrum development) with trabeculate pseudoparaphyses (Zhang et al. 2012a). Later, she modified her concept and included *Fenestella*, *Delitschia*, *Lojkania* and *Ohleriella* in *Fenestellaceae*. Characters included obovoid, obpyriform

ascomata, lacking a clypeus and phragmospores (Barr 1987a, 1990a; Zhang et al. 2012a). Barr (2000a) excluded *Ohleriella* and *Delitschia* and transferred to *Delitschiaceae* as they are hypersaprotrophic on old dung or aged exposed wood, whereas genera of *Fenestellaceae* are saprotrophic or hemibiotrophic on woody or herbaceous plants. Recently, *Fenestellaceae* comprise two genera, *Fenestella* and *Lojkania* (Lumbsch and Huhndorf 2010). The type species of this family form valsoid ascomata in pseudostromata; ascospores are initially pale yellow, becoming brown to dark brown or reddish brown when mature, muriform and broadly fusiform or ellipsoidal and asci are cylindrical to cylindrical-clavate, short to long pedicellate, and apically rounded, with a flattened ocular chamber (Fig. 1). In *Lojkania* however, ascomata are separate, clustered, scattered or gregarious and ascospores initially pale brown, becoming brown to dark brown, 1-septate and fusiform to ellipsoidal.

Sequence data is available in GenBank for a putative strain of *Fenestella princeps* (CBS 114122) which places *Fenestella* in a distinct family *Fenestellaceae* in the order *Pleosporales* (Fig. 1). Two species previously placed in *Lojkania* have sequence data in GenBank. *Lojkania enalia* belongs in *Verruculina* (*Testudinaceae*), while *L. striatistroma* clusters in *Herpotrichia* (*Pleosporales*). The type of *Lojkania*, *L. hungarica* Rehm has not been sequenced and its morphology suggest that the genus is unrelated to *Fenestella* as the ascomata are individual (not in valsoid groups) and papillate, while ascospores are 1-septate (Phookamsak, pers. obs.). We therefore tentatively include it in *Fenestellaceae*. Recollection, epitypification and molecular analysis are required to confirm the placement of genera and species.

Type: *Fenestella* Tul. & C. Tul., Select. fung. carpol. (Paris) 2: 207 (1863), MycoBank: MB 1983 Fig. 50

Possible synonyms:

Pleovalsa Kirschst., Anns mycol. 34(3): 207 (1936)

Schachtia Schulzer, Verh. zool.-bot. Ges. Wien 16: 59 (1866)

Saprobic or *hemibiotrophic* on branches of woody plants. Sexual state: *Fruiting bodies* comprising immersed, or semi-immersed ascomata in valsoid groups in clustered or scattered, medium to large sized pseudostromata, which form beneath the host periderm, surface smooth or roughened by protruding cells, cells between ascomata of compressed hyphae and host cells, immersed, globose, ovoid, obovoid or obpyriform, brown to dark brown or black, membranous, minutely papillate, or with rounded plane apex. *Peridium* thin-walled, composed of 4–5 layers of brown to dark brown or reddish brown, small pseudoparanchymatous cells, forming a *textura angularis*, less dark towards the centre, fusing at the outside with the host cells, widest in the upper regions. *Hamathecium* comprising numerous, anastomosing, trabeculate pseudoparaphyses, embedded in gelatinous matrix. *Asci*



Fig. 50 *Fenestella princeps* Material examined: SWITZERLAND, on dead branch [*Alnus* sp., Otth, autumn 1861, Delectum Otthianum Fungorum Thunensium] No. 33, PC0084496, as *Valsa macrospora*; authentic specimen, see Tulasne & Tulasne (1863, 1931). **a** Label and specimens. **b** Valsoid arrangement of ascomata in stroma on host. **c**

Stroma cut through horizontally. **d** Section through pseudostroma showing asci. **e** Section through peridium in lactoglycerol. **f** Asci with pseudoparaphyses. **g** Immature ascus. **h–k** Asci. **l–o** Ascospores. **p** Ascospore in lactoglycerol. Scale bars: **d**, **f**=100 μm , **e**, **g–k**=50 μm , **l–p**=20 μm

bitunicate, fissitunicate, cylindrical to cylindric-clavate, with a long pedicel, apically rounded, with a wide indistinct ocular chamber. *Ascospores* 1-seriate, muriform, ellipsoidal, broadly fusiform, fusoid or nearly oblong, with obtuse or acute ends, pale yellowish, brown to dark

brown, or reddish brown, almost hyaline at the extreme ends, usually constricted at the central septum, smooth-walled or verruculose, surrounded by narrow mucilaginous sheath extending to a small appendage at the ends. Asexual state: see notes.

Notes: *Fenestella* was introduced by Tulasne and Tulasne (1863) with three species, *F. princeps* Tul. & C. Tul., *F. media* Tul. and *F. minor* Tul. & C. Tul. from *Alnus*; which they were considered the most frequently collected and best known species in the genus. The species and genus concept of *Fenestella* were however confused. Tulasne and Tulasne (1863) did not illustrate these species but used length to width ratios of ascospores to identify species. *Fenestella princeps* was characterized by large spores ($57\text{--}65 \times 16\text{--}20 \mu\text{m}$) with acute ends, which had usually previously been named as *F. macrospora* by Fuckel (1871). Saccardo (1877) modified the concept of *Fenestella* that included *F. vestita* (Fr.) Sacc. (now known as *Mycothyridium vestitum* (Fr.) E. Müll.). He used the valsoid configuration of ascomata and brown dictyospores as important characters in the concept of *Fenestella*, but did not consider differences of ascus and centrum. This modified concept was incorrect and confusing in the literature until recently (Barr 1990b).

Fenestella is a poorly known genus associated with angiosperms and the asexual state is not clear (Barr 1987b). Kendrick and DiCosmo (1979) reported *Fenestella* asexual states as having microconidial conidiomata and similar to those of *Phoma* species. The most detailed description of the asexual state was that of Brefeld (1891). He described *Fenestella* sexual states as producing conidia from pycnidia. Huhndorf and Glawe (1990) illustrated and described the anatomical changes exhibited in germinating ascospores of *Fenestella princeps* and *F. macrospora*. They confirmed Brefeld (1891), reporting that ascospores of *Fenestella princeps* differentiate directly into pycnidia during germination and also reported that *Fenestella* have spermatial states (Huhndorf and Glawe 1990). Kirk et al. (2008) and Wijayawardene et al. (2012) reported the asexual state of *Fenestella* is *Pleurostromella*. Sixty-four epithets of *Fenestella* are listed in Index Fungorum (2013). Molecular data is available for only two strains of *Fenestella fenestrata* (Berk. & Broome) J. Schröt. (GU205220, GU205238) in GenBank. Therefore fresh collections and a phylogenetic study are required to enable epitypification of the type species and resolution of this family.

Type species: *Fenestella princeps* Tul. & C. Tul., Select. fung. carpol. (Paris) 2: 207 (1863), MycoBank: MB250108

Other accepted genera

Lojkania Rehm, Növényt. Közlem. 4: 2 (1905)

Type species: *Lojkania hungarica* Rehm, Növényt. Közlem. 4: 2 (1905)

Pleurostromella Petr., Annls mycol. 20(5/6): 336 (1922)

Type species: *Pleurostromella ulmicola* Petr., Annls mycol. 20(5/6): 336 (1922)

Key to genera of *Fenestellaceae*

1. Ascomata frequently forming under valsoid ascostromata, ascospores muriform, broadly fusiform, brown to dark brown or reddish brown *Fenestella*

1. Ascomata frequently scattered, clustered or gregarious, not forming valsoid ascostromata, ascospores 2-celled, 1-septate, brown to reddish brown *Lojkania*

Glioniaceae (Corda) Boehm et al., Mycol. Res. 113: 468 (2009), MycoBank No.: MB 511999

Possible synonym:

Glioniaceae Corda, Icones Fungorum, Hucusque Cognitorum. 5: 34 (1842)

Lignicolous, *corticulous*, on decorticated hardwoods, rarely on gymnosperms. In one case, *terrícolas* on soil and dolerite stone (*G. circumserpens*), temperate in distribution, in both hemispheres, cosmopolitan. Sexual state: *Ascomata* a modified hysterothecium, progressively dichotomously branched, laterally anastomosed along their length to form radiating flabelliform or pseudo-stellate composites; sometimes seated upon a conspicuous brown felt-like subiculum; when present, subiculum a dense mat of thick, dark hyphal strands, which anchors the ascoma to the substrate; sometimes lacking subicula, and ascoma borne in a loose stroma, rarely naked on the substrate. In vertical section, ascomata globose to obovoid, often laterally striate with age; the opening a distinct sulcus, sometimes possessing a cristate apex, sometimes a simple sulcus. *Peridium* thick, three-layered, as in the *Hysteriaceae*, but fragile, and prone to breakage as in the *Mytiliniaceae*; composed of small pseudoparenchymatous cells; the outer layer heavily encrusted with pigment and often longitudinally striate on the surface, the middle layer lighter in pigmentation and the inner layer distinctly thin-walled, pallid and compressed. *Hamathecium* composed of persistent narrow cellular pseudoparaphyses, often borne in a gel matrix, with tips darkened or branched at maturity. *Asci* borne in a basal layer, typically clavate to cylindrical at maturity, bitunicate, fissitunicate, 8-spored, with a distinct apical chamber. *Ascospores* overlapping bi-seriate, ranging from hyaline to light yellow, 1-septate, conspicuously constricted at the septum, fusoid in outline, with at least one end, often both, acuminate, and showing bipolar asymmetry in outline. Asexual state: see notes below.

Notes: Based on a four gene analysis Boehm et al. (2009a, b), showed that *Glonium*, as represented by two North American isolates of the type species *G. stellatum* Mühl., along with two Tasmanian isolates of *G. circumserpens* (Nyl.) Kantvilas & Coppins, does not reside within the *Hysteriaceae* (Zogg 1962). *Glonium* has close affinities to a well-defined monophyletic clade comprising members of the *Mytiliniaceae* in the *Mytiliniales*, distant from the *Hysteriales*. Corda (1842) originally proposed the *Glioniaceae* as a sub-familial taxonomic rank under the family *Hysteriaceae*, in which he placed two genera, namely *Hysterothecium* and *Glonium*. Based on molecular evidence, Boehm et al. (2009a) emended and restricted this sub-familial rank and elevated it to family rank, to include

the genus *Glonium*, as first circumscribed by von Höhnelt (1918a, b), and then later by Petrak (1923a). Species previously classified in the genus *Glonium*, but not belonging to the *Gloniaceae*, were retained within the *Hysteriaceae* (Boehm et al. 2009b), under the genus *Psiloglonium* as defined by von Höhnelt (1918a, b) and Petrak (1923a). Also, Zogg (1962) noted four species within the genus *Glonium* sensu lato that he grouped together in his key, as separate from the other species of *Glonium* based on features of the hysterothecium. Molecular data (Boehm et al. 2009a) now support this separation, with the former comprising the genus *Glonium*, whereas the latter comprising the genus *Psiloglonium* (Boehm et al. 2009b). However, the *Gloniaceae* are not included in the *Mytilinidiales*, with the *Mytiliniaceae*, on account of divergent character states between the two families. These include features associated with the modified hysterothecium, peridial wall thickness, hamathecial type and ascospore symmetry (Barr 1987a; Boehm et al. 2009b). Thus, at present, the family *Gloniaceae* is considered as a family *incertae sedis* in the *Pleosporomycetidae*.

Type: Glonium Mühl. Cont. Lab. Plant Disease Sci. Fac. Agric. Gifu Univ. 101 (1813).

Figure 51

Possible synonyms:

Solenarium Spreng., Syst. veg. 4(1): 376, 414 (1827).

Psiloglonium Höhn., Annl. mycol. 16(1): 149 (1918).

Notes: Zogg (1962) listed three species that he grouped together in his key, that later formed the basis for the *Gloniaceae* (Boehm et al. 2009a). These are the type species, *G. stellatum*, *G. graphicum* (Fr.) Duby, and *G. compactum* Kern, the latter associated with both subicula and stroma. To these three species, was added the recently described saxicolous, terricolous and lignicolous *G. circumserpens* (Nyl.) Kantvilas & Coppins, from Tasmania (Kantvilas and Coppins 1997). Although von Höhnelt (1918a, b) and Petrak (1923a) stressed the importance of subiculum as a synapomorphic character state, Zogg (1962) noted that *G. graphicum* may or may not be associated with a subiculum. This, combined with the observation that *Psiloglonium lineare* (Fr.) Petr. may also on occasion be associated with a subiculum, led Zogg (1962) not to accept the genus *Psiloglonium*. Data presented by Boehm et al. (2009a, b), however, indicate that the synapomorphic character state is not subicula per se, but the ascomata, which, in this case, are modified hysterothecia, progressively dichotomously branched, to form radiating pseudo-stellate composites on the substrate. This is most pronounced in *G. stellatum* and *G. circumserpens*, but may also be found to a lesser extent in *G. graphicum* (Zogg 1962). One distinguishing feature that separates *G. stellatum* from *G. circumserpens* is that, although both are associated with subicula, in the former this extends as a wide margin in front of the developing

hysterothecia, whereas in *G. circumserpens* the subicula is only associated with the under surface of the hysterothecia, closely appressed to the substrate, with only minor deviations from the long axis of the fruit body (Boehm et al. 2009b). Recently, Spatafora et al. (2011) provided molecular evidence that the ecologically important ectomycorrhizal asexual genus *Cenococcum* (LoBuglio et al. 1996) is associated with the *Gloniaceae*, and may represent the asexual state for the genus *Glonium*.

Type species: Glonium stellatum Mühl., Cat. Pl. Amer. Sept.: 101 (1813)

Other genera included

Cenococcum Moug. & Fr., in Fries, Syst. mycol. (Lundae) 3(1): 65 (1829)

Type species: Cenococcum geophilum Fr., Syst. mycol. (Lundae) 3(1): 66 (1829)

Cleistonium Speer, Bull. trimest. Soc. mycol. Fr. 102: 104 (1986)

Type species: Cleistonium parasiticum Speer, Bull. trimest. Soc. mycol. Fr. 102(1): 104 (1986)

Key to asexual states of *Gloniaceae*

1. Coelomycetous asexual state with aseptate, hyaline ellipsoid spore *Cleistonium*
2. Hyphomycetous asexual state as ectomycorrhiza *Cenococcum*

Halojulellaceae Suetrong et al., Phytotaxa 130 (1):5 (2013), MycoBank: MB803303

Saprobic on woody substrates, in mangrove habitats. Sexual state: *Ascomata* immersed, becoming erumpent, superficial, sphaeroid, short papillate, ostiolate, formed under a clypeus. *Peridium* two layered, thickened above with clypeal tissue, outer layer of small pseudoparenchymatous cells, brown to black, inner layer of hyaline cells. *Hamathecium* of simple, cellular, hypha-like, septate, pseudoparaphyses, in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cylindrical, with moderately long pedicel with club-like base, and distinctive apical apparatus. *Ascospores* biserial or partially uni-seriate, hyaline or pale golden brown at maturity, asymmetric or nearly symmetric, ellipsoid, muriform, smooth or verruculose, wall thin, surrounded by a mucilaginous sheath, guttulate, constricted at the septa. Asexual state: coelomycetous, “Phoma”-like sp., *Pycnidia* in culture brown, thin-walled, ostiolate. *Conidiophores* filiform, septate, branched. *Conidia* hyaline, aseptate, thin-walled, guttulate, ellipsoidal.

Notes: The family *Halojulellaceae* was introduced by Ariyawansa et al. (2013a) to accommodate *Julella avicenniae* (Borse) K.D. Hyde, where it forms a separate clade in the suborder *Pleosporineae*, of order *Pleosporales*, Dothideomycetes. This introduction was based on combined

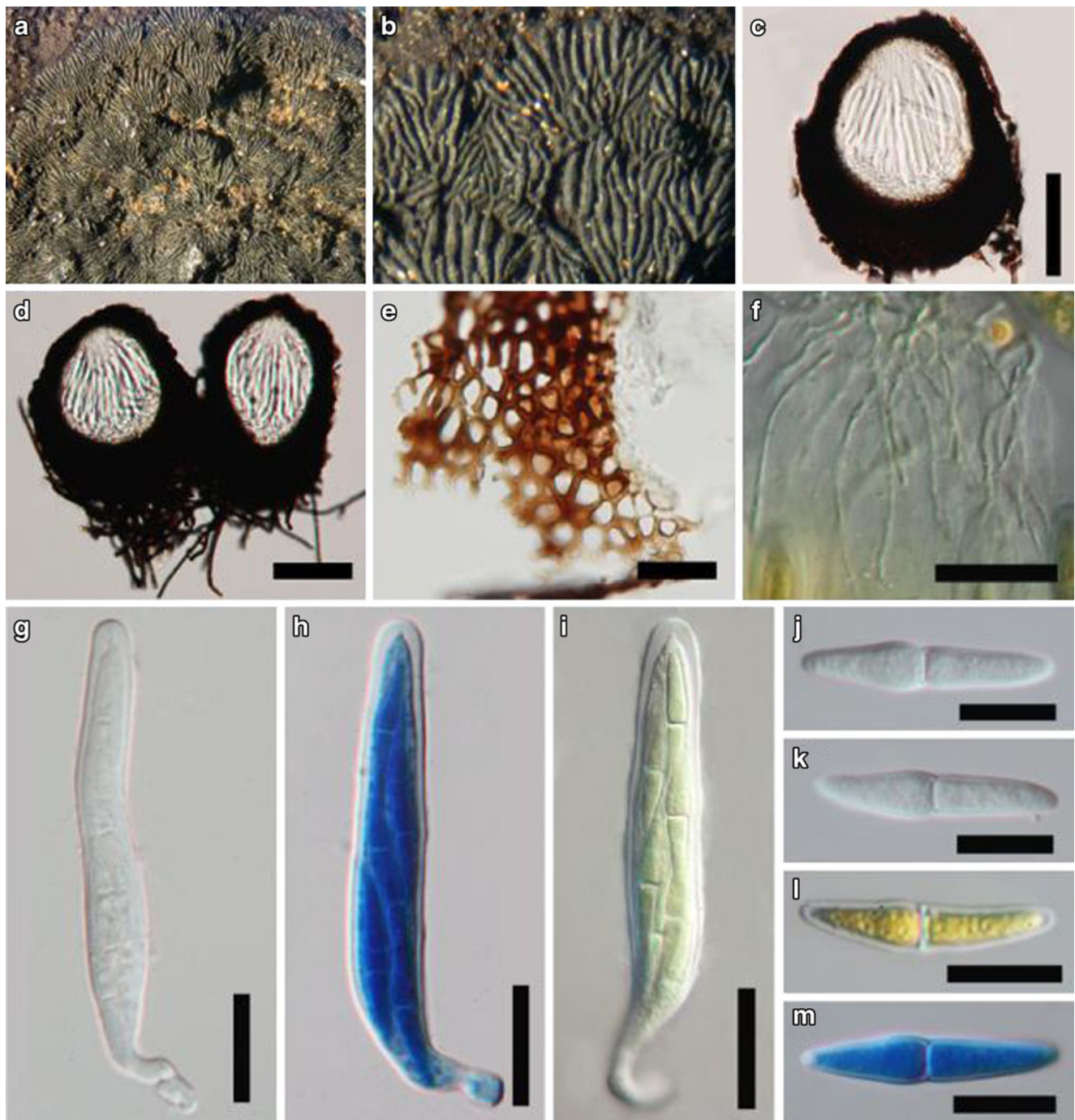


Fig. 51 *Glonium stellatum* (Material examined: ANM 41 ILLS). **a** Ascostromata on host. **b** Close-up ascostromata on host. **c** Section through ascostroma. **d** Section through ascostromata with subiculum. **e** Peridium. **f** Pseudoparaphyses. **g** Ascus. **h** Ascus in

lactophenol cotton blue. **i** Ascus in Melzer's reagent. **j**, **k** Ascospores. **l** Ascospore in Melzer's reagent. **m** Ascospore in lactophenol cotton blue. Scale bars: **c–d** = 100 μm , **e–i** = 20 μm , **j–m** = 10 μm

gene analysis of the large and small subunits of the nuclear ribosomal RNA genes (LSU, SSU) and RPB2 and TEF1 protein coding genes and morphology. *Halojulellaceae* share common features such as bitunicate and fissitunicate asci as well as cellular pseudoparaphyses among their well-arranged asci and uniloculate ascostromata, like most families of

Pleosporales, but differs in having a combination of immersed, medium-sized ascostromata with pseudoparenchymatous peridial cells, broad cellular pseudoparaphyses, asci with a distinctive apical apparatus and hyaline to pale, golden brown, muriform ascospores and a marine habitat (Ariyawansa et al. 2013a; Zhang et al. 2012a). *Julella* is also included in

Halojulellaceae but with uncertainty as no molecular data is available. Nelsen et al. (2011b) demonstrated that not all *Julella* species are monophyletic, with *Julella fallaciosa* (Stizenb. ex Arnold) R.C. Harris forming part of the family *Trypetheliaceae*. Harris (1995) retained *J. avicenniae* in *Julella* with hesitation, citing the spore colour and “Phoma”-like asexual morph as unusual for *Julella*. Harris (1995) noted that *Julella* probably consisted of a heterogeneous assemblage of species. Furthermore, Harris (1995) and Aptroot et al. (2008) have suggested that some *Julella* species are closely related to or even part of *Arthopyrenia*.

Type: *Halojulella* Suetrong et al., Phytotaxa 130 (1):5 (2013), MycoBank: MB 803342

Figure 52

Type species: *Halojulella avicenniae* (Borse) Suetrong et al., Phytotaxa 130 (1):5 (2013), MycoBank MB: 803343
 ≡ *Pleospora avicenniae* Borse, Curr. Sci. 56(21): 1109 (1987)

Notes: *Halojulella* was introduced in order to accommodate mangrove species, originally described from India as

Pleospora avicenniae by Borse (1987). Subsequently it was collected on a submerged root of *Avicennia alba* from north east coast of Queensland, and transferred to the genus *Julella* (Hyde 1992d). The significant characters that distinguish it from the genus *Pleospora* are ascomata in woody substrata, immersed beneath a clypeus, the peridium with a single layer of elongated cells and cellular, hyphae-like, pseudoparaphyses.

Haloththiaceae Yin. Zhang ter et al., Mycologia 105(3): 604 (2013), MycoBank MB 563123

Saprobic or *parasitic* on woody material or rhizomes of sea grasses, in freshwater and marine habitats. Sexual state: *Ascomata* perithecioid, medium to large-sized, immersed, erumpent or superficial, sometimes forming under a pseudoclypeus, ostiolate, or lacking an ostiole, carbonaceous or coriaceous. *Peridium* many layered, outer layer of small, irregular, thick-walled cells, inner layer with larger lumina, black. *Hamathecium* of narrowly cellular, septate, simple or branched pseudoparaphyses. *Asci* 8-spored, bitunicate,

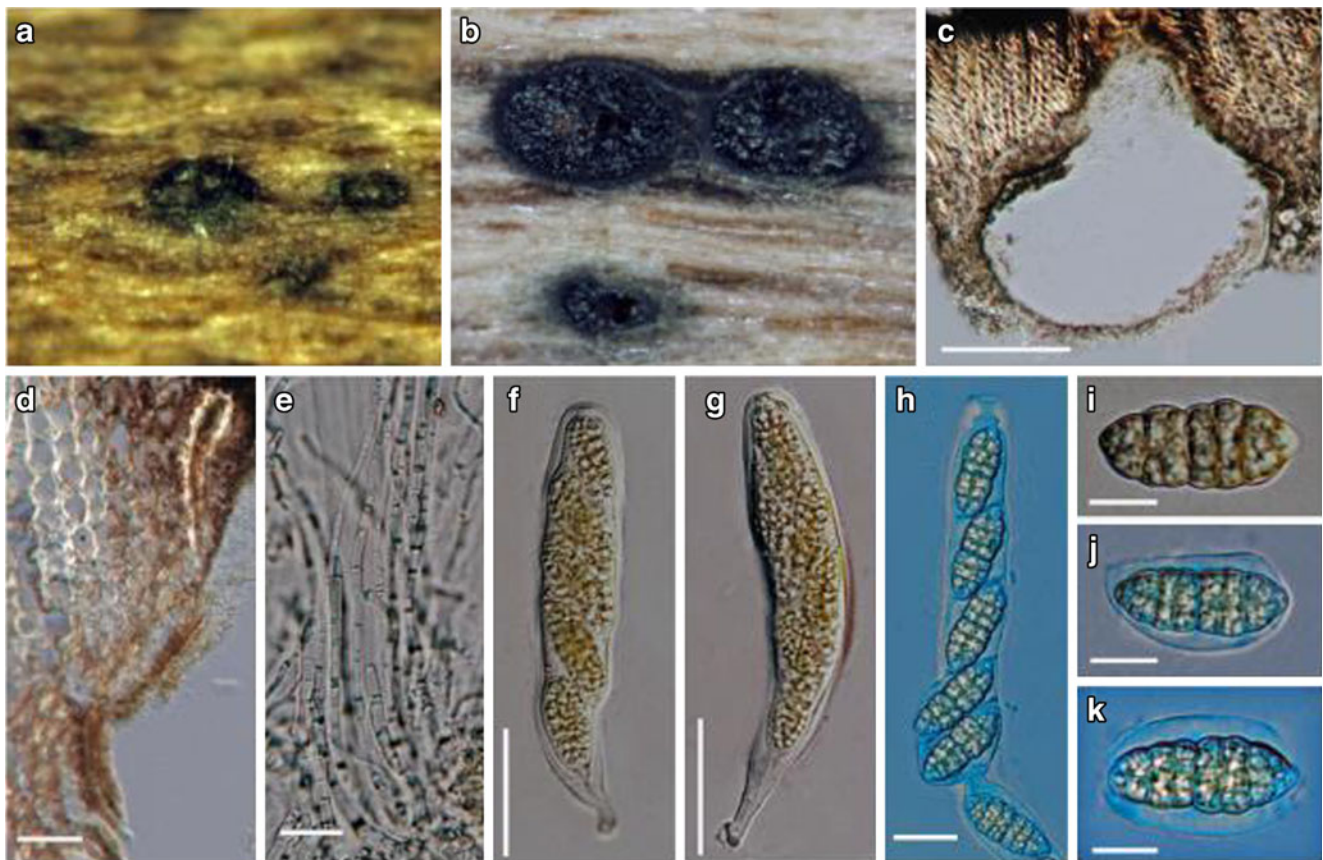


Fig. 52 *Halojulella avicenniae* (Material examined: THAILAND, Trat Province: Mu Ko Chang National Park, Laem Khai Ka, on *Avicennia* wood, 5 October 2005, S Suetrong et al. BBH 23406). **a** Surface view of ascomata on twigs of *Avicennia* wood. **b** Close up of the ascomata. **c** Section through mature ascoma. **d** Close up of the peridium **e** Cellular, septate pseudoparaphyses. **f**, **g** Eight spored asci with an ocular chamber

surrounded by distinct apical apparatus. **h** Apex of ascus, showing distinct apical apparatus. **i** Pale brown mature ascospore. **j–k** Ascospores mounted in lactophenol cotton blue to show mucilaginous sheath. Scale bars: **a–b**=200 μm ; **c**=150 μm **d–e**=40 μm ; **f–g**=80 μm , **h**=30 μm ; **i–l**=10 μm

fissitunicate, cylindrical, clavate to sphaerical, long or short pedicellate, ocular chamber not well-developed. *Ascospores* uni to tri-seriate, fusiform or biturbinate or ellipsoidal to subellipsoidal, 1-septate, phragmosporous or dictyosporous, constricted or not at the septum, pale brown to dark brown, septa with a dark band around the septum, without sheath or appendages. Asexual state: in *Halothia* pycnidial. *Conidiophores* simple obclavate. *Conidia* (or spermatia) subglobose, ovoid or ellipsoidal, hyaline.

Notes: The family *Halotthiaceae* was introduced by Zhang et al. (2012b) with the type species *Halothia*, and included the genera *Mauritiana*, *Phaeoseptum* and *Pontoporeia*, all monotypic genera. The *Halotthiaceae* grouped with the *Sporormiaceae* in two clades with no support in the *Pleosporales*, based on LSU rDNA analysis (Zhang et al. 2012b). In a wider study of four nuclear genes Suetrong et al. (2009) showed that the three marine genera *Halothia*, *Mauritiana* and *Pontoporeia* grouped in an unresolved clade with affinities to the *Testudinaceae*. In all analysis *Pontoporeia biturbinata* groups with *Halothia posidoniae* on a long branch (Suetrong et al. 2009; Zhang et al. 2012b). The family description has been emended to take into account the broad morphological characters of the four genera assigned to this family. A unifying feature is the 1-septate dark brown ascospores with a pronounced thickened appearance. They differ in that *P. biturbinata* lacks an ostiole and has clavate asci, the lack of a clypeus in *P. biturbinata* and *H. posidoniae*, in the thickness of the peridium wall, while *Phaeoseptum aquaticum* is a freshwater species. *Halothia posidoniae* and *P. biturbinata* occur on the rhizomes of the sea grass *Posidonia oceanica*, and studies are required to determine if they are parasitic. Both are common on the sea grass in the temperate zone and most collections have been of drift material (Kohlmeyer and Kohlmeyer 1979; Suetrong et al. 2009). Collections are known from Algeria, Cyprus, France, Greece, Italy, Libya, Spain, Turkey and Yugoslavia (Kohlmeyer and Kohlmeyer 1979; Cuomo et al. 1985; Suetrong et al. 2009).

Type: *Halothia* Kohlm., Nova Hedwigia 6: 9 (1963), MycoBank MB 2212 Fig. 53

Saprobic or *parasitic?* on the sea grass *Posidonia oceanica* in temperate climates. *Stromata* black, subepidermal. Sexual state: *Ascomata* solitary or gregarious, conical or semiglobose, immersed becoming erumpent, ostiolate, epapillate, carbonaceous. *Peridium* many layered, outer layer of small, irregular, thick-walled cells, inner layer with larger lumina, black. *Hamathecium* of narrowly cellular, septate, simple pseudoparaphyses, numerous, persistent. *Asci* 8-spored, cylindrical, pedicel, bitunicate, fissitunicate, persistent, with an ocular chamber. *Ascospores* uni-seriate, ellipsoidal, 1-septate, brown, septa with a dark band around the septum, constricted at the septum, walls thickened at both ends, appearing hyaline. Asexual state: pycnidial. *Conidiophores*

simple obclavate. *Conidia* (or spermatia) subglobose, ovoid or ellipsoidal, hyaline.

Notes: *Halothia* was introduced by Kohlmeyer (1963) for an ascomycete growing on *Posidonia oceanica*, initially described as *Sphaeria* and subsequently transferred to *Amphisphaeria* (Durieu and Montagne 1956, 1963). Kohlmeyer and Kohlmeyer (1979) referred the genus to the *Pleosporaceae* and thought it to be related to *Caryospora*, *Herpotrichia* and *Othia* (Kohlmeyer 1963). Malloch and Cain (1972) referred the genus to the *Zopfiaceae*, while Jones et al. (2009b) placed it in the *Pleosporales incertae sedis*. Suetrong et al. (2009), based on a four gene analyses showed it grouped with *Pontoporeia biturbinata* in the *Pleosporales*, but did not assign it to any order.

A widely collected species in the Mediterranean Sea, growing on the sea grass *Posidonia oceanica* with a frequency of occurrence of 52 % in collections in Bay of Naples (Cuomo et al. 1985), while Jones (unpublished data) found it to be more frequent than *P. biturbinata* in collections made in Cyprus (2007, 2008). In molecular studies, *H. posidoniae*, groups with *Pontoporeia biturbinata* with moderate support and is a sister group to *Mauritiana rhizophorae* (Zhang et al. 2012b).

Type species: *Halothia posidoniae* (Durieu & Monta.) Kohlm., Nova Hedwigia 6: 9 (1963)

≡ *Sphaeria posidoniae* Dur. & Montagne in Mont., Sylloge Generum Spesierumque Cryptogamarum, p 229, Bailliere & Fils, Paris, 1856

Pontoporeia Kohlm., Nova Hedwigia 6: 5(1963), MycoBank MB 4336 Fig. 54

Saprobic or *perthophytic* on living and drift rhizomes of *Posidonia oceanica*. Sexual state: *Ascomata* solitary or gregarious, globose, superficial on host surface, non-ostiolate, carbonaceous, black, smooth-walled. *Peridium* thick, outer layer of small irregular, dark brown, thick-walled cells, inner layer of cells with larger lumina, arranged in a *textura angularis*. *Hamathecium* of simple or branched, filiform, septate pseudoparaphyses. *Asci* 8-spored, bitunicate, broadly clavate, ovoid or ellipsoidal, long pedicellate, apically rounded, without an apical apparatus, asci arising from a hemisphaerical pulvinus composed of radiating hyphae. *Ascospores* 2–3-seriate, 1-septate, biturbinate to subellipsoidal, apically papillate, with apical germ pores, constricted at the septum, dark brown to blackish brown, walls two-layered. Asexual state: Unknown.

Notes: *Pontoporeia biturbinata* has been variously classified with Kohlmeyer and Kohlmeyer (1979) referring it to the *Pleosporaceae*, while Malloch and Cain (1972) placed it as a synonym of *Zopfia* (*Zopfiaceae*), and accepted by Hawksworth and Booth (1974). *Pontoporeia* differs from *Zopfia* in a number of respects, especially the production of the asci on a pulvinus, the ascomata are not strictly



Fig. 53 *Halothia posidoniae* (Material examined: FRANCE, Pyrénées-Orientales, dredged near Banyuls-sur-Mer, on *Posidonia oceanica*, 19 May 1962, J. Kohlmeyer No. 808c, NY 01389657, **type**). **a, b** Specimen and description. **c–d** Close up of ascomata. **e** Section through ascomata.

f, g Asci when immature. **h** Ocular chamber. **i** Hamathecium. **j** Ascospores pale brown when immature. **k, l** Ascospores with both round end, dark brown at maturity. Scale bars: **e** = 100 μ m, **f, g** = 50 μ m, **h–k** = 20 μ m

cleistothecial, ascospores walls are two-layered with a germ pore at each end and its marine habitat. Molecular studies show it does not belong in the *Zopfiaceae* and groups with genera in the *Halothiaceae* (Suetrong et al. 2009; Zhang et al. 2012b).

Type species: Pontoporeia biturbinata (Durieu & Mont.) Kohlm., Nova Hedwigia 6: 5 (1963)

Other genera included

Mauritiana Poonyth et al., Fungal Divers 4: 102 (2000)
Type species: Mauritiana rhizophorae Poonyth et al., Fungal Divers 4: 102 (2000)

Phaeoseptum YingZhang et al., in Zhang, Fournier, Phookamsak, Bahkali & Hyde, Mycologia 105: 606 (2013)

Type species: Phaeoseptum aquaticum Ying Zhang et al., in Zhang et al., Mycologia 105: 606 (2013)

Key to genera of Halothiaceae

- 1. Ascospores 1-septate2
- 1. Ascospores multi-septate or dictyosporus3
- 2. Ascomata ostiolate, asci cylindrical*Halothia*
- 2. Ascomata lacking an ostiole, asci clavate*Pontoporeia*
- 3. Ascospores dictyosporus, 9–13 (–16) transverse septa, in freshwater habitats*Phaeoseptum*



Fig. 54 *Pontoporeia biturbinata* (Material examined: SPAIN, Llançà, on the rhizome of *Posidonia oceanica*, March 1975 (B, **extype** slide), J. Kohlmeyer 819, 2 June 1962, NY - Kohlmeyer herbarium of Marine Fungi, 01349474 – 01349488, **extype** slides). **a** Drawing of ascomata on

host (from MycoBank 2013). **b** Ascomata on the host surface. **c** Vertical section of ascoma. **d** Asci at various stages of maturity. **e** Immature ascus. **f** Peridium. **g** Pseudoparaphyses. **h–k** Ascospores. Scale bars: **b** = 1 mm, **c** = 100 μ m, **d–e** = 20 μ m, **f** = 50 μ m, **g–k** = 20 μ m

3. Ascospores 9–13-septate, in marine habitats
*Mauritiana*

Hypsostromataceae Huhndorf, Mycologia 86: 266 (1994), MycoBank: MB 81962

Saprobic on wood. Sexual state: *Ascomata* clustered on a tormentose subiculum, superficial, obpyriform, stalked, hyaline to pale brown, surface roughened or hairy, with a papillate ostiole. *Peridium* coriaceous, three-layered, of *textura globosa*. *Hamathecium* comprising numerous, narrow, anastomosing, trabeculate pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 4–8-spored, bitunicate, type of dehiscence unclear, numerous, elongate clavate, very long pedicellate, basal on a columnar structure, apically rounded with an ocular chamber with fluoresces in

Calcifluor. *Ascospores* bi-seriate, oblong to narrowly fusiform, pale brown, 3-septate, disarticulating, with straight germ slit in each part-spore, with no appendages or sheath. Asexual state: “*Pleurophomopsis*”-like. *Pycnidia* obpyriform to ampulliform, roughened tuberculate with white, crust-like exudate, ostiolate, with prominent, broad papilla. *Conidiogenous cells* phialidic, cylindrical to elongate, hyaline, collarettes minute. *Conidia* ovoid, minute, aseptate, hyaline and guttulate.

Notes: The family *Hypsostromataceae* was introduced by Huhndorf (1994) for taxa with large superficial ascomata with trabeculate pseudoparaphyses, cylindrical to clavate asci and septate pale brown to brown ascospores. Two tropical genera, *Hypsostroma* and *Manglicola*, were included in the family. *Manglicola* (type species *M. guatemalensis* Kohlm. & E.

Kohlm.) was collected from dead roots of *Rhizophora mangle* in Guatemala (Kohlmeyer and Kohlmeyer 1971). Subsequently collections were made on intertidal prop roots of *Rhizophora apiculata* at Kapong Danay, Brunei (Hyde 1988), and on the palm *Nypa fruticans* in Thailand (Suetrong et al. 2010). Kohlmeyer and Kohlmeyer (1971) noted a close relationship of *M. guatemalensis* and the *Pleosporales* or *Venturiaceae*. A second species *M. samuelsii* Huhndorf was described by Huhndorf (1994) from Guyana and collected on bamboo culms. *Hypsostroma* was introduced by Huhndorf (1992) for two neotropical wood-inhabiting species *H. saxicola* (type species) and *H. caimitalensis* Huhndorf, collected in Dominican Republic and Venezuela, respectively. “Pleurophomopsis”-like pycnidia have been observed in *H. saxicola*.

Manglicola and *Hypsostroma* share the following features, superficial, large, elongate ascomata, short to long stalks, a soft-textured pseudoparenchymatous wall, trabeculate pseudoparaphyses, asci with an ocular chamber and fluorescing ring and pedicellate, basally arranged and fusiform, septate ascospores. Neither genus could be ascribed to a known family/order in the Dothideomycetes, although Huhndorf (1992) opined an affinity to the *Melanommatales* (= *Pleosporales*). Subsequently, Huhndorf (1994) referred both genera to the *Hypsostromataceae*. Later, Suetrong et al. (2011a) introduced a new family, *Manglicolaceae*, to accommodate *M. guatemalensis* in the *Jahnulales*, as it did not group in the *Pleosporales* (Suetrong et al. 2009). The position of *Manglicola samuelsii* remains unresolved as no sequence data is available to determine its higher taxonomic rank. Therefore only two *Hypsostroma* species can be assigned to the family *Hypsostromataceae* at the present time while the family *Manglicolaceae* (*Jahnulales*) is accepted for the marine species *Manglicola guatemalensis*.

Type: *Hypsostroma* Huhndorf, Mycologia 84: 750 (1992), MycoBank MB 25538

Figure 55

Notes: *Hypsostroma saxicola* and *H. caimitalensis* grouped together in a strongly supported clade (*Hypsostromataceae*) within *Pleosporales*, distinct from other families in the order (Fig. 1) (Mugambi and Huhndorf 2009b). However, in a more recent phylogenetic study, they group as a weakly supported sister clade to the *Aigialaceae*, *Pleosporales* (Suetrong et al. 2011a). Collections made in Kenya (*H. caimitalensis*) and Costa Rica (*H. saxicola*) extend the tropical distribution of these species (Mugambi and Huhndorf 2009b). The distinctive feature of the genus is the obpyriform stalked ascomata, the extremely long pedicels of the asci, the central columnar structure bearing asci and disarticulating ascospores with germ slits. *Manglicola samuelsii* differs from *Hypsostroma* species in possessing longer ascomatal stalks, asci not borne on a central columnar structure, more cylindrical asci, and ascospores that lack germ slits (Huhndorf 1994). The asexual state has only been reported for *H. saxicola*.

Type species: *Hypsostroma saxicola* Huhndorf, Mycologia 84: 750 (1992), MycoBank MB 360174

Hysteriaceae Chevall. [as ‘*Hysterineae*’], Fl. gén. env. Paris (Paris) 1: 432 (1826), MycoBank: MB 80901

Lignicolous or *corticulous*, commonly on well-decorticated hardwoods, rarely on conifers. Sexual state: *Ascomata* defined by hysterothecia, which are dense, persistent, thick-walled, carbonaceous, distinctly navicular in outline, bearing a pronounced longitudinal slit running the length of the long axis. *Hysterothecia* may be capable of opening partially to reveal a lenticular, disk-like hymenium or closing tightly in response to lowered relative humidity, suggesting that some may be perennial, capable of spore discharge over prolonged periods. They can be immersed to eruptent or entirely superficial, solitary, or gregarious, ellipsoid to greatly elongated, and are sometimes branched, triradiate, or borne on a subiculum. *Peridium* in vertical section, globose to obovoid, typically with a thick, three-layered peridium, composed of small pseudoparenchymatous cells, the outer layer heavily encrusted with pigment and often longitudinally striated on the surface, the middle layer lighter in pigmentation and the inner layer distinctly thin-walled, pallid, and compressed. *Hamathecium* composed of persistent cellular, hypha-like hyaline, septate, pseudoparaphyses, often borne in a gel matrix, with tips darkened or branched at maturity above the asci. *Asci* 8-spored, borne in a basal layer, typically clavate to cylindrical at maturity, bitunicate, fissitunicate, with a distinct apical chamber. *Ascospores* overlapping bi-seriate to uni-seriate, hyaline to light- or dark-brown, obovoid, clavate, ellipsoid or fusoid, 1– several septate, or muriform; often showing bipolar asymmetry, wall smooth, foveolate or verruculose, at times surrounded by a gel coating; contents granular, often with oil inclusions, especially when young. Asexual states: see under notes.

Notes: This cosmopolitan family was originally monographed by Zogg (1962), who accepted the following seven genera in the *Hysteriaceae*: *Farlowiella*, *Gloniella*, *Gloniopsis*, *Glonium*, *Hysterium*, *Hysterocharina*, and *Hystero-graphium*. Eriksson (2006) accepted these seven genera, adding the recently described *Actidiographium* (Vasilyeva 2000), and also tentatively included the genera *Hystero-glonium*, *Hystero-patella*, and *Pseudoscypha*. In addition to these, the genera *Encephalographa*, *Graphyllum*, and *Hemigrapha* were included by Kirk et al. (2001). The traditional circumscription of the *Hysteriaceae* was based on character states related to the hysterothecium and spore morphology (Eriksson 2006; Kirk et al. 2001; Zogg 1962), character states originally considered synapomorphic. However, recent molecular studies based on four nuclear genes (Boehm et al. 2009a, b; Mugambi and Huhndorf 2009a) has underscored the potential for morphology to be difficult to interpret, and even

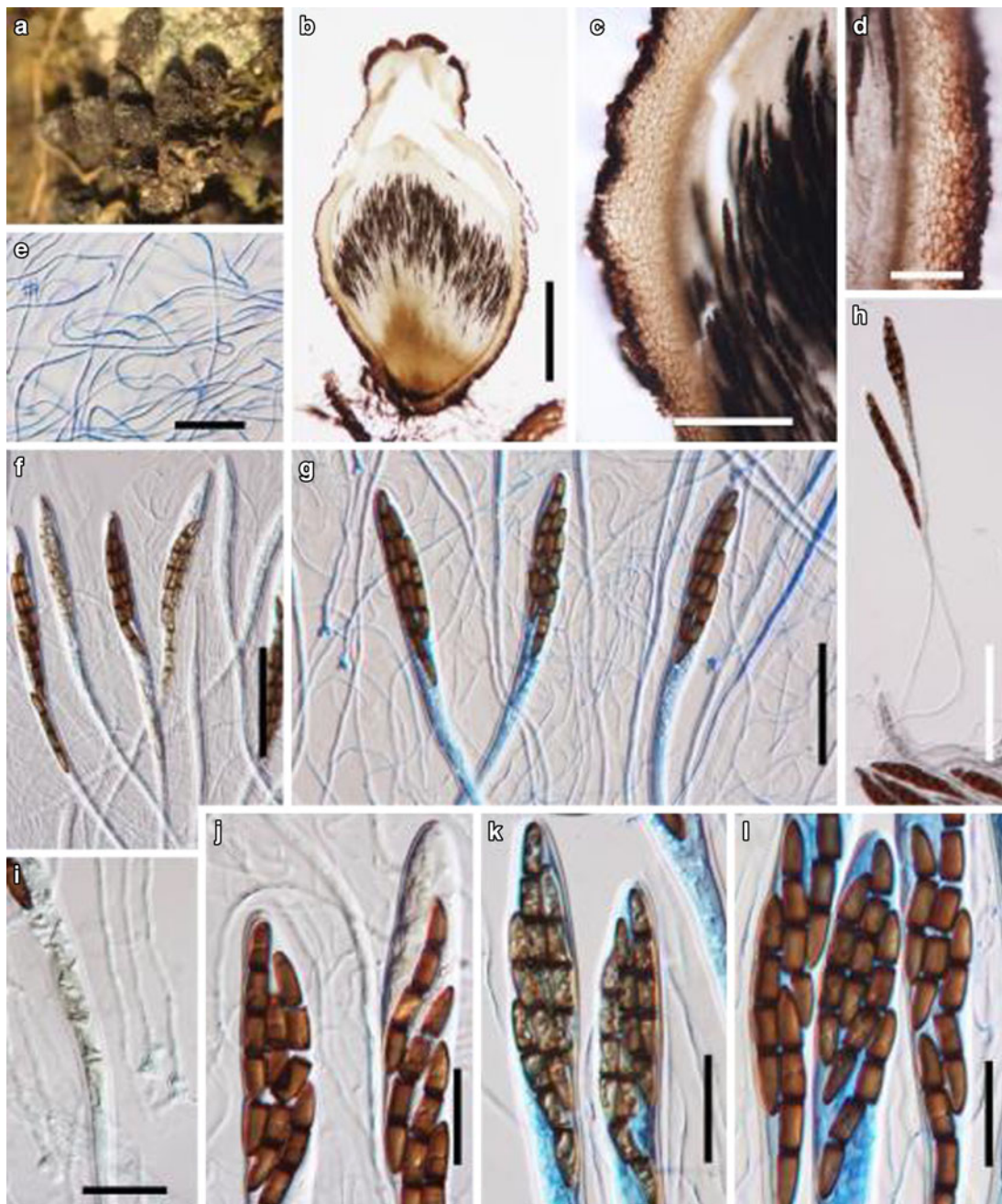


Fig. 55 *Hypsostroma saxicola* (holotype). **a** Ascomata on rock. **b** Longitudinal section through ascoma. **c**, **d** Peridium. **e** Pseudoparaphyses. **f**, **g**, **h** Asci. **i** Base of long stalked pedicles of asci.

j, **k** Asci with ocular chamber. **l** Ascospores. Scale bars: **b** = 500 μm , **c** = 200 μm , **h** = 100 μm , **f**, **g** = 50 μm , **e**, **i**–**l** = 20 μm

unhelpful, in phylogenetic inference and reconstruction for this group of fungi.

Molecular data (Boehm et al. 2009a, b) instead support the premise of a large number of convergent evolutionary lineages, which do not correspond to previously held assumptions of synapomorphy relating to spore morphology within the classical circumscription of the *Hysteriaceae*. As a result, three genera have been removed from the *Hysteriaceae*: *Glonium*, *Hysterographium* and *Farlowiella* (Boehm et al.

2009b). Species previously classified in the genus *Glonium* have been transferred to the genus *Psiloglonium* (von Höhnelt 1918a, b), within the *Hysteriaceae* (Boehm et al. 2009a), and to the genus *Anteaglonium* (Mugambi and Huhndorf 2009a), well outside the *Hysteriaceae*, in the *Pleosporales*. The type species of the genus *Glonium*, *Gl. stellatum*, is distantly related to the *Hysteriaceae*, residing now in its own family the *Gloniaceae*, closely related to the *Mytiliniaceae* (Boehm et al. 2009a, b). Species previously classified in the

genus *Hysterographium* have been transferred to the new genera *Oedohysterium* and *Hysterobrevium*, within the *Hysteriaceae*, with the type, *Hysterographium fraxini* (Pers.) De Not., as well as the genus *Farlowiella*, placed as *incertae sedis*, well outside of the *Hysteriaceae*. In addition, sequence data have necessitated a number of new combinations involving *Psilogonium*, *Oedohysterium*, *Hysterobrevium* and *Gloniopsis*. These taxonomic changes have de-emphasized both spore septation and spore pigmentation as reliable character states for deducing phylogenetic relationships within the *Hysteriaceae* (Boehm et al. 2009b).

Data have also necessitated (Boehm et al. 2009a, b) that the concept of the *Hysteriaceae* be expanded to include thin-walled mytilinioid forms previously in the *Mytiliniaceae* (e.g., *Ostreichnion*), as well as patellarioid forms previously in the *Patellariaceae* (e.g., *Rhytidhysterion*). Unlike most members of the family, the peridium in *Ostreichnion* is sclerenchymatoid and thin-walled, defining a fragile mytilinioid ascoma, and with a hamathecium typified by trabeculate pseudoparaphyses (Barr 1987a). Including the genus *Ostreichnion* in the *Hysteriaceae* implies that, either morphological features within the genus need to be re-evaluated, or that the family *Hysteriaceae* must also encompass mytilinioid forms. More difficult to understand perhaps is the inclusion of the genus *Rhytidhysterion* within the *Hysteriaceae*. Although included within the *Patellariaceae* (Kutorga and Hawksworth 1997), phylogenetic data presented by Boehm et al. (2009a, b) clearly indicate that this genus lies quite distant from other members of the *Patellariaceae*.

Some authors have included a number of additional genera within the *Hysteriaceae*. For instance, the genera *Hysteropatella*, *Hysterogonium* and *Pseudoscypha* were included in the *Hysteriaceae* by Eriksson (2006). In addition, the genera *Hemigrapha*, *Graphyllum*, and *Encephalographa* were included in the family by Kirk et al. (2001). Molecular data is lacking for most of these genera. However, Boehm et al. (2009a, b) were able to provide sequence data for *Hysteropatella* and *Encephalographa*. In Boehm et al. (2009a), two species belonging to *Hysteropatella*, namely *Hp. clavispota* (Peck) Höhn. and *Hp. Elliptica* (Fr.) Rehm, did not cluster with any of the hysteriaceous taxa surveyed. Instead, they, along with *Patellaria atrata* (Hedw.) Fr., formed a distant clade within the *Pleosporomycetidae*, postulated to represent the emergence of the *Patellariales*. Thus, *Hysteropatella* is not included in the *Hysteriaceae*. The genus *Encephalographa* was originally placed in the *Hysteriaceae* by Renobales and Aguirre (1990) and Tretiaich and Modenesi (1999). However, sequence data presented by Boehm et al. (2009b) indicate that *E. elisae* A. Massal. does not reside within the *Hysteriaceae*, instead lying quite distant, well outside of the *Pleosporomycetidae* and *Dothideomycetidae*. As for the genera *Hemigrapha*, *Graphyllum*, *Hysterogonium*, and *Pseudoscypha*, they are currently

regarded as *genera incertae sedis* until such time that molecular data become available.

The hysterothecium, thick-walled, navicular, and with a prominent longitudinal slit, has long been considered synapomorphic, defining the *Hysteriaceae* in the *Hysteriales*. However, this type of fruit body has evolved convergently no less than five times within the *Pleosporomycetidae* (e.g., *Farlowiella*, *Glonium*, *Anteaglonium*, *Hysterographium* and the *Hysteriaceae*). Similarly, thin-walled mytilinioid (e.g., *Ostreichnion*) and patellarioid (e.g., *Rhytidhysterion*) ascomata have also evolved at least twice within the subclass, the genera having been transferred from the *Mytiliniaceae* and *Patellariaceae*, respectively, to the *Hysteriaceae*. As such, character states relating not only to the external features of the ascoma and spore septation, but also to the centrum as well (e.g., cellular pseudoparaphyses versus trabeculae), previously considered to represent synapomorphies among these fungi, in fact, represent symplesiomorphies, and most likely have arisen multiple times through convergent evolutionary processes in response to common selective pressures. One selective advantage of the hysterothecium may be spore discharge over prolonged periods of time, since some, if not most, species may be perennial. The thick-walled peridium further contributes to xerotolerance, as many of these fungi persist on decorticated, weathered woody substrates prone to prolonged periods of desiccation. Thus, the ability to perennate, and time spore discharge with environmental conditions suitable for germination, spanning multiple seasons, may be the driving force behind the repeated evolution of the hysterothecium.

Both coelomycetous pycnidial states (e.g. *Aposphaeria*, *Hysteropycnis*) and dematiaceous hyphomycetous anamorphs (e.g. *Coniosporium*, *Septonema*, *Sirodesmium*, *Sphaeronaema*, and *Sporidesmium*) have been described for the family (e.g., Lohman 1934). *Aposphaeria* was accepted as *Melanommataceae* (de Gruyter et al. 2012) hence we conclude *Hysteriaceae* has “*Aposphaeria*”- like asexual state. Seifert et al. (2011) stated *Septonema* belongs to *Mytiliniaceae* and *Sirodesmium* was synonymized under *Coniosporium*. However Seifert et al. (2011) never listed *Sporidesmium* under *Hysteriaceae* hence we do not include it.

Type: **Hysterium** Pers., Tent. disp. meth. fung. (Lipsiae): 5 (1797), MycoBank MB 246 Fig. 56

Possible synonym:

Hypodermopsis Earle, Bulletin of the New York Botanical Garden 2: 345 (1902)

Lignicolous corticolous, commonly on well-decorticated hardwoods, rarely on conifers. Sexual state: *Ascomata* defined by dense, persistent, thick-walled, carbonaceous hysterothecia, distinctly navicular in outline, bearing a pronounced longitudinal slit. *Hysterothecia* erumpent to entirely superficial, solitary, or gregarious, ellipsoid to greatly elongated. *Peridium* in vertical section, globose to obovoid, typically

with a thick, three-layered peridium, composed of small pseudoparenchymatous cells, the outer layer heavily encrusted with pigment and often longitudinally striated on the surface, the middle layer lighter in pigmentation and the inner layer distinctly thin-walled, pallid, and compressed. *Hamathecium* composed of persistent cellular, hypha-like hyaline, septate, pseudoparaphyses, often borne in a gel matrix, with tips darkened or branched at maturity above the asci. *Asci* 8-spored, borne in a basal layer, typically clavate to cylindrical at maturity, bitunicate, fissitunicate, with a distinct ocular chamber. *Ascospores* phragmospores 3- or more transversely-septate, with cells often constricted at the septum, especially the median septum, pigmented versicolorous or

concolorous, often showing bipolar asymmetry, without swollen supra-median cell, overlapping bi-seriate, obvoid to clavate, ellipsoid or fusoid, sometimes with a thin gel coating when young. Asexual state: see notes below.

Notes: The cosmopolitan genus *Hysterium*, the type for the family *Hysteriaceae*, is attributed to Tode (1784), who was the first to apply the name to a group of fungi bearing a pronounced longitudinal slit, for which he gave the common name “*Venuschwämme*” (see Boehm et al. 2009a). Zogg (1962) recognized two morphological types within the genus. Type I is characterized by 3-septate phragmospores, and includes the versicolorous type species *H. pulicare* Tode, and

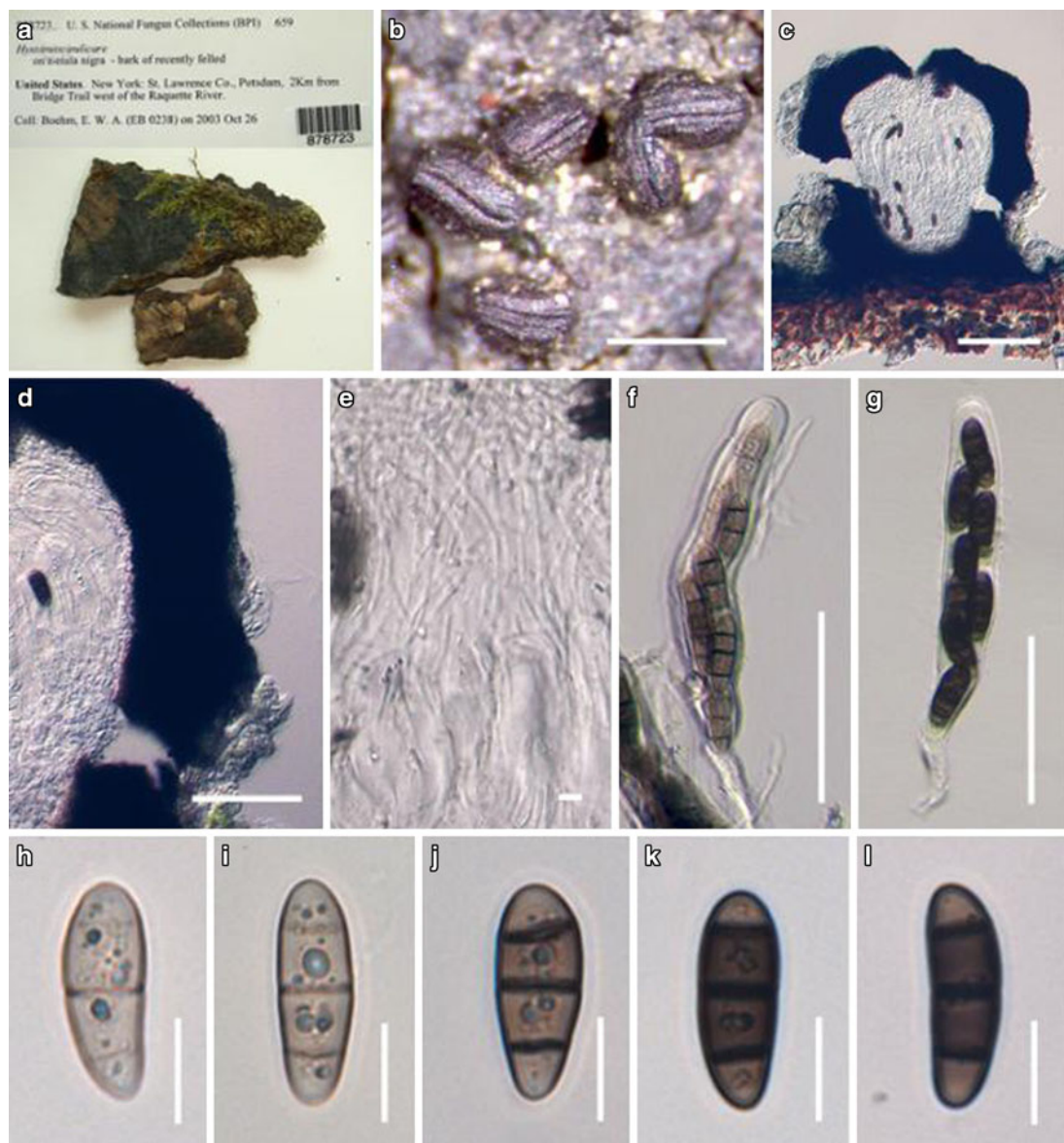


Fig. 56 *Hysterium pulicare* (Material examined: USA, New York. St. Lawrence Co., Potsdam, on bark of recently felled of *Betula nigra*, 2 km. from Bridge Trail west of the Raquette River, 26 October 2003, EWA Boehm, EB 0238 BPI 878723). **a** Herbarium specimen. **b** Hysterothecia

appearance on host substrate. **c** Vertical section of hysterothecium showing arrangement of asci and pseudoparaphyses. **d** Peridium. **e** Pseudoparaphyses. **f, g** Asci. **h–l** Ascospores with three septa. Scale bars: **b** = 500 μ m, **c** = 100 μ m, **e** = 5 μ m, **f–g** = 50 μ m, **h–l** = 10 μ m

its closely related concolorous counterpart, *H. angustatum* Pers., both extremely common in the temperate zones of both hemispheres. These are followed by *H. vermiforme* Masee, from Africa, and the much larger-spored *H. microsporum* Peck, reported from North America and China (Teng 1933). Although Zogg (1962) did not accept *H. hyalinum* Cooke & Peck, Lohman (1934) provided legitimacy to the epithet, noting that pigmentation is delayed in the maturation of the 3-septate ascospores. Type II corresponds to a different phragmospore, one in which, typically, there are five or more septa, and in which there exists a swollen cell, either just above the median septum (i.e., suprmedian) or, rarely, some distance up from the median septum. Type II includes, by increasing spore length, the cosmopolitan *H. insidens* Schwein., the larger-spored counterpart *H. sinense* Teng, and the unusual *H. magnisporum* W.R. Gerard, 7-septate, with three of the septa crowded to each end, the two central cells much larger. *Hysterium velloziae* Henn., provisionally included by Zogg (1962), with up to 21 septa at maturity, has only been reported from Africa (van der Linde 1992). An additional two species have been recently described. *Hysterium asymmetricum* Checa et al. (2007) from Costa Rica, has outer centrum tissues pigmented red, and 3-septate phragmospores, showing an extended basal cell. *Hysterium andinense* Messuti & Lorenzo has been recently described from the conifer *Austrocedrus chilensis* in Argentina (Messuti and Lorenzo 1997). However, molecular and morphological data (Boehm et al. 2009a) have placed this taxon in the *Mytilinidiaceae*, as *Mytilinidion andinense* (Messuti & Lorenzo) E.W.A. Boehm et al. An additional new species was recently described in Boehm et al. (2009b), namely *Hysterium barrianum* E.W.A. Boehm et al.

A wide taxon sampling strategy for the genus *Hysterium* was recently presented in Boehm et al. (2009b), including multiple isolates from wide geographic origins, for seven of the eleven recognized species. Multiple gene phylogenies indicate that the genus *Hysterium* is highly polyphyletic, along three separate lines, two within the *Hysteriaceae* and one outside of the family (Boehm et al. 2009b). This implies that the evolution of pigmented phragmospores borne in hysterothecia has occurred at least three times within the *Pleosporomycetidae*. Sequence data indicate a core monophyletic group for the genus *Hysterium*, including the type species, *H. pulicare*, as well as the closely related *H. angustatum*, and *H. vermiforme* Masee. All three with 3-septate, pigmented phragmospores, corresponding to Type I. Also, within the same clade resides *H. barrianum* E.W.A. Boehm et al., with 9-septate ascospores, belonging to Type II. Thus molecular data do not support the two types of phragmospore proposed initially by Zogg (1962). Molecular data also indicate that the remaining two species of *Hysterium* surveyed, namely *H. sinense* and *H. insidens* Schwein., are not related to the type *H. pulicare* (Lightf.) Pers. and

associated species. Rather, data indicate that, although belonging to the *Hysteriaceae*, these two species are distantly related to the core group of species constituting the genus *Hysterium*. As such, the new genus *Oedohysterium* E.W.A. Boehm & C.L. Schoch was proposed to accommodate these species (Boehm et al. 2009b). *Oedohysterium* is defined morphologically by the presence of a swollen supra-media cell, which is absent in the genus *Hysterium*.

Type species: Hysterium pulicare Pers., Neues Mag. Bot. 1: 85 (1794)

= *Hysterographium pulicare* (Pers.) Corda, Icon. fung. (Prague) 5: 77 (1842)

Other genera included

Actidiographium Lar.N. Vassiljeva, Mikol. Fitopatol. 34(6): 4 (2000)

Type species: Actidiographium orientale Lar.N. Vassiljeva, Mikol. Fitopatol. 34(6): 5 (2000)

Coniosporium Link, Mag. Gesell. naturf. Freunde, Berlin 3(1–2): 8 (1809)

Type species: Coniosporium olivaceum Link, Mag. Gesell. naturf. Freunde, Berlin 3(1–2): 8 (1809)

Gloniella Sacc., Syll. fung. (Abellini) 2: 765 (1883)

Type species: Gloniella sardoa Sacc. & Traverso, Syll. fung. (Abellini) 2: 765 (1883)

Gloniopsis De Not., G. bot. ital. 2(7–8): 12, 23 (1847)

Type species: Gloniopsis decipiens De Not., G. bot. ital. 2(7–8): 12, 23 (1847)

Hysterobrevium E. Boehm & C.L. Schoch, in Boehm et al., Stud. Mycol. 64: 62 (2010)

Type species: Hysterobrevium mori (Schwein.) E. Boehm & C.L. Schoch, in Boehm et al., Stud. Mycol. 64: 62 (2010)

Hysterocarina H. Zogg, Beitr Kenntn Brasil. Hysteriaceen: 59: 42 (1949)

Type species: Hysterocarina paulistae H. Zogg, Beitr. Kenntn. Brasil. Hysteriaceen 59: 42 (1949)

Hysteropycnis Hilitzer, Věd. Spisy čsl. Akad. zeměd. 3: 145 (1929)

Type species: non designated or noted.

Oedohysterium E. Boehm & C.L. Schoch, in Boehm et al., Stud. Mycol. 64: 59 (2009)

Type species: Oedohysterium insidens (Schwein.) E. Boehm & C.L. Schoch, in Boehm et al., Stud. Mycol. 64: 59 (2009)

Ostreichnion Duby, Mém. Soc. Phys. Hist. nat. Genève 16(1): 33 (1862)

Type species: Ostreichnion americanum Duby, Mém. Soc. Phys. Hist. nat. Genève 16(1): 34 (1862)

Psilogonium Höhn., Ann. mycol. 16(1/2): 149 (1918)

Type species: Psilogonium lineare (Fr.) Petr., Ann. mycol. 21(3/4): 227 (1923)

Rhytidhysterion Speg. [as ‘*Rhytidhysterion*’], Anal. Soc. cient. argent. 12(4): 188 (1881)

Type species: Rhytidhysterion brasiliense Speg., Anal. Soc. cient. argent. 12(4): 188 (1881)

Sphaeronaema Fr., Observ. mycol. (Havniae) 1: 187 (1815)

Type species: Sphaeronaema cylindricum (Tode) Fr., Observ. mycol. (Havniae) 1: 187 (1815)

Key to the genera and allied genera of the *Hysteriaceae*

Notes: Dichotomous keys are presented here for hysteriaceous fungi, with the caveat that phylogenetically unrelated taxa share the same key. Thus, despite their transference from the *Hysteriaceae* (Boehm et al. 2009a, b), the genera *Hysterographium*, *Farlowiella*, *Glonium* and *Anteaglonium* (Mugambi and Huhndorf 2009a, b), are nevertheless included in the key. This is because they typically possess ascomata that have traditionally been referred to as hysterothecia.

1. Ascomata apothecioid, opening widely when hydrated, fully exposing the hymenium, which may be red or black (i.e. patellarioid) *Rhytidhysterion*

1. Hysterothecia usually remaining closed, or only opening slightly through a longitudinal fissure or sulcus to reveal a lenticular, disk-like hymenium when hydrated and mature 2

2. Ascospores pedicellate amerospores, the upper cell pigmented and much larger than the lower, which remains un- or less-pigmented; asexual morphs: *Acrogenospora* *Farlowiella*

Note: The genus *Farlowiella* has been removed from the *Hysteriaceae* and is currently listed as *Pleosporomycetidae* gen. *incertae sedis* (Boehm et al. 2009a, b).

2. Ascospores not as above, didymospores, phragmospores or dictyospores, sometimes pigmented 3

3. Didymospores small, the two cells more or less equal in size 4

3. Ascospores not as above, phragmospores, dictyospores, +/- pigmentation, or very large didymospores (*O. curtisii*) 7

4. Ascospores hyaline 5

4. Ascospores pigmented *Actidiographium*

5. Didymospores less than 8 μm long *Anteaglonium*

Note: The genus *Anteaglonium* lies within the *Pleosporales* (Mugambi and Huhndorf 2009a, b), but is keyed out here with *Psiloglonium*.

5. Didymospores longer than 8 μm 6

6. Didymospores hyaline, borne in solitary or gregarious hysterothecia, rarely associated with a subiculum, not laterally anastomosed to form radiating stellate composites *Psiloglonium*

Note: One species of *Anteaglonium*, *A. latirostrum*, will key out here, but belongs in the *Pleosporales* (Mugambi and Huhndorf 2009a, b) and is also keyed out in the *Psiloglonium* key.

6. Didymospores hyaline, borne in modified hysterothecia, usually associated with a subiculum, strongly laterally

anastomosed along their length to form radiating stellate composites *Glonium*

Note: The genus *Glonium* has been transferred from the *Hysteriaceae* to the *Gloniaceae*, currently listed as *fam. incertae sedis* within the *Pleosporomycetidae* (Boehm et al. 2009a, b).

7. Ascospores transversely septate phragmospores, or if with dictyospores then also with red pigmentation 8

7. Ascospores transversely and longitudinally septate dictyospores, or very large didymospores (*O. curtisii*) 10

8. Ascospores hyaline phragmospores *Gloniella*

8. Ascospores pigmented phragmospores or in one case (*Od. pulchrum*) with pigmented dictyospores and red pigmentation in the hamathecium 9

9. Phragmospores 3-septate or rarely more, but without swollen supra-median cell(s) *Hysterium*

9. Phragmospores with swollen supra-median cell, usually more than 3-septate, in one case with pigmented dictyospores and red centrum pigmentation (*Od. pulchrum*) *Oedohysterium*

10. Dictyospores hyaline, +/- gelatinous sheath, or pigmented, but short, less than 25 μm in length *Hysterobrevium*

10. Dictyospores hyaline, +/- gelatinous sheath, or pigmented, but longer than 25 μm , or very large didymospores (*O. curtisii*) 11

11. Dictyospores, if hyaline, then longer than 25 μm , or if pigmented, then measuring (22–)25–34(–45) \times (6–)8–12(–17) μm , with 7–11 transverse and 1–2 vertical septa, and no red pigment associated with the hamathecium (*Gp. subrugosa*) *Gloniopsis*

11. Dictyospores pigmented, of different length, or if similar in length to *Gp. subrugosa*, then tropical with red pigment associated with the hamathecium, or very large didymospores (*O. curtisii*) 12

12. Dictyospores pigmented, borne in typical hysterothecia, that are erumpent or sessile on the substrate *Hysterographium*

Note: The genus *Hysterographium*, with the type species *Hg. fraxini*, has been transferred out of the *Hysteriaceae* as *Pleosporomycetidae* gen. *incertae sedis* (Boehm et al. 2009a, b). Residual species classified as *Hysterographium*, for which sequence data is lacking, are provisionally retained within the genus.

12. Hysterothecia borne within the substrate, hardly erumpent, with cristate longitudinal apex instead of a sulcus; neotropical *Hysterocarina*

12. Ascomata thin-walled, globoid to conchate, mytilinioid, without sunken longitudinal slit; pigmented dictyospores or very large didymospores *Ostreichnion*

Note: The genus *Ostreichnion*, previously in the *Mytiliniaceae*, was transferred to the *Hysteriaceae* (Boehm et al. 2009a).

Kirschsteiniotheliaceae S. Boonmee & K.D. Hyde, Mycologia 104(3): 705 (2012), MycoBank: MB 561021

Saprobic on decorticated submerged wood. Sexual state: *Ascomata* superficial, subglobose to globose, dark brown to black, membranaceous, solitary, sometimes clustered, with a central papilla. *Peridium* thick, composed of a single strata, comprising 3–4 layers of cells of *textura angularis*; inner layer pale brown, outer cells dark. *Hamathecium* comprising numerous, filiform, hyaline, pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical-clavate, with a long pedicel, apically rounded with an ocular chamber. *Ascospores* 2-seriate, ellipsoidal, slightly curved, 1–(–)2-septate, with median septum or in lower part, some ascospores with secondary septum, dull green, brown to dark brown at maturity, thick-walled, lacking a mucilaginous sheath. Asexual state: *Dendryphiopsis*. *Conidiophores* macronematous, mononematous, directly erect on substrate, apically branched, arising straight or slightly curved, solitary, elongate and thick-walled, septate, brown to dark brown, smooth-walled. *Conidiogenous cells* monoblastic, terminal, delimited, constricted at the septa. *Conidia* broadly ellipsoid-obovoid, initially 1-septate, latterly 2-transverse septa, occasionally 3-septate, constricted and darkly pigmented at the septa, rounded at both ends, light brown, red brown to dark brown, smooth-walled.

Notes: The family *Kirschsteiniotheliaceae* was recently proposed by Boonmee et al. (2012), for saprobic fungi occurring on dead wood, and was supported by molecular data. This is a small family with a single genus that is represented by *K. aethiops*, characteristically with superficial ascomata, globose, unilocular, heavily pigmented, bitunicate, fissitunicate asci, dull green, brown to dark brown, septate ascospores. Principally, the type species *K. aethiops* was connected with asexual form *Dendryphiopsis* (Hughes 1953a), with mononematous, erect, branched, septate, coloured conidiophores, broadly ellipsoid-obovoid, septate, light to dark brown conidia (Hughes 1953a; Hawksworth 1985b; Fig. 57n–r). The introduced family *Kirschsteiniotheliaceae* is well-supported by morphological characters and molecular phylogenetic analyses (Schoch et al. 2006; Shearer et al. 2009; Boonmee et al. 2012).

Type: ***Kirschsteiniothelia*** D. Hawksw., J. Linn. Soc., Bot. 91: 182 (1985), MycoBank: MB 25723 Fig. 57

Synonym:

Dendryphiopsis S. Hughes, Can. J. Bot. 31: 655 (1953)

Notes: Most species are widespread in tropical regions and commonly occur on dead wood. Additionally, both type species of sexual and asexual states are characteristic of the family (Boonmee et al. 2012). Currently three *Kirschsteiniothelia* species are assigned to the family: *K. aethiops*, *K. emarceis* Boonmee & K.D. Hyde and *K. lignicola* Boonmee & K.D. Hyde based on sequence data, while *K. maritima* (as *Halokirschsteiniothelia maritima* (Linder) Boonmee & K. D. Hyde) groups in the

Mytilindiaceae, and *K. elaterascus* (as *Morosphaeria elaterascus* (Shearer) Boonmee & K. D. Hyde) in *Morosphaeriaceae* (Boonmee et al. 2012). The placement of other *Kirschsteiniothelia* species remains to be resolved.

Type species: ***Kirschsteiniothelia aethiops*** (Sacc.) D. Hawksw., J. Linn. Soc., Bot. 91(1–2): 185 (1985), MycoBank: MB 104401

≡ *Sphaeria aethiops* Berk. & Curtis, Grevillea 4: 143 (1876)

≡ *Amphisphaeria aethiops* Sacc., Syll. fung. (Abellini) 1: 722 (1882)

Lentitheciaceae Yin. Zhang et al., in Zhang et al., Stud. Mycol. 64: 93 (2009), MycoBank: MB 515470

Saprobic on stems and twigs of herbaceous and woody plants in terrestrial or aquatic habitats. Sexual state: *Ascomata* scattered to gregarious, immersed to superficial, globose to lenticular, dark brown to black, glabrous or with brown hyphae. *Ascomatal opening* short-papillate or undeveloped, central with or without brown short setae. *Peridium* composed of hyaline to brown, polygonal to angular, thin-walled cells. *Hamathecium* of cellular, septate and branched pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to broadly clavate, with a short pedicel, and a shallow ocular chamber at rounded apex, basal to somewhat lateral. *Ascospores* bi-seriate to tri-seriate, sometimes fasciculate, narrowly fusiform to broadly cylindrical, filiform in some species, straight or slightly curved, mostly 1–3-septate (28–36-septate in some species), hyaline, smooth, surrounded by an entire mucilaginous sheath or elongated appendage-like sheath. Asexual morphs “*Stagonospora*”-like or “*Dendrophoma*”-like. *Conidiomata* pycnidial, globose, ostiolate. *Conidiogenous cells* enteroblastic. *Conidia* cylindrical, hyaline, smooth, 2–3-septate or one-celled.

Notes: The *Lentitheciaceae* include *Katumotoa*, *Lentithecium* and *Tingoldiogo*. Although sequence data for the type species of *Keissleriella* (*K. aesculi* (Höhn.) Höhn.) are unavailable, three species of this genus (*K. cladophila* (Niessl) Corbaz, *K. linearis* E. Müll. ex Dennis, and *K. rara* Kohlm. et al.) were positioned as members of the *Lentitheciaceae* in several phylogenetic studies (Suetrong et al. 2009; Zhang et al. 2009b). Therefore, *Keissleriella* was also tentatively assigned to this family (Zhang et al. 2009a).

There are several other species belonging to the family *Lentitheciaceae*; “*Massarina*” *lacustris* sensu Leuchtman (Leuchtman 1985a; Schoch et al. 2006; non *Wettsteinina lacustris*), “*Ophiosphaerella*” *sasicola* (Tanaka et al. 2009), and “*Stagonospora*” *macropycnidia* (Schoch et al. 2009a). These species, however, should probably be transferred to another or new genera, because they deviate from the type lineage, such as *Massarina eburnea* (Tul. & C. Tul.) Sacc. (*Massarinaceae*), *Ophiosphaerella graminicola* Speg. (no molecular evidence but may belong to *Phaeosphaeriaceae*



Fig. 57 *Kirschsteinothelia lignicola* (Material examined. THAILAND, Chiang Rai, Muang, Khun Korn Waterfall, alt 671 msl, N19°51–54' E99°35.39', on decaying wood of unidentified tree, 15 Aug 2009, Saranyaphat Boonmee, MFLU10–0036, **holotype**). **a** Ascoma appearance among its asexual morph. **b** Section through ascoma. **c** Peridium. **d** Pseudoparaphyses cylindrical, filiform and colourless. **e–g** Asci 8-

spored. Note fissitunicate ascus arrowed in **g**. **h–j** Ascospores. **k** Germinating ascospore. **l** Colony on MEA with asexual state. **m–p** Conidiophores with constricted conidiogenous cell and conidial attachment arrowed. **q, r** Conidia. Scale bars: **a–b** = 100 μ m, **c, m–r** = 20 μ m, **d** = 5 μ m, **e–g** = 40 μ m, **h–k** = 10 μ m, **l** = 1 cm

like *O. herpotricha* (Fr.) J. Walker) and typical *Stagonospora* species (*Phaeosphaeriaceae*).

Species of the *Lentitheciaceae* occur on herbaceous plants such as *Phragmites* (*Lentithecium fluviatile* (Aptroot & Van

Ryck.) K.D. Hyde et al., *L. arundinaceum* (Sowerby) K.D. Hyde et al., *Tingoldiogo graminicola* K. Hirayama & Kaz. Tanaka) and on submerged wood (*Lentithecium aquaticum* Yin. Zhang et al.) in freshwater environments (Zhang et al.

2012a). *Keissleriella rara* is reported from *Juncus* as a halotolerant species (Kohlmeyer et al. 1995a). *Katumotoa bambusicola* Kaz. Tanaka & Y. Harada and *Ophiosphaerella sasicola* (Nagas. & Y. Otani) Shoemaker & C.E. Babc. are bambusicolous species known from Japan (Nagasawa and Otani 1977; Tanaka and Harada 2005).

Asexual morphs previously reported for species in the *Lentitheciaceae* are *Stagonospora macropycnidia* (sexual state unknown; Cunnell 1961), “*Stagonospora*”-like sp. (for “*Massarina*” *lacustris*; Leuchtmann 1985a) and “*Dendrophoma*”-like (for *Keissleriella cladophila*; Bose 1961; Sivanesan 1984). They are coelomycetous asexual morphs having 2–3-septate or one-celled conidia. No hyphomycetous asexual morph is known in this family.

Type: Lentithecium K.D. Hyde et al., in Zhang et al., Fungal Divers. 38: 234 (2009), MycoBank: MB512790 Fig. 58

Saprobic on stems and twigs of herbaceous and woody plants in aquatic habitats. Sexual state: *Ascomata* pseudothecial, scattered or gregarious, immersed, globose to depressed globose, dark brown to black, with sparse brown hyphae at side and base, ostiolate. *Ascomatal opening* slightly papillate, without periphyses and apical setae. *Peridium* composed of several layers of brown-walled polygonal cells. *Hamathecium* of 2–3.5 μm wide, cellular, septate and branched pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to broadly clavate, short pedicellate, with a shallow ocular chamber at rounded apex, basal to somewhat lateral. *Ascospores* bi-seriate to tri-seriate above, uni-seriate below, fusiform with rounded ends, 1–3-septate, hyaline, surrounded by a conspicuous gelatinous sheath. Asexual state: Unknown.

Notes: The characters emphasized in establishment of *Lentithecium* (type: *L. fluviatile*) are lenticular ascomata with simple peridium structure and hyaline, 1-septate ascospores (Zhang et al. 2009b). This circumscription, however, needs modifying. Our examination based on the holotype of *L. fluviatile* (GENT; van Ryckegem and Aptroot 2001) revealed that the species has globose ascomata and 1 to 3-septate ascospores as shown in Fig. 58. *Massarina arundinacea* was transferred to *Lentithecium* based on the lenticular ascomata (Zhang et al. 2009b), but recent molecular studies indicate that the species does not belong to *Lentithecium* (Schoch et al. 2009a; Liu et al. 2011; Zhang et al. 2009a, 2012a). Similarly, *Tingoldiagio* characterized by narrowly fusiform ascospores with an elongated sheath (Hirayama et al. 2010) was regarded as a synonym of *Lentithecium* because of the lens-shaped ascomata (Zhang et al. 2012a). However, these phylogenetic relationships are poorly supported (less than 23 %; Zhang et al. 2012a; see also Shearer et al. 2009), as well as their morphological differences found in ascomata and ascospores, which may suggest that they are not congeneric. Further studies are needed.

Keissleriella linearis was transferred to *Lentithecium*, and a typical character of *Keissleriella*, such as short brown setae around apex of ascomatal ostiole, was considered to have little phylogenetic significance (Zhang et al. 2009b). *Keissleriella*, however, should be treated as a different genus as was suggested by recent studies based on molecular phylogeny (Suetrong et al. 2009; Zhang et al. 2012a).

Type species: Lentithecium fluviatile (Aptroot & Van Ryck.) K.D. Hyde et al., in Zhang et al., Fungal Divers. 38: 234 (2009), MycoBank: MB 512802

\equiv *Massarina fluviatilis* Aptroot & Van Ryck., in Van Ryckegem and Aptroot, Nova Hedwigia 73: 162 (2001)

Other genera included

Katumotoa Kaz. Tanaka & Y. Harada, in Tanaka et al., Mycoscience 46: 313 (2005)

Type species: Katumotoa bambusicola Kaz. Tanaka & Y. Harada, in Tanaka et al., Mycoscience 46: 313 (2005)

Tingoldiagio K. Hiray. & Kaz. Tanaka, in Hirayama et al., Mycologia 102: 740 (2010)

Type species: Tingoldiagio graminicola K. Hiray. & Kaz. Tanaka, in Hirayama et al., Mycologia 102: 740 (2010)

Keissleriella Höhn., Sber. Akad. Wiss. Wien math.-naturw. Kl. 128: 582 (1919)

Type species: Keissleriella aesculi (Höhn.) Höhn., Sber. Akad. Wiss. Wien math.-naturw. Kl. 128: 582 (1919)

Key to genera of Lentitheciaceae

1. Ascomata globose, with brown short setae around apex of ascomatal ostiole *Keissleriella*
1. Ascomata globose to lenticular, without ascomatal setae 2
2. Ascomata depressed subglobose; ascospores fusiform, asymmetrical, with a submedian septum (ca. 0.70); on bamboo *Katumotoa*
2. Ascomata globose to lenticular; ascospores nearly symmetrical; in freshwater 3
3. Ascomata lenticular to conical with a flattened base; ascospores narrowly fusiform with bipolar elongated sheath *Tingoldiagio*
3. Ascomata globose to subglobose; ascospores fusiform to broadly fusiform with an entire sheath *Lentithecium*

Leptopeltidaceae Höhn. ex Trotter [as ‘*Leptopeltineae*’], in Saccardo, Syll. fung. (Abellini) 24(2): 1255 (1928), MycoBank: MB 81594

Saprobic on dead stems, or leaves of flowering plants or ferns. Sexual state: *Ascomata* relatively small (80–300 μm diam, 20–40 μm high), superficial, scattered or gregarious, mostly solitary, immersed or subcuticular, perithecial or raised apothecial, visible as brown to dark brown, or black spots on the host tissue, waxy, lenticular, shield-shaped, conical, elongated or irregular in shape, wall smooth, some genera with



Fig. 58 *Lentithecium fluviatile* (Material examined: BELGIUM, East-Flanders, Tielrode tidal marsh near river Schelde, IFBL coordinates, C4 21 41, on leaf sheath of *Phragmites australis*, Van Ryckegem 509, 4 October 2000, GENT, **holotype** of *Massarina fluviatilis*). **a** Ascogonia on

host surface. **b, c** Ascogonia in longitudinal section. **d** Peridium. **e** Pseudoparaphyses. **f, g** Asci. **h** Apex of ascus. **i–n** Ascospores. Scale bars: **a** = 500 μm , **b, c** = 50 μm , **d–h** = 20 μm , **i–n** = 10 μm

mycelia immersed in host tissue, or easily to remove from host, ostiole central, dehiscence by pore or slit. *Peridium* thin-walled, composed of isodiametric or irregularly cells of *textura angularis*. *Hamathecium* comprising numerous, broad “pseudoparaphyses”, embedded in gelatinous matrix, or pseudoparaphyses lacking. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to cylindric-clavate, or saccate, pedicellate or apedicellate, apically rounded, with a indistinct, wide ocular chamber. *Ascospores* overlapping or 3–4-seriate, ellipsoidal, broadly fusiform, or cylindrical, with rounded ends, hyaline, 0–3-septate, rarely constricted at the septum, smooth to rough-walled. Asexual state: coelomycetous pycnidial, *conidiogenous cells* small, filiform, proliferating percurrently, *conidia* small, aseptate, thin-walled.

Notes: The *Leptopeltidaceae* was introduced by von Höhnelt (1917, as *Leptopeltineen*) and was accommodated in *Phacidiales*. The original prologue was “excipular stromatic, subcuticular with longitudinal irregular scutate at maturity, ascospores hyaline, uniloculate, fusoid with two cells, paraphyses, highly heterogeneous” (von Höhnelt 1917; Holm and Holm 1977). von Höhnelt (1917) included *Phacidina*, *Entopeltis*, *Thyriosis*, *Leptopeltella*, *Leptopeltis* and *Duplicaria* in this family. Petrak (1947) noted a hypostroma in the host tissue as an important taxonomic character and modified the taxonomic groups that circumscribed *Leptopeltidaceae* to include only *Leptopeltis* and *Leptopeltella*. Petrak (1947) had a very narrow generic concept that assumed differences in ascospore septation. Moreover, he also included *Ronnigeria* (Basionym: *Microthyrium arcticum* Oudem.), a saprobe on leaves of *Potentilla* spp., in *Leptopeltidaceae* (Holm and Holm 1977). von Arx and Müller (1975) re-defined *Leptopeltidaceae* as saprobes on stalks, stems or leaves of ferns or flowering plants, leaves of conifers, or on lichens, with sparse mycelium, immersed or subcuticular on host, forming stromatic crusts. Ascomata were described as subcuticular or superficial, becoming appressed on the cuticle, crustose or scutate, and roundish in the margins and asci as 20–30×8–11 μm , bitunicate, clavate, parallel or borne on a thin basal layer of isodiametric cells, ascospores small, usually uni- to multi-septate, hyaline or brownish and with filamentous, hyaline, paraphyses surrounding the asci. The asexual state was reported as *Leptothyrium*, a coelomycete forming small, one-celled conidia, borne in dimidiate or scutate pycnidial cavities” (von Arx and Müller 1975). von Arx and Müller (1975) included *Leptopeltis*, *Leptopeltopsis*, *Staibia*, *Moeszopeltis*, *Pycnothyrium*, *Thyriopsis*, *Dothiopeltis*, *Aulographum*, *Aulographina*, *Lembosina*, *Morenoina* and *Lichenopeltella* in *Leptopeltidaceae*. Holm and Holm (1977) revisited *Leptopeltidaceae* and gave a revised generic description with asci being unitunicate. Eriksson (1981) disagreed as he found the endotunica and ectotunica layers and considered the asci in *Leptopeltis* as morphologically bitunicate, but functionally unitunicate. Eriksson (1981) stated that asci

in *Leptopeltidaceae* may be bitunicate with a “Jack in the box” type of dehiscence, a type of ascus that has evolved several times by reduction of its closest relatives. It is difficult to state whether the ascus is bitunicate or unitunicate in many cases and *Leptopeltis* is one such case (Eriksson 1981).

Lumbsch and Huhndorf (2010) listed six genera in *Leptopeltidaceae* besides the type *Leptopeltis*. We have observed the type specimens of this family and confirmed that *Leptopeltidaceae* have bitunicate asci and exclude *Phacidina* which has unitunicate asci. However, molecular data is needed to confirm the genera included in *Leptopeltidaceae*. Presently there are no sequence data for *Leptopeltidaceae* in GenBank. In this study we accept *Leptopeltis*, *Dothiopeltis*, *Nannfeldtia*, *Ronnigeria* and *Staibia*.

The asexual state was reported as “Idriella”-like for *Dothiopeltis* and “Leptothyrium”-like for *Leptopeltis* (Hyde et al. 2011; Wijayawardene et al. 2012). “Idriella”-like taxa are hyphomycetous producing hyaline or brown hyphae, brown, simple, geniculate, aseptate conidiophores that taper towards the ends, and lunate or falcate conidia with acuminate tips, produced in dry heads, and dark brown chlamydospores, usually borne, laterally on main hyphae (Nelson and Wilhelm 1956) while “Leptothyrium”-like are coelomycetous forming small, one-celled conidia, borne in dimidiate or scutate pycnidial cavities (von Arx and Müller 1975).

Type: *Leptopeltis* Höhn., Ber. dt. bot. Ges. 35: 422 (1917), MycoBank: MB2786 Fig. 59

Saprobies on stems or leaves, commonly occurring on ferns or some flowering plants, visible as black circular spots or irregular longitudinal spots on the host surface. Sexual state: *Ascomata* relatively small (150–300 μm diam, 20–40 μm high), subcuticular or superficial, with hyphae immersed under host tissue, solitary, scattered to gregarious, elongate or irregular in shape, dark brown to black, waxy, easily to remove from host surface, ostiole central, dehiscence by slit. *Peridium* composed of a single layer of isodiametric cells, thin-walled, dark brown to black. *Hamathecium* comprising numerous, filiform, aseptate, broad pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, cylindrical to cylindric-clavate, ellipsoidal to oblong, apedicellate, apically rounded, with a wide indistinct ocular chamber. *Ascospores* overlapping or 3–4-seriate, fusiform, oblong to cylindrical, or sometimes falcate to reniform, hyaline, 0–3-septate, mostly non constricted at the septa, septa indistinct, smooth-walled. Asexual state: see notes.

Notes: *Leptopeltis* was introduced by von Höhnelt (1917) as type family *Leptopeltis filicina* (basionym: *Aulographum filicinum* Lib. 1834) as “perithecium adnate or sparsed, ovoid to oblong, simple or sometimes confluent furcate, opaque black, completely flattened, often with closed lips, asci ovoid, associated with stalks of *Aspidii*

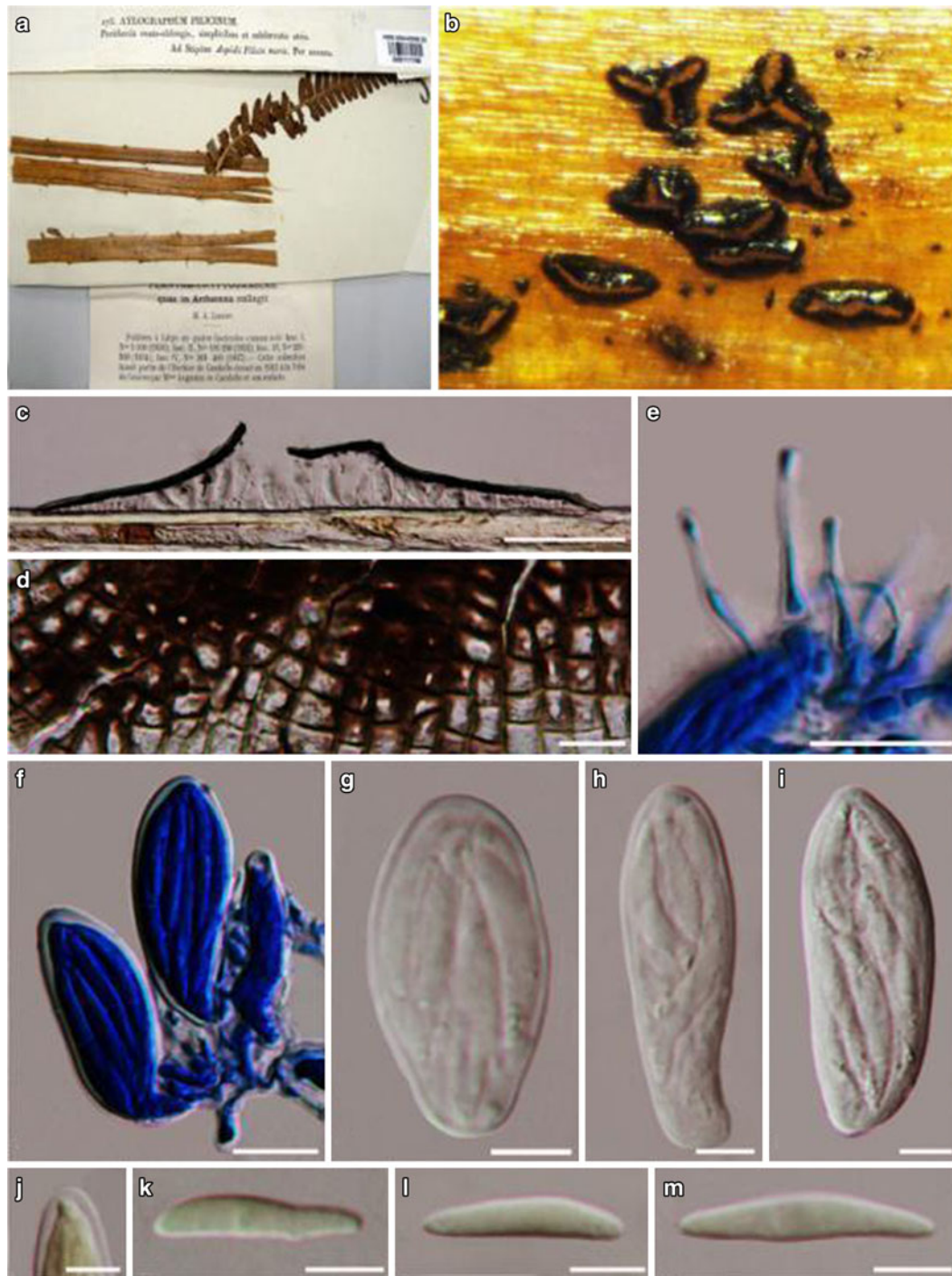


Fig. 59 *Leptopeltis filicina* (Material examined: BELGIUM, Ardennes, on petioles of dead fronds of *Aspidium filix-mas* [*Dryopteris f.-m.*], Libert, Pl. Crypt. Arduenna, no. 275, G 00111186, as *Aylographum filicinum*). **a** Label and specimens. **b** Ascumata on host. **c**

Section through ascoma. **d** Peridium. **e** Paraphyses stained in lactophenol cotton blue. **f** Asci stained by lactophenol cotton blue. **g–i** Asci. **j** Ocular chamber of ascus. **k–m** Ascospores stained in Melzer's reagent. Scale bars: **c**=50 μ m, **d**=20 μ m, **e**, **f**=10 μ m, **g–m**=5 μ m

filicis" (Saccardo 1883). This genus commonly associated with ferns and some flowering plants. There are 13 species epithets given in Index Fungorum (2013) and the genus is in need of a modern treatment.

Type species: Leptopeltis filicina (Lib.) Höhn., Ber. dt. bot. Ges. 35: 422 (1917)
 ≡ *Aulographum filicinum* Lib., Pl. crypt. Arduenna, fasc. (Liège) 3: no. 275 (1834)

Other genera included

Dothiopeltis E. Müll., Sydowia 10(1–6): 197 (1957) [1956]
Type species: Dothiopeltis arunci E. Müll., Sydowia 10(1–6): 198 (1957) [1956]

Nannfeldtia Petr., Sydowia 1(1–3): 18 (1947)
Type species: Nannfeldtia atra Petr., Sydowia 1(1–3): 18 (1947)

Phacidina Höhn., Annl. mycol. 15(5): 324 (1917) excluded from this family as it has unitunicate asci.

Type species: Phacidina gracilis (Niessl) Höhn., Annl. mycol. 15(5): 324 (1917)

Ronnigeria Petr., Sydowia 1(4–6): 310 (1947)
Type species: Ronnigeria arctica (Oudem.) Petr., Sydowia 1(4–6): 310 (1947)

Staibia Bat. & Peres, in Batista et al., Inst. Micol. Univ. Pernambuco 3: 142 (1966)

Type species: Staibia connari Bat. & Peres, in Batista et al., Atas Inst. Micol. Univ. Recife 3: 142 (1966)

Key to genera of Leptopeltidaceae

Phacidina is included in the key for historical reasons

1. Ascum perithecial2
2. Ascum apothecial, ascospores hyaline, rough-walled, associated on *Carex firma****Nannfeldtia***
2. Ascum orbicular, dimidiate to scutate3
2. Ascum elongate or irregularly-shaped, T or Y shaped, dehiscence by central longitudinal slit-like opening***Leptopeltis***
3. Ascospores 0–1-septate4
3. Ascospores muriform, paraphysate, associated with *Aruncus silvester****Dothiopeltis***
4. Ascospores aseptate5
4. Ascospores 1-septate, associated with *Conarus suberosus****Staibia***
5. Hamathecium lacking, associated with *Potentilla* spp. or *Sibbaldia procumbens****Ronnigeria***
5. Hamathecium present, forming broad paraphyses, associated on *Lycopodium* spp.***Phacidina***

Leptosphaeriaceae M.E. Barr, Mycotaxon 29: 503 (1987), MycoBank: MB 81843

Saprobic, hemibiotropic or parasitic usually occurring on dicotyledons, in terrestrial and aquatic habitats. Sexual state: *Ascum* immersed, erumpent to superficial, globose, subglobose or obpyriform, black to dark brown, coriaceous, ostiolate, paraphysate. *Ostiole* well-developed, broadly or narrowly conical, with a dark brown to black papilla, ostiolar canal filled with tissue of hyaline cells. *Peridium* thick, composed of large pigmented, thin-walled, scleroplectenchymatous cells of *textura angularis*. *Hamathecium* of dense, cellular broad, septate, pseudoparaphyses, embedded in mucilage. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to oblong with a furcate pedicel and ocular chamber. *Ascospores* uni-seriate

and partially overlapping, fusoid, narrowly fusoid, obovoid or oblong, brown, reddish brown or yellowish brown, septate and constricted at the septum with smooth or verruculose spore wall. Asexual states: coelomycetous (Zhang et al. 2012a), producing phialidic or annellidic conidiogenous cells.

Notes: The family *Leptosphaeriaceae* was proposed by Barr (1987a) in the order *Pleosporales* and typified by *Leptosphaeria* and separated from the *Pleosporaceae* because of its coelomycetous asexual state rather than hyphomycetous asexual morphs, as well as the ascus walls which are thinner and narrower. Initially, Barr (1987a) included *Ophiobolus*, *Leptosphaeria*, *Didymolepta*, *Heptamaeria*, and *Curreya*, but Eriksson and Yue (1990) included only *Ophiobolus* and *Leptosphaeria* in this family (Dong et al. 1998), while Zhang et al. (2012a) accepted only *Leptosphaeria* and *Neophaeosphaeria*. Combined analysis of LSU, SSU, RBP2 and TEF1 gene data have shown, members of *Leptosphaeriaceae* form a paraphyletic clade with moderate bootstrap support (Schoch et al. 2009b; Zhang et al. 2012a). Therefore based on molecular data, *Leptosphaeriaceae* is accommodated in *Pleosporineae*, which is a phylogenetically well-supported suborder of *Pleosporales* (Schoch et al. 2009b; Zhang et al. 2012a). In the same study *Ophiobolus* and *Shiraia* clustered in this family with minor support, but Zhang et al. (2012a) suggested that these genera may be more closely related to *Phaeosphaeriaceae*. *Leptosphaeriaceae* share similarities with *Phaeosphaeriaceae*, but can clearly be differentiated via the characters of the peridium, host and the asexual state. *Leptosphaeriaceae* usually occur on dicotyledons, have a peridium of scleroplectenchymatous cells, and asexual states are known as *Coniothyrium* and *Phoma* (Câmara et al. 2002; Kirk et al. 2008; Zhang et al. 2009a). *Phaeosphaeriaceae* species are generally associated with monocotyledons and the peridium comprises pseudoparenchymatous cells while asexual states are coelomycetous (Câmara et al. 2002; Kirk et al. 2008; Zhang et al. 2009a). *Coniothyrium* is considered an asexual state of *Leptosphaeria* (Muthumeenakshi et al. 2001; de Gruyter et al. 2009; Zhang et al. 2012a). de Gruyter et al. (2012) introduced another genus, *Paraleptosphaeria* in this family based on the phylogeny determined by analysis of sequence data of the large subunit 28S nrDNA (LSU) and Internal Transcribed Spacer regions 1 and 2 and 5.8S nrDNA (ITS). This genus is characterized by immersed, subglobose, solitary or aggregated, thick-walled ascum contain rather wide interascal filaments pseudoparaphyses with bitunicate, broadly ellipsoidal, 8-spored asci bearing fusiform, transversally 3–5-septate, hyaline to yellow brownish ascospores. *Paraleptosphaeria* was typified by *Paraleptosphaeria nitschkei* (Rehm ex G. Winter) Gruyter et al.

Wijayawardene et al. (2012) and Zhang et al. (2012a) listed the asexual states of *Leptosphaeriaceae* as *Camarosporium*,

Coniothyrium, *Phoma*, *Plenodomus* and *Pyrenochaeta*. Schoch et al. (2009a) phylogenetically showed that *Camarosporium quaternatum* Sacc. and *Pyrenochaeta nobilis* De Not., the types of *Camarosporium* and *Pyrenochaeta*, grouped in *Leptosphaeriaceae*. De Gruyter et al. (2009, 2010) and Aveskamp et al. (2010) showed that *Coniothyrium* and some species of *Phoma* also grouped in *Leptosphaeriaceae*. However, de Gruyter et al. (2012) restricted *Phoma* sensu stricto to *Didymellaceae* where the type *P. herbarum* is placed. In their analysis they showed that *Phoma* species grouped in four different clades with the other species moved to the new genera *Heterospora*, *Paraleptosphaeria*, *Plenodomus* and *Subplenodomus*. At the same time they moved some *Phoma* species to *Leptosphaeria*, and these species grouped in a different clade to *Leptosphaeria doliolum*, the type of *Leptosphaeria*. De Gruyter et al. (2012) also showed that *Coniothyrium palmarum* Corda, the type of *Coniothyrium*, clustered in a distinct lineage from *Leptosphaeriaceae*. Hence they reinstated the family *Coniothyriaceae* which was previously synonymized with *Leptosphaeriaceae* (Kirk et al. 2008). Therefore the accepted asexual morphs of *Leptosphaeriaceae* are presently *Camarosporium*, *Heterospora*, *Plenodomus*, and *Subplenodomus*. These all are coelomycetous genera.

Type: *Leptosphaeria* Ces. & De Not., Comm. Soc. crittog. Ital. 1(4): 234 (1863), MycoBank: MB 2800 Fig. 60

Saprobic, *hemibiotropic* or *parasitic* on stems and leaves of herbaceous or woody plants in terrestrial and aquatic habitats. Sexual state: *Ascomata* solitary, scattered or in small groups, erumpent to superficial, subglobose, broadly or narrowly conical, small- to medium-sized, smooth, easily removed from the host substrate, with a flattened base, black, coriaceous, usually with 2–4 ring-like ridges surrounding the ascomata surface, ostiolate. *Ostiole* apex with a conical, shiny, well-developed papilla, ostiolar canal filled with periphyses, dark brown to black. *Peridium* composed of two layers, outer layer composed of small thick-walled cells of *textura angularis*, surface heavily pigmented (often termed scleroplectenchyma), thinner at the apex, wide at sides, inner layer composed of subhyaline or light brown relatively thin-walled cells of *textura angularis*, cells near the base comparatively larger. *Hamathecium* of dense, long, broad, septate, and cellular pseudoparaphyses, branching and anastomosing, embedded in gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, rounded at the apex, pedicel furcate, with a large ocular chamber. *Ascospores* uni-seriate, partially overlapping, narrowly fusoid with sharp to narrowly rounded edges, reddish to yellowish brown, 3-septate, constricted at each septum with a smooth spore wall and without a sheath.

Notes: *Leptosphaeria* was introduced by Cesati and de Notaris (1863) including 26 species and *L. doliolum*

(Pers.:Fr.) Ces. & de Not. selected as the lectotype species for the genus (Shearer et al. 1990). Material used by Persoon (1800), based on collection of 12 specimens of *Sphaeria doliolum* present in National Herbarium Netherlands, Leiden University (L) was selected to lectotypify *S. doliolum* and thereby *L. doliolum* (Shearer et al. 1990). *Leptosphaeria* was initially described based on the characters of ascospore shape, being ellipsoid or fusoid and with one too many septa, and hyaline to dark brown (Crane and Shearer 1991). Saccardo (1891) amplified the genus description to include host and habitat as well as the pseudothecium and ascospore septation (Zhang et al. 2012a). Hohnel (1907) divided the genus based on centrum structure into three genera, viz. *Leptosphaeria*, *Scleropleella* and *Nodulosphaeria* (Zhang et al. 2012a). Considering ascospore characters as well as pseudothecial and centrum structure, Müller (1950) subdivided *Leptosphaeria* into four sections and this separation was modified by Munk (1957), who named these four sections as section I (*Euleptosphaeria*), section II (*Para-Leptosphaeria*), section III (*Scleropleella*) and section IV (*Nodulosphaeria*). Due to the uncertainty of the placement of this genus, several authors have included it under different families, such as, *Leptosphaeriaceae* (Barr 1987a; Eriksson and Hawksworth 1991) or *Phaeosphaeriaceae* (Eriksson and Hawksworth 1986a, b). Even though *Leptosphaeria* shares some similar morphological characters with *Amarenomyces*, *Bricookea*, *Diapleella*, *Entodesmium*, *Melanomma*, *Nodulosphaeria*, *Paraphaeosphaeria*, *Passeriniella*, *Phaeosphaeria* and *Trematosphaeria*, it differs in producing ascomata on non-woody parts of dicotyledonous hosts, in having cylindrical asci with short pedicels and smooth, fusoid multi-septate ascospores. Recent studies based on multi-gene analysis showed that *Leptosphaeria* clustered within the order *Pleosporales*, in the family *Leptosphaeriaceae*. Species of *Leptosphaeria* (including the type of *Leptosphaeriaceae*) and *Neophaeosphaeria* form a paraphyletic clade with moderate bootstrap support (Schoch et al. 2009a, b, c; Zhang et al. 2012a, b).

Type species: *Leptosphaeria doliolum* (Pers.) Ces. & De Not., Comm. Soc. Crittog. Ital. 1(4): 234, 1863, MycoBank: MB 183827

≡ *Sphaeria doliolum* Pers., 2: 39, t. 10:5–6, 1800

Other genera included

Neophaeosphaeria M.P.S. Câmara et al., in Câmara et al., Mycol. Res. 107(5): 519 (2003)

Type species: *Neophaeosphaeria filamentosa* (Ellis & Everh.) M.P.S. Câmara et al., in Câmara et al., Mycol. Res. 107(5): 519 (2003)

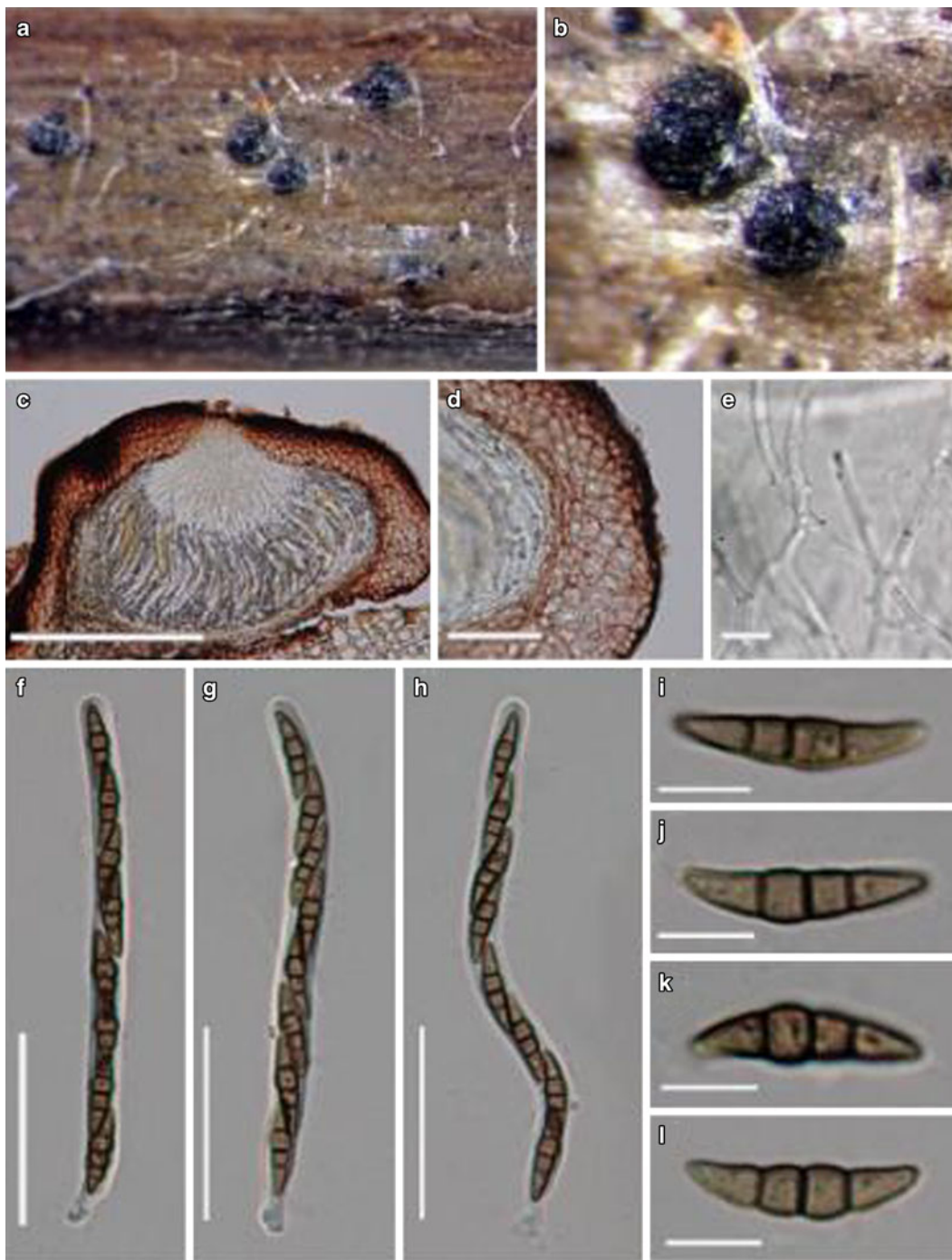


Fig. 60 *Leptosphaeria doliolum* (Material examined: Herb. Persoon, L 910270–650, **lectotype**) **a** Ascomata on host substrate. **b** Close up of ascomata. **c** Section of ascoma. **d** Close up of the peridium. **e** Pseudoparaphyses long, broad, anastomosing and branching and

embedded in gel matrix. **f–h** Asci bearing 8-spores and with short pedicel. **i–l** Ascospores with smooth walls. Scale bars: **c** = 200 μ m, **d** = 70 μ m, **e** = 10 μ m, **f–h** = 60 μ m, **i–l** = 10 μ m

Paraleptosphaeria Gruyter et al., in Gruyter et al., Stud. Mycol. 75: 20 (2012)

Type species: Paraleptosphaeria nitschkei (Rehm ex G. Winter) Gruyter et al., in Gruyter, et al., Stud. Mycol. 75: 20 (2012)

Key to sexual genera of Leptosphaeriaceae

- 1. Hamathecium of dense, long, broad, septate, and cellular pseudoparaphyses2
- 1. Hamathecium of dense interascal filaments pseudoparaphyses*Paraleptosphaeria*

2. Erumpent to superficial, subglobose, broadly or narrowly conical ascomata, with conical apex and usually shiny papilla**Leptosphaeria**
2. Immersed, depressed globose ascomata, with small ostiolar pore slightly penetrating above the surface and having a minute papilla**Neophaeosphaeria**

Key to asexual genera of *Leptosphaeriaceae*

1. Pycnidial cell wall initially pseudoparenchymatous, later scleroplectenchymatous, conidia aseptate**Plenodomus**
1. Pycnidial cell wall pseudoparenchymatous, conidia septate or aseptate2
2. Pycnidial cell wall mainly pseudoparenchymatous, conidia aseptate**Subplenodomus**
2. Pycnidial cell wall pseudoparenchymatous, conidia of two types: small aseptate and large septate**Heterospora**

Lichenotheliaceae Henssen, Syst. Ascom. 5: 137 (1986), MycoBank: MB 81652

Saprobic, loosely associated with algae or lichenicolous. *Colonizing* diverse types of rock substrates and sometimes found on lichens. Sexual state: *Thallus* endolithic or epilithic when saxicolous, episubstratic or endokapylic when lichenicolous, black, dispersed or continuous, areolate or not, rarely effigurate or frequently producing black superficial hyphae, branching or not, sometimes connecting scattered stromata; meristematic growth frequent. *Ascomata* perithecioid and with interascal filaments or fertile stromata without an ostiole and with asci forming in pseudoparenchymatous locules. *Asci* globose to broadly clavate, bitunicate, sometimes K/I+bluish around the outer layers or apex of the ascus. Interascal gel amyloid or not. *Ascospores* hyaline or brown, 8 per ascus (but often few mature), 1-septate to muriform (sometimes variable). Asexual state: *Macroconidia* black, originating from the surface of superficial hyphae, varying in shape and number of cells. *Pycnidia*, immersed in vegetative stromata, conidia hyaline, simple, rod-shaped or unknown.

Notes: The family *Lichenotheliaceae* was introduced by Henssen (in Eriksson and Hawksworth 1986a, b) for the two genera *Lichenothelia* D. Hawksw. and *Lichenostigma* Hafellner. The genus *Lichenothelia* was described by Hawksworth (1981) for two rock-colonizing species previously placed in the unrelated corticolous genus *Microthelia* Körb. Based on their ascolocular development, these two species (referred to as the *Microthelia aterrima*-group) had been previously placed in the *Dothideales* s.l. (Henssen and Jahns 1973). Hawksworth (1981) confirmed this placement in *Dothideales* s.l. based on ascus type, but suggested that *Lichenothelia* also shows affinities with the *Lecanorales* s.l. (Hawksworth 1981). The genus *Lichenostigma* was later described by Hafellner (1982) for *Lichenostigma maureri* Hafellner, a melanized lichenicolous species found on diverse

fruticose lichens. This author attributed *Lichenostigma* to the order *Arthoniales* based on ascus structure. Initially, *Lichenothelia* included only species with interascal filaments (Hawksworth 1981) whereas *Lichenostigma* was characterized by a pseudoparenchymatous hamathecium (Hafellner 1982). Henssen included both genera in the family *Lichenotheliaceae*. In the study in which she described 18 new species of *Lichenothelia* she included species with both hamathecial types in the genus, leading to an unclear separation between *Lichenothelia* and *Lichenostigma*. Several species of *Lichenothelia* described by Henssen (1987) have been suggested to belong to *Lichenostigma* (subgenus *Lichenostigma*) based on their pseudoparenchymatous hamathecium (Navarro-Rosinés and Hafellner 1996). A recent study placed some *Lichenostigma* species, including the type of the subgenus, *Lichenostigma maureri*, in the new order *Lichenostigmales* Ertz, Diederich & Lawrey in the *Arthoniales*, as well as *Lichenostigma rugosa* G. Thor in *Lichenothelia* (Ertz et al. 2013). Recent studies verified that several species of *Lichenothelia* with both hamathecial types were within the Dothideomyceta (Muggia et al. 2012; Muggia et al. in prep). Thus *Lichenostigma* is excluded from the monotypic family *Lichenotheliaceae* and the new order of *Lichenotheliales* K. Knudsen, Muggia & K.D. Hyde is introduced. Probably further species of *Lichenostigma*, included in the subgenus *Lichenostigma* Hafellner, belong to the genus *Lichenothelia*.

Type: **Lichenothelia** D. Hawksw., Lichenologist 13(2): 142 (1981), MycoBank: MB 2855

Figures 61 and 62

Possible synonym:

= *Anzia* Garov., Rev. Ist. Lomb., Milano, ser. 2 1: 558 (1868)

Thallus endolithic or epilithic, endokapylic or episubstratic, black, dispersed or continuous, areolate or not, rarely effigurate, or formed of superficial hyphae, branching or not, sometimes connecting stromata. Meristematic growth common. Sexual state: *Ascomata* perithecioid, ostiolate, with interascal filaments, the hymenial gel amyloid or not, or fertile stromata of various shapes, without an ostiole, the asci forming in pseudoparenchymatous locules, the interascal gel amyloid or not. *Asci* globose to broadly clavate, bitunicate, sometimes K/I+ bluish around the outer layers or apex of the ascus. *Ascospores* brown, 8 per ascus (but frequently few becoming mature), 1-septate to muriform (often variable), ellipsoid to subglobose, halonate or not, ornamented or not. Asexual state: *Macroconidia* black, originating from the surface of superficial hyphae, varying in shape and number of cells, common. *Pycnidia*, immersed in vegetative stromata, conidia hyaline, non-septate and rod-shaped (Henssen 1987) or unknown.

Notes: *Lichenothelia* is a cosmopolitan genus, currently comprising 25 species (MycoBank 2013),

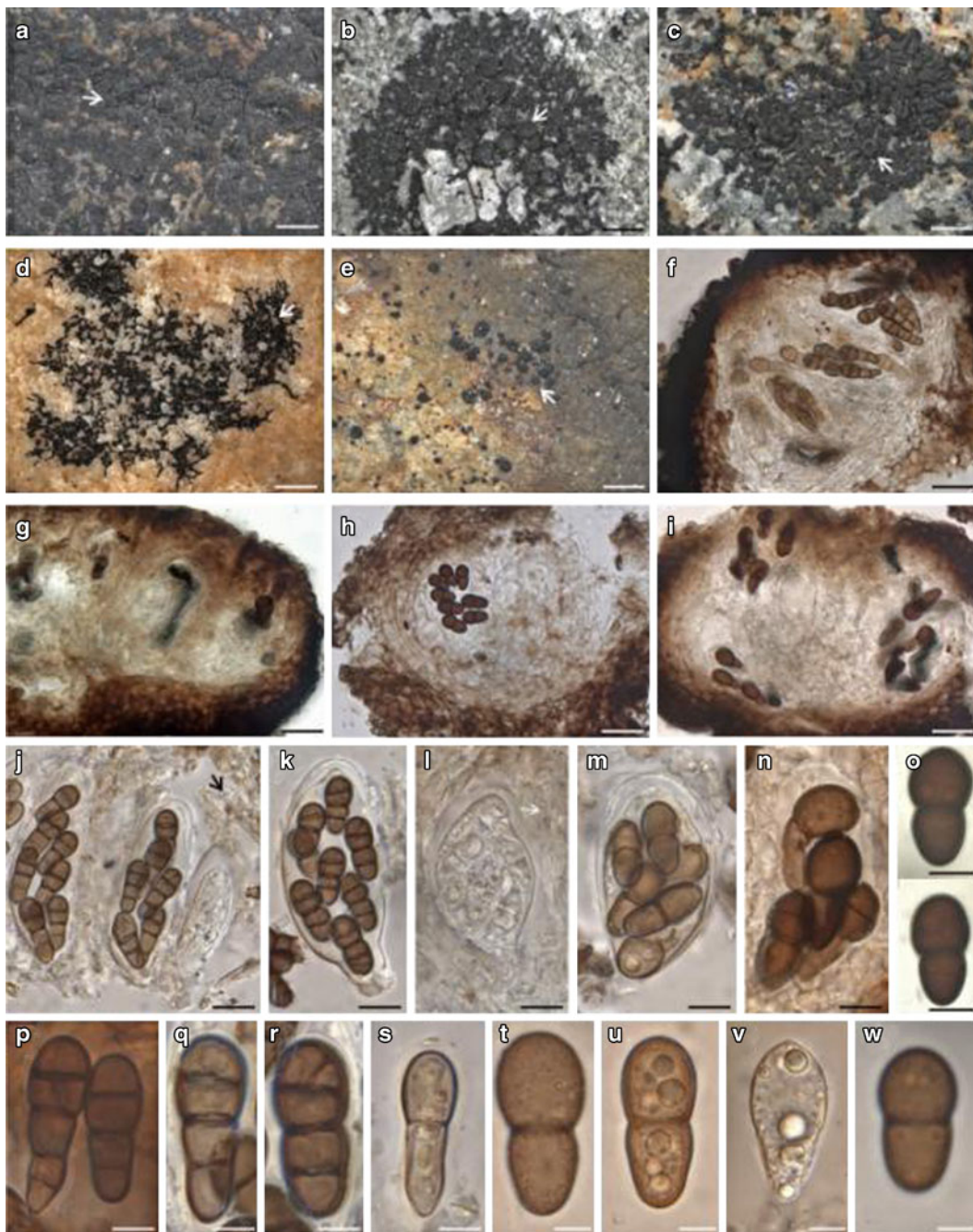


Fig. 61 Morphological and anatomical characters of *Lichenothelia* spp.: thallus of **a** *L. scopularia*. **b** *L. calcarea*. **c** *L. intermixta*. **d** *L. tenuissima*. **e** *L. convexa*; Transverse section of ascoma, with asci and spores of **f** *L. scopularia*. **g** *L. calcarea*. **h** *L. tenuissima*. **i** *L. intermixta*. **j k** Asci of *L. scopularia* containing 8 mature spores. **l, m** Asci of *L. tenuissima* containing young (**l**) and mature (**m**) ascospores. **n** Ascus of *L. intermixta* containing 8 mature ascospores; ascospores of **o** *L.*

calcarea. **p–s** *L. scopularia*. **t–v** *L. intermixta*. **w** *L. tenuissima*. Scale bars: **a–c**, **e** = 300 μ m, **d** = 1 mm, **f–i** = 20 μ m, **j–o** = 10 μ m, **p–w** = 5 μ m. Photomicrographs were prepared in water. Specimens photographed are: *Lichenothelia scopularia* Obermayer 1252 (GZU000303500); *L. calcarea* Knudsen 11749 (62127 UCR1); *L. intermixta* Knudsen 13472 (UCR-220508); *L. tenuissima* Knudsen 10406 (UCR-197485); *L. convexa* Knudsen 12452 (1304KK64)

occurring on calcareous and non-calcareous rocks, sometimes loosely associated with algae. Rock-inhabiting species are most likely saprobic. Some species are also parasitic on lichens and possibly associated with epilithic algae. *Lichenothelia convexa* Henssen occurs both on rock surfaces and is lichenicolous on a wide range of host species.

Lichenothelia rugosa (G. Thor) Ertz & Diederich was also recently discovered growing on adjacent rock surfaces as well as a common host *Diploschistes muscorum* (Scop.) R. Sant. on Catalina Island in California (Knudsen 15291.2 UCR). Two species, *L. renobalesiana* D. Hawksw. & W. Atienza on calcicolous *Verrucariaceae* and *L. spiratispora* Etayo on

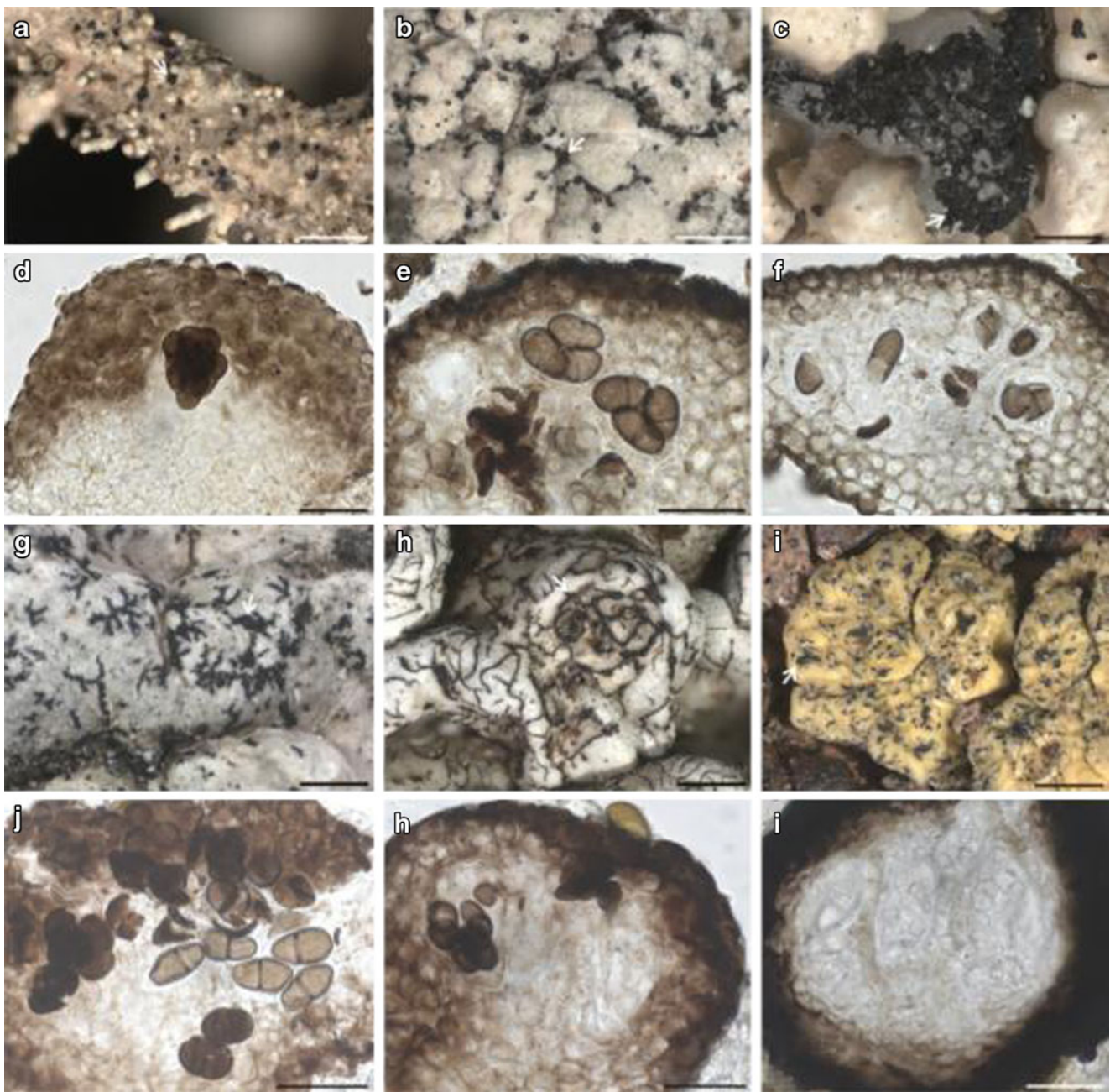


Fig. 62 Morphological and anatomical characters of *Lichenostigma* spp. and *Lichenostigma* subgen. *Lichenogramma* spp.: **a** *L. maureri*. **b** *L. rugosum*. **c** *L. epirupestre*; transversal section of ascoma of **d** *L. maureri* and **e, f** *L. epirupestre*. **g** *L. elongatum*. **h** *L. rouxii*. **i** *L. subradians*; transversal section of ascoma of **j, k** *L. elongatum* and **l** *L. subradians*. Scale bars: **a–c, g–i**=0.4 mm, **d–f, j–l**=20 μ m. Photomicrographs were prepared in water. Specimens photographed are:

Lichenostigma maureri on *Pseudevernia furfuracea* Hafellner 9886 (GZU000289898, paratype); *L. rugosum* on *Diploschistes diacapsis* Pérez-Ortega 1683; *L. epirupestre* on *Pertusaria pertusa* Pérez-Ortega 1433; *L. elongatum* on *Lobothallia radiosa* Hafellner 65534 (GZU000306021, paratype); *L. rouxii* on *Squamarina cartilaginea* Pérez-Ortega 1428; *L. subradians* on *Acarospora* sp. Hafellner 36841 (GZU000301218)

Acarospora sphaerospora H. Magn., are obligatory lichenicolous fungi.

Type: *Lichenothelia scopularia* (Nyl.) D. Hawksw., *Lichenologist* 13(2): 147 (1981). MB 112068

≡ *Verrucaria scopularia* Nyl., *Not. Sällsk. Fauna et Fl. Fenn. Förh.* 3: 85 (1861)

Other genus included

Lichenostigma Hafellner, *Herzogia* 6: 301, 1983[MycoBank: MB 2854]

Incl.: *Lichenostigma* subgen. *Lichenogramma* Nav.-Ros. & Hafellner, *Mycotaxon* 57: 219 (1996). MycoBank: MB 538839

Lichenicolous, rarely occurring also on rock surfaces adjacent to hosts. *Thallus* endokaprylic or episubstratic, formed by scattered stromata with or without networks of superficial black hyphae, branching or not, connecting stomata. Sexual state: *Stromata* black, superficial, cushion-shape to globose, paraplectenchymatous to subparaplectenchymatous, often dispersed. *Internal locules* lacking interascal filaments, the interascal space filled with round to irregular cells (pseudoparenchymatous locules), and interascal gel amyloid or not. *Asci* globose to broadly clavate, bitunicate, sometimes KI+ bluish around apex of the ocular chamber. *Ascospores* hyaline or brown, 1-septate to submuriform, ellipsoid to obovate, halonate or not, ornamented or not. Asexual state: Macroconidia, originating from the surface of superficial hyphae, black, rare. Conidiomata not observed.

Notes: *Lichenostigma* is a cosmopolitan genus of lichenicolous fungi comprised of 28 species (Mycobank 2013) occurring on a wide range of hosts. The genus is separated into two subgenera (Navarro-Rosinés and Hafellner 1996), depending on whether the ascomata are elongated and connected by superficial hyphae (subgenus *Lichenogramma*) or not (subgenus *Lichenostigma*). Two species, *L. lecanorae* Calat. & Nav.-Ros. and *L. saxicola* K. Knudsen & Kocourk., are lichenicolous, but can also occur on adjacent rock surfaces as does *Lichenothelia convexa* for instance.

Type species: *Lichenostigma maureri* Hafellner, Herzogia 6: 301 (1982). MycoBank: MB 109054 Fig. 62

Subtype species: *Lichenostigma elongatum* Nav.-Ros. & Hafellner, [as ‘*elongata*’], Mycotaxon 57: 213 (1996). MycoBank: MB 539620

Lichenconiaceae Diederich & Lawrey, **fam. nov.**, MycoBank: MB 803667

Lichenicolous. Sexual state: Unknown. Asexual state: *Conidiomata* pycnidial. *Pycnidia* dispersed or slightly aggregated, immersed to superficial, subsphaerical to ellipsoid, black, with an irregular pore-like opening. *Pycnidial wall* pseudoparenchymatic, composed of 2–4 layers of rounded to polyhedral, flattened cells, which are darker and thick-walled in outer layers and paler in inner layers, dark brown, usually becoming more olivaceous in 10 % KOH, in some species with additional pigments and typical colour reactions in KOH. *Conidiophores* absent. *Conidiogenous cells* covering the entire wall of the inner pycnidial cavity up to the pore, phialidic, often percurrently proliferating, hyaline and smooth, more rarely apically brown and verrucose, elongate ampulliform to subcylindrical. *Conidia* arising singly, mostly not catenate, in some species indistinctly catenate and adhering together in long chains, resulting in large masses of conidia covering the pycnidia, either irregularly or in mazaedium-like structures, subsphaerical, ellipsoid, obpyriform or elongate-clavate, basally indistinctly or distinctly truncate, with the basal scar variable in size, aseptate,

not visibly guttulate, surface always ornamented, varying from indistinctly verruculose to distinctly verrucose or echinulate, medium to dark brown, becoming more olivaceous in 10 % KOH.

Typus: *Lichenonium* Petr. & Syd.

Notes: As *Lichenonium* has no known sexual morphs, and as no morphologically similar genera are known, the phylogenetic position of the genus was unsettled until Lawrey et al. (2011) succeeded in culturing four species and presented a molecular phylogenetic analysis using nuLSU and mtSSU sequences. The type species was not included in this analysis, but morphologically it is so close to the other species of the genus that there is no doubt that it belongs to the same clade. The resulting phylogeny supported the monophyly of the genus *Lichenonium* and placed the genus in the Dothideomycetes. However, the genus was not supported as being closely related to any other recognized order within this class, but instead represented a novel lineage. Therefore, the description of a new family and a new order is appropriate, which is followed in this paper.

The conidiogenesis as interpreted by Hawksworth (1977) is unusual as conidiogenous cells appear to be phialidic, but at the same time often show percurrent proliferations and thus tend to be annellidic. No ultrastructural studies of the conidiogenesis have yet been done.

The family includes one genus and 15 species, all lichenicolous.

Type: *Lichenonium* Petr. & Syd., Beih. Reprint nov. Spec. Regni veg. 42(1): 432 (1927), MycoBank: MB8772 Fig. 63

Notes: All known species of *Lichenonium* are lichenicolous. Some are host-specific, such as the type species (on *Physcia*) or *L. aeruginosum* Diederich et al. (on *Cladonia*), whilst others occur on different non-related host genera. *L. erodens* M.S. Christ. & D. Hawksw. appears to be a virulent parasite, often invading lichen thalli previously weakened by the action of other lichenicolous fungi. An identification key to all known species (except the recently described *L. aeruginosum*, see Lawrey et al. 2011) was published by Cole and Hawksworth (2004).

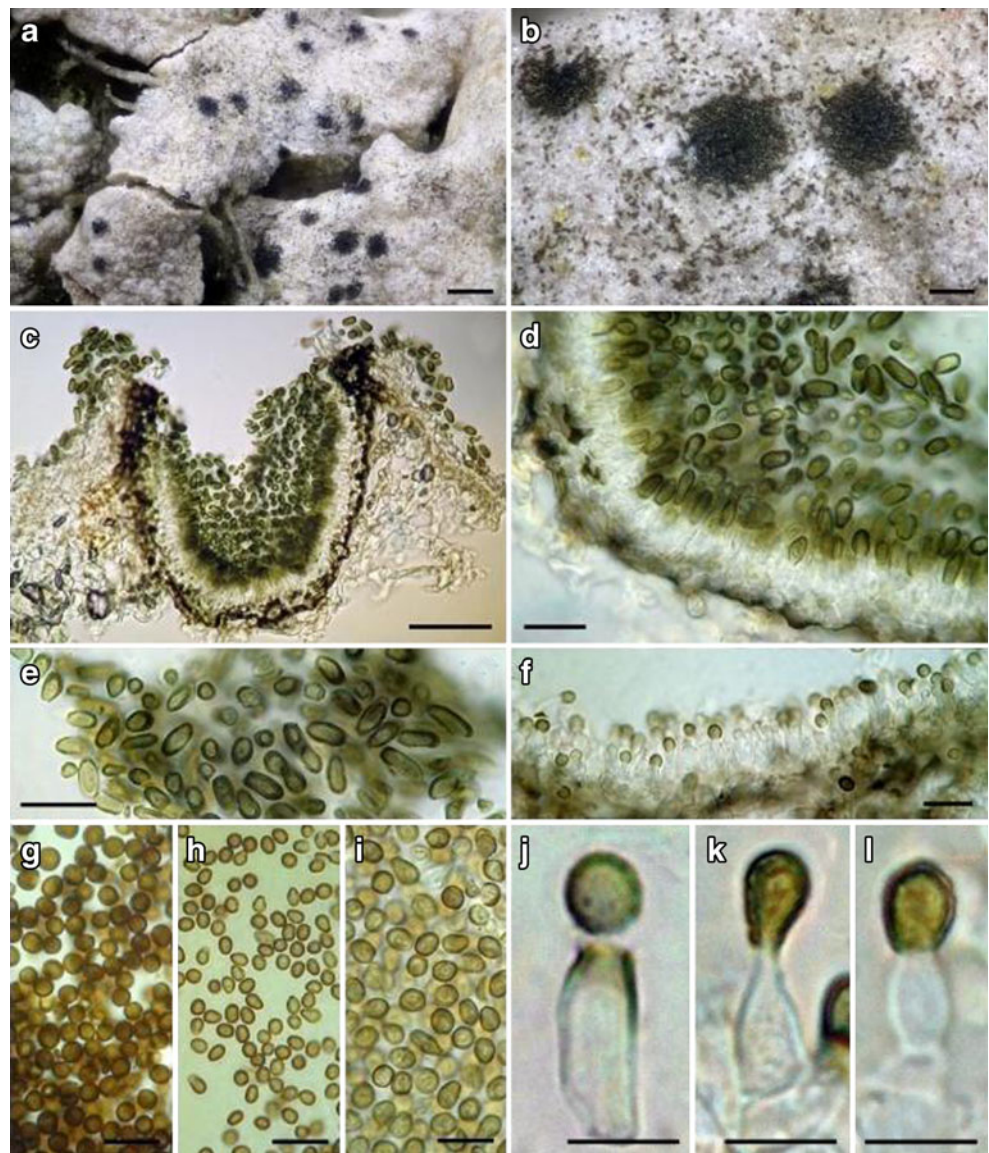
Type species: *Lichenonium lichenicola* (P. Karst.) Petr. & Syd. [as ‘*lichenicolum*’], Beih. Reprint nov. Spec. Regni veg. 42(1): 432 (1927) [1926], MycoBank: MB 269089

Note: The epithet of this species is often given as ‘*lichenicola*’. However, although compound words ending in ‘-cola’ are often treated as a noun and thus invariable, Karsten (1887) chose the epithet ‘*lichenicolum*’ to be an adjective, and thus an adjective ending is required in this name.

Lindgomycetaceae K. Hiray. et al., Mycologia 102: 732–3 (2010), MycoBank: MB 515187

Saprobic on submerged wood. Sexual state: *Ascomata* scattered to crowded, subglobose to globose, membranous,

Fig. 63 Morphological features of *Lichenoconium* spp. a–e *Lichenoconium lichenicolum* (Belgium, West-Vlaanderen, De Panne, 2008, Diederich 16728). **a** Black pycnidia on thallus of *Physcia adscendens*. **b** Pycnidia covered and surrounded by numerous, dark brown, ellipsoid conidia. **c** Section through pycnidium. **d** Same at higher magnification showing thin, dark brown pycnidial wall, hyaline layer of conidiogenous cells and olivaceous brown conidia. **e** Verrucose conidia. **f** *L. usneae* (France, Meuse, Damvillers, on *Ramalina fastigiata*, 1980, Diederich 2981), layer of conidiogenous cells. **g** *L. usneae* (Luxembourg, Pétange, on *Cladonia rei*, 2010, Diederich 16958), conidia. **h** *L. pyxidata* (Belgium, Luxembourg, Lischert, on *Cladonia fimbriata*, 2001, Diederich 15130), conidia. **i** *L. aeruginosum* (Netherlands, Zuid-Holland, Noordwijk, on *Cladonia pyxidata*, 1975, Brand 5546b), conidia. **j** *L. aeruginosum* (Netherlands, Limburg, Bemelen, on *C. pyxidata*, 2000, van den Boom 24752), conidiogenous cell. **k**, **l** *L. lecanorae* (Netherlands, Zeeland, Hoofdplaat, on *Lecanora*, 2009, Diederich 16891), conidiogenous cells. Scale bars: **a** = 200 μ m, **b–c** = 50 μ m, **d–i** = 10 μ m, **j–l** = 5 μ m



ostiolate, papillate. *Peridium* of hyaline to pale brown, small, thin-walled cells. *Hamathecium* of filamentous, numerous, septate, branched, anastomosing pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to clavate, rounded at the apex, pedicellate, with an ocular chamber. *Ascospores* fusiform to cylindrical, uni- to multi-septate, hyaline to brown, usually covered with an entire sheath and/or bipolar mucilaginous appendages. Asexual state: Unknown.

Notes: Hirayama et al. (2010) used molecular sequence data to establish the family *Lindgomycetaceae* based on *Lindgomyces ingoldianus* K. Hiray. et al. (\equiv *Massarina ingoldiana* Shearer & K.D. Hyde), a freshwater member of the Dothideomycetes similar to *Massarina eburnea* (Tul. & C. Tul.) Sacc., the type of *Massarina*. The molecular analyses, which included sequences for both *M. eburnea* and *L. ingoldianus*, revealed that the two species were distantly related in a phylogenetic tree based on a wide range of

Dothideomycete genera. Molecular phylogenetic studies using ribosomal sequence data from different lineages of Dothideomycetes belonging to freshwater, marine and terrestrial bitunicate fungi also showed that *Lindgomycetaceae* was a unique lineage among the Dothideomycetes and did not share phylogenetic affinities with *Massarina* sensu stricto (Shearer et al. 2009; Schoch et al. 2009a, b).

In addition to *Lindgomyces* species, the *Lindgomycetaceae* also includes *Massariosphaeria typhicola* (P. Karst.) Leucht. (strain KT 667, KT 797) (Hirayama et al. 2010). More recently, a new freshwater coelomycete, *Lolia aquatica* Abdel-Aziz & Abdel-Wahab (Abdel-Aziz and Abdel-Wahab 2010) was described and reported from decayed submerged *Phragmites australis* (Cav.) Steud. stems in Egypt. Phylogenetic analysis of partial LSU sequences showed that it had affinities to the family *Lindgomycetaceae* (Abdel-Aziz and Abdel-Wahab 2010).

Type: Lindgomyces K. Hiray. et al., in Hirayama et al., *Mycologia* 102(3): 733 (2010), MycoBank: MB515188 Fig. 64

Saprobic on submerged wood in freshwater. Sexual state: *Ascomata* scattered to clustered, brown, subglobose to globose, erumpent, membranous, ostiolate, short-papillate. *Peridium* composed of hyaline to pale brown, small, thin-walled cells. *Hamathecium* of filamentous, numerous, septate, branching, anastomosing pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical-clavate, with short, knob-like pedicel,

rounded at the apex, with an ocular chamber. *Ascospores* 2–3- overlapping seriate, fusiform to cylindrical, with a median primary septum, hyaline, becoming brown and 3(–5)-septate when senescent, usually covered with a sheath or bearing bipolar mucilaginous appendages. Asexual state: Unknown.

Notes: The overall morphology of *L. ingoldianus* is similar to that of *M. eburnea* in that both have pseudothecia of pseudoparenchyma, septate pseudoparaphyses, and one septate, hyaline ascospores, tardily becoming 3–5-septate and darkened, and surrounded by a gelatinous sheath (Shearer



Fig. 64 *Lindgomyces ingoldianus* (Material examined: a, c, d, f, h = ILLS 52289, holotype; b, e, j = KH100, g, i, k = ATCC 200398). a Ascomata on host surface. b, d Ascoma in longitudinal section. c

Peridium. e Ascus apex. f Ascus. g, h Ascospores. i–k Ascospore with a sheath (in India ink). Scale bars a = 125 μm , b, d = 50 μm ; c, e = 20 μm ; f = 30 μm ; g–h = 10 μm ; i–k = 50 μm

and Hyde 1997). One difference between the two taxa is that *L. ingoldianus* lacks the well-developed clypeus-stroma (sensu Munk 1957) found in *M. eburnea*, and the ascospore sheath in *L. ingoldianus* is extremely large compared to the ascospore sheath of *M. eburnea*. In addition, *L. ingoldianus* has been found only in aquatic habitats thus far, while *M. eburnea* is hemibiotrophic on *Fagus* spp. in terrestrial habitats. Currently seven species of *Lindgomyces* have been described and they were all collected from freshwater habitats (Shearer and Hyde 1997; Hirayama et al. 2010; Raja et al. 2011, 2013a; Zhang et al. in press).

Type species: Lindgomyces ingoldianus (Shearer & K.D. Hyde) K. Hirayama et al., in Hirayama et al., Mycologia 102(3): 733 (2010), MycoBank 515189

≡ *Massarina ingoldiana* Shearer & K.D. Hyde, Mycologia 89(1): 114 (1997)

Other genera included

Lolia Abdel-Aziz & Abdel-Wahab, Mycotaxon 114: 36 (2011)

Type species: Lolia aquatica Abdel-Aziz & Abdel-Wahab, Mycotaxon 114: 36 (2011)

Clohesyomyces K.D. Hyde, Aust. Syst. Bot. 6(2): 170 (1993)

Type species: Clohesyomyces aquaticus Zhang et al., Cryptogamie Mycologie 33: 333–346 (2012)

Lophiostomataceae Sacc. [as ‘*Lophiostomaceae*’], Syll fung (Abellini) 2: 672 (1883), MycoBank: MB 80966

Saprobic on herbaceous and woody substrates in terrestrial and aquatic environments. Sexual state: *Ascomata* scattered to gregarious, superficial or semi-immersed to densely erumpent, carbonaceous, dark brown to black, globose to subglobose. *Ostiole* slit-like, with a small to large, flat, crest-like apex, which is variable in shape and composed of pseudoparenchymatous cells. *Peridium* thick at the sides, broad at the apex and thinner at the base, one-layered, composed of small, lightly pigmented, thin-walled cells of *textura prismatica*. *Hamathecium* of septate, long, hyaline, anastomosing and branched, cellular pseudoparaphyses, embedded in gel matrix between and above the asci. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to clavate, with furcate pedicel, rounded at the apex with minute ocular chamber. *Ascospores* uni-seriate or partially bi-seriate, narrowly fusiform with acute ends, 3–5-septate and slightly constricted at each septum, or muriform, with a distinct oil drop in each cell, with a smooth spore wall, with terminal appendages, while senescent ascospores become hyaline to pale brown. Asexual state: *Mycelium* septate, smooth to roughened, or verrucose, yellowish brown, to reddish brown. *Pycnidia* scattered or semi-immersed, uni-loculate or rarely bi-loculate, subglobose, reddish brown, comprising dark reddish brown cells. *Ostiole* circular, surrounded by a thick-walled, well-developed neck, surrounded

by flexuous hyphae and an ostiolar canal filled with a tissue of hyaline cells. *Conidiophores* reduced to conidiogenous cells arising within the acervuli, cylindrical, septate and branched at the base, hyaline. *Conidiogenous cells* cylindrical, smooth, phialidic, formed at the end and on the sides, hyaline. *Conidia* cylindrical, aseptate, hyaline (Padhye et al. 1997)

Notes: Based on the formation of a slit-like ostiolar opening on a laterally compressed papilla, Nitschke (1869) (from Mugambi and Huhndorf 2009a, b), introduced the new family *Lophiostomataceae*. The ostiolar opening on a laterally compressed papilla was used as the characteristic feature for the family and the crest-like neck was considered as an evolutionary adaptation to the harsh conditions of long periods of dryness (Zhang et al. 2012a, b). The *Lophiostomataceae* were designated as a separate family in the order *Pleosporales* by Saccardo (1883). Taxa with laterally compressed apices have been included in this family by Chesters and Bell (1970), including *Lophiostoma*, and *Platystomum*, but due to the variation observed in the formation of the papilla, Holm and Holm (1988) came up with a broad concept where they included taxa with laterally compressed and rounded apices (*Lophiostoma*, *Lophiotrema*, *Massariosphaeria*, *Navicella* and *Trematosphaeria*) in this family (Mugambi and Huhndorf 2009a). Barr (1987a) combined the *Lophiostomataceae* and *Massarinaceae* as a single family after placing melanommataceous elements in a separate group that included *Dangeardiella*, *Herpotrichia*, *Massarina*, *Lophiostoma*, *Lophidiopsis*, *Trichometasphaeria*, and *Cilioplea* in the combined family. A combined gene analysis of LSU and SSU sequence data separated the *Lophiostomataceae* and *Massarinaceae* into different clades (Zhang et al. 2009a, b; Hirayama and Tanaka 2011). Mugambi and Huhndorf (2009a) included *Misturatosphaeria* in *Lophiostomataceae* due to the strong support the clade received in their combined gene analysis of LSU and TEF gene data. A similar result is observed in this study (Fig. 1), where *Misturatosphaeria* forms a strongly supported sister group to *Lophiostoma* and clustered within *Lophiostomataceae*. Therefore we refer *Misturatosphaeria* to *Lophiostomataceae*. *Platystomum* shares many characters with *Lophiostoma*, except that *Platystomum* has muriform ascospores. Consequentially, Holm and Holm (1988) treated *Platystomum* as a synonym of *Lophiostoma*, but Barr (1990c) placed *Platystomum* in *Melanommatales* based on the trabeculate hamathecium. This concept was accepted by Abdel-Wahab and Jones (2000), Hirayama and Tanaka (2011) and Tanaka and Harada (2003a). For this study we have accepted three genera for *Lophiostomataceae* i.e. *Lophiostoma*, *Misturatosphaeria* and *Tumularia*. Species are generally distributed in temperate regions as saprobes or necrotrophs on herbaceous and woody stems (Hirayama and Tanaka 2011; Zhang et al. 2012a, b)

Type: Lophiostoma Ces. & De Not., Comm. Soc crittog Ital 1(4): 219 (1863),

Mycobank: MB 2933 Fig. 65

Saprobic on herbaceous and woody substrates in terrestrial and aquatic environments. Sexual state: *Ascomata* scattered to gregarious, semi-immersed to densely erumpent, carbonaceous, dark brown to black, globose to subglobose. *Ostiole* slit-like with a small to large flat crest-like apex, which is variable in shape,

and apex composed of pseudoparenchymatous cells. *Peridium* thick at the sides, broad at the apex and thinner at the base, one-layered, composed of small lightly pigmented thin-walled cells of *textura prismatica*. *Hamathecium* of septate, long, hyaline, anastomosing and branched, cellular pseudoparaphyses, embedded in gelatinous matrix between and above the asci. *Asci* 8

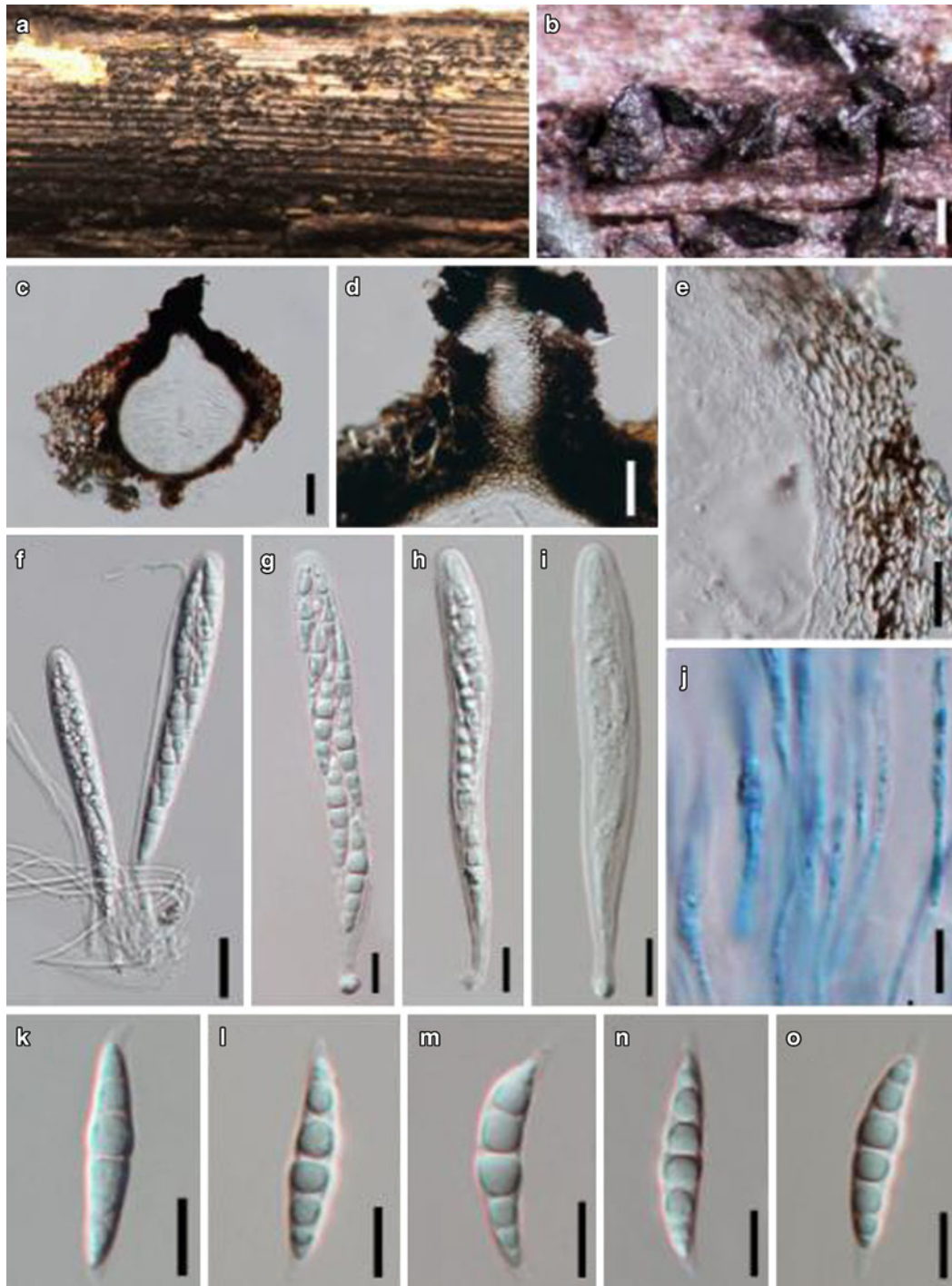


Fig. 65 *Lophiostoma macrostomum* (Material examined: FRANCE, Ariège, Rimont, Las Muros, on dead stems of *Vitis vinifera*, 2 September 1996, IFRD2005, **epitype**). **a, b** Ascomata on host surface. **c–e** Hand

section of ascomata, note ostiole with a small to large, flat, crest-like apex. **f–i** Asci with ascospores. **j** Hamathecium. **k–o** Ascospores. Scale bars: **c**=500 μm , **d**=100 μm , **e–f**=50 μm , **g–p**=10 μm

spored, bitunicate, fissitunicate, cylindrical to clavate, with furcate pedicel, rounded at the apex with a minute ocular chamber. *Ascospores* uniseriate or partially biseriate, narrowly fusiform with acute ends, 3–5-septate and slightly constricted at each septum, with a distinct oil drop in each cell, smooth-walled, with terminal appendages, senescent ascospores becoming hyaline to pale brown. Asexual state: *Mycelium* septate, walls smooth to rough or verrucose, comprising yellowish-brown to reddish-brown hyphae. *Pycnidia* scattered or semi-immersed, uniloculate or rarely biloculate, subglobose, reddish-brown, comprising dark reddish brown cells. *Ostiole* circular, surrounded by a thick-walled, well-developed neck, surrounded by flexuous hyphae and an ostiolar canal filled with a tissue of hyaline cells. *Conidiophores* reduced to conidiogenous cells arising within the acervuli, cylindrical, septate and branched at the base, hyaline. *Conidiogenous cells* cylindrical, smooth, phialidic, formed at the apex and on the sides, hyaline. *Conidia* cylindrical, aseptate, hyaline (Padhye et al. 1997).

Notes: *Lophiostoma* was formally established by Cesati and De Notaris (1863) and typified by *L. macrostomum* (Tanaka and Harada 2003a), and characterized by ascomata with laterally compressed- or crest-like apices (Zhang et al. 2009a, b). *Lophiostoma* is morphologically a well-studied genus (Zhang et al. 2009a, b), and as a result of several reviews, few species are now accommodated in the genus (Hyde et al. 2000; Tanaka and Harada 2003a). Combined gene analysis of LSU and SSU sequence data showed *Lophiostoma* to be polyphyletic, grouping into two well-supported monophyletic clades (Zhang et al. 2009a, b, c; Suetrong et al. 2009). Currently the genus comprises an estimated 30 species (Index Fungorum 2013) with more than 250 hits in GenBank. Molecular studies with carefully selected taxa are needed to resolve the characters, genera and species that should be placed in this family.

Type species: ***Lophiostoma macrostomum*** (Tode, Fungi mecklenberg. sel. (Lüneburg) 2: 12 (1791) Ces. & De Not., Commun Soc Critt Ital 1: 219, 1863, MycoBank: MB 149287 ≡ *Sphaeria macrostoma* Tode: Fr., Syst Mycol 2: 469, 1823

Other genera included

Misturatosphaeria Mugambi & Huhndorf, in Schoch et al., Stud. Mycol. 64: 108 (2009)

Type species: ***Misturatosphaeria aurantiacinotata*** Mugambi & Huhndorf [as '*Misturatosphaeria aurantonotata*'], Stud. Mycol. 64: 108 (2009)

Tumularia Descals & Marvanová, in Marvanová & Descals, Trans. Br. mycol. Soc. 89(4): 506 (1987)

Type species: ***Tumularia tuberculata*** (J. Gönczöl) Descals & Marvanová, in Marvanová & Descals, Trans. Br. mycol. Soc. 89(4): 506 (1987)

Key to sexual genera of *Lophiostomataceae*

1. Ascospores 3–5-septate, with terminal appendages ***Lophiostoma***

1. Ascospores muriform, without terminal appendages ***Misturatosphaeria***

Lophiotremataceae K. Hiray. & Kaz. Tanaka, Mycoscience 52(6): 405 (2011), MycoBank: MB 561063

Saprobic on woody and herbaceous substrates in terrestrial habitats. Sexual state: *Ascomata* subglobose to globose, scattered to crowded, opening compressed, with a slit-like ostiole. *Exciple* composed of pale brown, small, thin-walled cells of *textura angularis* to *globosa*. *Hamathecium* of filamentous, numerous, septate, branched, anastomosing trabeculate pseudoparaphyses. *Asci* 8-spored, fissitunicate, cylindrical, with a short pedicel or sessile, rounded at the apex, with an ocular chamber. *Ascospores* uni- to bi-seriate, fusiform to cylindrical, hyaline to brown, 1- to multi-septate, with or without an entire gelatinous sheath. Asexual state: "Pleurophomopsis"-like. *Conidiomata* pycnidial, globose, ostiolate. *Conidiogenous cells* phialidic. *Conidia* globose to cylindrical, hyaline, smooth, 1-celled.

Notes: The *Lophiotremataceae* are a monotypic family, which is represented by *Lophiotrema* (Hirayama and Tanaka 2011). The family *Lophiotremataceae* was introduced by Hirayama and Tanaka (2011) for lophiostomatoid taxa distinguished from *Lophiostoma* (*Lophiostomataceae*) by the smaller ascomata (<200 μm vs. 200–700 μm), thinner peridium (25 μm vs. ca 50 μm), exiple tissue type (*textura angularis* to *globosa* in *Lophiotremataceae* vs. of parallel, long, prismatic cells in *Lophiostoma*), ascus shape (cylindrical vs. clavate), ascospore colour (hyaline vs. pigmented), ascospore septation (mostly 1-septate vs. 1- to several septate), and ascospore appendage (without a gelatinous sheath vs. with or without appendages). *Lophiotremataceae* forms a well-supported monophyletic group on the dendrogram (Zhang et al. 2009b; Hirayama and Tanaka 2011).

Type species: ***Lophiotrema*** Sacc., Michelia 1(no. 3): 338 (1878), MycoBank: MB 2934

Figure 66

Notes: Species in *Lophiotrema* occur on various plant substrates as saprobes in terrestrial environment. For example, *L. nucula* (Fr.) Sacc., *L. brunneosporum* Yin. Zhang et al. and *L. lignicola* Yin. Zhang et al. are reported from woody plants (Zhang et al. 2009b), *L. neohysterioides* M.E. Barr and *L. vagabunda* (Sacc.) Sacc. are usually found on herbaceous plants (Tanaka and Harada 2003b) and *L. neoarundinaria* (Ellis & Everh.) Yin. Zhang et al. (*Massarina arundinariae*) is bambusicolous (Tanaka and Harada 2003c). *Lophiotrema rubi* (Fuckel) Yin. Zhang et al. is sometimes recorded from freshwater (as *Massarina rubi*; Fallah and Shearer 2001).

Knowledge of the cultural characteristics of *Lophiotrema* species is still incomplete. Several species are reported as homothallic (e.g., *L. neohysterioides*, *L. neoarundinaria*, *L. vagabunda*; Tanaka and Harada 2003b, c). "Pleurophomopsis" has been linked to the conidial state for *L. nucula*, the type species of this genus (Leuchtman 1985b), but this is probably a spermatial state.

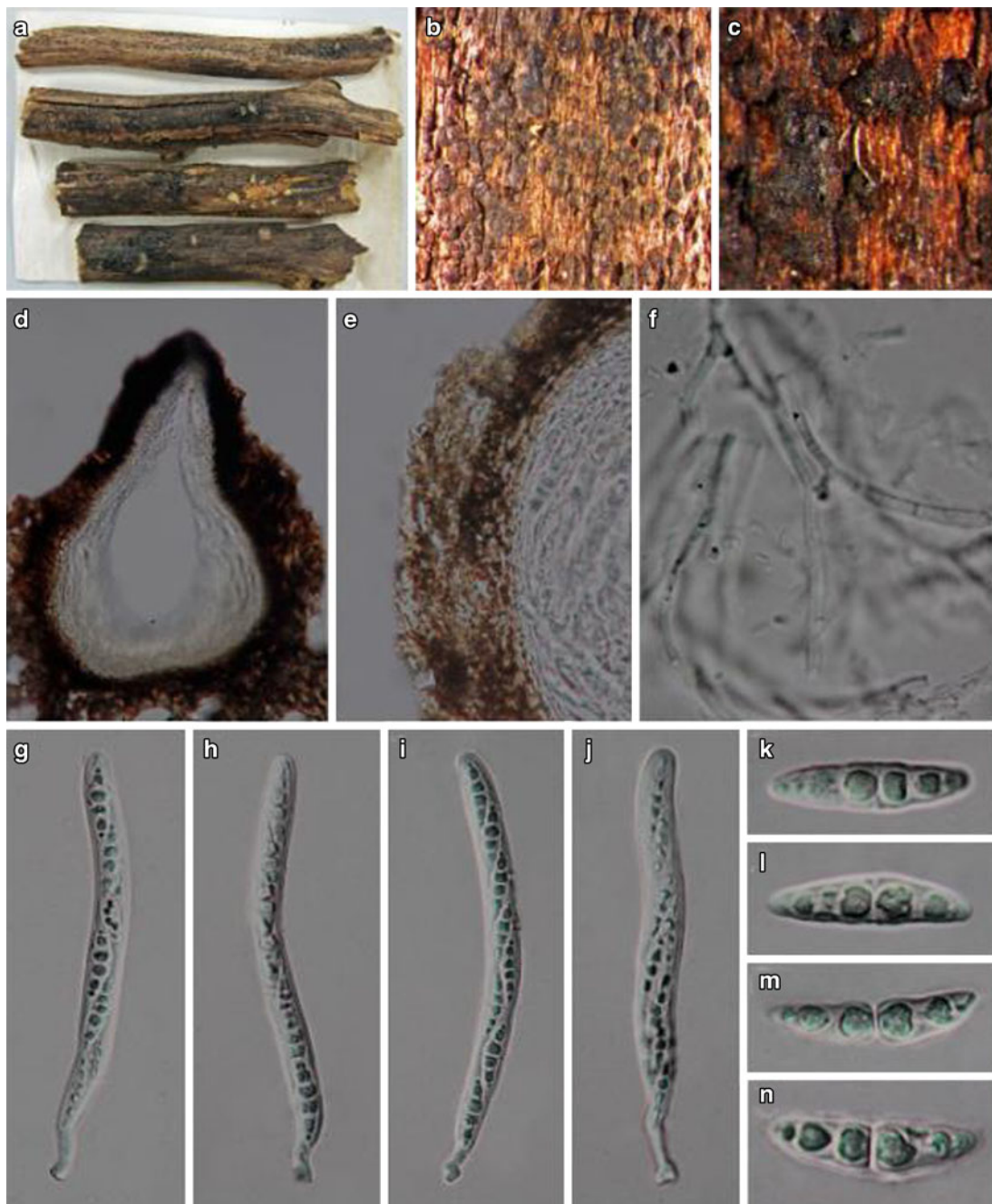


Fig. 66 *Lophiotrema nucula* (Material examined: GERMANY, Schwaben (Bayern), Krumbad, July 1876, Britzelmayer, S: 7300, original material of *Trematosphaeria corticivora* Rehm). **a–b** Ascomata on host substrate. **c** Close up of ascomata. **d** Section of ascocata. **e** Close up of

the peridium. **f** Filamentous, septate, branched, anastomosing pseudoparaphyses. **g–j** Asci with short, broad pedicel, bearing 8 ascospores. **k–n** Smooth-walled, immature and mature ascospores, without a sheath. Scale bars: **d** = 500 μm , **e–f** = 30 μm , **g–j** = 10 μm , **k–n** = 5 μm

As noted by Hirayama and Tanaka (2011), the ascus shape and stipe length can serve to differentiate between *Lophiostoma* (*Lophiostomataceae*) and *Lophiotrema* (*Lophiotremataceae*). This is noticeable feature that merits more attention in dothideonycetes.

Type species: Lophiotrema nucula (Fr.) Sacc., *Fungi Ital. Delin. (Pataxii)*: no. 249 (1878)

≡ *Sphaeria nucula* Fr., *Syst. mycol. (Lundae)* 2(2): 466 (1823)

Manglicolaceae Suetrong & E.B.G. Jones, *Fungal Divers.* 51: 183 (2011), MycoBank MB 563225

Saprobic on intertidal mangrove wood and *Nypa fruticans* in the tropics. Sexual state: *Ascomata* solitary, superficial, seated in the substrate with a hypostroma, obtuse clavate to fusiform, coriaceous, olive-brown, stipitate, ostiolate, epapillate, periphysate. *Peridium* thick, composed of 3–5 layers, inner layers hyaline outer layers pale brown to olive-

brown, cells of *textura angularis*. *Hamathecium* comprising numerous, simple, septate, trabeculate pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, with a short pedicel, thick-walled, with an ocular chamber, asci developing at the base of the ascocarp venter between the pseudoparaphyses. *Ascospores* uni-seriate, fusiform, apiculate, 1-septate; apical cell larger, dark brown; basal cell small, light brown; deliquescing appendages cover both ends. Asexual state: Unknown.

Notes: The family *Manglicolaceae* was introduced by Suetrong et al. (2011a) for a marine ascomycete with large, coriaceous ascomata, lacking a papilla, and with trabeculate pseudoparaphyses, cylindrical asci and ascospores, with a large apical cell, and a basal turbinate cell with gelatinous appendages at each end. The introduction of the family *Manglicolaceae* is strongly supported (100/100 support) by phylogenetic analysis of two nuclear genes (SSU and LSU) and also based on its unique morphology and the family is related to the *Aliquandostipitaceae*, *Jahnulales* (Suetrong et al. 2010, 2011a) (Fig. 1). The family shares a number of features with *Aliquandostipitaceae*: ascomata with short stalks, cylindrical asci, appendaged ascospores, wide hyphae (ca. 40 μm wide), and all are saprobic species in aquatic habitats. However, they differ in that *Manglicolaceae* ascomata are large (835–1,275 \times 185–387 μm), with a wide ostiole, surrounded by hyaline, clavate hyphae and periphysate ostioles, and have large, unequally, 1-septate ascospores, that are pale brown, with a turbinate basal cell, with few asci per ascoma, and also differ by their marine mangrove habitat. The family comprises a monotypic genus *Manglicola* found on mangrove substrata. No ex-holotype culture was available for study, but the type species (*Manglicola guatemalensis*) has been repeatedly collected in Thailand with over 30 strains isolated and deposited in the BCC culture collection (Suetrong et al. 2010).

Huhndorf (1994) referred *Manglicola* to the *Hypsostromataceae*, a family with no previously known relationship to any group in the *Dothideomycetes*, but “probably with affinities to the *Melanommatales*” (Mugambi and Huhndorf 2009a). Characteristics that unite *Manglicola* and the *Hypsostromataceae* include superficial, large, elongate ascomata (stalked) with a soft texture, trabeculate pseudoparaphyses, long pedicellate asci attached in a basal arrangement in the centrum and fusiform, and septate ascospores (Huhndorf 1994). Our dataset places *Hypsostroma saxicola* and *H. caimitalense* (*Hypsostromataceae*) in the *Pleosporales* with high bootstrap support (Fig. 1).

Type: *Manglicola* Kohlm. & E. Kohlm., Mycologia 63(4): 840 (1971), MycoBank: MB 2995 Fig. 67

Notes: The type species, *Manglicola guatemalensis*, was collected from dead roots of *Rhizophora mangle* in Guatemala (Kohlmeyer and Kohlmeyer 1971). Subsequently collections were made on intertidal prop roots of *Rhizophora apiculata* at

Kampong Danay, Brunei (Hyde 1988). Kohlmeyer and Kohlmeyer (1971) noted a close relationship of *M. guatemalensis* and the *Pleosporales* or *Venturiaceae*, while Huhndorf (1992) classified it in the *Hypsostromataceae*, order *incertae sedis*. A second species, *M. samuelsii* Huhndorf, was described by Huhndorf (1994) from dead culms of bamboo collected in Guyana. Both species have large, soft-textured, elongate ascomata that extend conspicuously above the substratum, a pseudoparenchymatous ascomatal wall, trabeculate pseudoparaphyses, cylindrical asci and septate, brown ascospores with paler end cells. *Manglicola guatemalensis* differs from *M. samuelsii* in a number of respects: host and habitat, number of asci per ascomata and degree of ascospore septation. *Manglicola guatemalensis* is marine, asci are few and ascospores are 1-septate, while *M. samuelsii* is terrestrial, found on bamboo in lowland rainforest and has numerous asci and 3-septate ascospores. No ex-holotype culture or isolates of *M. samuelsii* are available for molecular study. Although *M. guatemalensis* does not belong in the *Hypsostromataceae*, the taxonomic position of *M. samuelsii* remains unresolved until further collections are made and sequenced.

Type species: *Manglicola guatemalensis* Kohlm. & E. Kohlm., Mycologia 63: 840 (1971), MycoBank MB 317316

Massariaceae Nitschke, Verh. naturh. Ver. preuss. Rheinl. 26: 73 (1869), MycoBank: MB 80978

Sexual state: *Ascomata* (pseudothecia) relatively large (0.4–1.5 mm diam), scattered or clustered, globose, subglobose, pyriform to strongly depressed, immersed in bark and occasionally the outermost wood layer, typically in pseudostromatic tissues intermixed with substrate cells, often with blackened zones, and often clypeate, and ostiolate. *Ostioles* central or eccentric, short or long, solitary or converging in groups, projecting through the bark, stout papillate, at times surmounted by peaks of stromatic tissues that form coarsely sulcate tips above the bark surface. *Peridium* relatively wide, firm, opaque, composed of numerous rows of thin-walled, compressed angular cells, darkly pigmented externally, paler inwards. *Hamathecium* of numerous persistent, indistinctly septate, branching and anastomosing pseudoparaphyses, 1 (1.5 when fresh) μm wide in the upper part, up to 4 μm wide in lower and peripheral regions of the ascoma, in a gelatinous matrix. *Asci* 4–8-spored, bitunicate, fissitunicate, basal and peripheral, oblong, cylindrical or fusoid, less commonly saccate, pedicellate, apically with wide ocular chamber and refractive ring. *Ascospores* 2–3-seriate, relatively large, oblong, cylindrical, ellipsoidal or fusoid, rounded or tapered to subacute ends, hyaline or light to dark brown, always brown at maturity (after ejection), straight or slightly inequilateral, symmetric, biconoid and symmetrically 1-euseptate in early states, becoming 3-disto- and euseptate, not or slightly constricted at the septa, secondary septa usually closer to primary septum than to ends of ascospore; wall thick,

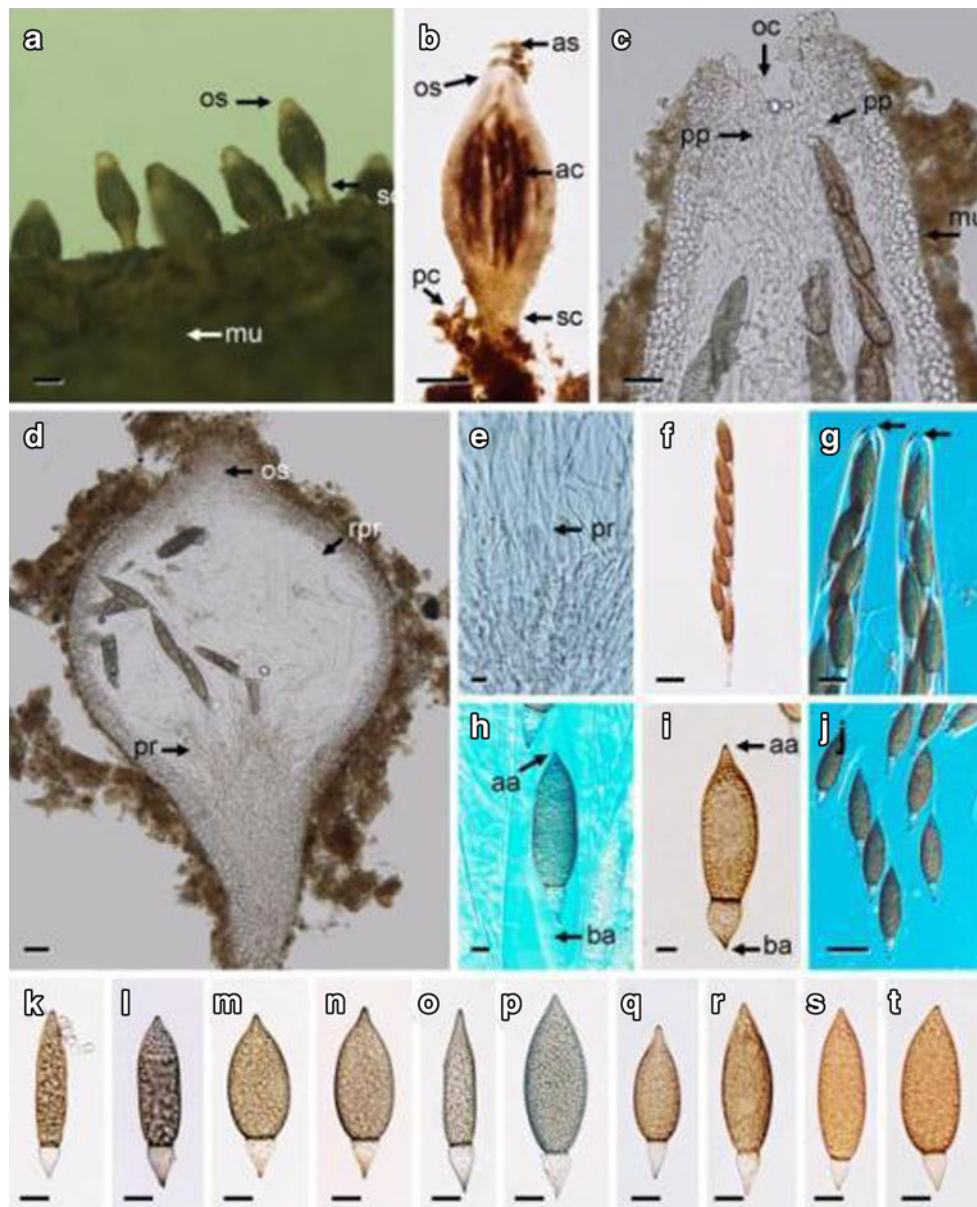


Fig. 67 *Manglicola guatemalensis* (Material examined: THAILAND, Trat Province: Mu Ko Chang National Park, Ban Salak Phet, on base frond of *Nypa fruticans*, 5 October 2005, S Suetrong et al. (BBH 23409 with BCC 24217, 20079, 21218); THAILAND, Trang Province: Ban Bang Sak, on base frond of *Nypa fruticans*, 14 November 2005, E.B.G. Jones et al.; THAILAND, Trat Province: Mu Ko Chang National Park, Ban Salak Phet, on base frond of *Nypa fruticans*, 14 December 2006, S Suetrong et al. (BBH 17801 with BCC 24275, 24296–24298, 24200–24203, 24299–24302, 24204, 25032–25042, 25052–25053). **a** Ascogonia on the surface of *Nypa fruticans*, partially immersed in mud. **b** Ascogonia seated on the substrata a hypostroma, composed of pseudoparenchymatous cells (PC) and dark ascospores (AS) in the mature asci (AC), visible

through thin wall; spores exuded at ostiole (OS). **c, d** Longitudinal section of ascogonia. **c** Ascogonia covered with mud (arrowed MU). Periphyses (PP) are simple; reticulate (arrowed RPR) and anastomosing; pseudoparaphyses in the upper part of the centrum arising from the venter wall; ostiolar canal (OC), trabeculate pseudoparaphyses (PR) arise between the asci from the base of the centrum. **d** Longitudinal section of ascogonia with stalk, asci and pseudoparaphyses. **e** Narrow pseudoparaphyses. **f** Cylindrical ascus. **g** Ascus tip with ocular chamber (arrows). **h, i** Ascospores in ascus with apical and basal appendages (arrow). Ascospore in ascus (**h**) with apical (AA) and basal (BA) appendages. **j–t** Bicelled ascospores. Scale bars: **a, b** = 250 μ m, **d** = 100 μ m, **c, f, g, j** = 50 μ m, **k–t** = 20 μ m, **e, h, i** = 10 μ m

smooth, surrounded by mucilaginous sheath; lumina rhomboid or lenticular in the central cells, conoid in the end cells.

Notes: Eriksson (1981) found *Trypethelium* and *Massaria* to resemble each other; the latter differing only in being non-lichenized and having larger asci and ascospores and therefore

Eriksson did not recognize *Massaria* as a separate family. Voglmayr and Jaklitsch (2011) however, provided a recent account of *Massaria* and found it to be a host-specific and phylogenetically isolated genus. *Massaria* was placed basal in the *Pleosporales* in a four gene (SSU, LSU, rpb2, tef1)

combined analysis and proved to be a monophyletic family represented only by *Massaria* species. The asexual state of *Massaria* is unknown.

Type: Massaria De Not., G. bot. ital. 1(1): 333 (1844), MycoBank: MB 3013 Fig. 68

Notes: Voglmayr and Jaklitsch (2011) treated 17 species, of which seven were newly introduced, and also discussed the host occurrence and distribution of *Massaria* species. They concluded that species are highly host-specific with biodiversity centered on *Acer* and *Rosaceae* hosts. They provided evidence to suggest that species have a hemibiotrophic life style and are weakly parasitic and that based on geographic distribution of species. Europe may be the centre of *Massaria* biodiversity.

Type species: Massaria inquinans (Tode) De Not., G. bot. ital. 1(1): 333 (1844), MycoBank: MB 230946

≡ *Sphaeria inquinans* Tode, Fung. mecklenb. sel. (Lüneburg) 1: Fig. 85 (1790)

Massarinaceae Munk, Friesia 5: 305 (1956), MycoBank: MB 80979

Habitat terrestrial, saprobic on wood or twigs. Sexual state: *Ascomata* immersed or superficial, scattered or clustered, globose, conical globose to lenticular, papillate or epapillate, ostiolate. *Peridium* thin, comprising a few layers of hyaline compressed cells, fusing at the outside with the host. *Hamathecium* of dense, filamentous, broad, septate, branching and hyaline cellular pseudoparaphyses, that lack or have anastomoses. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cylindrical, short pedicellate, apically rounded, ocular chamber not well-developed. *Ascospores* overlapping 2–3-seriate, ellipsoid to fusoid, hyaline, 1–3-septate, with or without mucilaginous sheath. Asexual states: “Ceratophoma”-like. *Conidiomata* pycnidial, globose to pyriform, ostiolate. *Conidiogenous cells* enteroblastic. *Conidia* oblong to globose-ovoid, hyaline, smooth, one-celled.

Notes: *Massarinaceae* was established based on *Keissleriella*, *Massarina*, *Metasphaeria*, *Pseudotruchia* and *Trichometasphaeria* (Munk 1956), but all genera except *Massarina* have subsequently been placed in other families (Zhang et al. 2012a, b). Following its introduction, this family name was not commonly used and *Massarina* was later placed within the *Lophiostomataceae* in the *Pleosporales*; thus the *Massarinaceae* is sometimes treated as a synonym of *Lophiostomataceae* (Barr 1987a). These two families, however, are now recognized as different lineages based on morphological and molecular evidence (Liew et al. 2002; Zhang et al. 2009b).

In addition to the type (*Massarina*) of this family, several genera have been suggested as a member of *Massarinaceae* based on molecular phylogenetic studies. They are *Aquaticheirosora* (*A. lignicola* Kodsueb & W.H. Ho; Kodsueb et al. 2007; Shearer et al. 2009), *Byssothecium* (*B. circinans* Fuckel; Zhang et al. 2012a, b), *Cheirosporium* (*C.*

triseriale L. Cai & K.D. Hyde; Shearer et al. 2009, *Corynespora* (*C. olivacea* (Wallr.) M.B. Ellis; Zhang et al. 2012a, b), *Helminthosporium* (*H. chlorophorae* M.B. Ellis, *H. solani* Durieu & Mont. and *H. velutinum* (Link) Link; Olivier et al. 2000; Suetrong et al. 2009), *Neottiosporina* (*N. paspali*; Zhang et al. 2012a, b), *Periconia* (*P. igniaria* E.W. Mason & M.B. Ellis; Zhang et al. 2012a, b), and *Saccharicola* (*S. bicolor* (D. Hawksw. et al.) D. Hawksw. & O.E. Erikss.; Eriksson and Hawksworth 2003; Kodsueb et al. 2007). Among these, *Massarina* sensu stricto has “Ceratophoma”-like pycnidial state with hyaline, small, ovoid, one-celled conidia (Bose 1961). *Aquaticheirosora* and *Cheirosporium* have synnematos and sporodochial conidiomata, respectively, and share melanized, multi-cellular, cheiroid conidia (Kodsueb et al. 2007; Cai et al. 2008). *Corynespora*, *Helminthosporium*, and *Periconia* have macronematous, mononematous conidiophores, and the former two genera are characterized by brown, elongate, multi-cellular, tretic conidia, while *Periconia* is characterized by globose to cylindrical, blastic conidia (Ellis 1971). *Neottiosporina* and *Saccharicola* produce pycnidial conidiomata with hyaline, ellipsoidal, transversely septate conidia (Sutton 1980; Sivanesan 1984). This morphological diversity found in their asexual morphs strongly suggests that *Massarinaceae* sensu lato is probably polyphyletic.

Recent molecular study on *Pleosporales* indicates that *Massarina cisti*, *M. eburnea*, *M. igniaria*, *Byssothecium circinans*, *Corynespora olivacea* and *Neottiosporina paspali* form a distinct monophyletic clade (*Massarinaceae*) supported by more than 92 % bootstrap value (Zhang et al. 2012a, b). However, further precise phylogenetic reassessment on these species and above mentioned genera (e.g., *Aquaticheirosora*, *Cheirosporium*, *Helminthosporium*, and *Saccharicola*), as well as morphological circumscription for *Massarinaceae*, is required.

Type: Massarina Sacc., Syll. fung. (Abellini) 2: 153 (1883), MycoBank: MB 3016

Figure 69

Notes: Aptroot (1998) examined nearly 1,000 specimens under the name *Massarina*. Of the 160 epithets listed in his monograph, only 43 species were accepted based on the morphological grounds. The current taxonomic concept of *Massarina* has been extensively amended based on its DNA sequence data, and several new genera, such as *Halomassarina*, *Lentithecium*, *Lindgomyces*, *Morosphaeria*, *Tetraplosphaeria* (a synonym of *Tetraploa*), and *Triplosphaeria*, have been proposed as segregates from *Massarina s. lato* (Suetrong et al. 2009; Tanaka et al. 2009; Zhang et al. 2009b; Hirayama et al. 2010).

Recently DNA sequence comparison indicated that *Massarina* sensu stricto includes only *M. eburnea* and *M. cisti* which are saprobic on woody substrates in terrestrial environments (Zhang et al. 2009a, b). They share

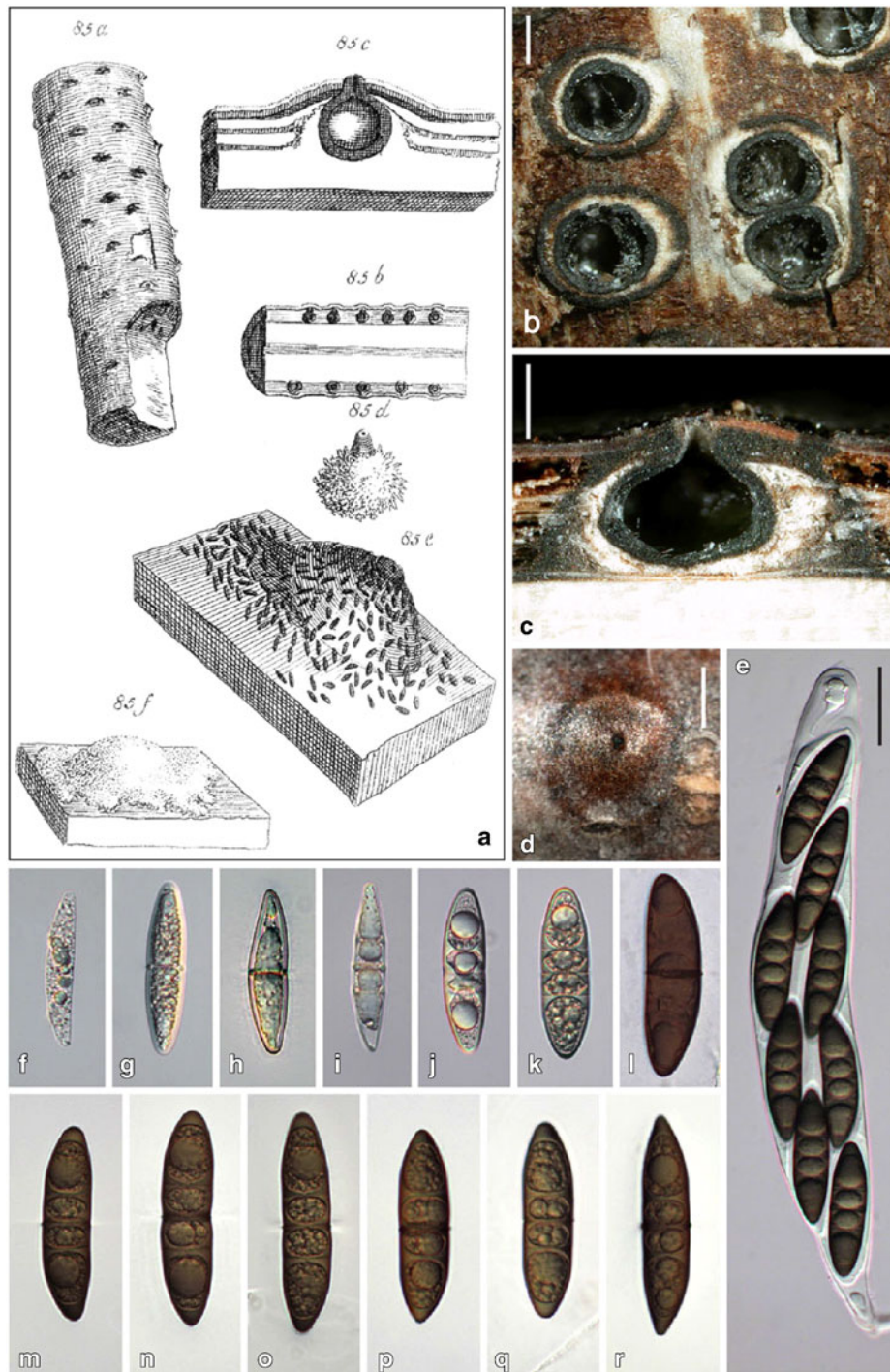


Fig. 68 *Massaria inquinans* (Material examined: AUSTRIA, Oberösterreich, Schärding, St. Willibald, Großer Salletwald, map grid 7648/1, on corticated twigs of *Acer pseudoplatanus* lying on the ground, 2 April 2009, H. Voglmayr M15 (WU 30526; **epitype**). **a** Lectotype. **b, c** Longitudinal and transverse sections through ascomata showing clypeus and pseudostromatic tissues. **d** Appearance of ascoma on host surface. **e**

Ascus. **f–r** Ascospores. Scale bars: **b–d** = 500 μm , **e** = 50 μm , **f–r** = 20 μm . Sources: **a** Library of Faculty Centre of Biodiversity, University of Vienna; **b, c, q** WU 30530; **d** WU 30528; **e** WU 30529; **f–l, r** WU 30526; **m–o** WU 30532; **p** WU 30531. (Reproduced with permission from Hermann Voglmayr and Walter M. Jaklitsch, 2010)

several morphological characteristics, including hyaline, broad to narrowly ellipsoidal ascospores and filamentous, broad, septate and hyaline cellular pseudoparaphyses, that

lack or have anastomoses or branching (Hyde 1995; Aptroot 1998), and produce “Ceratophoma”-like asexual morphs (Bose 1961).

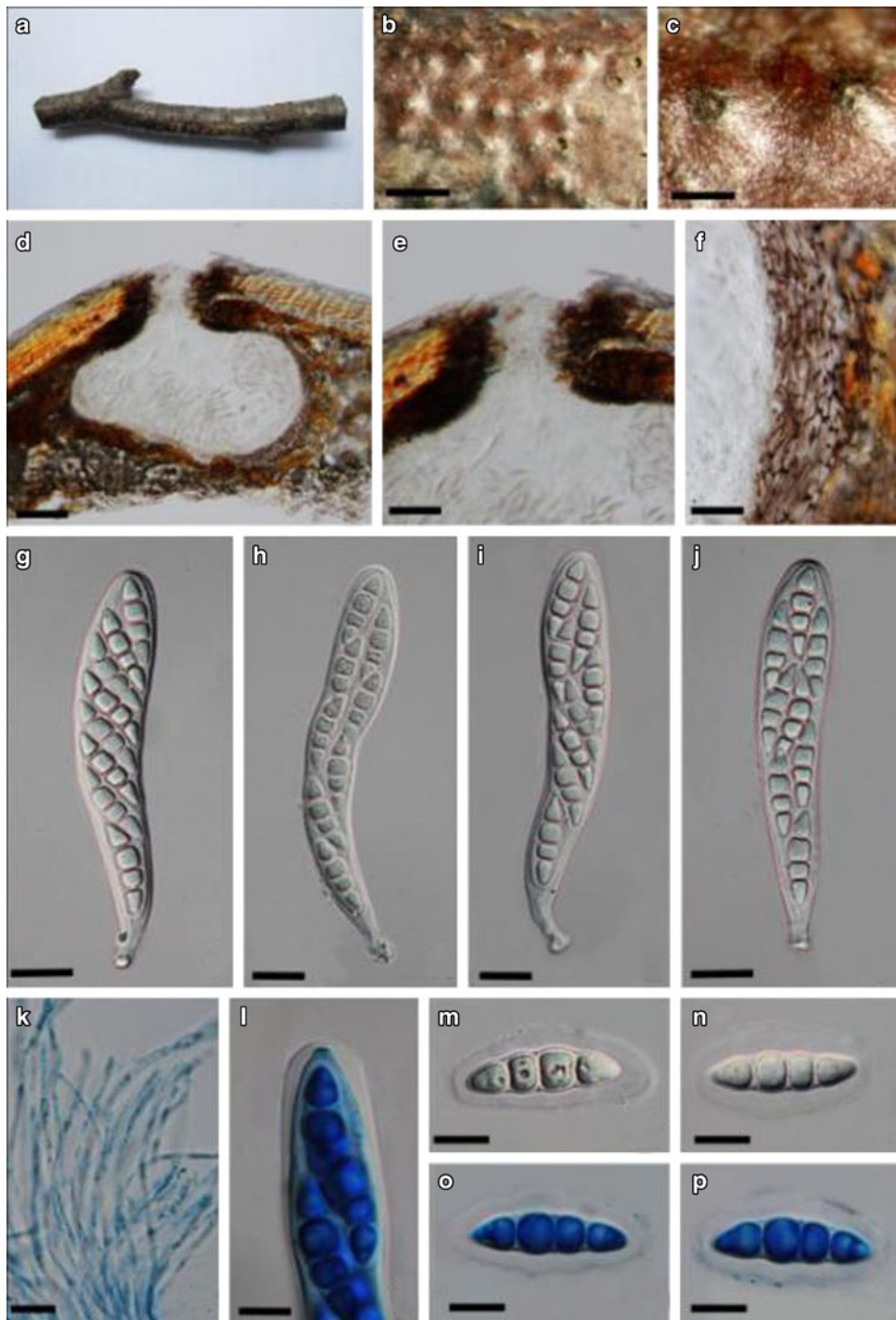


Fig. 69 *Massarina eburnea* (IFRD 2006, epitype). **a–c** Ascomata on the host. **d** Vertical section of ascostroma. **e** Ostiole. **f** Peridium wall. **g–j**, **l** Asci. Note fissitunicate dehiscence in **l**. **k** Pseudoparaphyses. **m–p**

Ascospores. Scale bars: **b–c**=500 μm , **d–e**=100 μm , **f**=20 μm , **g–j**, **l**=20 μm , **k**=20 μm , **m–p**=10 μm

Type species: Massarina eburnea (Tul. & C. Tul.) Sacc., Syll. fung. (Abellini) 2: 153 (1883), MycoBank: MB 191987

\equiv *Massaria eburnea* Tul. & C. Tul., Select. fung. carpol. (Paris) 2: 239 (1863)

Melanommataceae G. Winter [as '*Melanommeae*'], Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1.2: 220 (1885), MycoBank: MB 80990

Fungicolous, saprobic, parasitic or hyperparasitic, in terrestrial or marine or freshwater habitats, widespread in

temperate and subtropical regions. Sexual state: *Ascomata* scattered or gregarious, immersed to nearly superficial, globose to subglobose, carbonaceous or coriaceous, ostiolate, papillate or non papillate. *Peridium* composed of small, thick-walled, pseudoparenchymatous cells. *Hamathecium* of dense, trabeculate pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, clavate to nearly cylindrical, pedicellate, and with an ocular chamber. *Ascospores* obliquely uni-seriate or bi-seriate, fusoid to ellipsoidal, hyaline or brown, 1– multi-septate with or without a mucilaginous sheath. Asexual states: Wijayawardene et al. (2012) listed the asexual states as *Aposphaeria*, *Beverwykella*, *Exosporiella*, *Monodictys*, *Monotosporella*, *Nigrolentilocus*, *Pyrenochaeta* and *Sporidesmiella*. De Gruyter (2012) phylogenetically showed that *Aposphaeria* belongs to *Melanommataceae*. However Seifert et al. (2011) stated that *Monodictys* and *Monotosporella* are probably heterogeneous. We exclude *Pyrenochaeta* although *Melanommataceae* has “*Pyrenochaeta*”-like asexual states.

The family *Melanommataceae* was introduced by Winter (1885) based on globose or depressed perithecial ascomata, bitunicate and fissitunicate asci, pigmented phragmosporous ascospores as well as the trabeculate pseudoparaphyses and is typified by *Melanomma* (Barr 1990a, b; Sivanesan 1984; Zhang et al. 2012a). Barr (1983a) treated *Melanommataceae* as a separate order but recent molecular phylogenetic studies do not give any support to the separation of *Melanommatales* from *Pleosporales* (Liew et al. 2000; Mugambi and Huhndorf 2009a; Zhang et al. 2012a, b). Barr (1990c) included five genera in *Melanommataceae* based on erumpent to superficial ascomata with walls composed of small, thick-walled cells: *Byssosphaeria* Cooke, *Keissleriella* Höhn, *Melanomma*, *Ostropella*, *Strickeria*. Lumbsch and Huhndorf (2010) accept 14 genera with six tentatively placed. Multi-gene analysis has shown that the family is polyphyletic (Liew et al. 2000; Kodsueb et al. 2006a, b; Kruys et al. 2006) and some of the genera previously accommodated within *Melanommataceae* have been excluded: *Bimuria*, *Ostropella*, *Trematosphaeria* and *Xenolophium* (Mugambi and Huhndorf 2009a; Suetrong et al. 2011a). *Lophiostoma macrostomum*, the type species of *Lophiostoma*, was mistakenly included in the family and rejected by Tanaka and Hosoya (2008). Cannon and Kirk (2007) referred *Astrosphaeriella* to *Melanommataceae*, but phylogenetic analysis based on LSU and SSU nrDNA sequence data indicate that *Astrosphaeriella* is polyphyletic, and is located in the basal region of *Pleosporales* between *Testudinaceae* and *Zopfiaceae/Delitschiaceae* (Liu et al. 2011; Tanaka et al. 2009), or basal to *Aigialaceae* (Liu et al. 2011; Schoch et al. 2009b). Based on morphology and molecular analysis we refer *Melanommataceae* to the order *Pleosporales*. Asexual states are coelomycetous and rarely hyphomycetous, including different ontogenic structures, such as annellidic (*Exosporiella* and *Pseudospiropes*) and

coelomycetous (“*Aposphaeria*”-like and *Pyrenochaeta*) (Zhang et al. 2012a, b).

Type: Melanomma Nitschke ex Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 159 (1870)

[1869–70], MycoBank: MB 3070 Fig. 70

Possible synonym:

Moriolopis Norman ex Keissl. (1927)

Saprobic on wood and bark, terrestrial. Sexual state: *Ascomata* immersed, erumpent to nearly superficial, gregarious, medium to large-sized, globose to subglobose, coriaceous, dark brown to black, usually bearing remnants of wood fibers, ostiolate, short papillate, often somewhat puckered or sulcate, ostiolar canal filled with hyaline cells. *Peridium* coriaceous composed of two layers, an outer layer comprising small, heavily pigmented, thick-walled cells of *textura angularis* and an inner layer comprising lightly pigmented to hyaline, thin-walled cells of *textura angularis*, thin at the apex and wide at the base. *Hamathecium* of dense, filamentous, branching, anastomosing, septate, hyaline, pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical xto fusoid, with a short, furcate pedicel and with an ocular chamber. *Ascospores* obliquely uni-seriate and partially overlapping, broadly fusoid to fusoid with broadly rounded ends, straight or slightly curved, pale brown, reddish brown to olive-brown, 2– multi-septate, slightly constricted at main septa. Asexual state: *Aposphaeria*. *Conidiomata* pycnidial, superficial, globose, becoming collabent, black, shining, separate, unilocular; wall thin, composed of an outer layer of medium brown, thick-walled *textura angularis* and an inner layer of smaller-celled, thin-walled hyaline tissue. *Ostiole* single, circular, central, depressed. *Conidiophores* hyaline, branched at the base, septate above, short, cylindrical, formed from the inner cells of the pycnidial wall. *Conidiogenous cells* enteroblastic, phialidic, integrated or discrete, determinate, hyaline, smooth, apertures apical or lateral just below septa, collarete occasionally prominent, channel minute, periclinal wall thickened. *Conidia* hyaline, aseptate, thin-walled, eguttulate, cylindrical or ellipsoidal, smooth. *Mycelium* immersed, branched, septate, brown (Sutton 1980).

Notes: Melanomma was introduced by Fuckel (1870) and typified by *Melanomma pulvis-pyrius*. Winter (1887) placed *Melanomma* in *Melanommataceae* and this was followed by Barr (1990c). *Melanomma* is closely related to *Trematosphaeria* in sharing similar morphological characters, producing brittle and heavily carbonized ascomata, and brown, phragmosporous, elliptical to fusiform ascospores, while *Melanomma* differs in producing short and obscure ostioles, along with the rough peridium and cylindrical asci. This has been confirmed by molecular phylogenetic analysis (Zhang et al. 2008a, b). After observing the neotype of *Melanomma*, *M. pulvis-pyrius*, Zhang et al. (2008a)

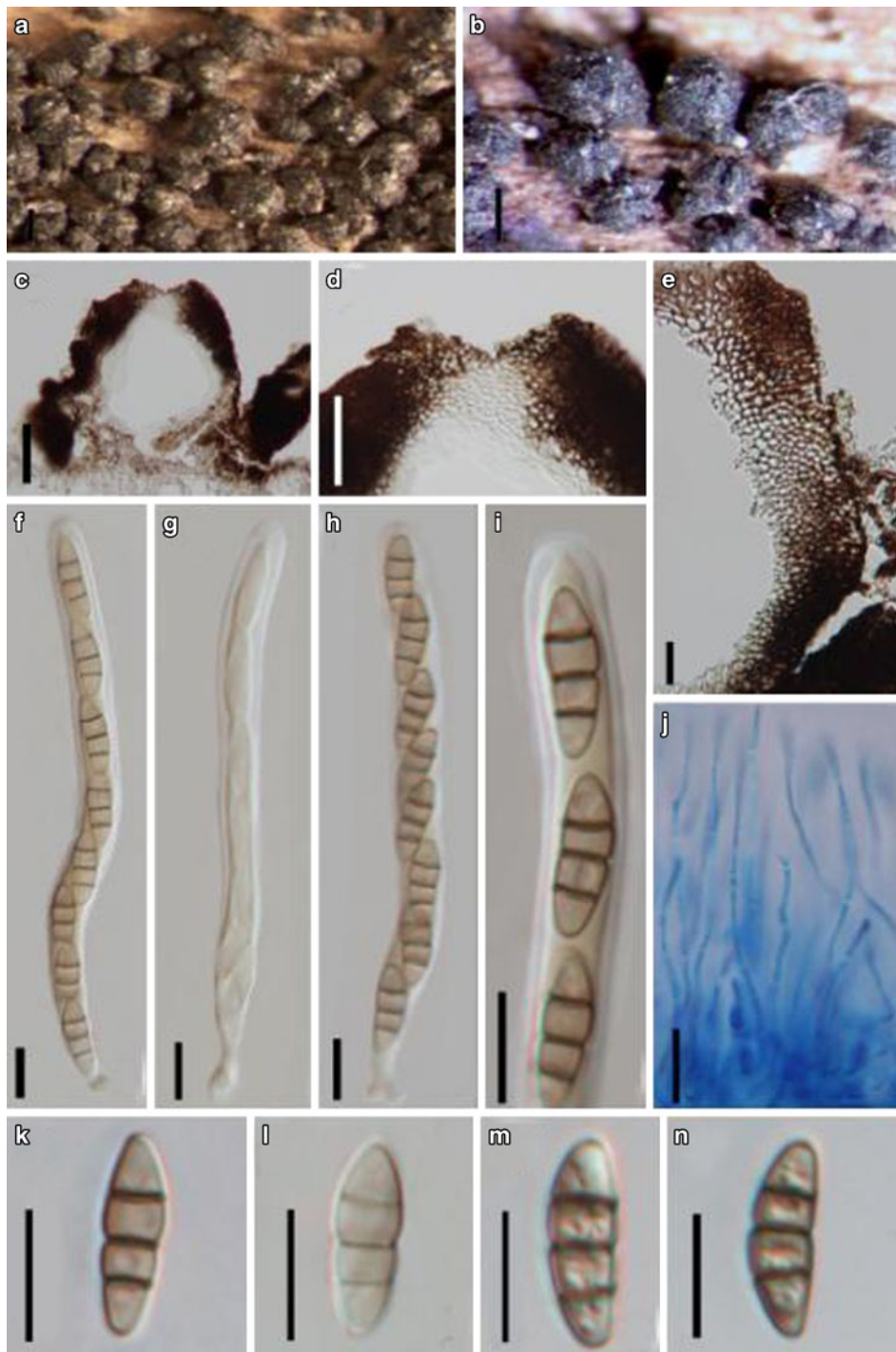


Fig. 70 *Melanomma pulvis-pyrius* (Material examined: FRANCE, Ariège, Rimont, Saurine, on bark of *Salix caprea*, 10 Apr. 2008, Jacques Fournier IFRD 2001, **epitype**). **a, b** Ascomata on host surface. **c–e** Hand

section of ascomata. **f–i** Asci with ascospores. **j** Hamathecium. **k–n** Ascospores. Scale bars: **a** = 200 μ m, **b** = 200 μ m, **c** = 100 μ m, **d** = 50 μ m, **e** = 20 μ m, **f–n** = 10 μ m

epitypified the species and provided an ex-epitype culture (IFRDCC 2044). Barr (1990c) had included 20 species in the genus (Kirk et al. 2001), while currently Index Fungorum (2013) lists 295 epithets, while there are more than 40 hits for sequence data in GenBank,

including putative strains of *M. pulvis-pyrius* (CBS 371.25), *M. radicans* (ATCC 42522) and *M. sanguinarium* (P. Karst.) Sacc (UPSC 1924). The placement of the genus has been clarified based on the molecular and morphological data.

Type species: Melanomma pulvis-pyrius (Pers.) Fuckel, Jb. nassau. Ver. Naturk. 23–24: 160 (1870) [1869–70], MycoBank: MB 182890

≡ *Sphaeria pulvis-pyrius* Pers., Syn. meth. fung. (Göttingen) 1: 86 (1801).

Other genera included

Anomalemma Sivan., Trans. Br. mycol. Soc. 81(2): 328 (1983)

Type species: Anomalemma epochnii (Berk. & Broome) Sivan., Trans. Br. mycol. Soc. 81(2): 328 (1983)

Asymmetricospora J. Fröhl. & K.D. Hyde, Sydowia 50(2): 183 (1998)

Type species: Asymmetricospora calamicola J. Fröhl. & K.D. Hyde, Sydowia 50(2): 184 (1998)

Bertiella (Sacc.) Sacc. & P. Syd., in Saccardo, Syll. fung. (Abellini) 14(1): 19 (1899)

Type species: Bertiella polyspora Kirschst., Verh. bot. Ver. Prov. Brandenb. 48: 51 (1907) [1906]

Beverwykella Tubaki, Trans. Mycol. Soc. Japan 16(2): 138 (1975)

Type species: Beverwykella pulmonaria (Beverw.) Tubaki, Trans. Mycol. Soc. Japan 16(2): 139 (1975)

Bicrouania Kohlm. & Volkm.-Kohlm., Mycol. Res. 94(5): 685 (1990)

Type species: Bicrouania maritima (P. Crouan & H. Crouan) Kohlm. & Volkm.-Kohlm., Mycol. Res. 94(5) 685 (1990)

Byssosphaeria Cooke, Grevillea 7(no. 43): 84 (1879)

Type species: Byssosphaeria keitii (Berk. & Broome) Cooke [as '*Byssosphaeria keithii*'], (1879),

Calyptronectria Speg., Anal. Mus. nac. B. Aires, Ser. 3 12: 412 (1909)

Type species: Calyptronectria platensis Speg., Anal. Mus. nac. B. Aires, Ser. 3 12: 412 (1909)

Caryosporella Kohlm., Proc. Indian Acad. Sci., Pl. Sci. 94(2–3): 355 (1985)

Type species: Caryosporella rhizophorae Kohlm., Proc. Indian Acad. Sci., Pl. Sci. 94(2–3): 356 (1985)

Exosporiella P. Karst., Finlands mögelsvampar, (Hyphomycetes fennici): 160 (1892)

Type species: Exosporiella fungorum (Fr.) P. Karst., Finlands mögelsvampar, (Hyphomycetes fennici): 161 (1892)

Herpotrichia Fuckel, Fungi rhenani exsic., suppl. 7(nos 2101–2200): no. 2171 (1868)

Type species: Herpotrichia rubi Fuckel, Jb. nassau. Ver. Naturk. 23–24: 146 (1870) [1869–70]

Mamillisphaeria K.D. Hyde et al., Nova Hedwigia 62(3–4): 514 (1996)

Type species: Mamillisphaeria dimorphospora K.D. Hyde et al., Nova Hedwigia 62(3–4): 515 (1996)

Nigrolentilocus R.F. Castañeda & Heredia, Cryptog. Mycol. 22(1): 13 (2001) R.F. Castañeda & Heredia, Cryptog. Mycol. 22(1): 13 (2001)

Type species: Nigrolentilocus africanus (B. Sutton) R.F. Castañeda & Heredia, in Castañeda Ruiz et al., Cryptog. Mycol. 22(1): 15 (2001)

Ohleria Fuckel, Fungi rhenani exsic., suppl. 7(nos 2101–2200): no. 2173 (1868)

Type species: Ohleria modesta Fuckel, Fungi rhenani exsic., suppl. 7(nos 2101–2200): no. 2173 (1868)

Pseudotrichia Kirschst., Anns mycol. 37(1/2): 125 (1939)

Type species: Pseudotrichia stromatophila Kirschst., Anns mycol. 37(1/2): 125 (1939)

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

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

Key to sexual genera of Melanommataceae

1. Habitat terrestrial and saprobic, parasitic or fungicolous on host3
1. Habitat fresh water or marine and saprobic on host2
2. Conical ascomata*Mamillisphaeria*
2. Globose to subglobose ascomata*Bicrouania*
3. Ascomata superficial on host4
3. Ascomata immersed or erumpent on host7
4. Ascomata without an ostiole*Byssosphaeria*
4. Ascomata with an ostiole5
5. Ascospores hyaline to pale brown with guttules*Bertiella*
5. Ascospores hyaline to reddish brown without guttules6
6. Ascospores with hyaline germ pore at each end*Caryosporella*
6. Ascospores without hyaline germ pore at each end*Anomalemma*
7. Hamathecium of dense, filamentous, trabeculate, branching, anastomosing pseudoparaphyses8
7. Hamathecium of dense, cellular, unbranched pseudoparaphyses*Pseudotrichia*
8. Asci with short pedicel9
8. Asci with furcate pedicel11
9. Ascospores with a mucilaginous sheath*Asymmetricospora*
9. Ascospores lacking a mucilaginous sheath10
10. Ascospores ellipsoid to fusoid, 2 to multi-septate, constricted at the main septum*Melanomma*
10. Ascospores broadly to narrowly fusoid, 3-septate, easily separating into two parts at the primary septum*Ohleria*
11. Ascospores 1-septate*Herpotrichia*
11. Asci with muriform ascospores*Calyptronectria*

Key to asexual genera of *Melannomataceae*

1. Conidiophores unbranched or sparingly branched2
1. Conidiophores branched, hyaline*Exosporiella*
2. Conidiophores unbranched3
2. Conidiophores unbranched or sparingly branched, conidia pale brown, with 2–3 apical setulae*Sporidesmiella*
3. Conidiophore unbranched, hyaline to pale brown; conidiogenous cells monoblastic, conidia brown, aseptate*Beverwykella*
3. Conidiophores unbranched, brown; conidiogenous cells polytretic, with dark scars, conidia brown, euseptate*Nigrolentilocus*

Mesnieraceae Arx & Müller, Stud. Mycol. 9: 94 (1975), MycoBank: MB 80998

Synonym:

Stegasphaeriaceae Syd. & P. Syd., Anns mycol. 14(5): 364 (1916)

Parasitic on leaves, causing necrotic patches, or saprobic. Sexual state: *Mycelium* hyaline, developing within host tissue. *Ascomata* densely gregarious, immersed, spherical, flattened or globose to subglobose, yellowish-green, uni-loculate, with numerous asci and pseudoparaphyses. *Ostiole* present or lacking, usually opening apically with a pore, or with wide and large hole in mature ascomata, erumpent through the upper epidermis, comprising elongated columnar cells. *Peridium* thin-walled, hyaline, composed of many layers of flattened cells of *textura angularis*, or comprising a few layers of elongate cells. *Hamathecium* comprising numerous, hypha-like, hyaline, filamentous, septate pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 4–24-spored, bitunicate, cylindrical to clavate, or elongate-ellipsoidal, short-pedicellate, inner membrane thickened in the upper part, apex rounded, with or without a well-developed ocular chamber. *Ascospores* 2– multi-seriate, dark brown to brown, or dark reddish-brown, ellipsoidal, aseptate or 1-septate, constricted at the septum, thick-walled, with or without a mucilaginous sheath. Asexual state: Unknown (Saccardo and Sydow 1902; Eriksson 1981; Hyde 1996).

Notes: The family was introduced by von Arx and Müller (1975) with *Mesniera rottlerae* (Racib.) Sacc. & P. Syd., as the type species. *Mesnieraceae* includes the genera *Bondiella*, *Mesniera* and *Stegasphaeria* (Kirk et al. 2008), while Lumbsch and Huhndorf (2010) include four genera with the addition of *Helochora*. *Bondiella* was observed, redescribed and illustrated by Hyde (1996) and is considered a good member in *Mesnieraceae* (Pirozynski 1972; Eriksson 1981). *Helochora* was isolated from *Puya* sp. in Chile, and described as a new genus by Sherwood (1979) and was accommodated in *Polystigmataceae*, and has ornamented spores which are uni-seriate in the asci. We observed the type specimen of *Helochora hypertropha* Sherwood and considered that

Helochora does not belong to *Mesnieraceae* and transfer it to Sordariomycetes genera *incertae sedis*.

Type: *Mesniera* Sacc. & Syd., Syll. Fung. 16: 440 (1902), MycoBank: MB 3134

Parasitic on leaves, causing necrotic patches, or saprobic. Sexual state: *Ascomata* densely gregarious, immersed in yellowish-green necrotic patches, with radial arrangement, ring or spirals with progressively younger ascomata towards periphery, apically opening with a pore, or widened and large hole in mature ascomata. *Peridium* thin-walled, hyaline, composed of flattened cells arranged in a *textura angularis*. *Hamathecium* comprising numerous, hypha-like, hyaline, filamentous, septate pseudoparaphyses. *Asci* 12–16-spored, bitunicate, cylindrical to clavate, short pedicellate, lacking an ocular chamber or apical ring. *Ascospores* crowded, ovoid to ellipsoidal, dark brown, 1-celled, without a mucilaginous sheath (von Arx and Müller 1975; Eriksson 1981).

Type species: *Mesniera rottlerae* (Racib.) Sacc. & P. Syd. [as ‘rotlerae’], Syll. fung. (Abellini) 16: 441 (1902), MycoBank: MB 210494

≡ *Anthostomella rottlerae* Racib., Parasit. Alg. Pilze Java’s (Jakarta) 2: 11 (1900)

Notes: Eriksson (1981) examined several collections of *Mesniera* and all had concentric rings of ascomata in necrotic patches, wide pores usually containing mature asci with ascospores, and mature ascomata present on both of the upper and lower side of the leaves. Unfortunately, we could not obtain a specimen of the type species of *Mesniera rottlerae* (≡ *Anthostomella rottlerae*), which may be lost, but we have observed *Bondiella palmicola* Piroz., *Stegasphaeria pavonina* Syd. from K and S respectively, and illustrate these here.

Other genera included

Bondiella Piroz., Mycol. Pap. 129: 6 (1972), MycoBank: MB 625 Fig. 71

Type species: *Bondiella palmicola* Piroz., Mycol. Pap. 129: 6 (1972), MycoBank: MB 309834

Sexual state: *Ascomata* solitary, immersed, subglobose, brown to dark brown, neck erumpent through the upper epidermis. *Ostiole* present, canal containing hyaline paraphyses. *Peridium* thin-walled, comprising cells of *textura angularis*, fusing with host at the outside. *Hamathecium* comprising numerous, cylindrical, septate pseudoparaphyses. *Asci* 24-spored, bitunicate, cylindrical to clavate, short-pedicellate, apically rounded, with an ocular chamber. *Ascospores* multi-seriate, ellipsoidal, reddish-brown, 2-celled, constricted at septum, surrounded by a mucilaginous sheath.

Stegasphaeria Syd. & P. Syd., Anns mycol. 14(5): 362 (1916) Fig. 72

Type species: *Stegasphaeria pavonina* Syd. & P. Syd., Anns mycol. 14(5): 362 (1916), MycoBank: MB 139864

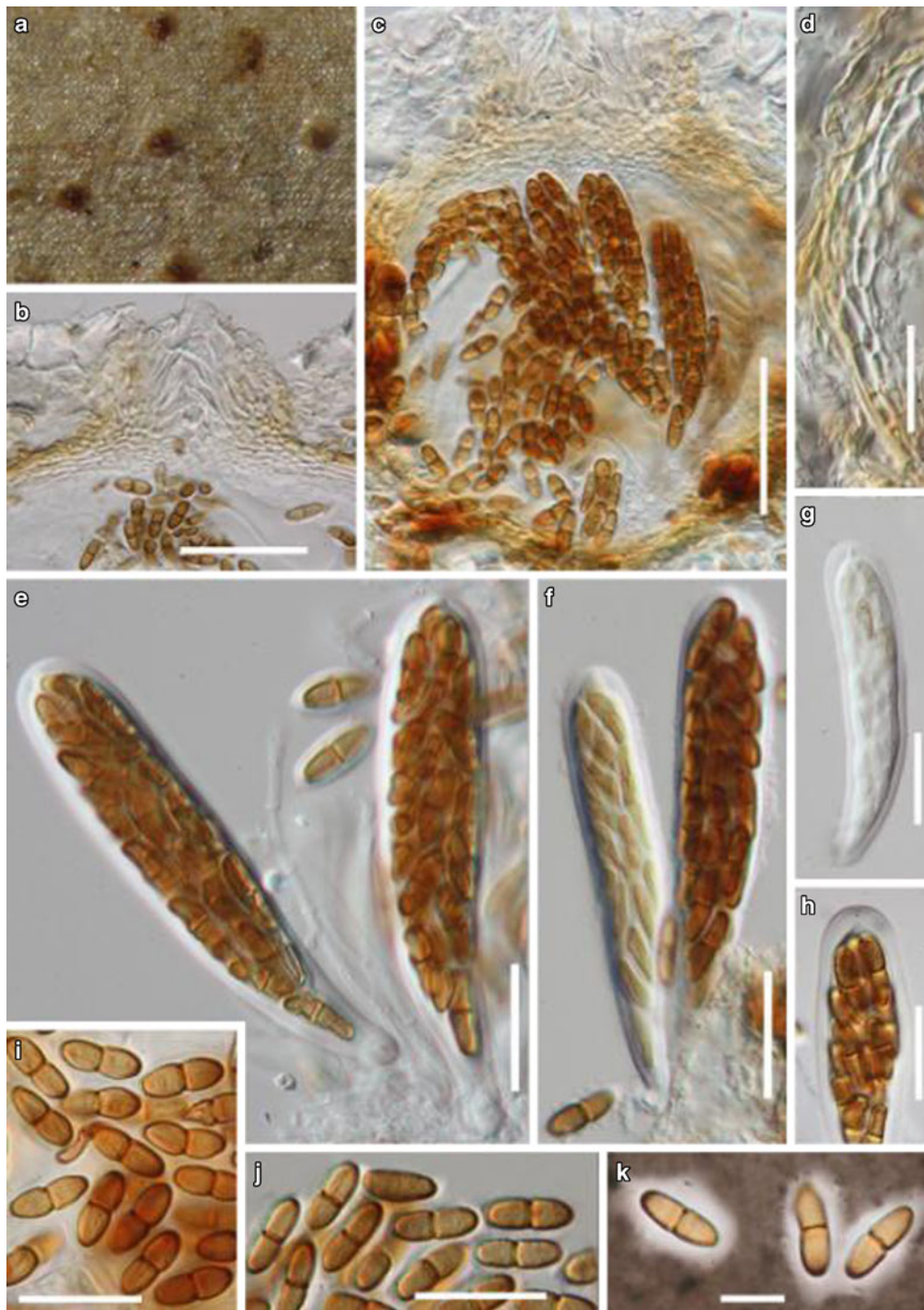


Fig. 71 *Bondiella palmicola* (Material examined: TANZANIA, Kigoma, Kakombe, on fallen fronds of *Elaeis guineensis*, 19 December 1963, K.A. Pirozynski M26c, IMI 105789c, **holotype**). **a** Ascomata semi-immersed on host. **b** Ostiolar canal with hyaline periphyses. **c**

Vertical section of ascoma. **d** Peridium. **e-h** Mature and immature bitunicate asci. **i-j** Ascospores with 2 cells. **k** Ascospores stained in India ink. Scale bars **c**=100 μ m, **b, e-g**=50 μ m, **d, h, i, j**=20 μ m, **k**=10 μ m

Spots distinct and numerous, with spiral or radially pattern on upper and lower side of leaf, yellow or yellowish-brown or greyish; stromata epiphyllous, black, shiny. Sexual state: *Ascomata* densely gregarious, immersed, spherical,

flattened-globose, erumpent through the upper epidermis, yellowish-brown. *Ostiole* with neck or opening with a pore. *Peridium* thin-walled, hyaline, composed of many layers of flattened cells of *textura angularis*. *Asci* not seen, but Sydow

Fig. 72 *Stegasphaeria pavonina* (Material examined: PHILIPPINES, Laguna, Mount Maquiling, near Los Baños, on living leaf of *Macaranga* sp. 7 March 1914, C.F. Baker no.4032, **holotype**). **a** Herbarium label and peridium. **b** Ostiolate ascomata on leaf spot on host. **c** Vertical section through ascoma. **d, e** Peridium. **f, g** Ascospores 2-celled. Scale bars: **c**=100 μ m, **d, e**=20 μ m, **a, f, g**=10 μ m



and Sydow (1916) report that the asci as 4–8-spored, generally cylindrical, with thickened apex and rounded base, short pedicelate, with hyaline pseudoparaphyses. *Ascospores* uniseriate, 2-celled, constricted at septum, broadly ellipsoidal, immature ascospores yellow or yellowish becoming blackish-brown when mature.

Key to genera of *Mesnieraceae*

1. Ascospores 1-celled, asci 12–16-spored*Mesniera*
1. Ascospores 2-celled, asci other than 16-spored2
2. Asci 4–8-spored*Stegasphaeria*
2. Asci 24-spored*Bondiella*

Metacapnodiaceae S. Hughes & Corlett, in Hughes, N.Z. JI Bot. 10: 239 (1972), MycoBank: MB 81649

Foliar epiphytes on plant leaves and stems. Sexual state: *Mycelium* superficial, subiculum spongy, friable, composed of brown to dark brown, moniliform, anastomosing, septate, smooth or coarsely roughened,

branched hyphae, sometimes lobed or in the form of hemispherical lumps, hyphae deeply constricted at the septa, thick-walled. *Ascomata* basally immersed in the subiculum, broadly ellipsoidal, or globose, with numerous, hypha-like, septate, appendages. *Peridium* comprising cells of *textura angularis*, at the outer peridium cells brown to dark brown. *Hamathecium* comprising pseudoparaphyses and asci are numerous. *Asci* 8-spored, bitunicate, ellipsoidal with pedicel, lacking an obvious ocular chamber. *Ascospores* 2–3-seriate, ellipsoidal with somewhat conical end cells, 3-septate, occasionally slightly constricted at the septa, thick-walled, brown to dark brown, rather dark brown at the septa. Asexual states: see notes below.

Notes: The distinctive hyphae of the *Metacapnodiaceae* are “broad, with dark brown walls, and composed of few or more cells with constrictions at the septa, giving the impression of a moniliform chain, the terminal cells are usually tapered towards the apex” (Hughes and Seifert 2012). This

sooty mould family has a hyphomycetous conidial state, which distinguishes it from *Capnodiaceae* (Hughes 1972). The family is not well documented, the best accounts are those of Hughes (1972) and Hughes and Seifert (2012). These are classic sooty molds with relatively small (less than 250 μm diam.) ascomata and a hyphomycetous asexual state forming on thick, brown to black, dense subicula with a basal pseudo-parenchymatous cushion and producing several synanamorphs. The fungus probably gains its nutrition from insect or plant exudates.

Sphaeria ericophila Link, which occurs on *Erica arborea* in the central mountains of Spain and Portugal, and the type species of *Antennaria* Link 1809 non Gaertn. 1791 and the replacement name *Antennularia* Reichenb. 1828, is also a species of *Metacapnodium* close to, but distinct from, *M. juniperi* (Hawksworth & Hughes, unpubl.). The generic name *Metacapnodium* thus requires conservation or protection over *Antennularia*. The new combination *Metacapnodium ericophilum* (Link) D. Hawksw. & S. Hughes **comb. nov.** (basonym: *Sphaeria ericophila* Link, Neues J. Bot. 3: 17, 1809); MycoBank MB 804963 is also therefore necessary.

The asexual state also occurs on the subiculum and comprise hyphae with broad, dark brown cells, and chains of globose, moniliform cells, with strong constrictions at the septa. The terminal cells are often conspicuously tapered near the apex and in some species schizolytically disarticulating cells can act as propagules (Hughes and Seifert 2012). *Hyphosoma* may be the appropriate name for such propagules according to Hughes and Seifert (2012). Asexual states have been reported in *Capnocybe*, *Capnophialophora*, *Capnosporium*, *Hormiokrypsis* and *Hyphosoma* (Hughes 1966, 1981; Seifert et al. 2011; Wijayawardene et al. 2012). All *Metacapnodiaceae* species have a *Capnophialophora* asexual state which have plump, ampulliform phialides on the narrowing parts of the moniliform conidiophores and produce small ameroconidia. Synanamorphs include *Hormiokrypsis* with solitary dry stauroconidia, *Capnocybe* with slimy heads of phragmoconidia, and *Capnosporium* with solitary, dry phragmoconidia which is produce phialides and microconidia (Batista and Nascimento 1957; Hughes 1966; Hughes and Seifert 2012). However, it is likely that more than one species will grow on the subiculum as with other sooty molds and care must be taken in interpretation (Chomnunti et al. 2011; Hughes and Seifert 2012).

Type: *Metacapnodium* Speg., Physis, B. Aires 4: 288 (1918), MycoBank: MB 3137

Figures 73, 74, 75 and 76

Foliar epiphytes as typical “sooty moulds” comprising black mycelium masses covering the twigs as subicula. Sexual state: *Mycelium* comprising dense, brown to dark brown, friable, spongy, septate hyphae, which are deeply

constricted at the septa, thick-walled, moniliform, and anastomosing. *Ascomata* relatively small, less than 200 μm diam, basically immersed in the subiculum, broadly ellipsoidal or globose, with numerous, septate, hypha-like appendages. *Peridium* comprising 3–4 layers of cells forming a *textura angularis*, inner cells hyaline to pale brown, outer layer cells brown to dark brown, especially at the outside. *Asci* 8-spored, bitunicate, ellipsoidal, short pedicellate, ocular chamber not observed. *Ascospores* bi or tri-seriate, ellipsoidal with somewhat conical end cells, 3-septate, some slightly constricted at septa, thick-walled, brown to dark brown, rather dark brown at the septa, smooth-walled. Asexual states: named as “Capnophialophora”: *Phialides* develop on ascospores and moniliform hyphae, which is more or less subspherical, ellipsoidal to cylindrical, tapered or slightly flared, pale brown to brown. Phialides occurring singly or in pairs on hyphae or on apex of ascospores, globose, pale brown to brown, with collarette, hyaline; phialoconidia not observed.

Notes: The asexual states of *Metacapnodium* comprise conidiogenous cells as phialides on moniliform hyphae, on ascostroma initials, on ascospores or on germ tubes (Sivanesan 1984). All species of *Metacapnodium* produce *Capnophialophora* phialides (Hughes and Seifert 2012), some species may produce other asexual states which have variously been named as symopodioconidia (*Capnobotrys*), as those with or without poroconidia (*Capnosporium*), or sympodioconidia (*Capnocybe*) (Hughes 1966). Seven New Zealand taxa of *Metacapnodium* which produce a *Capnobotrys* asexual state were illustrated and briefly described by Hughes (1981). Most species have *Capnophialophora* (Hughes 1966) asexual states and a few also produce *Capnosporium* states (Hughes 1976). Sooty moulds normally grow mixed together and caution must be taken when interpreting data. Microscopic examination by using collodion technique has so far been used to clarify relationships between morphs. No *Metacapnodiaceae* species have been obtained in culture and no sequence data is deposited in GenBank (Hughes and Seifert 2012).

Hughes (1966) stated that *Capnocybe fraseriae* S. Hughes, the type species of *Capnocybe*, is the asexual state of *Limacinia fraseriae* S. Hughes. However Hughes (1976) moved the latter species to *Metacapnodium*. In this study we observed both *M. spongiosum* and its asexual state, *C. spongiosa* on the same specimen which was collected from Spain (Fig. 73). Hughes (1976) also established the link between these two genera. Hence we reduce *Capnocybe* under the older name *Metacapnodium*.

Type species: *Metacapnodium juniperi* (W. Phillips & Plowr.) Speg., Physis, B. Aires 4: 288 (1918)

≡ *Capnodium juniperi* W. Phillips & Plowr., Grevillea 13(no. 67): 75 (1885)

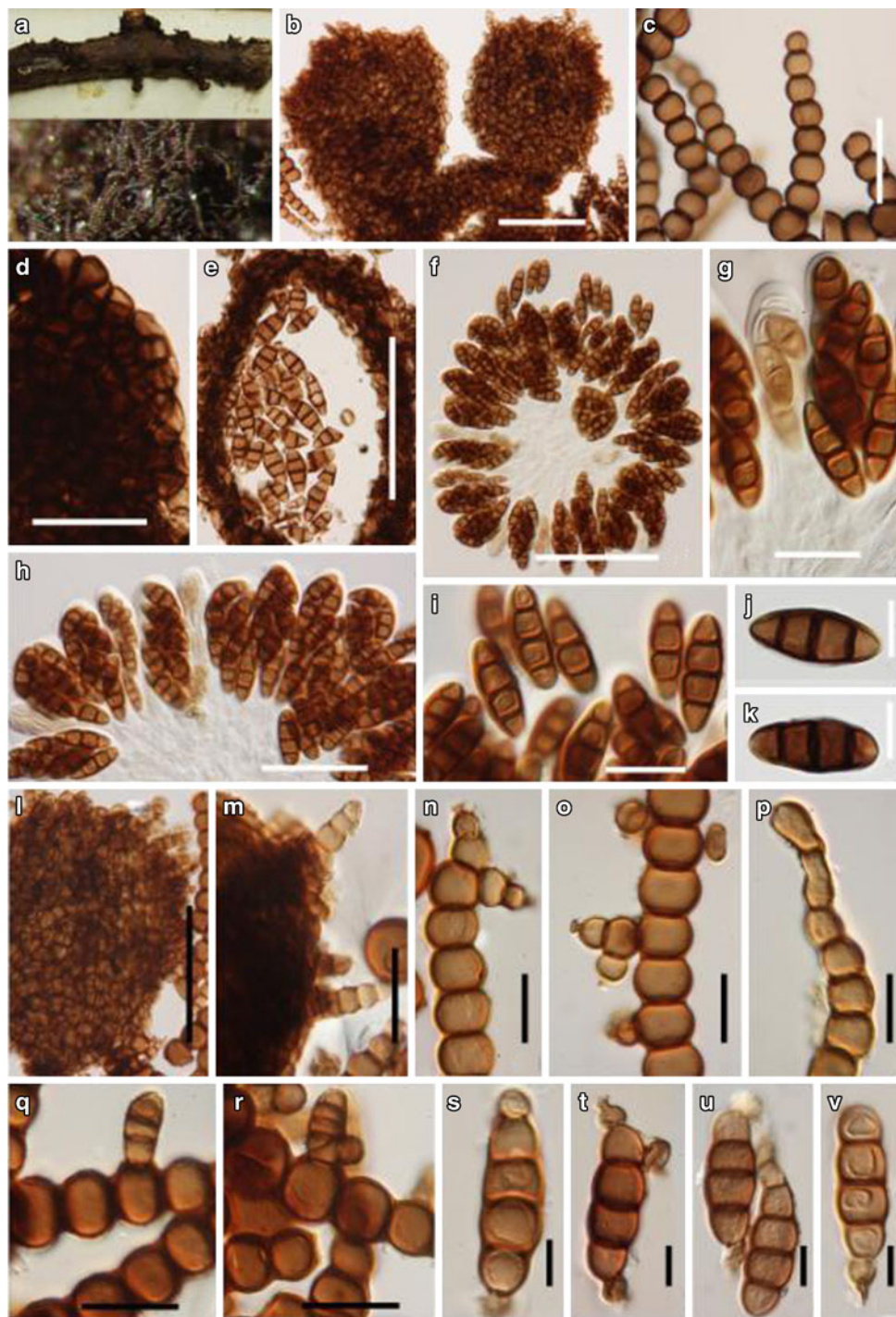


Fig. 73 *Metacapnodium juniperi* (Material examined: SCOTLAND, Moray coast, Forres, on bark of *Juniper* twigs, 2 June 1882, Rev. Dr. Keith ex herb. C.B. Plowright, K(M)164026, **holotype** of *Capnodium juniperi*). **a** Sooty mould-like appearance on bark of *Juniperus communis*. **b** Ascomata. **c** Moniliform hyphae. **d** Ascoma wall. **e**

Section through ascoma. **f–h** Asci. **i–k** Ascospores. **l, m** Ascoma wall with hypha-like appendages. **n–p** Phialides with collarette developing on hyphae. **q, r** Conidiophores. **s–v** Phialides developing on ascospores. Scale bars: **b, e, f, l** = 100 μm , **c, d** = 50 μm , **h, i, m–r** = 20 μm , **j, k, s–v** = 10 μm

Notes: The asexual state has been reported as *Capnocybe spongiosa* (Hoerl.) S. Hughes. There are eleven epithets known for *Metacapnodium* (Kirk et al. 2008) such as *Metacapnodium*

crassum (Pat.) S. Hughes, *M. dennisii* S. Hughes, *M. dingleyae* S. Hughes, *M. fraseriae* (S. Hughes) S. Hughes, *M. guava* (Cooke) S. Hughes, *M. juniper* (W. Phillips & Plowr.) Spég.,



Fig. 74 *Metacapnodium spongiosum* (Material examined: SPAIN, W from Jimena de la Frontera close to Las Cañillas, road 3331, on bark of *Erica arborea*, 21 March 2011, H. Voglmayr & W. Jaklitsch, MFLU 12–0140). **a** Thick woolly black mass of mycelium on *Erica arborea*. **b–c**

Section through globose ascomata. **d** Peridium. **e** Hyphae. **f–g** *Capnophialophora* state. **h–j** Ascospores. **k–m** *Capnocybe* conidia. Scale bars: **a**, **b** = 100 μ m, **c–e** = 50 μ m, **f**, **g** = 20 μ m, **i–m** = 10 μ m

M. moniliforme (Fraser) S. Hughes, *M. quinquesseptatum* (Barr) S. Hughes, *M. smilacinum* (Mendoza) S. Hughes, *M. spongiosum* S. Hughes with *Capnocybe spongiosa* (Hoerl.) S. Hughes as the asexual state and *M. succinum* (Dörfelt, A.R. Schmidt & J. Wunderl.) Rikkinen.

Other genera included

Capnobotrys S. Hughes N. Z. J. Bot. 8(2): 205 (1970),

Type species: Capnobotrys neesii S. Hughes, N.Z. J. Bot. 8(2): 205 (1970)

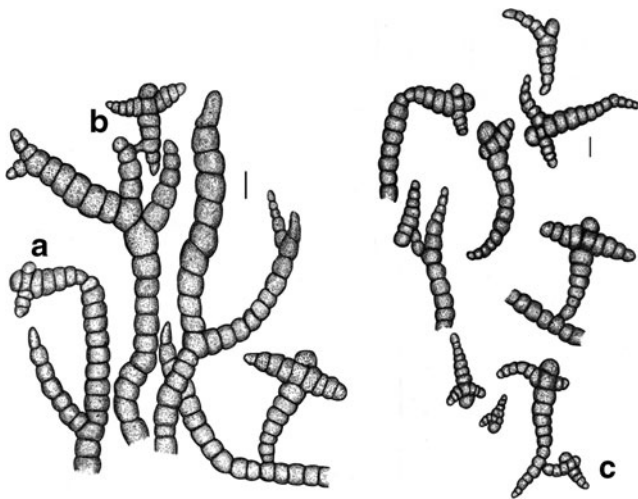


Fig. 75 *Hormiokrypsis libocedri* Bat. & Nasc. Conidia and hypha. **a** Lateral. **b** Origin. **c** free conidia. Scale bar: 20 μm (Redrawn from Batista and Nascimento 1957)

Capnophialophora S. Hughes, N. Z. J. Bot. 4: 352 (1966)

Type species: *Capnophialophora fraseriae* S. Hughes, N.Z. J. Bot. 4: 352 (1966)

Capnosporium S. Hughes, Mycologia 68(4): 752 (1976),

Type species: *Capnosporium moniliforme* S. Hughes, Mycologia 68(4): 752 (1976)

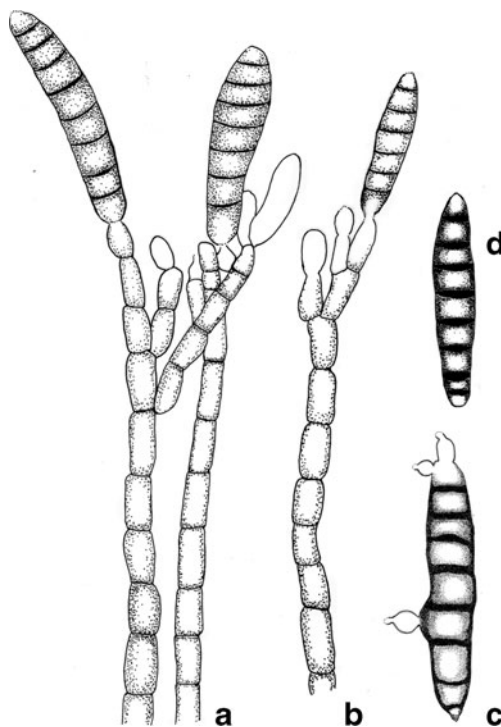


Fig. 76 *Capnocybe fraseriae* **a**, **b** Branched ends of synnematosus hyphae with sympodulae and sympoduloconidia. **c** Sympodioconidium bearing *Capnophialophora* phialides. **d** Sympodioconidia (Redrawn from Hughes 1966)

Hormiokrypsis Bat. & Nascim. Anais Soc. Biol. Pernambuco 15(2): 345 (1957),

Type species: *Hormiokrypsis libocedri* Bat. & Nascim., Anais Soc. Biol. Pernambuco 15(2): 346 (1957)

Hyphosoma Syd., Annls mycol 22(3/6): 315 (1924)

Type species: *Hyphosoma hypoxyloides* Syd., Annls mycol. 22(3/6): 315 (1924)

Key to genera of Metacapnodiaceae

1. Conidia hyaline to pale brown, conidiogenous cells phialides, phialoconidia, broadly ellipsoidal to subglobose, minute*Capnophialophora*
1. Conidia brown to dark brown2
2. Sympodioconidia3
2. Protoconidia4
3. Conidia develop successively on clustered sympodulae on mononematous hyphae, 1-septate or somewhat 2- to multi-septate*Capnobotrys*
3. Conidia develop successively on densely crowned sympodulae on synnematosus hyphae, 3–8-septate, ascospores ellipsoidal, 3-septate, brown.....
-*Metacapnodium* (= *Capnocybe*)
4. Conidiogenous cells monoblastic with poroid scars, conidia 3-septate, lacking lateral arms*Capnosporium*
4. Conidiogenous cells tetric, with lateral arms*Hormiokrypsis*

Micropeltidaceae Clem. & Shear [as ‘*Micropeltaceae*’], Gen. fung., Edn 2 (Minneapolis): 100 (1931), MycoBank: MB 81006

Possible synonym:

Hemihysteriaceae Sacc. & Traverso, Annls mycol. 5(4): 318 (1907)

Foliar epiphytes and *biotrophi*s on leaves of various plants. Superficial mycelium sparse or absent. Sexual state: *Thyriothecia* superficial, lacking a darkened rim, blue green, blue black to black, flattened, scutate, upper wall comprising non radiate, flattened, often meandrous interwoven cells, with a poorly developed basal layer. *Hamathecium* comprising narrowly cellular pseudoparaphyses, but often deliquescing in mature specimens and not always present. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cylindrical, or elongate, *asci* developing inclined towards the center of thyriothecia. *Ascospores* trans-septate, usually with more than two septa. Asexual state: see notes below

Notes: Kirk et al. (2008) estimated that there are 27 genera and 186 species in the family *Micropeltidaceae* which was introduced by Clements and Shear (1931). The *Micropeltidaceae* is rather unique family as ascomata comprise thyriothecia which develop superficially or in the outer cuticle on usually green living leaves of hosts and mycelium are few or absent, superficial and do not appear to penetrate the host (von Arx and Müller 1975). This family was accepted

by von Arx and Müller (1975) with eight genera, Barr (1987a) with five genera, Kirk et al. (2008) with 27 genera and Lumbsch and Huhndorf (2010) with 24 genera, but there is no modern treatment. Besides the monographs of Batista (1959), the family is rather poorly known and studied. Although resembling *Microthyriaceae* in having thyriothecia, *Micropeltidaceae* can be readily distinguished by the mostly bluish-green ascomata and structure of the peridium and long clavate ascospores with mostly more than two transverse septa. The pseudoparaphyses are narrowly cellular, but tend to deliquesce in mature specimens, and are not always present as distinguishing characters. In the type species, *Micropeltis applanata*, the peridium of the often bluish-green thyriothecia comprises an irregular meandering arrangement of compact hyphae, while the ascospores are long clavate with up to eight transverse septa. In our study we accept *Micropeltidaceae* as a distinct family and describe the type species (i.e. *Micropeltis applanata*).

Wijayawardene et al. (2012) listed the asexual states of *Micropeltidaceae* as *Cyclopeltella*, *Heliocephala*, *Holubovaniella* and *Sirothyriella*. Abarca et al. (2011) investigated the phylogenetic relationships among species of *Heliocephala* and *Holubovaniella* and concluded that *Stomiopeltis betulae* J.P. Ellis (*Micropeltidaceae*) are their closest relative. Wu et al. (2011a) transferred *Byssopeltis*, *Caudella* and *Scolecopeltidium* to this family. At present, we accept ten genera in this family.

Type: Micropeltis Mont., in Sagra, Historia física, polirica ynaytural de la islea de Cuba: 325 (1842) [1838–1842], MycoBank MB3180 Fig. 77

Foliar epiphytes on leaves, superficial mycelium absent or not observed. Sexual state: *Thyriothecia* circular, gregarious, superficial, membranous, bluish or greenish to black, lower peridium poorly developed, easily removed from the host surface, with a central irregular ostiole; in section lenticular, upper wall comprising of an irregular meandering arrangement of compact hyphae. *Peridium* black to light brown, comprising two strata, outer cells black and compact, inner cells comprising loosed light brown cells of *textura angularis*. *Hamathecium* comprising asci embedded in mucilage and asci inclined toward the central ostiole, pseudoparaphyses sparse or deliquescing. *Asci* 6–8-spored, bitunicate, fissitunicate, obclavate to widely fusiform, pedicellate, ocular chamber not well-developed. *Ascospores* 2–3 over-lapping seriate, hyaline, long clavate, trans-septate, smooth-walled. Asexual state: Unknown.

Notes: Micropeltis was established by Montagne (1842) and presently there are 260 names listed in Index Fungorum (2013). In a monograph of the taxon, Batista (1959) recognized 89 species and 2 varieties in *Micropeltis*. *Micropeltis* differs from *Microthyrium* in having blue-green to brown-black thyriothecia, with a peridium comprising an irregular meandering arrangement of compact hyphae with a central ostiole and multi-septate long clavate ascospores. Batista

(1959) used the colour of the ascomata as major character to separate species into five groups. Due to the variation of colour and size of thyriothecia, ascospore length and width, and the number of septa were used to distinguish species by Reynolds and Gilbert (2005, 2006).

Type species: Micropeltis applanata Mont., Anns Sci. Nat., Bot., sér. 217: 325 (1842) MycoBank: MB 222528

Other genera included

Caudella Syd. & P. Syd., Anns mycol. 14(1/2): 90 (1916).

Type species: Caudella oligotricha Syd. & P. Syd., Anns mycol. 14(1/2): 90 (1916)

Chaetothyria Theiss., Anns mycol. 11(6): 95 (1913)

Type species: Chaetothyria musarum (Speg.) Theiss., Anns mycol. 11(6): 495 (1913)

Dictyopeltella Bat. & I.H. Lima., in Batista, Publções Inst. Micol. Recife 56: 243 (1959)

Type species: Dictyopeltella domingensis (Petr. & Cif.) Bat. & I.H. Lima., in Batista, Publções Inst. Micol. Recife 56: 243 (1959)

Haplopeltica Bat. et al., in Batista et al., Publções Inst. Micol. Recife 388: 5 (1963)

Type species: Haplopeltica hyleensis Bat. et al., in Batista et al., Publicações. Instituto de Micologia da Universidade do Recife & Instituto Nacional de Pesquisas 388: 7 (1963)

Heliocephala V. Rao et al., Persoonia 12(3): 239 (1984)

Type species: Heliocephala proliferans V. Rao et al., Persoonia 12(3): 239 (1984)

Holubovaniella R.F. Castañeda, Deuteromycotina de Cuba, Hyphomycetes (La Habana) 3: 14 (1985)

Type species: Holubovaniella elegans R.F. Castañeda, Deuteromycotina de Cuba, Hyphomycetes (La Habana) 3: 16 (1985)

Scolecopeltidium F. Stevens & Manter, Bot. Gaz. 79(3): 282 (1925)

Type species: Scolecopeltidium mirabile F. Stevens & Manter, Bot. Gaz. 79(3): 283 (1925)

Sirothyriella Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 451 [59 repr.] (1910)

Type species: Stomiopeltis pinastri (Fuckel) Arx, in Müller & von Arx, Beitr. Kryptfl. Schweiz 11(no. 2): 545 (1962)

Stomiopeltis Theiss., Brotéria, sér. bot. 12: 85 (1914)

Type species: Stomiopeltis aspersa (Berk.) Theiss, Brotéria, sér. bot. 12: 85 (1914)

Stomiopeltopsis Bat. & Cavalc., in Batista, Bezerra, Cavalcante, Maia & Silva, Publções Inst. Micol. Recife 392: 30 (1963)

Type species: Stomiopeltopsis linacearum Bat. & Cavalc., in Batista et al., Publicações. Instituto de Micologia da Universidade do Recife & Instituto Nacional de Pesquisas 392: 31 (1963)

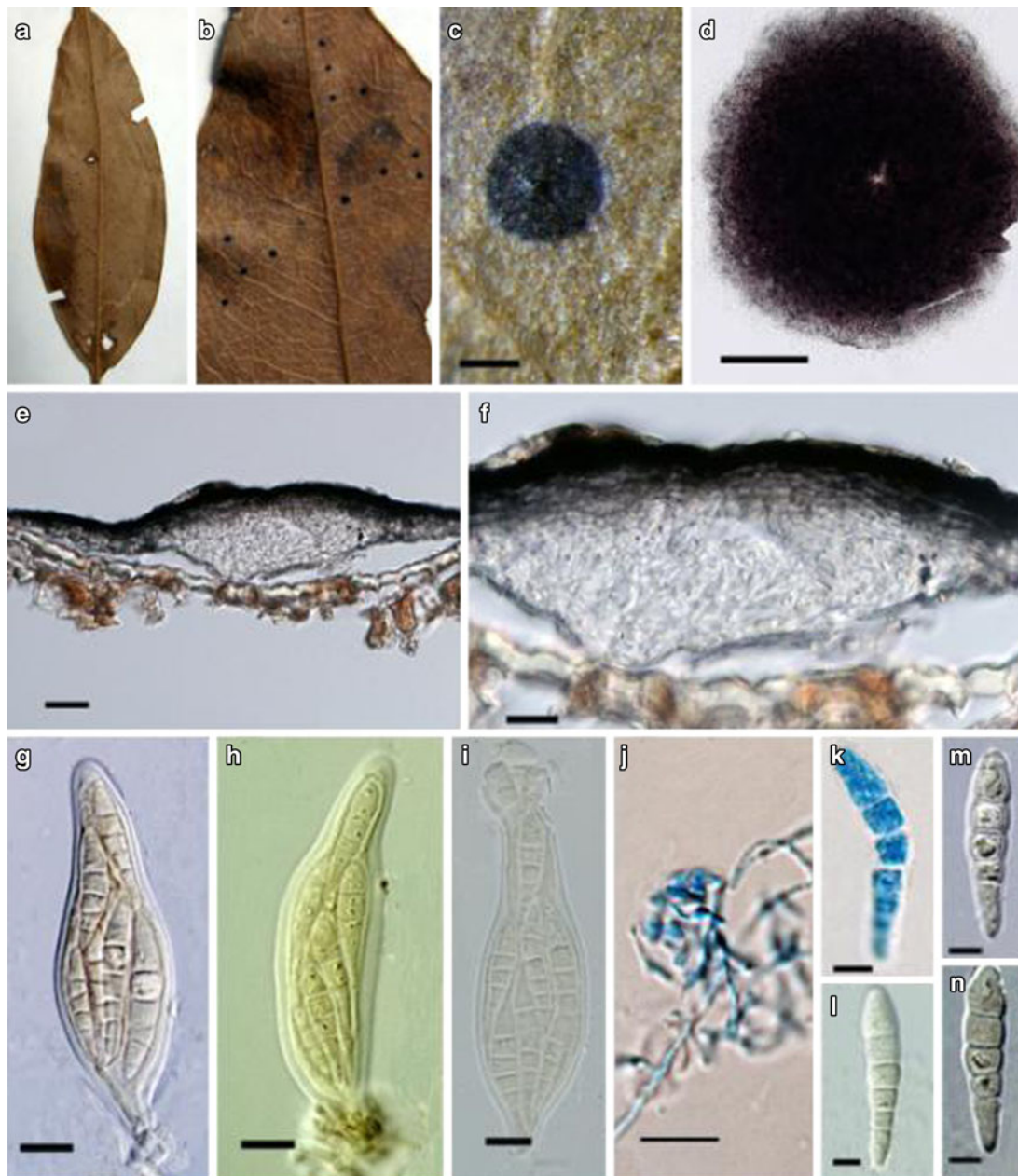


Fig. 77 *Micropeltis applanata* (Material examined: CUBA, no location or date, PC 0097156, **lectotype**) **a** Habit of fungus. **b, c** Appearance of ascomata on the host surface. **d** Squash mount of ascoma. **e, f** Section of

ascoma. Note the peridium. **g–i** Asci. **j** Pseudoparaphyses in a gelatinous matrix. **k–n** Ascospores. Scale bars: **c**=200 μ m, **d**=50 μ m, **e**=20 μ m, **g–j**=10 μ m, **k–n**=5 μ m

Stomiotheca Bat., Publções Inst. Micol. Recife 56: 453 (1959)

Type species: *Stomiotheca amazonensis* Bat., Publções Inst. Micol. Recife 56: 457 (1959)

Key to sexual genera of Micropeltidaceae

- 1. Superficial hyphae absent or inconspicuous2
- 1. Superficial hyphae often well-developed3
- 2. Pseudoparaphyses absent4
- 2. Pseudoparaphyses present5

- 3. Superficial hyphae with alternative sparse hyphopodia*Caudella*
- 3. Superficial hyphae without hyphopodia*Stomiotheca*
- 4. Ascospores two-celled, 1-septate*Chaetothyrina*
- 4. Ascospores with more than 2 septa6
- 5. Ascospores 1-septate7
- 5. Ascospores with more than 2 septa8
- 6. Ascospores usually 3–4-septate, ascomata larger than 500 μ m diam*Stomiopeltopsis*

6. Ascospores usually 3–6-septate, ascomata less than 400 µm diam *Haplopetheca*
 7. Ascomata smaller than 200 µm diam *Stomiopeltis*
 7. Ascomata larger than 200 µm diam *Dictyopeltella*
 8. Ascospores with less than 10 septa *Micropeltis*
 8. Ascospores with more than 20 septa *Scolecopeltidium*

Key to asexual genera of *Micropeltidaceae*

1. Coelomycetous form with pycnothyrial conidiomata *Sirothyriella*
 1. Hyphomycetous form 2
 2. Conidiogenous cell hyaline to pale brown; conidia phragmospores, rostrate *Heliocephala*
 2. Conidiogenous cell brown; conidia rostrate or with apical appendage *Holubovaniella*

Microthyriaceae Sacc., Syll. fung. (Abellini) 2: 658 (1883), MycoBank: MB 81008

Foliar epiphytes, biotrophs or saprotrophs on leaves of various plants. Sexual state: Superficial mycelium if present, brown, septate, some with hyphopodia, some mycelium forming haustoria. *Thyriothecia* superficial, relatively small (less than 200 µm diam), flattened, scutate, having an upper wall of neatly arranged cells which radiate from the prominent often darkened circular central ostiole in a somewhat parallel arrangement, with a poorly developed basal layer. *Hamathecium* of pseudoparaphyses which are often distinct, although sometimes deliquescing and lacking. *Asci* 8-spored, bitunicate, fissitunicate, elongate fusiform to cylindrical, with or without a pedicel, with an ocular chamber or ocular not distinct. *Ascospores* usually 1-septate, ovoid, fusiform to ellipsoidal, or clavate, sometimes with cilia or appendages which may be hard to observe, hyaline, or becoming brown when mature. Asexual state: see under notes.

Notes: Kirk et al. (2008) estimated there are 54 genera and 278 species in the family. Wu et al. (2011a) accept seven genera and approximately 220 species. The most distinctive family characteristic in *Microthyriaceae* is the thyriothecium (Doige 1942; Müller and von Arx 1962; Luttrell 1973; Barr 1987a, b, c; Hofmann and Piepenbring 2006; Hofmann et al. 2010; Wu et al. 2011a). In *Microthyriaceae* this is a typically flattened, scutate ascoma, having an upper wall of neatly arranged cells which radiate from the central, darkened, prominent ostiole in a somewhat parallel arrangement, but the wall is thin at the base. Thyriothecia in *Microthyriaceae* are relatively small, and some can easily be removed from the host surface; asci and pseudoparaphyses are arranged from a hymenium around the periphery of the ascomata and grow inwards towards the ostiole. The asci are bitunicate, fissitunicate, fusiform, obclavate to cylindro-clavate and ascospores are mostly two-celled. In recent studies, *Tothia* and *Muyocopron* with thyriothecia typical of *Microthyriaceae* cluster outside this family (Wu et al. 2011b; Fig. 1) and this

character appears to have evolved on more than one occasion. Various authors have also included genera with quite different characters in *Microthyriaceae*, generally but not always with thyriothecia in common. Wu et al. (2011a) restricted *Microthyriaceae* to the species with characters similar to *Microthyrium* with thyriothecia made up of cells radiating from the central ostiole, fusiform, obclavate to cylindro-clavate asci and bicelled hyaline or brown ascospore types which may or may not be ciliate.

Asterostomula, *Hansfordiella*, *Isthmospora*, *Leptothyrium*, *Xenoglocladiopsis* and *Zalerion* are listed as the sexual states of *Microthyriaceae* (Kirk et al. 2008; Seifert et al. 2011; Wijayawardene et al. 2012). However any of the above genera are not linked to their sexual states by molecular methods. The placement of *Zalerion* is not clear as many researchers linked this genus to different sexual states (Nakagiri 1984; Fisher and Webster 1992; Chatmala et al. 2002; Tanaka and Harada 2003c). Ramaley (1999) linked *Z. guadalupensis* A.W. Ramaley to *Microthyrium guadalupensis* A.W. Ramaley based on culture methods. *Xenoglocladiopsis* was introduced to accommodate the hyphomycetous conidial state of *Arnaudiella eucalyptorum* Crous & W.B. Kendr. Crous & Kendrick (1994)

Type: Microthyrium Desm., Anns Sci. Nat., Bot., sér. 2 15: 137 (1841), MycoBank: MB3206 Fig. 78

Saprobic or *biotrophic* mostly on the upper surface of leaves, appearing as very small black spots. Sexual state: *Mycelium* superficial, absent or inconspicuous, comprising almost colourless, branched, septate hyphae, with subcuticular haustoria. *Thyriothecia* circular, solitary or gregarious, superficial, membranaceous or slightly carbonaceous, light brown to brown, with a poorly developed basal layer, easily separated from host surface, with a prominent darker central ostiole; in section lenticular, upper wall comprising cells of *textura epidermoidea*, radiating outwardly in parallel rows from the darker central ostiole. *Hamathecium* comprising asci inclined from the base and rim towards the central ostiole, pseudoparaphyses not observed. *Asci* numerous, 8-spored, bitunicate, fissitunicate, narrowly obclavate to long fusiform, with small knob-like pedicel or pedicel lacking, ocular chamber not well-developed. *Ascospores* overlapping 2–3-seriate, fusiform to ellipsoidal, hyaline, 1-septate, fine appendages sometimes present, smooth-walled. Asexual state: “*Zalerion*”-like (Ramaley 1999).

Notes: *Microthyrium* was formally established by Desmazières (1841) based on ascomata with a radiating structure, called thyriothecia. The genus is widely distributed with a wide host range (Ellis 1976; Ramaley 1999). Desmazières (1841) described *Microthyrium microscopicum* from *Castanea sativa* and later added leaves of *Buxus sempervirens* and *Quercus ilex* as hosts to this species (Ellis 1976). Ellis (1976) described British *Microthyrium* species and similar fungi, and re-described and illustrated the type species of

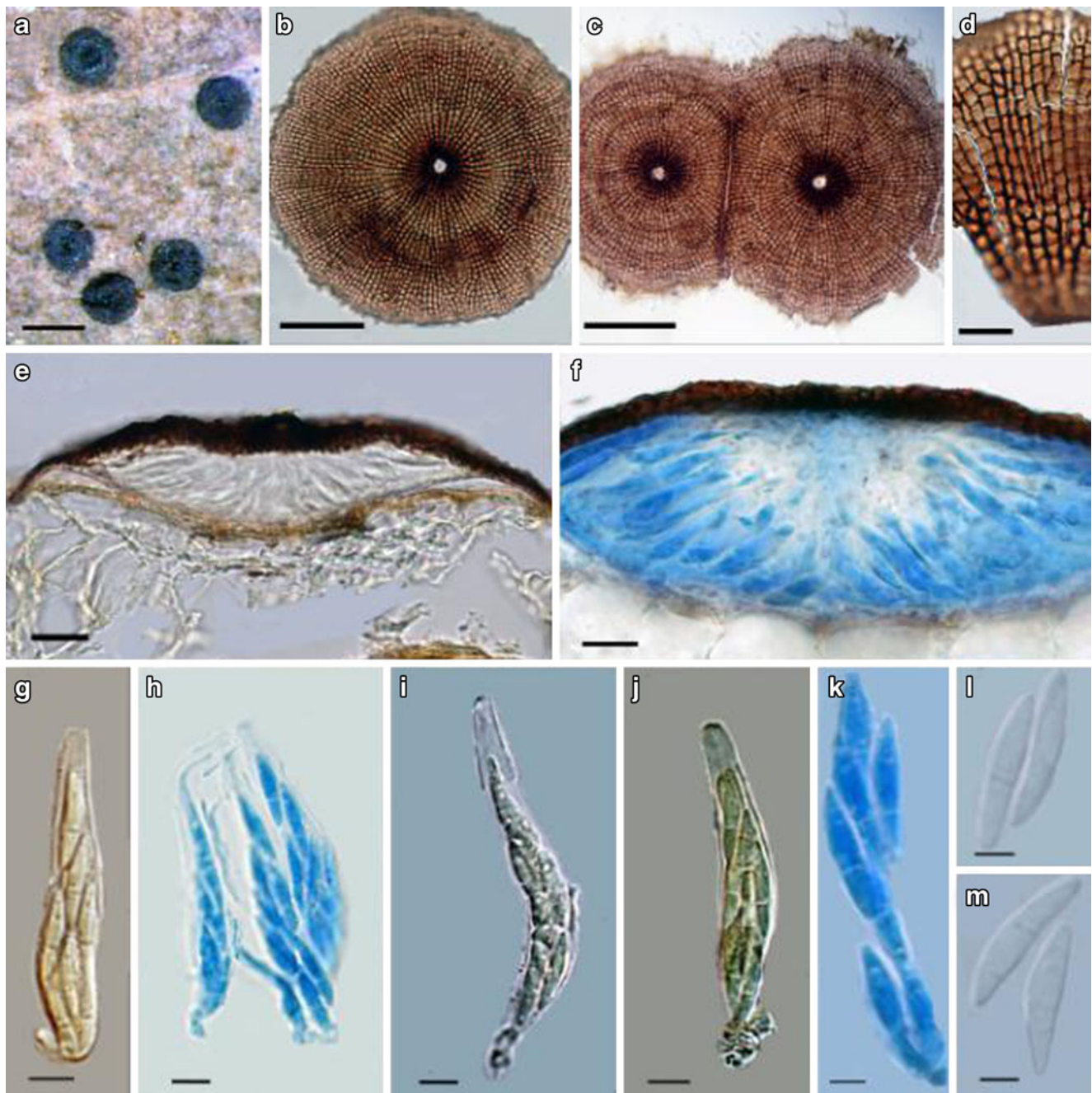


Fig. 78 *Microthyrium microscopicum* (Material examined: UK, Herefordshire, Forest of Dean, on dead leaves of *Quercus robur* (Fagaceae) September 2010, K.D. Hyde, MFLU 09–0653). **a** Thyriotheceae superficial on host. **b–c** Thyriotheceae with ostiole. **d** Arrangement of

thyriotheceum wall. **e–f** Section through the thyriotheceum with thin peridium. **g–k** Bitunicate asci. **l–m** Ascospores with appendages. Scale bars: **b, d** = 100 μ m, **c, e–j** = 20 μ m, **k–l** = 5 μ m

Microthyrium microscopicum. Ellis (1976) examined the type collection on a leaf of *Castanea vulgaris* and found mature ascospores with apical cilia, and commented that the cilia are sometimes visible, depending on the material and slide preparation. Ramaley (1999) described *Z. guadalupensis* from *M. guadalupensis* but the taxonomic position of *Zalerion* is quite confusing as the genus has been linked with many sexual states (Seifert et al. 2011).

Hence we conclude that *Microthyrium* has “Zalerion”-like asexual states.

Type species: Microthyrium microscopicum Desm., Anns Sci. Nat., Bot., sér. 2 15: 138 (1841), MycoBank: MB 213668 Fig. 78

Other genera included

Arnaudiella Petr., Anns mycol. 25(3/4): 339 (1927)

Type species: Arnaudiella caronae (Pass.) Petr., *Annls mycol.* 25(3/4): 339 (1927)

Asterostomula Theiss., *Annls mycol.* 14(3/4): 270 (1916)

Type species: Asterostomula loranthei Theiss., *Annls mycol.* 14(3/4): 270 (1916)

Calothyriopsis Höhn., *Sber. Akad. Wiss. Wien, Math. naturw. Kl., Abt. 1* 128: 552 (1919)

Type species: Calothyriopsis conferta (Theiss.) Höhn., *Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1* 128: 552 (1919)

Caribaeomyces Cif., *Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5* 19: 98 (1962)

Type species: Caribaeomyces tetrasporus (Toro) Cif. [as ‘*tetraspora*’], *Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5* 19: 98 (1962)

Hansfordiella S. Hughes, *Mycol. Pap.* 47: 10 (1951)

Type species: Hansfordiella asterinearum S. Hughes, *Mycol. Pap.* 47: 11 (1951)

Isthmospora F. Stevens, *Bot. Gaz.* 65(3): 244 (1918)

Type species: Isthmospora spinosa F. Stevens, *Bot. Gaz.* 65(3): 244, tab. 6, Fig. 17 (1918)

Leptothyrium Kunze, in Kunze & Schmidt, *Mykologische Hefte* (Leipzig) 2: 79 (1823)

Type species: Leptothyrium lunariae Kunze, in Kunze & Schmidt, *Mykologische Hefte* (Leipzig) 2: 79 (1823)

Palawania Syd. & P. Syd., *Philipp. J. Sci., C, Bot.* 9(2): 171 (1914).

Type species: Palawania grandis (Niessl) Syd. & P. Syd., *Philipp. J. Sci., C, Bot.* 9(2): 171 (1914).

Seynesiella G. Arnaud, *Annals d’École National d’Agric. de Montpellier, Série 2* 16(1–4): 202 (1918) [1917]

Type species: Seynesiella juniperi (Desm.) G. Arnaud, *Annals d’École National d’Agric. de Montpellier, Sér. 2* 16(1–4): 203 (1918) [1917]

Key to sexual genera of *Microthyriaceae*

1. Saprobic, superficial hyphae absent or inconspicuous2
1. Parasitic, superficial hyphae often well-developed3
2. Ascospores hyaline4
2. Ascospores pigmented when mature5
3. Superficial hyphae absent, ascospores pigmented*Seynesiella*
3. Superficial hyphae present, ascospores hyaline6
4. Ascospores 2–3-seriate*Microthyrium*
4. Ascospores uniseriate*Paramicrothyrium*
5. Ascospores without hyaline sheath*Arnaudiella*
5. Ascospores with a hyaline sheath*Palawania*
6. Mycelia without lateral hyphopodia*Calothyriopsis*
6. Mycelia with hyphopodia*Caribaeomyces*

Key to asexual genera of *Microthyriaceae*

1. Coelomycetous asexual states with pycnothyrial conidiomata2

1. Hyphomycetous asexual states3
2. Conidia hyaline*Leptothyrium*
2. Conidia pigmented*Asterostomula*
3. Conidiomata sporodochial with hyaline setae*Xenogliocladiopsis*
3. Conidiomata not sporodochia4
4. Conidiophores absent; conidiogenous cell blastic, paired, brown*Isthmospora*
4. Conidiophores reduced5
5. Conidiogenous cells monoblastic or polyblastic, scars present*Hansfordiella*
5. Conidiogenous monoblastic or solitary, thallic, brown*Zalerion*

Monoblastiaceae Walt. Watson, *New Phytol.* 28: 106 (1929), MycoBank: MB 81020

Lichenized on bark, more rarely on rocks, leaves (sub- or supra-cuticular) or possibly lichenicolous in rare cases; in terrestrial, chiefly lowland to montane tropical to subtropical habitats, with few species extending into temperate regions. Sexual state: *Thallus* reduced and ecorticate, white, to distinctly corticate, grey-green to olive brown, sometimes shiny. *Photobiont* trentepohlioid. *Ascomata* scattered, clustered, or aggregated, immersed to sessile, mostly black but sometimes covered by thallus, globose to pear-shaped or conical, carbonaceous, ostiolate, ostiole round, often eccentric. *Involucrellum* present or reduced, usually carbonized. *Excipulum* dense, consisting of compressed hyphae, appearing prosoplectenchymatous in thin, bleached sections, but structure sometimes difficult to observe due to carbonization, hyaline to brown or brown-black. *Hamathecium* comprising 0.5–0.7 μm wide paraphyses (trabeculate pseudoparaphyses according to Harris 1990, 1995), hyaline, straight, branched and anastomosing. *Asci* (1–)8-spored, bitunicate, fissitunicate, mostly cylindrical, short pedicellate, with narrow to broad, non-amyloid ocular chamber and fluorescent ring- or cap-structures. *Ascospores* irregularly arranged to uni- or biseriate, ellipsoid-oval to oblong or sometimes fusiform, hyaline to rarely brown, non-septate or 1–3-septate, with thin to rather thick eusepta and more or less rectangular lumina, smooth-walled or ornamented, sometimes slightly constricted at the septa, in 1-septate ascospores the upper cell often distinctly larger than the lower cell. Asexual state: *Pycnidia* common, immersed to sessile and visible as black dots, but sometimes conspicuous and flask-shaped with a short to long beak, or hair-like or asymmetrically cup- or ear-shaped (campylidia). *Conidia* acrogenous, either macro- or microconidia; macroconidia usually non-septate, ellipsoid to bacillar, usually larger than $5 \times 2.5 \mu\text{m}$, hyaline, often forming clusters embedded in a gelatinous matrix, these clusters in some species in the form of sacci or cirri; microconidia non-septate, globose to ellipsoid or fusiform, small, usually smaller than $4 \times 2 \mu\text{m}$, hyaline. *Chemistry*: Most species do not

contain secondary substances; lichexanthone and anthraquinone pigments are known from a few taxa.

Notes: Although *Monoblastiaceae* was introduced rather early by Watson (1929), the genera now included in this family were for a long time assigned to other groups. Its largest genus, *Anisomeridium*, and the type, *Monoblastia* were usually placed in *Strigulaceae* (Harris 1975), with many species that are now included in *Anisomeridium* first described in other genera, such as *Arthopyrenia* (Harris 1975). There are many similarities with *Strigulaceae* in hamathecium, ascus, and ascospore types, although the hamathecium of *Monoblastiaceae* also resembles that of *Trypetheliaceae* (Harris 1975, 1990, 1995; Aptroot 1991a; Lücking 2008). *Musaespora* was first placed in *Aspidotheliaceae* (Aptroot and Sipman 1993) before it was suggested to belong in *Monoblastiaceae* (Lücking and Sérusiaux 1996) and eventually synonymized with *Trypetheliopsis* (Kashiwadani et al. 2009). *Acrocordia* was placed as a subgenus of *Leiophloea* in *Mycoporaceae* by Riedl (1961) and later treated as a subgenus of *Arthopyrenia* (Swinscow 1970).

Eriksson (1981) suggested that *Monoblastiaceae* formed part of *Pertusariaceae* in Lecanoromycetes. Harris (1990, 1995) and Aptroot (1991a) argued for its retention as a separate family, which Eriksson and Hawksworth (1993) agreed with, and Harris (1990, 1995) was the first to provide a natural circumscription. Molecular studies have since demonstrated the placement of most of the core genera of *Monoblastiaceae* in a strongly supported clade in Dothideomycetes (Nelsen et al. 2009, 2011a) and we also introduce a new order to accommodate it. Specimens of *Monoblastia* however, have yet to be sequenced.

Generic delimitation within *Monoblastiaceae* has not been settled. *Monoblastia* and *Acrocordia* seem to form natural entities, set apart by their ascus and ascospore types (Harris 1990, 1995; Grube 1993; Sérusiaux and Aptroot 1998; Aptroot 2002b). *Anisomeridium* appears to be a collective genus including several smaller, natural entities (Harris 1995) and contains species which share similarities with other genera such as *Caprettia* (Sérusiaux and Lücking 2003). Some species with brown ascospores might belong in the unrelated genus *Mycomicrothelia* in *Trypetheliaceae* (Lücking et al. 2011). *Trypetheliopsis* (= *Musaespora*) is characterized by unique, campylidioid conidiomata, but there appears to be a close relationship to species currently placed in *Megalotremis*, both sharing also the same thallus type (Aptroot 1991b; Lücking 2008), a finding confirmed by molecular data (Nelsen et al. 2009). *Caprettia* shares similarities with some *Anisomeridium* species, such as their pycnidial morphology and the production of conidia in clusters (sacci) in a gelatinous matrix. Within *Caprettia*, two morphological groups exist, which are separated by their photobiont (*Cephaleuros* vs. *Phycopeltis*) and whether they grow sub-

or supracuticularly on leaves (Sérusiaux and Lücking 2003). These groups have been treated at both the generic (Vézda 1975, 2004) and subgeneric level (Sérusiaux and Lücking 2003).

Monoblastiaceae presently includes six genera and possibly over 200 species, most of them in *Anisomeridium* sensu lato (Batista and Maia 1965; Harris 1990, 1995; Aptroot 1991b, 1995a; Sérusiaux and Aptroot 1998; Lücking et al. 1998; Sérusiaux and Lücking 2003; Lücking 2008; Aptroot et al. 2008; Yeshitela et al. 2009). The bulk of these taxa grow on bark in tropical forests, but the family is also a common element of leaf-dwelling lichen communities (Aptroot and Sipman 1993; Lücking 2008).

Type: *Monoblastia* Riddle, *Mycologia* 15: 70 (1923), MycoBank: MB 3251 Fig. 79

Lichenized on bark or rarely on limestone, in terrestrial, chiefly lowland to montane tropical to subtropical habitats, with few species extending into temperate regions. Sexual state: *Thallus* usually ecorticate, white. *Photobiont* *Trentepohlia*. *Ascomata* scattered or rarely clustered, erumpent to sessile, mostly black, carbonaceous, ostiolate, ostiole round. *Involucrellum* present or reduced, carbonized. *Excipulum* dense, consisting of compressed hyphae, appearing prosoplectenchymatous in thin, bleached sections, hyaline to brown or brown-black. *Hamathecium* comprising 0.5–0.7 μm wide paraphyses, hyaline, straight, branched and anastomosing. *Asci* (2–)8-spored, bitunicate, fissitunicate, cylindrical, short pedicellate, with broad, non-amyloid ocular chamber and fluorescent cap-structures. *Ascospores* mostly uniseriate, ellipsoid-oval, hyaline, non-septate, ornamented with warts, short ridges or spines. Asexual state: *Pycnidia* rare. *Conidia* acrogenous, microconidia, non-septate, oblong to ellipsoid to fusiform, small, hyaline. **Chemistry:** Secondary substances absent.

Notes: *Monoblastia* is easily recognized by its peculiar, non-septate, spiny or warted ascospores which are unique at least in lichenized fungi. It is rather atypical for the family in this respect, although hamathecium and ascus type agree well with the other members of the family. The genus is rather small, with eleven species currently recognized (Riddle 1923; Zahlbruckner 1935; Hedrick 1942; Harris 1990, 1995; Aptroot 1991a; Sérusiaux and Aptroot 1998; Breuss 2001).

Type species: *Monoblastia palmicola* Riddle, *Mycologia* 15(2): 71 (1923), MycoBank: MB 395647

Other genera included

Acrocordia A. Massal., *Geneac. Lich.* (Verona): 17 (1854)

Type species: *Acrocordia garovaglioii* A. Massal. [as ‘*garovaglii*’], *Geneac. lich.* (Verona): 17 (1854)

Anisomeridium (Müll. Arg.) M. Choisy, *Icon. Lich. Univ.* 1: 24 (1928), MycoBank: MB 201

Figure 80

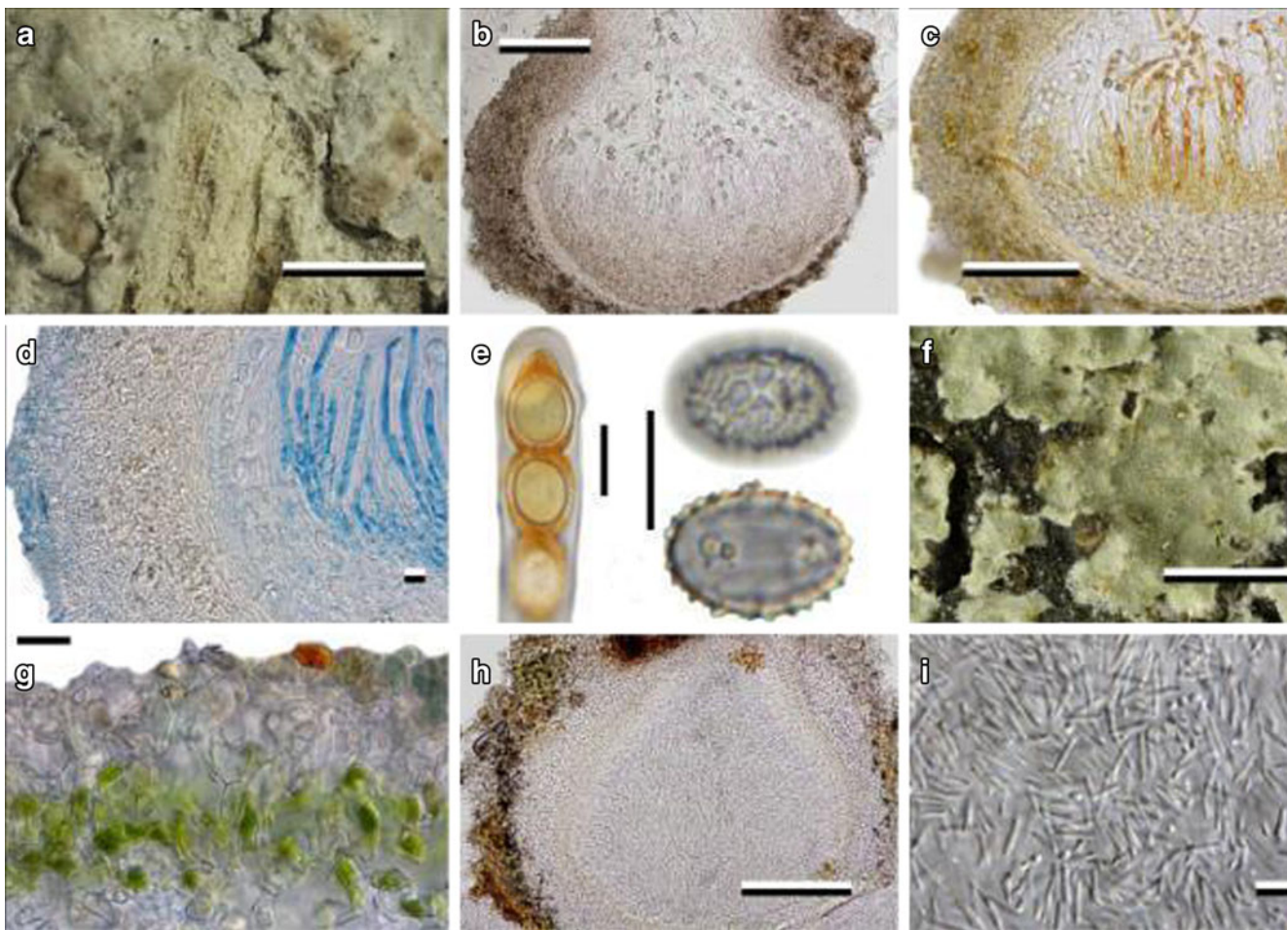


Fig. 79 *Monoblastia pellucida* (a–e Aptroot 15095, f–i Aptroot 17507). **a** Surface view of thallus and perithecial ascomata. **b–d** Section through ascoma, in **(c)** with iodine solution added. **e** Ascus (tip) and ascospores in median and surface view showing ornamentation. **f** Surface view of

thallus with pycnidia. **g** Section through thallus showing photobiont. **h** Section through pycnidium. **i** Microconidia. Scale bars: **f**=1 mm, **b–c**, **h**=100 μ m, **d–e**, **g**, **i**=10 μ m

Lichenized on bark or more rarely on leaves or rocks, possibly lichenicolous; in terrestrial, chiefly lowland to montane tropical to subtropical habitats, with few species extending into temperate regions. Sexual state: *Thallus* usually ecorticate or sometimes with thin cortex, white or shades of grey-green to green. *Photobiont* *Trentepohlia*. *Ascomata* scattered or rarely clustered, erumpent to sessile, mostly black, carbonaceous, ostiolate, ostiole round. *Involucrellum* present or reduced, carbonized. *Excipulum* dense, consisting of compressed hyphae, appearing prosoplectenchymatous in thin, bleached sections, hyaline to brown or brown-black. *Hamathecium* comprising 0.5–0.7 μ m wide paraphyses, hyaline, straight, branched and anastomosing. *Asci* (2–)8-spored, bitunicate, fission-tunicate, cylindrical, short pedicellate, with narrow, non-amyloid ocular chamber and fluorescent cap-like, or ring-like structures. *Ascospores* mostly uni- or biseriolate, ellipsoid-oval to broadly fusiform, hyaline to rarely brown, 1–3-septate, with thin eusepta and rectangular lumina, smooth-walled or rarely ornamented, sometimes slightly constricted at the septa, in 1-septate ascospores the upper cell

often distinctly larger than the lower cell. Asexual state: *Pycnidia* common, immersed to sessile, visible as black dots but sometimes conspicuous and flask-shaped. *Conidia* acrogenous, either macro- or microconidia; macroconidia usually non-septate, ellipsoid to bacillar, usually larger than $5 \times 2.5 \mu$ m, hyaline, often forming clusters embedded in a gelatinous matrix, these clusters in some species in the form of sacci or cirri; microconidia non-septate, ellipsoid to fusiform, small, usually smaller than $4 \times 2 \mu$ m, hyaline. *Chemistry*: Most species do not contain secondary substances; lichexanthone found in some taxa.

Notes: *Anisomeridium* is the largest genus within *Monoblastiaceae*, with close to 200 species currently accepted (Harris 1995). It forms the natural core of the family, but is in itself heterogeneous. Some of the species with brown ascospores might not actually belong here but in *Mycomicrothelia*, which is very easily confused with *Anisomeridium* except for ascospore pigmentation (Lücking et al. 2011). The relationships of species with beaked or flask-shaped pycnidia to *Capretzia* and *Megalotremis* need to be

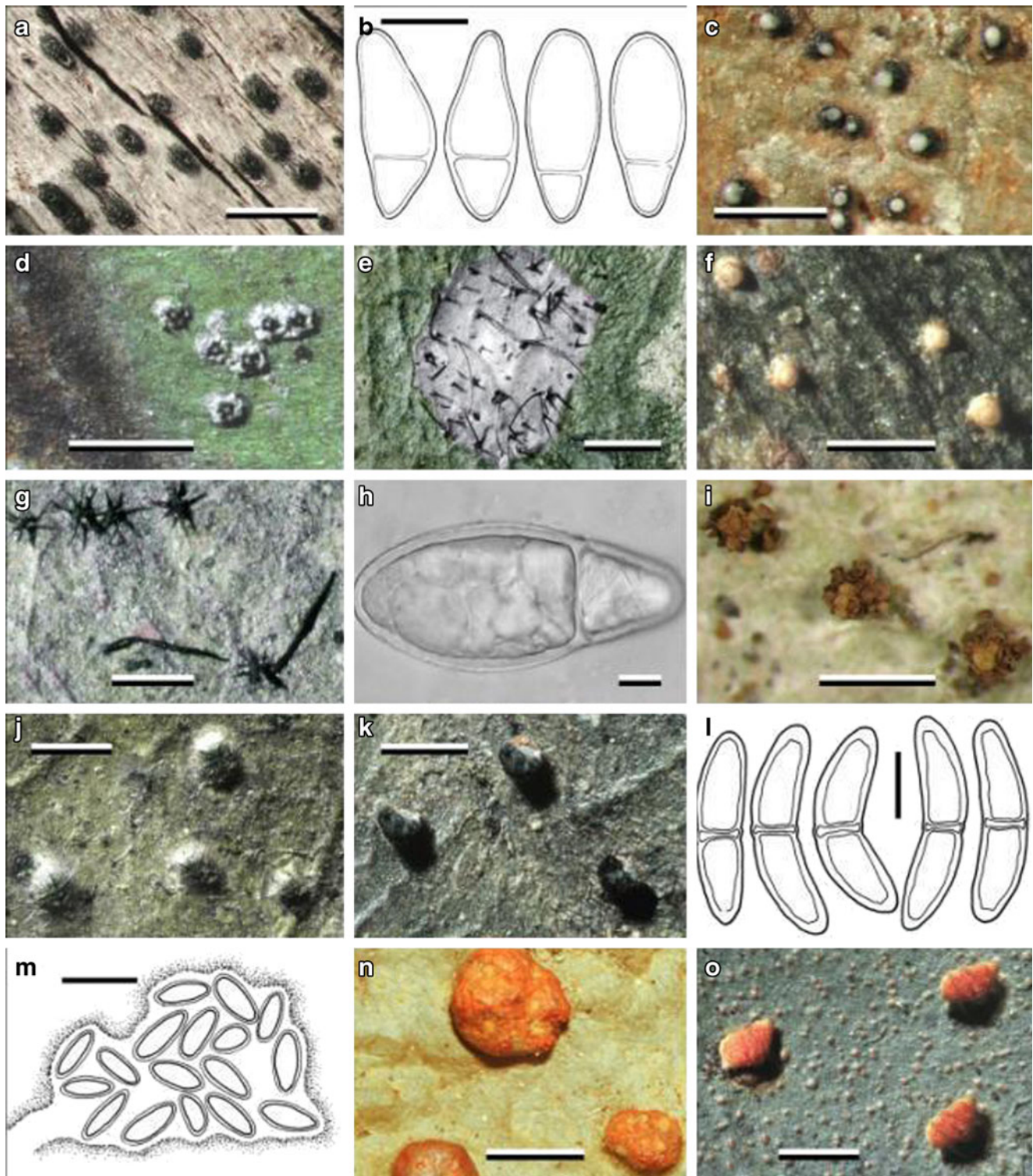


Fig. 80 *Monoblastiaceae* **a** Surface view of thallus and perithecial ascomata of *Anisomeridium subprostans*. **b** Ascospores of *A. musaesporoides*. **c** Pycnidia of *A. guttuliferum*. **d** Pycnidia of *A. foliicola*. **e** Pycnidia of *Caprettia amazonensis*. **f** Ascomata of *C. tanzanica*. **g** Ascomata and two pycnidia of *C. nyssaegenoides*. **h** Ascospore of *Megalotremis laterale*. **i** Pycnidia and clusters of

macroconidia embedded in hardened gelatinous matrix of *M. cauliflora*. **j** Ascomata of *Trypetheliopsis kalbii*. **k** Campylidiiform pycnidia of *T. kalbii*. **l** Ascospores of *T. kalbii*. **m** Macroconidia of *T. kalbii* embedded in gelatinous matrix. **n** Compound ascomata of *T. boninensis*. **o** Campylidioid pycnidia of *T. coccinea*. Scale bars: **a**, **c–g**, **i–k**, **n–o** = 1 mm, **b**, **h**, **l–m** = 10 μ m

studied further. Unfortunately, very few molecular data exist at present for the family as a whole and for *Anisomeridium* in particular (Nelsen et al. 2009, 2011a). The asexual species *Sarcinulella banksiae* B. Sutton & Alcorn (Sutton and Alcorn 1983) and *Composporiella deightonii* Sankaran & B. Sutton (Sankaran and Sutton 1991) are known to be the pycnidial forms of *Anisomeridium* species (Harris 1995; Aptroot 1999; Aptroot and Sipman 2001), sharing their distinctive morphology and expulsion of conidial masses in mucilage.

Pycnidia of *A. polypori* were reported as lichenicolous, growing on a dead *Sticta weigeli* in Guatemala, interpreted as a lichenicolous lichen (Etayo and Van den Boom 2006). It is unclear whether this fungus is a saprotroph, parasitizing the *Sticta* mycobiont, associated with its own photobiont, or associated with the photobiont from the host lichen. As *S. weigeli* associates exclusively with cyanobacteria, and *Anisomeridium* associates with *Trentepohliaceae*, an association with the *Sticta* photobiont seems unlikely. Etayo (2002) also discovered *Anisomeridium* on a decaying *Megalospora tuberculosa* thallus in the Pyrenees. At present, this possibly lichenicolous nutritional mode appears especially rare within *Monoblastiaceae*.

Type species: Arthopyrenia xylogena Müll. Arg., (1883)

Caprettia Bat. & H. Maia, Atas Inst. Micol. Univ. Pernambuco 2: 377 (1965)

Type species: Caprettia amazonensis Bat. & H. Maia, Atas Inst. Micol. Univ. Recife 2: 378 (1965) Fig. 80

Megalotremis Aptroot, Biblioth. Lichenol. 44: 124 (1991)

Type species: Megalotremis verrucosa (Makhija & Patw.) Aptroot, Biblioth. Lichenol. 44: 126 (1991) Fig. 80

Trypetheliopsis Asahina, J. Jap. Bot. 13: 319 (1937) Fig. 80

Type species: Trypetheliopsis boninensis Asahina, J. Jap. Bot. 13: 319 (1937)

Key to genera of *Monoblastiaceae*

1. Ascospores non-septate, with wart- or peg-like ornamentation **Monoblastia**
1. Ascospores 1–3-septate 2
2. Ascospores small (usually less than 50 μm long) and with thin walls and septa; thallus mostly thin and ecorticate or with thin cortex and matt 3
2. Ascospores large (usually more than 50 μm) and with thicker walls and septa and often needle-shaped crystals; thallus well-developed, corticate and often with metallic appearance 5
3. Asci with broad ocular chamber; ascospores oblong, granular ornamented; temperate regions **Acrocordia**
3. Asci with narrow ocular chamber; ascospores ellipsoid to fusiform, smooth to rarely ornamented; mostly tropical 4

4. Pycnidia forming long, filiform beaks; on leaves **Caprettia**
4. Pycnidia otherwise, if flask-shaped then on bark **Anisomeridium**
5. Pycnidia resembling campylidia **Trypetheliopsis**
5. Pycnidia variously shaped but not resembling campylidia **Megalotremis**

Montagnulaceae M.E. Barr, Mycotaxon 77: 194 (2001), MycoBank: MB 82111

Saprobic in terrestrial or aquatic environments. Sexual state: *Ascomata* scattered or gregarious, immersed in substrate, surrounded with hyphae forming an apical clypeus, dark brown to black, globose to rarely subglobose, medium to large sized, and coriaceous. *Ostiole* immersed to sub-immersed, periphysate when well-developed with short apex, narrow or wide, usually circular in section. *Peridium* 2-layered or often 3-layered in the upper region, composed of cells of *textura angularis*, dark brown to black, coriaceous, outermost layer consisting of black, highly pigmented thick-walled conglutinate cells or pseudoparenchymatous cells, middle layer with less pigmented cells visible via apex, innermost layer comprising narrow, compressed rows of cells. *Hamathecium* of dense, septate, narrow, cellular pseudoparaphyses often in a gelatinous matrix. *Asci* 4–8-spored, bitunicate, fissitunicate, cylindrical or oblong, pedicellate, often with an ocular chamber. *Ascospores* uniseriate or biseriate, often oblong to narrowly oblong, brown to reddish brown or dark yellowish brown, one to several septa (phragmosporous or muriform), walls verruculose, with or without a gelatinous sheath. Asexual states coelomycetous (Barr 2001) *Kalmusia* and *Paraphaeosphaeria* produce “Coniothyrium”-like, “Microsphaeropsis”-like and *Paraconiothyrium* asexual morphs (Zhang et al. 2012a, b).

Notes: Barr (2001) introduced the family, *Montagnulaceae* with three genera including *Kalmusia*, *Montagnula* and *Didymosphaerella* in the order *Pleosporales*. Characters included *ascomata* immersed under a clypeus, a small celled pseudoparenchymatous peridium, cylindrical or oblong, fissitunicate, pedicellate asci and brown, muriform ascospores. Ascospores in *Kalmusia* have two to many transverse septa, in *Montagnula* they were muriform and in *Didymosphaerella* ascospores have a single transverse septum (Barr 2001). The family was thought to be closely related to *Cucurbitariaceae*, but differed in its obtuse ascomal apex with a minute papillate ostiole and thinner-walled, pale ascospores (Barr 2001).

Combined analysis of LSU, SSU, RBP2 and TEF1 gene data (Schoch et al. 2009a, b; Zhang et al. 2012a), however, have shown *Montagnulaceae* to comprise the genera *Bimuria*, *Didymocrea*, *Kalmusia*, *Karstenula*, *Montagnula* and *Paraphaeosphaeria*. Some species of *Phaeosphaeria*, *Paraconiothyrium* and *Letendreaea* also cluster in

Montagnulaceae (Schoch et al. 2009a, b; Zhang et al. 2009a). A new genus *Paraconiothyrium*, was introduced by Verkley et al. (2004) to accommodate four new species, *P. estuarinum* Verkley & M. da Silva, *P. brasiliense* Verkley, *P. cyclothyrioides* Verkley, and *P. fungicola* Verkley & Wicklow. The sexual morphs of these species are unknown, but maximum parsimony analysis of ITS and partial SSU nrDNA sequences showed that these species cluster within *Pleosporales* and group in a clade including *Paraphaeosphaeria* in *Montagnulaceae* (Verkley et al. 2004). In the same study *Coniothyrium minitans* and *C. sporulosum* clustered in the same clade and were therefore also referred to the genus *Paraconiothyrium*. Damm et al. (2008) clearly showed that *Paraconiothyrium* can be accommodated with *Paraphaeosphaeria* in their SSU and ITS analyses. Zhang et al. (2012a) also showed that the asexual morphs of *Paraphaeosphaeria michotii* (Westend.) O.E. Erikss. and *P. pilleata* Kohlm. et al. are representative of *Paraconiothyrium* in their multi-gene analysis. Hence, Wijayawardene et al. (2013) propose to accept the older name *Paraphaeosphaeria* over *Paraconiothyrium*.

Didymosphaerella has been excluded from the family and placed in *Didymellaceae* (Zhang et al. 2012a, b). Schoch et al. (2009a) and Suetrong et al. (2009) showed that the marine ascomycete *Tremateia halophila* Kohlm. et al. grouped in the family. Zhang et al. (2012a) provided a description of *Montagnula*, the type in the family, and also included *Bimuria*, *Didymocrea*, *Karstenula*, *Letendraea*, *Montagnula*, *Paraphaeosphaeria*, and *Tremateia*. Ariyawansa et al. (2013a) added the new genus *Deniquelata*. Species are parasitic, saprotrophic or hemibiotrophic in large monocotyledons and this family now accommodates species which are even saprobic in terrestrial or aquatic environments (Barr 2001; Zhang et al. 2012a, b).

Type: *Montagnula* Berl., Icon. fung. (Abellini) 2: 68 (1896), MycoBank: MB 3265

Figure 81

Saprobic on leaves in terrestrial environments. *Ascomata* gregarious or grouped, immersed to erumpent, dark brown to black globose to subglobose, medium to large sized and coriaceous *Ostiole* short, black to dark brown, filled with hyaline closely adhering cells. *Peridium* 3-layered consisting of black, coriaceous cells, outer layer composed of heavily pigmented thick-walled small cells of *textura angularis*, inner layer consisting of narrow compressed cells and middle layer comparatively less pigmented. *Hamathecium* of dense, septate, broad, branched pseudoparaphyses, anastomosing above the asci, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissionitunicate, cylindro-clavate to clavate, with long pedicel and ocular chamber. *Ascospores* biseriate, partially overlapping, oblong to narrowly oblong, straight or somewhat curved, reddish

brown to dark yellowish-brown, septate with five transverse septa with a vertical septum in each central cell and constricted at the primary and secondary septa, with verruculose ascospore wall. *Asexual state*: Unknown.

Notes: *Montagnula* was introduced by Berlese (1896) in order to separate two dictyosporous species, *M. infernalis* (Niessl) Berl., and *M. gigantea* from *Pleospora*, based on the presence of hyphal stromatic tissue over the ascomata and asci with a long pedicel (Barr 2001). Wehmeyer (1957) placed *Montagnula* as a subgenus of *Pleospora* (1957). Chaverri et al. (2008) again treated *Montagnula* as a separate genus and divided the genus into two subgenera: *Montagnula* and *Rubiginospora* based on dark brown ascospores located on *Agavaceae* and reddish-brown ascospores on *Poaceae* (Barr 2001), but this placement was not accepted by many mycologists. Later, Leuchtmann (1985a) and Aptroot (1995a) included some phragmosporous and didymosporous species in the genus and eventually it became heterogenic (Zhang et al. 2012a, b). The genus presently has 28 epithets (Index Fungorum 2013). GenBank has 19 hits for the genus including putative strains of *Montagnula opulenta* (De Not.) Aptroot (CBS 168.34), *Montagnula aloes* P.W. Crous (CPC 19671), *Montagnula rhodophaea* (Bizz.) Leuchtm. (CBS 616.86), *Montagnula dura* (Niessl) Crivelli (CBS 380.54), *Montagnula spartii* (Fabre) Aptroot (CBS 183.58) and *Montagnula anthostomoides* (Rehm) Leuchtm. (CBS 615.86).

Type species: *Montagnula infernalis* (Niessl) Berl., Icon. fung. (Abellini) 2: 68 (1896), MycoBank: MB 180704

≡ *Leptosphaeria infernalis* Niessl, Inst. Coimbra 31: 13 (1883).

Other genera included

Bimuria D. Hawksw. et al., N.Z. J. Bot. 17(3): 267 (1979)

Type species: *Bimuria novae-zelandiae* D. Hawksw. et al., N.Z. J. Bot. 17(3): 268 (1979)

Deniquelata Ariyawansa & K.D. Hyde, Phytotaxa 105(1): 13 (2013b)

Type species: *Deniquelata barringtoniae* Ariyawansa & K.D. Hyde, Phytotaxa 105(1): 15 (2013b)

Didymocrea Kowalski, Mycologia 57(3): 405 (1965)

Type species: *Didymocrea sadasivanii* (T.K.R. Reddy) Kowalski, Mycologia 57(3): 405 (1965)

Kalmusia Niessl, Verh. nat. Ver. Brünn 10: 204 (1872)

Type species: *Kalmusia ebuli* Niessl, Verh. nat. Ver. Brünn 10: 204 (1872)

Karstenula Speg., Decades Mycologicae Italicae 7–12: no. 94 (in sched.) (1879)

Type species: *Karstenula rhodostoma* (Alb. & Schwein.) Speg., Decades Mycologicae Italicae 7–12: no. 94 (1879)

Letendraea Sacc., Michelia 2(no. 6): 73 (1880)

Type species: *Letendraea eurotioides* Sacc., Michelia 2(no. 6): 73 (1880)

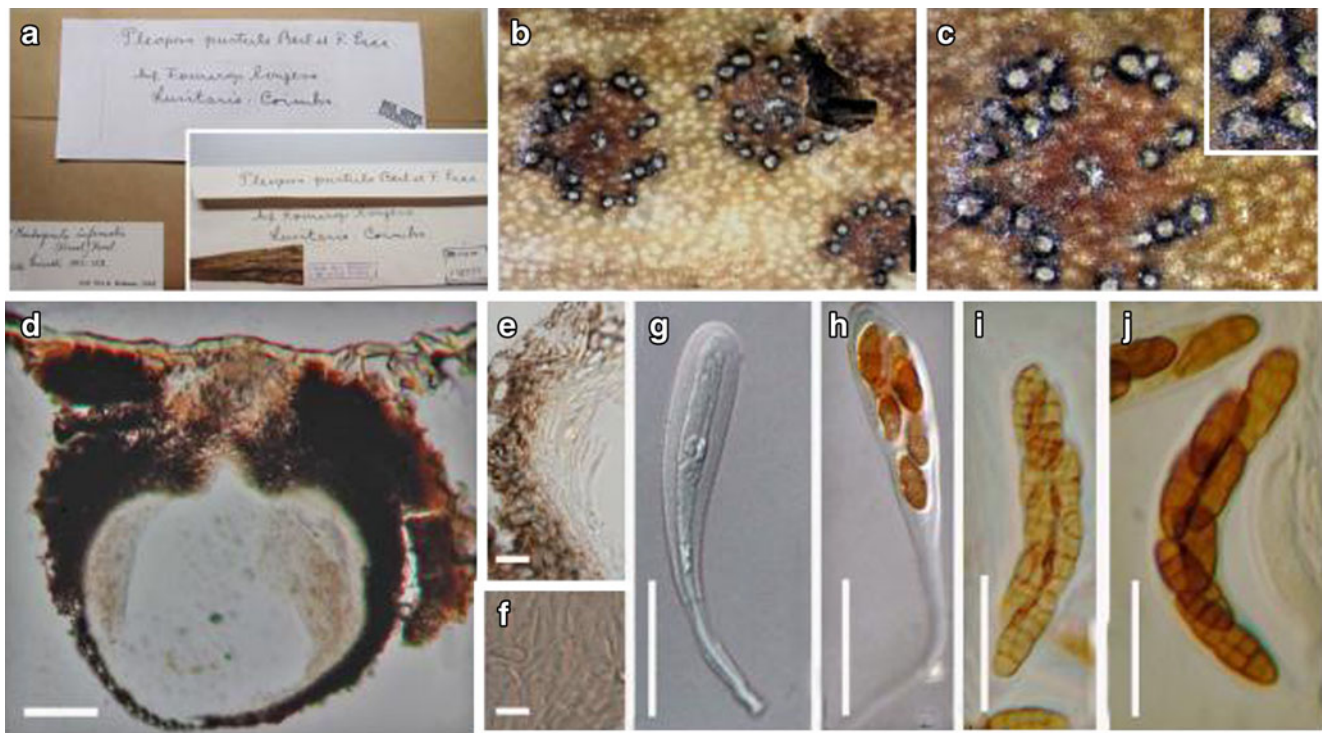


Fig. 81 *Montagnula infernalis* (Material examined: PORTUGAL, Coimbra Lusitania, on leaves of *Fourcroya longava*, February 1881, leg. Moller 1183, M holotype). **a** Herbarium material. **b, c** Dry black ascomata on host surface. **d** Ascoma in horizontal section. **e** Layers of

peridium. **f** Cellular Pseudoparaphyses. **g, h** Young and mature asci with long pedicel. **i, j** Asci bearing muriform ascospores. Scale bars: **a–c** = 0.5 mm, **d** = 100 μ m, **e–f** = 10 μ m, **g–j** = 20 μ m

Paraphaeosphaeria O.E. Erikss., Ark. Bot., Ser. 2 6: 405 (1967)

Type species: *Paraphaeosphaeria michotii* (Westend.) O.E. Erikss., Cryptogams of the Himalayas 6: 405 (1967)

Tremateia Kohlm. et al., Bot. Mar. 38(2): 165 (1995)

Type species: *Tremateia halophila* Kohlm. et al., Bot. Mar. 38(2): 166 (1995)

Key to genera of Montagnulaceae

- 1. Habit terrestrial, parasitic on living leaves*Deniquelata*
- 1. Habit either terrestrial, or marine and saprobic on dead wood2
- 2. Hamathecium of dense, filamentous pseudoparaphyses*Didymocrea*
- 2. Hamathecium of dense, filiform or cellular pseudoparaphyses3
- 3. Asci with short knob-like pedicel*Bimuria*
- 3. Asci with a short furcate pedicel4
- 4. Ascospores with a gelatinous sheath*Paraphaeosphaeria*
- 4. Ascospores without a gelatinous sheath5
- 5. Ascospores with longitudinal septa6
- 5. Ascospores with both longitudinal and vertical septa7
- 6. Ascospores 1-septate*Letendraea*

- 6. Ascospores 3-distoseptate*Kalmusia*
- 7. Asci bearing oblong to narrowly oblong ascospores*Montagnula*
- 7. Asci bearing ellipsoid to fusoid ascospores8
- 8. Ascomata with flattened top and rounded pore-like ostioles*Karstenula*
- 8. Ascomata without flattened top and rounded pore-like ostioles*Tremateia*

Morosphaeriaceae Suetrong et al., Stud. Mycol. 64: 161 (2009), MycoBank MB 515953

Saprobic on lignocellulosic materials in marine, and fresh-water habitats. Sexual state: *Ascomata* subglobose, conical, lenticular, immersed to superficial, brown to black, coriaceous or carbonaceous, single to gregarious, ostiolate and papillate, or pseudostromatic with 2–4 loculi, with a common central, periphysate ostiole. *Peridium* of flattened, thick-walled cells, forming a *textura angularis*. *Hamathecium* comprising hyaline, septate, unbranched to branched, filamentous, trabeculate to filamentous pseudoparaphyses, anastomosing above the asci and embedded in a gelatinous matrix. *Asci* 8-spored, thick-walled, bitunicate, fissionitunicate, clavate to cylindrical, pedicel often elastic, with an ocular chamber. *Ascospores* biseriate, fusiform to ellipsoidal, hyaline to brown, 1–3-septate, with or without a gelatinous sheath or cap. Asexual state: “Pleurophomopsis”-like asexual states in *Helicascus*.

Pycnidia uniloculate, superficial, with the base immersed, solitary, globose to subglobose, wall 2–4 cell layers, covered by mycelium, composed of brown thin-walled cells of *textura angularis*. *Conidiophores* form from the inner cells of pycnidia wall, cylindrical, hyaline, smooth, hardly separate from conidiogenous cells. *Conidiogenous cells* holoblastic, cylindrical to subcylindrical, hyaline, hardly differentiated from the inner wall cells. *Conidia* holoblastic, hyaline, unicellular, occasionally two-celled, ellipsoid to obovoid, thin-walled with 1 or 2 refractive globules, rounded at apex.

Notes: This family was introduced in the *Pleosporales* by Suetrong et al. (2009) for two *Massarina* species that did not group in the *Massarinaceae*: *Morosphaeria velatospora* (K.D. Hyde & Borse) Suetrong et al. and *M. ramunculicola* (K.D. Hyde) Suetrong et al. The taxa *Helicascus kanaloanus* Kohm. and *H. nypae* K.D. Hyde form a sister group to *Morosphaeria* species with high bootstrap support (Tam et al. 2003). *Kirschsteiniothelia elaterascus*, a freshwater ascomycete, also groups in this family (Shearer 1993; Liu et al. 2011; Suetrong et al. 2011b; Zhang et al. 2012a, b). Based on morphology and phylogenetic analyses of LSU and SSU rDNA, *Kirschsteiniothelia elaterascus* was transferred to the genus *Morosphaeria* (Boonmee et al. 2012). *Morosphaeria elaterascus* is comparable to *H. kanaloanus*, in having immersed lenticular ascomata clustered beneath a pseudoclypeus, clavate asci with long, narrow, coiled endoascus and brown, unequally two-celled ascospores. Zhang et al. (2012a) report that a strain of *Asteromassaria pulchra* (Desm.) Hohn., occurring on dead twigs of *Prunus spinosa*, is basal to other species of *Morosphaeriaceae*, with strong support. However, the inclusion of this genus in the family remains unresolved until the type species of *Asteromassaria* is sequenced.

Type: *Morosphaeria* Suetrong et al., Stud. Mycol. 64: 161 (2009), MycoBank MB 515954 Fig. 82

Saprobic on intertidal mangrove substrata. Sexual state: *Ascomata* solitary or gregarious, subglobose to lenticular, immersed, becoming superficial, coriaceous, brown to black, with a papillate ostiole, periphysate. *Hamathecium* comprising filamentous, hyaline, septate, anastomosing, branching and numerous, trabeculate to filamentous pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cylindrical, short pedicellate, thick-walled, with an ocular chamber. *Ascospores* uniseriate to overlapping biseriate, fusiform to ellipsoidal, hyaline, 1–3-septate, constricted at the septa, surrounded by a mucilaginous sheath. Asexual state: Unknown.

Notes: The taxonomy of *Massarina* and *Lophiostoma* species has been confusing with few morphological characters to separate them. Aptroot (1998) listed 160 *Massarina* names in the literature, but in his monograph only retained 43 taxa. Jones et al. (2009a) list ten marine *Massarina* species, with three subsequently referred to the genera *Morosphaeria* and

Halomassarina (Suetrong et al. 2009). *Morosphaeria* (*Massarina*) *velatospora* was described from intertidal mangrove wood (Hyde and Borse 1991) and has ascospores with a thick sheath, while in *M. ramunculicola* this is extended into a cap-like polar appendage (Read et al. 1997). Both species form a well-supported monophyletic group with *H. kanaloanus* and *H. nypae* forming a sister group with 100 % bootstrap support (Suetrong et al. 2009). Subsequently, *Kirschsteiniothelia elaterascus*, a freshwater ascomycete, was shown to have a close affinity with taxa in the *Morosphaeriaceae* and was therefore transferred to *Morosphaeria* (Boonmee et al. 2012). *Morosphaeria* (*Kirschsteiniothelia*) *elaterascus* morphologically shares some features in common with *Helicascus* species, especially the base of the endoascus that is narrow and coiled within ectoascus. It also groups with *Helicascus* species in some molecular trees (Suetrong et al. 2009; Liu et al. 2011; Zhang et al. 2012a, b) and further studies are required to confirm its generic placement.

Type species: *Morosphaeria velatospora* (K.D. Hyde & Borse) Suetrong et al., Stud. Mycol. 64: 161 (2009), MycoBank MB 515955

Other genus included

Helicascus Kohlm. Can. J. Bot. 47: 1471 (1969), MycoBank MB 2255

Type species: *Helicascus kanaloanus* Kohlm., Can. J. Bot. 47: 1471 (1969)

Key to genera of *Morosphaeriaceae*

1. Ascstromata with several locules and a single central ostiolar pore, ascospores brown *Helicascus*
1. Ascromata non stromatic, hyaline ascospores *Morosphaeria*

Muyocopronaceae K.D. Hyde, **fam. nov.**, MycoBank: MB804506

Muyocopronaceae Luttr. [as ‘Myiocopronaceae’], Univ. Mo. Stud. 24(3): 87 (1951), MycoBank: MB 81647, Nom. inval., Art. 36.1 (Index Fungorum 2013)

Saprobic on the surface of leaves or stems, as small black spots, superficial mycelium absent. Sexual state: *Ascomata* circular, scattered, flattened, rarely coalescing, superficial, carbonaceous and brittle, black, basal layer slightly developed, with a central irregular ostiole; in section lenticular. *Upper wall* comprising irregularly arranged radiating cells, cells at margin branching. *Peridium* comprising two strata, an outer layer composed of black-brown pseudoparenchymatous cells of compact thick-walled *textura epidermoidea*, an inner layer comprised of light brown cells of *textura angularis*. *Hamathecium* of dense, septate pseudoparaphyses which are longer than the asci and immersed in mucilage and inclined towards the centre. *Asci* 8-spored, bitunicate, fissitunicate,

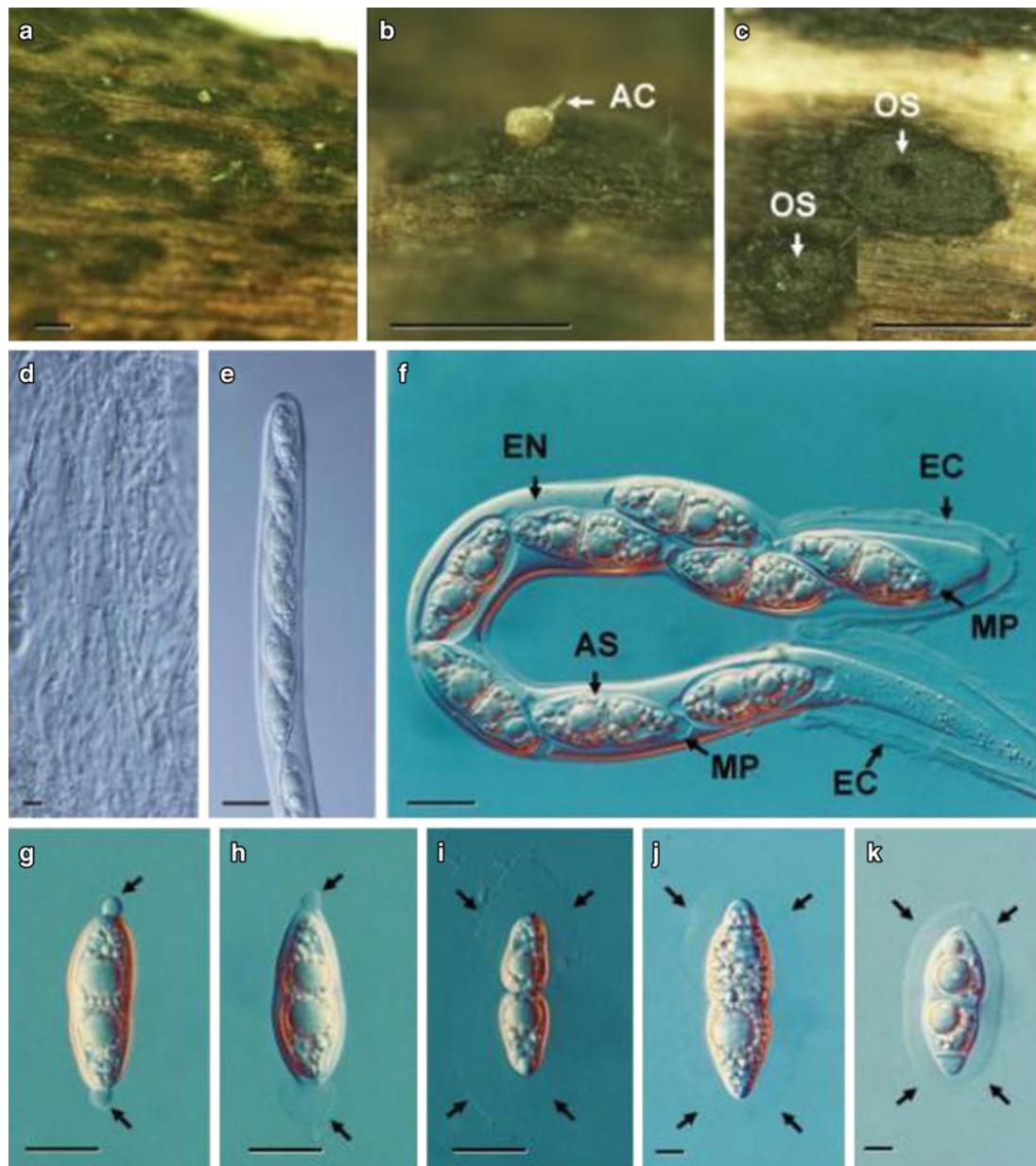


Fig. 82 [a–i] *Morosphaeria ramunculicola* (Material examined: MALAYSIA: Kuala Lumpur: Morib, on mangrove wood, 25 June 2007, E.B.G. Jones, BCC 18404, 18405, 28360, BBH 19760). j, k *Morosphaeria velatipora* (Material examined: THAILAND: Satun Province: Mueang Satun, Tammarang Pier, on mangrove wood, 1 September 2006, R. Choeyklin et al. (BCC 23306, 23307, 23902, 23977, 23985, 24040)]. **a** Surface view of mature ascomata on mangrove wood. **b, c** Released asci (arrow AC) from ostiole (arrows OS). **d** Trabeculate pseudoparaphyses. **e** Apical region of ascus with ocular chamber (l-). **f**

Mature ascus undergoing fissitunicate dehiscence. Ectoascus (arrow EC) has ruptured. Ascospores (arrow AS) in endoascus (arrow EN) showing mucilaginous pads (arrows MP). **g, h** Ascospores with sheath held close to the spore wall and with polar cap-like mucilaginous pads (arrows). **i** Ascospores with a fully swollen mucilaginous sheath (arrows). **j, k** Ascospores, 1–3-septate, hyaline and surrounded by indistinct mucilaginous sheath (arrows). Scale bars: a=500 μm ; b, c=250 μm ; e–k=25 μm ; d=10 μm

pedicellate, with small ocular chamber. *Ascospores* 2–3-seriate, ellipsoidal to ovate with obtuse ends, hyaline, one-celled, with granular appearance. Asexual state: Unknown.

The family *Muyocopronaceae* was introduced by Luttrell (1951) to include all *Hemisphaeriales* with a *Pleospora* type centrum in the *Stigmataceae*, and the majority of *Hemisphaeriaceae*, *Microthyriaceae* and *Polystomellaceae*

(Eriksson 1981). The family was not provided with a Latin diagnosis, and therefore the name is illegitimate and a synonym of *Microthyriaceae* (Wu et al. 2011a, b). In this paper we accept *Muyocopronaceae* as a distinct family, presently with a single genus *Muyocopron*. Since a Latin diagnosis is no longer required we provide an English diagnosis.

Typus: Muyocopron Speg., Anal. Soc. cient. argent. 12(3): 113 (1881), MycoBank: MB 3294

Figure 83

Notes: Muyocopron has 57 species epithets (Index Fungorum 2013) and the genus is certainly polyphyletic as *M. smilacis* has quite dissimilar asci to that of the type *Muyocopron corrientinum* Speg. Most authors have considered the genus and family to be similar to the *Microthyriaceae*

(Lumbsch and Huhndorf 2010; Index Fungorum 2013, MycoBank 2013), however recent molecular studies show this genus/family to be relatively distantly related to the *Microthyriaceae* (Wu et al. 2011a, b: Fig. 1) and Fig. 1 this study). Two unidentified *Muyocopron* species grouped with *Saccardoella rhizophorae*, in a strongly supported clade and are not referable to any order in the *Dothideomycetes* (Wu et al. 2011a, b). The morphology also indicates that these taxa

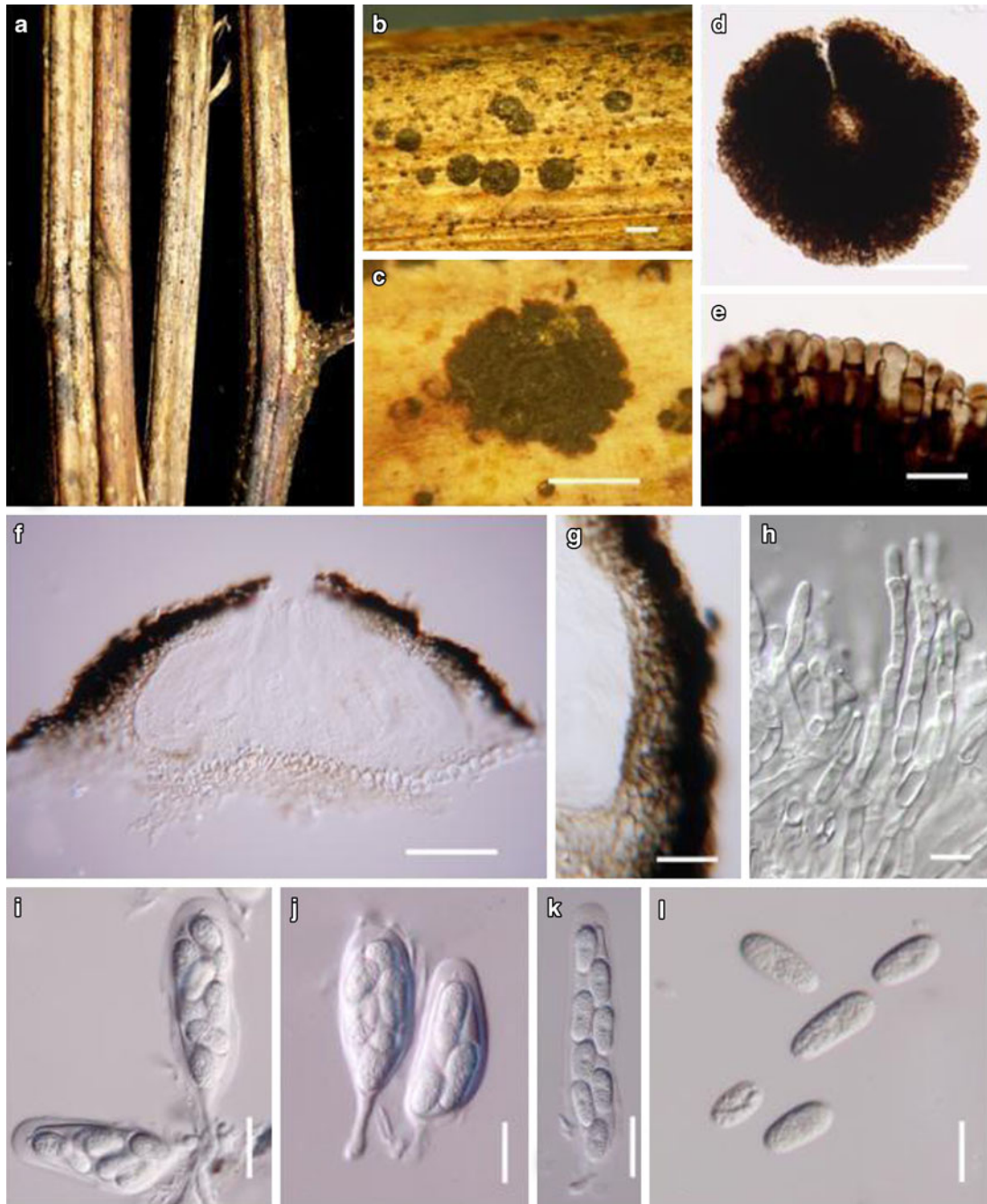


Fig. 83 *Muyocopron* cf. *corrientinum* (Material examined: THAILAND, Chiang Rai, Doi Pui, Elev. 403–936 m, on dried twigs of *Castanopsis indica*, 23 September 2009, Saranyaphat Boonmee, MFLU 10–0042). **a–c** Ascomata on surface of twig. **d, e** Squash of ascoma wall.

f, g Section of ascoma showing peridium with outwardly black occluded cells, and inwardly pale brown cells of *textura angularis*. **h** Pseudoparaphyses. **i–k** 8-spored asci. **l** Unicellular ascospores. Scale bars: **a–f** = 100 μm , **g** = 40 μm , **h** = 5 μm , **i–k** = 30 μm , **l** = 10 μm

may not be related. In *Microthyriaceae* (*Microthyrium*) ascomata are true thyrtothecia with a thin upper wall comprising parallel cells radiating from the central ostiole and a poorly developed base. Septate pseudoparaphyses develop above the asci, the latter being cylindro-clavate and relatively long and ascospores are two celled, and often ciliate (Wu et al. 2011a, b). In *Muyocoproneae* (*Muyocopron*) ascomata are not true thyrtothecia as the upper wall is relatively wide and comprises two layers, pseudoparaphyses that are longer than the asci, asci are broadly clavate and ascospores are unicellular without appendages.

Type species: Muyocopron corrientinum Speg., Anal. Soc. cient. argent. 12(3): 113 (1881), MycoBank: MB 173387

Mycoporaceae Zahlbr., in Engler & Prantl, Nat. Pflanzenfam., Teil. I (Leipzig) 1*: 77 (1903), MycoBank: MB 81042

Possible synonym:

Gloenodietyaceae Räsänen, Acta bot. fenn. 33: 31 (1943)

Non-lichenized or *facultatively lichenized*, growing on bark of trees or on stones. Sexual state: *Ascostromata* composed of pale mycelium, loose, copiously branched. *Hyphae* thick, almost hydroid-corticoid, yellowish, consisting of loose, branched, with finely verrucose, cells born at tips of hyphae resembling blastospores. *Locules* scattered, aggregated, botryose or immersed in a ascostroma, sphaerical or conical, erumpent or superficial, black, globose to subglobose or irregular, multi-loculate, locules without wall of their own, containing numerous asci. *Ostiole* forming an apical pore or an elongated channel. *Peridium* of pseudoparenchymatous cells, thin-walled, pale brown to brown, hyaline, hymenium often gelatinous, comprising of *textura globosa*. *Pseudoparaphyses* filiform, hyaline, often septate. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, obclavate or thickest in the middle, with a short-pedicel, ectotunica thin; endotunica very thick in upper half of ascus, thin in lower half without ring structures, with long tapering ocular chamber. *Ascospores* ellipsoidal, fusiform to clavate with upper hemispore broader, variably septate; transverse septa and sometimes longitudinal septa with divided by 5–7 transsepta and one longiseptum in two or all segments, not constricted at the septa, immature hyaline with thin gelatinous sheath asci firmly enclosed in strongly reticulate becoming brownish at maturity, irregularly arranged in asci. Asexual state: Unknown.

Notes: Mycoporaceae is of uncertain taxonomic placement in *Dothideomycetes*, it is a monotypic genus *Mycoporum* with a widespread distribution, and saprobic on woody tissue lichenized (Cannon and Kirk 2007; Kirk et al. 2008). von Arx and Müller (1975) mention that the typical characters of this family are unclear. It is difficult to distinguish the genus from *Pleosporaceae* as some genera are intermediate as they have a lichen habit which

is difficult to recognize. Lumbsch (1999) studied the structure and development of ascomata in *Mycoporum elabens* (Schaer.) Flot. ex Nyl., and placed this family in *Dothideales* sensu stricto. The genus *Cyrtidulama* may also belong in this family (Cannon and Kirk 2007). The ordinal position of the genus is unresolved with Lumbsch (1999) referring it to the *Dothideales*, while Index Fungorum (2013) and MycoBank (2013) list it as *Dothideomycetidae incertae sedis*. Molecular data is required to resolve its position within the *Dothideomycetes*.

Type: Mycoporum Flot. ex Nyl., Mém. Soc. Sci. nat. Cherbourg 3: 186 (1855), MycoBank: MB 3337 Fig. 84

The systematic position of *Mycoporum* has been unclear and a discussion is provided in Eriksson (1981), who noted that a relationship with *Arthopyreniaceae* was conceivable. Lumbsch (1999) interpreted this genus as being non-lichenized with algal cells found in the surroundings of the ascomata; they did not have close contact with the fungal hyphae. Lumbsch (1999) supported Harris (1973) and Poelt (1969) who had observed *M. elabens* and considered it as non-lichenized, while Eriksson (1981) had seen old material and unable to find any algal cells near ascomata or in the surrounding mycelium. Harris (1995) noted the presence of algae on some *Mycoporum* specimens, and commented that while the identity of these algae was unknown, they did not appear to be part of algal genera that are typically found in lichen thalli. Harris (1995) suggested that *Mycoporum* does not produce a lichen thallus, and that when algae are present, they are not *Trentepohlia* algae. Eriksson (1981) accepted *Mycoporaceae* with two species in *Mycoporum*; *M. elabens* and *M. pycnocarpum* Nyl., while Harris (1995) and Aptroot et al. (2008) considered several additional species to be included.

Type: Mycoporum elabens (A. Massal.) Flot. ex Nyl. [as ‘*elabeus*’], Act. Soc. linn. Bordeaux, Trois. sér. 21: 417 (1856), MycoBank: MB 395757

≡ *Lecidea elabens* Schaer., sect. 4–5: 199 (1833)

Mycosphaerellaceae Lindau, in Engler & Prantl, Nat. Pflanzenfam., Teil. I (Leipzig) 1(1): 421 (1897), MycoBank: MB 81043

Possible synonym:

Sphaerellaceae Nitschke, Verh. naturh. Ver. preuss. Rheinh. 26: 74 (1869)

Parasitic or *saprobic* on flowering plants or other fungi and lichens. Sexual state: *Ascostromata* semi immersed to superficial on host surface, uni- to multi-loculate, forming pseudostroma or clypeus or solitary, visible as dark brown to black or orange-brown, large circle or elongate area on host surface, or forming hypostroma within ovary of host, glabrous or covered by hair-like structures. *Ascomata* immersed to semi immersed within the pseudostroma or clypeus or superficial, solitary, forming hyphal nets or glabrous, small-

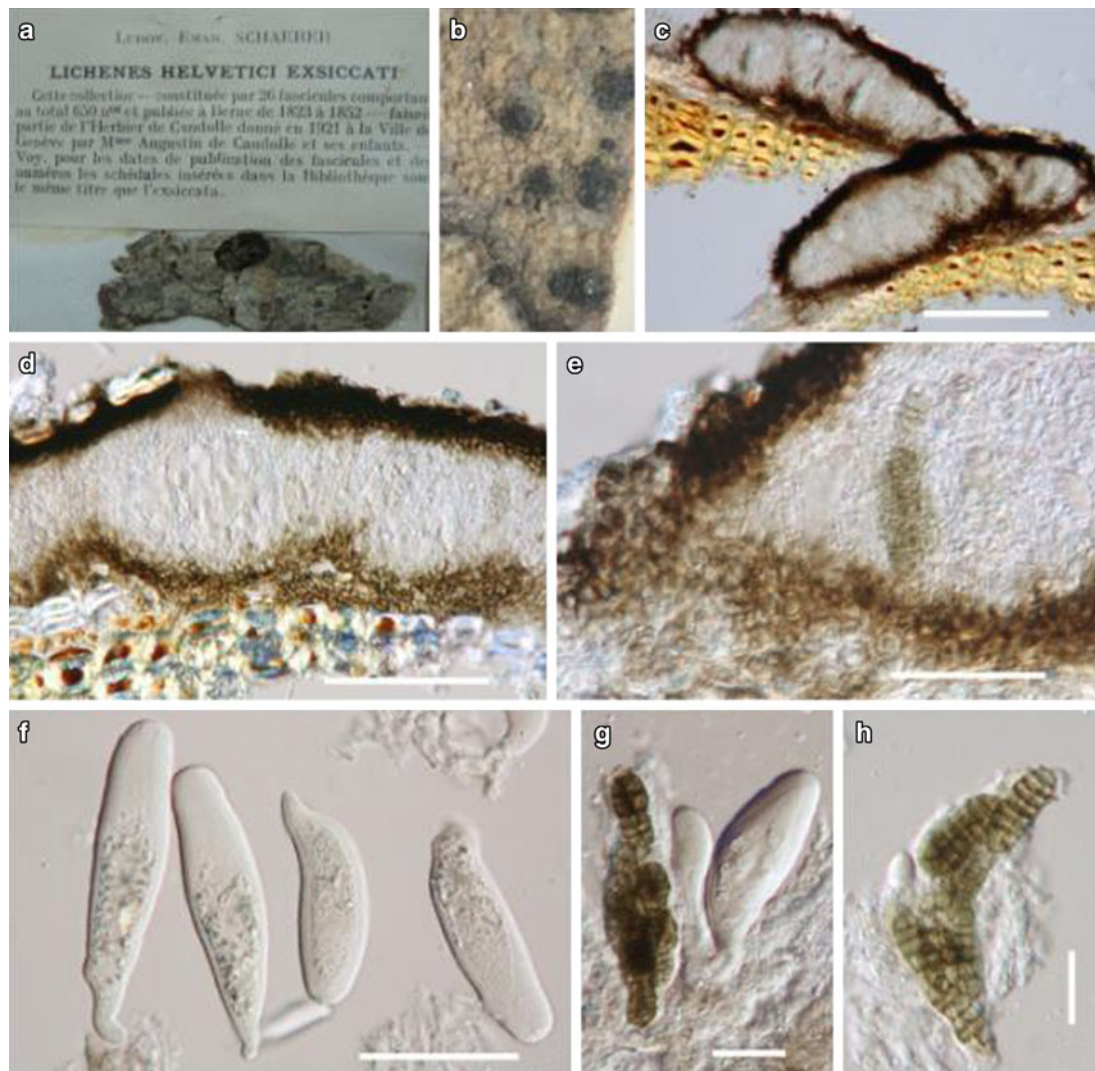


Fig. 84 *Mycoporum elabens* (Material examined: SWITZERLAND, Wachseidorn, on bark, Fries no. 232, G00110803, **type** of *Lecidea elabens*). **a** Herbarium specimen. **b** Superficial ascomata on host. **c–e**

Vertical section through ascomata and peridium. **f–h** Immature and mature asci and ascospores. Scale bars: **c**=200 μ m, **d**=100 μ m, **e–f**=50 μ m, **g–h**=20 μ m

medium size, globose to subglobose with protruding central papilla, ostiole central, dark brown to black, scattered or clustered, gregarious. *Peridium* thin to thick-walled, composed of several layers of *textura angularis*, dark brown to black or orange-brown. *Hamathecium* present or absent, with cellular pseudoparaphyses, anastomosing, branching, embedded in mucilaginous matrix, sometimes aparaphysate, covering asci by gelatinous matrix. *Asci* bitunicate, fissitunicate, 8-spored, cylindrical to cylindrical-clavate, ovoid to ampulliform or saccate, sessile or almost so, apically rounded with distinct or indistinct ocular chamber, sometimes thick-walled at the apex. *Ascospores* bi- to tri-seriate, or overlapping, ellipsoidal to obclavate, oblong to cylindrical, hyaline to subhyaline or pale yellowish, aseptate or septate, often constricted at the septum, smooth or rough-walled, with small guttules. Asexual states: [a wide range of asexual morphs, mucedinaceous and dematiaceous hyphomycetes

(conidiophores solitary, fasciculate, sporodochial or synnematosus), or acervular to pycnidial coelomycetes with hyaline to pigmented conidiophores and conidia. *Conidiogenesis* holoblastic, tretic or phialidic (in “Septoria”-like coelomycetes). *Conidiogenous cells* uni- to multiloculate, determinate, sympodial or percurrent. *Conidia* solitary or catenate, amero- to scolecosporous, transversely eu- or distoseptate to dictyosporous, secession schizolytic when holoblastic].

Notes: (1) Currently recognized and genetically proven asexual morph-typified genera; *Asperisporium*, *Caryophylloseptoria*, *Cercospora* [= *Cercosporina*], *Cercosporella*, *Colletogloeum*, *Cytostagonospora*, *Distocercospora*, *Lecanosticta*, *Microcyclosporella*, *Neoseptoria*, *Paracercospora* sensu stricto, *Passalora* emend. Crous & Braun (2003) [= *Berteromyces*, *Cercosporidium*, *Distocercospora*, *Dothistroma*, *Fulvia*, *Mycovellosiella*,

Ormathodium, *Oreophyllum*, *Pantospora*, *Phaeoramularia*, *Ragnhildiana*, *Tandonella*, *Walkeromyces*], *Pallidocercospora*, *Periconiella*, *Phaeophleospora*, *Phloeospora*, *Polyphialoseptoria*, *Polythrincium*, *Pseudocercospora* nom. cons. [= *Cercocladospora*, *Cercoseptoria*, *Cercostigmina*, *Helicomia*, *Paracercospora* pro parte, *Phaeoisariopsis* nom. rej., *Pseudophaeoramularia*, *Stigmina* nom. rej.], *Pseudocercospora*, *Ramularia*, *Ramulispora*, *Ruptoseptoria*, *Scolecostigmina*, *Septoria*, *Sonderhenia*, *Stromatoseptoria*, *Trochophora*, *Zasmidium* (= *Stenellopsis*, *Verrucisporota*), *Zymoseptoria* (Crous et al. 2000, 2007a, 2009c, d, 2012; Verkley and Priest 2000; Groenewald et al. 2013).

(2) Unproven genera with supposed affinity to *Mycosphaerellaceae* (sexual morphs “*Mycosphaerella*”-like or unknown, but in any case not genetically proven or data related to type species not yet available): *Cladosporiella*, *Denticularia*, *Elletevera*, *Eriocercospora*, *Eriocercospora*, *Fusicladiella* (with “*Mycosphaerella*”-like sexual morphs), *Miuraea*, *Neovularia*, *Neoramularia*, *Parastenella*, *Phacellium* (type species probably belongs to *Ramularia*), *Prathigada*, *Pseudocercosporidium*, *Pseudodidymaria*, *Quasiphloeospora*, *Ramulariopsis*, *Semipseudocercospora*, *Sirosporium*.

(3) Additional records (unclear, doubtful or wide interpretations and applications of genus names [sensu lato, morphologically similar, etc.]): *Anguillosporella*, “*Asteromella*”-like (asexual state of *Gillotia*, *Clypeispora*), “*Coniothyrium*”-like (asexual state of *Brunneosphaerella*), *Deightoniella*, *Didymochora* (asexual states of *Euryachora*), *Laocoön*, *Phaeothecoidea*, “*Placosphaeria*”-like (asexual states of *Euryachora*), “*Ramichloridium*”-like (asexual states of *Mycosphaerella*), *Rhabdospora*, “*Thegonia*”-like (Wijayawardene et al. 2012).

Mycosphaerellaceae was introduced by Lindau (1897) with the family type *Mycosphaerella* Johanson. von Arx and Müller (1975) circumscribed the *Mycosphaerellaceae* as parasitic or saprobic on vascular plants or lichens, often forming pseudostroma or stroma and with developed hyphae in host tissue. *Mycosphaerellaceae* included 18 sexual morph typified genera. Hawksworth et al. (1995) placed *Mycosphaerellaceae* in *Dothideales*, while Kirk et al. (2001) assigned *Mycosphaerellaceae* to the new order *Mycosphaerellales*. Kirk et al. (2008) listed 53 genera and 6,033 species in the *Mycosphaerellaceae* and placed the family in *Capnodiales*. Schoch et al. (2006) described the morphological sexual morph characters of *Mycosphaerellaceae* by “small pseudothecial ascomata, immersed in host tissue, single or superficial or embedded in pseudoparenchymatous stroma, ostiolate, papillate, interascal tissue, asci ovoid or saccate to subcylindrical, usually pedicellate with or without an apical chamber, lacking any other apical mechanism, ascospores hyaline to slightly pigmented, 1-septate, sometimes 3-

septate and sometimes enclosed in sheath and close to 30 asexual morph genera” (Crous et al. 2003a, 2007a, 2009a, d). They mentioned that the majority of asexual states of the family was commonly found as hyphomycetes with sympodially proliferating conidiogenous cells with scars, and dry conidia, and distinguished *Mycosphaerella* from *Davidiella* in lacking irregular lumens or inclusions in its ascospores and not having asexual morphs with protuberant, thickened, darkened, “*Cladosporium*”-like scars (Braun et al. 2003; Aptroot 2006; Schoch et al. 2006). Based on phylogenetic analyses, Schoch et al. (2006) assigned *Mycosphaerellaceae* to *Capnodiales*. Crous et al. (2009b) resolved the status of the *Capnodiales* and *Mycosphaerellales* and clearly stated that the *Mycosphaerellales* is phylogenetically not well-supported which led to the conclusion to retain all families in a single, diverse order, namely the *Capnodiales*. Crous et al. (2009a) obtained cultures from several fresh collections of *Leptosphaeria protearum* Syd. & P. Syd., mostly causing leaf spot and blight of *Protea* spp., and derived sequence data of these pathogens clustered in *Mycosphaerellaceae*. The fungus concerned is morphologically characterized by having bitunicate asci without pseudoparaphyses, brown, 3-septate ascospores, and a “*Coniothyrium*”-like asexual morph. They introduced for this species the new genus *Brunneosphaerella*.

Currently, the *Mycosphaerellaceae* represent 14 sexual morph-typified genera such as *Achorodopsis*, *Brunneosphaerella*, *Cymadothea*, *Euryachora*, *Gillotia*, *Melanodopsis*, *Mycosphaerella*, *Placocrea*, *Polysporella*, *Pseudostigmidium*, *Sphaerellothecium*, *Sphaerulina*, *Stigmidium*, and *Wernerella* (Lumbsch and Huhndorf 2010) as well as numerous asexual morph-typified genera (see above), including monophyletic and still less well-defined para- or polyphyletic genera (Crous et al. 2000, 2007a, 2009b, d, 2012; Verkley and Priest 2000).

The phylogeny of *Mycosphaerellaceae* was studied by Crous et al. (2007a, 2009b) and confirmed as *Capnodiales*, with variation at family level. They listed 20 genera, including several asexual morph-typified genera. The hyphomycete genus *Miuraea* was usually considered to be a genus associated with *Mycosphaerella*, but this assumption referred to the colourless *Miuraea persicae* (Sacc.) Hara, which has a “*Mycosphaerella*”-like sexual state [*Mycosphaerella prunipersicae* Deighton] (Braun 1995; Crous et al. 2013). However, the phylogenetic position of the type species of *Miuraea* (*M. degenerans* (Syd. & P. Syd.) Hara), which becomes pigmented with age, is still unproven and a sexual state of this species is unknown. *M. persicae* is very probably not congeneric with *M. degenerans*, and should be excluded and better be referred to as *Pseudocercospora*. *Thegonia*

was previously also considered an asexual morph genus of the *Mycosphaerella* complex (Braun 1995), but its type species, *T. ligustrina* (Boerema) B. Sutton, proved to belong to the *Helotiales* (Crous et al. 2013). *T. lupini* (Davis) U. Braun has a “*Mycosphaerella*”-like sexual state, clusters in the *Mycosphaerellaceae*, and must be reallocated, at best to the genus *Pseudocercospora* as well. *Xenostigmina* Crous (1998) is an additional genus that has to be excluded from the *Mycosphaerellaceae*. It also belongs to the *Pleosporales* (*Phaeosphaeriaceae*) as well (Crous et al. 2013). *Ramulariopsis* Speg. is another genus usually considered to be associated with *Mycosphaerella* (Braun 1998), based on *R. gossypii* (Speg.) U. Braun, which has a “*Mycosphaerella*”-like sexual morph (*Mycosphaerella areolata* Ehrlich & F.A. Wolf). However, the phylogenetic position of its type species, *R. cnidoscoli* Speg., is unproven and a sexual state of this species is unknown.

Placocrea is characterized by having pseudoparaphyses between asci which is unusual and not in agreement the general morphological character of this family. However, molecular data for this genus to confirm its proper phylogenetic position, and an epitypification is still lacking and urgently needed. The examination of the type specimen of *Brunneosphaerella* revealed the presence of interthecial filaments between asci, which is also unusual, confusing and in conflict with the general family concept, and which requires further studies.

Type: *Mycosphaerella* Johanson, Öfvers. K. Svensk. Vetensk.-Akad. Förhandl. 41(no. 9): 163 (1884), MycoBank: MB 3344 [= *Ramularia* Unger, Exanth. Pflanzen (Wien): 119 (1833)]

Figure 85

Parasitic or *saprobic* on flowering plants. Sexual state: *Ascomata* immersed to semi immersed with protruding papilla, visible as slightly blackened dot on host surface, small-sized, globose to subglobose, scattered or sometimes clustered, dark brown to black, gregarious, ostiole central, short papillate. *Peridium* thin, comprising 2–3 layers of *textura angularis*, wall brown to dark brown, paraphysate. *Asci* bitunicate, fissitunicate, 8-spored, cylindrical to cylindrical-clavate, sessile to subsessile, apically rounded with an ocular chamber. *Ascospores* 2–3-seriate at the base, 1-seriate at the apex or overlapping, clavate, oblong to cylindrical, hyaline, 1-septate, constricted at the septum, smooth or rough, thick-walled.

Notes: Within the family *Mycosphaerellaceae*, *Mycosphaerella* is the most controversially discussed and treated genus. The taxonomy and phylogeny of this genus is extremely intricate and complex. *Mycosphaerella* *sensu lato* proved to be polyphyletic (e.g., Crous et al. 2000, 2009b, d) and was previously applied to all kinds of ascomycetes with “*Mycosphaerella*”-like morphology. Some groups of previous *Mycosphaerella* species have been excluded and assigned to

other genera which now belong to other families, e.g. *Cladosporium* (= *Davidiella*), *Cladosporiaceae* (Bensch et al. 2012), *Dissoconium*, *Dissoconiaceae* (Schoch et al. 2009a, b, c) and various genera, including *Stenella* *sensu stricto*, that now belong in the *Teratosphaeriaceae* (Crous et al. 2007a, 2009b). The type species of *Mycosphaerella*, *M. punctiformis*, has an asexual morph described as *Ramularia endophylla* Verkley & U. Braun and clusters together with other *Ramularia* species in a monophyletic *Ramularia* clade within the *Mycosphaerellaceae* (Verkley et al. 2004; Crous et al. 2007a), so that *Mycosphaerella* becomes a facultative synonym of *Ramularia*. The older name *Ramularia* has priority and should be applied as holomorph name for this monophyletic unit composed of asexual morph, ana-holomorph and holomorph species with *Ramularia* states and “*Mycosphaerella*”-like sexual morphs in their life cycles. The further splitting of ascomycetes with “*Mycosphaerella*”-like sexual state is closely connected with and based on assemblages of certain species with particular asexual morphs for which asexual morph-typified genus names are available. *Cercospora* and *Pseudocercospora* as recently redefined and circumscribed in Groenewald et al. (2012) and Crous et al. (2013), respectively, proved to be monophyletic genera. *Cercospora*, *Ramularia*, *Ramulispora*, *Sonderhenia* and *Polythrincium* are additional well-resolved genera. The phylogeny of the genus *Septoria* *sensu lato* has recently been examined in detail, including a phylogenetic redefinition of *Septoria* *sensu stricto* and the introduction of numerous new, mainly phylogenetically circumscribed septorioid genera. The new genera belong in the *Mycosphaerellaceae*, numerous other new septorioid genera are phylogenetically related to the *Dothideaceae* and *Phaeosphaeriaceae* (Quaedvlieg et al. 2013, Verkley et al. 2013). However, based on available phylogenetic analyses, it is evident that several other genera like *Passalora*, *Pseudocercospora*, and *Zasmidium* are at least paraphyletic in their current circumscriptions. Taxonomy and phylogeny of *Mycosphaerella* *sensu lato* and associated asexual morph genera are far from being sufficiently examined and perceived. Molecular examinations based on a much broader sampling are necessary, above all phylogenetic data for numerous type species of several involved genera, e.g. *Mycovellosiella*, *Passalora*, *Ramulariopsis*, etc., are urgently needed. In the interim we have to accept and need paraphyletic or even polyphyletic genera in this complex. Sexual morphs with “*Mycosphaerella*”-like morphology can only be assigned to proper genera if they are connected with certain asexual morphs or on the base of molecular sequence analyses. In other cases, just based on morphology, and without asexual morphs, “*Mycosphaerella*”-like sexual morphs can only be referred to as *Mycosphaerella* *sensu lato*, which is a valid applicable genus name currently considered a facultative (heterotypic) synonym of *Ramularia*.

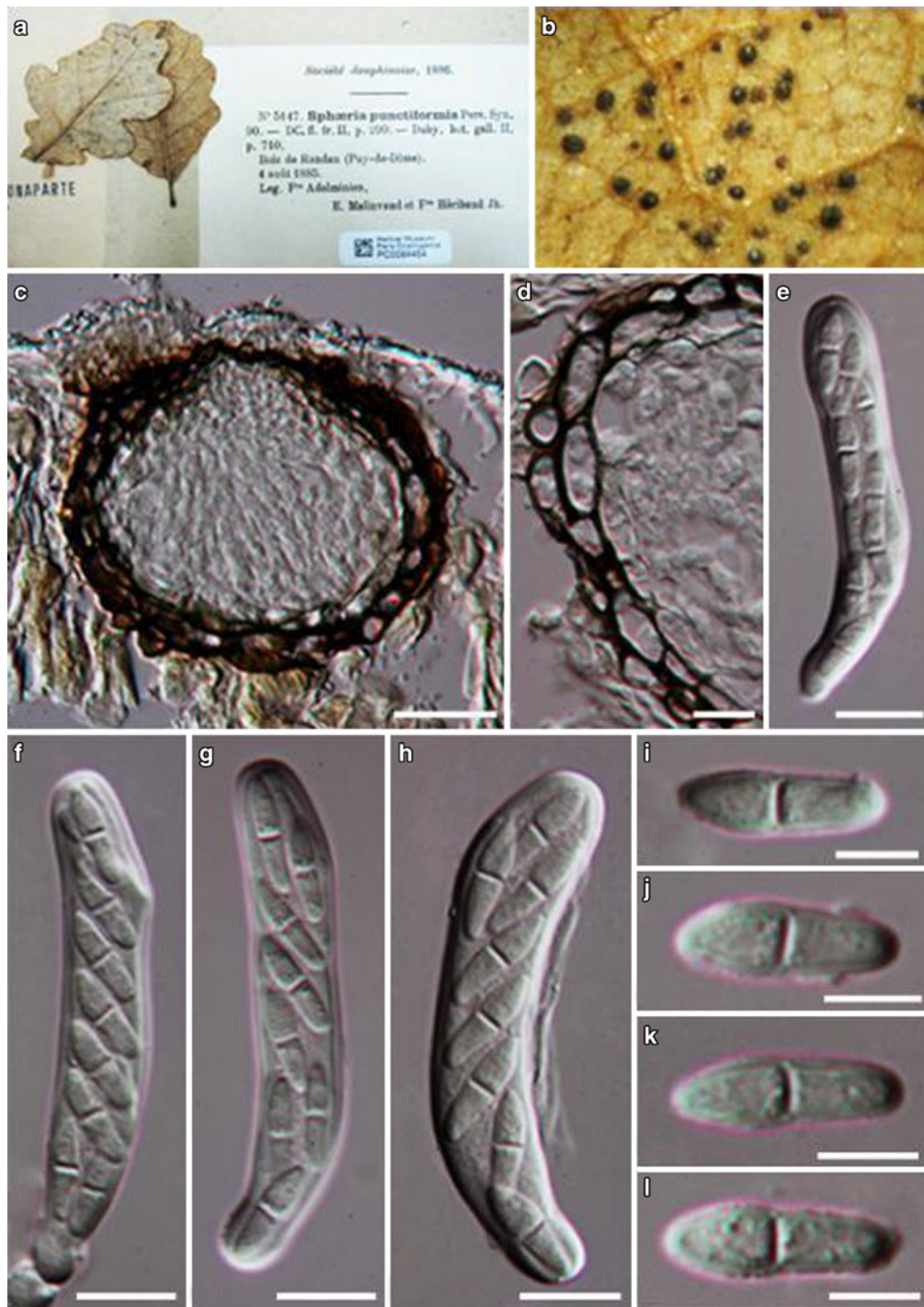


Fig. 85 *Mycosphaerella punctiformis* [= *Ramularia endophylla*] (Material examined: FRANCE, Bois de Randan (Puy-de-Dôme, on dead leaves, 4 August 1885, F^{TC} Adelminien (PC0084454, as *Sphaeria punctiformis* no. 5147). **a** Label and herbarium specimens of

Mycosphaerella punctiformis. **b** Appearance of ascomata on host surface. **c** Section through peridium. **d** Section through peridium. **e–h** Ascus. **i–l** Ascospores. Scale bars: **c**=50 μ m, **d–h**=10 μ m, **i–l**=5 μ m

Type species: Mycosphaerella punctiformis (Pers.) Starbäck, Bih. K. svenska Vetensk Akad. Handl., Afd. 3 15(no. 9): 163 (1889), MycoBank: MB 355991 [= *Ramularia endophylla* Verkley & U. Braun].

Other genera included

Achorodithis Syd., Annl. mycol. 24(5/6): 380 (1926)
Type species: Achorodithis poasensis Syd., Annl. mycol. 24(5/6): 380 (1926)

Notes: Considered to belong to the *Mycosphaerellaceae* (Lumbsch and Huhndorf 2010), but phylogenetically unproven.

Asperisporium Maubl., Bull. Soc. mycol. Fr. 29: 357 (1913)

Type species: *Asperisporium caricae* (Speg.) Maubl., Lavoura 16: 207 (1913)

Notes: The type species of *Asperisporium* has recently been sequenced and proved to belong to the *Passalora* (sensu lato) complex (Minnis et al. 2011), which is not monophyletic, but not yet sufficiently analysed by means of molecular methods (see *Passalora*). Therefore, *Asperisporium* is tentatively maintained as a separate genus.

Brunneosphaerella Crous, in Crous et al., Stud. Mycol. 64: 31 (2009)

Type species: *Brunneosphaerella protearum* (Syd. & P. Syd.) Crous, in Crous et al., Stud. Mycol. 64: 31 (2009)

Notes: This genus is “Mycosphaerella”-like, but the ascospores are pigmented and 3-septate, and a “Coniothyrium”-like asexual morph was found. Although not mentioned in the original description, the examination of the type specimen of *Brunneosphaerella* revealed the presence of interthecial filaments between asci, which is unusual and in conflict with the general family concept, which requires additional examination.

Cercospora Fresen., in Fuckel, Hedwigia 2: 133 (1863) and in Fuckel, Fungi Rhen. Exs., Fasc. II, No. 117 (1863)

Type species: *Cercospora penicillata* (Ces.) Fresen., in Fuckel, Hedwigia 2: 133 (1863) and in Fuckel, Fungi Rhen. Exs., Fasc. II, No. 117 (1863) [= *C. depazeoides* (Desm.) Sacc.]

Notes: *Cercospora* was previously applied in a very broad sense to all kinds of dematiaceous hyphomycetous asexual morphs with holoblastic conidiogenesis and at least partly associated with “Mycosphaerella”-like sexual morphs. However, for most species of this genus sexual morphs are unknown or they are ana-holomorphs. Later *Cercospora* was confined to species similar to the type species, *C. penicillata*, characterized by pigmented conidiophores, thickened and darkened conidiogenous loci and colourless conidia formed singly (Ellis 1971, 1976). A comprehensive phylogenetic analysis of *Cercospora* has recently been carried out by Groenewald et al. (2013). In its current circumscription, this genus is monophyletic.

Cercosporella Sacc., Michelia 2(no. 6): 20 (1880) emend. Deighton (1973)

Type species: *Cercosporella cana* Sacc., Michelia 2(no. 7): 364 (1881)

Notes: *Cercosporella* has been monographed by Braun (1995). Sexual morphs are, as far as known, “Mycosphaerella”-like. This genus seems to be phylogenetically distinct, but up to now only few species have been

cultured and included in phylogenetic analyses (Crous et al. 2009a, b, c, d).

Colletogloeum Petr., Sydowia 7(5–6): 368 (1953)

Type species: *Colletogloeum dalbergiae* (S. Ahmad) Petr., Sydowia 7(5–6): 369 (1953)

Notes: *Colletogloeum* is a coelomycetous acervular genus with “Mycosphaerella”-like sexual morphs as far as known (Sutton 1980; Verkley and Priest 2000). The morphological differentiation between *Colletogloeum* and *Phloeospora* is difficult and vague, above all with regard to some species with colorless conidia that have also been assigned to the latter genus.

Distocercospora Pons & B. Sutton, Mycol. Pap. 160: 60 (1988)

Type species: *Distocercospora pachyderma* (Syd. & P. Syd.) N. Pons & B. Sutton, Mycol. Pap. 160: 60 (1988)

Notes: The phylogenetic position of *Distocercospora* as separate genus within the *Mycosphaerellaceae* has recently been proven (not yet published, C. Nakashina, in litt.).

Dothistroma Hulbary, Bull. Ill. nat. Hist. Surv. 21: 235 (1941)

Type species: *Dothistroma pini* Hulbary, Bull. Ill. St. nat. Hist. Surv. 21(7): 235 (1941)

Notes: The asexual states of *Dothistroma* are acervular coelomycetes well-characterized by faintly pigmented conidiophores, at least at the base, but colorless conidiogenous cells and conidia formed in cream to brownish slimy masses (Barnes et al. 2004). The “Mycosphaerella”-like sexual morph of *Dothistroma septosporum* (Dorog.) M. Morelet (= *Mycosphaerella pini* Rostr.) was assigned to *Eruptio* by Barr (1996) [see *Lecanosticta*].

Euryachora Fuckel, Jb. nassau. Ver. Naturk. 23–24: 220 (1870) [1869–70]

Type species: *Euryachora sedi* (Link) Fuckel [as ‘sebi’], Jb. nassau. Ver. Naturk. 23–24: 220 (1870) [1869–70]

Notes: *Euryachora* was considered to belong to the *Mycosphaerellaceae* by the morphological characters as forming ascostromata with small locules on host (Lumbsch and Huhndorf 2010). However, the genus is phylogenetically unproven which molecular examinations and epitypification are necessary to elucidate the relations of this genus to the family.

Gillotia Sacc. & Trotter, Syll. fung. (Abellini) 22: 253 (1913)

Type species: *Gillotia orbicularis* (Syd. & P. Syd.) Sacc. & Trotter, Syll. fung. (Abellini) 22: 253 (1913)

Notes: Considered to belong to the *Mycosphaerellaceae* (Lumbsch and Huhndorf 2010), but phylogenetically unproven.

Lecanosticta Syd., in Sydow & Petrak, Anns mycol. 20(3/4): 211 (1922)

Generic type: *Lecanosticta pini* Syd., in Sydow & Petrak, Anns mycol. 20(3/4): 211 (1922)

Notes: *Lecanosticta* is a coelomycetous acervular genus with proven affinity to the *Mycosphaerellaceae* (Verkley et al. 2004; Minnis et al. 2012). Sexual states are “Mycosphaerella”-like. The sexual morph of *Lecanosticta acicola* is the type species of *Eruptio* (*E. acicola* (Dearn.) M.E. Barr ≡ *Mycosphaerella dearnesii* M.E. Barr). The older asexual morph-typified name *Lecanosticta* has priority and should be accepted.

Melanodothis R.H. Arnold, Can. J. Bot. 49: 2188 (1972) [1971]

Type species: ***Melanodothis caricis*** R.H. Arnold, Can. J. Bot. 49: 2188 (1972) [1971]

Notes: Considered to belong to the *Mycosphaerellaceae* (Lumbsch and Huhndorf 2010), but phylogenetically unproven.

Microcyclosporella J. Frank et al., in Frank et al., Persoonia 24: 101 (2010)

Type species: ***Microcyclosporella mali*** J. Frank et al., in Frank et al., Persoonia 24: 101 (2010)

Notes: *Microcyclosporella* was introduced on the basis of phylogenetic data, showing that it clusters within the *Mycosphaerellaceae*, and with morphological peculiarities. It is morphologically close to and confusable with species of *Microcyclospora* (*Teratosphaeriaceae*) and *Pseudocercospora* in the *Mycosphaerellaceae*. Sexual morphs are not yet known.

Pallidocercospora Crous, in P.W. Crous et al., Stud. Mycol. 75: 73 (2013)

Type species: ***Pallidocercospora heimii*** (Crous) Crous, in P.W. Crous et al., Stud. Mycol. 75: 74 (2013)

Notes: *Pallidocercospora* belongs to the *Pseudocercospora* complex, but was segregated on the base of phylogenetic data and the formation of red crystals in culture, which are characteristic for the “Mycosphaerella” *heimii* complex. Otherwise, the species concerned are morphologically indistinguishable from other *Pseudocercospora* species.

Paracercospora Deighton, Mycol. Pap. 144: 47 (1979)

Type species: ***Pseudocercospora egenula*** (Syd.) U. Braun & Crous, in Crous & Braun 2003

Notes: *Paracercospora* was introduced due to a special structure of the conidiogenous loci characterized by being circular with slightly thickened and darkened ultimate rim. Sexual morphs are, as far as formed, “Mycosphaerella”-like. The generic relevance of this special scar type was later questioned and *Paracercospora* was reduced to synonymy with *Pseudocercospora* (Crous and Braun 2003). However, the situation is complicated. Crous et al. (2013) demonstrated that the type species of *Paracercospora* clusters apart of *Pseudocercospora*, supporting *Paracercospora* (sensu stricto) as a recognizable genus, but other former *Paracercospora* species with indistinguishable conidiogenous loci cluster within the *Pseudocercospora* clade. Hence, *Paracercospora* is

currently just a phylogenetically defined genus morphologically indistinguishable from *Pseudocercospora*.

Passalora Fr., Summa veg. Scand., Section Post. (Stockholm): 500 (1849) emend. Crous & Braun (2003)

Type species: ***Passalora bacilligera*** (Mont. & Fr.) Fresen., Beitr. Mykol. 3: 94 (1863)

Notes: *Passalora* is the oldest name for cercosporoid asexual morphs associated with “Mycosphaerella”-like sexual morphs characterized by having pigmented conidiophores and conidia and thickened, darkened conidiogenous loci. In its current circumscription, *Passalora* is para- or even polyphyletic (Crous et al. 2009b). Further phylogenetic examination, based on a much broader sampling, including cultures of the type species of this genus and other genera reduced to synonymy with *Passalora*, are urgently necessary to perceive the complicated phylogeny of this complex.

Periconiella Sacc., in Saccardo & Berlese, Atti Ist. Veneto Sci. lett. ed Arti, Sér. 3 3: 727 (1885)

Type species: ***Periconiella velutina*** (G. Winter) Sacc., in Saccardo & Berlese, Atti Ist. Veneto Sci. lett. ed Arti, Sér. 3 3: 727 (1885)

Notes: The type species of *Periconiella* belongs to the *Mycosphaerellaceae* and clusters in a clade together with *Zasmidium* species (Crous et al. 2009b, d). “Mycosphaerella”-like sexual states are unknown. *Periconiella* is a large genus with numerous species. If all of them are congeneric with *P. velutina* is unclear and remains to be proven.

Phaeocercospora Crous, in Crous et al., Persoonia 28: 171 (2012)

Type species: ***Phaeocercospora colophospermi*** Crous, in Crous et al., Persoonia 28: 171 (2012)

Notes: Morphologically similar to and indistinguishable from *Pseudocercospora* species with consistently percurrently proliferating conidiogenous cells, but phylogenetically distinct. The genus is presently monotypic (Crous et al. 2012).

Phaeophleospora Rangel, Arq. Mus. Nac. Rio de Janeiro 18: 162 (1916)

Type species: ***Phaeophleospora eugeniae*** Rangel, Decheniana 18: 162 (1916)

Notes: Andjic et al. (2007) showed that this pycnidial genus with pigmented, verruculose, euseptate conidia belongs to the *Mycosphaerellaceae*. Sexual states are not known.

Phaeothecoidea Crous, in Crous et al., Fungal Divers. 26(1): 171 (2007)

Type species: ***Phaeothecoidea eucalypti*** Crous & Summerell, in Crous et al., Fungal Divers. 26(1): 171 (2007)

Notes: This hyphomycete genus, belonging to the *Mycosphaerellaceae*, is characterized by having verruculose, pigmented hyphae with end cells forming brown, thick-walled, verruculose endoconidia. Sexual states are not known (Crous et al. 2007b).

Phloeospora Wallr., Fl. crypt. Germ. (Norimbergae) 2: 176 (1833)

Type species: **Phloeospora ulmi** (Fr.) Wallr., Fl. crypt. Germ. (Norimbergae) 2: 177 (1833)

Notes: *Phloeospora* comprises acervular coelomycetes with “Mycosphaerella”-like sexual states. The phylogenetic position within the *Mycosphaerellaceae* has been proven. The relation to the pycnidial genus *Septoria* is, however, disputed and some authors prefer to reduce *Phloeospora* to synonymy with the latter genus (Verkley and Priest 2000; Verkley et al. 2004). Recent phylogenetic analyses have shown, however, that *Phloeospora* is distinct from *Septoria* (Quaedvlieg et al. 2013).

Placocrea Syd., Anns mycol. 37(4/5): 380 (1939).

Type species: **Placocrea pulchella** Syd., Anns mycol. 37(4/5): 380 (1939)

Notes: Listed as a member of the *Mycosphaerellaceae* with question mark in Lumbsch and Huhndorf (2010). This genus is phylogenetically unproven and its status is quite unclear. Phylogenetic data is urgently needed.

Polysporella Woron., Izv. Kavkaz. Muz. 10(1): 7 (1916)

Type species: **Polysporella woronowii** Woron., Izv. Kavkaz. Muz. 10(1): 7 (1916)

Notes: Considered to belong to the *Mycosphaerellaceae* (Lumbsch and Huhndorf 2010), which is doubtful and phylogenetically unproven.

Polythrincium Kunze, in Kunze & Schmidt, Mykologische Hefte (Leipzig) 1: 13 (1817)

= *Cymadothea* F.A. Wolf, Mycologia 27(1): 71 (1935)

Type species: **Polythrincium trifolii** Kunze, in Kunze & Schmidt, Mykologische Hefte (Leipzig) 1: 14 (1817)

Notes: The asexual morph-typified genus name *Polythrincium* is older than the sexual morph-typified genus name *Cymadothea*, which is recognized and recommended to be accepted as the asexual state of its type species is the causal agent of a common plant disease. Recent phylogenetic analyses conformed *Polythrincium* as a genus in *Mycosphaerellaceae* by Simon et al. (2009).

Pseudocercospora Speg., Anal. Mus. nac. B. Aires, Ser. 3 13: 437 (1910)

Generic type: *Pseudocercospora vitis* (Lév.) Speg., Anal. Mus. nac. B. Aires, Ser. 3 13: 438 (1910)

Notes: This genus comprises asexual morph species, anaholomorphs and species with asexual morphs and “Mycosphaerella”-like sexual morphs. The asexual states cause plant diseases, mostly leaf-spot symptoms. Conidiophores and mostly also the conidia are pigmented and the conidiogenous loci are inconspicuous or at least unthickened and not darkened (Deighton 1976; Crous and Braun 2003). Results of comprehensive molecular examinations of numerous *Pseudocercospora* species and a monophyletic circumscription of this genus have recently been published by Crous et al. (2013).

Pseudocercospora Deighton, Mycol. Pap. 133: 38 (1973)

Type species: **Pseudocercospora ipomoeae** Sawada ex Deighton, Mycol. Pap. 133: 38 (1973)

Pseudostigmidium Etayo, in Etayo & Sancho, Bibliotheca Lichenol. 98: 193 (2008)

Type species: **Pseudostigmidium nephromiarium** (Linds.) Etayo, in Etayo & Sancho Bibliotheca Lichenol. 98: 204 (2008)

Notes: *Pseudostigmidium*, comprising lichenicolous ascomycetes, is considered to be a genus belonging to the *Mycosphaerellaceae*, which is, however, phylogenetically unproven.

Notes: This genus has been monographed by Braun (1995).

Ramularia Unger, Exanth. Pflanzen (Wien): 119 (1833)

For possible synonyms see Braun (1998) and Index Fungorum (2013)

Type species: **Ramularia pusilla** Unger, Exanth. Pflanzen (Wien): 169 (1833)

Notes: *Ramularia* has been monographed by Braun (1998). This asexual morph-typified genus name is older than *Mycosphaerella* which has a type species associated with a *Ramularia* asexual morph. We prefer to accept this synonymy, above all since *Mycosphaerella* has previously been used in a very broad sense for all kinds of ascomycetes with “Mycosphaerella”-like sexual morphs which currently pertain to different genera, including various genera now belonging to other families.

Ramulispora Miura, Koshurei Agric. Exp. Sta. S. Manchur. Railway Co. Report 11: 43 (1920)

Type species: **Ramulispora andropogonis** Miura, Koshurei Agric. Exp. Sta. S. Manchur. Railway Co. Report 11: 43 (1920)

Notes: The genus *Ramulispora*, which is confined to grasses, is morphologically close to *Pseudocercospora*, but differs in forming abundant microsclerotia on leaves. The phylogenetic position within the *Mycosphaerellaceae* has been proven. Sexual states are unknown (Braun 1995; Crous et al. 2003a, 2009a). The eyespot fungi of cereals, previously treated as *Ramulispora herpotrichoides* (Fron) von Arx and allied species are excluded and belong to the genus *Helgardia* Crous & W. Gams with sexual morphs in *Oculimacula* Crous & W. Gams, *Helotiales*, *Dermateaceae* (Crous et al. 2003b).

Scolecostigmia U. Braun, in Braun et al., N.Z. J Bot. 37(2): 323 (1999)

Type species: **Scolecostigmia mangiferae** (Koord.) U. Braun & Mouch., in Braun et al., N.Z. J Bot. 37(2): 323 (1999)

Notes: *Scolecostigmia* is a segregation of *Stigmia* sensu lato, *Stigmia* sensu stricto is now a synonym of *Pseudocercospora* based on the phylogenetic position of its type species. *Scolecostigmia* has recently been proven to represent a separate, recognizable genus (Crous et al. 2013).

Septoria Sacc., Syll. fung. (Abellini) 3:474 (1884)

Type species: Septoria cytisi Desm., Annl. Sci. Nat., Bot., sér. 3 8: 24 (1847)

Notes: *Septoria* is one of the largest genera associated with “*Mycosphaerella*”-like sexual morphs. In its current circumscription, this genus is not monophyletic. The discrimination between pycnidial *Septoria* and acervular *Phloeospora* is controversially discussed, vague and morphologically as well as phylogenetically unclear. Further examinations are urgently needed (Verkley and Priest 2000; Verkley et al. 2004). Comprehensive phylogenetic analyses of *Septoria*-like species led to a phylogenetic redefinition and circumscription of *Septoria* sensu stricto, which belongs to *Mycosphaerellaceae*, several mainly phylogenetically defined new or reintroduced *mycosphaerellaceous* genera (*Caryophylloseptoria* Verkley et al., *Cytostagonospora* Bubák, *Neoseptoria* Verkley et al., *Polyphialoseptoria* Quaedvlieg et al., *Ruptoseptoria* Quaedvlieg et al., *Stromatoseptoria* Quaedvlieg et al. (Verkley et al. 2013, Quaedvlieg et al. 2013). Numerous other new septorioid genera introduced in the papers concerned belong to other families, viz. *Dothideaceae*, *Dothioraceae*, and *Phaeosphaeriaceae*). Clear morphological differentiations between these genera are not possible, i.e. they are mainly phylogenetically differentiated. Therefore, the genera concerned are not included in the following key.

Sonderhenia H.J. Swart & J. Walker, Trans. Br. mycol. Soc. 90(4): 640 (1988)

Type species: Sonderhenia eucalyptorum (Hansf.) H.J. Swart & J. Walker, Trans. Br. mycol. Soc. 90(4): 640 (1988)

Notes: *Sonderhenia* comprises fungi with coelomycetous (pycnidial) asexual morphs with brown conidiophores and brown, transversely distoseptate conidia and “*Mycosphaerella*”-like sexual morphs (Crous et al. 2012).

Sphaerellothecium Zopf, Nova Acta Acad. Caes. Leop.-Carol. German. Nat. Cur. 70: 184 (1897)

Type species: Sphaerellothecium araneosum (Rehm) Zopf, Nova Acta Acad. Caes. Leop.-Carol. German. Nat. Cur. 70: 178 (1897)

Notes: Considered to belong to the *Mycosphaerellaceae* (Lumbsch and Huhndorf 2010), but phylogenetically unproven.

Sphaerulina Sacc., Michelia 1(no. 4): 399 (1878)

Type species: Sphaerulina myriadea (DC.) Sacc., Michelia 1(no. 4): 399 (1878)

Notes: *Sphaerulina*, resembling *Mycosphaerella* but distinguished by having 3- to pluriseptate ascospores, is usually considered to be a genus of the *Mycosphaerellaceae* (Lumbsch and Huhndorf 2010). However, this genus is heterogeneous. Species with typical *Mycosphaerella* asexual morphs have been reallocated to *Mycosphaerella*, another species to *Sydowia*, and species with yeast-like asexual morphs seem to belong to the *Dothioraceae* (Crous et al. 2003c). Recent phylogenetic analyses have shown

Sphaerulina to be a distinct genus in the *Mycosphaerellaceae* Crous et al. 2011).

Stigmatidium Trevis., Conspect. Verruc.: 17 (1860)

Type species: Stigmatidium schaeferi (A. Massal.) Trevis., Conspect. Verruc.: 17 (1860)

Notes: *Stigmatidium*, comprising numerous lichenicolous ascomycete species, is usually considered a member of the *Mycosphaerellaceae* (Calatayud and Triebel 2003; Kocourková and Knudsen 2009; Lumbsch and Huhndorf 2010), which is phylogenetically still unproven. Roux and Triebel (1994) have suggested that the genus may have affinities with the *Verrucariales*. This genus is heterogeneous. *Stigmatidium* sensu stricto is characterized by having perithecioid ascomata with punctiform ostioles, a hamathecium of periphyses, periphysoids, and colourless, 1-septate ascospores (Calatayud and Triebel 2003; Kocourková and Knudsen 2009).

Trochophora R.T. Moore, Mycologia 47(1): 90 (1955)

Type species: Trochophora simplex (Petch) R.T. Moore, Mycologia 47(1): 90 (1955)

Notes: *Trochophora* clusters in the *Mycosphaerellaceae* (Crous et al. 2012). Sexual states are unknown.

?Wernerella Nav.-Ros. et al., Bull. Soc. linn. Provence 49: 138 (1998)

Type species: Wernerella maheui (Werner) Nav.-Ros. et al., Bull. Soc. linn. Provence 49: 138 (1998)

Notes: Considered to be a member of the *Mycosphaerellaceae* (Lumbsch and Huhndorf 2010), but phylogenetically unproven.

Zasmidium Fr., Summa veg. Scand., Section Post. (Stockholm): 407 (1849), Braun et al. (2010)

Type species: Zasmidium cellare (Pers.) Fr., Summa veg. Scand., Section Post. (Stockholm): 407 (1849)

Notes: *Zasmidium* encompasses “*Stenella*”-like asexual morphs belonging to the *Mycosphaerellaceae*, which were previously referred to as *Stenella* sensu lato (Braun et al. 2010). Sexual states are “*Mycosphaerella*”-like. *Stenella* sensu stricto with *S. araguata* Syd. as type species belong to the *Teratosphaeriaceae* (Arzanlou et al. 2007). *Zasmidium* in its current circumscription is paraphyletic (Crous et al. 2009b, d).

Zymoseptoria Quaedvlieg & Crous, Persoonia, 26: 64 (2011)

Type species: Zymoseptoria tritici (Desm.) Quaedvlieg & Crous, Persoonia, Mol. Phyl. Evol. Fungi 26: 64 (2011)

Notes: The genus *Zymoseptoria* is a phylogenetic segregation of *Septoria* based on some grass-inhabiting species which cluster apart of *Septoria* sensu stricto. *Zymoseptoria* species are characterized by forming three types of conidia in vitro (pycnidial, phragmosporous and yeast-like). Species of *Zymoseptoria* are distinguished from *Septoria* sensu stricto by their yeast-like growth in culture Quaedvlieg et al. (2011)

Key to genera of *Mycosphaerellaceae*

[This key only contains currently recognized, phylogenetically proven genera and a few additional unproven genera which are generally considered to belong to the *Mycosphaerellaceae* or with known associations to “*Mycosphaerella*”-like sexual morphs. Some sexual morph-typified genera and above all various asexual morph-typified genera have still unproven affinities to the *Mycosphaerellaceae* (see above under “asexual states (2) and (3)”). They are not keyed out. Comprehensive keys to such genera are available in Braun (1995, 1998, 2010)]

Key to sexual genera of *Mycosphaerellaceae*

1. Ascromata single, scattered2
1. Ascromata multi-loculate, immersed in hypostromata or pseudostromata7
2. Lichenicolous fungi3
2. Saprobic or parasitic on flowering plants5
3. Ascospores mostly 3-septate, only on thallus of *Pseudocyphellaria* and *Nephroma****Pseudostigmidium***
3. Ascospores 1-septate4
4. Hamathelial filaments short pseudoparaphyses originating from the upper part of the ascromatal cavity, not reaching the interascal space, ascospores hyaline, exceptionally brownish at maturity, vegetative hyphae hyaline or pale brown, smooth-walled, not forming a superficial net on the host thallus***Stigmidium***
4. Hamathelial filaments paraphysoids, usually present between asci, but often sparse, ascospores hyaline or brown, vegetative hyphae medium to dark brown, smooth or rugose, generally forming a superficial net over the host thallus or apothecia, more rarely immersed***Sphaerellothecium***
5. Ascospores mostly 1-septate, ellipsoidal to subclavate6
5. Ascospores 3-septate, long cylindrical***Sphaerulina***
6. Ascospores 1-septate, hyaline (rarely becoming yellow-brown and 3-septate at maturity), pseudoparaphyses of short cells, parasitic on *Proteaceae****Brunneosphaerella***
6. Ascospores always hyaline, pseudoparaphyses lacking, saprobic or parasitic on various hosts***Mycosphaerella*** sensu lato (“*Mycosphaerella*”-like sexual morphs) [*Mycosphaerella* sensu stricto is a heterotypic synonym of *Ramularia*, the further generic splitting is based on associated asexual morphs]
7. Ascospores aseptate8
7. Ascospores septate9
8. Ascospores rough-walled with small guttules, forming pseudostromata immersed to semi-immersed under epidermis, raised, occurring on *Acer negundo****Achorodopsis***
8. Ascospores smooth-walled, forming hypostromata within ovary of host, parasitic on inflorescences of *Carex* and *Cobresia****Melanodopsis***

9. Ascospores 1-septate, hyaline or pigmented 10
9. Ascospores 2–3-septate, pale yellowish, occurring on *Cactaceae* ***Gillotia***
10. Ascostromata easily detached, superficial 11
10. Ascostromata not easily detached, subcuticular, visible as black raised spot on host surface, causing black blotch or sooty blotch on *Trifolium* ***Polythrincium*** (= *Cymadothea*)
11. Ascostromata visible as red-brown to black, circular or undulate areas on host surface, ascromata extruding through the stromata, reddish-brown to brown, paraphyses present ***Placocrea***
11. Ascostromata visible as black lesions, with yellowish to brown edge, ascromata numerous, immersed in the stroma, dark brown to black, aseptate ***Euryachora***

Key to asexual genera of *Mycosphaerellaceae*

1. Coelomycetous asexual morphs (conidiomata acervular or pycnidial) 2
1. Hyphomycetous asexual morphs (conidiophores solitary, fasciculate, in sporodochia or synnemata) 9
2. Conidiomata acervular 3
2. Conidiomata pycnidial 7
3. Conidiophores and conidia distinctly pigmented, brown, verruculose ***Lecanosticta***
3. Conidiophores and conidia colourless or only pale brown, smooth or almost so 5
5. Conidiophores, conidiogenous cells and conidia subhyaline to usually pale brownish, conidiogenous cells only percurrently proliferating ***Colletogloeum***
5. Conidiogenous cells and conidia colourless, conidiogenous cells percurrently and sympodially proliferating 6
6. Conidia colourless in mass, not slimy, scolecosporous ***Phloeospora***
6. Conidia cream to brownish in mass, slimy, mostly amero- to phragmosporous, (0–)1–5-septate ***Dothistroma***
7. Conidia hyaline, smooth or almost so, usually scolecosporous ***Septoria*** [on grasses, conidiogenous cells phialidic or inconspicuously annellidic, with yeast-like growth in culture and three conidial types (pycnidial, phragmosporous and yeast-like in vitro), see Zymoseptoria (phylogenetically distinct from Septoria, but morphologically not generally distinguishable; Caryophylloseptoria, Neoseptoria, Polyphialoseptoria, Ruptoseptoria, and Stromatoseptoria are additional recently introduced phylogenetically proven septorioid genera, which are, however, morphologically barely distinguishable)]
7. Conidia pigmented, verruculose 8
8. Conidia euseptate ***Phaeophleospora***
8. Conidia distoseptate ***Sonderhenia***
9. Conidiophores in vivo in synnemata 10

9. Synnemata not formed 13
10. Synnemata, conidiophores and conidia colourless or at least conidiogenous cells and conidia colourless, conidia solitary or in chains, 0–1(–3)-septate **Phacellium**
10. Synnemata, conidiophores and conidia pigmented 11
11. Conidia strongly curved-helicoid, with few septa
..... **Trochophora**
11. Conidia straight or only slightly curved 12
12. Conidiogenous cells with inconspicuous loci, neither thickened nor darkened, at most slightly conspicuous by being denticle-like or somewhat refractive, conidia solitary, scolecosporous, transversely pluriseptate, rarely dictyosporous **Pseudocercospora**
pro parte (incl. *Phaeoisariopsis*)
[often dictyosporous, on *Guazuma ulmifolia*, South America, see *Pantospora*, phylogenetically distinct, but morphologically not clearly distinguishable from synnematous *Pseudocercospora* species]
12. Conidiogenous cells with conspicuous loci, thickened and darkened, solitary, rarely in chains, amero- to phragmosporous, rarely scolecosporous
..... **Passalora** pro parte (incl. *Tandonella*)
13. End cells of pigmented verruculose hyphae form brown, verruculose endoconidia, conidiophores lacking
..... **Phaeothecoidea**
13. Conidiophores not forming endoconidia 14
14. Conidia and conidiophores colourless 15
14. At least conidiophores pigmented 21
15. Conidiophores fasciculate, frequently branched from the base upward, conidiogenous cells often intercalary, with small lateral protuberances (conidiogenous loci).....
..... **Ramulariopsis**
15. Conidiophores unbranched or only sparingly branched, conidiogenous cells terminal, rarely intercalary 16
16. Conidiogenous loci inconspicuous, neither thickened nor darkened, at most slightly denticle-like 17
16. Conidiogenous loci conspicuous by being thickened and darkened or bulging-papillate 19
17. Conidiophores reduced to conidiogenous cells, conidia amero- to phragmosporous, slimy or yeast-like.....
..... **Micocyclosporella**
17. Conidia scolecosporous, neither slimy nor yeast-like 18
18. On *Poaceae* (grasses), causing sooty leaf-spots, often forming sclerotia **Ramulispora**
18. On ferns, dicotyledonous hosts and monocots of other families, without sclerotia **Pseudocercospora**
19. Conidiogenous loci convex, on geniculate conidiogenous cells, thickened and refractive, but not darkened, leaf spotting pathogens
..... **Cercospora**
19. Conidiogenous loci truncate, flat, thickened and darkened, visible in face view as minute dark circles 20
20. Conidia solitary, scolecosporous, pluriseptate *Cercospora* subgen **Hyalocercospora**
20. Conidia solitary or catenate, conidia amero- to phragmosporous **Ramularia**
21. Conidiogenous loci inconspicuous, neither thickened nor darkened or only slightly thickened and darkened around the ultimate rime 22
21. Conidiogenous loci conspicuous, thickened and darkened throughout except for a minute central pore, truncate [or convex, thickened, refractive, but not darkened, see **Cercospora**, subtropical-tropical species with faintly pigmented conidiophores] 26
22. Conidiogenous cells with a single conidiogenous locus, percurrently proliferating and annellate 23
22. Conidiogenous cells with a single or several conidiogenous loci, sympodially proliferating, sometimes sympodial and percurrent proliferations mixed 25
23. Conidia distoseptate, didymo- to phragmosporous **Pseudocercospora** pro parte (incl. former *Stigmia* sensu stricto)
23. Conidia aseptate or euseptate 24
24. Conidiophores and conidia rather thick-walled, dark, smooth to often verruculose, conidiogenous cells percurrent, with conspicuous, coarse annellations
..... **Scolecostigmia**
24. Conidiophores and conidia thin-walled, paler, smooth or almost so, annellations fine and often inconspicuous **Pseudocercospora** (incl. former *Cercostigmia*)
25. Conidiophores and conidia pigmented, conidia rarely subhyaline, conidia usually scolecosporous, pluriseptate, rarely amero- to phragmosporous, but neither slimy nor yeast-like
..... **Pseudocercospora**
[in culture (on WA, SNA, PDA and MEA) forming red crystals, see *Pallidocercospora* (otherwise morphologically indistinguishable from *Pseudocercospora*)]
25. Conidiophores faintly brownish, conidia hyaline, didymo- to phragmosporous, slimy or yeast-like
..... **Microcyclosporella**
26. Conidiophores terminally frequently branched or penicillate-verticillate, conidia solitary, amero- to phragmosporous **Periconiella**
26. Conidiophores unbranched or only sparingly branched 27
27. Conidiophores sinuous, wall unequally thickened, cicatrized, with unilateral conidiogenous loci, unequally pigmented, seemingly “virgate”, conidiogenous cells polytretic, conidia solitary, brown, didymosporous (pathogenic on *Trifolium*) **Polythrincium**
(= *Cymadotheca*)
27. Conidiophores with equally thickened walls, conidiogenous loci not unilateral, not “virgate”, conidiogenous cells polyblastic 28
28. In vivo with superficial mycelium 29

28. In vivo only with internal mycelium, superficial hyphae lacking 30
29. Superficial hyphae distinctly verruculose, conidiophores solitary or fasciculate, conidia solitary to catenate, smooth to mostly verruculose **Zasmidium**
29. Superficial hyphae smooth or almost so **Passalora** pro parte (incl. *Mycovellosiella*)
30. Conidiophores frequently branched from base to top, conidia consistently distoseptate **Distocercospora**
30. Conidiophores unbranched or rarely branched, conidia consistently euseptate, rarely eu- and distosepta mixed 31
30. Conidia solitary, very rarely in short chains (under high humidity), hyaline, usually scolecosporous and pluriseptate **Cercospora**
30. Conidia solitary or catenate, pigmented, mostly non-scolecosporous 31
31. Conidia solitary, amero- to phragmosporous, distinctly (coarsely) verruculose, conidiophores densely fasciculate, in sporodochium-like conidiomata **Asterisporium**
31. Conidia solitary to catenate, amero- to phragmosporous, occasionally scolecosporous, but always smooth or at most faintly rough **Passalora** pro parte (incl. *Phaeoramularia*)

Myriangiaceae Nyl., Mém. Soc. Sci. nat. Cherbourg 2: 9 (1854), MycoBank: MB81866

Possible synonym:

Phymatosphaeriaceae Speg., Anal. Soc. cient. argent. 26(1): 57 (1888)

Saprobic on bark, leaves and branches. Sexual state: *Ascostromata* usually on lower surface, superficial, scattered, solitary, aggregated or gregarious, pulvinate, erumpent, pale yellow to black, globose to oval, sometimes surrounded by the remains of the ruptured epidermis, multi-loculate, locules scattered in upper part of ascostromata, ascostromata comprising pseudoparenchymatous cells of pale yellow pigmented *textura angularis* to *textura globosa*. *Locules* with single ascus inside each locule, ostiolate. *Ostirole* minute, paraphyses absent. *Asci* 8-spored, bitunicate, fissionate, globose to subglobose, with a minute pedicel (except *Anhelia* which has a prominent pedicel) or pedicel lacking, and indistinct ocular chamber. *Ascospores* irregularly arranged, oblong or fusiform with slightly acute ends, with 4–7 transverse septa and muriform, smooth to verruculose, hyaline, constricted at the septum, lacking a sheath. Asexual state: Unknown.

Notes: *Myriangiaceae* is a family of saprobes, although a small number of species cause leaf spots, which belongs to order *Myriangiales*, the latter being erected by Starbäck (1899). *Myriangiaceae* was introduced by Nylander (1854) in “*Synopsis methodica Lichenum*” and included *Myriangium*

duriaei Mont. & Berk. and *M. curtisii* Mont. & Berk. Clements and Shear (1931) placed the family *Myriangiaceae* in the order *Dothideales*, due to the presence of ascostromata and locules. von Arx (1963) treated *Myriangiaceae* in *Myriangiales*. Many classical treatments have placed *Elsinoaceae* in synonymy with *Myriangiaceae*, but von Höhnelt (1910a) was convinced that the former constituted a separate family. Barr (1979a) and Eriksson (1981) were of the opinion that two separate families should be maintained as *Elsinoaceae* and *Myriangiaceae* with latter predominantly occurring on branches, while *Elsinoaceae* was restricted to foliar pathogens. According to Wolf and Wolf (1947) the type genus *Myriangium* including *M. duriaei*, *M. curtisii*, *M. montagnei* Berk. and *M. thwaitesii* Petch are parasitic on scale insects.

Nylander (1854) placed only two species under this family, but von Arx and Müller (1975) placed 17 species in the family. After differentiating *Elsinoaceae* as a separate family from *Myriangiaceae* with molecular evidence, Schoch et al. (2006) and Lumbsch and Huhndorf (2010) maintained only four genera in *Myriangiaceae*, and in this treatment we include only *Anhelia*, *Diplothea* and *Myriangium*. *Diplothea* shows an ascostromata with locules scattered in the upper part and is similar to the family type of *Myriangiaceae*. Earlier the familial position of *Anhelia* was uncertain (Lumbsch and Huhndorf 2010), however, phylogenetic analyses support its inclusion in the family (Danilo et al. 2012). Theissen and Sydow (1917) placed *Eurytheca* in family *Saccardiaceae*, while Lumbsch and Huhndorf (2010) referred the genus to the *Myriangiaceae*. Further molecular clarification is needed to clarify the familial position of the genus *Eurytheca*.

Type: **Myriangium** Mont. & Berk., in Berkeley, London J. Bot. 4: 72 (1845) Fig. 86

Possible synonyms:

Phymatodiscus Speg., Boln Acad. nac. Cienc. Córdoba 23: 484 (1919)

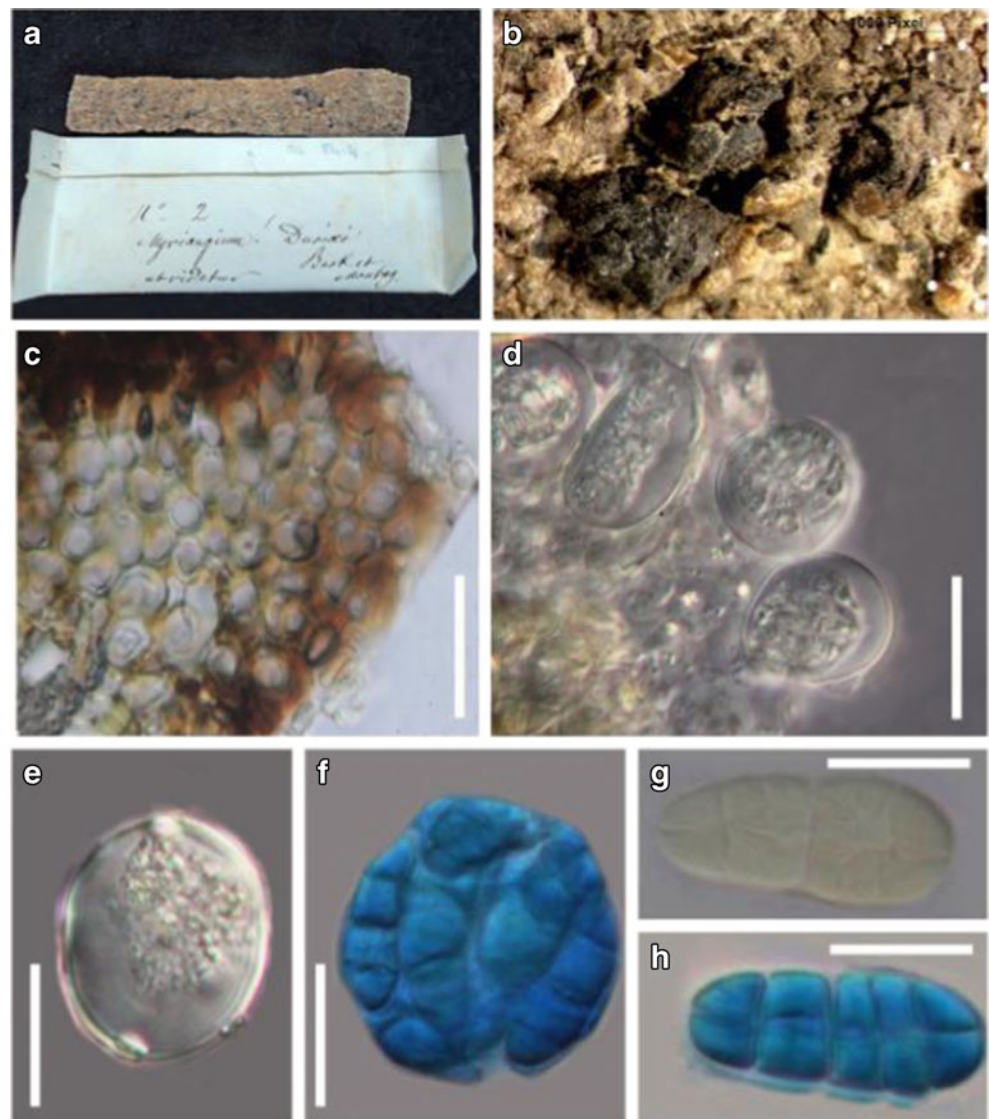
Phymatosphaeria Pass., Nuovo G. bot. ital. 7: 188 (1875)

Pyrenotheca Pat., Bull. Soc. bot. Fr. 33: 155 (1886)

Saprobic on bark of *Fraxinus*, *Acer*, *Citrus* and other plants. Sexual state: *Ascostromata* superficial, scattered, solitary, aggregated or gregarious, pulvinate, erumpent, globose to oval, pale yellow to black, containing scattered, embedded asci. *Cells of ascostromata* thick-walled, *textura angularis*, pigmented. *Asci* 8-spored, bitunicate, fissionate, globose to subglobose, pedicel minute, apically rounded with indistinct ocular chamber. *Ascospores* fasciculate, elliptical to oblong, muriform, usually with 7 transverse septa and one or more longitudinal septa, hyaline to subhyaline. Asexual state: Unknown.

Type species: **Myriangium duriaei** Mont. & Berk., in Berkeley, London J. Bot. 4: 73 (1845) MycoBank: MB: 218324

Fig. 86 *Myriangium duriae* (Material examined: ALGERIA, on living *Pistacia lentiscus*, PC, NL 8414). **a** Herbarium material. **b** Ascostromata on host surface. **c** Cross-section of part of ascostroma. **d–e** Asci bearing irregularly arranged 8-spores. **f** Ascus stained in lactophenol cotton blue reagent. **g** Muriform, hyaline ascospore. **h** Ascospore stained in lactophenol cotton blue reagent. Scale bar: **c** = 100 μm , **f** = 50 μm , **d–e**, **g–h** = 10 μm



Other genera included

Anhelia Racib., Parasit. Alg. Pilze Java's (Jakarta) 2: 10 (1900)

Type species: Anhelia tristis Racib., Parasit. Alg. Pilze Java's (Jakarta) 2: 10 (1900)

Diplothea Starbäck, Bot. Notiser: 30 (1893)

Type species: Diplothea tunae (Spreng.) Starbäck, Bot. Notiser: 30 (1893)

Key to the genera of *Myriangiaceae*

1. Asci lying at different levels in the ascostromata2
1. Asci aggregated in outer margin*Anhelia*
2. Ascstromata comprising several layers of thick-walled *textura angularis**Myriangium*
2. Ascstromata comprising several layers of thick-walled *textura globosa**Diplothea*

Mytilinidiaceae Kirschst. [as '*Mytilidiaceae*'], Verh. bot. Ver. Prov. Brandenb. 66: 28 (1924), MycoBank: MB 81049

Possible synonyms:

Lophiaceae H. Zogg ex Arx & E. Müll., Stud. Mycol. 9: 60. 1975.

Lophiaceae H. Zogg, Beitr. Kryptogamenfl. Schweiz. 11(3): 90. 1962, nom. inval. ICBN Art. 36.

Saprobic on wood, bark, resin, cones, scales, needles, seeds, and roots of gymnosperms, much less frequently on angiosperms. Predominantly temperate in distribution. Sexual state: *Ascomata* fragile, yet persistent, carbonaceous, globose to obovoid, to strongly laterally compressed erect, bivalve shell-shaped structures, standing on edge, with lateral walls more or less connivent, and extended vertically to a prominent longitudinal keel or cristate apex; distinctly clam- or mussel-shaped. Superficial, scattered to gregarious, black. Sometimes

less connivent, more appressed, hysterioid, grouped in triangular or radiating star-shaped or astral arrangement. *Peridium* fragile, thin-walled, scleroparenchymatous, rarely of multiple layers. *Hamathecium* of narrow trabeculate pseudoparaphyses, borne in a gel matrix, often sparse to lacking at maturity. *Asci* 8-spored, rarely 4-spored, bitunicate, fissitunicate, cylindrical, with a broad, short pedicel, ocular chamber not well-developed, borne on a basal cushion, centrally orientated within the centrum, rarely borne laterally. *Ascospores* overlapping uniseriate, biseriate or in one or two fascicles within the ascus, hyaline to pigmented yellow to dark brown, showing bipolar symmetry, highly variable in septation. Asexual states: see under notes.

Notes: Mytilinioid fungi have historically been classified in the family *Hysteriaceae* due to perceived similarities in ascomata morphology, specifically its means of longitudinal dehiscence (Bisby 1923). Modern authors have likewise included mytilinioid fungi within the *Hysteriaceae*, placing the family in the *Pseudosphaeriales* (Nannfeldt 1932; Gaumann 1949), the *Dothiorales* (Müller and von Arx 1950; von Arx and Müller 1954), the *Dothideales* (von Arx and Müller 1975), and in a separate order *Hysteriales*, closely related to the *Pleosporales* (Miller 1949; Luttrell 1955). The *Hysteriales* were placed in the subclass *Loculoascomycetes* by Luttrell (1955), due to the presence of bitunicate asci, corresponding to the *Ascoloculares* first proposed by Nannfeldt (1932). However, Luttrell (1973) held a wide concept of the *Hysteriales* and did not recognize the family *Lophiaceae*, instead proposing a subfamily within the *Hysteriaceae* to accommodate mytilinioid forms. Barr (1979a) however maintained the two-family distinction. The *Mytiliniaceae* was placed in the *Melanommatales*, based on a thin-walled peridium of scleroparenchymatous cells enclosing a hamathecium of narrow trabeculate pseudoparaphyses, asci borne in a peripheral layer and with ascospores typically showing bipolar symmetry (Barr 1987a, b, c, 1990a, b, c, d). Later, Barr and Huhndorf (2001) noted that the family was somewhat atypical of the *Melanommatales*, in that, as a consequence of reduced locule space attributed to lateral compression, they possess a basal, rather than peripheral, layer of asci and a reduced hamathecium at maturity. Barr (1983a) eventually abandoned the *Hysteriales* and placed the *Hysteriaceae* within the *Pleosporales* due to the presence of cellular pseudoparaphyses, asci borne in a basal rather than peripheral layer and ascospores typically showing bipolar asymmetry. Kirk et al. (2001) maintained both the *Hysteriaceae* and the *Mytiliniaceae* in the *Hysteriales*, but Eriksson (2006) removed the *Mytiliniaceae* from the *Hysteriales* and considered it as *Dothideomycetes et Chaetothyriomycetes incertae sedis*, leaving the *Hysteriaceae* as the sole family in the *Hysteriales*. Duby (1862), however, was the first to propose that hysterioid fungi be divided into two sections, the *Hystériées* and the *Lophiées*, the latter to

accommodate *Ostrechnion*, *Mytilinidion*, and *Lophium*. One hundred years later, Zogg (1962) proposed two families: the *Hysteriaceae* sensu stricto to accommodate thick-walled hysterioid forms, and the *Lophiaceae* H. Zogg ex von Arx and E. Müller (Zogg 1962; von Arx and Müller 1975) to accommodate thin-walled, mytilinioid forms. Zogg (1962) accepted the following genera: *Actidium*, *Mytilinidion* (as *Mytilidion*), *Lophium*, and *Glyphium*. Barr (1990a) made the argument for retention of the earlier name *Mytiliniaceae*, over the *Lophiaceae*, despite the proposal to conserve the latter (Hawksworth and Eriksson 1988).

Boehm et al. (2009a, b) were the first to present the first combined use of DNA and amino acid sequence data to reconstruct the phylogeny of hysterioid and mytilinioid fungi. These studies were based on a wide taxon sampling strategy, and employed four nuclear genes. A number of specific conclusions were reached. Multi-gene phylogenies provided strong support for the monophyly of both the *Hysteriaceae* and the *Mytiliniaceae*, within the *Pleosporomycetidae*. However, sequence data indicated that both families were not closely related within the subclass. Sequence data also indicated that while a number of genera were polyphyletic within the *Hysteriaceae*, involving numerous transfers, within the *Mytiliniaceae* the genera *Mytilinidion*, *Lophium* and *Quasiconcha* formed a highly monophyletic clade, defining a new order the *Mytiliniales* (Boehm et al. 2009b). The genus *Ostrechnion*, previously classified within the *Mytiliniaceae*, actually resided within the *Hysteriaceae*. The genus *Glonium*, previously within the *Hysteriaceae*, was shown to be polyphyletic along two highly divergent lines. A core group of species within *Glonium* found close affinities instead with the family *Mytiliniaceae*, for which was proposed the family *Gloniaceae* (Boehm et al. 2009a). These taxonomic changes presented a number of challenges for understanding evolution within this group of fungi. As a result, the revised *Hysteriaceae* bears little resemblance to the original concept of the family (Zogg 1962). Currently accepted genera in *Mytiliniaceae* include *Actidium*, *Lophium*, *Mytilinidion*, *Ostreola*, *Zoggium* and *Quasiconcha* (Barr 1975, 1990c; Barr and Blackwell 1980; Darker 1963; Lohman 1932b; Vasilyeva 2001; Zogg 1962). The genus *Glyphium* was originally included by Zogg (1962), Barr (1987a, 1990c) and others (e.g., Goree 1974; Lorenzo and Messuti 2005; Sutton 1970) in the *Mytiliniaceae*. However, recent molecular evidence indicates that the genus *Glyphium* does not reside within the family (Boehm and Schoch, unpublished data).

Aposphaeria was shown to be accommodated in *Melanommataceae* by de Gruyter et al. (2012). Although, the type species *A. pulviscula* (Sacc.) Sacc. was not included in this analysis, de Gruyter et al. (2012) have clearly shown that *A. populina* Died. and *A. corallinolutea* Gruyter, Aveskamp & Verkley group in *Melanommataceae*. De Gruyter et al. (2009, 2012) showed that *Pyrenochaeta nobilis*

De Not., the type species groups in *Cucurbitariaceae*. von Höhnelt (1918a, b) considered *Sclerochaeta* as a synonym for *Chaetopyrena* and de Gruyter et al. (2010) showed that *Chaetopyrena* belongs in *Didymellaceae*.

Type: *Mytilidion* Duby, Mém. Soc. Phys. Hist. nat. Genève 16(1): 34 (1861) [1862]

Figure 87

Possible synonyms:

Mytilidion Duby, Mém. Soc. Phys. Hist. nat. Genève 16(1): 34 (1861) [1862]

Hypodermopsis Earle, Bulletin of the New York Botanical Garden 2: 345 (1902)

Murashkinskiya Petr., Hedwigia 68: 203 (1928)

Saprobic and lignicolous on periderm, wood, twigs, leaves of members of *Pinaceae*, *Cupressaceae*, and *Taxodiaceae*; primarily temperate in distribution. Sexual state: *Ascomata* superficial, gregarious or scattered, occasionally two or three united, elongate or ellipsoid, conchate or shield shaped, small to medium sized; apex cristate, opening by longitudinal slit; surface black, smooth and shining or dull, often longitudinally

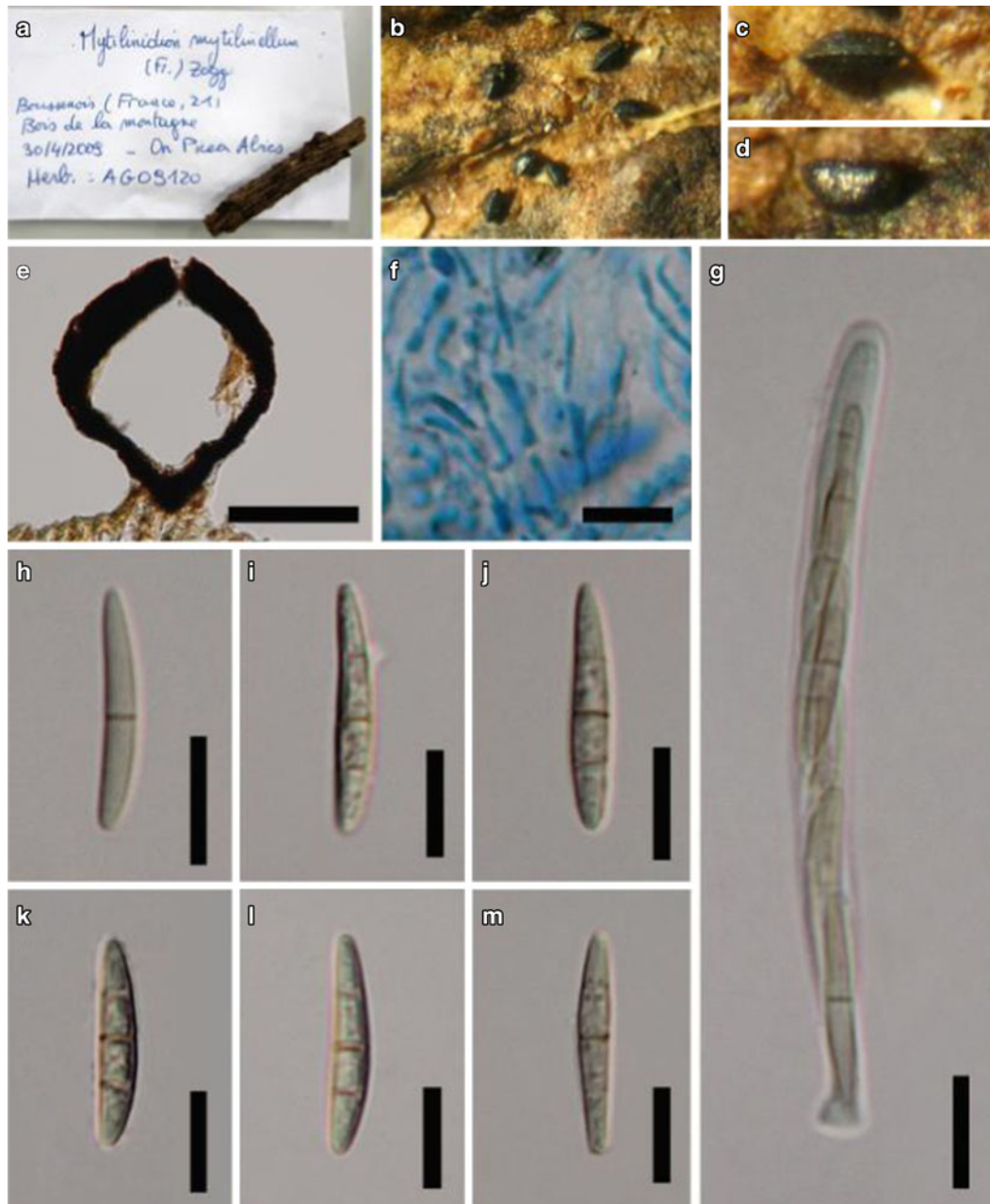


Fig. 87 *Mytilidion mytilinellum* (Material examined: France, Bois de la montagne, on *Picea abies*, 30 April 2009, Herb. AG09120). **a** Detail of specimen. **b** Ascomata on host surface. **c** Close-up of ascoma (top view)

d Close-up of ascoma (side view). **e** Section through ascoma. **f** Pseudoparaphyses. **g** Ascus. **h–m** Ascospores. Scale bars: **e**, **g** = 50 μm , **f**, **h–m** = 10 μm

striate. *Peridium* thin-walled, carbonaceous, brittle, composed of sclerenchymatous cells, in few layers. *Hamathecium* of narrow trabeculate pseudoparaphyses, borne in a gel matrix, often sparse to lacking at maturity. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to slender-clavate, with a short broad pedicel, ocular chamber not well-developed, borne on a basal cushion, centrally orientated within the centrum, rarely borne laterally. *Ascospores* overlapping uniseriate, biseriata or in one or two fascicles, ellipsoid, fusoid, obovoid to elongate, yellowish, light brown, reddish brown, transversely septate, three- to many-septate; phragmospores to scolecospores, ends obtuse or acute, longer, faintly constricted at the median septum or not; showing bipolar symmetry. Asexual states: primarily coelomycetous (e.g., *Aposphaeria*, *Pyrenochaeta*, *Camaroglobulus*, *Dothiorella*, and *Sclerochaeta*) and less frequently hyphomycetous (e.g., “Chalara”-like, *Papulaspora*, *Peyronelia*, *Septonema* and *Taeniolella*) (Blackwell and Gilbertson 1985; Lohman 1932b, 1933a, b; Speer 1986; Sutton 1970; Seifert et al. 2011; Wijayawardene et al. 2012). However *Aposphaeria*, *Pyrenochaeta* and *Dothiorella* have been placed in different families (de Gruyter et al. 2009, 2012; Liu et al. 2013). The taxonomic position of *Papulaspora* is also uncertain and is probably a heterogenous genus (Seifert et al. 2011).

Notes: The genus *Mytilinidion*, the type for the family *Mytiliniaceae*, was established by Duby (1862) for *M. aggregatum* de Candolle ex Duby, with an etymology from *Mytilus*, a genus of mussels. Zogg (1962) however pointed out that none of the *exsiccati* contained identifiable material and proposed that *M. mytilinellum* (Fr.) Zogg be designated the neotype (Barr 1990a, b). Saccardo (1883, p. 760) considered the name *Mytilinidion* to be invalid and replaced it with *Mytilidion* Duby, a proposal supported by nearly all subsequent authors (e.g., Clements and Shear 1931; Ellis and Everhart 1892; Kirschstein 1924; Luttrell 1973; Massee 1895; Rehm 1896; von Arx and Müller 1975; Zogg 1962), until Barr (1975) correctly pointed out that the name *Mytilinidion* had historical precedence (Rogers 1953), and should replace the later name *Mytilidion*. Lohman (1932b) proposed two sub-genera within the genus *Mytilinidion*: subgenus *Eu-Mytilinidion* for species with a spore ratio of length to width of 10:1 or less to include species with typical phragmospores, and subgenus *Lophiopsis* to include species with scolecospores, typified by a ratio of approximately 20:1, the latter to accommodate *M. scolecosporum* Lohman, *M. parvulum* Lohman and *M. austral* Lohman. These three scolecosporous species form a transitional series to connect the genus *Mytilinidion* sensu lato with the somewhat isolated genus *Lophium*. Lohman (1932b) noted that spore germination in the subgenus *Eu-Mytilinidion* is polar, with the terminal cells germinating first; whereas, in *Lophiopsis* spore germination is non-polar, with any cell capable of germinating first, as in the genus *Lophium*. Despite the presence of

scolecospores in *Lophiopsis*, they do not exceed half the length of the ascus, thus presenting a biseriata arrangement, as in *Eu-Mytilinidion*, and unlike the single fasciculate arrangement in the filiform genus *Lophium*. Zogg (1962) accepted Lohman's (1932b) two subgenera and recognized 13 species occurring on members of the *Pinaceae*, *Cupressaceae* and *Taxodiaceae*, one of which has been subsequently transferred to *Ostreichnion* (Barr 1975), with another recently described from the resin of *Araucaria* in Brazil (Speer 1986), and, Boehm et al. (2009a), recognized *M. andinense* (Messuti and Lorenzo) Boehm et al., thus bringing the total number of species in the genus to 15.

Several morphological lines can be identified in the genus *Mytilinidion* sensu lato. Two series can be discerned based on fruit body shape, namely scutate ascomata, seated on a spreading base fused to the substrate (*M. californicum* Ellis & Harkness and *M. acicola* Winter), and the remainder of the species that typically possess strongly laterally compressed, conchate fruit bodies, with lateral walls more or less connivent, and extended vertically to a prominent longitudinal keel or cristate apex. Ascospore morphology in the genus *Mytilinidion* sensu lato can also be used to discern four morphological transition series within the genus, listed here by increasing ascospore length: (1) Short squat phragmospores: *M. californicum* Ellis & Harkness, *M. acicola* Winter, *M. resiniae* Speer, *M. decipiens* (Karst.) Sacc., *M. tortile* (Schw.: Fr.) Sacc. and *M. resinicola* M.L. Lohman; (2) Fusoid or spindle-shaped spores: *M. thujarum* (Cooke & Peck) M.L. Lohman, *M. oblongisporum* Teng and *M. andinense* (Messuti and Lorenzo) Boehm et al.; (3) Elongate phragmospores, with a spore ratio of length to width of 10:1 or less: *M. mytilinellum* (Fr.) Zogg, *M. rhenanum* Fuckel and *M. gemmigenum* Fuckel; and (4) Highly elongated phragmospores (scolecospores), with a ratio of approximately 20:1 (subgenus *Lophiopsis*): *M. scolecosporum* M.L. Lohman, *M. parvulum* M.L. Lohman and *M. austral* M.L. Lohman.

Recent molecular studies (Boehm et al. 2009a, b) on *Mytilinidion*, based on a taxon sampling of seven of the 15 current species, including members from both the subgenus *Eu-Mytilinidion* and *Lophiopsis* indicate that the genus is monophyletic, forming a highly supported *Mytiliniaceae* clade, defined within the *Pleosporomycetidae* as *Mytilinidiales* (Boehm et al. 2009a). Phylogenetic data also provided little support for the two sub-genera proposed by Lohman (1932b). Thus, species belonging to the subgenus *Lophiopsis*, namely *M. scolecosporum* and *M. australe*, did not segregate from species belonging to the subgenus *Eu-Mytilinidion*, suggesting that the scolecospore had independent origins within the genus *Mytilinidion* (Boehm et al. 2009b). Thus, in contrast to the *Hysteriaceae*, the family *Mytiliniaceae* represents a highly monophyletic entity, defining the order *Mytilinidiales* (Boehm et al. 2009a). The conchate nature of the fruit body and the thin-walled peridium, seem to unite what at first may seem a

disparate group of fungi into a single family. Although monophyletic, sequence data indicate a complex pattern of speciation within the genus and family, one that is not premised on past assumptions based on spore morphology.

Type species: Mytilinidion aggregatum (DC.) Duby [as ‘Mytilidion’], Mém. Soc. Phys. Hist. nat. Genève 16(1): 34 (1861) [1862]

Other genera included

- Actidium* Fr., *Observ. mycol.* (Havniae) 1: 190 (1815)
Type species: Actidium hysterooides Fr., *Observ. mycol.* (Havniae) 2: 353 (1818)
- Camaroglobulus* Speer, *Bull. trimest. Soc. mycol. Fr.* 102: 100 (1986)
Type species: Camaroglobulus resinae Speer, *Bull. trimest. Soc. mycol. Fr.* 102(1): 100 (1986)
- Lophium* Fr., *Observ. mycol.* (Havniae) 2: 345 (1818)
Type species: Lophium mytilinum (Pers.) Fr., *Observ. mycol.* (Havniae) 2: 345 (1818)
- Ostreola* Darker, *Can. J. Bot.* 41: 1383 (1963)
Type species: Ostreola consociata Darker, *Can. J. Bot.* 41:1384 (1963)
- Peyronelia* Cif. & Gonz. *Frag., Boln Real Soc. Españ. Hist. Nat., Biologica* 27: 333 (1927)
Type species: Peyronelia sirodesmioides Cif. & Gonz. *Frag., Boln Real Soc. Españ. Hist. Nat., Biologica* 27: 334 (1927)
- Quasiconcha* M.E. Barr & M. Blackw., *Mycologia* 72(6): 1224 (1981) [1980]
Type species: Quasiconcha reticulata M.E. Barr & M. Blackw., *Mycologia* 72(6): 1224 (1981) [1980]
- Septonema* Corda, *Icon. fung. (Prague)* 1: 9 (1837)
Type species: Septonema secedens Corda, *Icon. fung. (Prague)* 1: 9 (1837)
- Taeniolella* S. Hughes, *Can. J. Bot.* 36: 816 (1958)
Type species: Taeniolella exilis (P. Karst.) S. Hughes, *Can. J. Bot.* 36: 817 (1958)
- Zoggiium* Lar.N. Vassiljeva, *Mikol. Fitopatol.* 35(1): 17 (2001)
Type species: Zoggiium mayorii (H. Zogg) Lar. N. Vassiljeva [as ‘mayori’], *Mikol. Fitopatol.* 35(1): 17 (2001)

Key to sexual genera of the Mytiliniaceae

Note: The genera *Glyphium* and *Ostreichnion* are retained for historical reasons, since the keys are provided to effectuate and expedite identification of morphologically similar fungi, regardless of whether close phylogeny is implied or not.

1. Ascospores 1-septate, less than 30 μm long2
1. Ascospores not didymosporous, or if 1-septate, then longer than 30 μm 3
2. Didymospores brown, ellipsoid, symmetric, wall coarsely reticulate; 6–8 \times 5–5.5 μm *Quasiconcha*

2. Didymospores olive to reddish brown, walls thin, smooth or delicately longitudinally striate; longer than 10 μm *Actidium*
3. Ascospores filiform, multi-septate, about equal in length to that of the ascus, in some cases, at maturity, longer than the ascus, often spirally arranged4
3. Ascospores ellipsoid, fusoid, cylindrical, if scolecospores then not equal in length to that of the ascus and not spirally arranged6
4. Ascomata conchate, solitary to gregarious, but never forming fused, ridge-like, assemblages*Lophium*
4. Ascomata either forming rigid, fused band- or ridge-like ascomata or solitary, erect and dolabrate5
5. Ascomata conchate, densely gregarious, forming band- or ridge-like assemblage*Zoggiium*
5. Ascomata erect, dolabrate to ligulate in outline; often with subtending hyphal strands; cosmopolitan*Glyphium*
 Note: Recent sequence data (Boehm and Schoch unpubl.) indicate that the genus *Glyphium* does not belong in Mytiliniaceae, but remains rather as Pleosporomycetidae, genera incertae sedis; it is included here for historical reasons.
6. Ascospores transversely septate phragmospores; if scolecospores, longer than 50 μm , then only 2–4 μm wide*Mytilinidion*
6. Ascospores dictyospores, or large and remaining 1-septate7
7. Ascomata conchate; ascospores ellipsoid, not over 30 \times 10 μm , with single longitudinal septum in mid-cell*Ostreola*
7. Ascomata conchate; ascospores ellipsoid or cylindrical, longer than 30 μm , with several longitudinal septa in cells or large and remaining 1-septate*Ostreichnion*
 Note: The genus *Ostreichnion* previously classified within the Mytiliniaceae (Barr 1975, 1987a) has been transferred to the family Hysteriaceae (Boehm et al. 2009a, b).

Key for asexual genera in Mytiliniaceae

1. Coelomycetous states with dark, ellipsoid, aseptate conidia*Camaroglobulus*
1. Hyphomycetous states2
2. Conidiophores reduced to conidiogenous cell*Peyronelia*
2. Unbranchd or sparingly branch conidiophores3
3. Conidiogenous cell monoblastic or sympodial, ramoconidia in branched chains*Septonema*
3. Conidiogenous cell monoblastic, conidia didymosporous or phragmosporous, in branch or unbranched chains*Taeniolella*

Naetrocymbaceae Höhnelt ex R.C. Harris, *More Florida Lichens, Incl. 10 Cent Tour Pyrenol.* (New York): 59 (1995), MycoBank: MB 81977

Epiphytic on twigs or wood; a small number of species regularly occur on stone, and at least one species appears lichenicolous. Sexual state: *Mycelium* branched, septate, brown to grayish, covering the host surface. *Ascomata* perithecial, superficial to immersed, globose to subglobose, dark brown to black, containing a single to multiple chambers, ostiolate. *Peridium* thin, composed of light brown to hyaline cells of *textura angularis* to epidermoidea. *Hamathecium* of coarse, hyaline, branching pseudoparaphyses, often with refractive or differentially-staining pseudoparaphyses tips. *Asci* 8-spored, bitunicate, fissitunicate, obpyriform, short pedicellate, apically rounded and endotunica thick-walled near apex, lacking an ocular chamber. *Ascospores* 2–3-seriate to multi-seriate, oblong to broad ellipsoid, elongate-ellipsoid, or fusiform, mostly hyaline, but becoming olivaceous-brown when mature, 1 to multi-septate, slightly constricted at septa, wall slightly ornamented. Asexual state: microconidia short and rod-shaped, macroconidia known from some *Leptorhaphis* species.

Notes: This family (as Naetrocymbeen) was originally described by von Höhnelt (1909a); however, this description was illegitimate as it was not in Latin or in accordance with ICBN rules (Harris 1995), but this taxon continued to be recognized to varying degrees through the 1990's. Batista and Ciferri (1963) treated the genus *Naetrocymbe* as part of *Capnodiaceae*, while Luttrell (1973) regarded *Naetrocymbe* as questionable and of uncertain taxonomic position. In contrast, Barr (1979a) and Eriksson (1981) informally recognized *Naetrocymbaceae* as a distinct family, albeit, with different circumscriptions. Harris (1995) later validated the family name and included four small genera: *Jarxia*, *Leptorhaphis*, *Naetrocymbe*, and *Tomasellia*. This circumscription is also currently recognized by Lumbsch and Huhndorf (2010).

Jarxia differs from *Naetrocymbe*, *Leptorhaphis* and *Tomasellia* in its brownish ascospores. *Naetrocymbe* forms clavate to obovoid asci, and differs from the other genera in the soleiform ascospores. Both *Leptorhaphis* and *Tomasellia* have semi-immersed, subglobose and dark brown ascomata and 8-spored, ellipsoid and apical rounded asci with an ocular chamber. However, *Leptorhaphis* forms fusiform ascospores, which differentiate it from *Tomasellia*, which has ellipsoid ascospores (Hawksworth and Mcmanus 1989).

Type: *Naetrocymbe* Körb. ex Körb., Lich. Select. Germ. 1–4: 58 (1865), MycoBank: MB 3410,

Figure 88

Possible synonyms:

Santessoniolichen Tomas. & Cif., Arch. Bot. (Forli) 28: 5 (1952)

Santessonimyces Cif. & Tomas., Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5 10(1): 29, 57 (1953)

Epiphytic on twigs or wood. Sexual state: *Mycelium* branched, septate, brown, covering the host surface.

Ascomata immersed, surrounding by dark brown fungal tissue, subglobose, black, containing a single chamber, ostiolate. *Peridium* thin, composed of dark brown to hyaline cells of *textura angularis*. *Hamathecium* of wide and hyaline pseudoparaphyses. *Asci* 8-spored, bitunicate, thick-walled, obpyriform, apically rounded, with an ocular chamber. *Ascospores* multi-seriate, oblong to long ellipsoid, hyaline, 1-septate, smooth-walled, slightly constricted at the septum. Asexual state: Unknown

Notes: *Naetrocymbe* includes approximately 12 species (Harris 1995; Alstrup et al. 2009; Knudsen and Lendemer 2009); although, the exact limits of this genus are debatable (see below). This genus is characterized by immersed, globose and black ascomata which are surrounded by dark brown fungal tissue, asci which are thick-walled, clavate to obovoid, and ascospores which are 1-septate, oblong to long ellipsoid and hyaline.

Reynolds (1971) reduced the size of *Naetrocymbe* by transferring most species to *Limacinula*; however, Luttrell (1973) regarded *Naetrocymbe* as being of questionable status. In contrast, Barr (1979a) and Eriksson (1981) continued to recognize *Naetrocymbe* as a distinct genus. *Naetrocymbe* was treated as a genus of non-lichen-forming fungi by Harris (1995); however, *N. saxicola* (A. Massal.) R.C. Harris and *N. atractospora* (Zahlbr.) R.C. Harris have been found associating with *Trentepohlia* algae (Roux 2009; Coppins 2002) as has the long-known (Harris 1975), but only recently described *N. herrei* (Knudsen and Lendemer 2009). The recognition of *Naetrocymbe* has proven controversial, with a number of authors treating *Naetrocymbe* species as part of *Arthopyrenia* (Aptroot 1998, 2002a; Coppins 2002; Orange 2009). Harris (1995) suggests *Naetrocymbe* differs from *Arthopyrenia* in its temperate to boreal distribution, its long, narrow physes, as well as its obpyriform asci, containing a distinct apical region lacking a nasse, ornamented ascospores, and short, rod-like conidia. *Naetrocymbe* species are mostly corticolous; however, some saxicolous species are known (Harris 1973, 1995; Knudsen and Lendemer 2009; Roux 2009).

Type species: *Naetrocymbe fuliginea* Körb., Lich. Select. Germ. 1–4: 58 (1865), MycoBank: MB 184333

Other genera included

Jarxia D. Hawksw., Stud. Mycol. 31: 93 (1989)

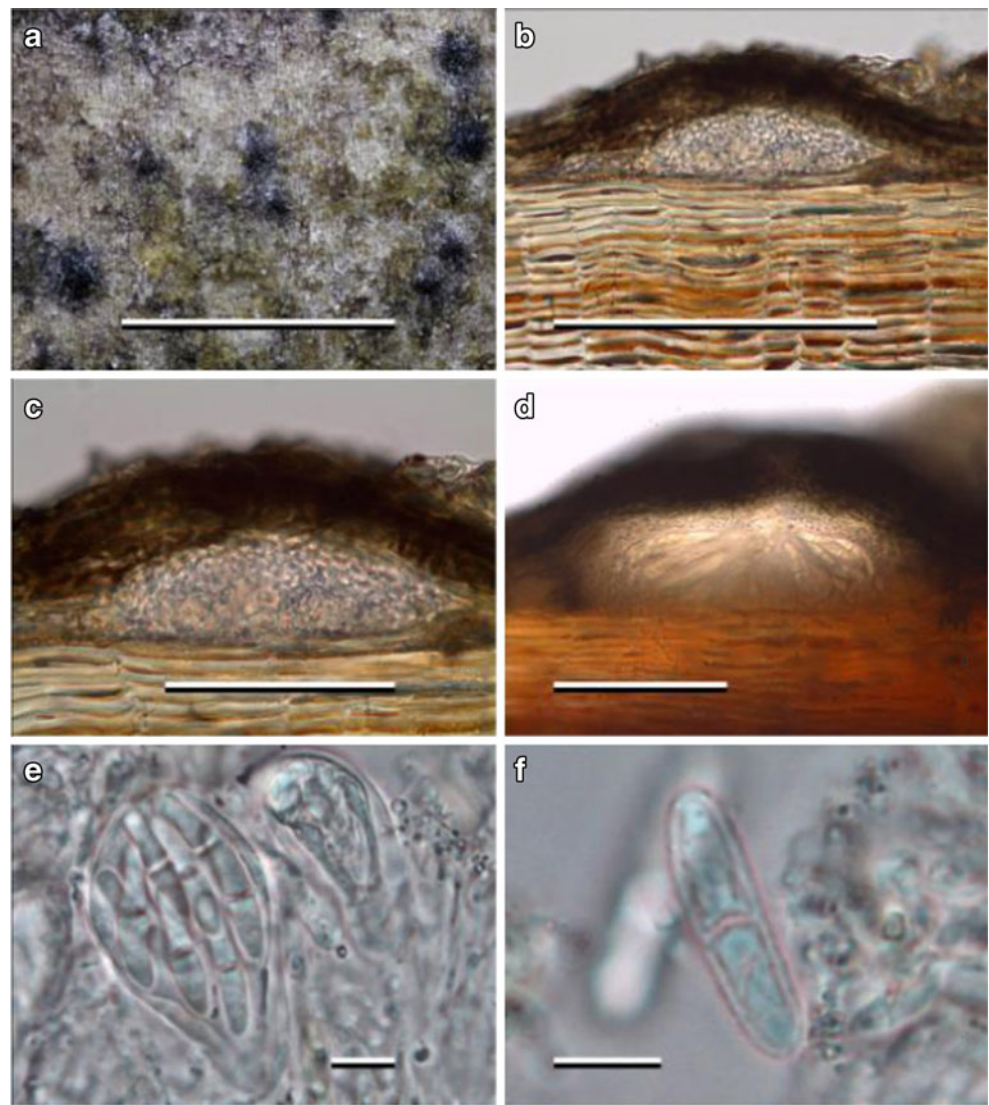
Type species: *Jarxia thelenula* (Müll. Arg.) D. Hawksw., Stud. Mycol. 31: 95 (1989)

Notes: *Jarxia* is a small genus of approximately two non-lichen-forming species known from subtropical habitats in the New World (Hawksworth 1985a, b; Hawksworth and Mcmanus 1989; Harris 1995).

Leptorhaphis Körb., Syst. lich. germ. (Breslau): 371 (1855)

Type species: *Leptorhaphis oxyspora* (Nyl.) Körb., Syst. lich. germ. (Breslau): 371 (1855)

Fig. 88 *Naetrocymbe punctiformis* (Material examined: a-d. LUXEMBOURG, Diederich 4785; e-f. France, Diederich 14320). **a** Ascomata on substrate. **b, c** Section of young ascoma. **d** Section of mature ascoma showing asci and persistent physes. **e** Mature ascus. **f** Ascospore. Scale bars: **a** = 1 mm, **b** = 120 μm , **c, d** = 50 μm , **e, f** = 10 μm



Notes: *Leptorhaphis* was revised (Aguirre-Hudson 1991) and eventually restricted to a relatively small group (12 species) of species occurring in temperate-boreal regions of the Northern Hemisphere. These taxa typically occur on bark and exhibit a high level of host-specificity (Aguirre-Hudson 1991, 2009; Aguirre-Hudson et al. 2002). Since this time, the additional species *L. opunticola* L.A. Fiol & M.B. Aguirre, occurring on *Opuntia* in the Balearic Islands of Spain, has been described (Aguirre-Hudson and Fiol 1993). Also, the lichenicolous *L. haematommatum* Hafellner & Kalb from New Zealand was introduced (Kalb et al. 1995), extending both the range and ecology of this genus. *Leptorhaphis* has typically been considered saprotrophic and non-lichen-forming (Vainio 1921; Swinscow 1965; Harris 1973, 1995; Aguirre-Hudson and Hawksworth 1987); however, some species have been observed to form loose associations with algae (Swinscow 1965; Aguirre-Hudson 1991, 2009; Aguirre-Hudson and Fiol 1993; Aguirre-Hudson et al. 2002), and

one species is lichenicolous (Kalb et al. 1995). Harris (1995) has treated *Leptorhaphis* as part of *Naetrocymbaceae*, a placement Aguirre-Hudson et al. (2002) accepted; however, Harris (1995) noted that *Leptorhaphis* differed from the remaining *Naetrocymbaceae* genera in its hamathecium, ascus and presence of macroconidia. Consequently, it is unclear if this genus will be retained in *Naetrocymbaceae* and molecular data is needed.

Tomasellia A. Massal., Flora, Jena 39: 283 (1856)

Type species: Tomasellia arthonioides (A. Massal.) A. Massal., Flora, Jena 39: 284 (1856)

Notes: *Tomasellia* has often been discussed with reference to *Mycoporum*; both form compound ascomata containing several locules, each producing their own ostiole (Harris 1995). The delimitation of these two genera has remained controversial. Harris (1995) reduced the size of *Tomasellia* by transferring most species to *Mycoporum* (*Mycoporaceae*) and suggested retaining five non-lichen-forming species in the

genus *Tomasellia*. Harris (1995) distinguished these two genera based on ascus, ascospore, conidial and hamathecial characters. The generic delimitations of Harris (1995) have been accepted by some (Sanderson and Coppins 2009a, b), while others (Aptroot 2002b, c) continue to employ a different circumscription of these genera.

Key to genera of *Naetrocymbaceae*

1. Ascomata superficial, ascospores pale brown to olivaceous *Jarxia*
1. Ascomata immersed, ascospores hyaline 2
2. Asci obpyriform *Naetrocymbe*
2. Asci cylindrical-clavate 3
3. Ascospores fusiform *Leptorhaphis*
3. Ascospores ellipsoid *Tomasellia*

Natipusillaceae Raja et al., Mycologia 104: 570 (2012), MycoBank MB 561948

Saprobic on submerged wood in freshwater habitats, in the neotropics. Sexual state: *Ascomata* small, on submerged wood, globose to subglobose, erumpent to superficial, hyaline to light brown. Peridial wall membranous, composed of pseudoparenchyma cells forming a *textura angularis* in surface view. Hamathecium of sparse, septate pseudoparaphyses, immersed in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissionate, globose, subglobose or obclavate, apedicellate, thick-walled at the apex, lacking an ocular chamber. *Ascospores* multi-seriate, fusiform to cylindrical, 1– several septate, multi-guttulate or not, hyaline, becoming brown with age, with or without a gelatinous sheath and/or appendages. Asexual state: Unknown.

Notes: The family *Natipusillaceae* was introduced by Raja et al. (2012) for four *Natipusilla* species collected on submerged wood in freshwater habitats. In an SSU and LSU rDNA data set, three *Natipusilla* species formed a well-supported monophyletic group in the Dothideomycetes (Ferrer et al. 2011), and formed an independent lineage with no phylogenetic relationship within the *Pleosporales* at the familial level. This family forms a separate lineage in our phylogenetic trees (Figs. 1 and 2) and a new order *Natipusillaceae* is introduced to accommodate it. The monophyletic status of the family *Natipusillaceae* was also recently reconfirmed using 18S and 28S rDNA molecular data (Raja et al. 2013b). *Minutisphaera* has many similar characteristics, but molecular data show this to cluster near *Farlowiella* (Ferrer et al. 2011).

Type: *Natipusilla* A. Ferrer et al., Mycologia 103: 417 (2011), MycoBank MB 518365

Figure 89

Notes: *Natipusilla* was described by Ferrer et al. (2011) for the type species *Natipusilla decrospora* A. Ferrer et al., from material on submerged wood in fresh water from Ecuador. In addition, two more species, *N. limonensis* A. Ferrer et al., and *N. naponensis* A. Ferrer et al. were also described based on morphological and 18S and 28S nrDNA molecular sequence

data (Ferrer et al. 2011). More recently, Raja et al. (2012) described an additional species, *N. bellaspora*, from material on submerged wood in freshwater from the Peruvian Amazon based on morphological data. Its phylogenetic relatedness to other *Natipusilla* species was confirmed using rDNA sequences (Raja et al. 2013b). Comparison with *Ascominuta* (Ranghoo and Hyde 2000; Hu et al. 2010) is essential as this may be an earlier name for *Natipusilla*.

Type species: *Natipusilla decorospora* A. Ferrer et al., Mycologia 103(2): 417 (2011)

Paranectriellaceae S. Boonmee & K.D. Hyde, **fam. nov.**, MycoBank: MB 804521

Parasitic (or *biotrophic*) on leaves. Sexual state: *Ascostromata* superficial, crustose, solitary, scattered, white to light orange, fleshy, soft in texture, with minute and colourless hairs, multi-loculate with ascomata arranged in a peripheral outer layer. *Locules* globose-subglobose, with individual ostioles. *Peridium* relatively thin, composed of light yellow, thick-walled cells of *textura angularis*. *Hamathecium* numerous, filiform, extending over asci, pseudoparaphyses 1–2 μm wide, branched, septate, embedded in a gelatinous layer. *Asci* 8-spored, bitunicate, fissionate, cylindrical, oblong-clavate, apedicellate rounded at the apex. *Ascospores* 2-seriate, broadly fusiform, hyaline, 3–4-septate, with apical spine-like appendages. Asexual state: hyphomycetous, staurosporous, in *Araneomyces*, *Tetracrium* and *Titaea*.

Typus: *Paranectriella* (P. Henn. ex Sacc & D. Sacc) Höhn.

Notes: *Paranectriellaceae* was introduced in this study to accommodate hyperparasitic fungi with bright coloured ascostroma, trans-septate and hyaline ascospores with prominent appendages. This family can be separated from *Tubeufiaceae* by its different morphology. The asexual morphs have are hyphomycetous. Seifert et al. (2011) and Wijayawardene et al. (2012) stated that *Araneomyces* and *Titaea* are possible asexual genera. *Paranectriella* and *Puttemansia* are included in this family as they have bright coloured ascostroma and hyaline, mostly 3-septate ascospores with appendages.

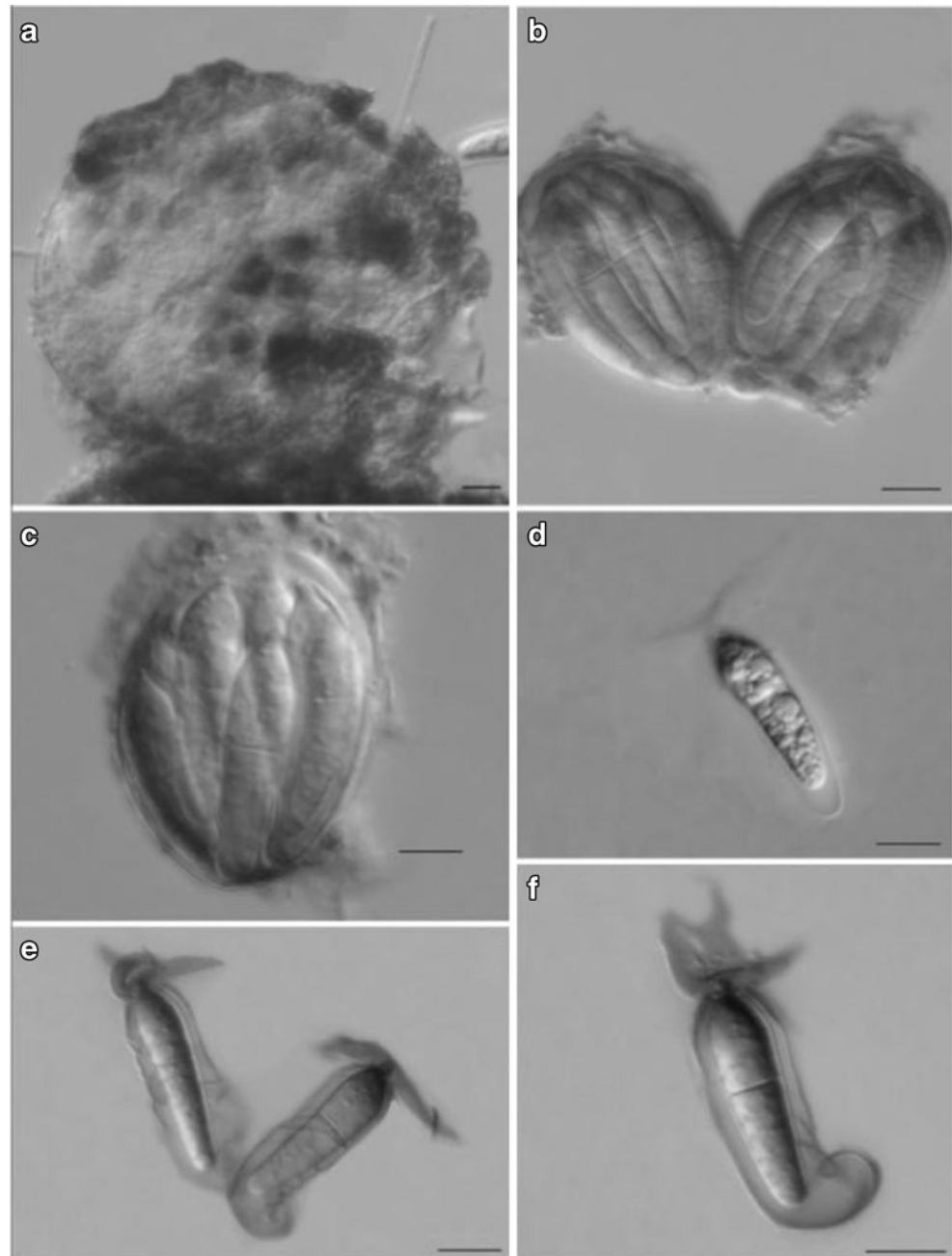
Type: *Paranectriella* (P. Henn. ex Sacc & D. Sacc) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 899 [23 repr.] (1910), MycoBank: MB3708 Fig. 90

Possible synonym:

Paranectria subgen. *Paranectriella* Henn. ex Sacc. & D. Sacc., Syll. fung. (Abellini) 17: 812 (1905)

Parasitic (or *biotrophic*) on leaves causing slight discolouration around fruiting bodies. Sexual state: *Ascostromata* superficial, crustose, solitary, scattered, white to light orange, fleshy, soft in texture, surrounded by colourless, sparse hairs, multi-loculate, with ascomata arranged in a peripheral outer layer. *Locules* globose to subglobose, with individual ostioles. *Peridium* relatively thin, composed of light yellow, thick-walled cells of *textura angularis*. *Hamathecium* comprising 1–2 μm wide, filiform, septate, branched,

Fig. 89 *Natipusilla decorospora* (AF 236–1, **holotype**). **a** Ascoma on the substrate. **b, c** Asci with 8-spores. **d** Ascospore in water showing gelatinous sheath and appendages. **e, f** Ascospores in water stained with aqueous nigrosin, note the gelatinous sheath and appendages at the apex. Scale bars=10 μ m. (Figure credit Astrid Ferrer)



pseudoparaphyses, extending over asci and embedded in a gelatinous layer. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, oblong-clavate, apedicellate, rounded at the apex. *Ascospores* 2-seriate, broadly fusiform, hyaline, narrowed at the ends, 3-septate, slightly constricted at the septa, with apical spine-like appendages. Asexual state: hyphomycetous, staurosporous, in *Araneomyces* and *Titaea*.

Notes: The genus is widely distributed in tropical regions, commonly found on leaf substrates. Presently, *Paranectriella* includes ten epithets as listed in Index Fungorum (2013). The type species *P. juruana*, is characterized by ascospores with

polar spine-like appendages (Fig. 90i–l). These characteristics and the light-coloured ascostromata with locules, exclude the genus from *Tubeufiaceae*.

Type species: *Paranectriella juruana* (Henn.) Henn. ex Piroz., Kew Bull 31: 598 (1977), MycoBank: MB319198
 \equiv *Paranectria juruana* Henn., Hedwigia 43(4): 245 (1904)

Other genera included

Puttemansia Henn., Hedwigia 41: 112 (1902)

Type species: *Puttemansia lanosa* Henn., Hedwigia 41: 112 (1902)

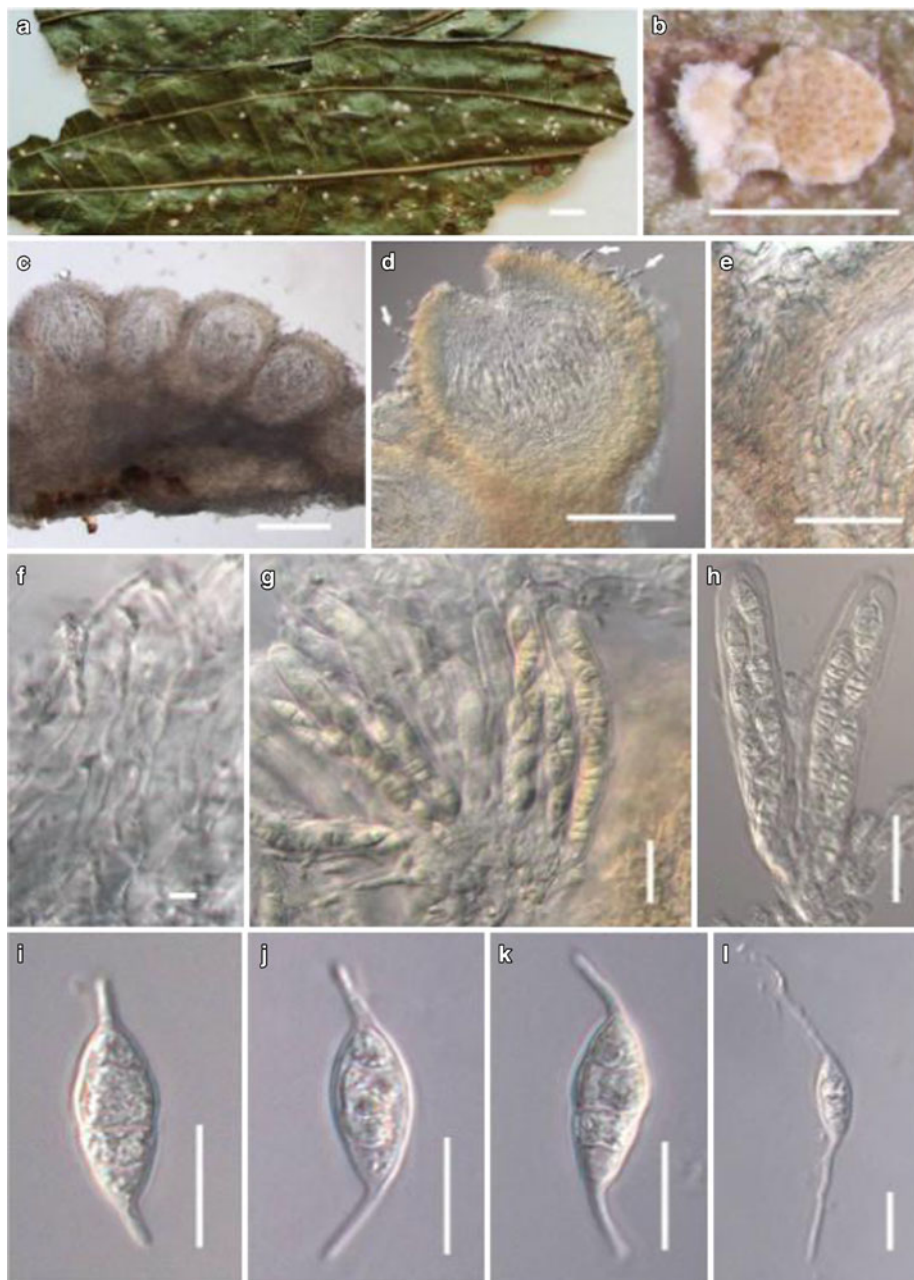


Fig. 90 *Paranectriella juruana* (Material examined: HAITI, Dept. de la Grand' anse, Massif de la Hotte, "Geffrard" 44 km south of Roseaux Road to Camp Perrin, alt. 780 m, 18°25'N 73°53'W, on leaves of *Miconia* sp., William R. Buck (9169), 14 November 1982, determined by A. Y. Rossman, BPI 632134). **a, b** Ascostromata. **c, d** Section through

ascostroma. **e** Peridium of locules. **f** Pseudoparaphyses. **g, h** Bitunicate asci. **i-l** Ascospores with spine-like extension at each end. Scale bars: **a** = 5 mm, **b** = 1 mm, **c, d** = 100 μ m, **e** = 50 μ m, **g, h** = 20 μ m, **f** = 5 μ m, **i-l** = 10 μ m

Key to genera of *Paranectriellaceae*

1. Ascostromata with numerous locules, minutely hairy, ascospores with apical spine-like appendages*Paranectriella*
1. Ascostromata with few locules, with flexuous hairs, ascospores with basal appendage only*Puttemansia*

Parmulariaceae E. Müll. & Arx ex M.E. Barr, Mycologia 71(5): 944 (1979), MycoBank: MB 81109

Saprobic on leaves or lichens. *Colonies* foliicolous, lichenicolous, superficial, dark brown to black. Sexual state: *Hyphae* growing out from ascomata, brown, septate, branching, sinuous, with or lacking appressoria. *Ascostromata* solitary to gregarious, or in groups, superficial to immersed, shield-like to star-shaped, elliptical to boat-shaped, dark brown to black, carbonaceous to membranaceous, strongly flattened, or longitudinal slits slightly protuberant, and contain numerous asci. *Locules*

immersed in ascostromata or in longitudinal ridges radiating from the centre. *Stromata* wall thin to thick, composed of black, large cells of *textura prismatica*. *Peridium* thin to thick, composed of dark brown to hyaline smaller cells of *textura angularis*. *Hamathecium* of dark brown to hyaline, septate, pseudoparaphyses or pseudoparaphyses lacking. *Asci* 8-spored, thick-walled, bitunicate, fissitunicate, long ovate, broad cylindrical, broad-clavate, or obclavate, globose to subglobose, short pedicellate, with a distinct ocular chamber. *Ascospores* 2–multi-seriate, hyaline to dark brown, oblong to ellipsoid, ellipsoid to ovate, ends rounded, 1-septate, constricted at the septum or not, wall smooth to verrucose. Asexual state: coelomycetous or hyphomycetous. *Conidiomata* pycnothyrial or sporodochia, scattered, sub-immersed, dark. Setae present in *Excipulariopsis*, brown, septate. *Pycnidium* wall composed of a single layer of thick-walled, hyaline cells of *textura angularis*. *Conidiophores* present (stromatic) or reduced to conidiogenous cells, arising from basal cells on inner conidiomata wall. *Conidiogenous cells* monoblastic. *Conidia* fusiform to cylindrical, aseptate or 1–2-septate, hyaline to brown, smooth-walled.

Notes: The family *Parmulariaceae* was introduced by Müller and von Arx (1962) for taxa with colonies growing on the surface of living plant tissues, mostly leaves, but was invalid as it lacked a Latin diagnosis. The family was validated by Barr (1979a). The family is clearly polyphyletic and contains a range of ascostromata types, ascomata and even thyriothecia, ascus and ascospores forms (Inácio and Cannon 2008). Lumbsch and Huhndorf (2010) included 34 genera in the family and Inácio and Cannon (2008) included 35 genera. We examined type herbarium specimens of several genera; *Coccodothis*, *Dothidasteroma*, *Englerodonthis* and *Perischizon* are not typical of this family. *Englerodonthis* and *Perischizon* have enclosed ascomata and only one ascomata wall layer composed of cells of *textura angularis* (Inácio and Cannon 2008). *Coccodothis* has subglobose ascomata, *Aldona* has irregular ascomata and *Dothidasteroma* has ascomata with ostioles (Inácio and Cannon 2008).

The family *Parmulariaceae* differs from *Asterinaceae* in having ascostromata formed by several layers of pigmented cells, pseudoparaphyses, broadly ellipsoidal to obclavate asci, and lack appressoria (Inácio and Cannon 2008; Inácio et al. 2012). Species of *Asterinaceae* have superficial hyphae mostly with appressoria, thyriothecia with a thin upper wall layer and poorly developed base and subglobose asci (Pirozynski and Shoemaker 1970; Inácio et al. 2012). Asexual states of this family include *Excipulariopsis* which is linked to *Kentingia* (Sivanesan and Hsieh 1989).

Type: *Parmularia* Lév., Annl. Sci. Nat., Bot., sér. 3 5: 286 (1846), MycoBank: MB 3744

Figure 91

Possible synonyms:

Clypeum Masee, J. Bot., Lond. 34: 145 (1896)

Pycnographa Müll. Arg., Flora, Jena 73: 194 (1890)

Schneepia Speg., Anal. Soc. cient. argent. 19(6): 259 (1885)

Saprobic on leaves. Sexual state: *Ascostromata* solitary to gregarious, or in groups, superficial, shield-like, dark brown to black, carbonaceous, flattened, with ridges radiating from the centre to the outer rim, ridges containing elongate locules, which open by a longitudinal slit and contain numerous asci, cells of ascostromata thick-walled and elongate and composed of black, amorphous tissues in the stromatic crust. *Hamathecium* of dark brown to hyaline, septate, pseudoparaphyses, swollen and brown at their apices. *Asci* 8-spored, thick-walled, bitunicate, cylindrical, short-pedicellate, with a distinct ocular chamber. *Ascospores* 2–3-seriate, ellipsoidal, with rounded ends, hyaline to dark brown, 1-septate, constricted at the septum, smooth-walled. Asexual state: Unknown.

Notes: *Parmularia* is characterized by shield-like, flattened, ascostromata, with ridges radiating from the centre to the outer rim, ridges comprising elongate, radiating locules, cylindrical asci and ellipsoid, 1-septate ascospores (Inácio and Cannon 2008). The genus contains numerous species with 53 names in Index Fungorum and Kirk et al. (2008) estimating 30 species.

Type species: *Parmularia styracis* Lév., Annl. Sci. Nat., Bot., sér. 3 5: 286 (1846), MycoBank: MB 1846

Other genera included

Aldona Racib., Parasit. Alg. Pilze Java's (Jakarta) 1: 19 (1900)

Type species: *Aldona stella-nigra* Racib., Parasit. Alg. Pilze Java's (Jakarta) 1: 19 (1900)

Aldonata Sivan. & A.R.P. Sinha, Mycol. Res. 92(2): 248 (1989)

Type species: *Aldonata pterocarpi* Sivan. & A.R.P. Sinha, Mycol. Res. 92(2): 249 (1989)

Antoniomyces Inácio, Mycol Progress 11: 1–6 (2012)

Type species: *Antoniomyces loranthicola* Inácio, Mycol Progress 11: 1–6 (2012)

Aulacostroma Syd. & P. Syd., Philipp. J. Sci., C, Bot. 9: 176 (1914)

Type species: *Aulacostroma palawanense* Syd. & P. Syd., Philipp. J. Sci., C, Bot. 9(2): 176 (1914)

Campoa Speg., Boln Acad. nac. Cienc. Córdoba 25: 90 (1921)

Type species: *Campoa pulcherrima* Speg., Boln Acad. nac. Cienc. Córdoba 25: 90 [no. 173, reprint pages 92] (1921)

Cocconia Sacc., Syll. fung. (Abellini) 8: 738 (1889)

Type species: *Cocconia placenta* (Berk. & Broome) Sacc., Syll. fung. (Abellini) 8: 738 (1889)

Cycloschizon Henn., Bot. Jb. 33: 39 (1902)

Type species: *Cycloschizon brachylaenae* (Rehm) Henn., Bot. Jb. 33: 39 (1902)

Cyclostomella Pat., Bull. Herb. Boissier 4: 656 (1896)

Type species: *Cyclostomella disciformis* Pat., Bull. Herb. Boissier 4: 656 (1896)



Fig. 91 *Parmularia styracis* (Material examined: BRAZIL, Brasilia, São Paulo, near Urbem Faxina, on leaves of *Styracis* sp., August 1901, v. Wettstein & Schiffner (SF21306). **a** Herbarium packet. **b, c** Ascostromata on leaf surface. **d** Black shield-like ascostroma. **e, f** Sections of ascostroma showing locules. **g** Walls of ascostroma. **h** Dark

brown ascostroma wall from above. **i, j** Asci with ascospores. **k** Pseudoparaphyses with brown swollen tips. **l–n** Immature ascospores. Scale bars: **b, c**=10 mm, **d**=500 μ m, **e, f**=100 μ m, **g**=50 μ m, **h–n**=10 μ m

Dictyocyclus Sivan. et al., J. Linn. Soc., Bot. 126(4): 324 (1998)

Type species: Dictyocyclus hydrangeae Sivan. et al., J. Linn. Soc., Bot. 126(4): 324 (1998)

Ferrarisia Sacc., Atti Inst. Veneto Sci. lett., ed Arti 10: 61 (1919)

Type species: Ferrarisia philippina Sacc., Atti Soc. Veneto-Trent. Sci. Nat., Padova 23: 61 (1917)

Hemigrapha (Müll. Arg.) R. Sant. ex D. Hawksw., Kew Bull. 30(1): 9 (1975)

Type species: Hemigrapha asteriscus (Müll. Arg.) R. Sant. ex D. Hawksw., Kew Bull. 30(1): 191 (1975)

Hysterostomella Speg., Anal. Soc. cient. argent. 19(6): 260 (1885)

Type species: Hysterostomella guaranitica Speg., Anal. Soc. cient. argent. 19(6): 260 [no. 305] (1885)

Inocyclus Theiss. & Syd., Anns mycol. 13(3/4): 211 (1915)

Type species: Inocyclus psychotriae (Syd. & P. Syd.) Theiss. & Syd., Anns mycol. 13(3/4): 211 (1915)

Kiehlia Viégas, Bragantia 4(1–6): 156 (1944)

Type species: Kiehlia obscura Viégas, Bragantia 4(1–6): 156 (1944)

Mintera Inácio & P.F. Cannon, Mycol. Res. 107(1): 86 (2003)

Type species: Mintera reticulata (Starbäck) Inácio & P.F. Cannon, Mycol. Res. 107(1): 86 (2003)

Pachypatella Theiss. & Syd., Anns mycol. 13(3/4): 228 (1915)

Type species: Pachypatella alsophilae (Racib.) Theiss. & Syd., Anns mycol. 13(3/4): 228 (1915)

Palawaniella Doidge, Bothalia 1(1): 16 (1921)

Type species: Palawaniella eucleae Doidge, Bothalia 1(1): 16 (1921)

Parmulariopsella Sivan., Trans. Br. mycol. Soc. 55(3): 509 (1970)

Type species: Parmulariopsella burseracearum Sivan., Trans. Br. mycol. Soc. 55(3): 509 (1970)

Parmulariopsis Petr., Sydowia 8(1–6): 186 (1954)

Type species: Parmulariopsis pulchella Petr., Sydowia 8(1–6): 186 (1954)

Parmulina Theiss. & Syd., Anns mycol. 12(2): 194 (1914)

Type species: Parmulina exsculpta (Berk.) Theiss. & Syd. [as ‘exculpta’], Anns mycol. 12(1): 45 (1914)

Polycyclina Theiss. & Syd., Anns mycol. 13(3/4): 212 (1915)

Type species: Polycyclina rhytismoides (Speg.) Theiss. & Syd., Anns mycol. 13(3/4): 212 (1915)

Polycyclus Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 1542 [82 repr.] (1909)

Type species: Polycyclus andinus (Pat.) Theiss. & Syd., Anns mycol. 13(3/4): 210 (1915)

Protothyrium G. Arnaud, C. r. hebd. Séanc. Acad. Sci., Paris 164: 574 (1917)

Type species: Protothyrium salvadorae (Cooke) G. Arnaud, Annals d’École National d’Agric. de Montpellier, Série 2 16(1–4): 101 (1918) [1917]

Pseudolembosia Theiss., Anns mycol. 11(5): 432 (1913)

Type species: Pseudolembosia geographica (Masse) Theiss., Anns mycol. 11(5): 432 (1913)

Rhagadolobium Henn. & Lindau, Bot. Jb. 23: 287 (1897)

Type species: Rhagadolobium hemiteliae Henn. & Lindau [as ‘Rhagadolobium hemitheliae’], (1897)

Rhipidocarpon (Theiss.) Theiss. & Syd., Anns mycol. 13(3/4): 197 (1915)

Type species: Rhipidocarpon javanicum (Pat.) Theiss. & Syd., Anns mycol. 13(3/4): 197 (1915)

Symphaeophyma Speg., Anal. Mus. nac. Hist. nat. B. Aires 23: 97 (1912)

Type species: Symphaeophyma subtropicale Speg., Anal. Mus. nac. Hist. nat. B. Aires 23: 97 (1912)

Thallomyces H.J. Swart, Trans. Br. mycol. Soc. 65(1): 84 (1975)

Type species: Thallomyces oritis (Hansf.) H.J. Swart, Trans. Br. mycol. Soc. 65(1): 85 (1975)

Viegasella Inácio & P.F. Cannon, Mycol. Res. 107(1): 82 (2003)

Type species: Viegasella pulchella (Speg.) Inácio & P.F. Cannon, Mycol. Res. 107(1): 83 (2003)

Key to genera of Parmulariaceae

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 27. Ascospores with transverse and longitudinal septum*Aldonata*
 28. Ascomata sometimes dimorphic, one type superficial and the other immersed and opening by lifting epidermis and cuticle*Rhagadolobium*
 28. Ascomata always subcuticular*Pseudolembosia*
 29. Upper wall of ascoma composed of *textura angularis**Pachypatella*
 29. Upper wall of ascoma composed of *textura prismatica**Kiehlia*

Parodiellaceae Theiss. & Syd. ex M.E. Barr, Mycotaxon 29: 503 (1987), MycoBank: MB 81844

Biotrophic on upper side of leaves. Sexual state: *Ascomata* superficial, scattered and gregarious between veins, uniloculate, subglobose to globose, with short stalk when mature, smooth or verrucose, black, with blackened fungal tissue in the leaf below stalk. *Ostiole* central with periphyses. *Peridium* thick-walled, comprising brown to dark brown cells of *textura angularis* at the outside and pale brown, flattened cells toward the inner region. *Hamathecium* of irregular pseudoparaphyses. *Asci* 8-spored, bitunicate, cylindrical to clavate, with broad, lobed pedicle, apically rounded with ocular chamber. *Ascospores* 1–2-overlapping seriate, fusoid to ellipsoidal, brown to dark brown, 1-septate, constricted at septum, inequilateral, with upper cell broader and longer than lower cell, slightly narrowed at the ends, smooth-walled or striated, lacking a mucilaginous sheath. Asexual state: assumed as *Ascochytopsis*. *Conidiomata* thick-walled, black. *Conidiogenous cell* cylindrical, proliferating percurrently. *Conidia* straight to falcate, hyaline, aseptate (Sivanesan 1984; Cannon and Kirk 2007).

Notes: The family *Parodiellaceae* (*Pleosporales*) was invalidly introduced by Theissen and Sydow (1918) and was validated by Barr (1987a). Barr (1987b), in her exhaustive treatment of the pleosporalean fungi, includes also the genera *Neopeckia* and *Pododimeria* in the family. *Parodiella* has been placed in various families: *Pleosporaceae* in having broadly cellular pseudoparaphyses and in their reproduction (Tilak 1963; Tendulkar 1971; Müller and von Arx 1962); von Arx and Müller (1975) transferred *Parodiella* to *Stigmataceae* and indicated that *Scleroparodia leguminosarum* Petr. is the asexual state of *Parodiella*. Luttrell (1973) suggested that the genus should be placed in the family *Venturiaceae*. Eriksson (1981) indicated that *Parodiella* is an obligate parasite as ascospores can germinate, but are unable to produce colonies on agar media (Ullasa 1969). *Parodiella* may be related to *Cucurbitariaceae*

(Barr 1979a, b), however Eriksson (1981) preferred to place *Parodiella* in the separate family *Parodiellaceae*. *Parodiella* is monotypic with only *Parodiella* belonging to *Parodiellaceae* (Lumbsch and Huhndorf 2010), while Kirk et al. (2008) and Barr (1987a) include two and three genera, respectively (*Neopeckia*, *Pododimeria*). Distribution is in tropical regions, especially on *Leguminosae* (Cannon and Kirk 2007). In this paper we illustrate *Parodiella hedysari* (Schwein.) S. Hughes as we could not locate the type of *Parodiella perisporioides* (Berk. & M.A. Curtis) Speg.

Type: *Parodiella* Speg., Anal. Soc. cient. argent. 9(4): 178 (1880), MycoBank MB 3749

Figure 92

Possible synonyms:

Diplodiopsis Henn., Hedwigia 43: 386 (1904)

Pyrnochaetina Syd. & P. Syd., Annl. mycol. 14(1/2): 94 (1916)

Type species: *Parodiella perisporioides* (Berk. & M.A. Curtis) Speg., Anal. Soc. cient. argent. 9(4): 178 (1898), MycoBank MB 229209

Patellariaceae Corda, Icon. Fung. 2: 37 (1838), MycoBank: MB 81111

Possible synonym:

Lecanidiaceae O.E. Erikss., Op. bot. Soc. bot. Lund 60: 78 (1981)

Saprobic on dead wood in terrestrial habitats, rarely lichenicolous. Sexual state: *Ascomata* apothecium or hysterothecium-like, closed when young and opening to exposed at maturity, superficial without stalk or foot, sometimes cupulate or discoid or rolled inside at the margin, dark-coloured with carbonized cells. *Exciple* pseudoparenchymatous, thick-walled, with dark brown isodiametric cells on the outer layers, pale to light brown at inner wall layer cells and cell-bases. *Hypotheorium* hymenium always extending from lower part and can be flanked or standing beside the excipulum, the latter composed of thick-walled, prosenchymatous cells. *Hamathecium* composed of pseudoparaphyses, in a few cases with an epithecium, I- or I+ blue. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to clavate, pedicellate, apically rounded with an ocular chamber. *Ascospores* overlapping 2–3-seriate, obovoid or clavate to oblong, hyaline or light brown, 1–3-septate, in some cases muriform. Asexual states: See under notes.

Notes: Corda (1838) introduced the family *Patellariaceae* to place *Cryptodiscus* and *Mellitiosporium*, based on cup-shaped ascomata and septate ascospores. Since the establishment, members of *Patellariaceae* were shifted into different taxonomic groups. Rehm (1896) included 20 genera under two groups, *Pseudopatellariaceae* and *Eupatellariaceae*. He was followed by Saccardo and Sydow (1899) who added 13 more genera based on number of spore septa. Clements and Shear (1931)

included more genera (some are lichen forming) having dark, waxy, ascomata with carbonaceous peridium and concluded the family comprised 55 genera.

Nannfeldt (1932) introduced two new groups which belong to eu-ascomycetes i.e. *Ascoloculares* and *Ascohymeniales*. However, Nannfeldt (1932) excluded *Patellaria* from both these groups by mentioning it is a discolichen with thick-walled asci embedded in a layer of gelatine along with paraphyses. His observation was re-examined by Luttrell (1951) who stated that some fungi in *Hysteriaceae* and *Patellariaceae* might have a close relationships by their bitunicate ascus character. Later, Luttrell (1955) moved the family *Patellariaceae* to *Pleosporales*.

On the other hand, Müller and von Arx (1962) and von Arx and Müller (1975) suggested that *Patellariaceae* should be placed in *Dothiorales* under *Loculoascomycetes*. This arrangement was accepted by Barr (1979a) who reinstated *Patellaria* in *Patellariaceae* together with five other genera (*Endotryblium*, *Hysteropatella*, *Karschia*, *Melittosporium* and *Rhizocarpon*). These genera were combined with the previous 13 (*Abrothallus*, *Annajenkinsia*, *Baggea*, *Banhegyia*, *Buellia*, *Eutrybliella*, *Kymadiscus*, *Lecanidion*, *Melaspilea*, *Protoscypha*, *Rhytidhysterium*, *Scutula* and *Tryblidaria*) that were included by von Arx and Müller (1975), whereas *Annajenkinsia* and *Melaspilea* were removed because they comprised saprobic, lichenized and lichenicolous species. *Kymadiscus* is an excluded genus as the type species *K. haliotrephus* (Kohlm. & E. Kohlm.) Kohlm. & E. Kohlm. was subsequently transferred to *Dactylospora* in the *Lecanorales* (Jones et al. 2012). Eriksson (1981) removed *Buellia* and *Melaspilea* from this family as most were lichenized and their structure was different from the former.

Hawksworth and Eriksson (1986) revised *Patellariaceae* and established *Patellariales* and this was accepted by Barr (1987a) while adding nine new non-lichenized genera. The members of *Patellariaceae* have been re-arranged several times by researchers (Samuels and Müller 1979; Reid and Pirozynski 1966; Petrini et al. 1979; Hafellner 1979; Eriksson and Hawksworth 1993). Kutorga and Hawksworth (1997) accommodated twelve genera in *Patellariaceae*. Zhang and Hyde (2009) transferred *Pseudoparodia* into *Patellariaceae*. Boehm et al. (2009b) and Schoch et al. (2009b) showed that *Rhytidhysterion* does not belong in *Patellariaceae* but can be placed in *Hysteriaceae*, while *Banhegyia* was placed in *Mycomelaspilea* (*Melaspileaceae*, *Arthoniomycetes*) based on its apothecial ascomata and presence of bristle-like ascospore appendages (Sanderson et al. 2009).

Wijayawardene et al. (2012) stated that *Rhytidhysterion* has “Aposphaeria”-like and “Diplodia”-like asexual states. However the taxonomic placement of *Rhytidhysterion* is not well-defined hence we could not conclude the asexual states of *Patellariaceae*.



Fig. 92 *Parodiella hedysari* (Material examined: USA, South Carolina, on leaves of *Rhynchosia* sp., 1879, H.W Ravenel s.n. [ex herb M.J. Berkeley], K(M) 176017, **syntype**). **a, b** Ascomata on host. **c–d, g**

Vertical section through the ascomata and peridium. **e–f, h** Bitunicate asci. **i** Pedicel of ascus. **j–l** Ascospores. Scale bars: **d**=200 μ m, **c**=100 μ m, **e–g**=50 μ m, **h, i**=20 μ m, **j–l**=10 μ m

Type: Patellaria Fr., Syst. mycol. (Lundae) 2(1): 158 (1822), MycoBank MB 3765

Figure 93

Possible synonym:

Lecanidion Endl., Fl. poson.: 46 (1830)

Saprobic on dead wood, stems or rotten paper in terrestrial habitats. Sexual state: *Ascomata* scattered, closed at first and opening at maturity, longitudinally wide, apothecioid, superficial, circular or elongate, with a carbonaceous rim, exposed flat, dark-brown. *Exciple* multi-layered and composed of isodiametric, thick-walled, dark brown cells at the outer layer, and lighter

colored cells at inner layers. *Hamathecium* composed of pseudoparaphyses, septate, slender, hyaline, apically branched filaments when mature, forming a greenish brown epithecium above the asci. *Asci* 4–8-spored, bitunicate, fissitunicate, clavate to cylindrical, sometimes slightly fusiform, short-pedicellate, apically rounded with an ocular chamber. *Ascospores* biseriata or overlapping 3-seriate, clavate, hyaline, slightly curved, and distoseptate. Asexual state: Unknown.

Notes: The main and distinguishing characters of this genus are apothecioid ascomata, superficial, black, a greenish black epithecium formed by branched and swollen paraphyses,

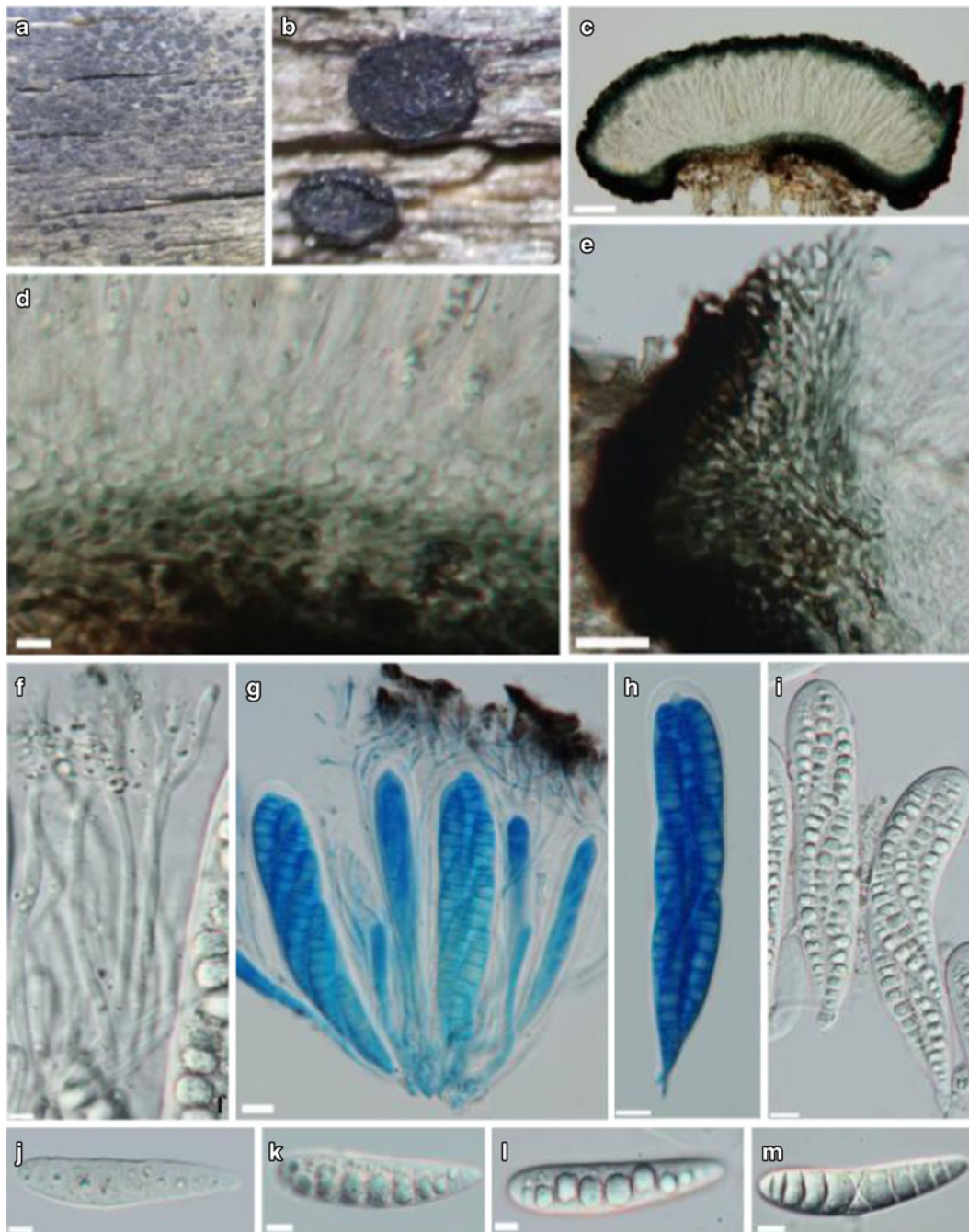


Fig. 93 *Patellaria atrata* (IMI 32777). **a, b** Apothecia on host tissue. **c** Hand section of apothecia. **d** Peridium with *textura angularis*. **e** Exciple with elongated and radiating cells. **f** Hamathecial tissue. **g** Young and

mature asci showing ocular chamber in lactophenol cotton blue. **i** Mature asci with 8-spores. **j–m** Ascospores. Scale bars: **c**=50 μm , **d, g–i**=10 μm , **e**=20 μm , **f, j–m**=5 μm

bitunicate, fissitunicate asci, clavate to cylindrical and hyaline, phragmo-septate ascospores. There are variations in number of asci and spore size, and number of spores within the asci. The importance of these taxonomic criteria need to be established. There have been only a few molecular investigations, especially of *Patellaria atrata* (Suetrong et al. 2009; Boehm et al. 2009b; Schoch et al. 2009b; Suetrong and Jones 2006).

Type species: Patellaria atrata (Hedw.) Fr., Syst. Mycol. 2(1): 158 (1822)
 \equiv *Lichen atratus* Hedw., Descr. micr.-anal. musc. frond. 2(3): 61 (1788) [1789]

Other genera included

Baggea Auersw., Hedwigia 5(1): 1 (1866)

Type species: Baggea pachyascus Auersw., Hedwigia 5(1): 1 (1866)

Endotryblidium Petr., Sydowia 13(1–6): 244 (1959)

Type species: Endotryblidium insculptum (Cooke) Petr., Sydowia 13(1–6): 245 (1959)

Holmiella Petrini et al., Ber. schweiz. bot. Ges. 89(1–2): 83 (1979)

Type species: Holmiella sabina (De Not.) Petrini Samuels & E. Müll., Ber. schweiz. bot. Ges. 89(1–2): 84 (1979)

Lecanidiella Sherwood, Sydowia 38: 272 (1986) [1985]

Type species: Lecanidiella contortae Sherwood, Sydowia 38: 274 (1986) [1985]

Lirellodisca Aptroot, in Aptroot & Iperen, Nova Hedwigia 67(3–4): 485 (1998)

Type species: Lirellodisca pyrenulispora Aptroot [as ‘pyrenulaspora’], in Aptroot & Iperen, Nova Hedwigia 67(3–4): 485 (1998)

Murangium Seaver, North American Cup-fungi, (Inoperculates) (New York): 367 (1951)

Type species: Murangium sequoiae (Plowr. ex W. Phillips) Seaver, North American Cup-fungi, (Inoperculates) (New York): 368 (1951)

Poetschia Körb., Parerga lichenol. (Breslau): 280 (1861)

Type species: Poetschia buellioides Körb., Parerga lichenol. (Breslau): 280 (1861)

Pseudoparodia Theiss. & Syd., Annls mycol. 15(1/2): 138 (1917)

Type species: Pseudoparodia pseudopeziza (Pat.) Thesis. & Syd., Sydowia 1(4–6): 169 (1947)

Rhizodiscina Hafellner, Nova Hedwigia, Beih. 62: 195 (1979)

Type species: Rhizodiscina lignyota (Fr.) Hafellner, Beih. Nova Hedwigia 62: 195 (1979)

Schrakia Hafellner, Nova Hedwigia, Beih. 62: 204 (1979)

Type species: Schrakia crassula (Starbäck) Hafellner, Nova Hedwigia, Beih. 62: 204 (1979)

Stratisporella Hafellner, Nova Hedwigia, Beih. 62: 207 (1979)

Type species: Stratisporella episemoides (Nyl.) Hafellner, Beih. Nova Hedwigia 62: 207 (1979)

Tryblidaria (Sacc.) Rehm, Hedwigia 42: 173 (1903)

Type species: Tryblidaria breutelii Rehm, Hedwigia 42: 173 (1903)

Key to genera of Patellariaceae

We include *Banhegyia* for historical reasons.

1. Ascromata perithecial*Pseudoparodia*
1. Ascromata apothecial2
2. Apothecium immersed or erumpent3
2. Apothecium superficial4
3. Asci cylindrical, bitunicate, uniseriate, verrucose lichenicolous*Stratisporella*
3. Asci clavate, bitunicate, crowded, smooth not growing on lichens*Endotryblidium*

4. Asci with more than 8 spores*Baggea*
4. Asci with 8 or less spores5
5. Ascospores muriform6
5. Ascospores with transverse septa or distoseptate7
6. Ascospore brown at maturity*Murangium*
6. Ascospores hyaline when mature*Tryblidaria*
7. Ascospores distoseptate only*Lirellodisca*
7. Ascospores with transverse septate only8
8. Ascospores 1-septate9
8. Ascospores 3-septate or more13
9. Ascospores with small hair-like appendages*Banhegyia*
9. Ascospores lacking appendages10
10. Ascospores shorter than 15 μm *Rhizodiscina*
10. Ascospores longer than 15 μm 11
11. Ascromata 1–1.5 mm wide, folded at the margin, hypothecium of *textura intricata*, on *Juniperus**Holmiella*
11. Ascromata less than 1 mm wide, pseudoparenchymatous12
12. Apothecia reddish-brown*Schrakia*
12. Apothecia dark brown*Poetschia*
13. Ascospores with 4 cells (3-septate)*Lecanidiella*
13. Ascospores with more than 6 cells*Patellaria*

Perisporiopsidaceae E. Müll. & Arx ex R. Kirschner & T.A. Hofm., in Kirschner et al., Sydowia 62(2): 238 (2012), MycoBank: MB 81875

Possible synonyms:

Parodiopsidaceae Toro, J. Agric. Univ. P. Rico 36: 66 (1952)

Parodiellinaceae G. Arnaud [as ‘Parodiellinacées’], Annals d’École National d’Agric. de Montpellier, Série 2 16(1–4): 21 (1918) [1917]

Parasitic on living leaves or sooty moulds, pantropical. Sexual state: *Ascromata* superficial, solitary or gregarious, always unilocular, globose to subglobose, or ovate, brown to dark brown, with a dissolving pore, covered by hairy light brown hyphae, superficial mycelium, brown, septate, hyphopodia present or absent. *Peridium* dark brown, 3–4 cell layers of *textura angularis*. *Hamathecium* composed of hyaline, membranous tissues in a gelatinous matrix, pseudoparaphyses absent. *Asci* 8-spored, thick-walled, bitunicate, fissitunicate, ellipsoid-subclavate to broadly clavate, pedicellate, sometimes sessile. *Ascospores* 2–3-seriate, broadly ellipsoid-fusiform to oblong, 2–3-septate, not constricted at the septum, hyaline to pale brown. Asexual state: hyphomycetous represented by simple conidiophores, with monoblastic, annellidic or sympodial conidiogenous cells, producing pigmented, septate conidia.

Notes: The family *Parodiopsidaceae* was introduced (invalidly) by Arnaud (1920) to accommodate the genera *Parodiopsis*, *Perisporiopsis* and *Perisporina*, based mainly on their occurrence on leaf surfaces as mycelium with superficial ascromata. The family has since been compared with several families and orders (Arnaud 1918, 1921; Hansford 1946; Luttrell 1951, 1955; von Arx and Müller 1975; Barr 1976,

1979a, 1987a). The type, *Parodiopsis* was found to be a later homonym of *Perisporiopsis* by Arnaud (1915) and therefore, *Perisporiopsis* is the type representative of the family, which is based mainly on the original description of Hennings (1904c). The family includes species with globose-pigmented ascomata, usually present on superficial mycelium, and sometimes setose or hyphopodiate, lacking pseudoparaphyses, and with broadly clavate asci and ellipsoidal-fusiform, septate, hyaline ascospores, which may be brownish when mature. The family *Perisporiopsidaceae* was invalidly introduced by Müller and von Arx (1962) to combine the families of *Parodiellinaceae* and *Parodiopsidaceae*. Kirschner et al. (2010) validated *Perisporiopsidaceae* by providing a Latin diagnosis, while *Parodiopsidaceae* was treated as a synonym. Although the latter family name is younger it makes sense using *Perisporiopsidaceae* for a family represented by the genus *Perisporiopsis* (= *Parodiopsis*). Currently, there are 19 genera included in *Perisporiopsidaceae* which is grouped in *Dothideomycetes incertae sedis* (Lumbsch and Huhndorf 2010). Members of *Perisporiopsidaceae*, are mostly superficial, with uni-loculate ascomata, with external mycelium, and some genera are characterized by hyphal hyphopodia, such as *Alina*, *Balladyna* or *Balladynopsis* (Barr 1997; Sivanesan 1981, 1984). The family itself is certainly polyphyletic based on the morphology of its genera, the common denominator being small, often setose, ascomata on leaves. Molecular phylogenetic analysis is available for putative endophytic *Perisporiopsis* strains (Chaverii and Gazis 2010), which shows the genus to be a possible member of *Pleosporales*. The placement of other genera in *Parodiopsidaceae* needs verification by molecular data and overall the family is poorly understood.

The asexual states of most genera in *Perisporiopsidaceae* are reasonably well known and are hyphomycetous represented by simple conidiophores, with monoblastic, annellidic or sympodial conidiogenous cells, producing pigmented, septate conidia (Sivanesan 1984; Kirschner et al. 2010). *Alina* and *Balladynopsis urtiaga* Sivan. have *Tretospora* asexual morphs (Sivanesan 1981, 1984; Kirschner et al. 2010) and since the type of *Tretospora* is linked to *Balladynopsis* we synonymize these genera under *Balladynopsis* below.

Type: *Perisporiopsis* Henn., Hedwigia 43: 83 (1904), MycoBank: MB 3827 Fig. 94

Parasitic causing leaf spots on living leaves of *Struthanthus* sp., pantropical. Sexual state: *Subiculum* comprising hairy, light brown, superficial mycelium covering ascomata, some hyphae entering the stomata and forming sausage-shaped haustoria in adjacent host cells. *Ascomata* immersed in subiculum, but superficial on host, solitary or gregarious, globose, subglobose to ovate, brown to dark brown, unilocular, opening by a pore in the upper lighter part of the ascomata, often stalked, hyphopodia not observed. *Peridium* comprising 3–4 layers of thick-walled, dark brown, cells of *textura angularis*. *Hamathecium* comprising hyaline,

membranous tissue, in a gelatinous matrix, lacking pseudoparaphyses. *Asci* 8-spored, thick-walled, bitunicate, fissitunicate, ellipsoid-subclavate to broadly clavate, with a short indistinct pedicellate or sometime sessile, apically rounded and thickened, with an indistinct ocular chamber and apical ring. *Ascospores* 2–3-seriate, broadly ellipsoid-fusiform to oblong, 2–3-septate, not constricted at the septum, greenish hyaline to pale brown, minutely guttulate, smooth-walled. Asexual state: “*Septoidium*” hyphomycetous.

Notes: The generic name *Perisporiopsis* was introduced by Hennings (1904c) with a single species *P. struthanthi* Henn. Maublanc (in Arnaud 1915) also introduced *Parodiopsis* for species having aerial mycelium and producing haustoria, and included *P. meliolooides* (Wint.) Maubl., *P. lateritia* (Speg.) Maubl., *P. struthanthi* (Henn.) G. Arnaud, *P. manaosensis* (Henn.) G. Arnaud and *P. viridescens* (Rehm.). Arnaud (1915) re-examined all type species of *Parodiopsis* and considered these taxa to be one genus (Eriksson 1981). *Perisporiopsis* is the earlier name and so *Parodiella meliolooides* was synonymized under *Perisporiopsis meliolooides* (Berk. & M.A. Curtis) Arx (Müller and von Arx 1962) and thus *Perisporiopsis struthanthi* is also the correct name. In this study, we examined and illustrate the fungal type specimen of *Perisporiopsis struthanthi* with ascospores that are 1–2-septate.

Perisporiopsis presently comprises 21 species epithets (Index Fungorum 2013), although *P. wrightii* (Berk. & M.A. Curtis) F. Stevens was transferred to *Myriangiaceae* by Stevens (1917). Several species of *Perisporiopsis* including the type *P. struthanthi* are linked to hyphomycetous *Septoidium* asexual states (Arnaud 1921; Hansford 1946; Müller and von Arx 1962; von Arx and Müller 1975; Sivanesan 1984; Kirk et al. 2008; Chaverri and Gazis 2010; Wijayawardene et al. 2012). The genus is not well-known.

Type species: *Perisporiopsis struthanthi* Henn., Hedwigia, Beibl. 43: 83 (1904), MycoBank: MB 216818

Other genera included

Alina Racib., Bull. int. Acad. Sci. Lett. Cracovie, Cl. sci. math. nat. Sér. B, sci. nat. 3: 374 (1909) (link to *Septoidium*, *Tretospora* asexual morphs)

Type species: *Alina jasmini* Racib., Bull. int. Acad. Sci. Lett. Cracovie, Cl. sci. math. nat. Sér. B, sci. nat. 3: 375 (1909)

Balladyna Racib., Parasit. Alg. Pilze Java's (Jakarta) 2: 6 (1900)

Type species: *Balladyna gardeniae* Racib., Parasit. Alg. Pilze Java's (Jakarta) 2:6 (1900)

Balladynocallia Bat., in Batista et al., Atas Inst. Micol. Univ. Pernambuco 2: 216 (1965)

Type species: *Balladynocallia glabra* (Hansf.) Bat., in Batista et al., Atas Inst. Micol. Univ. Recife 2: 216 (1965)

Balladynopsis Theiss. & Syd., Annl. mycol. 15(6): 475 (1918) [1917]. [*Tretospora* asexual morph]



Fig. 94 *Perisporiopsis struthanthi* (Material examined: BRAZIL, Rio de Janeiro, Serra dos Orgãos, on leaves of *Struthanthus* sp., August 1899, E. Ule's No. 2631, PC0084481 as a specimens of *Paradiopsis* cf. *struthanthi*, type), *Uleomyces struthanthi*. **a** Herbarium material. **b** Ascomata covered by

brown mycelium. **c** Section of ascoma. **d** Peridium composed of cells of *textura angularis*. **e–g** Asci. **h–k** Ascospores. Scale bars: **a**=1 cm, **b**=200 μ m, **c**=100 μ m, **d**=20 μ m, **e–g**=50 μ m, **h–k**=40 μ m

Type species: Balladynopsis philippinensis Syd. & P. Syd., *Annl. mycol.* 15(6): 476 (1918) [1917]

Chevalieropsis G. Arnaud, *Annl. Épiphyt.* 9: 2 (1923). [*Septoidium* asexual morph]

Type species: Chevalieropsis ctenotricha (Pat. & Har.) G. Arnaud, *Annl. Épiphyt.* 9: 2 (1923)

Cleistosphaera Syd. & P. Syd., *Annl. mycol.* 14(1/2): 74 (1916)

Type species: Cleistosphaera macrostegia Syd. & P. Syd. [as 'macrostegiae'], *Annl. mycol.* 14(1/2): 75 (1916)

Dimeriella Speg., *Revta Mus. La Plata* 15(2):12 (1908)

Type species: Dimeriella hirtula Speg., *Revta Mus. La Plata* 15(2): 12 (1908)

Dimerium (Sacc. & P. Syd.) McAlpine, *Proc. Linn. Soc. N.S.W.* 28: 98 (1903)

Type species: Dimerium pulveraceum (Speg.) Theiss., *Beih. bot. Zbl., Abt. 2* 29: 66 (1912)

Dysrhynchis Clem., *Gen. fung.* (Minneapolis): 32 (1909)

Type species: Dysrhynchis pulchella (Sacc.) Clem., in Clements & Shear, *Gen. fung.*, Edn 2 (Minneapolis): 253 (1931)

Hyalomeliolina F. Stevens, *Illinois Biol. Monogr.* (Urbana) 8: 193 (1924)

Type species: Hyalomeliolina guianensis F. Stevens, *Illinois Biol. Monogr.* (Urbana) 8: 193 (1923)

Leptomeliola Höhn., *Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1* 128: 557 (1919)

Type species: Leptomeliola hyalospora (Lév.) Höhn., *Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1* 128: 558 (1919)

dark brown, thick-walled, *textura angularis* and on the inside of hyaline, thin-walled, smaller cells. *Ostiole* single, circular, central, occasionally papillate. *Conidiophores* absent. *Conidiogenous cells* holoblastic, occasionally annellidic, with a single proliferation, discrete, indeterminate, doliiform, hyaline, formed from the inner cells of the pycnidial wall. *Conidia* hyaline, smooth, with several transverse eusepta, continuous or constricted, cylindrical or fusiform, straight or slightly curved, often with many minute guttules (Sutton 1980).

Notes: *Phaeosphaeriaceae* was introduced by Barr (1979a) with the type *Phaeosphaeria*. In the original family description characters were given as “saprobic, pathogenic or hyperparasitic fungi on plants, ascomata are immersed, erumpent or superficial, globose or conical, sometimes multi-locular, short papillate or rostrate, small to medium sized, asci bitunicate, ascospores hyaline, yellowish or brown, narrowly or widely obovoid or acerose, aseptate or septate” (Barr 1979a). She included 15 genera in this family; i.e. *Comoclathris*, *Didymella*, *Eudarlucua*, *Heptameria*, *Leptosphaeria*, *Loculohyphoxylon*, *Metameris*, *Microthelia*, *Nodulosphaeria*, *Ophiobolus*, *Paraphaeosphaeria*, *Phaeosphaeria*, *Rhopoglyphus*, *Scirrhomothis* and *Teichospora*. Various genera were subsequently transferred to other families, such as *Comoclathris* was placed in the *Diademaceae*, *Didymella* in the *Didymellaceae*, *Heptameria* and *Rhopoglyphus* treated as *Dothideomycetes incertae sedis*, *Leptosphaeria* in the *Leptosphaeriaceae*, *Loculohyphoxylon* and *Teichospora* to the *Teichosporaceae*, and *Paraphaeosphaeria* in the *Montagnulaceae* (Lumbsch and Huhndorf 2010; Zhang et al. 2009a, 2012a). Jones et al. (2009a) tentatively included the genera *Carinispora* and *Lautitia* in *Phaeosphaeriaceae*. Based on multi-gene phylogenetic analysis, *Loratospora* was found to be related to *Phaeosphaeriaceae*, whereas based on morphological observations; it had previously been placed in *Planistromellaceae*. The placement of *Carinispora* could not be resolved (Suetrong et al. 2009; Zhang et al. 2012a). Kirk et al. (2008) reported 19 genera and 394 species in *Phaeosphaeriaceae*. Lumbsch and Huhndorf (2010) included 20 genera, while Zhang et al. (2012a) showed four genera within the familial concept based on multi-gene phylogenetic analysis. *Phaeosphaeriaceae* are usually associated with monocotyledons, with small to medium sized ascomata, and septate, ellipsoidal to fusiform or filiform ascospores (Zhang et al. 2012a). Therefore Zhang et al. (2012a) included 18 genera based on morphology and phylogenetic analysis. They excluded the marine genus *Carinispora* from the family, while *Ocala* grouped as a sister clade to the *Jahnulales* without statistical support based on the combined LSU and SSU phylogeny (Shearer et al. 2009).

Phaeosphaeriaceae is a large and important family in the *Pleosporales* that comprises more than 300 species. This

family is similar to *Leptosphaeriaceae* and often confused. However *Phaeosphaeriaceae* was distinguished from *Leptosphaeriaceae* by its asexual morphs, peridium structure, and host preferences (Câmara et al. 2002; Khashnobish and Shearer 1996). The *Phaeosphaeriaceae* are mostly associated with monocotyledons, a peridium of pseudoparenchymatous cells and asexual state are pycnidial coelomycetes, mostly classified in *Stagonospora*. *Leptosphaeriaceae* usually occur on dicotyledons, have a peridium of scleroplectenchymatous cells, and asexual states are known as *Coniothyrium* and *Phoma* (Câmara et al. 2002; Kirk et al. 2008; Zhang et al. 2009a, b). Zhang et al. (2012a) listed the asexual states of *Phaeosphaeriaceae* as *Amarenographium*, *Ampelomyces*, *Chaetosphaeronema*, *Coniothyrium*, *Hendersonia*, *Neosetophoma*, *?Parahendersonia*, *Paraphoma*, *Phaeoseptoria*, *Rhabdospora*, *Scolecosporella*, *Setophoma*, *Sphaerellopsis*, *Stagonospora*, *Tiarospora* and *Wojnowicia*. However, our phylogenetic analysis shows that *Amarenographium* groups outside *Phaeosphaeriaceae* and this is supported by Hodhod et al. (2012). *Wojnowicia* was shown to be an asexual state in *Phaeosphaeriaceae* by de Gruyter et al. (2009) and this is supported by Wijayawardene et al. (2013). *Phoma* was considered as a polyphyletic genus, but de Gruyter et al. (2012) stated that *Phoma* should be restricted only to *Didymellaceae*. However, Lawrey et al. (2012) placed all lichenicolous *Phoma* species in *Phaeosphaeriaceae*. This contradiction must be resolved by transferring all “Phoma”-like lichenicolous species into another genus. *Coniothyrium concentricum* (Desm.) Sacc. groups in the *Phaeosphaeriaceae* which is distantly related to the type, *C. palmarum*. Much research has been carried out to resolve the phylogenetic relationships of *Coniothyrium* species, hence *Paraconiothyrium* (Verkley et al. 2004) was introduced to accommodate *C. minitans* and *C. sporulosum* in *Montagnulaceae*. Therefore the taxonomic placement of *C. concentricum* needs further clarification.

Various phylogenetic studies have shown that *Phaeosphaeriaceae* is heterogeneous group of taxa. However, several genera in the family lack phylogenetic data. Recollecting and epitypification of types and phylogenetic analysis are required to establish the genera that should be included in the *Phaeosphaeriaceae* with confidence.

Type: *Phaeosphaeria* I. Miyake, Bot. Mag., Tokyo 23: 93 (1909), MycoBank: MB39519

Figure 95

Saprobic or *parasitic* on monocotyledons or rarely dicotyledons visible as black dots on host tissues. Sexual state: *Ascomata* scattered or sometimes clustered, or solitary, immersed to semi-immersed, globose to subglobose, brown to dark brown, with pore-like or papillate central ostiole. *Peridium* thin, smooth-walled, of equal thickness, comprising 2–3 layers of brown to dark brown, pseudoparenchymatous cells of *textura angularis*. *Hamathecium* comprising filiform,



Fig. 95 *Phaeosphaeria oryzae* (Material examined, JAPAN, Shizuoka, Suruya, on *Oryza sativa* L., September 1907 (S-F9572, **lectotype**). **a** Label and herbarium specimens of *Phaeosphaeria oryzae*. **b** Appearance of ascomata apices on host tissue. **c** Section through ascoma. **d**

Section through peridium. **e** Asci with relatively broad pseudoparaphyses. **f–i** Asci. **j–l** Ascospores. Scale bars: **b**=200 μ m, **c, e–i**=20 μ m, **d, j–l**=10 μ m

sparse, broadly cellular pseudoparaphyses, branching at the apex, often constricted at the septa. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to cylindric-clavate, short pedicellate or sessile, apically rounded with an ocular chamber. *Ascospores* overlapping biserial, ellipsoidal, cylindrical or fusiform, pale brown to brown, phragmosporous, with rounded ends, constricted at the septum smooth-walled. Asexual states: reported as *Phaeoseptoria* and *Stagonospora* (Verkley et al. 2004; Kirk et al. 2008).

Notes: *Phaeosphaeria* was introduced by Miyake (1909) and a lectotype was designated by Eriksson (1967), but the genus was considered as a synonym of *Leptosphaeria* for a long time. *Phaeosphaeria* was divided to six subgenera based on the differences of ascospores shape and septation such as

Fusispora, *Ovispora*, *Phaeosphaeria*, *Sicispora*, *Spathispora* and *Vagispora* (Shoemaker and Babcock 1989; Zhang et al. 2012a). Phylogenetic analysis (Câmara et al. 2002; Schoch et al. 2009b; Zhang et al. 2009a, b) showed that *Phaeosphaeria* and *Leptosphaeria* are distinct genera in separate families. The subgenera were not supported by phylogenetic results. Câmara et al. (2002) reported that asexual states of *Phaeosphaeria* often produce elongate to filiform, hyaline or pale brown, multi-septate conidia, mostly form holoblastic conidiogenous cells in pycnidial conidiomata. *Phaeosphaeria* separated into four clades (Zhang et al. 2009a, b). The type species, *Phaeosphaeria oryzae*, was included in the same clade with *Phaeosphaeria juncina* (Auersw.) L. Holm, *Phaeoseptoria musae* Sawada, and a *Phaeoseptoria* sp. that occurs on

monocotyledons (ascmata composed of pseudoparenchymatous cells, and forming pycnidia which contained pale, filiform conidia). The second clade included the majority of *Phaeosphaeria* species (asexual state with elongate to filiform, yellowish brown or pale brown conidia). *Phaeosphaeria nodorum* (E. Müll.) Hedjar., *Phaeosphaeria avenaria* (G.F. Weber) O.E. Erikss., and *Stagonospora foliicola* (Bres.) Bubák differ in producing hyaline conidia, while *Phaeosphaeria spartinae* (Ellis & Everh.) Shoemaker & C.E. Babc. forms a *Microsphaeropsis* asexual state.

Type species: Phaeosphaeria oryzae I. Miyake, Bot. Mag., Tokyo 23: 93 (1909), MycoBank: MB 142561

Other genera included

- Ampelomyces* Ces. ex Schltdl., Bot. Ztg. 10: 303 (1852)
Type species: Ampelomyces quisqualis Ces., Bot. Ztg. 10: 301 (1852)
- Barria* Z.Q. Yuan, Mycotaxon 51: 313 (1994)
Type species: Barria piceae Z.Q. Yuan, Mycotaxon 51: 314 (1994)
- Bricookea* M.E. Barr, Mycotaxon 15: 346 (1982)
Type species: Bricookea sepalorum (Vleugel) M.E. Barr, Mycotaxon 15: 346 (1982)
- Chaetoplea* (Sacc.) Clem., in Clements & Shear, Gen. fung., Edn 2 (Minneapolis): 275 (1931)
Type species: Chaetoplea calvescens (Fr.) Clem., in Clements & Shear, Gen. fung., Edn 2 (Minneapolis): 275 (1931)
- Chaetosphaeronema* Moesz, Bot. Közl. 14: 152 (1915)
Type species: Chaetosphaeronema hispidulum (Corda) Moesz, Bot. Közl. 14: 152 (1915)
- Eudarluka* Speg., Revta Mus. La Plata 15: 22 (1908)
Type species: Eudarluka australis Speg., Revta Mus. La Plata 15: 22 (1908)
- Entodesmium* Reiss, Hedwigia 1(6): 28 (1854)
Type species: Entodesmium rude Riess, Hedwigia 1(6): 28 (1854)
- Hadrospora* Boise, Mem. N. Y. bot. Gdn 49: 310 (1989)
Type species: Hadrospora fallax (Mouton) Boise, Mem. N. Y. bot. Gdn 49: 310 (1989)
- Lautitia* S. Schatz, Can. J. Bot. 62(1): 31 (1984)
Type species: Lautitia danica (Berl.) S. Schatz, Can. J. Bot. 62(1): 31 (1984)
- Loratospora* Kohlm. & Volkm.-Kohlm., Syst. Ascom. 12(1–2): 10 (1993)
Type species: Loratospora aestuarii Kohlm. & Volkm.-Kohlm., Syst. Ascom. 12(1–2): 10 (1993)
- Metameris* Theiss. & Syd., Anns mycol. 13(3/4): 342 (1915)
Type species: Metameris japonica (Syd. & P. Syd.) Syd., in Theissen & Sydow, Anns mycol. 13(3/4): 342 (1915)
- Mixtura* O.E. Erikss. & J.Z. Yue, Mycotaxon 38: 203 (1990)
Type species: Mixtura saginata (Syd.) O.E. Erikss. & J.Z. Yue, Mycotaxon 38: 203 (1990)

Neosetophoma Gruyter et al., Mycologia 102(5): 1075 (2010)

Type species: Neosetophoma samararum (Desm.) Gruyter et al. [as ‘samarorum’], Mycologia 102(5): 1075 (2010)

Nodulosphaeria Rabenh., Klotzschii Herb. Viv. Mycol., Edn 2: no. 725 (in sched.) (1858)

Type species: Nodulosphaeria hirta Rabenh., Klotzschii Herb. Viv. Mycol., Edn 2: no. 725 (in sched.) (1858)

Ophiobolus Reiss, Hedwigia 1(6): 27 (1854)

Type species: Ophiobolus disseminans Riess, Hedwigia 1(6): 27 (1854)

Ophiosphaerella Speg., Anal. Mus. nac. B. Aires, Ser. 3 12: 401 (1909)

Type species: Ophiosphaerella graminicola Speg., Anal. Mus. nac. B. Aires, Ser. 3 12: 401 (1909)

Parahendersonia A.W. Ramaley, Aliso 14(2): 152 (1995)

Type species: Parahendersonia dasylirii A.W. Ramaley [as ‘dasylirionis’], Aliso 14(2): 152 (1995)

Paraphoma Morgan-Jones & J.F. White, Mycotaxon 18(1): 58 (1983)

Type species: Paraphoma radicina (McAlpine) Morgan-Jones & J.F. White, Mycotaxon 18(1): 60 (1983)

Phaeoseptoria Speg., Revta Mus. La Plata 15: 39 (1908)

Type species: Phaeoseptoria papayae Speg., Revta Mus. La Plata: 39 (1908)

Phaeosphaeriopsis M.P.S. Câmara et al., in Câmara et al. Mycol. Res. 107(5): 519 (2003)

Type species: Phaeosphaeriopsis glaucopunctata (Grev.) M.P.S. Câmara et al. [as ‘glaucopunctata’], in Câmara et al., Mycol. Res. 107(5): 519 (2003)

Pleoseptum A.W. Ramaley & M.E. Barr, Mycotaxon 54: 76 (1995)

Type species: Pleoseptum yuccaesedum A.W. Ramaley & M.E. Barr, Mycotaxon 54: 76 (1995)

Setomelanomma M. Morelet, Bull. Soc. Sci. nat. Arch. Toulon et du Var 227: 15 (1980)

Type species: Setomelanomma holmii M. Morelet, Bull. Soc. Sci. nat. Arch. Toulon et du Var 36(no. 227): 15 (1980)

Setophoma Gruyter et al., Mycologia 102(5): 1077 (2010)

Type species: Setophoma terrestris (H.N. Hansen) Gruyter et al., Mycologia 102(5): 1077 (2010)

Tiarospora Sacc. & Marchal, Revue mycol., Toulouse 7(no. 26): 148 (1885)

Type species: Tiarospora westendorpii Sacc. & Marchal, Revue mycol., Toulouse 7(no. 26): 148 (1885)

Wilmia Dianese et al., Mycologia 93(5): 1014 (2001)

Type species: Wilmia brasiliensis Dianese et al., Mycologia 93(5): 1014 (2001)

Wojnowicia Sacc., Syll. fung. (Abellini) 10: 328 (1892)

Type species: Wojnowicia hirta (J. Schröt.) Sacc., Syll. fung. (Abellini) 14(2): 960 (1899)

Key to sexual genera of *Phaeosphaeriaceae*

(*Carinispora* and *Ocala* are included in the key for convenience)

1. Found in aquatic habitats2
1. Found in terrestrial habitats5
2. Found in freshwater habitats3
2. Found in marine habitats4
3. Ascospores cylindrical, 12–17-septate with central isthmus (much smaller central cell), surrounded by a mucilaginous sheath*Isthmosporella*
3. Ascospores narrowly ellipsoidal to fusiform, 9–12-septate, with apical appendages*Ocala*
4. Ascospores 1-septate, with mucilaginous pad at apex, parasite on *Chondrus**Lautitia*
4. Ascospores 7-septate, surround by triangular mucilaginous sheath, saprobic on palms*Carinispora*
5. Ascospores 1–2-septate6
5. Ascospores more than 2 septate8
6. Ascospores 1-septate7
6. Ascospores mostly 2-septate*Eudarlucia*
7. Ascospores parasite on *Picea**Barria*
7. Ascospores hemibiotrophic on *Memora pedunculata**Wilmia*
8. Ascospores phragmospores or scoleospores9
8. Ascospores muriform*Pleoseptum*
9. Ascospores phragmospores10
9. Ascospores scoleospores17
10. Ascospores 3-septate11
10. Ascospores more than 3-septate15
11. Ascospores mostly hyaline12
11. Ascospores pale yellowish to brown13
12. Ascostromata mostly multi-loculate, forming pseudostroma, ascospores ellipsoidal to fusiform, lacking a mucilaginous sheath*Bricookea*
12. Ascostromata single, ascospores elongate-fusiform or cylindrical, surrounded by mucilaginous sheath*Loratospora*
13. Ascostromata glabrous14
13. Ascostromata covered by setae*Setomelanomma*
14. On dicotyledons, ascospores ellipsoidal, peridium wide with hyaline inner layer*Chaetoplea*
14. On monocotyledons, ascospores narrowly fusiform, peridium 1–2-layers of brown-walled cells*Phaeosphaeria*
15. Ascospores fusiform to broadly fusiform, smooth-walled, asci saccate or ampulliform16
15. Ascospores oblong to cylindrical, verrucose, asci cylindrical to cylindrical-clavate*Phaeosphaeriopsis*
16. Ascospores reddish-brown, 6–8-septate, euseptate, saprobic on grasses*Hadrospora*
16. Ascospores yellowish-brown, 7-septate, distoseptate, parasitic on *Chusquea**Mixtura*
17. Ascospores filiform, if cells swollen then near centre18
17. Ascospores fusiform to elongate-fusiform, one cell in upper part swollen*Nodulosphaeria*

18. Ascospores not strongly constricted at the septa19
18. Ascospore strongly constricted at the septa*Entodesmium*
19. Ascospores filamentous, without swollen cells or appendages, or not separating into part spores*Ophiosphaerella*
19. Ascospores filamentous, narrower towards the lower end, often separating into two part spores from the central septum, the second cell of each part spore swollen*Ophiobolus*

Key to asexual genera of *Phaeosphaeriaceae*

1. Conidiophore present*Chaetosphaeronema*
1. Conidiophore absent2
2. Conidia hyaline3
2. Conidia pigmented4
3. Pycnidia with setae*Paraphoma*
3. Pycnidia without setae (in vitro on agar)*Setophoma*
4. Two types of conidia*Phaeosphaeriopsis* (incl. *Phaeostagonospora*)
4. One type of conidia5
5. Conidia yellowish*Neosetophoma*
5. Conidia brown6
6. Conidia aseptate*Ampelomyces*
6. Conidia septate7
7. Conidia with 1 median euseptum*Tiarospora*
7. Conidia with more than 1 septa8
8. Conidia filiform, 8–13-euseptate*Phaeoseptoria*
8. Conidia fusiform or cylindrical, 1–8-euseptate*Wojnowicia*

Phaeotrichaceae Cain, Can. J. Bot. 34: 676 (1956), MycoBank: MB 81144

Habitat terrestrial, saprobic (coprophilous). Sexual state: *Ascomata* solitary, or in small groups, superficial, unilocular, stromatic, globose, black, perithecial or cleistothecial setose. *Peridium* thin, carbonaceous, membranous. *Hamathecium* tissue absent or of evanescent cellular pseudoparaphyses *Asci* 8-spored, bitunicate, fissitunicate, in irregular or arranged in little groups or bundles and evanescent at maturity. *Ascospores* uniseriate?, dark brown to reddish brown, sometimes fragmenting, composed of terminal germ pores, with or without a sheath. Asexual state: Unknown

Notes: *Phaeotrichaceae* was initially described by Cain (1956) in order to accommodate a single genus *Phaeotrichum*, characterized by dark brown, septate ascospores with terminal germ pores. Initially the family was classified under order *Pleosporales* (Cannon and Kirk 2007). Barr (1987a) included *Sporormiaceae* under *Phaeotrichaceae* and treated it as a synonym. Later, Barr (1990a) restricted *Phaeotrichaceae* to two genera based on terminal germ pores in the ascospores and classified the genus under *Sordariales*, considering them as unitunicate fungi. Cain (1956) suggested that *Trichodelitschia* Munk (1953) was closely related to this

family resembling the features of the ascospores and the setose ascomata. Later, Lindquist (1964), assigned *Trichodelitschia* to the family. Subsequently, Barr (2000b) reclassified the family under the *Pleosporales* based on the bitunicate and fissitunicate asci with a well-developed refractive apical ring. However, the lack of pseudoparaphyses, cleistothecial ascomata with long setae, and conspicuous ascospores with germ pores at each end deviate from the current concept of the *Pleosporales* (Zhang et al. 2009a), therefore *Phaeotrichaceae* was excluded from *Pleosporales* and assigned to *Dothideomycetes incertae sedis* (Zhang et al. 2012a). This was confirmed by DNA based phylogenies (Schoch et al. 2009b; Zhang et al. 2012a). Currently the family comprises three genera i.e. *Echinoascotheca*, *Phaeotrichum* and *Trichodelitschia* (Zhang et al. 2012a, b). In our phylogenetic analysis, this family forms a distinct clade and we therefore introduce a new order to accommodate it.

Type: Phaeotrichum Cain & M.E. Barr, Can. J. Bot. 34: 676 (1956), MycoBank: MB 3967 Fig. 96

Habitat terrestrial, saprobic (coprophilous). *Sexual state: Ascomata* small, cleistothecial, solitary, or in small groups, superficial, unilocular, stromatic, thin-walled, black appendages evenly scattered on the surface of the ascomata, globose, black, shiny, carbonaceous, membranaceous. *Peridium* thin, carbonaceous or membranaceous, 1-layered, composed of dark brown thick-walled cells of *textura angularis*. *Hamathecium* of dense asci, lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, broadly clavate, with a relatively thick, long broad pedicel. *Ascospores* oblong to ellipsoid, hyaline when young, turning reddish brown at maturity, 1-septate, deeply constricted at the septum, each end with a subhyaline with a broadly rounded germ pore, readily forming part spores at the septum at maturity without a sheath.

Notes: Phaeotrichum was introduced to accommodate two new coprophilous fungi, i.e. *P. hystricinum* and *P. circinatum* Cain, and typified by *P. hystricinum* (Cain 1956). The genus was characterized by dark brown, septate ascospores with terminal germ pores, a coprophilous habitat, superficial cleistothecial ascocarps covered by long hairy appendages (Cain 1956). Cain (1956) suggested that *Phaeotrichum* shows similarities with the setose perithecial genus *Trichodelitschia*. This genus was placed in *Sporormiaceae* by Munk (1957), but Lindquist (1964) suggested that it would be better transferred to *Phaeotrichaceae*, and this concept was accepted by Barr (2000b). *Phaeotrichum* possesses untypical bitunicate asci, and the ascospore release mechanism is described by Cain (1956) as “simply break down and allow the contents to become free in the cavity of the ascocarp”. This type of ascospore release was considered as evolutionarily developed by Cain (1956) as compared to those that “discharge the ascospores through an apical pore”. Even though *Phaeotrichum* has an unusual bitunicate ascus, Cain (1956) assigned *Phaeotrichum* to *Pleosporales*. Sequence data from

a single unverified isolate of *Phaeotrichum benjaminii* however, placed it in a separate clade to the order *Pleosporales* in a multi-gene analysis of *Dothideomycetes* species (Schoch et al. 2009b). Absence of a hamathecium as well as the non typical bitunicate ascus are all distinct characters from members of *Pleosporales*, therefore Zhang et al. (2012a) excluded this genus from the order and assigned it to *Dothideomycetes incertae sedis*. Currently the genus comprises five species epithets, listed in the Index Fungorum (2013) and nine hits in GenBank. Therefore the correct placement of this genus is in doubt and further molecular and morphological studies are required.

Type species: Phaeotrichum hystricinum Cain & M.E. Barr [as ‘hystricinum’], Can. J. Bot. 34: 677 (1956)

Other genera included

Echinoascotheca Matsush., Matsush. Mycol. Mem. 8: 19 (1995)

Type species: Echinoascotheca duploformis Matsush., Matsush. Mycol. Mem. 8: 19 (1995)

Trichodelitschia Munk, Dansk bot. Ark. 15(no. 2): 109 (1953)

Type species: Trichodelitschia bisporula (P. Crouan & H. Crouan) Munk, Dansk bot. Ark. 15(no. 2): 109 (1953)

Key to genera of Phaeotrichaceae

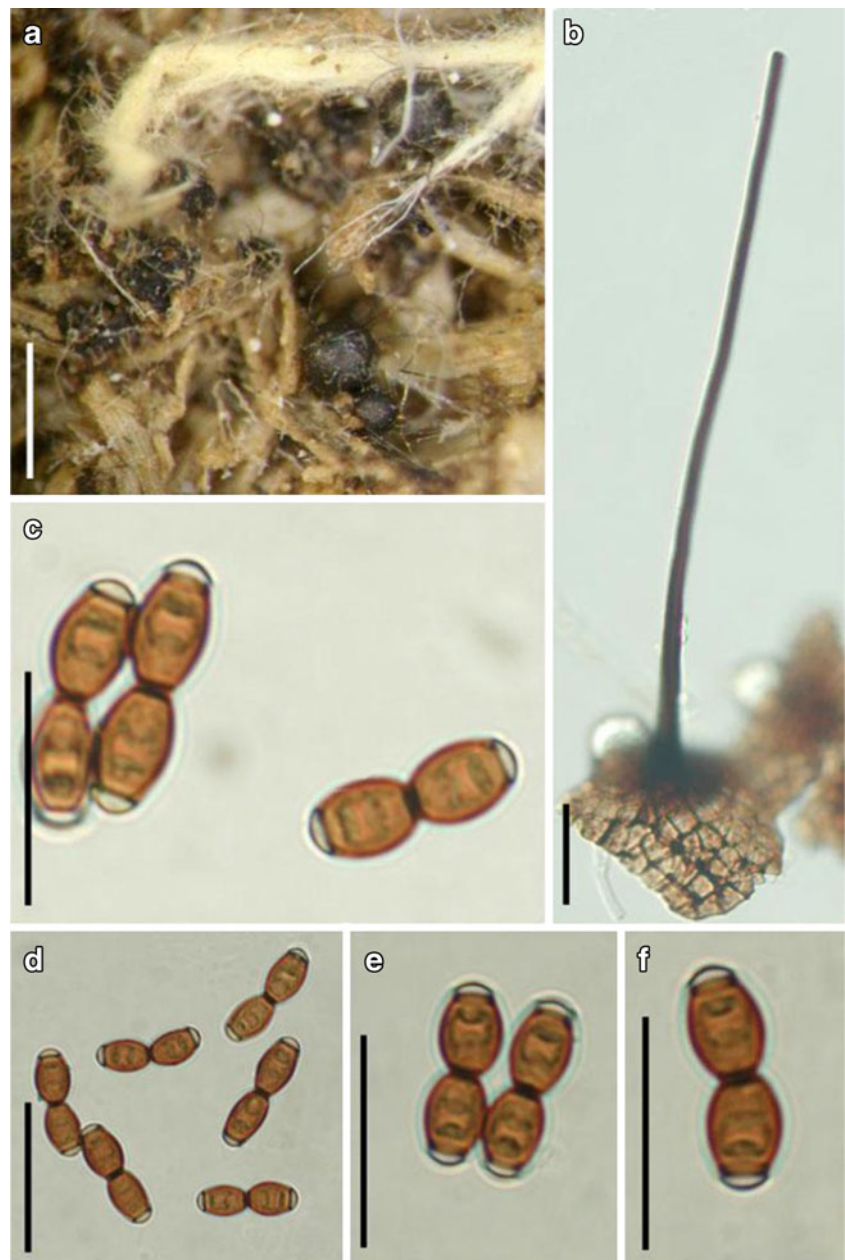
1. Ascospores without a gelatinous sheath*Phaeotrichum*
1. Ascospores with a gelatinous sheath2
2. Ascus with an apical ring*Trichodelitschia*
2. Ascus without an apical ring*Echinoascotheca*

Phyllostictaceae Fr. [as ‘Phyllosticti’], Summa veg. Scand., Section Post. (Stockholm): 420 (1849), MycoBank: MB 81162

Endophytic or pathogenic on leaves of a wide range of hosts. *Sexual state: Ascomata* gregarious, circular, brown to black, coriaceous, with a central ostiole. *Asci* (6–)8-spored, bitunicate, fissitunicate, clavate, with a gelatinous pedicel and ocular chamber. *Ascospores* irregularly biseriolate, hyaline, aseptate, ellipsoid to broadly fusoid, but much wider in the centre, smooth-walled, usually with mucilaginous pads at one or both ends or surrounded by a mucilaginous sheath. *Asexual state: Pycnidia* circular, brown to black, coriaceous, with a central ostiole. *Peridium* comprising brown cells of *textura angularis*. *Conidiogenous cells* lining wall of pycnidium, phialidic, cylindrical, hyaline. *Conidia* hyaline, ellipsoidal, aseptate, smooth-walled, surrounded by a mucilaginous sheath, bearing a single apical appendage.

Notes: Phyllosticta has been reviewed by Wikee et al. (2011) and there have also been several other modern treatments of the genus (Wulandari et al. 2009; Glienke et al. 2011; Wong et al. 2012). The generic type (*Phyllosticta convallariae* Pers.) lacks any recent collections or sequence

Fig. 96 *Phaeotrichum hystrixinum* (Material examined: CANADA, Ontario, Muskoka, Stoneleigh, on porcupine dung, 18 August 1932, Cain TRTC 4361, **holotype**). **a** Superficial ascomata on host surface. Note the long black appendages. **b** Part of peridium. Note the large cells in surface view. **c–f** Released reddish brown ascospores with hyaline end cells. Note the strongly constricted middle septum. Scale bars: **a**=0.5 mm, **b–f**=20 μ m



data and this is certainly required. The sexual state *Guignardia* is clearly linked to *Phyllosticta* and Wikee et al. (2011) proposed that *Phyllosticta* should be used for this genus with *Guignardia* listed as a synonym and this has already been used in *Index Fungorum* and by various authors (Glienke et al. 2011; Wikee et al. 2011; Wong et al. 2012; Liu et al. 2012a, b).

Type: *Phyllosticta* Pers., *Traité sur les Champignons Comestibles* (Paris):55, 147 (1818), MycoBank: MB 9384 Figs. 97 and 98

Endophytic or **pathogenic** on leaves of a wide range of hosts. **Sexual state:** *Ascomata* gregarious, circular, brown to

black, coriaceous, with a central ostiole. *Asci* (6–)8-spored, bitunicate, fissitunicate, clavate, with a gelatinous pedicel and ocular chamber. *Ascospores* irregularly biserial, hyaline, aseptate, ellipsoid to broadly fusoid, but much wider in the centre, smooth-walled, usually with mucilaginous pads at one or both ends or surrounded by a mucilaginous sheath. **Asexual state:** *Pycnidia* circular, brown to black, coriaceous, with a central ostiole. *Peridium* comprising brown cells of *textura angularis*. *Conidiogenous cells* lining wall of pycnidium, phialidic, cylindrical, hyaline. *Conidia* hyaline, ellipsoidal, aseptate, smooth-walled, surrounded by a mucilaginous sheath bearing a single apical appendage.



Fig. 97 *Phyllosticta arecae* (MFLU 12–2220). **a–b** Disease symptom on leaves. **c** Vertical section through ascoma. **d–f** Asci. **g–j** Ascospores. Scale bars: **c** = 50 μm , **d–f** = 20 μm , **g–j** = 10 μm

Notes: The genus *Phyllosticta* has recently been well-studied, however, presently sequence data is only available for extype strains of 15 species and therefore more work is required before we can really start to understand this important genus. Phylogenetic analysis based on ITS, ACT, TEF and GPDH combined genes have proven to be informative in this genus (Wikee et al. 2011; Wong et al. 2012). *Saccharata* and *Melanops* probably do not belong in this family (Fig. 1) will be described as new families (Slippers et al. 2013, in press). We presently include these genera in *Phyllostictaceae* pending further molecular study since the classification is not well-resolved.

Type species: *Phyllosticta convallariae* Pers., *Traité sur les Champignons Comestibles* (Paris): 148 (1818)

Piedraiaceae Viégas ex Cif. et al., *Publicões Inst. Micol. Recife* 45(1–6): 7 (1956), MycoBank: MB 82066

Pathogen of human hair. Sexual state: *Ascostromata* consisting of pseudoparenchymatic tissue, scattered singly on the underlying part of primate hairs, variable in shape and size, but usually flat, elongated and with a rough surface, dark in colour, multi-loculate in section, containing numerous cavities, irregularly distributed throughout. Each locule becomes erumpent as the asci mature, and can be visible as small dimple, and contains a single ascus. *Pseudostiolate* locules, without pseudoparaphyses, with paraphysoids. *Asci* 8-spored, bitunicate, subglobose to broadly ellipsoidal. *Ascospores* 1-celled, hyaline, rarely light yellowish or greenish, without septa, thin-walled, fusiform, curved, more or less straight to falcate, tapering toward both ends, with tapering gelatinous appendages or without appendages. Germination by several germ tubes. (Ciferri et al. 1956; von Arx and Müller 1975; Eriksson 1981; Liu 2011). Asexual state: Unclear.



Fig. 98 *Phyllosticta maculata* (MFLU 12–2219). **a–c** Fruiting bodies on fruit and leaf. **d, e** Vertical section through pycnidium, showing developing conidia. **f** Vertical section through spermatogonium. **g, h** Asci. **i–k** Conidia. **l–n** Ascospores. Scale bars=10 μm , except **d, f**=50 μm , **g, h**=20 μm

Notes: *Piedraiaceae* was established by Viegas (1943) and first described in Ciferri et al. (1956) in order *Myriangiales*. This family only comprises the genus *Piedraia*, which is widespread mostly in tropical regions and has two species (Kirk et al. 2008); *P. hortae* Fonseca & Leão the type species and *P. quintanilhae* Uden et al.. *Piedraia hortae* is a keratinolytic fungus, causing a condition called ‘black piedra’ in humans. It produces sexual spores in its parasitic phase, while *P. quintanilhae* has unknown pathogenicity in humans, and differs from *P. hortae* in having ascospores without appendages. ‘Piedra’ is a superficial fungal infection of hairs that forms hard nodes on the hair shaft. There are two types of ‘piedra’: the ascospores producing stroma, *Piedraia hortae*, is known as black piedra, while the term white piedra is used for

Trichosporon Behrend (1890), which is a genus of basidiomycetous anamorphic yeasts and capable of infecting hair, while both can be cultured on Saouraud agar (Liu 2011).

Piedraia is also commonly present in soil as well as stagnant water and crops in tropical regions as a dematiaceous filamentous fungus. It is a more important disease in South America, Asia and some Pacific islands. The sultry environment, and use of plant oils on hair, facilitates the growth of the fungus. The infection results on the formation of asymptomatic brown to black nodules. The nodules consist of ascostromata containing asci and aseptate ascospores (Braun-Falco et al. 2000; Liu 2011).

Schoch et al. (2006) used multi-gene analysis of Dothideomycetes and placed *Piedraiaceae* in *Capnodiales*;

Piedraia hortae allied with *Capnodiales* not *Myriangiiales*, as Lindemuth et al. (2001) earlier reported and *P. hortae* is closely related to *Mycosphaerella* which supports the result from Selbmann et al. (2005). Crous et al. (2009b) sequenced five strains of *P. hortae* and one *P. quintailhae* strain which formed a well-supported monophyletic clade in *Teratosphaeriaceae*. *Piedraiaceae* appears to represent a separate lineage within the *Teratosphaeriaceae*, which is presently too widely defined, and will be addressed in future studies (Binder et al. in prep.).

Type: *Piedraia* Fonseca & Leão, Mem. Inst. Oswaldo Cruz 4(Suppl.): 125 (1928), MycoBank: MB 4098 Fig. 99

Notes: The genus was established by Fonseca and Leão (1928) and causes disease of human hair. Index Fungorum (2013) list ten epithets, but only two species are generally accepted: *P. hortae* and *P. quintailhae*. *Piedraia* is a filamentous fungus, causing infection of hairs and forms hard nodes on hair shafts (Liu 2011). *Trichosporon hortae* Brumpt is listed as a synonym in Index Fungorum (2013).

Type species: *Piedraia hortae* (Brumpt) Fonseca & Leão, Memórias do Instituto Oswaldo Cruz, Suplemento 4 (Suppl.): 124 (1928), MycoBank: MB 267365

Planistromellaceae M.E. Barr, Mycotaxon 60: 433 (1996), MycoBank: MB 81919

Biotrophic, hemibiotrophic or *saprobic* on leaves and stems of various plants in terrestrial habitats. Sexual state: *Ascstromata* multi- or uniloculate, immersed to erumpent through cracking or splitting of the host tissue, solitary to gregarious, with periphysate ostioles, with or without papillate. *Cells of ascstromata* thick-walled, composed of several layers of dark brown cells, arranged in a *textura angularis*. *Locules* ovoid to globose, developing in the same stroma of the conidiogenous and/or spermatogenous locules, empty locule collapsing, ostiole periphysate. *Peridium* of locules

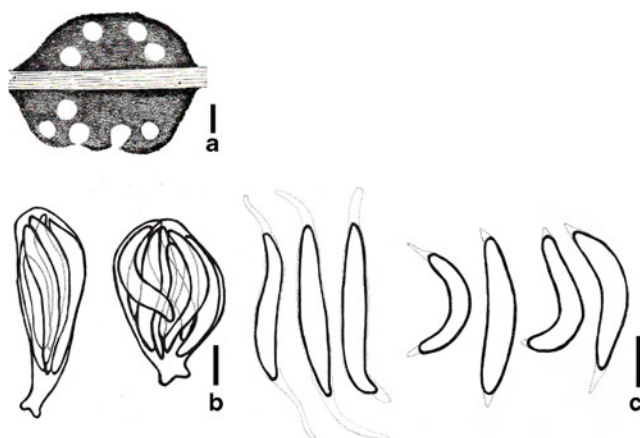


Fig. 99 *Piedraia hortae*. **a** Ascstromata on hair with numerous locules (image from Ciferri et al. 1956) **b** Asci. **c** Ascospores (redrawn from Shoemaker and Egger 1982). Scale bars: **a** = 100 μ m, **b**, **c** = 10 μ m

composed of a few layers of hyaline to light brown flattened cells. *Hamathecium* lacking pseudoparaphyses, interascal cells abundant even at maturity. *Asci* 8-spored, bitunicate, fissitunicate, oblong, clavate to nearly cylindrical, with a pedicel and with an ocular chamber, forming in a basal layer, often interspersed with and covered by cellular remnants of interthecial tissues. *Ascospores* overlapping 1–3-seriate, hyaline or lightly pigmented, yellowish to brownish, ellipsoid to broadly obovoid, aseptate or with 1–2 transverse septa; wall thin, with or without a gelatinous sheath, contents guttulate. Asexual state: *Conidiomata* subepidermal, dark, immersed to erumpent, solitary to gregarious, pycnidia, locules or acervuli in a stroma, or bearing conidia over stroma surface prior to locule formation, ostiolate. *Conidiomata walls* comprising several layers with cells of *textura angularis*, the outer layers composed of dark thick-walled cells, lighter towards the inner layers of hyaline cells. *Conidiogenous cells* short cylindrical, conidiogenesis holoblastic, hyaline, smooth. *Conidia* oblong, ellipsoid-cylindric, aseptate or one to several transversely septate, hyaline to brown, wall smooth or verruculose, with or without one or more apical appendages at times. *Spermatial state* developing in the same or separate locules. *Spermatogenous cells* discrete or integrated, phialidic, cylindrical to elongate-conical, determinate, hyaline, smooth-walled. *Spermatia* bacillary, hyaline, aseptate, smooth.

Notes: The family *Planistromellaceae* was introduced by Barr (1996) with the type species *Planistromella*. Presently, the genera *Comminutispora*, *Eruptio*, *Loratospora*, *Microcyclus*, *Mycosphaerellopsis*, *Planistroma* and *Planistromella* are included in this family (Lumbsch and Huhndorf 2010). The *Planistromellaceae* is reduced to include *Kellermania* and *Planistroma* based on molecular data (Monkai et al. 2013). *Mycosphaerellopsis* is tentatively included, based on morphology, however there are no molecular data to support this. The family belongs in the *Botryosphaeriales* (Minnis et al. 2012; Monkai et al. 2013). The type species, *Kellermania yuccifoliorum* is characterized by subepidermal, immersed, multi-locular ascstromata with periphysate ostioles, bitunicate, slightly clavate or nearly cylindrical asci, and smooth, hyaline, septate ascospores. The asexual state of *K. yuccifoliorum* is characterized by uniloculate conidiomata, which develop in the same stroma as the ascogenous locules and has 2-septate conidia with a unique apical appendage (Ramaley 1993). Molecular data indicate that *Comminutispora* does not belong in *Botryosphaeriales*, as it clusters and is more typical of *Capnodiales* (Hambleton et al. 2003; Crous et al. 2009a; Schoch et al. 2009b). *Eruptio* is typical of *Mycosphaerellaceae* and this is confirmed by molecular data (Crous et al. 2001, 2009a, b; Verkley et al. 2004). Molecular data (Suetrong et al. 2009) place *Loratospora* in the family *Phaeosphaeriaceae* and the characters of this genus are also in concordance with this finding. *Microcyclus* may be a member of *Mycosphaerellaceae* based on its morphology.

Type: Kellermania Ellis & Everh., J. Mycol. 1(12): 153 (1885), MycoBank: MB 22437

Biotrophic, hemibiotrophic and saprotrophic on leaves and stems. *Ascostromata* subepidermal, immersed, becoming erumpent, solitary to gregarious, multi-locular, subglobose to ovoid, dark brown to black, thick-walled. *Cells of ascostromata* composed of several layers of dark brown cells of *textura angularis*. The upper part of the ascostromata comprises columns of elongated cells attached with the host epidermis. *Locules* ovoid to globose, the collapsed locule producing conidia or spermatia or both, periphysate ostiole. *Peridium* of locules composed of a few layers of hyaline to light brown flattened cells. *Hamathecium* lacking pseudoparaphyses when mature, interascal cells abundant, filamentous. *Asci* 8-spored, bitunicate, fissitunicate, clavate to nearly cylindrical, with a short, knob-like pedicel and an ocular chamber. *Ascospores* overlapping 1–2-seriate, ellipsoid and slightly curved with bluntly rounded ends, hyaline, 1–2-septate, guttulate. *Conidiomata* subepidermal, dark, immersed, erumpent by remaining at the rim covered by epidermis, solitary to gregarious, unilocular, ostiolate. *Conidiomata walls* comprising several layers with cells of *textura angularis*, the outer layers composed of 6–12 layers of dark, thick-walled cell, lighter toward the inner layers composed of 2–3 layers of hyaline cells. *Conidiogenesis* holoblastic. *Conidiophores* absent. *Macroconidiogenous cells* short cylindrical, hyaline, smooth-walled, each forming acrogenous holoblastic conidia. *Macroconidia* narrowly ellipsoid-cylindric, the base bluntly rounded, the apex more pointed and often surrounded by an appendage, mostly 2-septate. *Microconidiogenous cells* arising on the upper wall of conidioma and in ostiolar channel. *Microconidia* more or less cylindrical, aseptate, smooth-walled, hyaline. *Spermatia* formed in the central locule of a stroma or in the locule in the vertical column of the lateral walls of some conidiomata. *Spermatogenous cells* discrete or integrated on one-celled conidiophores, phialidic, cylindrical to elongate-conical. *Spermatia* bacillary, hyaline, smooth (asexual morph description follows Ramaley 1993).

Notes: The type species of *Kellermania* (*K. yuccifoliorum* ≡ *Planistromella yuccifoliorum*) differs from other genera in *Planistromellaceae* in having 1–2-septate ascospores (Ramaley 1993; Barr 1996). The asexual state of *K. yuccifoliorum* is characterized by uniloculate conidiomata, which develops in the same stroma as the ascogenous locules and has 2-septate conidia with a unique apical appendage (Ramaley 1993). Several other species of *Kellermania* are illustrated by Minnis et al. (2012) and range from having 0 to several trans-septa and with or lacking appendages. Species in this genus are known from the genera *Agave* and *Nolina* (*Asparagaceae*). There are 13 species recorded in *Index Fungorum*. Five species have been reported with both sexual and asexual states (Ramaley 1993, 1995, 1998; Barr 1996).

Phylogenetic analysis of *Kellermania* and *Piptarthron* based on SSU, ITS and LSU genes from Minnis et al. (2012) showed that both genera group in the same clade and they combined *Piptarthron*, *Planistroma* and *Planistromella* under *Kellermania*. However, in Monkai et al. (2013) the phylogenetic tree based on molecular data from LSU and ITS genes shows that the type species of *Kellermania*, which is also the type of *Planistromella* clusters separately from *Planistroma*. *Planistroma* is accepted as a distinct genus as both molecular and morphological data show these genera to be different.

Type species: Kellermania yuccifoliorum A.W. Ramaley, Mycotaxon 47: 262 (1993), MycoBank: MB 360149 (Figs. 100 and 101).

≡ *Planistromella yuccifoliorum* A.W. Ramaley, Mycotaxon 47: 261 (1993)

Other genera included

Mycosphaerellopsis Höhn., Anns. mycol. 16(1/2): 157 (1918)

Type species: Mycosphaerellopsis myricariae (Fuckel) Höhn., Anns. mycol. 16(1/2): 157 (1918)

Planistroma A.W. Ramaley, Mycotaxon 42: 69 (1991), MycoBank: MB 25358

Type species: Planistroma yuccigenum A.W. Ramaley, Mycotaxon 42: 69 (1991), MycoBank: MB 358836

Key to genera of Planistromellaceae

1. Ascostromata uniloculate, ascospores 1-septate, broadly obovoid *Mycosphaerellopsis*
1. Ascostromata multi-loculate 2
2. Ascospores 2-septate, conidia with 1–3 septa and appendages *Kellermania*
2. Ascospores aseptate, conidia lacking septa or appendages *Planistroma*

Platystomaceae J. Schröt. [as ‘Platystomacei’], in Cohn, Krypt.-Fl. Schlesien (Breslau) 3.2(3): 323 (1894) [1908], MycoBank: MB 81185

Saprobic on woody substrates or hypersaprobic on other ascomycetes. Sexual state: *Ascomata* immersed with apices erumpent, or erumpent superficial with bases immersed, at times in a subiculum, separate or gregarious or in valsoid groups, globose or conoid and applanate with flattened bases (small), medium to large sized; apex well-developed, papillate or short beaked, rounded or compressed or angular, at times pore area red, orange or yellow with pigment encrusting tips of pseudoparaphyses; surface smooth or tomentose, tomentum and/or subiculum brown or brightly pigmented (yellowish, greenish, ochraceous, ferruginous, orange, vinaceous), sometimes as disc over papillate ascomata; peridium firm, composed of several rows of small compressed cells, reddish brown. *Hamathecium* of trabeculate pseudoparaphyses, branched and anastomosing in gel matrix. *Asci* 8-spored, bitunicate, peripheral or basal in tall narrow ascomata, clavate

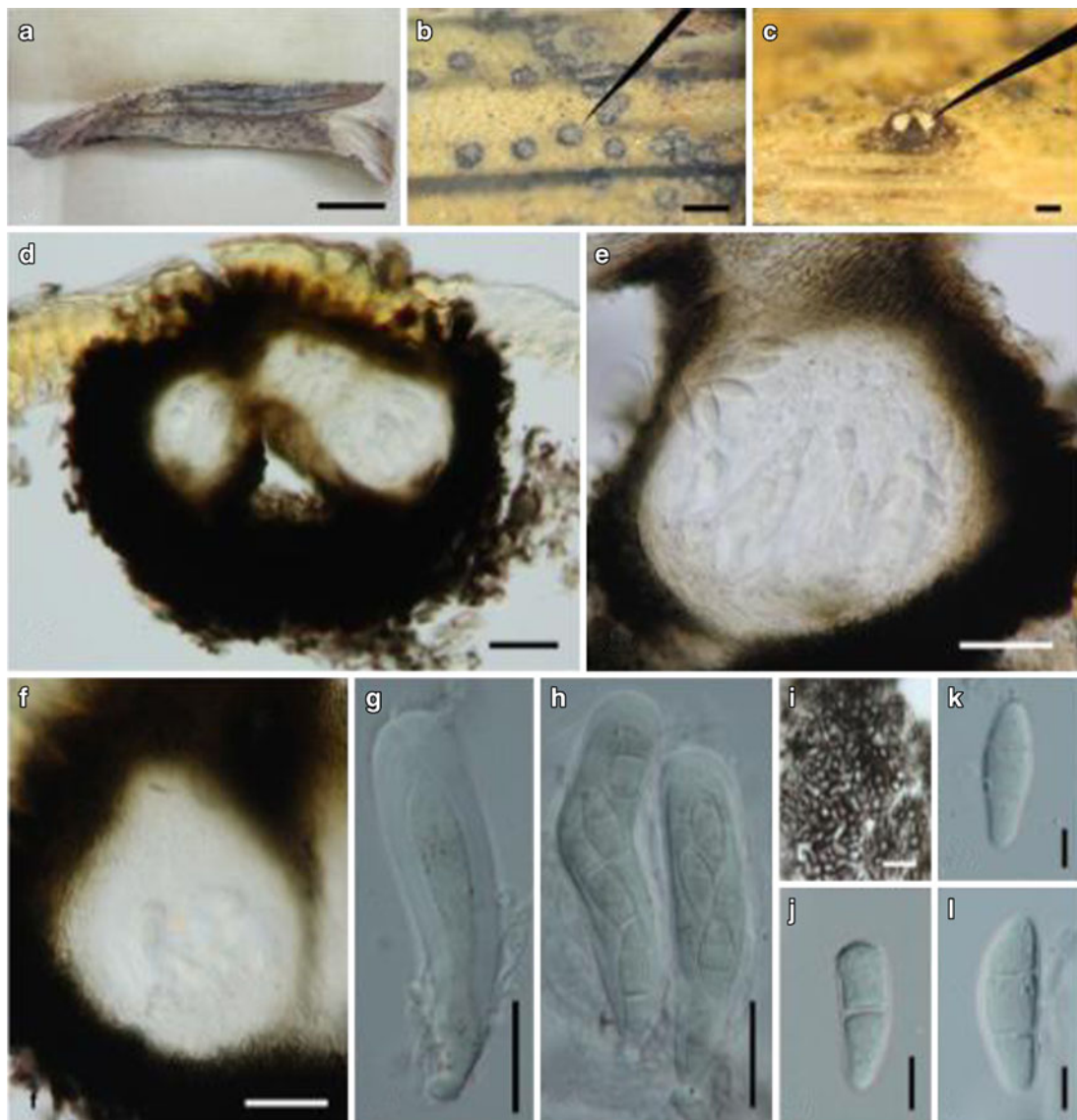


Fig. 100 *Kellermania yuccifoliorum* (Material illustrated: USA: California, San Bernardino County, Roadside 20 miles east of Baker (Hwy. 91/466), on leaves of *Yucca brevifolia* Engelman, 14 April 1960, Isabelle Tavares No.466 (UC 1202973, **holotype** of *Planistromella yuccifoliorum*). **a, b** Ascostromata on the host surface. **c, d** Section of

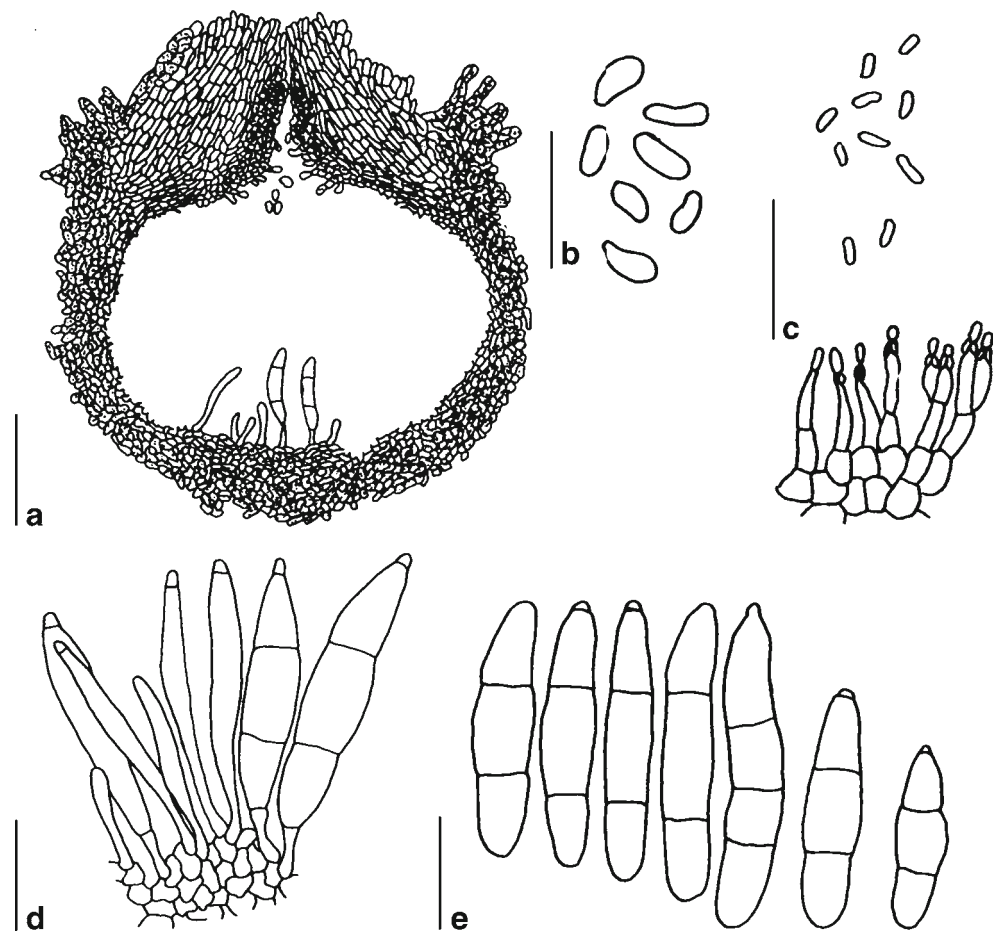
ascostroma. **e, f** Ascoma. **g** Immature ascus. **h** Mature asci. **i** Cells of ascostroma. **j** Immature ascospore. **k, l** Mature ascospores. Scale bars: **a**=1 cm, **b**=1,000 μ m, **c**=200 μ m, **d**=100 μ m, **e, f**=50 μ m, **g, h**=30 μ m, **i**=20 μ m, **j–l**=10 μ m

or cylindric, with small ocular chamber. *Ascospores* hyaline, light clear brown, reddish brown, or dark brown, ends pale at times, ellipsoid or fusoid, ends obtuse or acute, several septate, some muriform, constricted at first-formed septum; wall smooth or verruculose or longitudinally striate, occasionally surrounded by gel coating; contents with large globule per cell; overlapping uniseriate or biseriate in the ascus. Asexual state: coelomycetous. *Conidiogenous cells* phialidic. *Conidia* light brown, one-celled.

Notes: This is a family of uncertain status. Some taxa in the *Platystomaceae* are morphologically similar to those in the *Lophiostomataceae* especially the characteristics of the papilla. As a result, Holm and Holm (1988) treated the

Platystomaceae as a synonym of the *Lophiostomataceae* and the type *Platystomum compressum* is listed as a synonym of *Lophiostoma compressum* (Pers.) Ces. & De Not. in Index Fungorum (2013). Phylogenetically, the *Platystomaceae* does not form a monophyletic relationship with the *Lophiostomataceae* but is inseparable with taxa of the *Testudinaceae*, such as *Quintaria*, *Ulospora* and *Verruculina* (Mugambi and Huhndorf 2009b; Schoch et al. 2009b). The family *Platystomaceae* is poorly understood both morphologically and phylogenetically. Sequence data from genera in this family and the *Testudinaceae* are required to resolve the phylogeny of this lineage, especially the type of the *Testudinaceae*, *T. terrestris*. Although we include the family in Dothideomycetes at

Fig. 101 *Kellermania yuccifoliorum* (redrawn from Ramaley 1993). **a** Conidioma. **b** Microconidia. **c** Spermata and spermatogenesis. **d** Conidiogenesis and appearance of apical appendage. **e** Conidia. Scale bars: a=80 μ m, b–d=27 μ m, e=40 μ m



this time, its inclusion may be questionable and further studies involving studying the type, new collections and sequence data is needed to resolve this conflicting group.

Type: Platystomum Trevis., Bull. Soc. R. Bot. Belg. 16: 16 (1877), MycoBank: MB 4185

Figure 102

Saprobic on woody substrates. Sexual state: *Ascomata* immersed, becoming erumpent, globose, medium to large sized; apex well-developed, papillate or beak-like, compressed, pore slit-like, externally dark reddish brown, composed of rows of compressed cells, internally pallid. *Hamathecium* comprising trabeculate pseudoparaphyses in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical or clavate, pedicellate, apically rounded with an ocular chamber, peripheral. *Ascospores* uniseriate or biseriata, clear brown or dark reddish brown, ends sometimes paler, fusoid or ellipsoid, sometimes somewhat asymmetric and obovoid, muriform, longitudinal septa often in mid cells only; wall firm, dark, smooth or verruculose, often surrounded by gel coating, sometimes coating prolonged over tips as appendages; one globule per cell. Asexual state: Unknown.

Notes: The type, *Platystomum compressum* (Pers.) Trevis., forms a monophyletic group with species of the genera

Ostropella, *Pseudotrichia* and *Xenolophium*, while distantly related to *Lophiostoma macrostomum* (Tode) Ces. & De Not., the type species of *Lophiostoma* and should be kept separate (Mugambi and Huhndorf 2009b). *Lepidosphaeria nicotiae* Parg.-Leduc and *Ulospora bilgramii* (D. Hawksw. et al.) D. Hawksw. et al. (*Testudinaceae*) also form part of this group (Mugambi and Huhndorf 2009a; Schoch et al. 2009b). Results from other phylogenetic studies suggest that four marine taxa (*Carinispora nypae* K.D. Hyde, *Massarina ricifera*, *Quintaria lignatilis* (Kohlm.) Kohlm. & Volkm.-Kohlm. and *Verruculina enalia* (Kohlm.) Kohlm. et al. Kohlm. & Volkm.-Kohlm.) may be phylogenetically related to this group (Schoch et al. 2009b; Suetrong et al. 2009). However, taxa in this group have little morphology in common and further taxa sampling is required to resolve the phylogeny within this group and amongst other families in the *Dothideomycetes*. In this treatise, four genera are included in the *Platystomaceae* (Lumbsch and Huhndorf 2010).

Type species: Platystomum compressum (Pers.) Trevis., Bull. Soc. R. Bot. Belg. 16: 16 (1877)

Figure 102

≡ *Sphaeria compressa* Pers., Syn. meth. fung. (Göttingen) 1: 56 (1801)



Fig. 102 *Platystomum compressum* (Material examined: HUNGARY, Somogy, Kaposvár in Ungarn. Lojka, 1872 (S F7232, type of *Lophiostoma lojkanum* Sacc). **a** Herbarium material. **b, c** Ascomata on the surface or immersed in the host. **d** Vertical hand section of ascoma. **e**

Ostiole. **f** Vertical hand section of peridium. **g** Immature ascus. **h–k** Asci with ascospores. **l** Pseudoparaphyses. **m–p** Ascospores. Scale bars: **b**=500 μ m, **c**=200 μ m, **d**=100 μ m, **e**=50 μ m, **f**=20 μ m, **g–k**=10 μ m, **l–p**=5 μ m

Other genera included:

Ostropella (Sacc.) Höhn., *Annls mycol.* 16(1/2): 144 (1918)

Type species: Ostropella albocincta (Berk. & M.A. Curtis) Höhn., *Annls mycol.* 16(1/2): 144 (1918)

Pseudotrichia Kirschst., *Annls mycol.* 37(1/2): 125 (1939)

Type species: Pseudotrichia stromatophila Kirschst., *Annls mycol.* 37(1/2): 125 (1939)

Xenolophium Syd., in Stevens, *Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii* 19: 96 (1925)

Type species: Xenolophium laeve Syd. [as '*Xenolophium leve*'], *Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii* 19: 97 (1925)

Key to genera of *Platystomaceae*

1. Ascomatal surface glabrous or roughened2
1. Ascomata always covered by coloured hyphae3
2. Ascospores muriform*Platystomum*
2. Ascospores with longitudinal septa only*Xenolophium*
3. Asci clavate*Pseudotrichia*
3. Asci elongate-clavate, with a long stalk*Ostropella*

Pleomassariaceae M.E. Barr, Mycologia 71(5): 949 (1979), MycoBank: MB 81634

Saprobic or *parasitic* on wood or lichens in terrestrial environments. Sexual state: *Ascomata* medium to large, solitary, scattered or in small groups, immersed, erumpent to superficial, globose or depressed globose, ostiolate. *Ostirole* flattened, papillate, open via minute slit or a small conical swelling in the host. *Peridium* comprises one to few layers, thickened at the side, thin at the base and apex. *Hamathecium* of narrow cellular pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, oblong, cylindrical or clavate, with a furcate pedicel and minute ocular chamber. *Ascospores* obliquely uniseriate and partially overlapping to biseriate, clavate, ellipsoidal or oblong 1-septate, multi-septate or muriform, mostly distoseptate, brown, constricted at the septa, usually with a gelatinous sheath. Asexual state: hyphomycetous or coelomycetous, *Shearia*, *Prosthemium* *Ceuthodiplospora*, *Myxocyclus* and *Stegonsporium* are currently reported asexual morphs for the family.

Notes: Barr (1979a) introduced *Pleomassariaceae* as a new family in the order *Pleosporales* based on the ascomata wall being thickened at the sides and thin at base and ascospores usually being distoseptate and dark brown. *Pleomassaria* was assigned as the type for the family. Initially *Asteromassaria* and *Splanchnonema* were also included in the family. Aptroot (1991a) included *Eopyrenula*, a lichenized species under *Pleomassariaceae* (Barr 1993a). Originally *Kirschsteiniothelia* was included within the *Pleosporaceae* (Hawksworth 1985b; Barr 1987a), but (Barr 1993a), based on host, morphology and asexual state, suggested that *Kirschsteiniothelia* showed a greater affinity to the *Pleomassariaceae*. *Macrovalsaria* was assigned to *Pleomassariaceae* based on its saprobic or lichenized habitat in woody branches, with an ascomata wall thickened at sides and thin at base, with cellular pseudoparaphyses, ascus wall thick towards the apex, producing brown or rarely light brown, thick-walled, one or several distoseptate ascospores (Barr 1993a). Barr (1979a) included *Pleomassaria*, *Splanchnonema*, and *Asteromassaria* in the family *Pleomassariaceae*. *Pleomassaria* differs from the other two genera in producing muriform and somewhat asymmetrical ascospores with a sub median primary septum. Boise (1985a) added three species to the *Pleomassariaceae* and suggested that taxa in the *Pleomassariaceae* and *Massarinaceae* shared some similar characters and might be closely related. Barr (1993a) treated *Pleomassaria* as a synonym of *Splanchnonema* based on their

similarities except for ascospore septation, but this proposal was not followed by many researches (Zhang et al. 2012a). Calatayud et al. (2001) introduced a new genus, a gall-forming lichenicolous taxon *Lichenopyrenis* for the family based on perithecioid ascomata with a cellular wall, formed by relatively large, somewhat compressed cells, fissitunicate asci, wide hamathecium filaments, and 1-septate, distoseptate, pale orange brown ascospores, which at maturity, seemingly bulge from the exospore wall at the septum and apices. Currently the family comprises *Lichenopyrenis*, *Splanchnonema*, *Peridiothelia* and *Pleomassaria* (Zhang et al. 2012a).

The asexual states of the *Pleomassariaceae* are mostly coelomycetous. The type of *Pleomassaria* (*P. siparia*) is linked with *Prosthemium betulinum* Kunze. *Shearia* and *Prosthemium* are asexual states of *Pleomassaria* (Barr 1982; Sivanesan 1984; Tanaka et al. 2010). Molecular studies based nucSSU, nucLSU rDNA, TEF1, RPB1 and RPB2 placed *Pleomassariaceae* within *Melanommataceae* and thus *Pleomassariaceae* was treated as a synonym of *Melanommataceae* (Zhang et al. 2009a). This is because the types of *Melanomma* (*M. pulvis-pyrius*) and *Pleomassaria* (*P. siparia*) clustered in the same clade with strong bootstrap support. A similar result was obtained by Tanaka et al. (2010). Subsequently Zhang et al. (2012a) showed that *Pleomassaria siparia* and four *Prosthemium* species formed a well-supported monophyletic clade and a sister clade to the *Melanommataceae*, Zhang et al. (2012a) therefore reinstated *Pleomassariaceae* as a separate family in the order *Pleosporales*.

Type: *Pleomassaria* Speg., Anal. Soc. cient. argent. 9: (in tabula ad p.192) (1880), MycoBank: MB 4214 Fig. 103

Saprobic in terrestrial habitats. Sexual state: *Ascomata* solitary, scattered, or in small groups, immersed, erumpent a depressed globose, medium to large, black, ostiolate. *Ostirole* papillate, opening via a minute slit or a small conical swelling in the bark, ostiolar canal filled with a tissue of hyaline small cells. *Peridium* 1-layered, composed of small pigmented thick-walled compressed cells, base consists of small, pigmented, thick-walled cells of *textura angularis* and apex comprises comparatively large cells. *Hamathecium* of dense, cellular, filiform, broad, septate pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, ellipsoid, broadly cylindrical to broadly cylindro-clavate, with a short, narrow, thick pedicel, rounded at the apex with a minute ocular chamber. *Ascospores* biseriate, partially overlapping, narrowly oblong with broadly to narrowly rounded ends, brown to golden brown, muriform, 5–8 transverse septate and 1–2 vertical septate in some cells, constricted at each septum, comprises smooth to verrucose spore wall with a mucilaginous sheath. Asexual state: *Prosthemium*. *Mycelium* immersed, branched, septate, pale brown. *Acervulus* corticolous, subepidermal, thick-walled, upper wall composed cells of *textura angularis* discrete, dark brown,

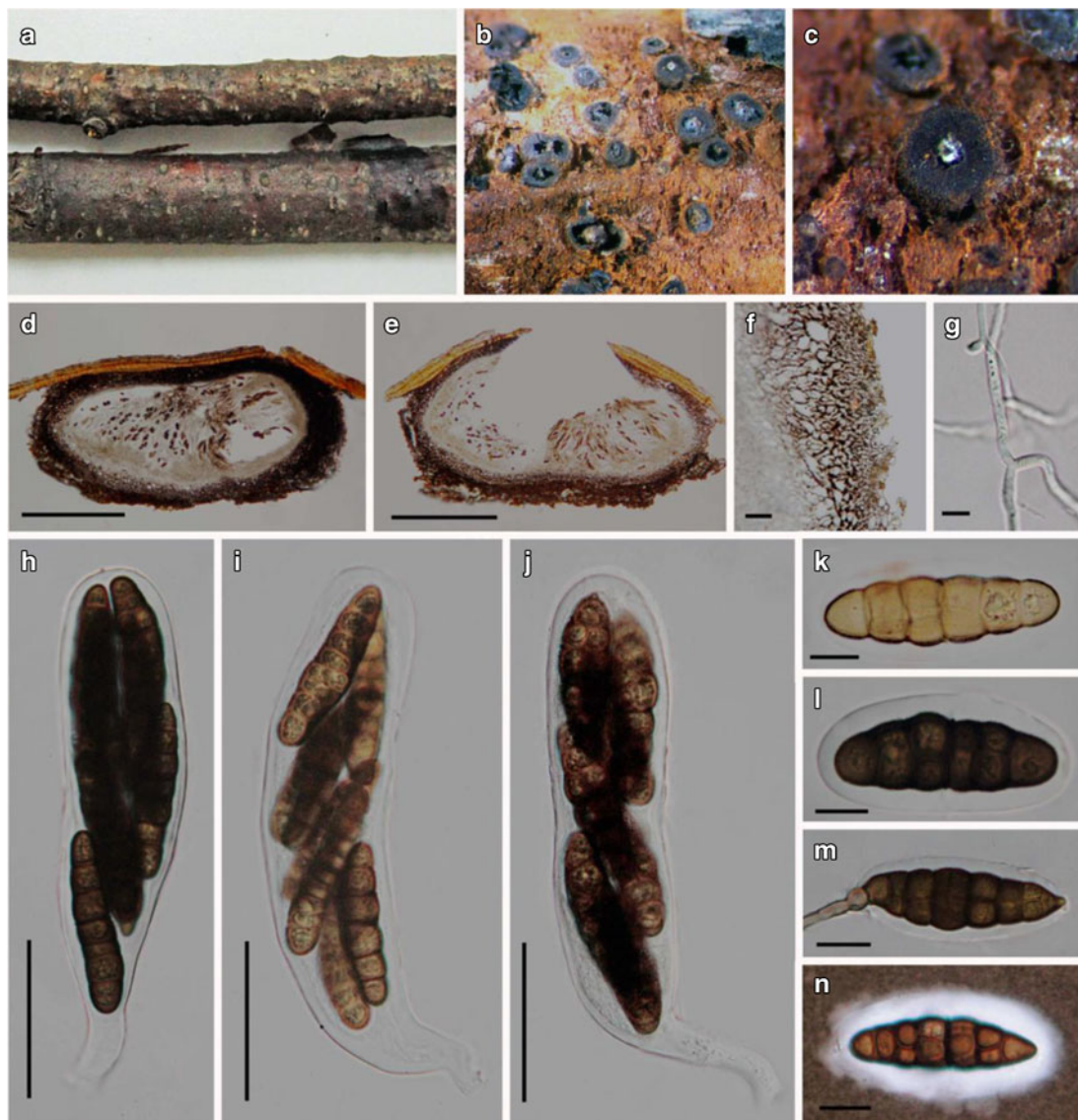


Fig. 103 *Pleomassaria siparia* (Material examined: UK, Wiltshire, Spye Park, on the branches of *Hendersonia polycystis*, C.E. Broome, S, F221552, **non type**). **a** Ascomata on host substrate. **b, c** Close up of ascomata. **d, e** Section of Ascomata. **f** Close up of the peridium. **g** Broad,

hyaline anastomosing and branching pseudoparaphyses. **h–j** Asci with short, broad pedicel bearing 8-spores. **k–n** Mature and immature ascospores with mucilaginous sheath. **n** Ascospores stained with Indian ink. Scale bars: **d–e**=600 μm , **f**=30 μm , **g**=5 μm **h–j**=50 μm , **k–n**=20 μm

opening via irregular rupture of the overlying tissues. *Conidiophores* filiform, septate, hyaline, confined to the basal region. *Conidiogenous cells* holoblastic, integrated, cylindrical, terminal, forming a single conidium at the apex. *Conidia* consist of radiating transversely septate arms connected to a central cell, smooth, brown (Sivanesan 1984).

Notes: *Pleomassaria* was introduced by Spegazzini (1880) and Barr (1982) characterized the genus with medium- to large-sized, immersed ascomata, cellular pseudoparaphyses, clavate to oblong asci and large, and muriform ascospores (Barr 1982; Sivanesan 1984). Barr (1982) included five north American species in the genus, while Tanaka et al. (2005) described *Pleomassaria maxima* Ellis & Everh., *P. swidae* Kaz. Tanaka et al. and *P. siparia* (Berk. & Broome) Sacc. from Japan.

Tanaka et al. (2005) proposed that some species originally included in *Splanchnonema*, such as *S. arbuti* M.E. Barr, *S. vaccinii* M.E. Barr (Barr 1993a), *S. noliae* A.W. Ramaley & M.E. Barr (Ramaley and Barr 1995), and *S. dasylirionis* A.W. Ramaley (Ramaley 1995) should be included in *Pleomassaria*. Currently 40 species epithets are given in Index Fungorum (2013). Recent phylogenetic studies show that *Pleomassaria siparia*, the type of *Pleomassaria*, forms a robust phylogenetic clade with *Melanomma pulvis-pyrius* (Schoch et al. 2009b; Zhang et al. 2009a). GenBank has seven hits for the genus including putative strains of *Pleomassaria siparia* (CBS 279.74). Confirmation of the taxonomic placement of these taxa requires fresh collections of the types of these genera for molecular analysis.

Type species: Pleomassaria siparia (Berk. & Broome) Sacc., Syll. fung. 2: 239 (1883), MycoBank: MB 238646
 = *Sphaeria siparia* Berk. & Broome, Ann. Mag. nat. Hist., Ser. 2 9: 321 (1852)

Other genera included

Lichenopyrenis Calat. et al., Mycol. Res. 105(5): 634 (2001).

Type species: Lichenopyrenis galligena Calat. et al., Mycol. Res. 105(5): 636 (2001)

Peridiothelia D. Hawksw., Bull. Br. Mus. nat. Hist., Bot. 14(2): 120 (1985).

Type species: Peridiothelia fuliguncta (Norman) D. Hawksw., Bull. Br. Mus. nat. Hist., Bot. 14(2): 121 (1985).

= *Microthelia fuliguncta* Norman, Öfvers. K. Svensk. Vetensk.-Akad. Förhandl. 41(no. 8): 36 (1884)

Splanchnonema Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 2: 115 (1829).

Type species: Splanchnonema pustulatum Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 2: 115 (1829).

Key to genera of Pleomassariaceae

1. Parasitic or saprobic on lichens2
1. Saprobian on dead wood or leaves3
2. Ascomata with non clypeate peridium*Peridiothelia*
2. Ascomata with clypeate peridium*Lichenopyrenis*
3. Asci with a short, narrowed, furcate pedicel
*Splanchnonema*
3. Asci with a short, thick pedicel*Pleomassaria*

Pleosporaceae Nitschke, Verh. naturh. Ver. preuss. Rheinl. 26: 74 (1869), MycoBank: MB 81188

Pathogens or saprobes on wood and dead herbaceous stems or leaves. Sexual state: *Ascomata* perithecial, initially immersed and becoming erumpent to nearly superficial, black, globose, subglobose or ovoid, sometimes hairy or setose, ostiolate. *Ostiole* papillate or apapillate, sometimes with a pore-like ostiole, ostiolar canal filled with or lacking periphyses. *Peridium* thin, usually thick at the sides, thinner at the base. *Hamathecium* of hyaline, septate, cellular pseudoparaphyses interspersed with asci. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical, with an ocular chamber. *Ascospores* uniseriate or biseriate, partially overlapping, phragmosporous or muriform, brown or pale brown, with or without mucilaginous sheath. *Asexual state*: coelomycetous or hyphomycetous, and the conidiogenous cells can be phialidic, annellidic or sympodial blastoc.

Notes: Nitschke (1869) introduced *Pleosporaceae* based on the immersed ascomata and presence of pseudoparaphyses, which was assigned to *Sphaeriales*. The family was transferred to *Pseudosphaeriaceae* and later raised to ordinal rank as the *Pseudosphaeriales* (Theissen and Sydow 1917). Luttrell (1955) assigned the *Pleosporaceae*, *Venturiaceae* and *Lophiostomataceae* under *Pleosporales*, while treating

Pseudosphaeriales as a synonym of the *Pleosporales*. Luttrell (1973) included eight families in *Pleosporales* including *Pleosporaceae*. Preliminary genera were added to this family based on ascospore characteristics, including shape, colour, septation, pigmentation and presence or absence of mucilaginous sheaths (Luttrell 1955, 1973; Wehmeyer 1961; Eriksson 1981; Sivanesan 1984; Barr 1987b; Abler 2003). Many of these characters were also found in other families, such as *Leptosphaeriaceae*, *Melanommataceae*, *Phaeosphaeriaceae* and *Sporormiaceae*. This led for confusion in the intergeneric and familial classification (Luttrell 1955, 1973; Wehmeyer 1961, 1975; von Arx and Müller 1975; Sivanesan 1984; Barr 1987a, b; Eriksson and Hawksworth 1986a, b, 1991). Multi-gene phylogenetic studies has shown that the familial placement of *Pleosporaceae* with respect to other families in order *Pleosporales* is valid (Lumbsch and Huhndorf 2010; Zhang et al. 2012a).

The asexual morphs of *Pleosporaceae* can be coelomycetous or hyphomycetous. Some of the genera in *Pleosporaceae* have been linked with their asexual morphs. The type species of the family *Pleospora* has linked to *Stemphylium*, which causes leaf disease (Sivanesan 1984). *Bipolaris* was shown to be the asexual morph of “*Cochliobolus*”, and cause plant disease or infect human beings (Khan et al. 2000). The nomenclatural conflict in this complex is resolved by giving priority to the more commonly used established generic name *Bipolaris* (Manamgoda et al. 2012). At the same time Manamgoda et al. (2012) showed that *Curvularia* group with “*Pseudocochliobolus*”. The type species of *Pleoseptum* (*P. yuccaesedum* A.W. Ramaley & M.E. Barr) has been linked with *Camarosporium yuccaesedum* Fairm. (Ramaley and Barr 1995) and *Pyrenophora* has the asexual morph *Drechslera* (Farr et al. 1989). *Alternaria*, *Bipolaris*, “*Phoma*”-like and *Stemphylium* are more common asexual morphs in *Pleosporaceae* and they can be saprobic or parasitic on various hosts. Currently 11 genera are accepted in *Pleosporaceae* based on morphological and molecular data (Zhang et al. 2012a). Molecular studies based on combine gene analysis showed that two putative strains of *Clathrospora elynae* (CBS 196.54) and *Clathrospora diplospora* (IMI 68086) clustered within *Pleosporaceae* (Schoch et al. 2009b; Zhang et al. 2011a). So we refer *Clathrospora* as a separate genus to *Pleosporaceae*

Type: Pleospora Rabenh. ex Ces. & De Not., Comm. Soc. crittog. Ital. 1(4): 217 (1863), MycoBank: MB 4233 Fig. 104
 Synonym:

Stemphylium Wallr., Fl. crypt. Germ. (Norimbergae) 2: 300 (1833)

Habitat terrestrial, saprobic or parasitic. Sexual state: *Ascomata* small to medium-sized, immersed, erumpent to superficial, base not easy to remove from the substrate, broadly to narrowly oblong and flattened, ostiolate. *Ostiole* papillate, black, smooth, ostiolar canal filled with hyaline cells. *Peridium* thin, usually with two layers, thick at the sides and

thinner at the base, outer layer heavily pigmented thick wall cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*, coriaceous. *Hamathecium* of cellular, hyaline, septate, broad, dense pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to clavate, with furcate pedicel and minute ocular chamber. *Ascospores* uniseriate or partially overlapping, mostly ellipsoidal, muriform, brown or pale brown, with or without sheath. Asexual state: *Stemphylium*. *Mycelium* immersed or nearly superficial, brown. *Stroma* sometimes present. *Conidiophores* macronematous, mononematous, scattered or caespitose, unbranched or rarely loosely branched, straight or flexuous, usually nodose with a number of vesicular swellings, pale to mid brown or olivaceous brown, smooth or in part verruculose. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent, at first clavate or

subsphaerical with the wall at the apex thin. *Conidia* solitary, dry, acrogenous, oblong, rounded at the ends, ellipsoidal, obclavate or subsphaerical, pale to mid dark or olivaceous brown, smooth, verrucose or echinulate, muriform, often constricted at one or more of the septa, cicatrized at the base. *Colonies* effuse, grey, brown, olivaceous brown or black, velvety or cottony (Ellis 1971).

Notes: *Pleospora* was originally described by Rabenhorst (1863) and is typified by *Pleospora herbarum* (Pers.) Rabenh. (Kirk et al. 2008). Initially the genus was included in *Sphaeriales* and later *Pseudosphaeriales* and *Pleosporales*, respectively (Wehmeyer 1961). All species belonging to *Pleospora* have muriform ascospores (Wehmeyer 1961, 1975). Pseudoparaphyses arrangement (downward growing) within the ascomata of “*Pleospora*-type” development (Luttrell 1951) is considered to be the main feature for the

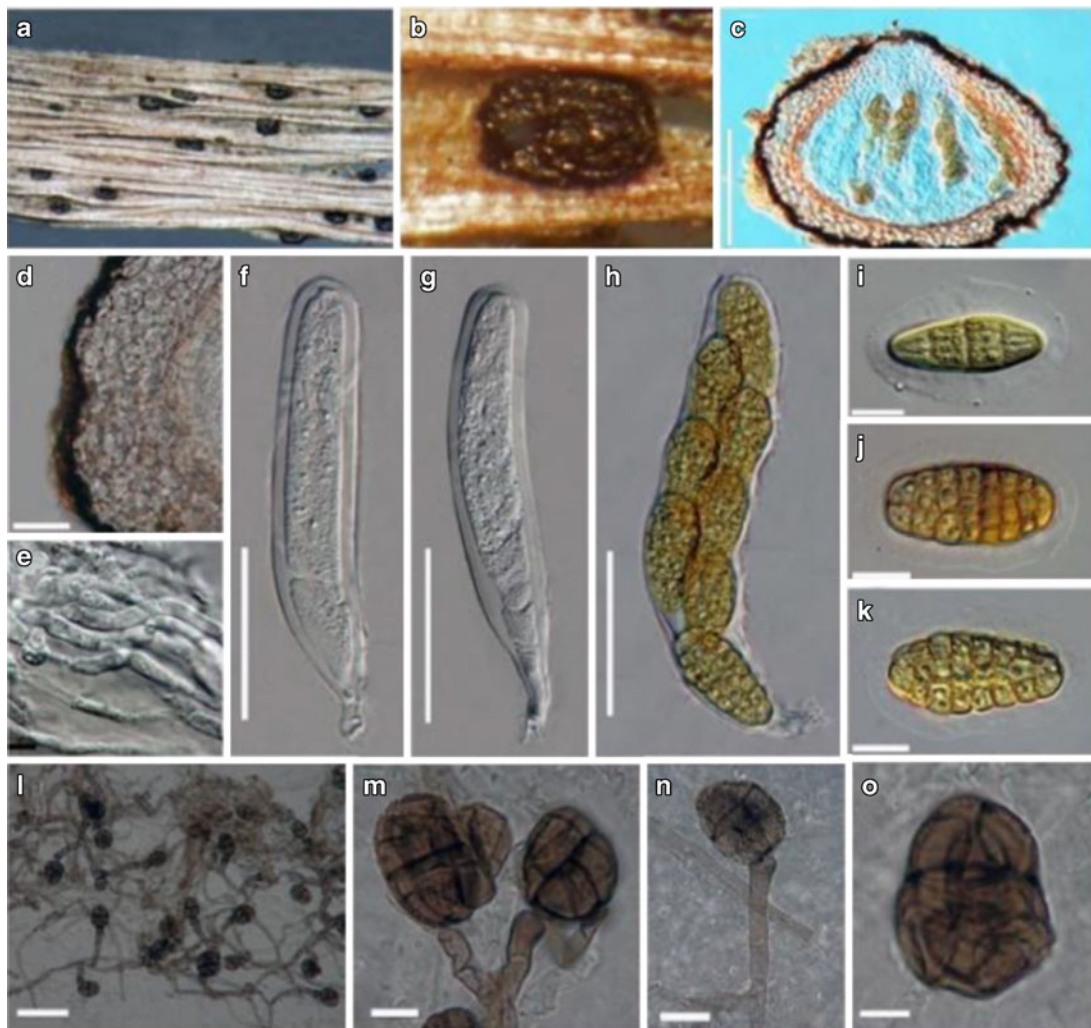


Fig. 104 *Pleospora herbarum* (Material examined: ITALY, Forli-Cesena, Montevescovo, on dead stem of *Brassica nigra*, 01 January 2012, C. Erio, MFLU 12–2216). **a** Ascomata on host substrate. **b** Close up of ascoma **c** Section of ascoma. **d** Close up of the peridium. **e** Cellular, hyaline, septate, broad pseudoparaphyses. **f–h** Asci with short, broad

pedicel bearing 8-spores **i–k** Mature and immature ascospores with mucilaginous sheath. *Stemphylium* Sp. **l–o** Conidiophores with pale to mid dark or olivaceous brown, smooth conidia Scale bars: **c**=100 μ m, **d**=50 μ m, **e**=20 μ m, **f–g**=60 μ m, **i–k**=10 μ m, **l–o**=10 μ m

genus. Various authors had included and excluded different species in *Pleospora* at various times. Barr (1981) placed *Curreya* in *Pleospora* however, von Arx and van der Aa (1983) treated it as separate genus, because of its *Coniothyrium* asexual morph. Petrak (1952) transferred *Graphyllum* to *Pleospora*, and noted that the elongate ascomata and closely grouped rows of small ascomata are not sufficient to recognize the genus. Barr (1987b, 1990b) supported this proposal. Due to the heterogenous nature of *Pleospora* several subgenera have been included. i.e. *Teichosporoides* contains species of *Pleospora* with immersed ascomata, and *Pleosphaeria* with superficial and setose ascomata (Wehmeyer 1961). *Pleospora* species have a wide host range, especially on monocotyledons as well as dicotyledonous plants (Wehmeyer 1975). They can be saprobic or parasitic, for example *Stemphylium botryosum* Wallr., the asexual morph of *Pleospora herbarum*, which causes leaf disease of olive trees (Malathrakis 1979; Zhang et al. 2012a).

There are numerous species of Dothideomycetes that have muriform ascospores and have at one time or another been placed in *Pleospora* (Wehmeyer 1961). *Pleospora* is however, rather distinctive and should be confined to species with characters that are similar to *Pleospora herbarum*. The ascomata in *P. herbarum* are immersed and usually become erumpent, the peridium is unusual in having three strata, a thin inner layer of thin-walled, hyaline to light brown flattened cells, a relatively wide central layer of thin-walled, hyaline to light brown angular cells, and an outer very thin black amorphous cells, which gives the blackened colour to the ascomata. The asci are broadly clavate and have a distinctive, squarish, wide, ocular chamber and ascospores are muriform with at least three longitudinal septa per transverse row, and surrounded by a mucilaginous sheath. The asexual state is *Stemphylium*. For this reason several *Pleospora*-like species are now transferred to other genera (e.g. *Curreya*).

Type species: Pleospora herbarum (Pers.) Rabenh., Klotzschii Herb. Viv. Mycol. 2: no. 547 (1854). MycoBank: MB 208023

≡ *Sphaeria herbarum* Pers., Syn. meth. fung. (Göttingen) 1: 78 (1801)

Other genera included

Alternaria Nees, Syst. Pilze (Würzburg): 72 (1816) [1816–17]

Type species: Alternaria tenuis Nees, Syst. Pilze (Würzburg): 72 (1816) [1816–17]

Alternariaster E.G. Simmons, CBS Diversity Ser. (Utrecht) 6: 667 (2007)

Type species: Alternariaster helianthi (Hansf.) E.G. Simmons, CBS Diversity Ser. (Utrecht) 6: 667 (2007)

Bipolaris Shoemaker, Can. J. Bot. 37(5): 882 (1959)

Synonym:

Cochliobolus Drechsler, Phytopathology 24: 973 (1934) (See Wijayawardene et al. in prep)

Type species: Bipolaris maydis (Y. Nisik. & C. Miyake) Shoemaker 1959

Brachycladium Corda, Icon. fung. (Prague) 2: 14 (1838)

Type species: Brachycladium penicillatum Corda, Icon. fung. (Prague) 2: 14 (1838)

Chalastospora E.G. Simmons, CBS Diversity Ser. (Utrecht) 6: 668 (2007)

Type species: Chalastospora cetera (E.G. Simmons) E.G. Simmons, CBS Diversity Ser. (Utrecht) 6: 668 (2007)

Clathrospora Rabenh., Hedwigia 1(18): 116 (1857)

Type species: Clathrospora elyanae Rabenh., Hedwigia 1: 116 (1857)

Curvularia Boedijn, Bull. Jard. bot. Buitenz, 3 Sér. 13(1): 123 (1933)

Type species: Curvularia lunata (Wakker) Boedijn, Bull. Jard. bot. Buitenz, 3 Sér. 13(1): 127 (1933)

Decorospora Inderb. et al., in Inderbitzin et al., Mycol. Progr. 1(4): 657 (2002). MycoBank: MB 28671

Type species: Decorospora gaudefroyi (Pat.) Inderb. et al., in Inderbitzin et al., Mycol. Progr. 94(4): 657 (2002).

Dendryphion Wallr., Fl. crypt. Germ. (Norimbergae) 2: 300 (1833)

Type species: Dendryphion comosum Wallr., Fl. crypt. Germ. (Norimbergae) 2: 300 (1833)

Edenia M.C. González et al., in González et al., Mycotaxon 101: 254 (2007)

Type species: Edenia gomezpompae M.C. González et al., in González et al., Mycotaxon 101: 254 (2007)

Embellisia E.G. Simmons, Mycologia 63(2): 380 (1971)

Type species: Embellisia alli (Campan.) E.G. Simmons, Mycologia 63(2): 382 (1971)

Exserohilum K.J. Leonard & Suggs, Mycologia 66(2): 289 (1974)

Type species: Exserohilum turcicum (Pass.) K.J. Leonard & Suggs, Mycologia 66(2): 291 (1974)

Extrawettsteinina M.E. Barr, Contr. Univ. Mich. Herb. 9(8): 538 (1972)

Type species: Extrawettsteinina minuta M.E. Barr, Contr. Univ. Mich. Herb. 9(8): 538 (1972)

Macrospora Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 139 (1870) [1869–70]

Type species: Macrospora scirpicola (DC.) Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 139 (1870) [1869–70]

Mariellottia Shoemaker, Can. J. Bot. 76(9): 1559 (1999) [1998]

Type species: Mariellottia biseptata (Sacc. & Roum.) Shoemaker, Can. J. Bot. 76(9): 1560 (1999) [1998]

Platysporoides (Wehm.) Shoemaker & C.E. Babc., Can. J. Bot. 70(8): 1648 (1992)



Fig. 105 *Pyrenophora phaeocomes* (Material examined: SWEDEN, on leaves of *Anthoxanthum*, 7 August 1951, J. A. Nannfeldt (UPS:170980, **neotype**). **a–b** Ascomata on host substrate. **c** Close up of ascoma. **d** Side view of ascomata covered with setae. **e–f** Section of ascomata. **h** Ostiole,

centrally covered with setae. **g** Close up of the peridium. **j** Light brown seta. **k–m** Asci with short, broad pedicel. **n–q** Mature and immature muriform ascospores. Scale bars: **e–f** = 200 μm , **g** = 30 μm , **h** = 80 μm , **j** = 50 μm , **k–m** = 50 μm , **n–q** = 15 μm

Type species: Platysporoides chartarum (Fuckel) Shoemaker & C.E. Babco., Can. J. Bot. 70(8): 1650 (1992). MycoBank: MB 308273

Pseudoyuconia Lar.N. Vassiljeva, Nov. sist. Niz. Rast. 20: 71 (1983). MycoBank: 25842

Type species: Pseudoyuconia thalictri (G. Winter) Lar.N. Vassiljeva [as 'thalicti'], Nov. sist. Niz. Rast. 20: 71 (1983)

Pyrenophora Fr., Summa veg. Scand., Section Post. (Stockholm): 397 (1849). MycoBank: MB 4596 Fig. 105

Synonym:

Drechslera S. Ito, Proc. Imp. Acad. Japan 6: 355 (1930) (See Wijayawardene et al. in prep)

Habit on leaves and wood. Sexual state: *Ascomata*, solitary or scattered, initially immersed, becoming erumpent to near superficial, globose to subglobose, broadly or narrowly conical, coriaceous, ostiolate. *Ostiole* usually widely porate, broadly papillate, ostiolar canal filled with a tissue of hyaline cells and central and covered with setae. *Setae* brown to reddish brown, darkened at the base, septate and tapered towards the apex. *Peridium* comprising

2–4 layers of thick-walled, heavily pigmented, small cells, of *textura angularis*. *Pseudoparaphyses* not observed. *Asci* 8-spored, bitunicate, fissitunicate, clavate to sub-cylindrical, with a short, broad pedicel, thickened and rounded at apex, with a distinct ocular chamber. *Ascospores* uniseriate or distichously arranged, partially overlapping, ellipsoidal with broadly rounded ends, multi-septate, muriform, constricted at the septum, smooth, thick-walled, without a sheath, hyaline to light brown when immature becoming brown to chestnut brown when mature. Asexual state: *Mycelium* mostly immersed. *Stroma* present in some species. Sclerotia or protothecia often formed in culture. Setae and hyphopodia absent. *Conidiophores* macronematous, mononematous, sometimes caespitose, straight or flexuous, often geniculate, unbranched or in a few species loosely branched, brown, smooth in most species. *Conidiogenous cells* polytretic, integrated, terminal, frequently becoming intercalary, sympodial, cylindrical, cicatrized. *Conidia* solitary, in certain species also sometimes catenate or forming secondary conidiophores which bear conidia, acropleurogenous, simple, straight or curved, clavate, cylindrical rounded at the ends, ellipsoidal, fusiform or obclavate, straw-coloured or pale to dark brown or olivaceous brown, sometimes with cells unequally coloured, the end cells then being paler than intermediate ones, mostly smooth, rarely verruculose, pseudoseptate. *Colonies* effuse, grey, brown or blackish brown, often hairy, sometimes velvety (Ellis 1971).

Notes: Based on both morphology and molecular phylogeny, *Pyrenophora* has been assigned to *Pleosporaceae* (Zhang et al. 2012a). The genus is characterized by immersed, erumpent to nearly superficial ascomata, asci usually with a large apical ring with a clear ocular chamber, muriform, terete ascospores and lack of pseudoparaphyses (Sivanesan 1984). Currently 199 species of *Pyrenophora* are listed in Index Fungorum (2013). Over 3,000 hits are found in GenBank including the putative strain of *Pyrenophora phaeocomes* (Rebent.) Fr. (DAOM 222769), which is the type species for this genus.

Type species: *Pyrenophora phaeocomes* (Rebent.) Fr., Summa veg. Scand., Section Post. (Stockholm): 397 (1849). MycoBank: MB 222199

≡ *Sphaeria phaeocomes* Rebent., Prodr. fl. neomarch. (Berolini): 338 (1804)

Setosphaeria K.J. Leonard & Suggs, Mycologia 66(2): 294 (1974). MycoBank: 5014

Type species: *Setosphaeria turcica* (Luttr.) K.J. Leonard & Suggs, Mycologia 66(2): 295 (1974).

Sinomyces Yong Wang bis & X.G. Zhang, Fungal Biology 115(2): 192 (2009)

Type species: *Sinomyces fusoides* Yong Wang bis & X.G. Zhang, Fungal Biology 115(2): 192 (2009)

Teretispora E.G. Simmons, CBS Diversity Ser. (Utrecht) 6: 674 (2007)

Type species: *Teretispora leucanthemi* (Nelen) E.G. Simmons, CBS Diversity Ser. (Utrecht) 6: 674 (2007)

Ulocladium Preuss, Linnaea 24: 111 (1851)

Type species: *Ulocladium botrytis* Preuss, Linnaea 24: 111 (1851)

Key to genera of *Pleosporaceae*

1. Perithecial wall with setae2
1. Perithecial wall without setae3
2. Hamathecium without pseudoparaphyses*Pyrenophora*
2. Hamathecium dense with pseudoparaphyses*Setosphaeria*
3. Ascomata superficial on host*Extrawettsteinina*
3. Ascomata initially immersed, becoming erumpent to near superficial on host, globose to subglobose4
4. Hamathecium with cellular pseudoparaphyses5
4. Hamathecium with filiform pseudoparaphyses*Pseudoyuconia*
5. Ascospores only with vertical septa*Crivellia*
5. Ascospores with both longitudinal and vertical septa6
6. Asci with ellipsoid to fusoid ascospores7
6. Asci with applanate, broadly fusoid to slightly clavate ascospores10
7. Ascospores without a sheath*Lewia*
7. Ascospores with a sheath8
8. Ascospores enclosed in a sheath with 4–5 apical extensions*Decorospora*
8. Ascospores enclosed in a sheath without apical extensions9
9. Ascomata with short and blunt ostiole*Platysporoides*
9. Ascomata with broadly to narrowly oblong and flattened, ostiole*Pleospora*
10. Ascomata opening with an intraepidermal discoid lid*Clathrospora*
10. Ascomata opening without an intraepidermal discoid lid*Macrospora*

Polystomellaceae Theiss. & P. Syd., Ann Mycol. 13: 158 (1915), MycoBank: MB 81205

Possible synonym:

Munkiellaceae (Theiss. & Syd.) Luttr., in Ainsworth et al., The fungi (London) 4a: 154 (1973)

Biotrophic or ***parasitic*** on leaves, confined to tropical zones. Sexual state: *Ascostromata* black, immersed or well-developed, erumpent, pulvinate, and circular to suborbicular, elliptical or elongate, rugulose, comprising mostly fungal tissue, globose to subglobose, uniloculate or multi-loculate (with 5– numerous locules), with individual central ostioles. *Cells of ascostromata* dark brown-walled *textura angularis*. *Peridium* of locules composed of small heavily pigmented thick-walled cells of *textura angularis*. *Hamathecium* of numerous, hyaline, septate or non-septate, cellular pseudoparaphyses without branching, often deliquescent at maturity. *Asci* 8-spored, bitunicate, fissitunicate, oblong,

cylindro-clavate or occasionally obclavate, often ventricose, with a short pedicel, apically rounded, with a small ocular chamber. *Ascospores* uni- to bi-seriate, hyaline, yellowish to olive brown, fusiform to ellipsoidal or obpyriform, one to two celled, upper cell wider and shorter than the lower cell, euseptate, septate near the lower end or middle, with or without constrictions at the septum, lacking a sheath. Asexual state: coelomycetous, acervular, linked to *Lasmenia* and *Stictochorella* (Wakefield 1940; Swart 1987; Kirk et al. 2008).

Notes: This family was introduced by Theissen and Sydow (1915) for *Munkiella*, *Parmularia* and *Polystomella* (the type species). However, other names used for this family include *Stigmataceae* (Theissen 1916), and *Munkiellaceae* (Luttrell 1973). The *Polystomellaceae* include taxa with superficial ascomata, while in the *Munkiellaceae* ascomata are subcuticular, but the two families were combined by Eriksson (1981). Barr (1987a) accepted *Polystomellaceae* as a family in the *Pleosporales* with the genera *Atopospora*, *Hormotheca* (currently referred to the *Venturiaceae*) and *Ellisiodothis* (currently referred to the *Microthyriaceae*). Lumbsch and Huhndorf (2010) included three genera *Dothidella* (= *Polystomella*), *Munkiella* and *Parastigmatea* in the *Polystomellaceae* under Dothideomycetes, family *incertae sedis*, and this followed by Index Fungorum (2013) and MycoBank (2013). They share similar characters such as a stromatic ascomata resulting from ascolocular ontogeny, with uni- to multi-ocular ascostromata, and hyaline ascospores, with one or two cells. von Arx and Muller (1954) placed *Parastigmatea* under *Botryosphaeriaceae*, while in a recent review of the family, Liu et al. (2012a) did not include the genus in this family. The three genera placed in *Polystomellaceae* were described before 1965 (Index Fungorum 2013) and no molecular sequence data is available; thus fresh collections are needed to established the phylogenetic relationships of the genera and family *Polystomellaceae*. *Munkiella* and *Parastigmatea* are presently listed in *Polystomellaceae*, but their inclusion is tentative for the purpose of keying out the genera.

Type: *Dothidella* Speg., Anal. Soc. Cient. Argent. 9: 9 (1880), MycoBank: MB 1695

Figure 106

Possible synonyms:

Pluriporus F. Stevens & R.W. Ryan, in Stevens, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 65 (1925)

Polystomella Speg., Anal. Soc. cient. argent. 26(1): 53 (1888)

Biotrophic or *parasitic* on leaves, confined to tropical areas. Sexual state: *Ascostromata* black, well-developed, erumpent, pulvinate, and circular to suborbicular, elliptical or elongate, rugulose, comprising mostly fungal

tissue, globose to subglobose, with five to numerous locules, with individual central ostioles, cells of ascostromata dark brown-walled *textura angularis*. *Peridium* of locules composed of small heavily pigmented thick-walled cells of *textura angularis*. *Hamathecium* of numerous, hyaline, septate or non-septate pseudoparaphyses without branching. *Asci* 8-spored, bitunicate, fissitunicate, oblong, cylindro-clavate or occasionally obclavate, often ventricose, with a short pedicel, apically rounded, with a small ocular chamber. *Ascospores* biserial, hyaline, septate, ellipsoidal or obpyriform, 1-septate, upper cell wider and shorter than the lower cell, euseptate, with a constricted at the septum, lacking a sheath. Asexual state: linked linked to *Stictochorella* (Wakefield 1940; Swart 1987).

Notes: *Dothidella* was introduced by Spegazzini (1880) with *D. australis* as the type species. Many species of *Dothidella* were transferred to *Endodothella*, *Microcyclus*, *Phyllachora*, *Rehmiodothis* and *Stigmochora* which belong to *Mycosphaerellaceae* and *Phyllachoraceae* (Index Fungorum 2013). They share similar characters such as being *biotrophic* or *parasitic* on leaves, and 1–2-celled hyaline ascospores. However, *Dothidella* differs from other genera by its multi-loculate ascostromata and ellipsoidal hyaline two celled ascospores, while *Phyllachora* (*Phyllachoraceae*) has unilocular ascostromata, unitunicate asci and one celled, hyaline ascospores, and *Microcyclus* (*Mycosphaerellaceae*) has multi-loculate ascostromata with two celled hyaline obovoid ascospores (Liu et al. 2012a, b; Monkai et al. 2013).

Type species: *Dothidella australis* Speg., Anal. Soc. Cient. Argent. 10: 21 (1880), MycoBank: MB 233978

Other genera included

Dermatodothella Viégas, Bragantia 4(1–6): 150 (1944)

Type species: *Dermatodothella multiseptata* Viégas, Bragantia 4(1–6): 150 (1944)

Munkiella Speg., Anal. Soc. Cient. Argent. 19(6): 248 (1885)

Type species: *Munkiella caa-guazu* Speg., Anal. Soc. cient. argent. 19: 248 (1885)

Parastigmatea Doidge, Bothalia 1(1): 22 (1921)

Type species: *Parastigmatea nervisita* Doidge, Bothalia 1(1): 22 (1921)

Key to genera of *Polystomellaceae*

1. Ascospores 2-celled2
1. Ascospores non 2-celled3
2. Ascospores septate near the middle*Dothidella*
2. Ascospores septate near the lower end*Munkiella*
3. Ascospores 1-celled*Parastigmatea*
3. Ascospores with small apical cells or 5–7-septate when mature*Dermatodothella*

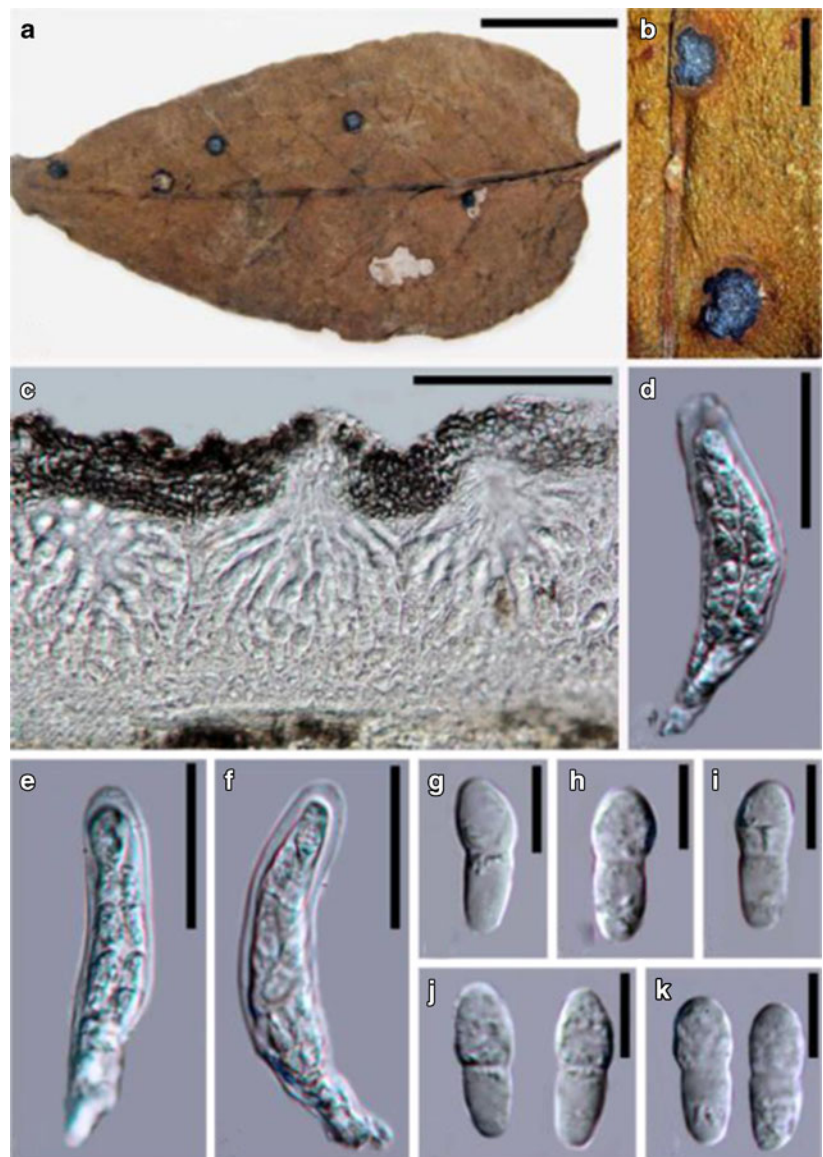
Protoscyphaceae Kutorga & D. Hawksw., Syst. Ascom. 15(1–2): 70 (1997), MycoBank: MB 81924

Parasitic on living leaves of *Miconia thomasiana*. Sexual state: *Ascstromata* superficial, solitary, scattered, occurring on the lower leaf surface, discoid or cup-shaped, slightly convex or raised pulvinate, semi-immersed, flattened and thickened at the base, occurring in lesions of light brown regions and surrounded by external black mycelial areas up to 2–3 mm diam., multi-locular, opening by rupturing or cracking of the apical ascostromata. *Peridium* thick, composed of dark cells arranged in a *textura angularis*. *Hamathecium* comprising hyaline, relatively wide, anastomosing, septate pseudoparaphyses, often with swollen cells, intermixed with reddish brown colouration, and surrounded by a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, subglobose-oblong, broadly cylindrical to subclavate, somewhat thickened

at the apex, short pedicellate, with a wide, but short ocular chamber. *Ascospores* 2–3-seriate in the ascus, muriform, oblong to oval-sub ellipsoid, 3–7 trans-septate, with 1 longitudinal septa in each transverse row, highly constricted at the septum, hyaline, pale brown or light brown, surrounded by a thin gelatinous sheath. Asexual state: Unknown.

Notes: The family *Protoscyphaceae* was introduced by Kutorga and Hawksworth (1997) for a fungal pathogen on living leaves, with discoid ascostromata similar to taxa in the *Cookellaceae*, *Elsinoaceae* and *Myriangiaceae* (von Arx and Müller 1975; Kutorga and Hawksworth 1997). The symptoms are most conspicuous on the leaf, with light brown and black areas, and roundish lesions up to 1 mm diam. The representative genus of this monotypic family is *Protoscypha* (Sydow 1925). Ascostromata are typically darkened, containing a single row of monoascus locules, asci are bitunicate, broadly

Fig. 106 *Dothidella australis*
[Material examined:
ARGENTINA, Buenos Aires,
Tigre; on the leaves of *Solanum*
boerhaviaefolium, O. Schnyder,
April 1880 (LPS 318, **holotype**)].
a, b Stromata on leaves. **c**
Section through stroma. **d–f**
Asci. **g–k** Ascospores. Scale
Bars: **a** = 1 cm, **b** = 2 mm,
c = 100 μ m, **d–f** = 30 μ m,
g–k = 10 μ m



cylindrical to subclavate and thick-walled and ascospores are muriform, oblong to oval-subellipsoid, septate, hyaline to light brown, and covered by a thin gel. Kutorga and Hawksworth (1997) excluded *Protoscypha* from *Patellariaceae* and *Arthoniaceae* because of its distinctive morphology and referred to the *Dothideales incertae sedis*. There are no molecular data that confirm this relationship, however, Kirk et al. (2008), and Lumbsch and Huhndorf (2010) refer the genus to *Dothideomycetes incertae sedis*.

Type: Protoscypha Syd., *Annls mycol.* 23(3/6): 402 (1925), MycoBank: MB 4394

Figure 107

Possible synonym:

Pittierodothis Chardón, *Boln Soc. Venez. Cienc. Nat.* 5(no. 40): 346 ('246') (1939)

Notes: *Protoscypha* was introduced by Sydow (1925) based on the type species *Protoscypha pulla*. The genus comprises two tropical species (*P. pulla* Syd. and *P. subtropicum* (G. Winter) Petr.), and both are unusual as discussed above (Sydow 1925; Kutorga and Hawksworth 1997). Features of these two species are discoid or cup-like ascostromata, arranged as a single locule of oblong-subclavate asci, each locule separated by filamentous pseudoparaphyses.

Type species: Protoscypha pulla Syd., *Annls mycol.* 23(3/6): 403 (1925), MycoBank: MB 275651

Pseudoperisporiaceae Toro, in Seaver & Palacios Chardon, *Scient. Surv. P. Rico* 8(1): 0 (1926), MycoBank: MB 81227

Possible synonym:

Epipolaeaceae Theiss. & P. Syd., *Annls mycol.* 16(1/2): 7 (1918)

Parasitic or *saprobic* on leaves, or other fungi, primarily in tropical regions. Sexual state: *Ascomata* superficial, solitary to gregarious, scattered, globose to subglobose, collapsed when dry, surrounded by brown mycelium at the base, central ostiole with 14–20 μm diam (on mounted slide) and surrounded by brown septate, setae, tapering to subacute apex. *Peridium* composed of *textura angularis*, brown to red brown, thin-walled, collapsed when dry. *Hamathecium* of cylindrical, filiform, hyaline, branched, septate pseudoparaphyses, in a gelatinous matrix. *Asci* bitunicate, fissitunicate, 8-spored, oblong-clavate, slightly curved, thickened at the apex, sessile, or with knob-like pedicel, with small ocular chamber. *Ascospores* biseriate, fusoid-ellipsoid, rounded and subacute ends, 1-septate, slightly constricted at the septum, hyaline, becoming brownish at maturity, wall minutely verrucose. Asexual state: coelomycetous *Chaetosticta*.

Notes: The family *Pseudoperisporiaceae* was introduced by Toro in Seaver and Chardón (1926) for mycoparasitic genera with superficial ascomata, mostly surrounded by external mycelium, with or without setae, darkly pigmented, asci and with variously-shaped ascospores, with the genus *Pseudoperisporium* as type and based on *Dimeriella erigeronicola* F. Stevens

(Seaver and Chardón 1926). *Pseudoperisporium erigeronicola* is synonym of *Lasiostemma melioloides* (Berk. & Ravenel) Theiss. et al., the latter the type species of *Lasiostemma*, the earlier generic name. Finally, the genus *Pseudoperisporium* was replaced by *Lasiostemma* as the correct name (Barr 1987a, 1997). Therefore, *Lasiostemma* is the type of the *Pseudoperisporiaceae*. The asexual state is *Chaetosticta* (coelomycetes), which is related with *Lasiostemma* and *Nematostoma* (Kirk et al. 2008; Hyde et al. 2011). Lumbsch and Huhndorf (2010) list 22 genera in *Pseudoperisporiaceae* in *Dothideomycetes incertae sedis*. However, molecular studies are required to elucidate the phylogenetic relationships of various genera in the family which has generally been treated as a dustbin for hard to place genera. Molecular data is available for the genera *Brychiton* and *Lizonia* (Stenroos et al. 2010).

Type: Lasiostemma Theiss et al., in Sydow & Sydow, *Annls mycol.* 15(3/4): 218 (1917), MycoBank: MB2660 Fig. 108

Saprobic on leaves of plants, or parasitic on sooty moulds, primarily in tropical regions. Sexual state: *Ascomata* superficial, solitary to gregarious, scattered, globose to subglobose, surrounded by brown mycelium at the base, collapsing when dry, ostiole central and surrounded by brown, septate setae, tapering toward the subacute apex. *Peridium* composed of reddish brown cells of *textura angula* to *subglobose*. *Hamathecium* of wide, hyaline, branched, septate, pseudoparaphyses, often deliquescing, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, oblong-clavate, slightly curved, sessile or with knob-like pedicel, thickened at the apex with a small ocular chamber. *Ascospores* biseriate, fusoid-ellipsoid, rounded and subacute at the ends, hyaline, becoming brownish at maturity, 1-septate, slightly constricted at the septum, minute verrucose. Asexual state: coelomycetous, *Chaetosticta*.

Notes: The genus *Lasiostemma* was accepted by Barr (1997) with the type species *L. melioloides* (Berk. & M.A. Curtis) Theiss. & Syd. and is characterized by superficial, spherical ascomata, with numerous mycelium at the base, a central ostiole surrounded by setae (Farr 1979). Seventeen *Lasiostemma* species are listed in *Index Fungorum* (2013), while two species *L. fimbriatum* (Dearn. & House) M.E. Barr and *L. irradians* (Pat.) M.L. Farr were transferred to the genera *Wentomyces* and *Epipolaeum*, respectively (Barr 1968; Theissen and Sydow 1918). The asexual state was reported as *Chaetosticta* (Crane 1971; Hyde et al. 2011).

Type species: Lasiostemma melioloides (Berk. & Ravenel) Theiss., Syd. & P. Syd., in Sydow & Sydow, *Annls mycol.* 15(3/4): 218 (1917), MycoBank: MB 102249

\equiv *Dimeriella melioloides* Berk. & Ravenel.

Other genera included

Aphanostigme Syd., *Annls mycol.* 24(5/6): 368 (1926)

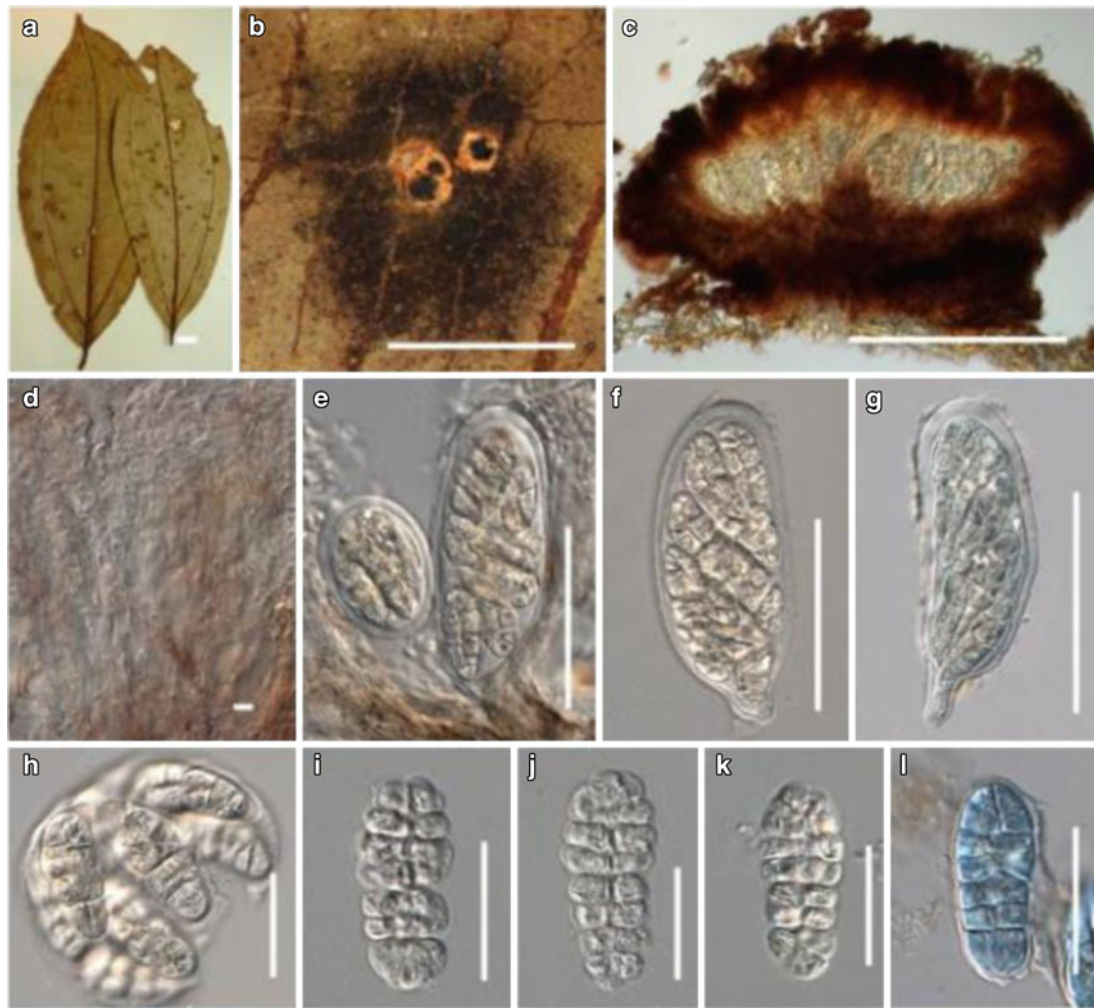


Fig. 107 *Protoscypha pulla* (Material examined: COSTA RICA, Los Angeles de San Ramon, on leaves of *Miconia thomasiana*, H. Sydow, 30 January 1925, BPI663043, **type**). **a** Herbarium specimen. **b** Ascostromata on host. **c** Section of ascostroma. **d** Pseudoparaphyses. **e–h** Asci. Note the

rather thick walls and papillate pedicels. **i–l** Highly constricted muriform ascospores with 5–6 transverse septa and a single longitudinal septum in each transverse row. **g** and **l** stained in lactophenol cotton blue. Scale bars: **a–b**=2 mm, **c**=200 μ m, **d–g**=50 μ m, **h–l**=20 μ m

Type species: Aphanostigme solani Syd., Anns mycol. 24(5/6): 368 (1926)

Bryochiton Döbbeler & Poelt, in Döbbeler, Mitt. bot. StSamml., Münch. 14: 208 (1978)

Type species: Bryochiton monascus Döbbeler & Poelt, Mitt. bot. StSamml., Münch. 14: 218 (1978)

Bryomyces Döbbeler, Mitt. bot. StSamml., Münch. 14: 233 (1978)

Type species: Bryomyces scapaniae Döbbeler, Mitt. bot. StSamml., Münch. 14: 254 (1978)

Epibryon Döbbeler, Mitt. bot. StSamml., Münch. 14: 260 (1978)

Type species: Epibryon plagiophilae (Gonz. Frag.) Döbbeler, Mitt. bot. StSamml., Münch. 14: 293 (1978)

Episphaerella Petr., Anns mycol. 22(1/2): 126 (1924)

Type species: Episphaerella manihotis (Henn.) Petr., Anns mycol. 22(1/2): 126 (1924)

Eudimeriolium Speg., Anal. Mus. nac. Hist. nat. B. Aires 23: 36 (1912)

Type species: Eudimeriolium elegans Speg., Anal. Mus. nac. Hist. nat. B. Aires 23: 36 (1912)

Eumela Syd., Anns mycol. 23(3/6): 335 (1925)

Type species: Eumela chiococcae Syd., Anns mycol. 23(3/6): 335 (1925)

Keratosphaera H.B.P. Upadhyay, Publções Inst. Micol. Recife 402: 5 (1964)

Type species: Keratosphaera batistae H.B.P. Upadhyay, Publções Inst. Micol. Recife 402: 6 (1964)

Lasiostemma Theiss. et al., in Sydow & Sydow, Anns mycol. 15(3/4): 218 (1917)

Type species: Lasiostemma melioloides (Berk. & Ravenel) Theiss. et al., in Sydow & Sydow, Anns mycol. 15(3/4): 218 (1917)

Lizonia (Ces. & De Not.) De Not., Sfer. Ital.: 72 (1863)

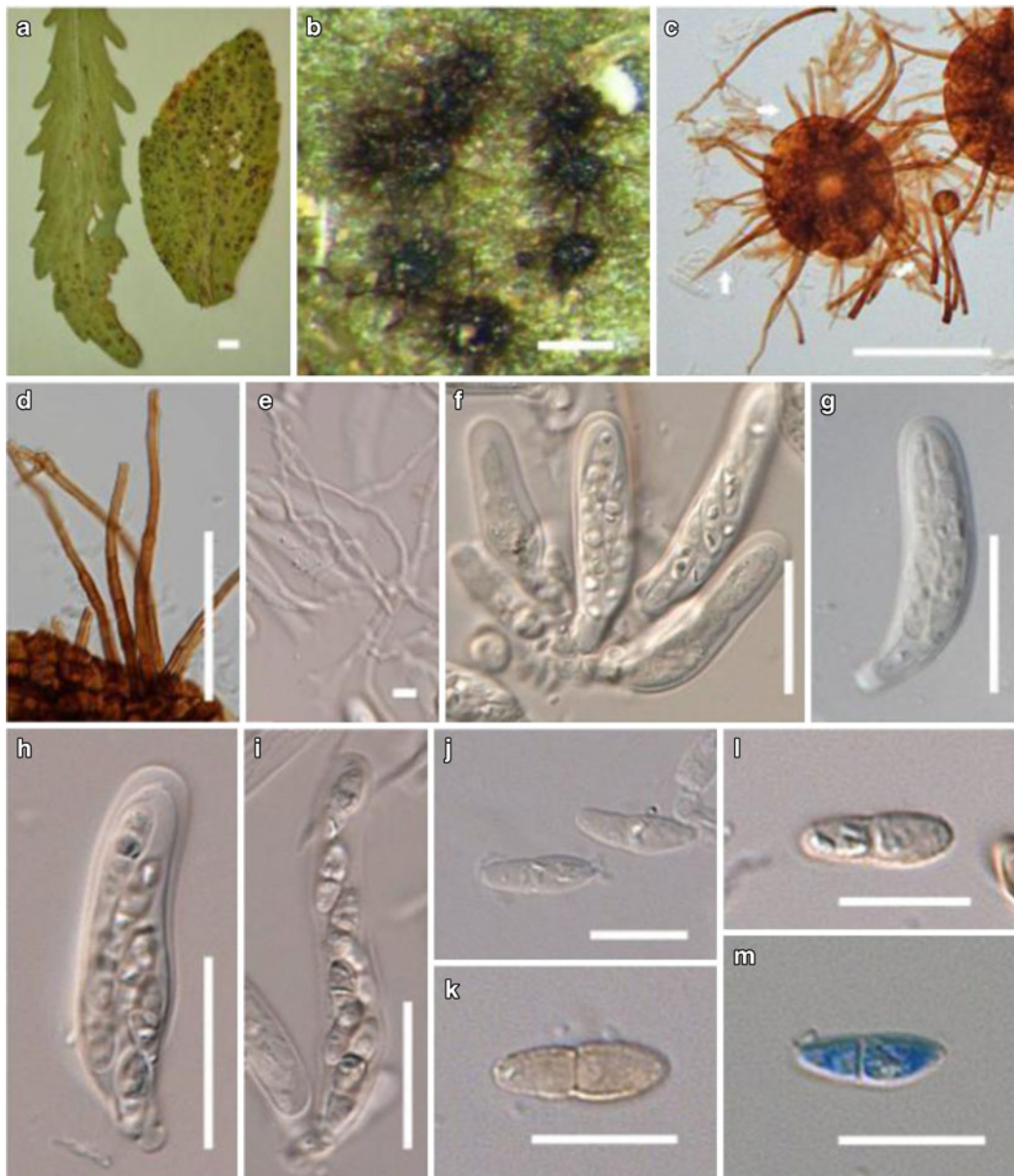


Fig. 108 *LasioSTEMMA melioloides* (Material examined: VENEZUELA, Federal district, Puerto La Cruz Valley, El Limón, on leaves of *Erigeron bonariensis*, H. Sydow, Fungi venezuelani No. 249), 16 January 1928, BPI699548). **a** Herbarium specimen. **b** Ascomata on leaf surface. **c** Squash mount of ascoma showing peridium;

light coloured ostiole surrounded by setae (arrowed). **d** Setae. **e** Pseudoparaphyses. **f–i** Immature and mature asci with small ocular chamber (fissitunicate ascus in **i**). **j–m** Ascospores (strained in lactophenol cotton blue reagent in **m**). Scale bars: **a**=5 mm, **b–c**=100 μ m, **d**=50 μ m, **f–i**=20 μ m, **j–m**=10 μ m

Type species: Lizonia empirigonia (Auersw.) De Not., Sfer. Ital.: 72 (1863)

Myxophora Döbbeler & Poelt, Mitt. bot. StSamml., Münch. 14: 315 (1978)

Type species: Myxophora amerospora Döbbeler & Poelt, Mitt. bot. StSamml., Münch. 14: 315 (1978)

Nematostigma Syd. & P. Syd., Anns mycol. 11(3): 262 (1913)

Type species: Nematostigma obducens Syd. & P. Syd., Anns mycol. 11(3): 262 (1913)

Nematostoma Syd. & P. Syd., Anns mycol. 12(2): 161 (1914)

Type species: Nematostoma artemisiae Syd. & P. Syd., Anns mycol. 12(2): 161 (1914)

Nematothecium Syd. & P. Syd., Leafl. of Philipp. Bot. 5: 1534 (1912)

Type species: Nematothecium vinosum Syd. & P. Syd.,
Leafl. of Philipp. Bot. 5(76): 1534 (1912)

Neocoleroa Petr., Hedwigia 74:38 (1934)

Type species: Neocoleroa sibirica Petr., Hedwigia 74: 38
(1934)

Ophiociliomyces Bat. & I.H. Lima, Anais Soc. Biol.
Pernambuco 13(2): 29 (1955)

Type species: Ophiociliomyces bauhiniae Bat. &
I.H. Lima, Anais Soc. Biol. Pernambuco 13(2): 30 (1955)

Phaeodimeriella Speg., Revta Mus. La Plata 15(2): 13
(1908)

Type species: Phaeodimeriella occulta (Racib.) Speg.,
Revta Mus. La Plata 15(2): 13 (1908)

Phaeostigme Syd. & P. Syd., Anns mycol. 15(3/4): 199
(1917)

Type species: Phaeostigme picea (Berk. & M.A. Curtis)
Syd. & P. Syd., Anns mycol. 15(3/4): 200 (1917)

Phragmeriella Hansf., Mycol. Pap. 15: 89 (1946)

Type species: Phragmeriella ireninae Hansf., Mycol. Pap.
15: 89 (1946)

Pododimeria E. Müll., Sydowia 12(1–6): 193 (1959) [1958]

Type species: Pododimeria gallica E. Müll., Sydowia
12(1–6): 195 (1959) [1958]

Raciborskiomyces Siemaszko, Acta Soc. Bot. Pol. 2: 270
(1925)

Type species: Raciborskiomyces polonicus Siemaszko,
Acta Soc. Bot. Pol. 2(4): 270 (1925)

Toroa Syd., in Toro, J. Dept. Agric. Porto Rico 10(2): 19
(1926)

Type species: Toroa dimerosporioides (Speg.) Syd.
[as ‘dimerosporoides’], J. Dept. Agric. Porto Rico 2:
20 (1926)

Key to genera of *Pseudoperisporiaceae*

1. Ascumata superficial, with setae and/or hyphae2
1. Ascumata superficial, without setae and/or hyphae12
2. Pseudoparaphyses present; ascospores only 1-septate3
2. Pseudoparaphyses present; ascospores more than 1-septate
.....7
3. Asci subglobose, ellipsoid-obclavate*Eumela*
3. Asci broadly cylindrical-clavate, saccate4
4. Ascumata collapsed when dry; ascospores minute
verrucose*Lasiostemma*
4. Ascumata not collapsed; ascospores non verrucose5
5. Ascospores 1-septate, green-olivaceous to brownish-
olivaceous*Raciborskiomyces*
5. Ascospores 1-septate, hyaline6
6. Ascospores ellipsoid- narrowly fusiform, 10–12.5 μm \times
2.5 μm *Neocoleroa*
6. Ascospores ellipsoid-fusiform, 13–15(–17) \times 4–5.5 μm
.....*Epibryon*
7. Ascospores 3-septate8
7. Ascospores more than 3-septate11

8. Asci ellipsoid-obclavate, subglobose*Keratosphaera*
8. Asci cylindrical-clavate9
9. Ascospores pale brown*Nematostoma*
9. Ascospores hyaline10
10. Ascospores narrowly fusiform-subclavate, with gelatinous
sheath*Aphanostigme*
10. Ascospores ellipsoid-subclavate, without gelatinous
sheath*Phragmeriella*
11. Ascospores broadly fusiform, hyaline*Nematostigma*
11. Ascospores parallel, elongate fusiform, brown to
reddish brown*Nematothecium*
12. Ascospores without septate*Myxophora*
12. Ascospores with septate13
13. Ascospores dictyosporous*Bryochiton*
13. Ascospores didymosporous, phragmosporous14
14. Ascospores 1-septate15
14. Ascospores more than 1-septate21
15. Ascospores hyaline16
15. Ascospores pale brown, light brown, brown, red brown
.....17
16. Ascospores narrowly oblong-ellipsoid*Episphaerella*
16. Ascospores ellipsoid-subfusiform*Eudimeriolum*
17. Ascospores hyaline, brown to red brown, with gelatinous
sheath*Phaeostigme*
17. Ascospores hyaline, brown, without gelatinous sheath
.....18
18. Ascospores broadly ellipsoid, rounded ends
.....*Bryomyces*
18. Ascospores ellipsoid, obovoid19
19. Ascumata with pedicel; ascospores olivaceous-brown
.....*Pododimeria*
19. Ascumata without pedicel; ascospores light brown to
brown20
20. Ascospores oblong fusiform*Lizonia*
20. Ascospores narrow ellipsoid*Phaeodimeriella*
21. Ascumata collapsed, ascospores elongate cylindrical-
fusiform, hyaline*Ophiociliomyces*
21. Ascumata not collapsed, ascospores ellipsoid-fusiform,
brown to red brown*Toroa*

Rousoellaceae J.K. Liu et al., in prep, MycoBank: MB
804651

Saprobic on decaying bamboo culms or palm fronds.
Sexual state: *Ascostromata* immersed, forming under dark-
ened, slightly raised, somewhat liner or dome-shaped stroma
on the host, with a flush intra-epidermal papilla, gregarious; in
vertical section subglobose with a flattened base, immerse
under clypeus, with one to several locules. *Peridium* compris-
ing several layers of elongate cells with interdispersed brown
melanin particles, dark brown outwardly. *Hamathecium*
hypha-like, septate, numerous, straight, narrowing towards
the ends, anastomosing above the asci and embedded in a
gelatinous matix. *Asci* 8-spored, bitunicate, cylindrical to

clavate, with a long knob-like pedicel, relatively thin-walled, apically rounded, with a distinct ocular chamber. *Ascospores* overlapping uniseriate, fusiform-ellipsoidal, straight, 2-celled, constricted at the septum, brown, ornamented and surrounded by a wide mucilaginous sheath. Asexual state: linked to *Cytoplea* (Hyde et al. 1996) and *Melanconiopsis* or *Neomelanconium*-like (Tanaka et al. 2009). *Conidiomata* pycnothyrial, semi-immersed, subglobose, dark-brown to black, multi-loculate, locules separated by vertical columns of darkly pigmented pseudoparenchyma. *Peridium* comprising several brown to dark brown layers with cells of *textura angularis*. *Conidiophores* reduced to *conidiogenous cells*, holoblastic to annellidic, discrete, hyaline, cylindrical to ellipsoidal, smooth, formed from cells lining the innermost later of the pycnidium. *Conidia* oblong ellipsoidal or globose, base truncate, narrower towards the apex, brown or dark, thick-walled, often biguttulate, minutely warty, sometimes surrounded by an entire gelatinous material.

Notes: *Roussoella* was introduced by Saccardo for the single species *R. nitidula* Sacc. & Paol. (Saccardo and Paoletti 1888). This genus is characterized as having immersed gregarious, clypeate ascomata, containing trabeculate pseudoparaphyses, embedded in a gel matrix, long cylindrical bitunicate asci without obvious fissitunicate dehiscence and brown, bicelled ornamented ascospores. *Roussoella* is currently placed in *Didymosphaeriaceae* (Lumbsch and Huhndorf 2010); however recent molecular data did not support this and suggested that *Roussoella* clustered in *Arthopyreniaceae* (Tanaka et al. 2009; Schoch et al. 2009a, b; Zhang et al. 2012a, b). The relationship between *Roussoella* and *Arthopyreniaceae* are not resolved because of the morphological differences between these taxa, although the molecular data suggested *Roussoella* belongs to *Arthopyreniaceae*. Most of the taxa in *Arthopyreniaceae* have a lichenized nature, having hemispherical ascomata containing cellular pseudoparaphyses, fissitunicate asci and mostly hyaline ascospores (Eriksson 1981; Cannon and Kirk 2007), these are significantly distinct from *Roussoella*. *Roussoellopsis* was introduced by Hino and Katumoto (1965), typified by *R. japonica* (I. Hino & Katum.) I. Hino & Katum, and it is similar with *Roussoella*, but it differs in having clavate asci and large-sized fusiform ascospores which are strongly constricted at the submedian septum. In addition, *Roussoellopsis* has *Melanconiopsis* or “*Neomelanconium*”-like asexual morphs, producing annellidic *conidiogenous cells*, and almost globose, black, aseptate, thick-walled conidia (Tanaka et al. 2009), while *Roussoella* has a *Cytoplea* asexual state (Hyde et al. 1996). Based on the unique morphological characters and more recent molecular data (Figs. 1 and 2), the family *Roussoellaceae* is established by Liu et al. (2013 in prep) to accommodate the taxa of *Roussoella* and *Roussoellopsis*. Most of the taxa from *Roussoellaceae* are known from bamboo and palms.

Type: *Roussoella* Sacc., Atti dell’Istituto Veneto Scienze, 6: 410, 1888. MycoBank: MB 4799 Fig. 109

Saprobic on decaying bamboo culms or palm fronds. Sexual state: *Ascostromata* immersed, forming under darkened, slightly raised, somewhat linear or dome-shaped stroma on the host, with a flush intra-epidermal papilla, gregarious; in vertical section subglobose with a flattened base, immersed under stroma, with one to several locules. *Peridium* comprising several layers of elongate cells with interdispersed brown melanin particles, dark brown outwardly. *Hamathecium* 1–2 μ m diam., hypha-like, septate, numerous, straight, narrowing towards the ends, anastomosing above the asci and embedded in a gelatinous matix. *Asci* 8-spored, bitunicate, long cylindrical. short pedicellate, apically rounded, with a distinct ocular chamber. *Ascospores* overlapping uniseriate, fusiform-ellipsoidal, straight, 2-celled, constricted at the septum, brown, ornamented and surrounded by a wide mucilaginous sheath. Asexual state: linked to *Cytoplea* (Hyde et al. 1996). *Conidiomata* pycnothyrial, semi-immersed, subglobose, dark-brown to black, multi-loculate, separated by vertical columns of darkly pigmented pseudoparenchyma. *Peridium* comprising several brown to dark brown layers with cells of *textura angularis*. *Conidiophores* reduced to *conidiogenous cells*, holoblastic discrete, hyaline, cylindrical to ellipsoidal, smooth, formed from cells lining the innermost later of the pycnidium. *Conidia* oblong ellipsoidal, narrower towards the apex, brown, thick-walled, often biguttulate, minutely warty.

Notes: *Roussoella* was introduced by Saccardo (Saccardo and Paoletti 1888). Hyde et al. (1996) redescribed the genus and reported the asexual species *Cytoplea hysteroioides* K.D. Hyde for *Roussoella hysteroioides* (Ces.) Höhn. Subsequently, Hyde (1997) reviewed this genus and provided a modified key for *Roussoella* species. *Roussoella* was assigned to *Didymosphaeriaceae* (Lumbsch and Huhndorf 2010), and recent molecular studies showed that this genus is closely related to *Arthopyreniaceae* (Tanaka et al. 2009; Schoch et al. 2009b; Zhang et al. 2012a). However, there is only two isolates of *Arthopyrenia salicis*, which are not the type of *Arthopyrenia* included in these molecular studies. Further molecular data is required to confirm the placement of *Arthopyrenia* sensu stricto. Liu et al. (2013, in prep) introduce a new family *Roussoellaceae* to accommodate the genera *Roussoella* and *Roussoellopsis*, with most *Roussoella* species being known from bamboo.

Type species: *Roussoella nitidula* Sacc. & Paol., Atti Ist. Veneto Sci., Ser. 6, 6:410. 1888. MycoBank: MB 177454

Other genera included

Roussoellopsis I. Hino & Katum., J. Jap. Bot. 40: 86 (1965)

Type species: *Roussoellopsis japonica* (I. Hino & Katum.) I. Hino & Katum., J. Jap. Bot. 40: 86 (1965)

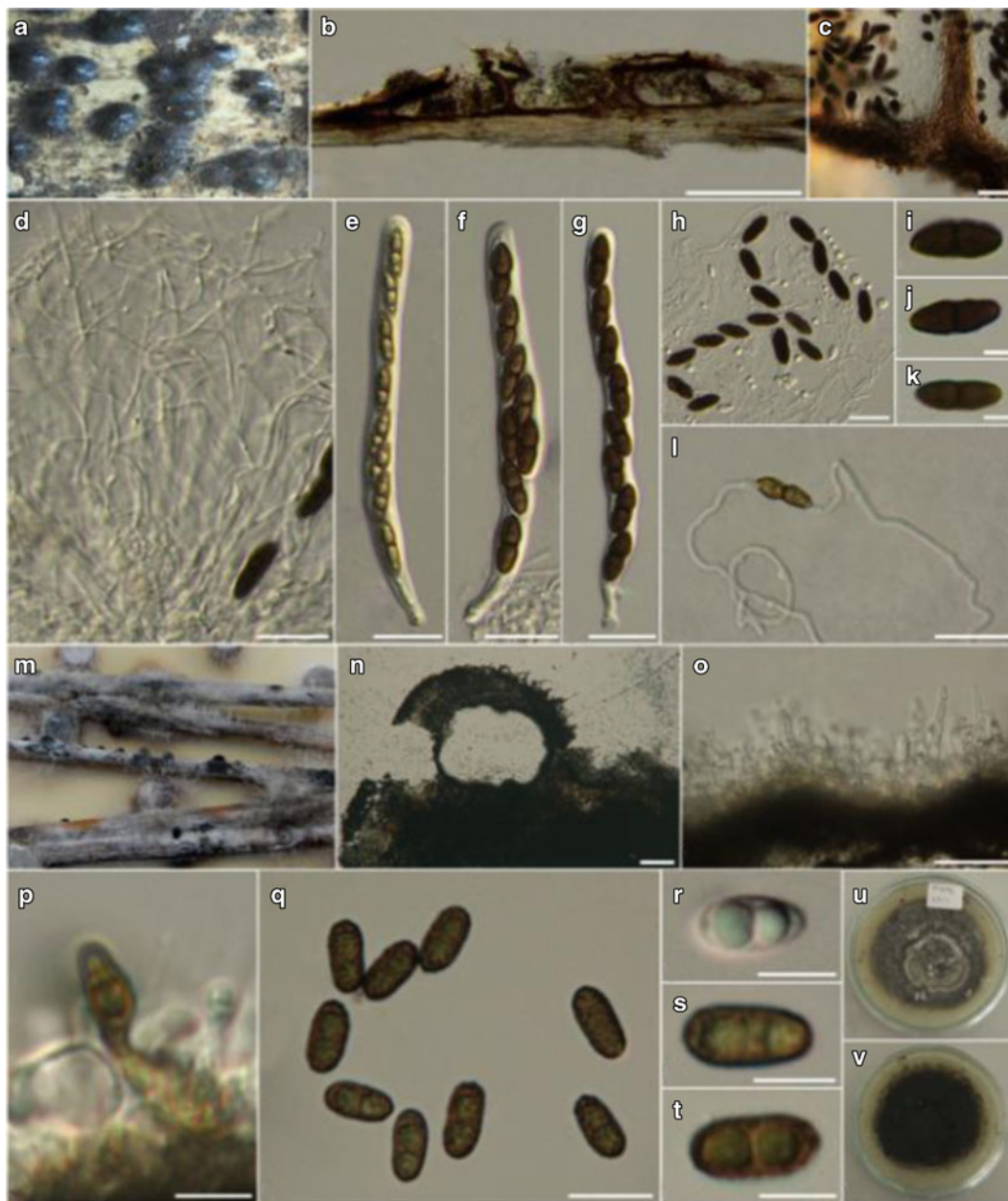


Fig. 109 *Roussoella hysterioides* (Material examined: THAILAND, Chiang Rai Province, Muang District, Khun Korn Waterfall, dead stem of *Dendrocalamus*, 17 December 2010, R. Phookamsak RP0098, MFLU 11–0218.). **a** Ascostromata on host surface. **b** Vertical section through ascomata **c** Section through peridium. **d** Pseudoparaphyses. **e–g** Ascus.

h Ascospores. **i–k** Ascospore. **l** Spore germination. **m** Conidiomata on bamboo toothpicks. **n** Section through conidiomata. **o–p** Conidiophores. **q** Conidia. **r–t** Conidium. **u–v** Colony on media. Scale bars: **b** = 500 μm , **n** = 200 μm , **c–h**, **l**, **o** = 20 μm , **i–k**, **p**, **r–t** = 5 μm , **q** = 10 μm

Key to genera of Roussoellaceae

- 1. Asci long cylindrical, 2-celled, ascospores ornamented; if asexual morphs present, with holoblastic conidiogenous cells, and oblong ellipsoidal, brown to dark brown, 1–2-septate conidia**Roussoella**
- 1. Clavate asci, ascospores large, fusiform, with strongly constricted septum; if asexual morphs present, with annelidic conidiogenous cells, and almost globose, black, aseptate conidia**Roussoellopsis**

Salsugineaceae K.D. Hyde & S. Tibpromma, **fam. nov.**, MycoBank MB 804579

Saprobic on decaying wood submerged in brackish waters in mangroves. Sexual state: *Ascomata* immersed beneath a raised dark brown to black pseudoclypeus, which may be above individual ascoma or form above a group of ascomata, brown to black, coriaceous or carbonaceous, comprising host cells and dark fungal hyphae, solitary, in section subglobose to flask-shaped, or conical,

with a protruding papilla. *Papilla* conspicuous, central, cone-shaped, brown to black, ostiolate. *Peridium* comprising a single layer of, light brown cells of *textura porrecta*, in *Salsuginea* emerging at the outside with the host, where *textura angulata* cells of fungus become irregular and contorted and intermingle with host cells. *Hamathecium* comprising numerous, 0.9–1.8 μm , filiform, branched, septate, hyaline pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical to cylindro-clavate, with an apical apparatus, rounded, with an ocular chamber and ring. *Ascospores* uni-seriate, obovoid, or broad ellipsoidal, symmetrical with rounded ends, or tapering toward sub-acute ends or, 1-septate in centre or lower third cell, constricted at the septum, hyaline, brown, dark brown to black, with colourless, germ pore at both ends or lacking, smooth-walled. Asexual state: Unknown.

Typus: *Salsuginea* K.D. Hyde

Notes: The monotypic genus *Salsuginea* is found on submerged wood in mangroves and was originally thought to be similar to *Helicascus* (Hyde 1991). However, the ascospores with apical germ pores/extensions and peridium of *textura porrecta* are unique. *Salsuginea ramicola* clusters with *Acrocordiopsis patilii* in the phylogenetic tree (Figs. 1 and 2) in a distinct lineage and therefore we introduce a new family to accommodate these two genera (Suetrong et al. 2009). In *Acrocordiopsis* the ascomata form a thin, black pseudostromata on the host surface and cover the raised, carbonaceous ascomata (Alias and Jones 2009). The asci are cylindrical and contain eight hyaline bicelled ascospores. Thus besides molecular data (71 % BS support), arrangement of cells as *textura porrecta* and narrow pseudoparaphyses, these two genera share few characteristics that unite them into the family *Salsugineaceae*.

Type: *Salsuginea* K.D. Hyde, Bot. Mar. 34(4): 315 (1991)

Saprobic on decaying wood submerged in brackish waters in mangroves. Sexual state: *Ascomata* immersed beneath a raised dark brown to black pseudoclypeus, comprising host cells and dark fungal hyphae, solitary, in section subglobose to flask-shaped, with a protruding papilla. *Papilla* conspicuous, central, cone-shaped, brown to black, ostiolate. *Peridium* comprising a single layer of, light brown cells of *textura porrecta*, merging at the outside with the host, where *textura angulata* cells of fungus become irregular and contorted and intermingle with host cells. *Hamathecium* comprising numerous, 2–3 μm wide, filiform, branched, septate, hyaline pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, cylindrical-clavate, with an apical apparatus, apically rounded, with an ocular chamber and prominent ring. *Ascospores* uni-seriate, obovoid, tapering toward sub-acute ends, 1-septate in lower third cell, constricted at the septum, brown, dark brown to black, with colourless, germ pore at both ends, smooth-walled. Asexual state: Unknown.

Type species: *Salsuginea ramicola* K.D. Hyde, Bot. Mar. 34(4): 316 (1991) (Fig. 110)

Other genus included

Acrocordiopsis Borse & K.D. Hyde, Mycotaxon 34(2): 535 (1989)

Type species: *Acrocordiopsis patilii* Borse & K.D. Hyde, Mycotaxon 34(2): 536 (1989)

Key to genera of *Salsugineaceae*

- 1. Ascospores brown *Salsuginea*
- 1. Ascospores hyaline *Acrocordiopsis*

Schizothyriaceae Höhn. ex Trotter et al. [as '*Schizothyriaceae*'], in Saccardo, Syll. fung. (Abellini) 24(2): 1254 (1928), MycoBank: MB 81266

Possible synonym:

Microthyriellaceae Luttr., Univ. Mo. Stud. 24(3): 79 (1951)

Epiphytic, *parasitic* or *saprobic* on leaves, branches, fruits or other parts of plants, epiphyllous or hypophyllous, visible as dark brown or dark grey to black dots on host surface. Sexual state: *Ascomata* superficial or subcuticular, circular to ellipsoidal, or irregular structures on host surface, small to large-sized, flattened, thyriothecium-like, dimidiate, scutate or orbicular, subhyaline to light brown or dark brown or black, transparent to opaque, with smooth to rough walls, in some genera surrounded by setae, membranaceous, uni to multilocular, scattered or clustered, solitary to gregarious, ostiole central, opening by pore or slit, in some ostioles not apparent. *Peridium* thin, dark brown to black, membranaceous, comprising 1–2 layers of *textura angularis* or *textura epidermoidea*, base poorly developed. *Hamathecium* sometimes comprising rare or numerous, broadly cellular, branching, anastomosing, net-like pseudoparaphyses, embedded in a gelatinous matrix, or pseudoparaphyses absent. *Asci* 4–8-spored, bitunicate, fissitunicate, globose to subglobose, saccate, ovoid, cylindrical-clavate to clavate, sessile to sessile, short pedicellate, apical region rounded with distinct or indistinct ocular chamber. *Ascospores* overlapping to irregularly seriate, hyaline to light brown or dark brown at maturity, ellipsoidal, oblong, cylindrical, broadly fusiform or elongate, with two to many transverse septa, or muriform, sometimes distoseptate, constricted at the septa, thin to thick-walled, smooth to rough with small guttules. Asexual states: *Pycnothyria* brown, in most cases reticulate. *Conidiophores* absent or when present, unbranched to monoverticillate, and brown. *Conidiogenous cells* medium brown, finely verruculose, doliiform to elongate-subcylindrical. *Conidia* hyaline, fusiform to obclavate, septate or aseptate.

Notes: The family *Schizothyriaceae* was introduced by Höhn. ex Trotter et al. (1928) and when introduced comprised *Clypeolum*, *Mycrothyriella*, *Polyclypeolum*,



Fig. 110 *Salsuginea ramicola* (Material examined: THAILAND, Ranong, 09° 58' N, 098° 37' E, in mangrove, on submerged decaying wood of *Aegiceras cornicelatum* in brackish water, October 1988, K.D. Hyde, BRIP 17102a, **holotype**). **a** Appearance of pseudoclypeus on host substrate. **b, c** Section of ascomata. Note the brown pseudoclypeus. **d**

Section of peridium. **e** Pseudoparaphyses. **f, g** Asci with minute pedicel bearing eight irregularly arranged ascospores. **h–j** Ascospores with apical germ pores. Scale bars: **a–c** = 500 μm , **d** = 20 μm , **e** = 5 μm , **f, g** = 100 μm , **h–j** = 20 μm

Phragmothyriella and the type *Schizothyrium*. von Arx and Müller (1975) diagnosed *Schizothyriaceae* as saprobes, superficial on leaves, stems, fruits or other parts of living plants, with superficial, scutate or dimidiate, subcuticular ascomata. Asci formed in a single layer, and are bitunicate, clavate, sphaerical or obovoid, surrounded by a slimy mass or paraphyses-like filaments. Ascospores are uni to multi-septate, hyaline or brownish. von Arx and Müller (1975) included twelve genera in this family and transferred some genera to *Saccardiaceae*. Barr (1979a) and Eriksson (1981) treated this family as a

separate clade within *Asterinales*; Lumbsch and Huhndorf (2010) placed 15 genera in *Schizothyriaceae* comprising *Amazonotheca*, *Chaetoplaca*, *Henningsiella*, *Hexagonella*, *Kerniomyces*, *Lecideopsella*, *Linopeltis*, *Mendogia*, *Metathyriella*, *Mycerema*, *Myriangiella*, *Neopeltella*, *Orthobellus*, *Plochmopeltis* and *Schizothyrium*, while Kirk et al. (2008) report 16 genera in the family.

The phylogeny of *Schizothyriaceae* was partly studied by Crous et al. (2007a, 2009b) and Batzer et al. (2008). Crous et al. (2007a, 2009b) showed that *Schizothyriaceae* belongs in

Capnodiales. Following phylogenetic analysis based on 18S, 5.8S and 28S nrRNA gene sequences, the *Schizothyriaceae* clade was basal in the *Capnodiales* and shown to be allied to *Mycosphaerellaceae*. However, *Schizothyriaceae* was less well-supported as being separate from *Mycosphaerellaceae*. Batzer et al. (2008) confirmed that *Zygophiala* is the asexual state of *Schizothyrium* which is a pathogen on apple and pears causing sooty blotch and flyspeck disease.

We have observed the type specimens of many genera of *Schizothyriaceae* and could not find superficial or subcuticular vegetative mycelium; only *Linopeltis* had vegetative hyphae surrounding the ascomata and also superficial on host surface. The family has two types of ascomata, thyrithecium-like and those membranaceous structures covering the hamathecium and some are covered by setae. Thus this family is morphologically widely variable and fresh collections and epitypification are required and make clear the phylogenetic relationships of the various genera.

Type: Schizothyrium Desm., *Annl. Sci. Nat., Bot.*, sér. 3 11: 360 (1849), MycoBank: MB 4911 Fig. 111

Epiphytic, or *saprobic* on leaves or branches, forming small fruiting bodies, visible as dark brown to black spots on the host surface. Sexual state: *Ascomata* superficial, or subcuticular, solitary or scattered, visible as circular or ellipsoidal spots on the host surface, flattened, thyrithecium-like, dark brown to black, ostiole central, opening by pore, walls rough. *Peridium* comprising 1–2 layers of dark brown to black, thin walled cells of *textura angularis*, base poorly developed. *Hamathecium* forming broadly cellular, short, unbranched, net-like pseudoparaphyses, with largest cells at apex. *Asci* 8-spored, bitunicate, fissitunicate, subglobose to ovoid, sessile to subsessile, apically thick-walled and rounded, with an indistinct ocular chamber. *Ascospores* irregularly arranged in the ascus, 1-septate, hyaline, ellipsoidal or oblong to broadly fusiform, constrict at the septum, wall thick and roughened, minutely guttulate. Asexual state: was reported as *Zygophiala* (Batzer et al. 2008; Hyde et al. 2011; Wijayawardene et al. 2012).

Notes: Schizothyrium was designated by Desmazières (1849) with the type *Schizothyrium acerinum* (Mont. & Fr.) Arx with the protocol as superficial, black, shiny, rounded or ovate, scutate ascomata; ovoid to pyriform asci and minute, oblong, guttulate ascospores with obtuse ends (Saccardo 1883). Eriksson (1981) re-described the morphological characters of *Schizothyrium pomi* (Mont. & Fr.) Arx which is a synonym of *Schizothyrium acerinum*. The asexual state was reported by Batzer et al. (2008) as *Zygophiala*; a monotypic genus having a wide host range and wide geographic distribution. *Zygophiala* has conidiophores arising from superficial hyphae with circular, dark thickened conidiogenous cells with refractive conidial scars which produce slightly granular, 1-septate conidia in pairs, with prominently thickened, dark, refractive scars (Batzer et al.

2008). Batzer et al. (2008) and Ma et al. (2010) showed that *Z. cryptogama* Batzer & Crous, *Z. tardicrescens* Batzer & Crous, *Z. wisconsinensis* Batzer & Crous and *Z. qianensis* G.Y. Sun & Y.Q. Ma grouped with *Schizothyrium pomi*. However, no *Zygophiala* sp. is linked to *Schizothyrium acerinum* Desm., the type species of *Schizothyrium*. Batzer et al. (2008) mentioned that *Schizothyrium*, as based on *Schizothyrium pomi*, was traditionally placed in *Dothideales* by von Arx and Müller (1975), while Kirk et al. (2008) placed *Schizothyrium* (*Schizothyriaceae*) in *Capnodiales*. Eriksson (2006) placed *Schizothyriaceae* in the *Dothideomycetes* which was supported by phylogenetic analysis. However, *Schizothyriaceae* was less well-supported as being separate from *Mycosphaerellaceae*, and further studies are required with more taxa. Twenty-one nucleotides of *Schizothyrium* have been placed in GenBank and there are 58 epithets in Index Fungorum.

Type species: Schizothyrium acerinum Desm., *Annl. Sci. Nat., Bot.*, sér. 3 11: 360 (1849)

Other accepted genera

Amazonotheca Bat. & H. Maia, in Batista, *Publ. Inst. Micol. Recife* 56: 408 (1959).

Type species: Amazonotheca santiriae Bat. & H. Maia, in Batista, *Publ. Inst. Micol. Recife* 56: 408 (1959)

Chaetoplaca Syd. & P. Syd., *Annl. mycol.* 15(3/4): 232 (1917)

Type species: Chaetoplaca memecyli Syd. & P. Syd., *Annl. mycol.* 15(3/4): 232 (1917)

Henningsiella Rehm, *Hedwigia* 34(Beibl.): 160 (1895)

Type species: Henningsiella quitensis Rehm, *Hedwigia* 34(Beibl.): 160 (1895)

Hexagonella F. Stevens & Guba ex F. Stevens, *Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii* 19: 89 (1925)

Type species: Hexagonella peleae F. Stevens & Guba ex F. Stevens, *Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii* 19: 89 (1925)

Kerniomyces Toro, *J. Agric. Univ. Puerto Rico* 22: 452 (1939)

Type species: Kerniomyces costi Toro, *J. Agric. Univ. Puerto Rico* 22: 453 (1939)

Lecideopsella Höhn., *Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1* 118: 1229 [73 repr.] (1909)

Type species: Lecideopsella gelatinosa Höhn., *Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1* 118: 1230 [74 repr.] (1909)

Linopeltis I. Hino & Katum., *J. Jap. Bot.* 36: 99 (1961)

Type species: Linopeltis ryukyensis I. Hino & Katum., *J. Jap. Bot.* 36: 100 (1961)

Mendogia Racib., *Parasit. Alg. Pilze Java's (Jakarta)* 3: 31 (1900)



Fig. 111 *Schizothyrium acerinum* (Material examined: FRANCE, Paris, dead twig of *Acer negundo*, 1863, Desmazières, PC0084488 [a, b, d–g, i–k, n–p]; on dry twigs of *Acer negundo*, Desmazières, BR 5020103861716 [c, h, l, m] authentic specimens). a Herbarium label and specimens. b Superficial ascomata on host tissue c Section through

ascoma. d Section through peridium. e Net-like pseudoparaphyses visible in horizontal section. f Arrangement of asci in ascoma. g Asci with pseudoparaphyses. h–k Asci. l–o Ascospores. p Ascospore stained in lactophenol cotton blue. Scale bars: c=50 μ m, f, g=20 μ m, d, e, h–k=10 μ m, l–p=5 μ m

Type species: Mendogia bambusina Racib., Parasit. Alg. Pilze Java's (Jakarta) 3: 31 (1900)

Metathyriella Syd., Anns mycol. 25(1/2): 96 (1927)

Type species: Metathyriella roupalae Syd., Anns mycol. 25(1/2): 96 (1927)

Mycerema Bat. et al., in Batista, Bezerra, Cavalcante, Maia & Silva, Publções Inst. Micol. Recife 392: 5 (1963)

Type species: Mycerema vochysiacearum Bat. et al., in Batista et al., Publicações. Instituto de Micologia da Universidade do Recife & Instituto Nacional de Pesquis 392: 7 (1963)

Myriangiella Zimm., Zentbl. Bakt. ParasitKde, Abt. II 8: 183 (1902)

Type species: *Myriangiella orbicularis* Zimm., Zentbl. Bakt. ParasitKde, Abt. II 8: 183 (1902)

Neopeltella Petr., Sydowia 4(1–6): 329 (1950)

Type species: *Neopeltella aequatoriensis* Petr., Sydowia 4(1–6): 329 (1950)

Orthobellus A.A. Silva & Cavalc., in Silva et al., Publicações Inst. Micol. Recife 691: 4 (1973)

Type species: *Orthobellus leguminosarum* A.A. Silva & Cavalc., in Silva et al., Publicações. Instituto de Micologia da Universidade de Pernambuco 678: 5 (1973)

Plochrompeltis Theiss., Brotéria, sér. bot. 12: 87 (1914)

Type species: *Plochrompeltis intricata* (Ellis & G. Martin) Theiss., Brotéria, sér. bot. 12: 87 (1914)

Key to genera of *Schizothyriaceae*

1. Ascospores 1-septate, hyaline to lightly pigmented2
1. Ascospores 2-multi-septate, or muriform, hyaline to lightly pigmented8
2. Ascomata glabrous3
2. Ascomata surrounded by setae, hypophyllous*Chaetoplaca*
3. Ascomata coriaceous, thyriothecium, membranaceous4
3. Ascomata lacking covered layers, forming brown pseudoparaphyses, associated on *Quercus**Plochrompeltis*
4. Ascomata membranous5
4. Ascomata coriaceous*Schizothyrium*
5. Ascomata uni-loculate, not forming stromata6
5. Ascomata multi-loculate, developing on a radiating, basal stroma*Henningsiella*
6. Pseudoparaphyses present, or forming net-like structures between ascus7
6. Pseudoparaphyses absent*Mycerema*
7. Ascomata dimidiate or scutate, ascospores oblong, obovoid to ellipsoidal*Orthobellus*
7. Ascomata rounded or irregular in shape; ascospores cylindrical to oblong or obovoid, lying parallel at both ends*Lecideopsella*
8. Ascospores 2-multi-septate9
8. Ascospores muriform*Mendogia*
9. Ascospores multi-septate or distoseptate10
9. Ascospores 2-septate12
10. Ascospores multi-septate, constricted at the septum, hyaline to pale yellowish11
10. Ascospores distoseptate, hyaline to brown at the maturity*Linopeltis*
11. Ascospores, cylindrical to elongate*Neopeltella*
11. Ascospores oblong*Myriangiella*
12. Pseudoparaphyses present13
12. Pseudoparaphyses absent*Hexagonella*
13. Ascomata membranaceous, flattened to scutate, yellowish to light brown; ascospores subcylindrical, brown*Amazonotheca*

13. Ascomata thyriothecium, flattened or lenticular, yellowish or olive-brown, ascospores oblong to clavate, hyaline*Metathyriella*

Seynesiopeltidaceae K.D. Hyde, **fam. nov.**, MycoBank: MB 804042

Foliar epiphytes on leaves, causing black spots, usually confluent, forming black colonies. Sexual state: *Mycelium* superficial, sparse, septate, olive-green. *Thyriothecia* solitary or gregarious, superficial, with a circular, shield-like, shallow, conical, dome-like, flattened, upper region, carbonaceous, unilocular, brown to black, basal layer poorly developed, lacking a distinct central ostiole. *Upper wall* comprising radiating parallel cells, cells at margin branching; in section. *Pseudoparaphyses* not observed. *Asci* 8-spored, bitunicate, fissitunicate, saccate, with a knob-like pedicel, and conspicuous ocular chamber (in Congo red). *Ascospores* irregularly 2–3-seriate, dark brown when mature, 1-septate, strongly constricted at septum, upper cells longer and wider, basal cell shorter and narrower with an acute base, with a thick, structured, hyaline, cell wall. Asexual state: Unknown.

Notes: The unusual genus *Seynesiopeltis* accommodated in *Microthyriaceae* by Müller and von Arx (1962), von Arx and Müller (1975) and Lumbsch and Huhndorf (2010) and moved to *Dothideomycetes genera incertae sedis* by Wu et al. (2011a) is unlike any other member of the class (Dothideomycetes) and a new family is therefore introduced to accommodate it. The remarkable brown ascospores have very thick structured walls, while asci have very thick walls and stain in Congo red. The cells of the peridium comprise two strata, with inner rows of *textura angularis*. The ascomata are thyriothecia-like and yet their appearance is more typical of some genera in *Parmulariaceae* (e.g. *Polycyclus andinus*, Inácio and Cannon 2008). Genera such as *Dothidasteroma* and *Cocconia* (also *Parmulariaceae*) may be related as they have brown ascospores, however the asci differ considerably (Inácio and Cannon 2008). Most importantly *Seynesiopeltis* differs markedly from *Parmularia styracis* Lév., the type of *Parmulariaceae*. In *P. styracis* the thyriothecia have a similar appearance to shells on the host surface, the asci are obclavate and ascospores are hyaline.

Typus: *Seynesiopeltis* F. Stevens & R.W. Ryan, in Stevens, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 69 (1925), MycoBank MB: 5020 Fig. 112

Notes: *Seynesiopeltis* was established by Stevens (1925) as a monotypic genus with *S. tetraplasandrae* as the type, and has remained monotypic. Stevens (1925) mentioned in the notes on this taxon that there are one to several ascomata in one fungus body and that this bears setae; this would also increase the uniqueness of the genus (and family). However we did not observe setae in the type specimen, which may have been lost during storage especially being fragile features. The genus is presently monotypic and needs recollecting.

Type species: Seynesiopeltis tetraplasandrae F. Stevens & R.W. Ryan, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 69–70 (1925), MycoBank: MB 158371

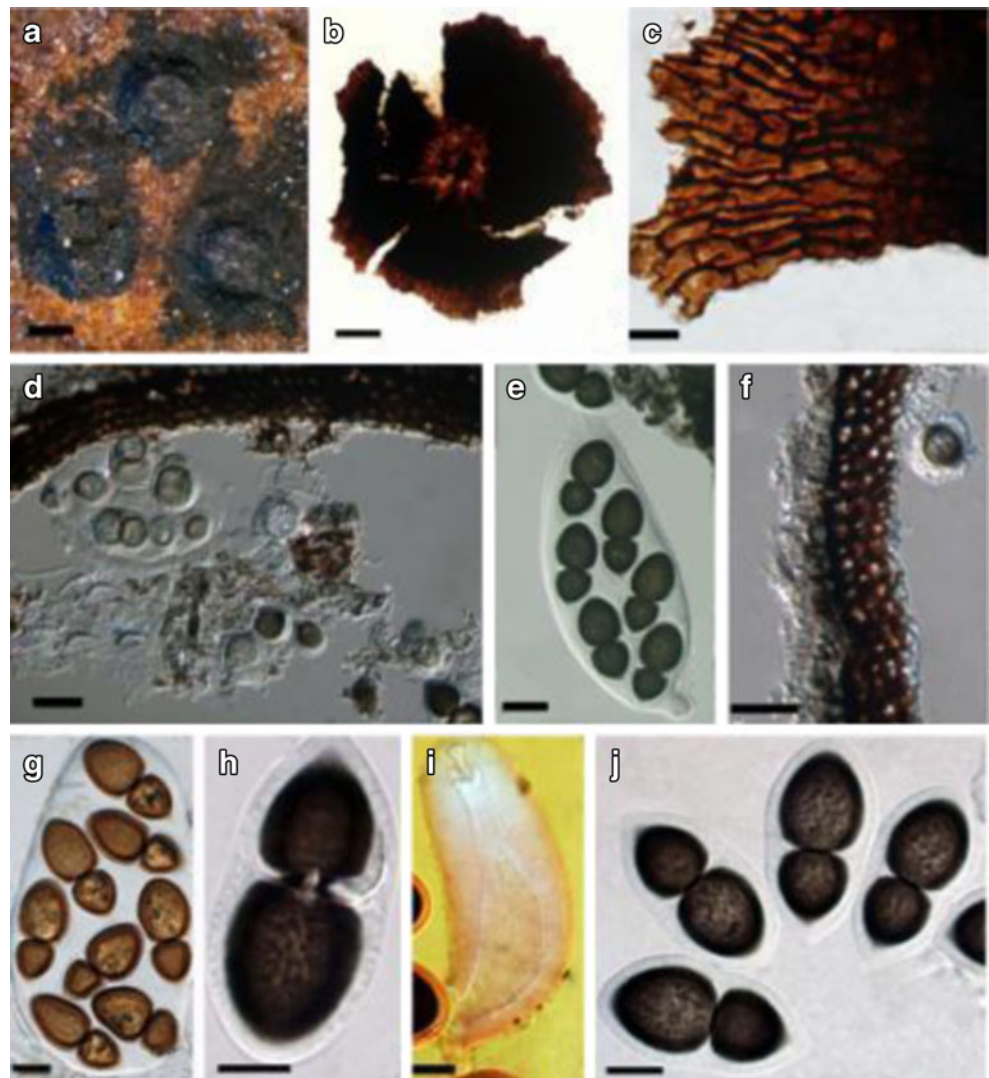
Shiraiaceae Liu YX et al., Phytotaxon 103(1): 53 (2013), MycoBank: MB 803214

Endophytic or *parasitic* on bamboo. Sexual state: *Ascstromata* forming near ends of host branches, near petiole bases, superficial, pinkish, irregular, tuberculate, fleshy, ascstromata comprising cells of *textura intricata*, easily peeling off host tissues without damage. *Locules* immersed, arranged in a peripheral layer, subspherical or ellipsoidal, ostiolate. *Peridium of locules* comprising a single layer of light brown-walled cells. *Hamathecium* comprising relatively narrow, numerous, cellular pseudoparaphyses. *Asci* containing 6 ascospores, bitunicate, fissitunicate, cylindrical, with a long pedicel and a distinct ocular chamber. *Ascospores* uniseriate, fusiform, symmetrical, hyaline to light brown, muriform.

Asexual state: forming in young ascstromata. *Locules* immersed, arranged in rows or irregularly in ascstromata, cylindrical, ampulliform, globose, subglobose or irregular, lining comprising thick-walled cells of *textura angularis*. *Conidiophores* reduced to conidiogenous cells, arising all around the basal region of the locules. *Conidiogenous cells* holoblastic, unbranched, discrete, indeterminate, cylindrical, septate, hyaline, smooth. *Conidia* fusiform, muriform, asymmetrical, hyaline to light brown, with irregularly arranged transverse and longitudinal septa, acute at base, apex obtuse, or obtuse at both ends, thick-walled, smooth.

Notes: This unusual dothideomycete was introduced as a new family based on its unique morphology and separation from *Phaeosphaeriaceae* (88 % bootstrap support) based on LSU sequence data. *Shiraiaceae* falls in the subclass order Pleosporineae of Zhang et al. (2012a) and is basal to all other families. The genus is most likely parasitic on bamboo and produces pinkish ascstromata containing numerous locules

Fig. 112 *Seynesiopeltis tetraplasandrae* (Material examined: HAWAII, Oahu, Hamakua, upper ditch trail, on leaves of *Tetraplasandra* (*Araliaceae*), 31 May 1921. F.L. Stevens, BISH 1089, **holotype**). **a** Appearance of thriothecia on the host surface. **b** Squash mount of ascoma. **c** Thyriothecia showing radiating cells. **d** Section of ascoma. **e, g, i** Asci. Note **e, g** in water and **i** in Congo red. **f** Section of peridium showing thick-walled cells of *textura angularis*. **h–j** Ascospores. Note the larger apical cell and smaller pointed basal cell, constricted septum and wide structured wall. Scale bars: **a** = 200 μm , **b** = 5 μm , **c, g–j** = 10 μm , **d–f** = 20 μm



arranged in an outer layer, bitunicate asci with six symmetrical, muriform ascospores. The asexual state is produced in immature ascostromata and produce hyaline muriform, but asymmetrical conidia. Another genus *Grandigallia* was added by Ariyawansa et al. (in prep) which differs from *Shiraia* in having black ascostromata and a *Polylepis* (*Rosaceae*) host.

Type: Shiraia Henn. Engl. Bot. Jahrb. 28: 274 (1900)
Mycobank: MB 5025

Figures 113 and 114

Parasitic on bamboo. Sexual state: *Ascostromata* forming near ends of host branches, near petiole bases, superficial, pinkish, irregular, tuberculate, fleshy, slightly pink, cells of ascostromata comprising cells of *textura intricata*. *Locules* immersed, arranged in a peripheral layer, subspherical or ellipsoidal, ostiolate. *Peridium* of *locules* comprising a single layer of light brown-walled cells. *Hamathecium* comprising relatively narrow, numerous, cellular pseudoparaphyses. *Asci* containing 6 ascospores, bitunicate, fissitunicate, cylindrical, with a long pedicel and a distinct ocular chamber. *Ascospores* uniseriate, fusiform, symmetrical, hyaline to light brown, muriform. Asexual state: forming in young ascostromata. *Locules* immersed in ascostroma, arranged in rows or irregularly in the inner layer, cylindrical, ampulliform, globose, subglobose or irregular, thick-walled cells. *Conidiophores* reduced to conidiogenous cells, arising all around the basal region of the locules. *Conidiogenous cells* holoblastic, unbranched, discrete, indeterminate, cylindrical, septate, hyaline, smooth. *Conidia* fusiform, muriform, asymmetrical, hyaline to light brown, with irregularly arranged transverse and longitudinal septa, acute at basal, apex obtuse, or obtuse at both ends, thick-walled, smooth-walled.

Notes: Shiraia was described by Hennings (1900) based on *Shiraia bambusicola* Henn. and has remained monotypic. This genus is important in Chinese Traditional Medicine. Morakotkarn et al. (2008) isolated seven *Shiraia*-like strains as endophytes from bamboo in Japan. One taxon produced a coelomycetous asexual morph in culture with phialidic, ampulliform, conidiophores and small, cylindrical to ellipsoidal, aseptate, hyaline conidia.

Type species: Shiraia bambusicola Henn., Bot. Jb. 28: 274 (1900) Mycobank: 158454

Other genera included

Grandigallia M.E. Barr et al., Mycotaxon 29: 196 (1987)

Type species: Grandigallia dictyospora M.E. Barr et al., Mycotaxon 29: 196 (1987)

Key to genera of *Shiraiaceae*

1. Ascostromata orange, on bamboo*Shiraia*
2. Ascostromata black, on *Polylepis**Grandigallia*

Sporormiaceae Munk, Dansk bot. Ark. 17(no.1): 450 (1957),
Mycobank: MB 81414

Saprobic mostly on dung, sometimes on other substrates including plant debris, soil and wood exceptionally endophytic. Sexual state: *Ascomata* solitary or gregarious, scattered, perithecioid or cleistothecioid, ascolocular pseudothecia, immersed to erumpent or superficial, dark pigmented, globose to pyriform, membranous or coriaceous. *Peridium* smooth or hairy, fairly thick, with dark-pigmented, outermost cells thick-walled. *Hamathecium* comprising abundant cellular pseudoparaphyses, lacking periphyses. *Asci* usually 8-spored, fissitunicate, non-amyloid, clavate, globose or cylindrical, usually with a pedicel, apical apparatus scarcely developed, non refractive, with a narrow endotunica. *Ascospores* often partly overlapping inside the asci, uni-to triseriate, sometimes fasciculate or crowded, exceptionally one-celled, usually septate and poly-celled, oval to cylindrical, thick-walled, smooth, exceptionally ornamented, dark brown, constricted at septa and often fragmenting into part-spores at maturity, often with germ slits, sometimes surrounded by a mucilaginous sheath, Asexual states: rare, when present coelomycetous, pycnidial, "Phoma"-like, conidia bacillary.

Notes: Sporormiaceae has more than 100 cosmopolitan species within five genera including *Preussia*, *Sporormia*, *Westerdykella*, *Chaetopreussia* and *Pleophragma* (Kruys and Wedin 2009; Zhang et al. 2012a, b). Species in this family are mostly saprobic on dung, sometimes on other substrates including plant debris, soil and wood (Hausmann et al. 2002; van Geel et al. 2003; Burney et al. 2003; Kruys and Wedin 2009), or exceptionally endophytic (van Geel et al. 2003). The most species rich genus in this family is *Preussia*. Barr (1990a) assigned *Sporormiella* as a synonym of *Ohleriella*, whereas others (Eriksson 2006; Kirk et al. 2008; Lumbsch and Huhndorf 2010) regarded it as an independent genus in *Sporormiaceae*. Based on morphological and molecular data (Kruys and Wedin 2009; Zhang et al. 2009a, 2012a), *Sporormiella* has been included in *Preussia* as a synonym, together with *Spororminula*.

Type: Sporormia De Not., Micr. Ital. Novi 5: 10 (1845),
Mycobank: MB 144802

Figure 115

Saprobic on dung. Sexual state: *Ascomata* solitary, scattered, immersed to erumpent, globose to subglobose, black, smooth, apex without an obvious papilla, ostiolate. *Peridium* membranaceous, thin, composed of brown, relatively thick-walled cells. *Hamathecium* comprising sparse septate, cellular pseudoparaphyses. *Asci* 8-spored, bitunicate, short, cylindrical, with a short, narrowed, furcate pedicel, lacking an apical apparatus. *Ascospores* fasciculate, 15–32-celled, cylindrical, dark brown at maturity, smooth, multiseptate, easily separating into part-spores, germ pores absent, germ slits usually absent, spores joined together in a truncate bundle with one common gelatinous coat, better observable when released from the ascus. Asexual state: Unknown.

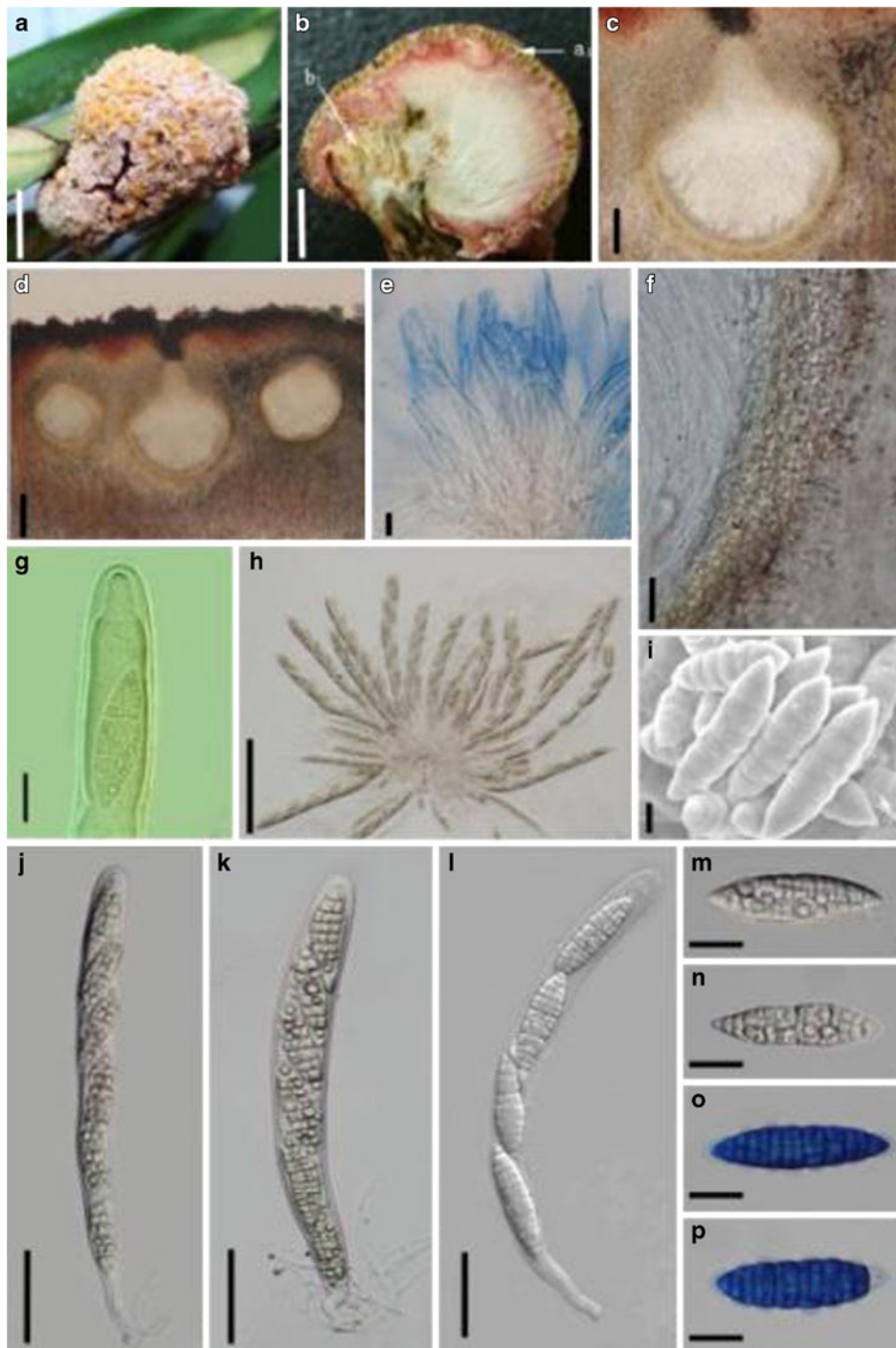


Fig. 113 *Shiraia bambusicola* (Material examined: MFLU 12–2041, **epitype**). **a–f, h, g, j–p** light microscopy and **i** SEM **a** Ascostroma of *S. bambusicola* with yellow ascospore mass. **b** Cross section of ascostroma. Note the sexual locules lining the periphery of the ascostroma (arrowed **a**) and the asexual locules near the centre of the ascostroma (labeled **b**). The outer part is pink, while the inner part is white to light pink. **c, d** Vertical section of ascomata. **e** Pseudoparaphyses. **f** Wall of

ascomata. Note the cells of *textura angularis* at the inside fusing with cells of *textura intricata* of the ascostroma at the outside. **g, h, j–l** Asci. Note fissitunicate nature in **g**. **i, m–p** Ascospores (Note. **o–p** stained in lactic acid phenol Medan). Scale bars: **a**=1 cm, **b**=1.5 cm, **c–d**=100 μ m, **e**=20 μ m, **f**=20 μ m, **g**=20 μ m, **h, j–l**=50 μ m, **i**=10 μ m, **m–p**=20 μ m

Notes: *Sporormia* was introduced by de Notaris (1845) to accommodate a single species, *S. fimetaria*, characterized by

16–20-celled ascospores lacking germ slits. Three other species were later published, one of which, *S. fimicola*,

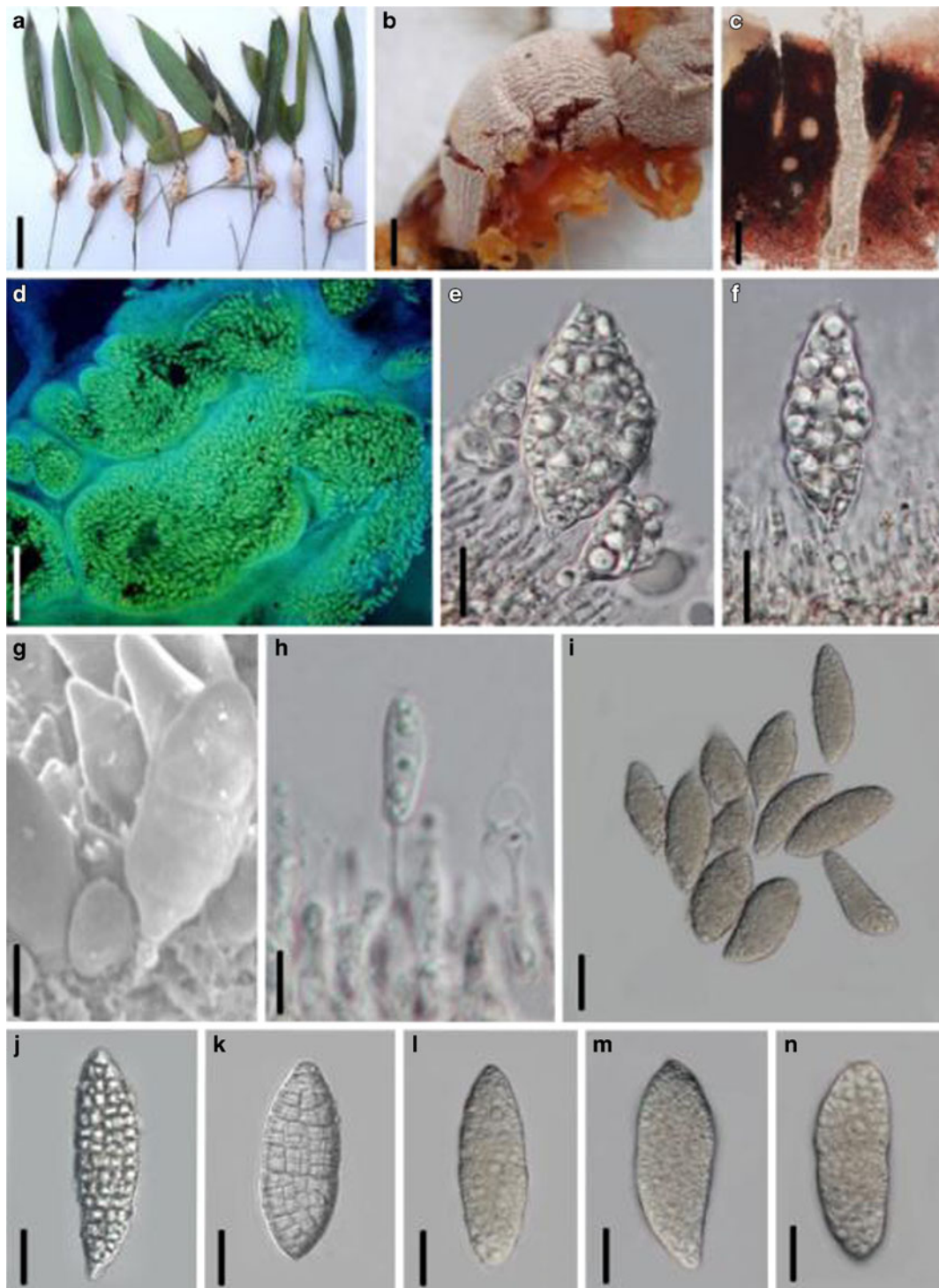


Fig. 114 *Shiraia bambusicola* (MFLU 12–2041). (a–f, h–n) light microscopy and **g** SEM, **epitype**. **a** Ascostromata of *S. bambusicola* on bamboo branches. Note that the ascostromata form at the end of branches, but below the leaf petioles. **b** Ascostroma of *S. bambusicola* with yellow

conidium mass. **c, d** Asexual locule (**d**: fluorescent microscopy stained in Hoechst 33258). **e–h** Conidiogenous cells and developing conidia. **i–n** Conidia Scale bars: **a** = 2 cm, **b** = 1 cm, **c** = 200 mm, **d** = 300 μ m, **e–g** = 20 μ m, **h** = 5 μ m, **i–n** = 20 μ m

somewhat diverging from the genus as having 29–32-celled ascospores with germ slits (Ahmed and Asad 1968).

Sporormia and *Sporormiella* were monographed by Ahmed and Cain (1972).

Type species: Sporormia fimetaria (Rabenh) De Not., *Micr. Ital. Novi* 5; 10 (1845), MycoBank: MB 144802

≡ *Sphaeria fimetaria* Rabenh., *Klotzschii Herb. Viv. Mycol., Edn 1: no. 1733* (1845)

Other genera included

Chaetopreussia Locq.-Lin., *Revue Mycol., Paris* 41 (2): 185(1977).

Type species: Chaetopreussia chadefaudii Locq.-Lin., *Revue Mycol., Paris* 41 (2): 187 (1977)

Pleophragmia Fuckel, *Jb. Nassau. Ver. Naturk.* 23– 24: 243 (1870) [1869–70]

Type species: Pleophragmia leporum Fuckel, *Jb. Nassau. Ver. Naturk.* 23– 24: 243 (1870) [1869–70]

Preussia Fuckel, *Hedwigia* 6: 175 (1867) [1869–70]

Type species: Preussia funiculata (Preuss) Fuckel, *Jb. Nassau. Ver. Naturk.* 23–24: 91 (1870) [1869–70]



Fig. 115 *Sporormia fimetaria* (Material examined: MFLU 12–2218). **a** Ascomata on natural substrate. **b** Cross section of ascoma. **c** Peridium. **d** Indistinct ostiole. **e** Surface of the ascoma. **f** Pseudoparaphyses. **g–i** Asci

in water. **j–k** Ascospores in water. Scale bars: **a** = 1,000 μm , **b** = 50 μm , **c–e** = 10 μm , **f–h** = 50 μm , **i–j** = 10 μm

Westerdykella Stolk, Trans. Br. Mycol. Soc. 38 (4): 422 (1955).

Type species: Westerdykella ornata Stolk, Trans. Br. Mycol. Soc. 38 (4): 422 (1955)

Key to genera of *Sporormiaceae*

1. Ascospores 1-celled, without germ slits, smooth or ornamented with spiral bands. Asci 32-spored subglobose to saccate. Ascomata cleistothecoid *Westerdykella*
1. Ascospores poly-celled, smooth. Asci 8– (rarely 4–) spored. Ascomata cleistothecoid or perithecioid 2
2. Ascospores muriform, without germ slits, each with a gelatinous sheath. Asci cylindrical-clavate to clavate. Ascomata perithecioid *Pleophragmia*
2. Ascospores transversely septate 3
3. Ascospores 16–32-celled, fasciculate, usually lacking germ slits, linked together by a common gelatinous sheath. Asci cylindrical. Ascomata ostiolate, although unclearly *Sporormia*
3. Ascospores not fasciculate but 2– or 3– (exceptionally 1–) seriate inside the asci, each with an individual gelatinous sheath or without a sheath. Asci cylindrical-clavate to broadly clavate 4
4. Ascospores 4-celled, without germ slits and sheaths. Ascomata cleistothecoid, hairy *Chaetopreussia*
4. Ascospores 4–13-celled, with germ slits and sheaths. Ascomata cleistothecoid and smooth, or perithecioid and sometimes with a hairy neck *Preussia*

Strigulaceae Zahlbr., in Engler, Syllabus, Edn 2 (Berlin): 46 (1898), MycoBank: MB 81870

Possible synonym:

Phyllobatheliaceae Bitter & F. Schill., Hedwigia, Beibl. 67: 272 (1927), MycoBank: MB 81159

Lichenized on leaves or more rarely on bark and rocks in terrestrial, chiefly lowland to montane tropical habitats, with few species extending into temperate regions. Sexual state: *Thallus* reduced and ecorticate, white, to distinctly corticate, grey-green to bright green, sometimes with metallic appearance. *Photobiont Trentepohlia* sensu lato (including *Cephaleuros* and *Phycopeltis*). *Ascomata* perithecia, scattered, clustered, or aggregated in pseudostromata, immersed to prominent (to sessile), mostly brown or black, but often covered by thallus, globose to pear-shaped or conical, coriaceous to carbonaceous, ostiolate, ostiole round. *Involucrellum* present in some genera, usually carbonized. *Excipulum* dense, consisting of compressed hyphae, appearing prosoplectenchymatous in thin, bleached sections, but structure sometimes difficult to observe due to carbonization, hyaline to brown or brown-black. *Hamathecium* comprising 0.5–0.7(–1.5) μm wide paraphyses, hyaline, flexuous, unbranched or rarely branched and sometimes anastomosing. *Asci* (1–)8-spored, bitunicate, fissitunicate, obclavate to

mostly cylindrical, short pedicellate, with narrow to broad, non-amyloid ocular chamber. *Ascospores* irregularly arranged to uni- or biseriate, fusiform to ellipsoid, hyaline, septate to muriform, with eusepta and rectangular lumina, smooth-walled, often constricted at the septa. Asexual state: *Pycnidia* common, immersed to erumpent, visible as black dots, sometimes in specific, pseudostromatic areas on fertile thalli, or whole thalli only producing pycnidia. *Conidia* acrogenous, either macro- or microconidia; macroconidia septate to muriform, ellipsoid to bacillar, sometimes becoming rather large, with gelatinous appendages, hyaline; microconidia usually non-septate, ellipsoid to fusiform, small, hyaline. *Chemistry*: Most species do not contain secondary substances. Crystalline anthraquinone pigments are found in *Flavobathelium*.

Notes: Strigulaceae was originally introduced to include all pyrenocarpus lichens growing on leaves (Zahlbruckner 1898). Notably, in doing so, Zahlbruckner separated foliicolous species of *Porina* as *Phylloporina* in *Strigulaceae*, whereas non-foliicolous species were kept by him as *Porina* sensu stricto in *Pyrenulaceae*, emphasizing the highly artificial nature of this classification. The circumscription and systematic placement of *Strigulaceae* has been much discussed in the literature. Santesson (1952) retained taxa with ascohymenial development and euseptate ascospores in the family, excluding some of Zahlbruckner's original elements, but keeping *Porina* sensu lato, aware of the heterogeneity of this group. Eriksson (1981) and Vězda (1984) provided the first natural circumscription of *Strigulaceae* and restricted it to three genera: *Strigula*, *Phylloporis* and *Raciborskiella*, the latter two now synonyms of *Strigula* (Harris 1995; Lücking 2008; McCarthy 2009). Harris (1995) suggested including *Phyllobathelium* and possibly even merging this genus with *Strigula*. Including *Phyllobathelium* in *Strigulaceae*, but keeping it separate from *Strigula*, was accepted by subsequent workers (Aptroot et al. 1997; Lücking 2008; McCarthy 2009), whereas Eriksson et al. (2004) and Eriksson (2005) placed the genus in its own family, *Phyllobatheliaceae*. Two new genera, *Phyllocratera* and *Flavobathelium*, were added (Aptroot et al. 1997; Lücking et al. 1997), and the family was further emended by adding non-foliicolous species, particularly in the genus *Strigula* (Harris 1995; McCarthy 1995, 1997). *Strigulaceae* was also disputed. While the family had been variously included in *Pyrenulales* and *Melanommatales* (= *Pleosporales*; Lumbsch and Huhndorf 2010), the first molecular approach (Schmitt et al. 2005) seemed to suggest placement of *Strigula stigmatella* in *Chaetothyriomycetidae*, more precisely in the *Verrucariaceae*. However, this was based on a misidentification of the sequenced specimen, which actually turned out to be a species of *Verrucaria* sensu lato close to *V. aquatilis* (Lücking et al., unpubl. data). The image of ascus and ascospores of *Strigula stigmatella* presented in Schmitt et al. (2005) is actually not based on

the sequenced specimen. This underlines that results from phylogenetic studies have to be interpreted with great care and verified by additional data. A broader approach including specimens of *Strigula*, *Phyllobathelium*, and *Flavobathelium* showed that *Strigulaceae* is monophyletic in its current sense and belongs in Dothideomycetes (Nelsen et al. 2009). The family does not belong to any orders within this class and represent which is introduced in this paper.

Generic delimitation in the family has not yet been tested with molecular data, but it seems that the bulk of foliicolous species currently assigned to *Strigula* (including *Phylloporis* and *Raciborskiella*) and *Phyllobathelium* each form monophyletic groups characterized by a number of phenotypic synapomorphies, such as thallus anatomy, perithecial arrangement and anatomy, and degree of development of an involucrellum, as well as conidial types and their appendages (Harris 1995; Lücking 2008; McCarthy 2009). The non-foliicolous species of *Strigula* are more difficult to assign to a specific clade without sequence data, and at least some of them might not represent genuine *Strigula* species but further, unrecognized genera within the family. On the other hand, *Phyllocratera*, which is here maintained as separate genus, could well be a muriform-spored representative of the group formerly separated as *Phylloporis* and hence belong in *Strigula* sensu stricto.

Strigulaceae thus presently includes four accepted genera and roughly 80 species, most of them assigned to *Strigula* (Harris 1995; Lücking 2008). The bulk of taxa are found growing on living leaves in tropical forests, but several species of *Strigula* grow exclusively on bark and rock surfaces (Harris 1995; McCarthy 1995, 1997, 2001, 2009).

Type: Strigula Fr., Syst. Mycol. (Lundae) 2(2): 535 (1823), MycoBank: MB 5285

Figure 116

Lichenized on leaves or more rarely on bark and rocks in terrestrial, lowland to lower montane tropical to subtropical and extending into temperate habitats. Sexual state: *Thallus* ecorticate or corticate, white to grey-green or bright green, in foliicolous species often subcuticular and sometimes damaging the supporting leaf. *Photobiont* *Trentepohlia* sensu lato (including *Cephaleuros* in subcuticular species). *Ascomata* perithecia, scattered, erumpent to prominent, usually black or covered by thallus layer, lens-shaped to wart-shaped or conical, usually carbonaceous, ostiolate, ostiole round. *Involucrellum* usually present and carbonized. *Excipulum* prosoplectenchymatous, dark brown to brown-black. *Hamathecium* comprising 0.5–0.7 μm wide paraphyses, hyaline, flexuose, unbranched or rarely branched and anastomosing. *Asci* usually 8-spored but sometimes appearing 9–16-spored due to ascospores breaking in halves within the asci, bitunicate, fissitunicate, cylindrical to narrowly obclavate, short pedicellate, with narrow, non-amyloid ocular chamber. *Ascospores* irregularly arranged to uni- or

biseriate, fusiform to ellipsoid or bacillar, hyaline, mostly 1-septate but in some species multiseptate or muriform, with thin eusepta and rectangular lumina, smooth-walled, often constricted (and sometimes breaking apart) at the septa. Asexual state: *Pycnidia* common, immersed to erumpent, visible as black dots, rarely in pseudostromatic areas, often whole thalli only producing pycnidia. *Conidia* acrogenous, either macro- or microconidia; macroconidia mostly 1-septate, ellipsoid to bacillar, with ciliate gelatinous appendages, hyaline; microconidia usually non-septate, ellipsoid to fusiform, small, hyaline. *Chemistry*: The known species do not contain secondary substances.

Notes: Strigula is a mostly tropical, lichenized genus of approximately 70 species found predominantly on leaves but also on bark and rock surfaces, in shaded to exposed situations. Many foliicolous species are subcuticular and can withstand desiccation and therefore dominate foliicolous lichen communities especially in drier forest vegetation (Lücking 2008). *Strigula* is in fact the most typical and most frequently encountered foliicolous lichen genus. A few species grow exclusively on the leaf underside; these have previously been recognized in a separate genus, *Raciborskiella*, but anatomically and morphologically they are not different from other *Strigula* species and in fact not closely related among each other (Harris 1995; Lücking 2008). The subcuticular species of *Strigula* are associated with a so-called *Cephaleuros* photobiont, which is a semi parasitic clade nested within *Trentepohlia* sensu lato (Nelsen et al. 2011a). These lichens can damage their supporting leaves to some extent (Lücking 2008). Another group of species, previously recognized as *Phylloporis*, grows supracuticularly with a different photobiont. These species seem to be closely related among each other, having very similar ascospore types and arrangement in the asci and similar perithecial anatomy; however, on account of their ascomatal features, they cannot be separated from *Strigula*, but rather form a clade nested within the latter.

Type species: Strigula smaragdula Fr., Linnaea 5: 550 (1830), MycoBank: MB 431363 [= *Strigula elegans* (Fée) Müll. Arg., Flora 63: 41 (1880). Notes: Even if the basionym of the latter name, *Phyllocharis elegans* Fée, was described prior to *S. smaragdula*, the latter takes precedence because of the sanctioning of fungal names used in works by Fries (Hawksworth and Eriksson (1986)].

Other genera included

Flabobathelium Lücking, Aptroot & Thor, Lichenologist 29: 221 (1997)

Type species: Flavobathelium epiphyllum Lücking, Aptroot & G. Thor, Lichenologist 29: 221 (1997)

Phyllobathelium (Müll. Arg.) Müll. Arg., Flora 73: 195 (1890), MycoBank: MB 4057 Fig. 117

Lichenized on leaves or rarely on bark in terrestrial, lowland to lower montane tropical to subtropical forests. Sexual

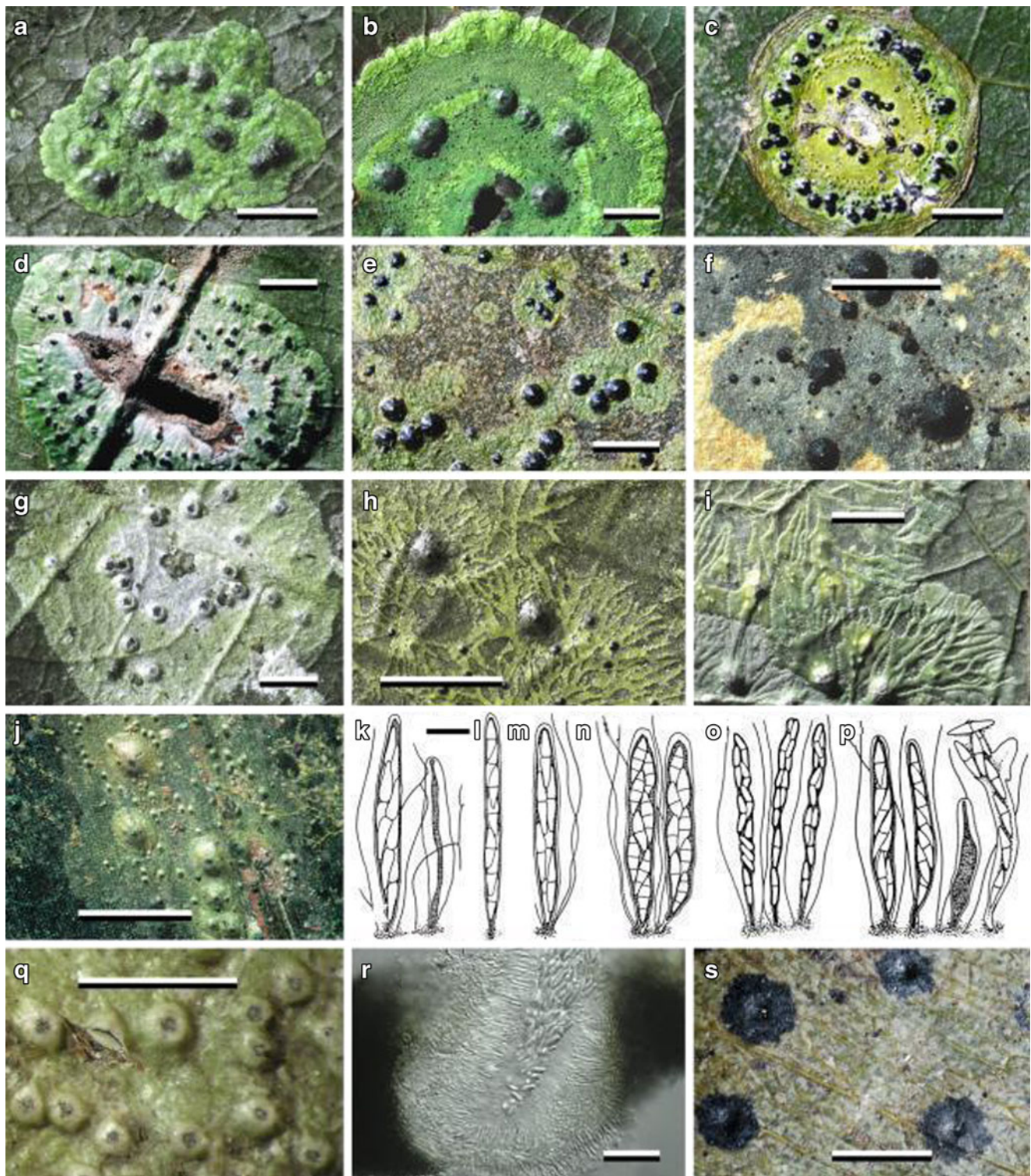


Fig. 116 *Strigula* and *Phyllocratera* a–j Thallus and ascomata. a *Strigula smaragdula*. b *S. macrocarpa*. c *S. schizospora*. d *S. microspora*. e *S. nitidula*. f *S. janeirensis*. g *S. orbicularis*. h *S. subtilissima*. i *S. nemathora*. j *S. viridis*. k Asci and ascospores of *S. janeirensis*. l Same, *S. macrocarpa*. m Same, *S. subtilissima*. n Same,

S. orbicularis. o Same, *S. schizospora*. p Same, *S. phyllogena*. q Pycnidia of undescribed *Strigula* sp. r Section through pycnidium of undescribed *Strigula* sp. s Thallus and perithecial ascomata of *Phyllocratera papuana*. Scale bars: a–j, q, s = 1 mm, k–p, r = 10 μm

state: *Thallus* corticate, grey-green with characteristic metallic appearance, often minutely verrucose. *Photobiont*

Trentepohlia. *Ascomata* perithecia, scattered, prominent to sessile, covered by thallus layer and often a thick medulla of

black, powdery crystals, wart-shaped, ostiolate, ostiole round. *Involucrum* reduced. *Excipulum* prosoplectenchymatous, colourless. *Hamathecium* comprising 1.5–2 μm wide paraphyses, hyaline, flexuose, unbranched to sparsely branched. *Asci* 8-spored, bitunicate, fissitunicate, broadly cylindrical, short pedicellate, with broad, non-amyloid ocular chamber. *Ascospores* irregularly arranged to uni- or biseriata, fusiform to ellipsoid, hyaline, muriform, with thin eusepta and rectangular lumina, smooth-walled, often constricted at the septa. Asexual state: *Pycnidia* common, immersed, visible as brown to black dots in flat to conical, pseudostromatic areas filled with black, powdery crystals, often whole thalli only producing pycnidia. *Conidia* acrogenous, only macroconidia known; macroconidia septate to muriform, ellipsoid to bacillar, with ciliate gelatinous appendages, hyaline. *Chemistry*: Unidentified black, powdery crystals in ascomata warts and pycnidial pseudostromata.

Notes: A tropical, lichenized genus found on living leaves, usually in semi-exposed situations in tropical rain forests. *Phyllobathelium* is easily recognized by its comparatively large thalli (for a foliicolous lichen) with metallic appearance. Its most notable features are the abundant pycnidia formed on the thalli and the large, muriform conidia produced by some species. The conidia produced by *P. thaxteri* (Vain.) Zahlbr. are by far the largest conidia known among the Fungi, being up to $220 \times 35 \mu\text{m}$. The large conidia were originally mistaken for single-spored asci and the perithecial and conidial forms were considered separate species, *P. megapotamicum* and *P. thaxteri* (Santesson 1952; Lücking 2008).

Type species: *Phyllobathelium epiphyllum* (Müll. Arg.) Müll. Arg., Flora, Jena 73: 195 (no. 1547) (1890)

Phyllocratera Sérus. & Aptroot in Aptroot, *Bibliotheca Lichenol.* 64: 132 (1997)

Type species: *Phyllocratera papuana* Sérus. & Aptroot, in Aptroot, *Bibliotheca Lichenol.* 64: 132 (1997)

Key to genera of *Strigulaceae*

1. Ascomata in pseudostromatic areas filled with ochraceous-yellow, K + blood-red crystals *Flavobathelium*
1. Ascomata exposed or covered by thin thallus layer or in thallus warts filled with black, powdery crystals 2
2. Ascospores transversely septate; paraphyses less than 1 μm thick; perithecia never in thallus warts filled with black, powdery crystals *Strigula*
2. Ascospores muriform; paraphyses less than 1 μm thick and then perithecia exposed or covered by thin thallus layer; or paraphyses 1–2 μm thick and then perithecia in thallus warts filled with black, powdery crystals 3
3. Ascomata in thallus warts filled with black, powdery crystals; paraphyses 1–2 μm thick *Phyllobathelium*
3. Ascomata exposed or covered by thin thallus layer; paraphyses usually less than 1 μm thick 4

4. Growing on leaves *Phyllocratera*
4. Growing on bark or rocks *Strigula*

Sympoventuriaceae Ying Zhang et al., Fungal Divers. 51(1): 253 (2011), MycoBank: MB 563117

Saprobic on upper surface of leaves. Sexual state: *Ascomata* pseudothecia, solitary or aggregated, immersed in host tissue, becoming erumpent and raising the host cuticle at maturity, subglobose globose, substomatal, subepidermal, inconspicuous; walls pigmented; papillate, ostiolate. *Peridium* thick-walled, composed of 2–3 layers of brown to dark brown *textura angularis*. *Hamathecium* of 2 μm , septate, hyaline pseudoparaphyses, anastomosing between and above the asci, constricted at the septa. *Asci* 8-spored, bitunicate, fissitunicate, subcylindrical, pedicellate. *Ascospores* crowded or partially overlapping in asci, symmetrical, fusoid-ellipsoidal, hyaline, medianly 1-septate, constricted at the septum, widest in the middle of each cell, guttulate, smooth to slightly rough end. Asexual states: “*Sympodiella*”-like, “*Fusicladium*”-like, *Veronaeopsis*. *Mycelium* forming a superficial network with pigmented, thin-to thick-walled, smooth, septate, anastomosing hyphae. *Conidiogenous cells* integrated, mono- or polyblastic, sympodial, with inconspicuous scars. *Conidiophores* septate, solitary, producing conidial chains with up to 20 conidia. *Conidia* thin-walled, 1–5 septate, in unbranched chains on terminal portion of the conidiophores, cylindrical at maturity, with truncate ends, hyaline to pale brown, smooth, with inconspicuous scars, finely guttulate or not.

Notes: The genus *Sympoventuria* was originally collected on leaf litter of *Eucalyptus* from the Western Cape Province of South Africa (Crous et al. 2007a). It was placed in the *Venturiales* based on morphological and DNA phylogenetic data. Although morphologically similar to *Venturia*, it is phylogenetically distinct, and also has asexual morphs typical of the *Venturiaceae* (Crous et al. 2007b). Zhang et al. (2011a) established the *Sympoventuriaceae*, which contains *Sympoventuria*, the asexual genus *Veronaeopsis* and “*Fusicladium*”-like species. *Sympoventuria* is the only monotypic ascomycetous genus in the *Sympoventuriaceae*, distinguished from the *Venturiales* by its saprobic habitat, pseudoparaphyses, and hyaline, symmetrical ascospores. The asexual morph of *Sympoventuria* was described as “*Sympodiella*”-like by Crous et al. (2007b).

Type: *Sympoventuria* Crous & Seifert, in Crous et al., Fungal Divers 25: 31 (2007), MycoBank: MB 563117

Type species: *Sympoventuria capensis* Crous & Seifert, in Crous et al., Fungal Divers. 25: 32 (2007) (Fig. 118)

Teichosporaceae M.E. Barr, Mycotaxon 82: 374 (2002), MycoBank: MB 82136

Saprobic on wood, herbaceous roots, rhizomes, stout culms, or hypersaprotrophic on other ascomycetes. Sexual state: *Ascomata* initially immersed, becoming erumpent to

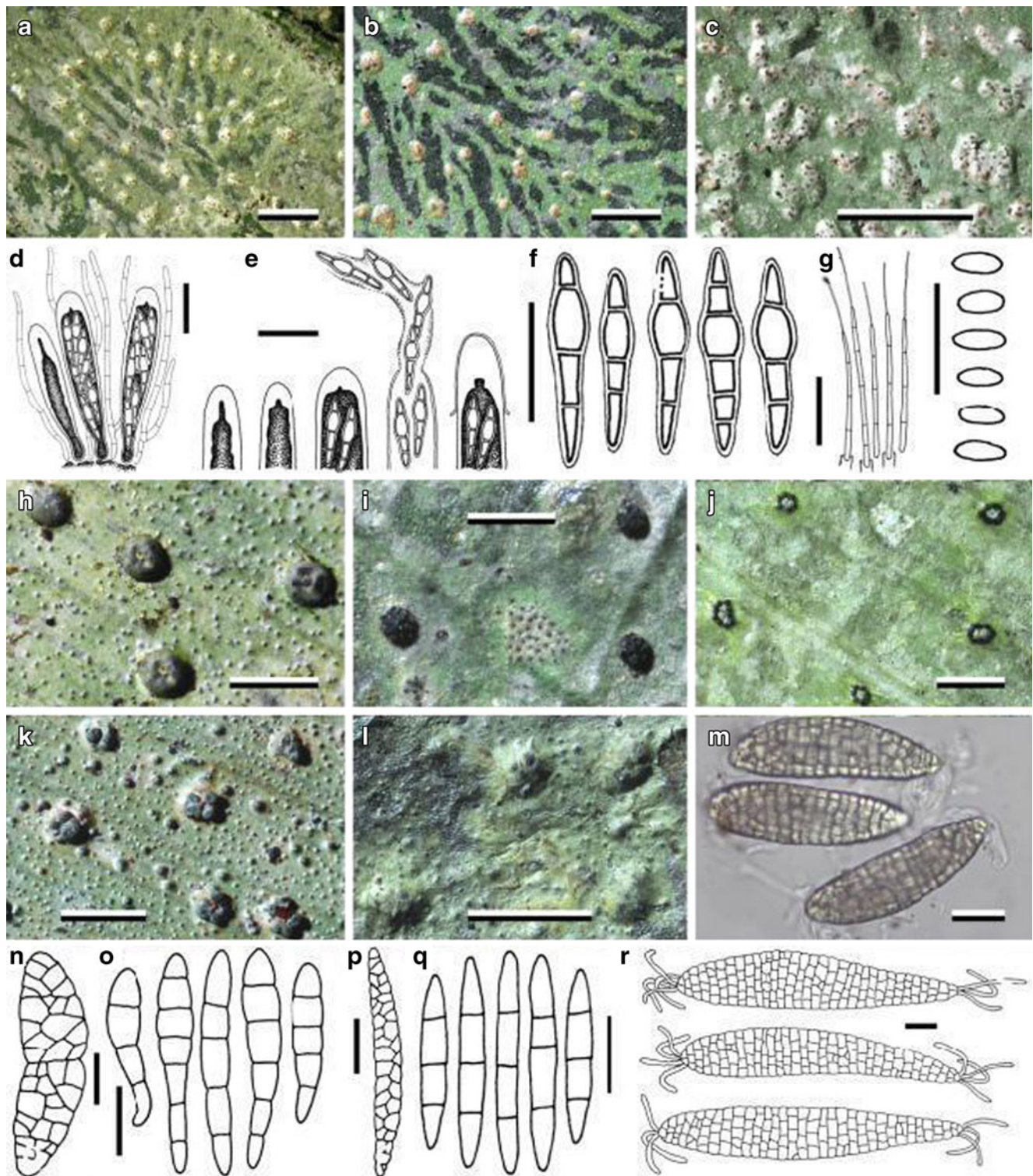


Fig. 117 *Flavobathelium* and *Phyllobathelium*. **a–b** Thallus and pseudostromatic ascomata of *Flavobathelium epiphyllum*. **c** Pseudostromatic pycnidia. **d** Paraphyses, asci and ascospores. **e** Ascus tips of developing, mature and ascospore-extruding asci. **f** Ascospores. **g** Macro- (left) and microconidia (right). **h** Thallus and perithecial warts of *Phyllobathelium firmum*. **i** Exposed ascomata and pseudostromatic

pycnidia of *P. leguminosae*. **j** Pseudostromatic pycnidia of *P. nigrum*. **k** Ascoma warts and pseudostromatic pycnidia of *P. thaxteri*. **l** Pseudostromatic pycnidia enlarged. **m** Macroconidia. **n–o** Ascospores and macroconidia of *P. firmum*. **p–q** Ascospores and macroconidia of *P. leguminosae*. **r** Macroconidia of *P. thaxteri*. Scale bars: **a–c, h–l** = 1 mm, **d–g, m–r** = 10 μ m

superficial, dark brown to black, generally medium sized, rarely large, perithecial, obpyriform, ovoid or globose, ostiolate, smooth. *Ostiole* apex wide, bluntly papillate, pore rounded, ostiolar canal filled with periphyses, white, yellowish or reddened at times, smooth or roughened, with protruding cells or hyphal appendages. *Peridium* usually 3-layered, outermost layer consisting of small, loosely arranged cells, often thick-walled, highly pigmented with melanin, reddish brown or black, middle layer composed of small cells with thickened walls, lumina narrow, often visible towards the apex, innermost layer consisting of narrow, compressed rows of cells. *Hamathecium* comprising numerous, hyaline, narrowly septate pseudoparaphyses, rarely embedded in gel matrix. *Asci* 4–8-spored or multi-spored, bitunicate, fissitunicate, cylindrical to oblong or occasionally clavate, pedicellate, inner wall narrow in apical region, with a minute ocular chamber. *Ascospores* uniseriate, or partially overlapping biseriate, hyaline, brown or versicolorous, fusoid or ellipsoid, symmetric or asymmetric, aseptate, multi-septate or muriform, with smooth or verruculose wall, rarely with a gelatinous sheath. Asexual states: “Aposphaeria”-like or “Coniothyrium”-like.

Notes: The family *Teichosporaceae* was proposed by Barr (2002) in the order *Pleosporales* to accommodate eight genera most of which were previously assigned to *Dacampiaceae* based on their peridium structure, ascus morphology and tropic states. Most members of *Dacampiaceae* are lichenicolous, so Barr introduced *Teichosporaceae* in order to segregate some saprotrophic taxa in woody stems or hypersaprotrophic on other ascomycetes, from *Dacampiaceae* (Barr 2002). Four families of *Pleosporales* possess ascomata with a three layered peridium. Among them are *Hysteriaceae* and *Cucurbitariaceae* but they differ in the opening of the ostiole. *Hysteriaceae* produce a longitudinal slit to release the spores while *Cucurbitariaceae* have an apex which opens by a minute ostiole. *Teichosporaceae* and *Montagnulaceae* generally have a thick medium layer in the peridium above the hymenium, but they differ in the placement and the structure of the ascomata and the structure of the ostiole. *Montagnulaceae* has immersed, globose ascomata with a short and well-developed papillate ostiole, while *Teichosporaceae* produce erumpent to superficial ascomata with a wide blunt papillate ostiole (Barr 2002). Currently, the family comprises *Chaetomastia*, *Immothia*, *Loculohypoxylon*, *Sinodidymella* and *Teichospora*. *Moristroma*, *Byssothecium* and *Bertiella* (once included in *Teichosporaceae*) have been referred to *Chaetothyriomycetidae*, *Massariaceae* and *Melanommataceae*, respectively (Lumbsch and Huhndorf 2010). For better phylogenetic placement of this family, further molecular studies are needed because currently there are very few sequences available for *Teichosporaceae* in GenBank.

Type: *Teichospora* Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 160 (1870) [1869–70], MycoBank: MB5360

Saprobic on wood. Sexual state: *Ascomata* solitary or scattered, semi-immersed, globose to subglobose, dark brown to black, smooth, coriaceous, ostiolate. *Ostiole* long broad neck with an elongated furrow at the top, ostiolar canal filled with tissue of hyaline cells. *Peridium* of three layers, outermost layer consisting of small, thick-walled, highly pigmented with melanin, or reddish brown or black, loosely arranged cells of *textura angularis*, middle layer composed of small cells with thickened walls, often visible toward apex, innermost layer consisting of narrow, dark brown to black, compressed rows of cells of *textura angularis*. *Hamathecium* of dense, ca. 2 μ m wide septate, narrow, hyaline, pseudoparaphyses, lacking a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, clavate to cylindrical, pedicel short and furcate, rounded at apex with a minute ocular chamber. *Ascospores* uniseriate or overlapping biseriate, ellipsoidal with broadly rounded ends, brown to chestnut brown, with three transverse septa, but when mature longitudinal septa appear in each cell, muriform, slightly constricted at the septa, smooth, thin-walled, without a sheath. Asexual states: Unknown.

Notes: *Teichospora* was introduced by Fuckel (1870), and was typified by *T. trubicola*, with four more species included, i.e. *T. brevisporis* Fuckel, *T. dura* Fuckel, *T. morthieri* Fuckel and *T. obducens* (Schumach.) Fuckel. Only *T. brevisporis* and *T. trubicola* are retained in *Teichospora* (Barr 1987b; Zhang et al. 2012a, b). Hawksworth et al. (1995) placed this genus under *Dothideales incertae sedis*, while von Arx and Müller (1975) referred *Teichospora* to the *Pleosporaceae*, and typified *Teichospora* by *T. obducens* (Barr 2002). Saccardo (1883) initially treated *Teichospora* species under three subdivisions i.e. *Euteichospora*, *Strickeria* and *Teichosporella* (Routien 1958). Later, he differentiated *Teichospora* from *Strickeria*, and placed it in *Pleosporales*, while *Strickeria* was classified in *Melanommatales*. Wehmeyer (1948) suggested that most of the characters of the genus *Pleospora* were shared with *Teichospora*, which is probably derived from *Pleospora*. Further *Teichospora* species have been described i.e. *T. hesperia* Barr, *T. borealis* Ellis & Everh., *T. solitaria* Ellis. *Teichospora clavispora* Ellis & Everh. was reduced to synonymy with *Lophidium pachystoma* Ellis & Everh. and assigned to the *Lophiostomataceae*, a family in the *Melanommatales* (Barr and Huhndorf 2001). Currently, the genus comprises more than 250 species epithets listed in the Index Fungorum (2013), but only five hits are available in GenBank and no molecular phylogenetic work has been reported for this genus and placement of this taxon requires a molecular and phylogenetic study.

Type species: *Teichospora trubicola* Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 161 (1870) [1869–70], MycoBank: MB 180961 (Fig. 119).

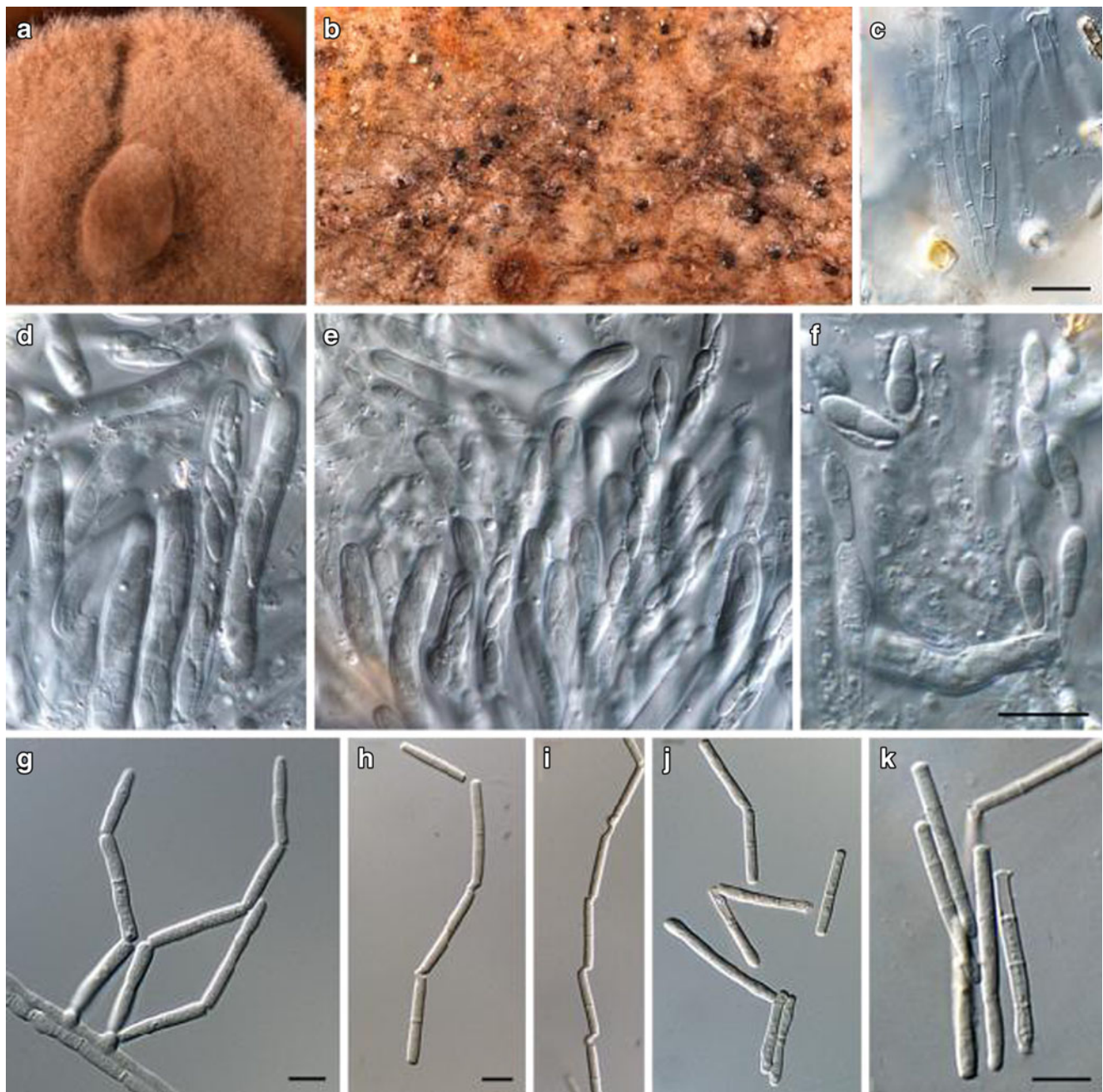


Fig. 118 *Sympoventuria capensis* (CBS-H 19757, CBS 120136). **a** Colony on PDA. **b** Ascomata in host tissue. **c** Pseudoparaphyses. **d–f** Asci and ascospores. **g–k** Catenulate conidia and conidiogenous cells. Scale bars=10 μ m

Other genera included

Chaetomastia (Sacc.) Berl., Icon. fung. (Abellini) 1(1): 38 (1891)

Type species: Chaetomastia hirtula (P. Karst.) Berl., Icon. fung. (Abellini) 1(1): 38 (1891).

Loculohypoxylon M.E. Barr, Mycotaxon 3(3): 326 (1976)

Type species: Loculohypoxylon grandineum (Berk. & Ravenel) M.E. Barr, Mycotaxon 3(3): 326 (1976)

Sinodidymella J.Z. Yue & O.E. Erikss., Mycotaxon 24: 295 (1985)

Type species: Sinodidymella verrucosa (Petr.) J.Z. Yue & O.E. Erikss., Mycotaxon 24: 295 (1985)

Key to the genera of Teichosporaceae

1. Ascospores without septa*Loculohypoxylon*
1. Ascospores with septa2
2. Ascospores with a single transverse septum ...*Sinodidymella*
2. Ascospores with more than one transverse septa3
3. Ascospores brown with 2 or many transverse septa*Chaetomastia*
3. Ascospores brown, muriform*Teichospora*



Fig. 119 *Teichospora trabicola* (Material examined: GERMANY, Hessen, Oestrich (Nassau), on *Quercus* poles, Fuckel, BPI 626159, **type**). **a** Herbarium package and material. **b–c** Ascomata on host substrate. **d–e** Section of ascoma. **f** Peridium. **g** Broad, hyaline pseudoparaphyses. **h–k**

Asci with short, broad pedicel bearing eight ascospores. **l–p** Smooth-walled muriform ascospores. Scale bars: **d–e** = 100 μ m, **f** = 20 μ m, **g** = 5 μ m, **h–l** = 20 μ m, **m–p** = 10 μ m

Teratosphaeriaceae Crous & U. Braun, Stud. Mycol. 58: 8 (2007), MycoBank: MB 504465

Saprobic or *pathogenic* on leaves and stems of various hosts. Sexual state: *Ascomata* pseudothecial, immersed to superficial, frequently situated in a stroma of brown pseudoparenchymatal tissue, globose, unilocular, papillate, ostiolate. *Ostiolar canal* periphysate. *Peridium* comprising several layers of brown-walled cells of *textura angularis*, inner layer comprising flattened, hyaline cells. *Hamathecium* mostly absent, when present consisting of subcylindrical, branched, septate, anastomosing pseudoparaphyses. *Asci* 8-spored, bitunicate, frequently with multi-layered endotunica, sessile, obclavate to globose or saccate, pedicellate, narrowing to a rounded and slightly thickened apex, ocular chamber mostly

well defined. *Ascospores* multi-seriate, ellipsoid-fusoid to obovoid, 1-septate, hyaline, but becoming pale brown and verruculose, frequently covered in mucoid sheath. Asexual states: Hyphae submerged to superficial, disarticulating or not into arthroconidia, or forming endoconidia, pale to dark brown, thick-walled, sphaerical or cylindrical, smooth to verruculose. *Conidiomata* pycnidial to acervular, well-developed, enclosed by host tissue or erumpent, brown to black, fasciculate to sporodochial or solitary. *Conidiophores* absent or short, brown, subcylindrical, solitary, with or without penicillate, branched or unbranched conidiogenous apparatus, fasciculate to synnematosus or sporodochial. *Conidiogenous cells* integrated in hyphae or in the distal ends of hyphae, holoblastic-thalloblastic, uniloculate, with conspicuous

annellations or periclinal thickening. *Conidia* in chains, holoblastic, solitary, on indistinct to well defined phialides on hyphae, thick-walled, smooth, brown, with or without hyaline basal appendages, aseptate or transversely or uniformly septate, conidia with subtruncate ends, smooth to verruculose, ellipsoidal to subglobose or globose to subcylindrical, with dehiscence scars on conidial body (Crous et al. 2007a, b, c, 2009b).

Notes: *Teratosphaeriaceae* was introduced by Crous et al. (2007a) based on ascospore morphology, culture characteristics, associated asexual states (Crous et al. 2009b) and its phylogenetic position within the *Capnodiales*, with some genera causing important diseases (Crous et al. 2007a). *Teratosphaeriaceae* is presently too broadly defined and comprises several unresolved lineages (Crous et al. 2009c). This family contains saprobes (*Catenulostroma* spp.), and halophilic, hyperhydrotic or lipophilic species that have been reported from humans (*Piedraia*, *Hortaea*, *Penidiella*, *Stenella*) (de Hoog et al. 2000; Bonifaz et al. 2008; Plemenitaš et al. 2008), with the most derived clades tending to contain plant pathogens (*Parapenidiella*, *Readeriella*, *Teratosphaeria*) (Crous et al. 2009c). Crous et al. (2009a) accepted nine genera in *Teratosphaeriaceae*, namely *Baudoinia*, *Capnobotryella*, *Catenulostroma*, *Devriesia*, *Penidiella*, *Phaeothecoidea*, *Readeriella*, *Staninwardia* and *Teratosphaeria* based on DNA sequence data derived from the LSU gene. Crous et al. (2009b) described many new species in *Teratosphaeriaceae* based on multi-genes sequence data and morphology of asexual states, including *Penidiella pseudotasmansiensis* Crous, *P. tenuiramis* Crous & Summerell, *Phaeothecoidea intermedia* Crous & Summerell, *P. minutispora* Crous & Summerell, *Readeriella angustia* Crous & Summerell, *R. eucalyptigena* Crous & Summerell, *R. menaisensis* Crous & Summerell, *R. pseudocallista*, *R. tasmanica*, *Teratosphaeria alboconidia* Crous & Summerell, *T. complicata* Crous & Summerell, *T. majorizuluensis*, *T. miniata*, *T. profusa* on *Eucalyptus* from Australia, and *Teratosphaeria xenocryptica* Crous & M.J. Wingf. from Chile. The genera and asexual states in this family are polyphyletic, further studies are required to resolve its status (Binder et al. in prep.).

Type: *Teratosphaeria* Syd. & P. Syd. *Annls mycol.* 10(1): 39 (1912), MycoBank: MB 5377

Possible synonyms:

Colletogloeopsis Crous & M.J. Wingf., *Can. J. Bot.* 75(4): 668 (1997)

Kirramyces J. Walker, B. Sutton & Pascoe, *Mycol. Res.* 96(11): 919 (1992)

Pathogenic on leaves. *Stromata* consisting of brown, septate hyphae, superficial or immersed in host tissue, at times linking ascomata together. Sexual state: *Ascomata* separate or immersed in densely branched fibrils, arranged under a brown, flattened, root-like stroma in the leaf surface, subglobose to globose, black,

uniloculate, thick-walled, with well-developed ostiolar periphyses, somewhat pseudoparaphysoidal in immature ascomata. *Peridium* thick-walled, comprising 2–3 brown cell layers of *textura angularis*; inner cells of flattened, hyaline cells. *Hamathecium* when present consisting of subcylindrical, branched, septate pseudoparaphyses, or reduced to hyaline periphysoids lining the ostiole. *Asci* 8-spored, bitunicate with endotunica, sessile or short pedicellate, clavate, apex rounded or tapered, with ocular chamber. *Ascospores* overlapping, fusiform to cylindrical, 1-septate, slightly constricted at the septum or not, often curved, rounded on both sides and upper cell slightly obtuse, rough and thick-walled, hyaline to brown. Asexual state: hyphae dark brown, septate, branched, mostly immersed. *Conidiomata* acervular to sporodochial, well-developed or reduced, solitary, brown, with pseudoparenchymatal wall. *Conidiogenous cells* integrated, terminal or reduced to conidiogenous cells, proliferating percurrently and sympodially. *Conidia* verruculose, thin- to thick-walled, brown, with dehiscence scars on conidial body (Crous et al. 2009b).

Notes: *Teratosphaeria* was introduced by Sydow and Sydow (1912) with *T. fibrillosa* as the type species which is associated with leaves of *Protea grandiflora* (= *P. nitida*) (Taylor et al. 2003). *Teratosphaeria* can be distinguished from *Mycosphaerella* species based on its asci with multi-layered endotunica, ascospores that darken in older asci and frequently upon germination, and associated asexual genera. Taylor et al. (2003) reduced *Teratosphaeria* to synonymy with *Mycosphaerella* based on ITS DNA sequence data, while LSU sequence data generated by Crous et al. (2007a) provided the first evidence that *Mycosphaerella* was polyphyletic, and split this complex into several families and numerous genera. Cortinas et al. (2006) treated the species associated with stem cankers of *Eucalyptus*. Numerous species are associated with stem cankers and defoliation of *Eucalyptus* plantations worldwide, as recently reported from Uruguay (Pérez et al. (2009) Australia (Carnegie et al. 2011) and Brazil (Teodoro et al. 2012).

Type species: *Teratosphaeria fibrillosa* Syd. & P. Syd. *Annls mycol.* 10(1): 39 (1912), MycoBank: MB 245140 (Fig. 120)

Other genera included in *Teratosphaeriaceae*

Acidomyces B.J. Baker et al., ex Selbmann et al., *Stud. Mycol.* 61: 16 (2008)

Type species: *Acidomyces acidophilus* (Sigler & J.W. Carmich.) Selbmann et al., *Stud. Mycol.* 61: 17 (2008)

Batcheloromyces Marasas et al., *Jl S. Afr. Bot.* 41(1): 41 (1975)

Type species: *Batcheloromyces proteae* Marasas et al., *Jl S. Afr. Bot.* 41(1): 43 (1975)

- Baudoinia** J.A. Scott & Unter., in Scott et al., *Mycologia* 99(4): 594 (2007)
Type species: Baudoinia compniacensis (Richon) J.A. Scott & Unter., in Scott et al., *Mycologia* 99(4): 594 (2007)
- Camarosporula** Petr., *Sydowia* 8(1–6): 99 (1954)
Type species: Camarosporula persoonii (Henn.) Petr., *Sydowia* 8(1–6): 99 (1954)
- Capnobotryella** Sugiy., *Pleomorphic Fungi: The Diversity and its Taxonomic Implications* (Tokyo): 148 (1987)
Type species: Capnobotryella renispora Sugiy., in Sugiyama & Amano, *Pleomorphic Fungi: The Diversity and its Taxonomic Implications* (Tokyo): 148 (1987)
- Catenulostroma** Crous & U. Braun, in Crous et al., *Stud. Mycol.* 58: 13 (2007)
Type species: Catenulostroma protearum (Crous & M.E. Palm) Crous & U. Braun, in Crous et al., *Stud. Mycol.* 58: 17 (2007)
- Devriesia** Seifert & N.L. Nick., in Seifert et al., *Can. J. Bot.* 82(7): 919 (2004)
Type species: Devriesia staurophora (W.B. Kendr.) Seifert & N.L. Nick., in Seifert et al., *Can. J. Bot.* 82(7): 919 (2004)
- Elasticomyces** Zucconi & Selbmann, in Selbmann et al., *Stud. Mycol.* 61: 11 (2008)
Type species: Elasticomyces elasticus Zucconi & Selbmann, *Stud. Mycol.* 61: 11 (2008)
- Friedmanniomyces** Onofri, in Onofri et al., *Nova Hedwigia* 68(1–2): 176 (1999)
Type species: Friedmanniomyces endolithicus Onofri, *Nova Hedwigia* 68(1–2): 177 (1999)
- Hispidiconidioma** Tsuneda & M.L. Davey, *Botany* 88: 473 (2010)
Type species: Hispidiconidioma alpinum Tsuneda & M.L. Davey [as ‘alpina’], *Botany* 88(5): 473 (2010)
- Hortaea** Nishim. & Miyaji, *Jap. J. med. Mycol.* 26(2): 145 (1984)
Type species: Hortaea werneckii (Horta) Nishim. & Miyaji, *Jap. J. Med. Mycol.* 26(2): 145 (1984)
- Mycophycias** Kohlm. & Volkm.-Kohlm., *Syst. Ascom.* 16(1–2): 2 (1998)
Type species: Mycophycias ascophylli (Cotton) Kohlm. & Volkm.-Kohlm., *Syst. Ascom.* 16(1–2): 3 (1998)
Notes: Mycophycias ascophylli (Cotton) Kohlm. & Volkm.-Kohlm. (= *Mycosphaerella ascophylli*) was referred to the *Verrucariales* by Kohlmeyer and Volkmann-Kohlmeyer (1998a) based periphysate ostioles and periphysoids arising from the upper peridium and its mycophyobioses with marine macroalgae. Molecular data places this genus in the *Capnodiales* and the family *Teratosphaeriaceae* with high support (Toxopeus et al. 2011).
- Parapendiella** Crous & Summerell, *Persoonia* 29: 185 (2012)
Type species: Parapendiella pseudotasmaniensis (Crous) Crous, *Persoonia* 29: 185 (2012)
- Pendiella** Crous & U. Braun, in Crous et al., *Stud. Mycol.* 58: 17 (2007)
Type species: Pendiella columbiana Crous & U. Braun, *Stud. Mycol.* 58: 18 (2007)
- Phacellium** Bonord., in Rabenhorst, *Fungi europ. exsicc.*, Edn 2, ser. 2: no. 288 (1860)
Type species: Phacellium dishonestum Bonord., in Rabenhorst, *Fungi europ. exsicc.*, Edn 2, ser. 2: no. 288 (1860)
Notes: Crous et al. (2009a) showed that ‘Phacellium’ paspali (“Phacellium”-like) belongs in the *Teratosphaeriaceae*.
- Phaeothecoidea** Crous, *Fungal Divers.* 26(1): 171 (2007)
Type species: Phaeothecoidea eucalypti Crous & Summerell, *Fungal Divers.* 26(1): 171 (2007)
- Pseudoramichloridium** Cheew. & Crous, *Persoonia* 23: 75 (2009)
Type species: Pseudoramichloridium henryi Cheew. & Crous, *Persoonia* 23: 75 (2009)
- Pseudotaeniolina** J.L. Crane & Schokn., *Mycologia* 78(1): 88 (1986)
Type species: Pseudotaeniolina convolvuli (Esfand.) J.L. Crane & Schokn., *Mycologia* 78(1): 88 (1986)
- Readeriella** Syd. & P. Syd., *Annls mycol.* 6(5): 484 (1908)
Type species: Readeriella mirabilis Syd. & P. Syd., *Annls mycol.* 6(5): 484 (1908)
Notes: Crous et al. (2009a) showed that Readeriella has “Teratosphaeria”-like sexual states, but represented a genus distinct from *Kirramyces*, in contrast to an earlier view on this generic complex (Crous et al. 2007a). At the same time they synonymized *Nothostrasseria* and *Cibiessia* under *Readeriella*.
- Recurvomyces** Selbmann & de Hoog, *Stud. Mycol.* 61: 10 (2008)
Type species: Recurvomyces mirabilis Selbmann & de Hoog, *Stud. Mycol.* 61: 11 (2008)
- Staninwardia** B. Sutton, *Trans. Br. mycol. Soc.* 57(3): 540 (1971)
Type species: Staninwardia breviscula B. Sutton, *Trans. Br. mycol. Soc.* 57(3): 541 (1971)
- Stenella** Syd., *Annls mycol.* 28(1/2): 205 (1930)
Type species: Stenella araguata Syd., *Annls mycol.* 28(1/2): 205 (1930)
Notes: Arzanlou et al. (2007, 2008) showed that the type of Stenella, S. araguata, clusters in the Teratosphaeriaceae. Most names described in Stenella in fact represent species of Zasmidium (Crous et al. 2009a).
- Xenoconiothyrium** Crous & Marinc., *Persoonia* 27: 20 (2011)
Type species: Xenoconiothyrium catenata Crous & Marinc., *Persoonia* 27: 42 (2011).



Fig. 120 *Teratosphaeria fibrillosa* (Material examined: SOUTH AFRICA, near Wellington, Bains Kloof, on living leaves of *Protea grandiflora*, 21 February 1912, E.M. Doidge (BPI 619596, **authentic specimen**). **a** Herbarium specimen. **b** Ascomata arranged under a brown flattened,

root-like stroma on the leaf surface. **c** Hyphae. **d** Vertical section through ascoma. **e** Peridium. **f–i** Asci. **j–n** Ascospores. Scale bars: **e** = 200 μm , **d** = 100 μm , **f–j** = 50 μm , **c, k–m** = 20 μm

Testudinaceae Arx, Persoonia 6(3): 366 (1971), MycoBank: MB 81456

Saprobic, isolated from soil, decaying plant material and woody substrata, in terrestrial and marine habitats. Sexual state: *Stromata* absent. *Ascomata* cleistothecial or perithecial, carbonaceous, dark brown to black, immersed, clypeate,

papillate, ostiolate or lacking ostiole, periphysate. *Peridium* composed of up to six layers, of thick-walled cells of *textura angularis*. *Hamathecium* comprising branched, septate pseudoparaphyses, evanescent to persistent. *Asci* 8-spored, thick-walled, bitunicate, fissitunicate, clavate to cylindrical, short pedicel, lacking an apical structure or with an ocular

chamber, evanescent to persistent. *Ascospores* uniseriate, relatively small, brown, 1-septate, verrucose to verruculose. Asexual state: Unknown.

Notes: The family *Testudinaceae* was introduced by von Arx (1971) to accommodate “astomatous ascomata with a dark peridium, which is often made up of plates, with bitunicate asci, and dark 2-celled ascospores, about 10 μ m long” and referred to the order *Pseudosphaeriales* (= *Pleosporales*). The type was *Testudina*, and *Argynna* (now in family *Argynnaceae*, Shearer and Crane 1980), *Lepidosphaeria*, *Neotestudina* and *Pseudophaeotrichum* (synonym of *Neotestudina* Hawksworth 1979) were considered related as they possessed ascomatous ascomata. Hawksworth and Booth (1974) regarded the *Testudinaceae* as a synonym of *Zopfiaceae*, but subsequently Hawksworth (1979) treated the *Zopfiaceae* as a synonym of *Testudinaceae* based on SEM studies of the ascospores. Eriksson (1981) accepted both families and *Zopfiaceae* was validated by Eriksson and Hawksworth (1992).

The distinguishing features between these two families are ascospores size and substrate. None of these opinions discussed above were based on molecular studies until Krus et al. (2006) examined the phylogenetic relationships of selected coprophilous *Pleosporales*. The ascomycetes *Lepidosphaeria nicotiae* Parg.-Leduc, *Neotestudina rosatii* Segretain & Destombes, *Ulospora bilgramii* (D. Hawksw. et al.) D. Hawksw. et al. and *Verruculina enalia* (Kohlm.) Kohlm. & Volkm.-Kohlm. formed a well-supported clade in *Pleosporales*, and were considered to share the following morphological features: dark, 1-septate ascospores with or without germ-pores, and with or without ornamentation. *Verruculina enalia* shares few characters with other members of the family and additionally is a marine species, while the other genera are terrestrial (Suetrong et al. 2009; Tanaka et al. 2009; Schoch et al. 2009a, b).

Other genera in the *Testudinaceae* include the monotypic genera *Lepidosphaeria* and *Ulospora*, while three species are found in *Neotestudina* (*N. cuninhamae* (D. Hawksw. & C. Booth) Arx & E. Müll., *N. diploidoides* M.E. Barr, *N. rosatii*). In the study by Suetrong et al. (2009), *Massarina ricifera*, an obligate marine ascomycete growing on *Juncus roemerianus*, forms a sister group to *U. bilgramii* and *N. rosatii*, with weak support. Schoch et al. (2009a) showed that another marine ascomycete, *Quintaria lignatilis* also groups in the *Testudinaceae*, and this is supported by Suetrong et al. (2009). Further taxon sampling is required to resolve the taxonomic placement of *Quintaria lignatilis* and *Massarina ricifera*, both with perithecial ascomata and cylindrical to clavate asci.

Type: *Testudina* Bizz., Atti Ist. Veneto Sci. lett. ed Arti, Sér. 3: 303 (1885), MycoBank: MB 5381

Possible synonym:

Marchaliella G. Winter ex E. Bommer & M. Rousseau, Bull. Soc. R. Bot. Belg. 29(1): 243 (1891)

Saprobic or *parasitic* on coniferous twigs. Sexual state: *Ascomata* superficial, scattered, or gregarious, globose, sphaerical or tuberous, not easily removed from the substrate, usually containing host particles, wall dark, carbonaceous. *Peridium* composed of thick-walled, brown cells in radiating rows. *Hamathecium* comprising septate, hyaline, pseudoparaphyses. *Asci* 8-spored, bitunicate, obovate, broadly clavate or sphaerical, rounded at the apex with a short pedicel. *Ascospores* uniseriate, brown, 1-septate, slightly constricted at the septum, composed of rounded cells, wall reticulate. Asexual state: Unknown.

Notes: A temperate ascomycete in terrestrial habitats, often under xeric conditions. This monotypic genus was introduced by Bizzozero (1885) with *T. terrestris* as the type species. The genus is characterized by its superficial carbonaceous ascomata, which are scattered or gregarious on host and reticulately ridged ascospores (Hawksworth 1979; Zhang et al. 2012a, b). The species is usually associated with other fungi, or on decaying wood and *Pinus* or on the fallen leaves of *Taxus* in Europe. This taxon has been previously referred to *Cephalothecaceae* (von Höhnelt 1917) and *Pseudeurotiaceae* (Malloch and Cain 1971). Because of its dark-walled ascomata and bitunicate asci with 1-septate dark ascospores, von Arx (1971) assigned *Testudina* to *Testudinaceae*. No molecular data is available for this genus (Schoch et al. 2009a, b; Suetrong et al. 2009). Fresh collections of species in the genus are needed so that molecular data can be used to confirm the natural taxonomic affinities of this genus.

Type species: *Testudina terrestris* Bizz., Fl. Ven. Funghi 3: 303 (1885), MycoBank MB 243476

Other genera included

Lepidosphaeria Parg.-Leduc, C. r. hebd. Séanc. Acad. Sci. Paris, Ser. D 270: 2784 (1970)

Type species: *Lepidosphaeria nicotiae* Parg.-Leduc, *Pubbl. Staz. Zool. Napoli*, I 270: 2784 (1970)

Neotestudina Segretain & Drestombes, C. r. hebd. Séanc. Acad. Sci. Paris 253: 2579 (1961)

Type species: *Neotestudina rosatii* Segretain & Drestombes, C. r. hebd. Séanc. Acad. Sci. Paris 253: 2579 (1961)

Ulospora D. Hawksw., Malloch & Sivan. Can. J. Bot. 57: 96 (1979)

Type species: *Ulospora bilgramii* (D. Hawksw., C. Booth & Morgan-Jones) D. Hawksw., Malloch & Sivan. Can. J. Bot. 57: 96 (1979)

Verruculina Kohlm. & Volkm.-Kohlm., Mycol. Res. 94(5): 689 (1990), MycoBank: MB 25469 Fig. 121

Saprobic on woody material, especially common on mangrove wood. *Ascomata* subglobose, ampulliform or depressed ellipsoidal, black, carbonaceous, partly or completely immersed, clypeate, solitary, ostiolate, papillate. Necks

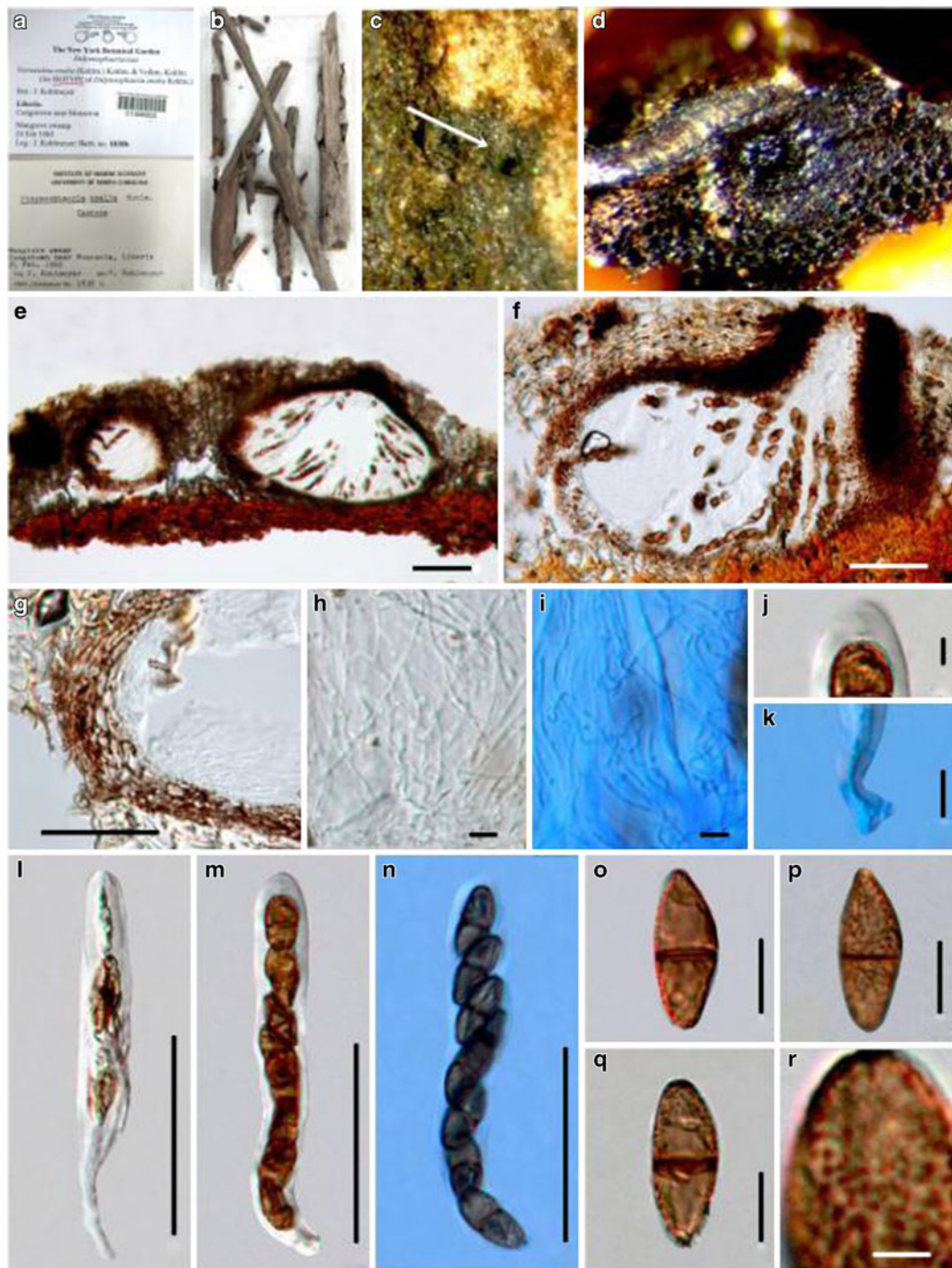


Fig. 121 *Verruculina enalia* (Material examined: LIBERIA, Paynesville, Congotown near Monrovia, on submerged wood in mangrove swamp, 24 February 1965, J. Kohlmeyer, NY0139820, **isotype** of *Didymosphaeria enalia*). **a, b** Herbarium specimens and packet. **c** Ascomata in woody tissue. **d–f** Section through ascomata. **g** Peridium. **h** Hamathecium of narrow pseudoparaphyses. **i** Hamathecium in

Lactophenol cotton blue reagent. **j** Ocular chamber of ascus. **k** Rounded pedicel. **l** Ascus when immature. **m** Asci at maturity. **n** Asci at maturity in Lactophenol cotton blue reagent. **o–q** Ascospores. **r** Verrucose wall of ascospore at maturity. Scale bars: **e** = 100 μm , **g** = 50 μm , **h–k** = 10 μm , **l–n** = 50 μm , **o–q** = 10 μm , **r** = 2 μm

relatively long, periphysate. *Peridium* thick, one-layered, composed of about six or more layers of irregular roundish

or elongate, thick-walled cells, forming a *textura angularis*. *Hamathecium* comprising rarely branched, septate, 1.5–2 μm

diam pseudoparaphyses. *Asci* 8-spored, thick-walled, bitunicate, cylindrical, persistent, pedicellate. *Ascospores* uniseriate, dark brown, ellipsoidal, 1-septate, constricted at the septum, verrucose to verruculose, sometimes with a distinct small, hyaline tubercle at each apex, probably a germ pore. *Asexual state*: Unknown.

Notes: Molecular data place *Verruculina* in the *Testudinaceae* (Kruijs et al. 2006; Schoch et al. 2006, 2009a) and this is supported by a recent study by Suetrong et al. (2009) with *Ulospora bilgramii* and *Neotestudina rosatii* as a sister group with good support in a combined SSU and LSU rDNA and TEF-1-alpha dataset. *Verruculina enalia* is a core mangrove species (Alias and Jones 2009), a dominant colonizer of mangrove wood, dead roots, prop roots and pneumatophores of trees along the shore (Pang et al. 2011). It appears to be restricted to tropical locations.

Type species: *Verruculina enalia* (Kohlm.) Kohlm. & Volk. Mycol. Res. 94(5): 689 (1990)

Key to genera of *Testudinaceae*

1. Ascumata perithecial, peridium lacking plates *Verruculina*
1. Ascumata cleistothecial, peridium composed of plates 2
2. Ascospores ornamented 3
2. Ascospores glabrous 4
3. *Asci* obovate or broadly clavate, ascospores reticulate *Testudina*
3. *Asci* clavate, with a long stalk, ascospores finely echinulate, darker near the septum *Lepidosphaeria*
4. *Asci* obovate or nearly sphaerical, ascospores not darker near the septum *Neotestudina*
4. Ascospores with germ-slits *Ulospora*

Tetraplosphaeriaceae Kaz. Tanaka & K. Hiray., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 177 (2009)

Mycobank: MB 515253

Saprobic on culms, twigs, and leaves of bamboo and other *Gramineae*. Sexual state: *Ascumata* scattered to gregarious, immersed to superficial, globose to hemispherical with flattened base, black to dark brown, glabrous or with brown hyphae. *Ascumatal opening* short-papillate to cylindrical, central. *Peridium* composed of hyaline to brown, polygonal to hyphoid cells, sometimes with rim-like structure at the sides and poorly developed at the base. *Hamathecium* of cellular or trabeculate, septate, branched pseudoparaphyses. *Asci* 8-spored, bitunicate fissionate, cylindrical to clavate, short pedicellate, with a shallow ocular chamber at rounded apex, basal to somewhat lateral. *Ascospores* biseriata above, uniseriate below, narrowly fusiform to broadly cylindrical, straight or slightly curved, 1–3-septate, hyaline to pale brown, smooth-walled, surrounded by an entire mucilaginous sheath

or narrow appendage-like sheath. Asexual state: “*Tetraploa*”-like. hyphomycetous. *Conidiogenous cells* monoblastic. *Conidia* cylindrical to obpyriform and composed of 3–8 columns or globose with internal hyphal structure, brown, mostly verrucose at the base, with more than 3–8 setose appendages.

Notes: The family *Tetraplosphaeriaceae* was established by Tanaka et al. (2009) using *Tetraplosphaeria*, as the type. According to the recent ICN (Art. 59), however, the genus should be treated as a synonym of *Tetraploa*, which has been applied previously to asexual states. *Tetraplosphaeriaceae* comprises five genera, *Tetraploa*, *Triplosphaeria*, *Polyposphaeria*, *Pseudotetraploa*, and *Quadricrura*. They are characterized by “*Massarina*”-like sexual morphs with almost hyaline 1(–3)-septate ascospores and/or “*Tetraploa*”-like asexual morphs with several setose appendages, as the most common diagnostic features. The latter two genera are known only from their asexual states. Most species are reported from bamboo, such as *Chimonobambusa*, *Phyllostachys*, *Pleioblastus* and *Sasa* (Tanaka et al. 2009), but *Tetraploa aristata* sensu lato is recorded on more than 80 diverse plant substrates (Farr and Rossman 2012).

Type: *Tetraploa* Berk. & Broome, Ann. Mag. nat. Hist., Ser. 2 5: 459 (1850), MycoBank: MB10199 Fig. 122

= *Tetraplosphaeria* Kaz. Tanaka & K. Hiray., in Tanaka et al., Stud. Mycol. 64: 177 (2009)

Saprobic on culms, twigs, and leaves of bamboo and other *Gramineae*. Sexual state: *Ascumata* scattered to gregarious, immersed to erumpent, black to dark brown, globose to subglobose, glabrous, ca. 150–350 μm diam. *Ascumatal opening* short-papillate to cylindrical, central, with periphyses. *Peridium* composed of nearly rectangular to polygonal thin-walled cells, sometimes poorly developed at the base. *Hamathecium* of 1–4 μm wide, cellular, septate and branched pseudoparaphyses. *Asci* 8-spored, bitunicate, fissionate, cylindrical to clavate, short pedicellate, with a shallow ocular chamber at rounded apex, basal to somewhat lateral. *Ascospores* biseriata above, uniseriate below, narrowly fusiform, straight or slightly curved, with a septum and slightly constricted, hyaline, smooth-walled, surrounded by a narrow mucilaginous appendage-like sheath. Asexual state *Tetraploa* sensu stricto, hyphomycetous. *Conidiogenous cells* monoblastic. *Conidia* composed of 4 columns, short-cylindrical, brown, verrucose at the base, euseptate, with four brown setose appendages at the apex.

Notes: *Tetraploa* is characterized by relatively small globose ascumata, narrowly fusiform ascospores having appendage-like sheath, and an asexual state belonging to *Tetraploa* sensu stricto having conidia with four setose appendages. Conidia found in *Tetraploa* are similar to those of *Triplosphaeria*, but the latter genus has conidia

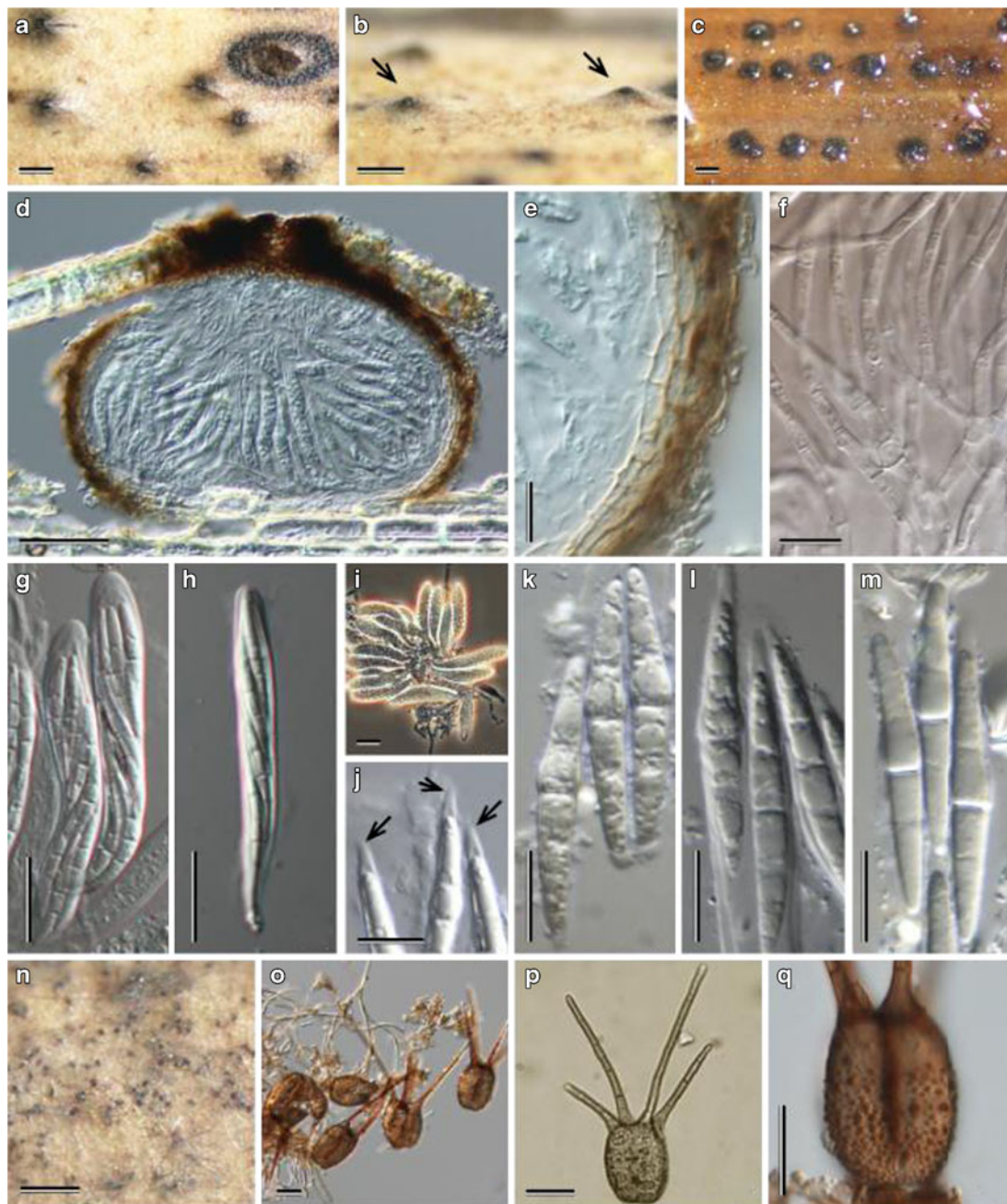


Fig. 122 *Tetraploa sasicola* (Material examined: JAPAN, Hokkaido, Yoichi, Sawamachi, on culms of *Sasa senanensis*, 7 July 2001, K. Tanaka (HHUF 27566, holotype). **a, b** Ascomata on host surface (**b** arrows indicate eruptent ostiole). **c** Ascomata produced on rice straw in culture. **d** Ascoma in longitudinal section. **e** Peridium. **f** Pseudoparaphyses. **g–i**

Asci. **j** Appendage-like sheath of ascospores (arrows). **k–m** Ascospores. **n** Conidia produced on rice straw in culture. **o, p** Conidia. **q** Verrucose texture of base of conidial wall. **c, i, n–q** from ex-type strain (JCM 13167=MAFF 239677). Scale bars: **a–c**=200 μ m, **d**=50 μ m, **e, f, j–m**=10 μ m, **g–i, o–q**=20 μ m, **n**=200 μ m

with three appendages. Likewise, it also resembles to *Pseudotetraploa*, but the conidial body of *Pseudotetraploa* is obpyriform to long obpyriform, rather than short cylindrical, and has pseudosepta rather than eusepta (Hatakeyama et al. 2005; Tanaka et al. 2009).

Tetraploa aristata, the type species of *Tetraploa* (Berkeley and Broome 1850), is a well-known dematiaceous hyphomycete (Ellis 1949). This species has been reported as saprobic

on leaves or stems of various plants, as a “facultative aquatic hyphomycete” or “terrestrial-aquatic hyphomycete”, as an airborne fungus, and sometimes as a human pathogen causing keratomycosis or phaeohyphomycotic cysts, and thus *T. aristata* has been believed to have high ecological diversity. However, molecular analysis of *Tetraploa* spp. revealed that *T. aristata* sensu lato (e.g. Ellis 1949) is a species complex composed of several morphologically similar but

phylogenetically distinct species (Tanaka et al. 2009). Therefore, morphological re-assessment of *T. aristata* based on the type specimen (Berkeley and Broome 1850) as well as molecular evidence obtained from epitype strain is required. The asexual state of *Massarina tetraploa* has been identified as *T. aristata* (Scheuer 1991), but the conidia has relatively longer setose appendages (Tanaka et al. 2009) as compared with illustration of *T. aristata* in the protologue (Berkeley and Broome 1850). In this paper, these two taxa (*M. tetraploa* and *T. aristata*) are regarded as different species, and a new name, *Tetraploa scheueri*, is proposed for *M. tetraploa* to avoid a tautonym. The other species in *Tetraplosphaeria* are also transferred to *Tetraploa* (see below).

Type species: Tetraploa aristata Berk. & Broome, Ann. Mag. nat. Hist., Ser. 2 5: 459 (1850), MycoBank: MB 148113

Other species examined

Tetraploa sasicola (Kaz. Tanaka & K. Hiray.) Kaz. Tanaka & K. Hiray., **comb. nov.**

MycoBank: MB 801977

Basionym: *Tetraplosphaeria sasicola* Kaz. Tanaka & K. Hiray., in Tanaka et al. Stud. Mycol. 64: 180 (2009)

MycoBank: MB 515260

Material examined: JAPAN, Hokkaido, Yoichi, Sawamachi, on culms of *Sasa senanensis*, K. Tanaka, 7 July 2001 (HHUF 27566, **holotype**).

Tetraploa nagasakiensis (Kaz. Tanaka & K. Hiray.) Kaz. Tanaka & K. Hiray., **comb. nov.**

MycoBank: MB 801978

Basionym: *Tetraplosphaeria nagasakiensis* Kaz. Tanaka & K. Hiray., in Tanaka et al. Stud. Mycol. 64: 180 (2009)

MycoBank: MB 515259

Material examined: JAPAN, Nagasaki, Nagayo, Nagasaki Siebold University, on culms of bamboo, K. Tanaka & S. Hatakeyama, 30 May 2004 (HHUF 29378, **holotype**).

Tetraploa scheueri Kaz. Tanaka & K. Hiray., **nom. nov.**

MycoBank: MB 801979

Basionym: *Massarina tetraploa* Scheuer, Mycol. Res. 95: 126 (1991)

MycoBank: MB 128409

= *Tetraplosphaeria tetraploa* (Scheuer) Kaz. Tanaka & K. Hiray., in Tanaka et al. Stud. Mycol. 64: 182 (2009)

MycoBank: MB 515261

Material examined: UK, England, Exeter, Exminster marshes, on leaves of *Carex acutiformis*, Ch. Scheuer, 13 Nov. 1988 (GZU000298329, **holotype**).

Tetraploa yakushimensis (Kaz. Tanaka, K. Hiray. & Hosoya) Kaz. Tanaka & K. Hiray., **comb. nov.**

MycoBank: MB 801980

Basionym: *Tetraplosphaeria yakushimensis* Kaz. Tanaka, K. Hiray. & Hosoya, in Tanaka et al. Stud. Mycol. 64: 184 (2009), MycoBank: MB 515262

Material examined: JAPAN, Kagoshima, Isl. Yakushima, near the mouth of Kurio River, on culms of *Arundo donax*, K. Tanaka & T. Hosoya, 20 Oct. 2005 (HHUF 29652, **holotype**).

Other genera included

Polyposphaeria Kaz. Tanaka & K. Hiray., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 192 (2009)

Type species: Polyposphaeria fusca Kaz. Tanaka & K. Hiray., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 193 (2009)

Pseudotetraploa Kaz. Tanaka & K. Hiray., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 193 (2009)

Type species: Pseudotetraploa curviappendiculata (Sat. Hatak., Kaz. Tanaka & Y. Harad) Kaz. Tanaka & K. Hiray., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 195 (2009)

Quadricrura Kaz. Tanaka, K. Hiray. & Sat. Hatak., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 196 (2009)

Type species: Quadricrura septentrionalis Kaz. Tanaka, K. Hiray. & Sat. Hatak., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 196 (2009)

Triplosphaeria Kaz. Tanaka & K. Hiray., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 186 (2009)

Type species: Triplosphaeria maxima Kaz. Tanaka & K. Hiray., in Tanaka, Hirayama, Yonezawa, Hatakeyama, Harada, Sano, Shirouzu & Hosoya, Stud. Mycol. 64: 188 (2009)

Key to genera of Tetraplosphaeriaceae

1. Conidia short cylindrical to obpyriform, mostly with 3–4 setose appendages2
1. Conidia globose to subglobose, usually with more than 4 setose appendages4
2. Conidia composed of 3 columns, ovoid to obpyriform, with 3 setose appendages; ascospores narrowly fusiform, with an entire sheath*Triplosphaeria*
2. Conidia composed of more than 3 columns; ascospores almost globose3
3. Conidia composed of 4 columns, cylindrical, euseptate, with 4 setose appendages; ascospores narrowly fusiform, surrounded by a narrow mucilaginous appendage-like sheath*Tetraploa*
3. Conidia composed of 4 to 8 columns, obpyriform to long obpyriform, pseudoseptate, with 4 (rarely 6 to 8) setose appendages; ascospores unknown*Pseudotetraploa*

4. Conidia with 3 to 8 setose uniform appendages; ascomata globose, surrounded by brown hyphae, ascospores hyaline to pale olive-brown***Polyposphaeria***
 4. Conidia with 1 or 2 long apical setose appendages and 4 to 5 short basal setose appendages; ascomatal state unknown
***Quadricrura***

Thyridariaceae Q. Tian & K.D. Hyde, **fam. nov.**, MycoBank: MB 805172

Saprobic under periderm or immersed in woody plant substrates. Sexual state: *Ascomata* perithecial, immersed or semi-immersed, gregarious, circular, globose, coriaceous, black, smooth-walled, surrounded by a subiculum. *Peridium* two-layered, at the outside composed of irregular, thick-walled, brown to black cells of *textura angularis*, the inner layer composed of slightly, larger cells of *textura angularis*. *Hamathecium* comprising long, branched or simple, septate, cellular, encircling the asci and embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, thick-walled, cylindrical to subclavate, with a short broad pedicel, apically rounded with an ocular chamber. *Ascospores* overlapping uniseriate or bi-seriate, ellipsoid to fusiform, dark brown to blackish-brown, 2–3-septate, constricted at the medium septum, septa darkened, ends rounded, smooth-walled. Asexual state: *Cyclothyrium*.

Typus: ***Thyridaria*** Sacc.

Notes: A new family *Thyridariaceae* is introduced to accommodate the genus *Thyridaria* based on its unique morphology and clustering in a unique family in the Dothideomycete phylogeny in Figs. 1 and 2. The placement of *Thyridaria* has been unsettled with the genus being placed in *Didymosphaeriaceae*, *Lophiostomataceae*, *Melanommataceae*, *Platystomataceae*, *Pleosporaceae*, and *Sphaeriaceae* by various authors (Barr 1979a, b, 2003; Dennis 1978; Luttrell 1973; Munk 1957; Müller and von Arx 1973; Wehmeyer 1941, 1975; Mugambi and Huhndorf 2009a, b). In Schoch et al. (2009a), *Thyridaria* clustered as a distinct group within *Pleosporales* and this is confirmed in Figs. 1 and 2. As there is no family to accommodate this genus, a new family *Thyridariaceae* in the *Pleosporales* is introduced here.

Type: ***Thyridaria*** Sacc., *Grevillea* 4(29): 21 (1875), MycoBank: MB5463 (Fig. 123)

Notes: *Thyridaria* was introduced by Saccardo (1875) with *T. incrustans* as the type species. The placement of *Thyridaria* has been uncertain and it was assigned to *Melanommataceae*, *Platystomataceae*, *Pleosporaceae* and *Sphaeriaceae* at various times (Barr 1979a, b; Dennis 1978; Luttrell 1973; Munk 1957; Müller and Arx 1973; Wehmeyer 1941; Wehmeyer 1975). Recently, Barr (2003) summarized the varied description of *Thyridaria* and suggested that the genus could be characterized by having an ample subiculum surrounding ascomata, which formed under the periderm or in woody plant substrates, with ascospores having both thickened

and darkened septa and walls. Barr (2003) concluded that *Thyridaria* sensu stricto should be placed in *Didymosphaeriaceae*. This was not followed by Lumbsch and Huhndorf (2010) who placed the genus in Dothideomycetes, genera *incertae sedis*.

Recent molecular phylogenetic data showed that *Thyridaria* is a distinct group within *Pleosporales* (Schoch et al. 2009a, b), however no family is available to accommodate this genus (Verkley et al. 2004; Damm et al. 2008; de Gruyter et al. 2012). Mugambi and Huhndorf (2009a) studied the families *Melanommataceae* and *Lophostomataceae* based on molecular and morphological data; three isolates of *T. macrostomoides* (De Not.) M.E. Barr were included and clustered in *Lophiostomataceae* according to their phylogenetic analysis. However *T. macrostomoides* is not the type of *Thyridaria*. A putative strain of *T. rubronotata* (Berk. & Broome) Sacc. was included in the analysis of Schoch et al. (2009a) and in this paper (Figs. 1 and 2). However, we have examined both species and they are similar. Fresh collections of *T. incrustans* are needed for epitypification and obtaining sequence data.

Type species: ***Thyridaria incrustans*** Sacc., *Atti Soc. Veneto-Trent. Sci. Nat.* 2: 170 (1873), MycoBank: MB238522

Trematosphaeriaceae K.D. Hyde et al., in Suetrong et al., *Cryptog. Mycol.* 32(4): 347 (2011), MycoBank MB 519506

Saprobic on lignocellulosic material in mangroves and terrestrial habitats. Sexual state: *Ascomata* solitary, scattered, or in groups, initially immersed, becoming erumpent, to semi-immersed, subglobose, black; apex with a short papilla. *Peridium* coriaceous, comprising heavily pigmented thick-walled cells of *textura angularis*. *Hamathecium* comprising relatively wide pseudoparaphyses, embedded in mucilage, branching and anastomosing between and above the asci. *Asci* 8-spored, bitunicate, fissitunicate, cylindro-clavate, pedicellate, with an ocular chamber. *Ascospores* biseriate to uniseriate, fusiform, hyaline or dark brown, trans-septate, and variously ornamented. Asexual state: Unknown.

Notes: *Trematosphaeriaceae* was introduced by Suetrong et al. (2011b) to accommodate the genera *Falciformispora*, *Halomassarina* and *Trematosphaeria*. The main distinguishing characters of the family are medium-sized rounded ascomata with a papillate ostiole, a relatively wide, coriaceous peridium, cellular pseudoparaphyses and cylindro-clavate asci. The ascospores are two-celled or many celled, hyaline or brown. Phylogenetic analysis inferred from combined nuclear SSU and LSU rRNA and translation elongation factor 1-alpha (TEF-1-alpha) and second largest subunit of RNA polymerase (RPB2) datasets show that these genera form a strongly supported cluster within the *Pleosporales*. Previous studies by Schoch et al. (2009a), Suetrong et al. (2009) and Zhang et al. (2009b) also referred to the *Trematosphaeriaceae* in their



Fig. 123 *Thyridaria incrustans* (Material examined: ITALY: Veneto, Padova, in rotting branch of *Broussonetia papyrifera*, Martio 1873, S F6232, **holotype**). **a** Herbarium material. **b, c** Ascomata semi-immersed in the host. **d, e** Vertical hand section of ascomata. **f** Vertical hand section

of peridium. **g, h, j, k** Asci with ascospores. **i** Immature ascus. **l** Pseudoparaphyses **m–p** Ascospores. Scale bars: **b** = 500 μm , **c** = 200 μm , **d, e** = 50 μm , **f** = 20 μm , **g–p** = 10 μm

phylogenetic trees as a family to represent a well-supported clade. The family name however, was not formally introduced and Lumbsch and Huhndorf (2010) regarded it as *nomen nudum*. The *Trematosphaeriaceae* shares a phylogenetic

relationship and common node with four families in the *Pleosporales*: *Montagnulaceae*, *Massarinaceae*, *Lentitheciaceae*, and *Morosphaeriaceae* (Suetrong et al. 2011b), with many taxa based on *Massarina* and

Lophiostoma species that do not group with the type species *Massarina eburnea*. The *Trematosphaeriaceae* clade (Fig. 123) comprises four strains of *Halomassarina thalassiae* (Kohlm. & Volkm.-Kohlm.) Suetrong et al., a common species on mangrove wood, with two strains of *Trematosphaeria pertusa* (Pers.) Fuckel and as a sister group. *Falciformispora lignatilis* K.D. Hyde also groups within this clade with high support, and known from mangrove wood, freshwater and on the terrestrial oil palm. All three are type species of monotypic genera. The position of *Asteromassarina pulchra* is unresolved, grouping in the *Trematosphaeriaceae* (Schoch et al. 2009a, b; Zhang et al. 2009a), but also in the *Morosphaeriaceae* (Suetrong et al. 2009).

Asteromassarina pulchra (Harkn.) Shoemaker & P.M. LeClair has been included in the family in previous phylogenetic publications (Schoch et al. 2009a, b, c; Zhang et al. 2009b), however, since the type of the genus (*A. macrospora* (Desm.) Höhn.), was not included in their phylogenetic analysis the familial placement cannot be confirmed. Furthermore *A. pulchra* did not cluster in the *Trematosphaeriaceae* in the analysis by Suetrong et al. (2011b), but formed a weakly supported clade with the *Morosphaeriaceae* and *Trematosphaeriaceae* as sister clades. Barr (1979a) referred the genus *Asteromassarina* to the *Pleomassariniaceae* based on morphological observations “host woody substrates, rather large ascomata with wide lateral walls, large ascospores and conidia, both often distoseptate”. The position of this species cannot be resolved until the type species is sequenced.

Type: *Trematosphaeria* Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 161 (1870)

[1869–70], MycoBank MB 5522 Fig. 124

Possible synonym:

Botanamphora Nogrsek & Scheuer, in Nogrsek, Bibliotheca Mycol. 133: 50 (1990) according to Scheuer and Nogrsek (1993).

Saprobic on terrestrial wood. Sexual state: *Ascomata* solitary, scattered, or in groups, initially immersed, becoming erumpent, to semi-immersed, subglobose, black, coriaceous; apex with a short ostiole, usually slightly conical and widely porate, to 100 μm high. *Peridium* wide laterally, thinner at the base, coriaceous, comprising a single cell type of small heavily pigmented thick-walled cells of *textura angularis*. *Hamathecium* comprising narrow (1.5–2.5 μm), septate, cellular pseudoparaphyses, embedded in mucilage, branching and anastomosing between and above the asci. *Asci* 8-spored, bitunicate, dehiscence fissitunicate, cylindrical-clavate, with a short, thick, furcate pedicel, and a truncate ocular chamber. *Ascospores* biseriate to uniseriate near the base, fusiform with broadly to narrowly rounded ends, dark-brown, 1–3-septate, secondary septum forming late or often absent, deeply constricted at the median septum, the upper cell often shorter and broader than the lower one, smooth to finely verruculose, containing refractive globules. Asexual state:

Unknown, however, hyphopodia-like structures produced in culture (Zhang et al. 2008a, b).

Notes: *Trematosphaeria pertusa*, the lectotype species of *Trematosphaeria* (Clements and Shear 1931), is characterized by semi-immersed to erumpent ascomata, cellular pseudoparaphyses, cylindrical-clavate asci, and fusiform, one-septate reddish brown to dark brown ascospores (Boise 1985a, b; Zhang et al. 2008a). *Trematosphaeria pertusa* usually grows on the surface of decaying terrestrial wood, but can also survive within fresh water. The genus forms a robust phylogenetic clade with *Falciformispora lignatilis* and *Halomassarina thalassiae* (Figs. 1 and 2).

Type species: *Trematosphaeria pertusa* Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 161 (1870) [1869–70]

Other genera included

Falciformispora K.D. Hyde, Mycol. Res. 96(1): 26 (1992), MycoBank MB 25457

Type species: *Falciformispora lignatilis* K.D. Hyde, Mycol. Res. 96(1): 27 (1992)

Halomassarina Suetrong, Sakayaroj, E.B.G. Jones, Kohlm., Volkm.-Kohlm. & C.L. Schoch, Stud. Mycol. 64: 161 (2009)

Type species: *Halomassarina thalassiae* (Kohlm. & Volkm.-Kohlm.) Suetrong et al., in Suetrong et al., Stud. Mycol. 64: 161 (2009)

Key to the genera of *Trematosphaeriaceae*

1. Asci clavate, ascospores brown, lacking appendages *Trematosphaeria*
1. Asci cylindro-clavate, ascospores hyaline, with a sheath or appendage 2
2. Ascospores 6–8-septate, with a thin mucilaginous sheath, and a single scythe-like appendage at the base *Falciformispora*
2. Ascospores 3-septate, surrounded by a gelatinous sheath *Halomassarina*

Trichothyriaceae Theiss., Beih. bot. Zbl., Abt. 2 32: 3 (1914), MycoBank: MB 81497

Possible synonyms:

Trichopeltidaceae Theiss. [as ‘Trichopeltaceae’], Zentbl. Bakt. ParasitKde, Abt. II 39: 629 (1914) [1913]

Trichopeltinaceae Bat., C.A.A. Costa & Cif., Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5 15: 37 (1958)

Fungicolous on ascomycetes (*Meliolaceae* and *Diatrypaceae*) and lichens or on their conidial states. *Mycelium* developing on the parasitized fungus in one genus forming thalli. Sexual state: *Thyriothecia* superficial, on stalked cells or hyphae, flattened, discoid or lenticular and circular with a central ostiolar pore and comprising radiating rows of brownish cells. *Peridium* well-developed above and below. *Asci* 8-spored, bitunicate, fissitunicate, obclavate, apedicellate and without a distinct ocular chamber, arranged

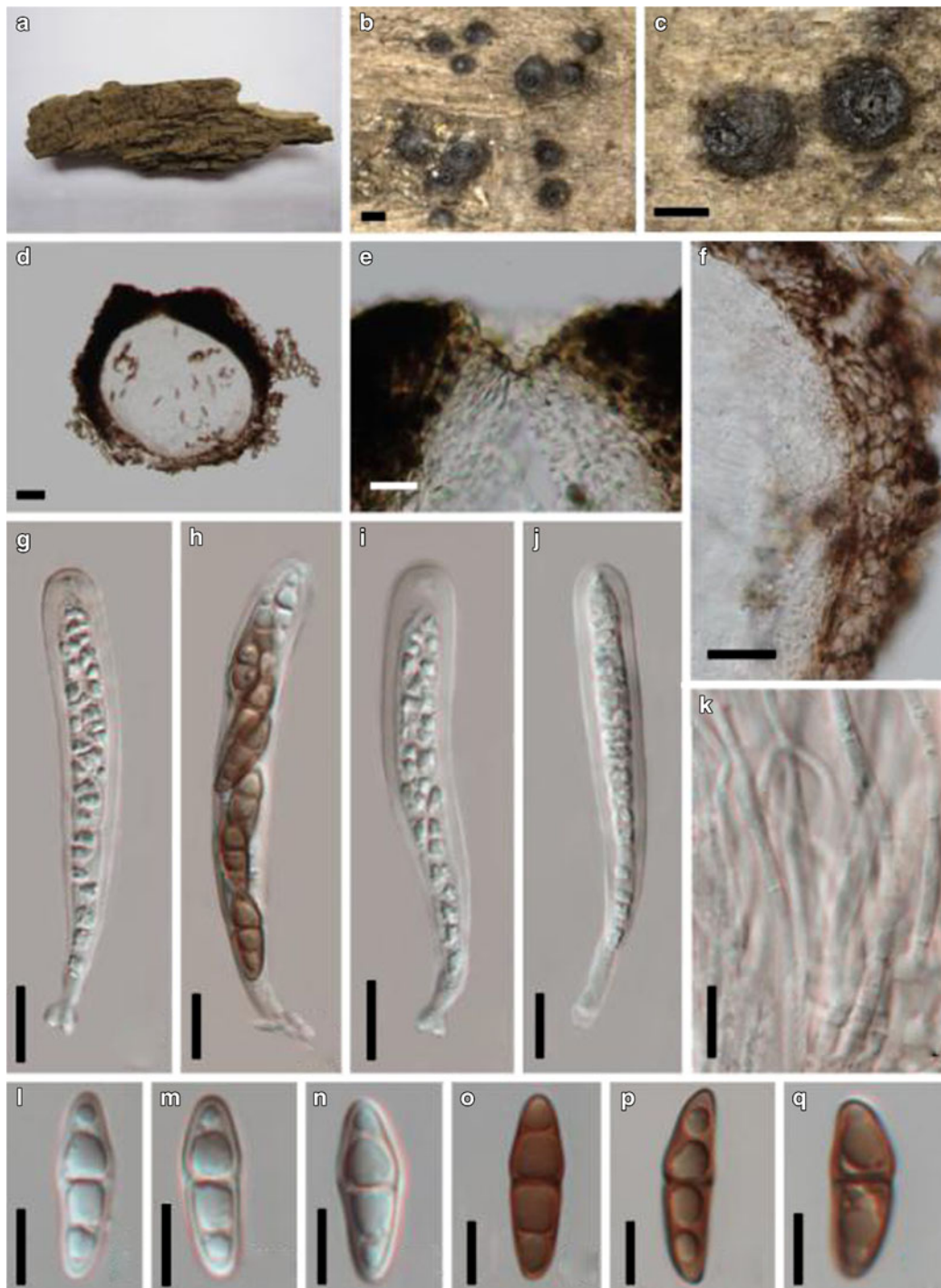


Fig. 124 *Trematosphaeria pertusa* (Material examined: FRANCE: Deux-Sèvres, Lansais, Le Vanneau, Les Grandes, Mottines swamp, on bark of a dead stump of *Fraxinus excelsior*, 25 April 2004, Jacques Fournier, IFRD 2002, **epitype**) **a–c** Ascomata on host surface. **d–f** Hand

section of ascomata showing peridium. **g–j** Asci with ascospores. **k** Pseudoparaphyses. **l–q** Ascospores. Scale bars: **b**, **c**=200 μ m, **d**=50 μ m, **e**, **f**=20 μ m, **g**, **q**=10 μ m

at the periphery and converge towards the central pore. *Ascospores* overlapping, small, hyaline or light brown, 1-septate, may have ciliate appendages. Asexual state: reported in *Hansfordiella* and *Isthmospora* (Hyde et al. 2011).

Notes: The *Trichothyriaceae* was introduced by Theissen (1914a) and maintained as a distinct family by Hughes (1953a), Müller and von Arx (1962), von Arx and Müller (1975) and Eriksson (1981). Hawksworth et al. (1983),

however, included *Trichothyriaceae* under *Microthyriaceae* and this was supported by Eriksson (1981) and was subsequently followed (Lumbsch and Huhndorf 2010). *Trichothyriaceae* has been used to accommodate several genera now placed in *Microthyriaceae* and in a study of this family, Wu et al. (2011a) maintained *Trichothyriaceae*. They considered the peridium, that is well-developed above and below important, and in this sense differ from *Asterinaceae*, *Micropeltidaceae*, *Microthyriaceae* and other thyrriothecial families. Spooner and Kirk (1990) have stated that “any attempt to rationalize the taxonomy of *Trichothyriaceae* (and this also applies to *Microthyriaceae*) based solely on morphology is likely to prove unsatisfactory and will lead to both artificial segregation of closely related species and to the inclusion of unrelated species in the same genus”. This is because the group has too few morphological characters of any taxonomic significance. The genera thus need recollecting, epitypifying and sequencing to establish their taxonomic affinities. von Arx and Müller (1975) included four genera (*Actinopeltis* Höhn., *Trichothyrina* (Petr.) Petr., *Trichothyrinula* Petr. and *Trichothyrium* Speg.) in *Trichothyriaceae*.

Type: *Trichothyrium* Speg., Boln Acad. nac. Cienc. Córdoba 11(4): 555 (1889), MycoBank: MB 5598 Fig. 125

Fungicolous on fungi on the upper surface of host leaves. *Mycelium* superficial with hyphopodia, forming lobed thalli. Sexual state: *Thyrriothecia* solitary or gregarious, circular, superficial, membranaceous, brown to dark brown, basal peridium well developed, with a central ostiole; in section lenticular. *Upper wall* comprising rows of radiating cells which form parallel lines from the central ostiole to the outer rim. *Hamathecium* of asci arranged from the periphery towards the central ostiole and sparse pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, obclavate, apedicellate. *Ascospores* overlapping, obclavate, hyaline, two-celled, smooth-walled. Asexual state: reported in *Hansfordiella* and *Isthmospora* (Hyde et al. 2011).

Notes: *Trichothyrium* was established by Spegazzini (1889a) with *Trichothyrium sarciniferum* as the type species. Later, Hughes (1953a) gave the earlier name for *T. sarciniferum* as *T. asterophorum* (Berk. & Broome) Höhn. and this is written by Spegazzini on the herbarium package as “*Trichothyrium* sp. (n.gen.) *sarciniferum* sp. or *Micropeltis? asterophora* B. & Br. c.f.?” There are 37 records *Trichothyrium* in Index Fungorum (2013). Wu et al. (2011a) transferred *Trichothyrium* from *Microthyriaceae* to *Trichothyriaceae*. It is not certain that we can term the ascomata thyrriothecia since they are well-developed both above and below. This genus has frequently been collected in the past as is evident in the number of genera synonymized under it. However, we have been looking for this genus in Thailand for 3 years and have not found it.

Type species: *Trichothyrium sarciniferum* Speg., Boln Acad. nac. Cienc. Córdoba 11(4): 556 (1889), MycoBank: MB 161963

Other genera included

Lichenopeltella Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 128: 553 (1919)

Type species: *Lichenopeltella maculans* (Zopf) Höhn. Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1128(7–8): 553 (1919)

Macrographa Etayo, in Etayo & Sancho, Bibliotheca Lichenol. 98: 116 (2008)

Type species: *Macrographa antarctica* Etayo, in Etayo & Sancho, Bibliotheca Lichenol. 98: 116 (2008)

Pachythyrium G. Arnaud ex Spooner & P.M. Kirk, Mycol. Res. 94(2): 228 (1990)

Type species: *Pachythyrium parasiticum* (Fabre) G. Arnaud ex Spooner & P.M. Kirk, Mycol. Res. 94(2): 228 (1990)

Key to genera of *Trichothyriaceae*

1. Fungicolous on *Meliolaceae*, mycelium superficial and forming thalli *Trichothyrium*
1. Fungicolous on ascomycetes and lichens, mycelium absent or not forming thalli 2
2. Fungicolous on ascomycetes *Pachythyrium*
2. Lichenicolous 3
3. Ascomata uniloculate (or with two locules) *Lichenopeltella*
3. Ascomata multi-loculate, ascospores ellipsoidal-fusiform *Macrographa*

Trypetheliaceae Zenker in Goebel & Kunze, Pharmaceutische Waarenkunde: 123 (1827).

MycoBank: MB 81884

Possible synonyms:

Astrotheliaceae Zahlbr., in Engler, Syllabus, Edn 2 (Berlin): 46 (1898)

Cryptotheliaceae Walt. Watson, New Phytol. 28: 113 (1929)

Hyalophragmiaceae Räsänen, Acta bot. fenn. 33: 31 (1943)

Laureraceae Vězda ex Poelt, in Ahmadjian & Hale, The Lichens: 609 (1974)

Lichenized on bark or rarely on bryophytes over soil; in terrestrial, chiefly lowland to lower montane tropical habitats, with few species extending into temperate regions. *Thallus* reduced and ecorticate, white, to distinctly corticate, yellow-brown to olive-green, sometimes partly or completely bright yellow, orange or red due to superficial anthraquinone pigments. *Photobiont* *Trentepohlia*. Sexual state: *Ascomata* scattered, clustered, aggregated in pseudostromata, or fused with common ostiole, immersed to sessile, brown-black but usually covered by thallus, globose to pear-shaped or conical, coriaceous to carbonaceous, ostiolate, ostiole round.

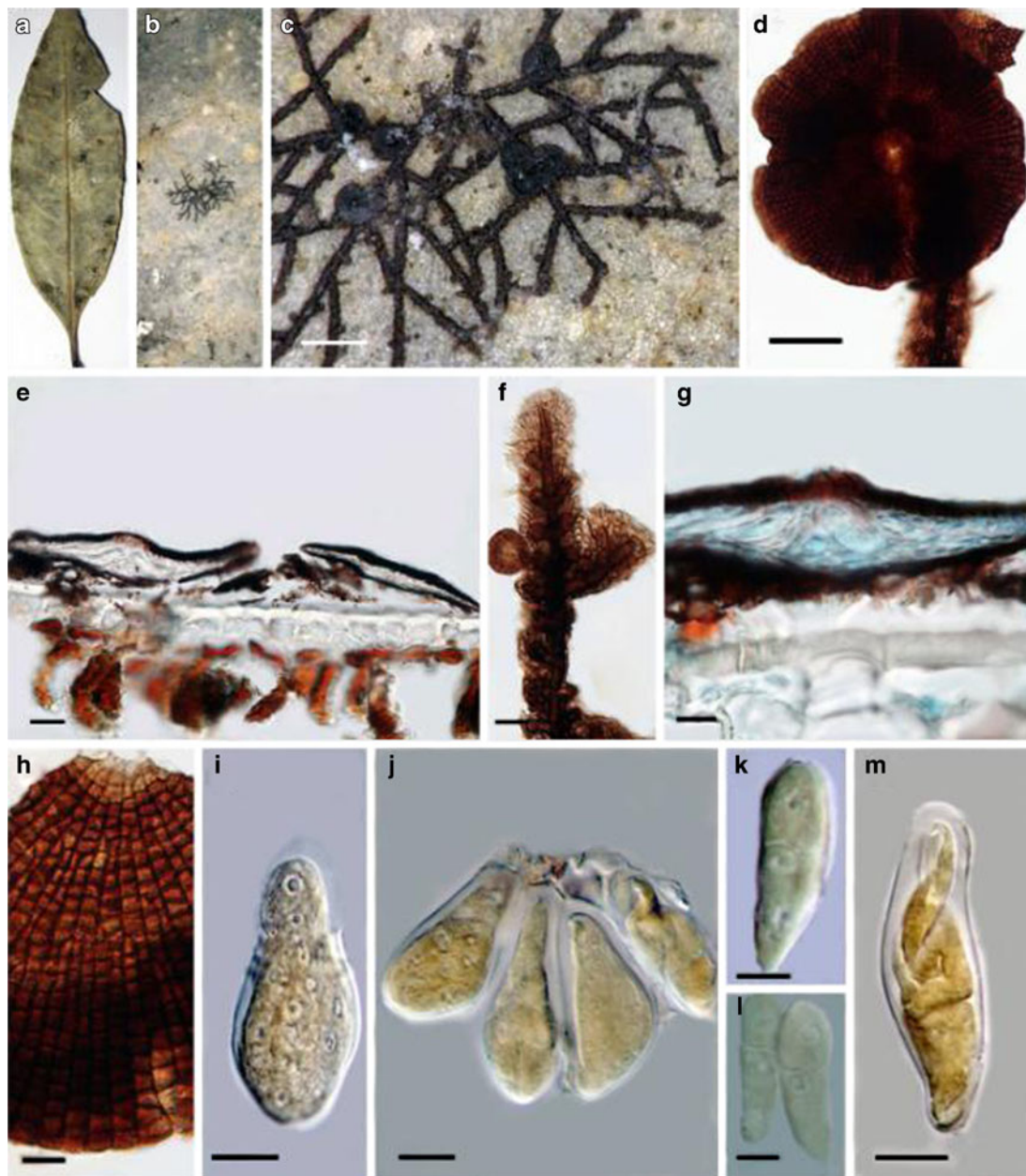


Fig. 125 *Trichothyrium sarciniferum* (Material examined: BRAZIL, Apizhy, on Meliolaceae on unidentified leaves, 1881, C. Spegazzini, LPS1441, **holotype**). **a–c** Appearance of colony and ascomata on the host surface. **d, h** Squash mount of ascoma. Note h Upper wall. **e, g**

Section of ascoma. Note the peridium. **f** Superficial mycelium. Note forming thalli. **i, j, m** Asci. Note i mounted in Melzer's reagent. **k–l** Two-celled ascospores. Scale bars: **c**=200 μm , **d**=50 μm , **e, f**=20 μm , **g–j, m**=10 μm , **k, l**=5 μm

Excipulum dense, consisting of compressed hyphae, appearing prosoplectenchymatous in thin, bleached sections but structure usually difficult to observe due to heavy carbonization, generally dark brown to brown-black. *Hamathecium* comprising 0.5–0.7(–1.5) μm wide paraphysoids, hyaline, straight or rarely flexuose, branched and usually anastomosing, usually embedded in a thick, gelatinous matrix, occasionally with hyaline or yellow oil inspersion. *Asci* 1–8-spored, bitunicate, fissionitunicate, obclavate to cylindrical, short pedicellate, with refractive ring and very wide, non-amyloid

ocular chamber comprising more than half of the width of the ascus. *Ascospores* irregularly arranged to biserial, fusiform-ellipsoid to oblong, hyaline to dark brown, septate to muriform, with distosepta and sometimes additional eusepta and rectangular to diamond-shaped (generally six-angled) lumina, smooth-walled or rarely ornamented, not or slightly constricted at the septa, with evanescent mucilaginous material on the outside, either as polar pads or irregular median pads or a complete sheath enveloping the whole ascospore. Asexual state: *Pycnidia* known from a few species,

immersed, visible as black dots in specific, often pseudostromatic areas on fertile thalli, or whole thalli only producing pycnidia; rarely old ascospores within asci transforming into pycnidia. *Conidia* acrogenous, rod-shaped, hyaline. *Chemistry*: lichexanthone sometimes produced on thallus surface; yellow to orange or red anthraquinones and perylenequinones often produced in the medulla of the thalline layer covering the perithecia and sometimes in the thallus medulla or superficial on various parts of the thallus.

Notes: *Trypetheliaceae* (Zenker in Goebel and Kunze 1827) is one of the oldest described families of lichenized *Ascomycota*. Its delimitation was obscure throughout the past nearly 200 years, but in general the family included pyrenocarpous, epiphytic lichens with crustose thalli containing a *Trentepohlia* photobiont, thin, anastomosing paraphysoids forming a network embedded in a gelatinous matrix, bitunicate asci, and hyaline, distoseptate ascospores with diamond-shaped lumina (Aptroot 1991a, b; Harris 1995; Aptroot et al. 2008). Several genera were variously included or excluded throughout the years, such as *Megalotremis*, *Ornatopyrenis*, and *Trypetheliopsis* (Aptroot 1991a, b; Harris 1995; Lumbsch and Huhndorf 2010). The generic concept was traditionally based on thallus development, ascoma arrangement, and ascospore septation, recognizing seven genera: *Pseudopyrenula* (ecorticate, white; ascomata solitary, with acical ostiole; ascospores septate with diamond-shaped lumina), *Polymeridium* (ecorticate, white; ascomata solitary with apical ostiole; ascospores septate to muriform, lacking endospore and with rectangular lumina), *Trypethelium* (corticate; ascomata solitary to pseudostromatic, with apical ostiole; ascospores septate), *Laurera* (corticate; ascomata solitary to pseudostromatic, with apical ostiole; ascospores muriform), *Astrothelium* (corticate; ascomata fused with common ostiole; ascospores septate), *Campylothelium* (corticate; ascomata solitary with lateral ostiole; ascospores muriform), and *Cryptothelium* (corticate; ascomata fused with common ostiole; ascospores muriform). Further genera were segregated or added based on particular ascoma or ascospore features (Aptroot 1991a, b; Tucker and Harris 1980; Harris 1984, 1995; Lücking et al. 2007): *Exiliseptum* (thallus corticate; ascomata fused with common ostiole; ascospores submuriform, lacking endospore and with rectangular lumina), *Bathelium* (thallus corticate; ascomata pseudostromatic, with walls composed of brown, jigsaw-puzzle-shaped hyphal cells), *Architrypethelium* (thallus corticate; ascomata solitary with apical or lateral ostiole; ascospores septate, very large, hyaline or brown), and *Aptrootia* (thallus corticate, over bryophytes on soil; ascomata solitary with apical ostiole; ascospores muriform, dark brown).

Molecular phylogenetic data have deeply challenged both the family circumscription of *Trypetheliaceae* and the delimitation of genus-level taxa (Del Prado et al. 2006; Nelsen et al.

2009, 2011a). Apart from the core *Trypetheliaceae*, the family has been shown to also contain a probably large number of species currently placed in the genera *Arthopyrenia*, *Julella*, and *Mycomicrothelia*, thus far separated in the unrelated family *Arthopyreniaceae* in *Pleosporales*. Whether the type of *Arthopyrenia*, *A. rhyponia*, belongs also in *Trypetheliaceae* cannot be said at present; in that case, *Arthopyreniaceae* would become a synonym of *Trypetheliaceae*. The inclusion of these species in *Trypetheliaceae* is surprising, since the type of interascal filaments and ascospore septa and wall ornamentation is different from the core *Trypetheliaceae*. As a whole, *Trypetheliaceae* form a strongly supported, somewhat isolated clade within *Dothideomycetes* and have therefore been assigned to their own order, *Trypetheliales* (Aptroot et al. 2008).

Genus-level delimitations have changed considerably within *Trypetheliaceae*. Whereas genera already characterized by particular features, such as *Aptrootia*, *Architrypethelium*, *Bathelium*, and *Pseudopyrenula*, have been confirmed by molecular data, the ascospore- and ascomata-based genera *Astrothelium*, *Cryptothelium*, *Laurera*, and *Trypethelium* do not represent natural groups (Nelsen et al. 2009, 2011a), as already predicted by Harris (1995). The type genus, *Trypethelium*, is now restricted to species with pseudostromatic ascomata and multiseptate ascospores lacking a distinct endospore and with more or less rectangular lumina. On the other hand, the bulk of the remaining species, with variable ascoma arrangement and ascospore septation, appears to belong in a single genus for which the oldest name is *Astrothelium* (including *Cryptothelium* and *Laurera*).

Awaiting a revised monographic treatment (Aptroot et al., in prep), the family now includes at least seven named genera plus another three to five genus-level clades and well over 250 species, mostly found in tropical lowland to lower montane, rain forest, dry forest, and savanna habitats. As many species are not yet validly combined or new genera validly described, some species illustrated here (Figs. 2 and 3) still bear the names of traditional genera.

Type: ***Trypethelium*** Spreng., Anleit. Kennt. Gew. 3: 350 (1804), MycoBank: MB 5628

Figure 126

Lichenized on bark in terrestrial, lowland to lower montane tropical habitats. *Thallus* corticate with yellow-brown to olive-green color. *Photobiont* *Trentepohlia*. *Sexual state*: *Ascomata* aggregated in pseudostromata, sessile, brown-black or covered by algal-free, sterile tissue filled with crystalline, yellow to orange, KOH + red to purple pigment, globose, coriaceous to carbonaceous, ostiolate, ostiole round. *Excipulum* prosoplectenchymatous, dark brown to brown-black. *Hamathecium* comprising 0.5–0.7 μm wide paraphysoids, hyaline, straight, branched and anastomosing, embedded in a thick, gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, obclavate, short pedicellate, with

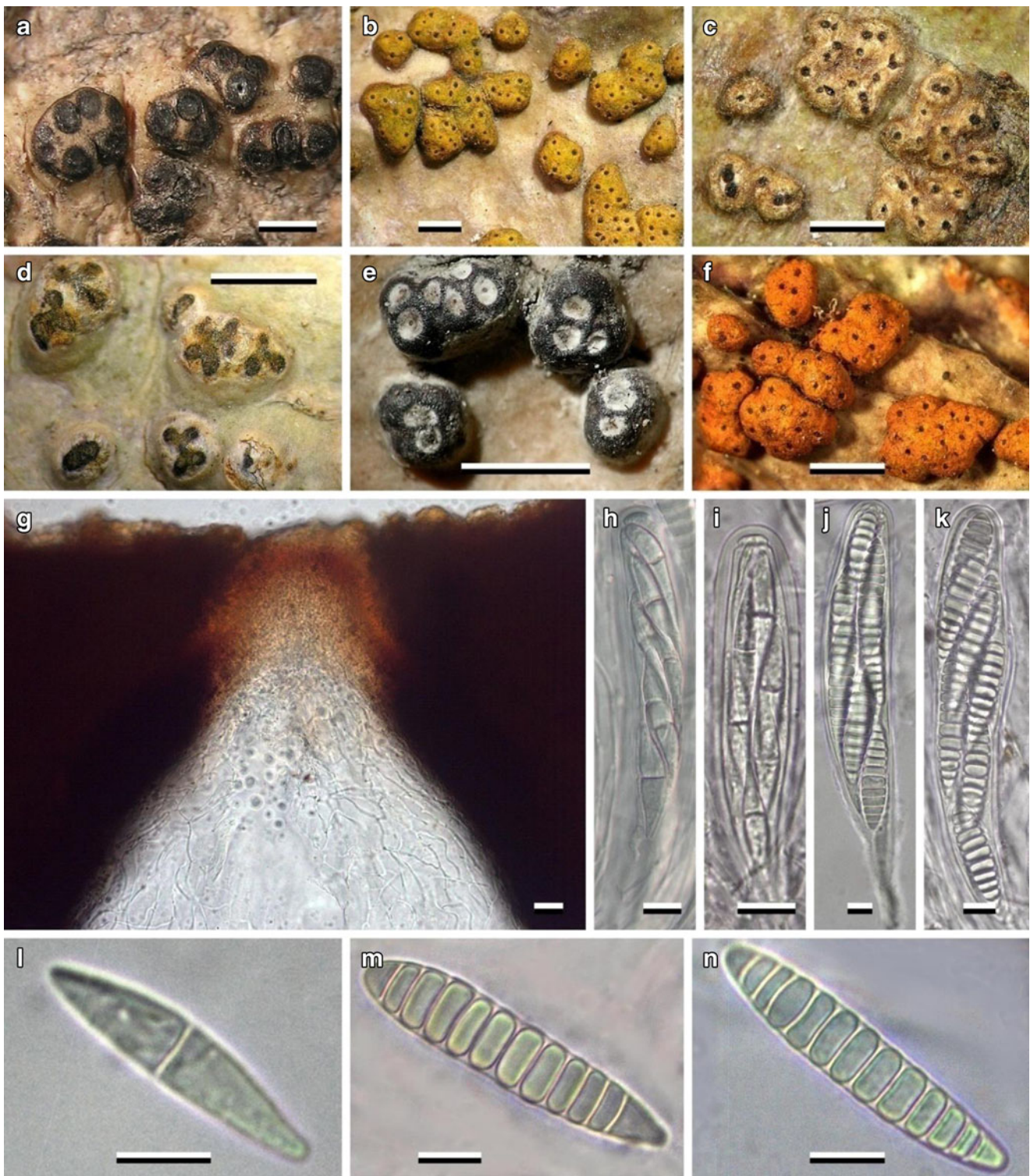


Fig. 126 *Trypethelium* **a** Surface view of thallus and pseudostromatic ascomata of *T. regnellii* (BRAZIL, Malme 2600). **b** Same, *T. eluteriae* (COLOMBIA, Moncada 3399). **c** Same, *T. foveolatum* (Puerto Rico, Harris 24390). **d** Same, *T. platystomum* (Brazil, Brako 5561). **e** Same, *T. sphaerocephalum* (holotype of *T. platystomum* var. *leucostomum*). **f**

Same, *T. subeluteriae* (Florida, Nelsen s.n.). **g** Section through ostiolar region of perithecium in *T. eluteriae* showing upper connection of paraphysoids to the excipulum (Colombia, Moncada 3399). **h–k** Asci with developing and mature ascospores. **l–n** Developing and mature ascospores. Scale bars: **a–f**=1 mm, **g–n**=10 μ m

refractile ring and non-amyloid ocular chamber. *Ascospores* irregularly arranged to biserial, fusiform, hyaline, multiseptate,

with thin distosepta and more or less rectangular lumina, smooth-walled, not constricted at the septa, surrounded by an

evanescent mucilaginous sheath. Asexual state: Unknown. *Chemistry*: Yellow to orange or red anthraquinones and perylenequinones produced in the pseudostromata.

Notes: A tropical, lichenized genus found on bark of branches and trunks of trees, usually in (semi-) exposed situations. Traditionally, *Trypethelium* included all *Trypetheliaceae* with thallus-dominated perithecia with separate, apical ostioles and transversely septate ascospores. In its modern circumscription, the genus is restricted to species with pseudostromatic perithecia with the pseudostromata containing yellow to orange, crystalline pigments, and multiseptate ascospores with more or less thin septa and walls and rectangular lumina.

Type species: *Trypethelium eluteriae* Spreng., Anleit. Kennt. Gew. 3: 350 (1804), MycoBank: MB 122402

Astrothelium Eschw., Syst. Lich.: 18, 26 (1824), MycoBank: MB 443 Fig. 127

Possible synonyms:

Heufleria Trevis., Spighe Paglie: 19 (1853)

Pyrenodium Fée, Essai Crypt. Exot., Suppl. Révis. (Paris): 68 (1837)

Lichenized on bark in terrestrial, chiefly lowland to lower montane tropical habitats. *Thallus* distinctly corticate with yellow-brown to mostly green color. *Photobiont* *Trentepohlia*. Sexual state: *Excipulum* prosoplectenchymatous, dark brown to brown-black. *Hamathecium* comprising 0.5–0.7 µm wide paraphysoids, hyaline, straight, branched and anastomosing, embedded in a thick, gelatinous matrix. *Asci* 1–8-spored, bitunicate, fissitunicate, obclavate, short pedicellate, with a non-amyloid ocular chamber. *Ascospores* irregularly arranged to uni- or biseriate, fusiform-ellipsoid to oblong-cylindrical, hyaline, septate to muriform, with distinct distosepta and sometimes eusepta and diamond-shaped lumina (best visible in septate ascospores), smooth-walled, not or slightly constricted at the septa, often surrounded by an evanescent mucilaginous material on the outside, either as polar pads, or irregular median pads or a complete sheath enveloping the whole ascospore. Asexual state: *Pycnidia* known from a few species, immersed to erumpent, visible as black dots. *Conidia* acrogenous, rod-shaped, hyaline. *Chemistry*: lichexanthone sometimes produced on thallus surface; yellow to orange or red anthraquinones and perylenequinones often produced in the medulla of the thalline layer covering the perithecia and sometimes in the thallus medulla or superficial on various parts of the thallus.

Notes: A tropical, lichenized genus found on bark of branches and trunks of trees, usually in shaded to semi-exposed situations. Traditionally, *Astrothelium* included all *Trypetheliaceae* with thallus-dominated perithecia with fused, lateral ostioles and transversely septate ascospores. In its modern circumscription, the genus is the largest in the family and exhibits much variation in perithecial arrangement and

ascospore septation, including species with both transversely septate and muriform ascospores and with apical, lateral, or fused ostioles, previously placed in the artificial genera *Bathelium*, *Cryptothelium*, *Laurera*, and *Trypethelium*. Pending molecular data of the type species, both *Cryptothelium* and *Laurera* are to be considered synonyms of *Astrothelium* and hence no longer in use. Harris (1995) predicted the circumscription of this clade but suggested the use of the name *Laurera* which is, however, younger than *Astrothelium*. The ascospores of this clade are typically astrothelioid, i.e. with thick distosepta giving the lumina a diamond-shaped outline, at least when young or immature in the case of muriform ascospores (Sweetwood et al. 2012). Similar ascospores are found in unrelated or distantly related families like the *Graphidaceae* (*Fissurinoideae*) and *Massariaceae* (Eriksson 1981; Voglmayr and Jaklitsch 2011; Rivas Plata et al. 2012).

Type species: *Astrothelium conicum* Eschw., Syst. Lich.: 26 (1824), MycoBank: MB 377819

Other genera included Fig. 128

Architrypethelium Aptroot, Biblioth. Lichenol. 44: 120 (1991)

Type species: *Architrypethelium seminudum* (Mont.) Aptroot, Biblioth. Lichenol. 44: 120 (1991)

Bathelium Ach., Method. Lich.: 111 (1803)

Type species: *Bathelium mastoideum* Afz. ex Ach., Method. Lich.: 111 (1803)

Polymeridium (Müll. Arg.) R.C. Harris in Tucker & Harris, Bryologist 83(1): 12 (1980)

Type species: *Polymeridium contendens* (Nyl.) R.C. Harris in Tucker & Harris, Bryologist 83(1): 12 (1980).

Pseudopyrenula Müll. Arg., Flora, Jena 66: 247 (1883)

Type species: *Pseudopyrenula diluta* (Fée) Müll. Arg., Flora, Jena 66: 247 (1883)

Notes: Several species currently classified as *Arthopyrenia*, *Julella* and *Mycomicrothelia* also fall within *Trypetheliaceae*, but for some of them it is unclear at present whether the generic types belong here or into other clades within *Dothideomycetes*. Therefore, these genera have not been listed here. Most likely, the tropical species of *Arthopyrenia* and *Julella* s.lat. clustering in *Trypetheliaceae* will require new generic names, whereas the name *Bogoriella* is available for tropical species of *Mycomicrothelia* if the type turns out to be unrelated to that group (Aptroot 2012) (Fig. 129).

Key to genera of *Trypetheliaceae*

1. Thallus white, ecorticate, leaving ascomata exposed2
1. Thallus yellow-brown to green, corticate, usually at least in part covering ascomata, or else ascomata in pseudostromata ...5
2. Ascospores 3-septate, distinctly distoseptate with diamond-shaped lumina, always hyaline*Pseudopyrenula*



Fig. 127 *Astrothelium* in its modern circumscription, including species previously placed in *Cryptothelium*, *Laurera*, and *Trypethelium*. **a** Surface view of thallus and ascomata of *A. eustomum* (BRAZIL, Cáceres 2076). **b** Same, *A. galbineum* (USA, Florida, Harris 41750). **c** Same, *Cryptothelium sepultum* (VENEZUELA, Guariglia 1485). **d** Surface view of thallus and ascomata of *C. sepultum* (Peru, Lücking s.n.). **e** Surface view of thallus and ascomata of *Laurera giganteospora* (PUERTO RICO, Harris 27863B). **f** Same, *L. megasperma* (USA, Florida, Harris 30083). **g–h** Perithecia ejecting ascospores in *L. megasperma* (PANAMA, Lücking

s.n.). **i** Surface view of thallus and ascomata of *Trypethelium aeneum* (HONDURAS, Allen 14398). **j** Same, *T. brachysporum* (JAMAICA, Buck 6036). **k** Same, *T. nitidiusculum* (COSTA RICA, Lücking 8402). **l** Same, *T. tuberculosum* (Costa Rica, Lücking 16305). **m–q** Ascospore development in *Astrothelium diplocarpoides* (USA, Florida, Lücking 26627). **r–u** Ascospore development in *Laurera giganteospora* (PHILIPPINES, Rivas-Plata 2128). **v–x** Ascospore development in *L. megasperma* (USA, Florida, Lücking 26710). Scale bars: **a–l**=1 mm, **m–n**=20 μ m, **o–q**=50 μ m, **r–x**=100 μ m

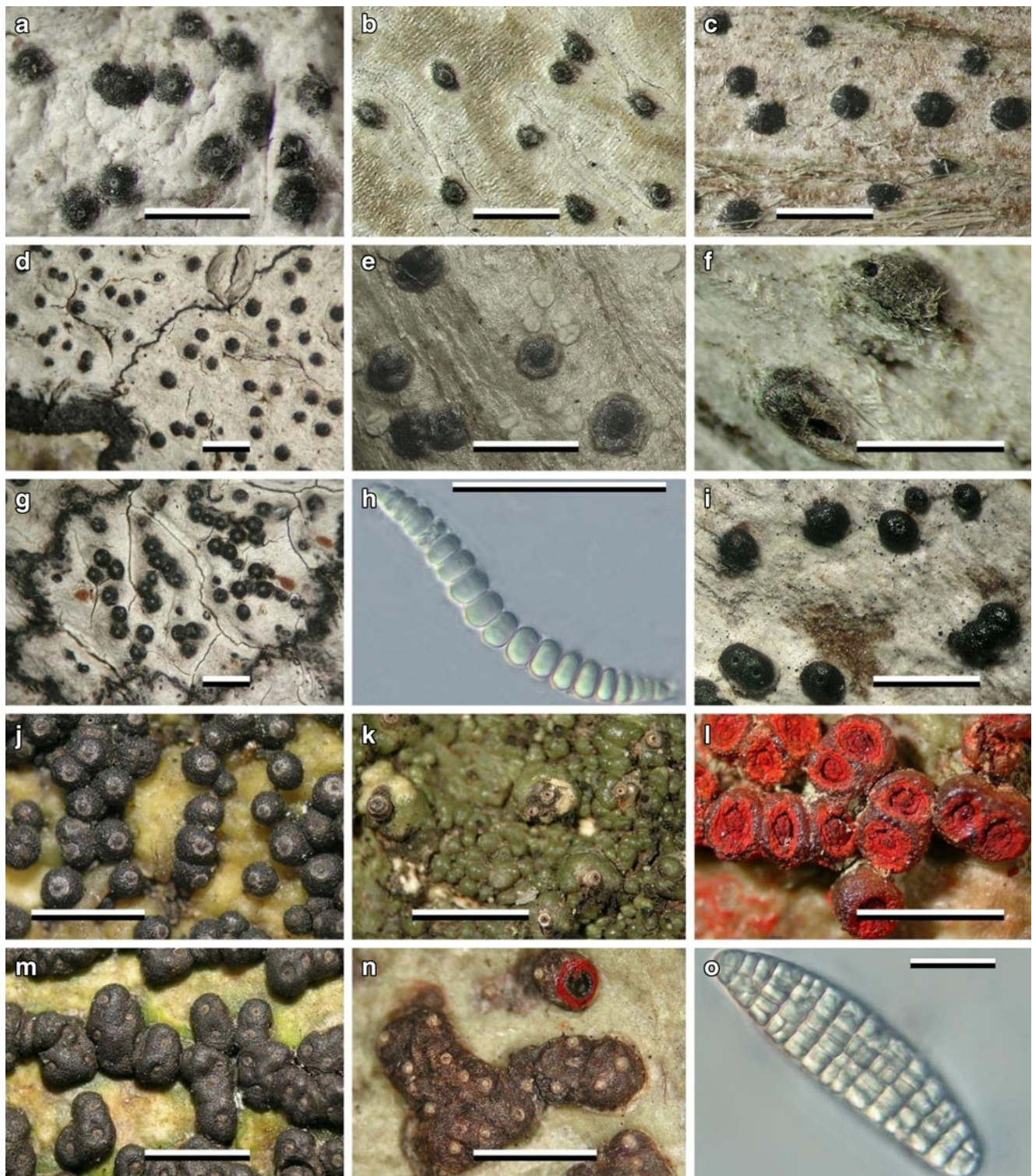


Fig. 128 Morphological features of the remaining genera of *Trypetheliaceae*. **a** Surface view of thallus and ascomata of *Arhopyrenia cinchonae* (COSTA RICA, Lücking 44). **b** Same, *A. lyrata* (COSTA RICA, Lücking s.n.). **c** Same, *Mycomicrothelia subfallens* (Florida, Lücking 26772). **d** Same, *Polymeridium catapastum* (Bahamas, Britton 6650). **e** Same, *P. chioneum* (COSTA RICA, Wolf 12512D). **f** Same, *P. subcinereum*, note the lateral ostioles (COSTA RICA, Buck 43907). **g** Same, *P. subcinereum* (DOMINICAN REPUBLIC, Harris 19593). **h** Ascospore of undescribed *Polymeridium* sp. (BRAZIL, Lücking

31068). **i** Surface view of thallus and ascomata of *Pseudopyrenula subgregaria* (Costa Rica, Sipman 47823). **j** Same, *Trypethelium tropicum* (COLOMBIA, Lücking 32544). **k** Same, *Campylothelium puiggarii* (BRAZIL, Osorio SM25). **l** Same, *Laurera purpurina* (BRAZIL, Brako 7381). **m** Same, *Bathelium mastoideum* (COLOMBIA, Lücking 32550). **n** Same, *Laurera sanguinaria* (BRAZIL, Brako 7136). **o** Ascospore of *Bathelium tuberculosum* (INDIA, Lumbsch 19735). Scale bars: **a–g, i–n**=1 mm, **h**=50 μ m, **o**=10 μ m

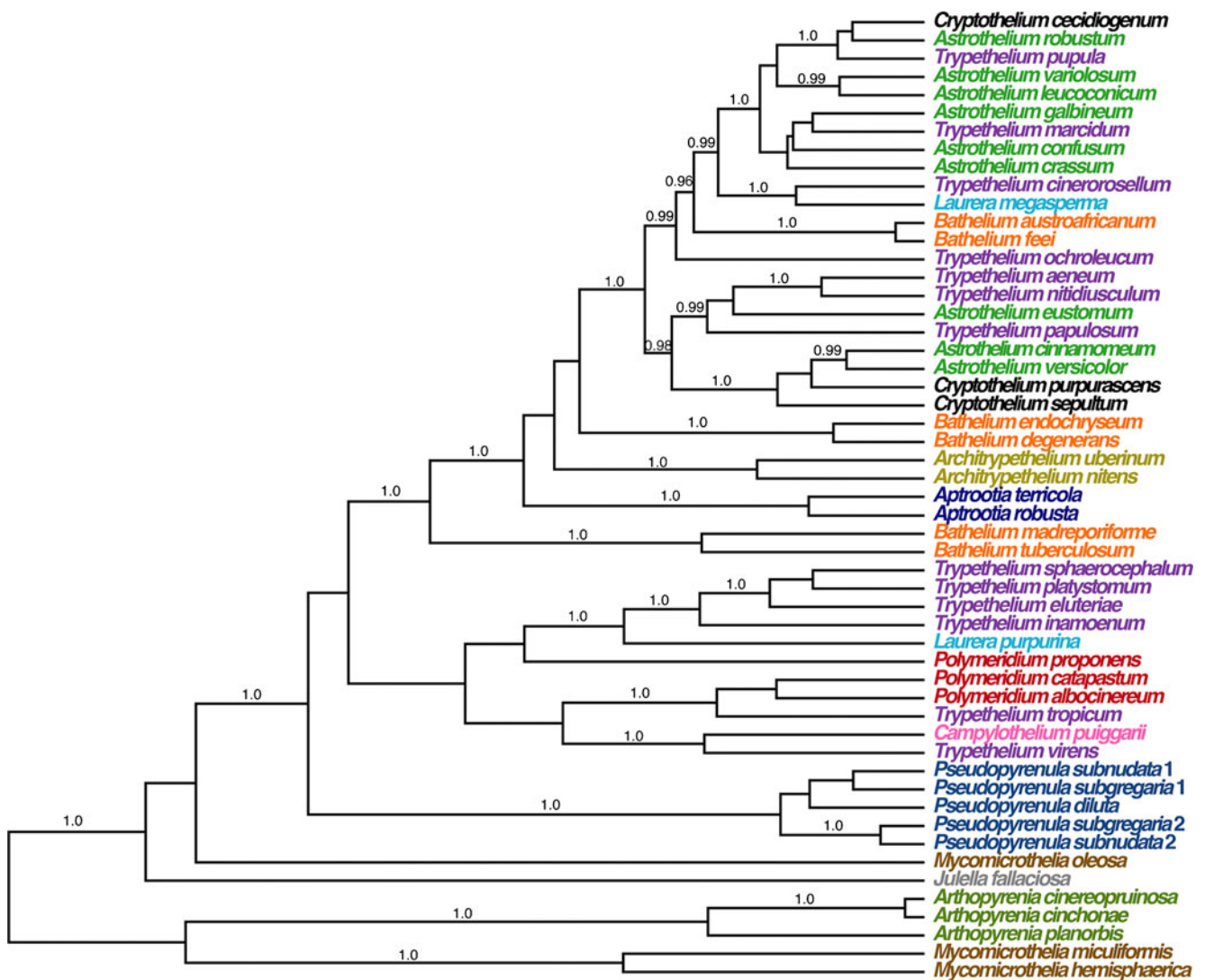


Fig. 129 Ultrametric tree showing phylogeny of *Trypetheliaceae* based on mtSSU and nuLSU sequences, reconstructed by means of Bayesian analysis. Traditional genera are indicated in different colors (from Nelsen et al. 2013)

- 2. Ascospores 1-septate to muriform, weakly disto-septate or euseptate with rectangular lumina, hyaline to brown3
- 3. Ascospores 3-septate to muriform***Polymeridium***
- 3. Ascospores 1-septate4
- 4. Ascospores brown***Mycomicrothelia*** pro parte
- 4. Ascospores hyaline***Arthopyrenia*** pro parte
- 5. Ascospores richly muriform, dark brown, outer layer easily breaking under pressure; usually on bryophytes in mountain areas***Aptrootia***
- 5. Ascospores septate or muriform, if muriform, hyaline; on bark in tropical forests or savanna6
- 6. Ascospores 3(–5)-septate and very large (over 100 μm), with angular lumina when mature, hyaline to dark brown***Architypethelium***
- 6. Ascospores variously septate but if very large (over 100 μm), then either muriform or with more than 3 septa and always distinctly disto-septate with diamond-shaped lumina when mature, always hyaline7

- 7. Ascomata solitary to clustered or with fused ostiole, erumpent to sessile with algiferous thalline cover, but not in distinct pseudostromata; ascospores 3-septate to muriform, if septate then distinctly distoseptate with diamond-shaped lumina; thallus mostly (olive-) green except when covered with lichexanthone crystals (then pale yellow)***Astrothelium***
- 7. Ascomata always in distinct, sessile pseudostromata that lack algae; ascospores septate or muriform, if septate then with rather thin septa and almost rectangular lumina and always with more than 3 septa; thallus mostly yellow-brown, rarely green8
- 8. Ascospores septate***Trypethelium***
- 8. Ascospores muriform9
- 9. Pseudostromata bright orange or red outside, often containing one or few perithecia only, with a split between the excipulum and pseudostromatal cover***Laurera purpurina*** group

9. Pseudostromata dark brown with yellow pigment inside, mostly containing several perithecia, lacking a split between the excipulum and pseudostromatal cover**Bathelium**

Tubeufiaceae M.E. Barr, Mycologia 71(5): 948 (1979), MycoBank: MB 81599

Saprobic on decorticated or decaying woody and herbaceous substrates, in terrestrial habitats, widespread in temperate and tropical regions. Sexual state: *Ascomata* completely superficial, seated on subiculum or hyphal pack, unilocular, globose-subglobose or clavate to obovate, coriaceous, solitary to gregarious, light brown to reddish-brown, glabrous or setose, papillate, ostiole central, occasionally translucent, sometimes collapsed when dry, radiating mycelium or appendages at the base. *Peridium* somewhat thick, composed of cells of *textura angularis*, pale yellow, brownish to brown in external layer, inwardly hyaline and connected with membranous tissues. *Hamathecium* comprising numerous branched, septate, hyaline, filiform pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, fissitunicate, saccate or cylindrical-clavate, sessile or with pedicel, apically rounded, with or without ocular chamber. *Ascospores* fasciculate, elongate cylindrical-subfusiform or narrowly oblong, tapering towards narrow and subacute ends, distinctly multi-septate, occasionally constricted at the median septa, hyaline, occasionally pale brown to light brown, guttulate when immature, smooth-walled. Asexual state: hyphomycetous, helicosporous, *Helicoma*, *Helicomycetes*, *Helicosporium* or chlamydosporous. *Asexual state* hyphomycetous, helicosporous. *Conidiophores* mononematous, macro to micronematous, erect or flexuous, septate, moderately to dark brown in colour. *Conidiogenous* cells holoblastic, mono- or polyblastic, integrated or discrete, terminal or intercalary. *Conidia* elongated, filiform to fusiform, curved, helicoid with varied number of coils, septate, sometimes dictyosporous, phragmosporous, hyaline to variedly coloured, smooth to verrucose, as *Aquaphila*, *Chlamydotubeufia*, *Helicoma*, *Helicomycetes*, *Helicosporium*, “Monodictys”-like, *Pendulispora*, *Peziotrichum*, *Tamhinispora* and *Xenosporium*.

Notes: The family *Tubeufiaceae* was introduced by Barr (1979a) for saprobes and parasites with superficial, brightly coloured ascomata, saccate asci, narrow, hyaline, multi-septate ascospores, and hyphomycetous asexual forms (Barr 1979a, b, 1980; Sivanesan 1984; Kodsueb et al. 2006a, b; Boonmee et al. 2012). Various genera have been assigned to the *Tubeufiaceae* ranging from four to six (Barr 1979a, b, Barr 1987b), 12 (Rossman 1987), 23 (Eriksson 2005) and 32 (Kirk et al. 2008). Molecular data, based on 28S rDNA, established the *Tubeufiaceae* as a well-supported family in the *Pleosporales* with sequences of eight taxa, comprising sexual and asexual morphs (Kodsueb et al. 2006a, b). Kodsueb et al. (2006a) accepted 18 genera although not all were examined. Boonmee et al. (2012) revisited the family and included

sequences from fresh collections of the type species of the genera *Acanthostigma*, *Acanthophiobolus*, *Kamalomyces*, *Podonectria*, *Thaxteriella* and *Thaxteriellopsis* in their phylogenetic analyses of LSU. They maintained 21 genera, while some genera were excluded because of inconsistent morphology and lack of molecular data (*Allonecte*, *Byssocallis*, *Letendraeopsis*, *Taphrophila* and *Thaxterina*). Based on combined ITS and LSU sequences with parsimony and Bayesian analyses, representatives of the *Tubeufiaceae* grouped in six well-supported clades. Currently, many genera are retained in *Tubeufiaceae* with distinctly different characters and molecular data is required to evaluate their placement. Asexual links to genera in the family have been shown by ITS and LSU sequences of 46 taxa (Tsui et al. 2006, 2007) resulting in the identification of nine well-supported clades. Based on recent morphological and molecular phylogenetic studies, we conclude that *Tubeufiaceae* comprises 16 genera i.e. *Acanthophiobolus*, *Acanthostigma*, *Acanthostigmia*, *Aquaphila*, *Boerlagiomyces*, *Chaetosphaerulina*, *Chlamydotubeufia*, *Helicoma*, *Helicomycetes*, *Helicosporium*, *Kamalomyces*, *Podonectria*, *Tamhinispora*, *Thaxteriella*, *Thaxteriellopsis* and *Tubeufia* (Boonmee et al. 2011; Rajeshkumar and Sharma 2013; Boonmee et al. in prep.).

Type: *Tubeufia* Penz. & Sacc., Malpighia 11(11–12): 517 (1898), MycoBank: MB 5635 Fig. 130

Possible synonym:

Linobolus Syd. & P. Syd., Anns mycol. 15(3/4): 204 (1917)

Saprobic on decorticated or decaying woody and herbaceous substrates, in terrestrial habitats, widespread in temperate and tropical regions. Sexual state: *Ascomata* superficial, seated on a subiculum, solitary to gregarious, or partially grouped, uniloculate, globose to subglobose, or clavate to obovate, coriaceous, translucent, light brown to reddish brown, ostiole central, sometimes collapsed when dry, radiating mycelium or appendages at the base. *Peridium* somewhat thick, composed of *textura angularis*, external layer pale yellow, brownish to brown, inner layer hyaline and connected with membranous tissues, in a gelatinous matrix. *Hamathecium* comprising numerous, branched, septate, hyaline, filiform pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, saccate or cylindrical-clavate, sessile or with a sometimes long pedicel, apically rounded, with or without an ocular chamber. *Ascospores* fasciculate, elongate cylindrical-subfusiform or narrowly oblong, tapering towards narrow and subacute ends, multi-septate, hyaline, occasionally pale brown to light brown, guttulate when immature, smooth-walled. Asexual state: hyphomycetous, i.e. *Helicoma*, *Helicomycetes* and *Helicosporium* or chlamydosporous.

Notes: The genus *Tubeufia* was introduced by Penzig and Saccardo (1898) with *Tubeufia javanica* as the type and described from *Bambusa emarcidis* in Java,

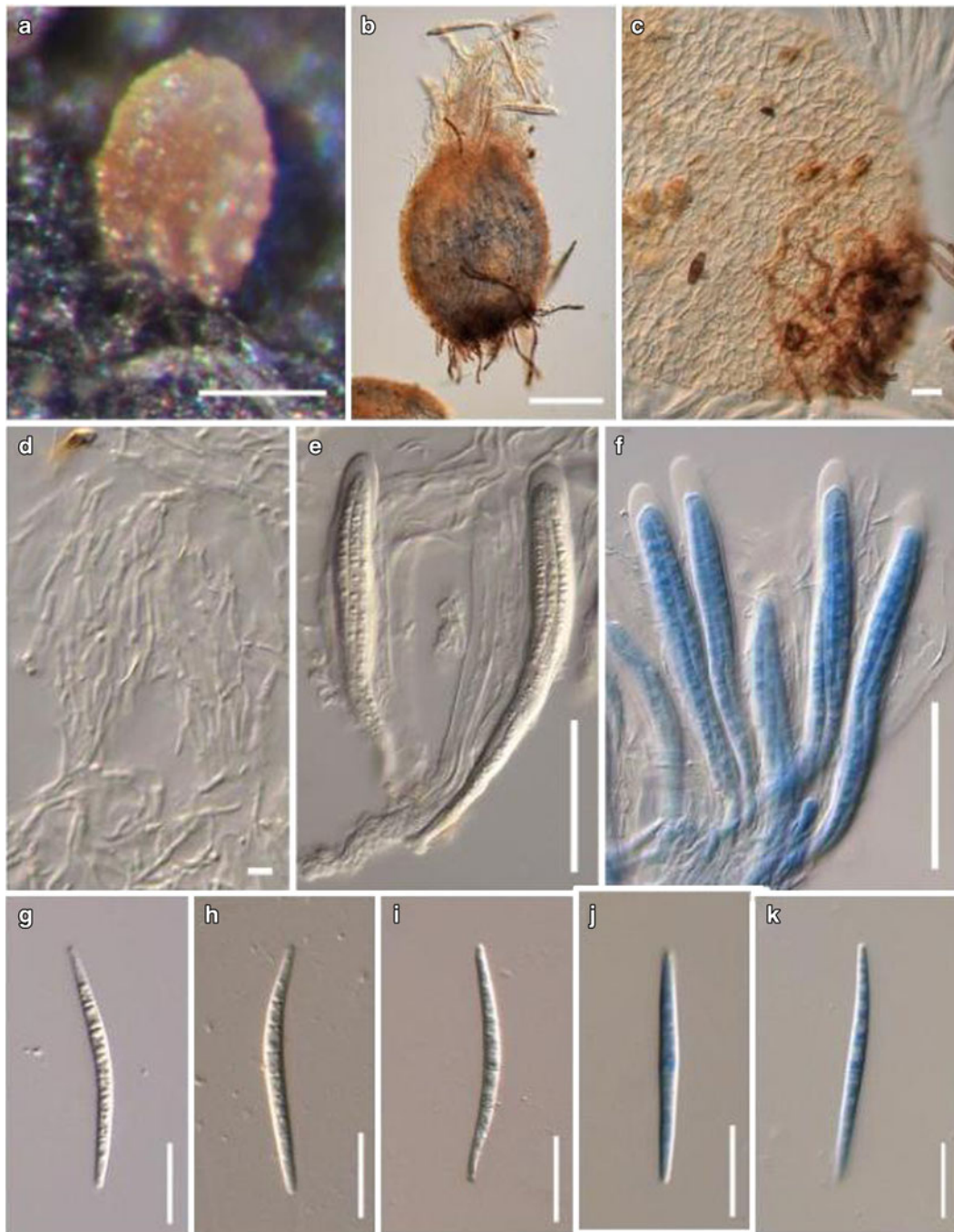


Fig. 130 *Tubeufia paludosa* (Material examined: USA, Tennessee, Blount Co., Great Smoky Mountains National Park, 25 mi W Gatlinburg, Cades Cove, Gregory Ridge Trail, alt. 1,950 ft. 35°33'45"N 83°50'45"W, on wood rotten of unidentified angiosperm, 6 September 2005, A.Y. Rossman, AR4206: BPI 871087). **a** Ascogonium seated on sparse hyphae.

b–c Squash mount showing peridium surface. **d** Pseudoparaphyses. **e–f** Asci thickened at the apex and with short pedicels. **g–k** Ascospores. Note asci and ascospores in figures **f, j–k** were stained with lactophenol cotton blue. Scale bars: **a–b** = 100 μ m, **c** = 20 μ m, **d** = 5 μ m, **e–f** = 50 μ m, **g–k** = 20 μ m

Indonesia. Currently 49 epithets are listed for the genus in Index Fungorum (2013). Other species are presumed to be related with *Tubeufia* sensu stricto based on similar morphology, such as superficial ascomata, some seated on a subiculum, that are globose-subglobose to

obclavate and brightly or darkly pigmented, and asci and ascospores that are mostly narrow, cylindrical-oblong, with many septa, and hyaline to pale brown. Some *Tubeufia* species reproduce asexually in culture and are connected with asexual genera i.e. *Aquaphila*,

Helicoma, *Helicomycetes* or *Helicosporium*. Most of these established links have been confirmed by cultural methods and phylogenetic relationships (Tsui et al. 2006, 2007; Promputtha and Miller 2010; Sanchez and Bianchinotti 2010; Sánchez et al. 2012; Boonmee et al. 2013, in prep.).

Type species: Tubeufia javanica Penz. & Sacc., Malpighia 11(11–12): 517 (1898), MycoBank: MB 244755

Other genera included

Acanthophiobolus Berl., Atti Congl. Bot. Intern. di Genova, 1892: 571 (1893) [1892]

Type species: Acanthophiobolus helminthosporus (Rehm) Berl., Die Pilze des Weinstockes, Vienna: 571 (1893) [1892]

Acanthostigma De Not., Sfer. Ital.: 85 (1863)

Type species: Acanthostigma perpusillum De Not., Sfer. Ital.: 207 (1863)

Acanthostigmina Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 1499 [39 repr.] (1909)

Type species: Acanthostigmina minuta (Fuckel) Clem. & Shear, Gen. Fung. (Minneapolis): 270 (1931)

Aquaphila Goh et al., Mycol. Res. 102(5): 588 (1998)

Type species: Aquaphila albicans Goh et al., Mycol. Res. 102(5): 588 (1998)

Boerlagiomyces Butzin, Willdenowia 8(1): 39 (1977)

Type species: Boerlagiomyces velutinus (Penz. & Sacc.) Butzin, Willdenowia 8(1): 39 (1977)

Chaetosphaerulina I. Hino, Bull. Miyazaki Coll. Agric. Forest. 10: 62 (1938)

Type species: Chaetosphaerulina yasudai I. Hino, Canad. J. Plant Sci. 10: 62 (1938)

Chlamydotubeufia Boonmee & K.D. Hyde, Fungal Divers. 51(1): 78 (2011)

Type species: Chlamydotubeufia huaikangplaensis Boonmee & K.D. Hyde, Fungal Divers. 51(1): 78 (2011)

Helicoma Corda, Icon. fung. (Prague) 1: 15 (1837)

Type species: Helicoma muelleri Corda, Icon. fung. (Prague) 1: 15 (1837)

Helicomycetes Link, Mag. Gesell. naturf. Freunde, Berlin 3(1–2): 21 (1809)

Type species: Helicomycetes roseus Link, Mag. Gesell. naturf. Freunde, Berlin 3(1–2): 21 (1809)

Helicosporium Nees, Syst. Pilze (Würzburg): 68 (1816) [1816–17]

Type species: Helicosporium vegetum Nees, Syst. Pilze (Würzburg): 68 (1816) [1816–17]

Kamalomyces R.K. Verma et al., Forest Fungi of Central India: 196 (2008)

Type species: Kamalomyces indicus R.K. Verma et al., Forest Fungi of Central India: 196 (2008)

Podonectria Petch, Trans. Br. mycol. Soc. 7(3): 146 (1921)

Type species: Podonectria coccicola (Ellis & Everh.) Petch, Trans. Br. mycol. Soc. 7(3): 146 (1921)

Tamhinispora Rajeshkumar & Rahul Sharma, Mycosphere 4(2): 166 (2013)

Type species: Tamhinispora indica Rajeshkumar & Rahul Sharma, Mycosphere 4(2): 167 (2013)

Thaxteriella Petr., Anns mycol. 22(1/2): 63 (1924)

Type species: Thaxteriella corticola Petr., Anns mycol. 22(1/2): 63 (1924)

Thaxteriellopsis Sivan. et al., Kavaka 4: 39 (1977) [1976]

Type species: Thaxteriellopsis lignicola Sivan. et al., Kavaka 4: 39 (1977) [1976]

Key to sexual genera of Tubeufiaceae

1. Ascomata globose-subglobose, with setae/hyphae2
1. Ascomata subglobose, ellipsoid, obovate, without setae/hyphae9
2. Ascomata covered by stiff setae, brown to dark brown, apically acute3
2. Ascomata covered by flexuous hairy hyphae7
3. Ascospores narrowly filiform, spiral, longer than 100 μm *Acanthophiobolus*
3. Ascospores fusiform or clavate-fusiform, not spiral, shorter than 100 μm 4
4. Ascospores equally 5-septate*Thaxteriellopsis*
4. Ascospores greater than 5-septate5
5. Ascospores heavily guttulate*Chlamydotubeufia*
5. Ascospores non-guttulate6
6. Ascospores hyaline, non mucilaginous sheath*Acanthostigma*
6. Ascospores hyaline to pale brown, thin mucilaginous sheath*Acanthostigmina*
7. Ascospores elongate-fusiform, with less than 25-septa*Chaetosphaerulina*
7. Ascospores clavate-fusiform, cylindrical-fusoid, with more than 25-septa8
8. Ascospores muriform*Boerlagiomyces*
8. Ascospores not muriform*Kamalomyces*
9. Ascospores formed on scale insects*Podonectria*
9. Ascospores formed on decaying or rotting wood10
10. Ascospores allantoid or worm-like, 7-septate*Thaxteriella*
10. Ascospores elongated cylindrical-subfusiform, with more than 7-septa*Tubeufia*

Key to asexual genera of Tubeufiaceae

1. Conidia dictyosporous, apically appendaged, heavily pigmented*Tamhinispora*
1. Conidia not dictyosporous, without appendages, hyaline, pale brown to brown2
2. Conidia phragmosporous, fusoid to sickle-shaped, slightly curved*Aquaphila*
2. Conidia helicosporous3

3. Conidiophores absent, conidia arising directly on hyphae***Helicomyses***
 3. Conidiophores present, dark brown, many septate4
 4. Conidia coiled 1-1½ times, conidial filament wider than 6 µm***Helicoma***
 4. Conidia coiled 3½-4½ times, conidial filament narrower than 6 µm***Helicosporium***

Venturiaceae E. Müll. & Arx ex M.E. Barr, Mycologia 71(5): 947 (1979), MycoBank: MB 81516

Possible synonym:

Gibberaceae Petr. [as ‘Gibberaceen’], Sydowia 7(5–6): 361 (1953)

Saprobic or *parasitic* on leaves or stems of dicotyledons, rarely on monocotyledons. Sexual state: *Ascomata* superficial or immersed, or slightly erumpent at maturity, scattered or gregarious, single locules in a stroma or below a blackened clypeus, globose to subglobose, membranous or carbonaceous, usually with seta or without seta, ostiolate, sometimes occurring on a well-developed subiculum with *ascomata*. *Peridium* a single layer of *textura angularis* with pigmented cells. *Hamathecium* comprising branched, pseudoparaphyses, asci crowded. *Asci* 8-spored, bitunicate, fissitunicate, evanescent, broadly or usually obclavate or cylindrical, usually lacking a pedicel or with very shortly pedicel, some with ocular chamber. *Ascospores* uniseriate or overlapping biseriate, cylindrical to ellipsoidal, with broadly rounded ends, without gelatinous sheath, hyaline or light greenish, or pale yellow to brown, 1-septate, slightly constricted or not constricted at the septum, upper cell shorter and broader than lower one. Asexual states: hyphomycetous. *Conidiophores* pigmented, singly or in clusters, simple or branched, *conidiogenous cells* integrated, terminal or sometimes intercalary, proliferating sympodially or percurrently, with conspicuous annellations, *conidia* aseptate or euseptate, pigmented, solitary or in chains. *Acroconidiellina pro parte*, *Fusicladium* Bonord., emend. Schubert et al. (2003), nom. cons. (= *Spilocaea*, *Cycloconium*, *Napicladium*, *Basiascum*, *Hormocladium*, *Fusicladiopsis*, *Pollaccia*, *Megacladosporium*, *Ramaria*, *Karakulinia*, *Fusicladosporium*) and *Pseudocladosporium*.

Notes: The family *Venturiaceae* was introduced by Müller and von Arx (1950), while Von Arx (1952) provided a systematic key to genera of *Venturiaceae*. The generic type of *Venturiaceae* is *Venturia inaequalis* (Cooke) G. Winter (asexual morph: *Fusicladium pomi* (Fr.) Lind). *Venturia* species are noted by Sivanesan (1977) as having very thin-walled asci. Barr (1979a) included 12 genera in *Venturiaceae* and provided a first detailed description with important diagnostic characters. Furthermore, Barr (1989a) provided a key to North American genera and species. Lumbsch and Huhndorf (2010) included 27 genera in *Venturiaceae*, but Zhang et al. (2011a) included only *Acantharia*, *Apiosporina* (incl. *Dibotryon*), *Caproventuria*, *Coleroa*, *Metacoleroa*, *Pseudoparodiella*,

Tyrannosorus and *Venturia* based on morphological, ecological and molecular phylogenetic data. Another seven genera included in *Venturiaceae* lacked molecular phylogenetic information and placement needs further study; *Zeuctomorpha* was treated as a synonym of *Acantharia*. Molecular analysis is necessary to confirm the inclusion of some genera, such as, *Acantharia*, *Coleroa* and *Pseudoparodiella* in *Venturiaceae* (Zhang et al. 2011a, b). Asexual states of *Venturiaceae* are *Acroconidiellina*, “Cladosporium”-like, “Fusicladium”-like, *Helicodendron*, *Pithosira*, *Spilocaea* and *Spilodochium* (Seifert et al. 2011; Zhang et al. 2011a, b; Wijayawardene et al. 2012). However, only a few of these connections are proven by molecular phylogenetic analyses. “Fusicladium”-like species were reported to be the asexual states of *Acantharia* (Zhang et al. 2011a, b) and *Venturia* (Schubert et al. 2003; Kirk et al. 2008; Seifert et al. 2011). However, Zhang et al. (2011a) showed that *Fusicladium sensu stricto* is better placed with *Symptoventuria* (*Symptoventuriaceae*, *Venturiales*) in their phylogenetic analyses.

Molecular study placed *Venturiaceae* in a well-supported monophyletic clade based on combined nuSSU, nuLSU and mtSSU DNA sequence data with members of *Phaeotrichaceae* (Kruys et al. 2006) and was distinct from *Pleosporales*. At the same time Kodsueb et al. (2006a) indicated a closer relationship of *Venturiaceae* with *Tubeufiaceae* based on 28S nrDNA sequences and less support for the *Pleosporales*. Members of *Venturiaceae* formed a robust clade separate from the core members of *Pleosporales* (Schoch et al. 2009a, b, c). Zhang et al. (2012a) therefore introduced a new order *Venturiales*. In this study we include *Protoventuria* in *Venturiaceae* base on morphological and phylogenetic analyses (Zhang et al. 2011a, b). Therefore we accept *Acantharia*, *Apiosporina* (= *Dibotryon*), *Caproventuria*, *Coleroa*, *Metacoleroa*, *Protoventuria*, *Pseudoparodiella*, *Tyrannosorus* and *Venturia* in *Venturiaceae*.

Type: ***Venturia*** E. Müll. & Arx ex M.E. Barr 1979, Mycologia 71: 947 (1979), MycoBank: MB 81516

Parasitic or *endophytic* on of dicotyledonous leaves, bark and wood. Sexual state: *Ascomata* small, solitary or scattered or gregarious, immersed and becoming erumpent, black, globose, subglobose, papillate, ostiolate. *Peridium* thin, 1-layer, dark brown to black, comprised of *textura angularis*. *Hamathecium* rarely observed, or evanescent at maturity. *Asci* 8-spored, bitunicate, fissitunicate, oblong to obclavate, pedicel thick or sometimes lacking, with an ocular chamber. *Ascospores* partially overlapping, with broadly rounded ends, hyaline to pale brown, 1-septate, slightly constricted at the septum, with upper cell shorter than the lower cell, smooth-walled.

Notes: *Venturia* was introduced by Saccardo (1882) with *V. inaequalis* as the type species and currently 263 epithets are listed in Index Fungorum (2013). Molecular data show it to be

a well-supported monophyletic group and variously referred to the orders *Microthyriales* with the *Phaeotrichaceae* as a sister clade (Schoch et al. 2009a, b). *Venturia*, based on a sexual morph type, is threatened by the older anamorph-typified name *Fusicladium* (*nom. cons.*), which has priority according to the new Art. 59, of the new ICN. However, a proposal to use *Venturia* as holomorph name and to treat *Fusicladium* as heterotypic synonym is planned.

Schubert et al. (2003) reported that *Spilocaea* is the asexual state of *Venturia*. However, Seifert et al. (2011) reduced *Spilocaea* and synonymized it under *Fusicladium*, but Zhang et al. (2011a) clearly showed that *Spilocaea pomi* Fr., the type species of *Spilocaea* is a well-resolved group in *Venturiaceae* with *Venturia inaequalis* (Cooke) G. Winter. Hence we conclude that *Spilocaea* is the asexual state of *Venturia* and we reduce it to synonymy under *Venturia*. Although *Spilocaea* is the older name, we propose *Venturia* over *Spilocaea* as the number of epithets of *Venturia* is far higher than for *Spilocaea* (Index Fungorum 2013).

Type species: Venturia inaequalis (Cooke) G. Winter, in Thümen, Mycoth. Univ., cent. 3: no. 261 (1875), MycoBank: MB164141

Figure 131

= *Sphaerella inaequalis* Cooke, Journal of botany, British and foreign 4: 248, pl. 51 Fig. 26 (1866)

Other genera included

Acantharia Theiss. & Syd., Anns mycol. 16(1/2): 15 (1918)

Type species: Acantharia echinata (Ellis & Everh.) Theiss. & Syd., Anns mycol. 16(1/2): 15 (1918)

Acroconidiellina M.B. Ellis, Mycol. Pap. 125: 22 (1971)

Type species: Acroconidiellina loudetiae M.B. Ellis, Mycol. Pap. 125: 23 (1971)

Apiosporina Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 439 [47 repr.] (1910)

Type species: Apiosporina collinsii (Schwein.) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 439 [47 repr.] (1910)

Atopospora Petr., Anns mycol. 23(1/2): 100 (1925)

Type species: Atopospora betulina (Fr.) Petr., Anns mycol. 23(1/2): 101 (1925)

Caproventuria U. Braun, Monogr. Cercospora, Ramularia Allied Genera (Phytopath. Hyphom.) 2: 396 (1998) Fig. 132

Saprobic on roots and stems of *Lupinus luteus*. Sexual state: *Ascomata* with long setae, globose to subglobose, non-stromatic, membranaceous, comprising darkly pigmented cells, papillate, ostiolate. *Setae* throughout, non-septate, dark brown, slightly forked on surface of ascomata, acute at the apex, blunted and broad at base, thickened below but thin at apex, smooth-walled. *Peridium* comprising 1-layer of brown

cells of *textura angularis*. *Hamathecium* comprising branched, pseudoparaphyses. *Asci* 8-spored, bitunicate, fissitunicate, numerous, obclavate or broadly cylindrical, evanescent, with very shortly pedicel, and ocular chamber. *Ascospores* slightly overlapping, cylindrical to ellipsoidal, rounded at both ends, hyaline to pale brown and slightly light greenish, 1-septate, constricted and dark brown at the septum, upper cell slightly shorter and broader than lower cell, surface slightly roughened. Asexual state: See under notes.

Type species: Caproventuria hanliniana (U. Braun & Feiler) U. Braun, Monogr. Cercospora, Ramularia Allied Genera (Phytopath. Hyphom.) 2: 396 (1998), MycoBank: MB 444756

= *Capronia hanliniana* U. Braun & Feiler, Microbiol. Res. 150(1): 90 (1995)

Notes: Crous et al. (2007c) and Seifert et al. (2011) treated *Pseudocladosporium* as synonym of *Fusicladium*. However, Zhang et al. (2011a) concluded *Pseudocladosporium* to be asexual state of *Caproventuria*. In this study we accept *Pseudocladosporium* as asexual state of *Caproventuria* but this needs confirmation by phylogenetic analyses.

Coleroa Rabenh., Klotzschii Herb. Viv. Mycol., Edn 1: no. 1456 (in sched.) (1850)

Type species: Coleroa chaetomium (Kunze) Rabenh., Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 1: 198 (1850)

Helicodendron Peyronel, Nuovo G. bot. ital. 25: 460 (1918)

Type species: Helicodendron paradoxum Peyr., Nuovo G. bot. ital. 25: 461 (1918)

Metacoleroa Petr., Anns mycol. 25(3/4): 332 (1927)

Type species: Metacoleroa dickiei (Berk. & Broome) Petr. [as 'dieckiei'], Anns mycol. 25(3/4): 332 (1927)

Pithosira Petr., Sydowia 3(1–6): 259 (1949)

Type species: Pithosira sydowii Petr., Sydowia 3(1–6): 259 (1949)

Protoventuria Berl. & Sacc., Atti Soc. Veneto-Trent. Sci. Nat. 10(1): 174 (1887)

Type species: Protoventuria rosae (De Not.) Berl. & Sacc., Atti Soc. Veneto-Trent. Sci. Nat. 10(1): 174 (1886)

Pseudocladosporium U. Braun, Monogr. Cercospora, Ramularia Allied Genera (Phytopath. Hyphom.) 2: 392 (1998)

Type species: Pseudocladosporium brevicatenatum (U. Braun & Feiler) U. Braun, Monogr. Cercospora, Ramularia Allied Genera (Phytopath. Hyphom.) 2: 393 (1998)

Pseudoparodiella F. Stevens, Illinois Biol. Monogr. (Urbana) 11(2): 14 (1927)

Type species: Pseudoparodiella vernoniae F. Stevens, Illinois Biol. Monogr. (Urbana) 11(2): 166 (1927)

?*Spilodochium* Syd., Anns mycol. 25(1/2): 158 (1927)

Type species: Spilodochium vernoniae Syd., Anns mycol. 25(1/2): 158 (1927)



Fig. 131 *Venturia inaequalis* (Material examined: GERMANY, Brno, Moravia, on lower leaf surface of *Sorbus torminalis*, Rabenh., Fungi europ. 2663 (distributed in 1881), de Niessl, L 0054534, type of *Didymosphaeria inaequalis* (Cooke) Niessl.). **a–e** Herbarium specimens and packets. **f** Ascomata erumpent on lower surface of substrate. **g**

Ascoma. **h** Section through ascoma. **i** Upper walls of ascoma. **j** Ascus. **k** Ascus in Melzer’s reagent. **l–m** Ascospores. **n** Ascospore in Melzer’s reagent. **o** Ascospore in 70 % lactic acid. Scale bars: **g–h** = 50 μ m, **i–k** = 20 μ m, **l–o** = 10 μ m

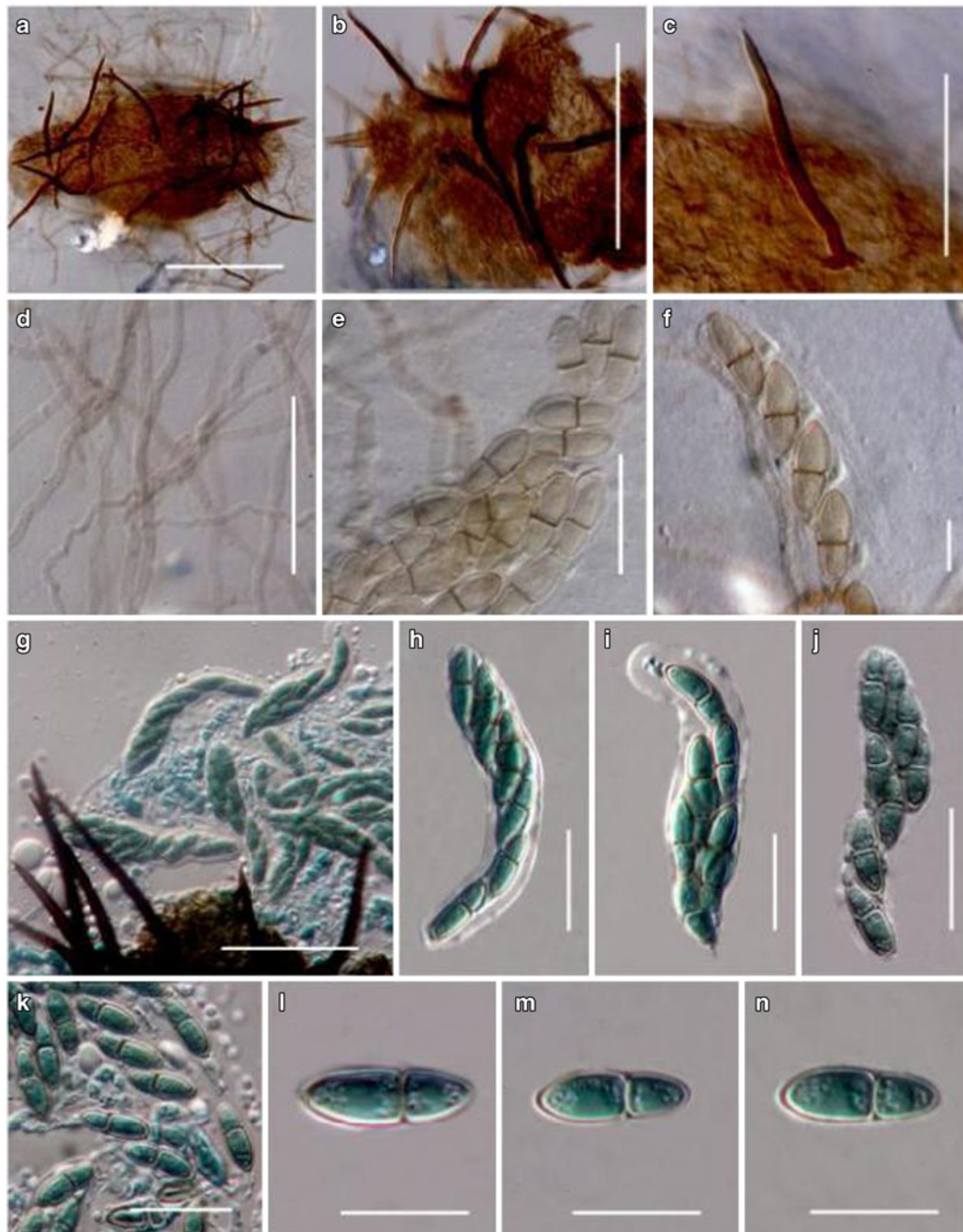


Fig. 132 *Caproventuria hanliniana* (Material examined: GERMANY, Mecklenburg, Bornhof, from roots and stems of *Lupinus luteus*, HAL, Feiler 7623, **holotype**). **a, b** Ascomata with black setae. **c** Seta on surface of ascoma with knob at base. **d** Hyaline to pale brown mycelium. **e, f**

Ascospores pale brown at maturity. **g–j** Obclavate asci with short pedicel, stained in lactophenol cotton blue. **k–n** Ellipsoidal, ascospores with round ends, stained in lactophenol cotton blue. Scale bars: **a–b** = 50 μm , **c, d** = 20 μm , **e–f** = 10 μm , **h–n** = 10 μm

Tyrannosorus Unter. & Malloch, Mycol. Res. 99(8): 910 (1995)

Type species: Tyrannosorus pinicola (Petrini & P.J. Fisher) Unter. & Malloch, Mycol. Res. 99(8): 910 (1995)

Key to sexual genera of *Venturiaceae*

1. Ascostromata superficial2
1. Ascostromata erumpent7
2. Ascostromata superficial with setae3

2. Ascostromata superficial without setae5
 3. Hyphae intramatrical4
 3. Hyphae superficial as well as intramatrical.....
 *Coleroa*
 4. Intramatrical penetrating tissue *Protoventuria*
 4. Intramatrical hyphae thin, subcuticular.....
 *Metacoleroa*
 5. Ascospores 1-septate, septum near middle6
 5. Ascospores 1-septate, apiosporous, septum near base
 *Apiosporina*
 6. Ascostromata cupulate when dry, ascospore dark brown
 when mature (asexual state: *Acroconidiellina*, conidiomata
 with setae, conidia 1-septate) *Acantharia*
 6. Ascostromata not cupulate when dry, ascospore pale brown
 when mature (asexual state: *Spilodochium*, conidiomata with-
 out setae, conidia 0–1-septate, branched, schizolytic)
 *Pseudoparodiella*
 7. Ascostromata erumpent with setae8
 7. Ascostromata erumpent without setae *Venturia*
 8. Ascospore without germ slits (asexual state: *Spilocae*,
 conidiogenous cell thickened, conidia 0- multi-septate)
 *Caproventuria*
 8. Ascospore with germ slits (asexual state: *Helicodendron*
 with helicosporeous conidia, coiling in three dimensions)
 *Tyrannosorus*

Key to asexual genera of *Venturiaceae*

1. Conidiomata lacking, hyphomycetous2
 1. With conidiomata, coelomycetous5
 2. Conidiophores branched3
 2. Conidiophores unbranched4
 3. Conidiogenous cells monoblastic, conidia helicosporeous,
 coiling in three dimensions *Helicodendron*
 3. Conidiogenous cells sympodial, conidia 0- multi-septate,
 brown “*Cladosporium*”-like
 4. Conidiogenous cells thin-walled, not darkened, conidia 0–
 1-septate *Caproventuria* (including *Pseudocladosporiu*)
 4. Conidiogenous cells thickened, brown, conidia 0- multi-
 septate *Venturia* (including *Spilocae*
 5. Conidiomata with unbranched setae, conidia 1-septate
 *Acroconidiellina*
 5. Conidiomata without setae6
 6. Conidiogenous cells thallic-arthric, conidia 1-septate,
 schizolytic *Pithosira*
 6. Conidiogenous cells monoblastic or sympodial, conidia 0–
 1-septate, schizolytic *Spilodochium*

Vizellaceae H.J. Swart, Trans. Br. mycol. Soc. 57: 456 (1971),
 MycoBank: MB 81519

Possible synonyms:

Entopeltidaceae Arx & E. Müll. [as ‘Entopeltaceae’],
 Beitr. Kryptfl. Schweiz 11(no. 1): 98 (1954)

Haplosporaceae Räsänen, Acta bot. fenn. 33: 31 (1943)

Parasitic or *saprobic* on leaves, tropical and subtropical in
 distribution, developing in or beneath the cuticle, often
 forming an intracuticular mycelium, without superficial hy-
 phae. Sexual state: *Ascostromata* dimidiate, scutate or crus-
 tose, roundish or elongated in outline, with a thin wall com-
 posed of small, dark cells, opening by a fissure or dehiscence,
 central part of loculus may be sterile. *Hamathecium* compris-
 ing filamentous pseudoparaphyses, often filling the central
 part of the loculus or may be sparse or absent. *Asci* 6–8-
 spored, bitunicate, probably evanescent, broadly clavate or
 nearly cylindrical, short pedicellate or apedicellate, apically
 rounded with ocular chamber. *Ascospores* 2–3 overlapping
 seriate, hyaline to brown, 1–2-celled or apiosporous with
 small cell at the base, brown, with a light transverse band.
 Asexual state: linked to *Chrysogloeam* and *Manginula*
 (Hughes 1953a, b; Petrak 1953). *Pycnidia* disc-shaped with
 upper wall of irregularly arranged cells, subglobose, dark
 brown to black, scutate or crustose. *Conidiogenous cells*
 hyaline, cylindrical, holoblastic. *Conidia* ovoid to ellipsoidal
 or rarely subglobose, brown to dark brown, with transverse
 hyaline band, formed on phialidic, hyaline cells lining the
 inner cavity of the upper wall.

Notes: *Vizellaceae* was established to accommodate
Blasdalea and *Vizella* by Swart (1971), with *Vizella* as the
 type species. The position of *Vizella* within the ascomycetes is
 not clear, as different authors place it in various orders and
 families. Following the classification proposed by von Arx
 and Muller (1954) and Müller and von Arx (1962), the genus
 is placed in the order *Dothideales*. Within the order, von Arx
 and Muller (1954) proposed the new family *Entopeltaceae* to
 include *Vizella*, *Entopeltis* and *Blasdalea*. Publication of this
 family name was not valid, because no Latin diagnosis was
 given (Cooke and Hawksworth 1970). Swart (1971) proposed
 the same family under a different name *Vizellaceae*, choosing
Vizella as the type and treated *Entopeltis* as the synonym of
Vizella. Species of *Vizella* are leaf parasites. They are either
 subcuticular or grow in the thick cuticle of their host. The
 mycelium is very characteristic; hyphae are ribbon-like. Walls
 are generally thin and, when hyaline, almost invisible. Septa
 are usually thickened and dark. Swart (1971) suggested that
 the mycelium might well be of diagnostic value, but several
 authors failed to observe this. Hughes (1953a) described the
 mycelium of the type species from the type collection and
 confirmed the presence of characteristic mycelium composed
 of hyaline to light brown hyphae with thick, with dark brown
 cross walls. Swart (1971) proposed that it is possible that in
 species where no mycelium had been observed, these are
 present, but entirely hyaline and thus very difficult to see. In
 most species the mycelium branches frequently at fairly wide
 angles, and so forms a network without radial orientation.

Vizella was introduced by Saccardo (1883) with *V.*
conferta (Cooke) Sacc. as the type species, and is character-
 ized by dimidiate, superficial ascomata and one-celled, brown

ascospores. Later, von Höhnelt (1910a, b) established the new genus *Entopeltis* which he distinguished from *Vizella* mainly based on the subcuticular position of the mycelium and ascomata in the type species, *E. interrupta*. Studies were carried out on the type species of both genera by several mycologists (Theissen 1914a, b; Theissen and Sydow 1917; Petrak and Sydow 1929). Hughes (1953a) re-examined the type species of *Vizella* and *Entopeltis*, and confirmed the presence of characteristic mycelium composed of hyaline to light brown hyphae with thick, dark brown cross walls in both genera. He found the ascospores of *Entopeltis* to be continuous with a remarkable transverse hyaline band, while those of *Vizella* were composed of a large upper cell with a hyaline transverse band and a small hyaline to brown basal cell. Some one-celled ascospores lacking the basal cell were, however, also seen in the type collection of *V. conferta*. Because of these observations, Hughes (1953a) placed *Entopeltis* in synonymy with *Vizella*. von Arx and Müller (1954) were not in agreement with Hughes (1953a) and reinstated *Entopeltis*, which they distinguished from *Vizella* as having intracuticular mycelium and ascomata with the upper wall composed a single layer of cells, while in *Vizella*, the upper wall is composed of several cell layers and the presence of a central column of sterile tissue in the ascomata. In addition, von Arx and Müller (1975) insisted that the two genera can be distinguished by the arrangement of the asci in a ring around a central column of sterile tissue in the ascomata of *Vizella* and also by the ascospores which are one-celled in *Entopeltis*, but having a basal cell in *Vizella*. By studying the type species and other *Entopeltis* and *Vizella* species, van Wyk et al. (1976) suggested that 1): the types of the mycelium; 2): the cell layers of the upper wall of ascomata; 3): the presence/absence of a central column of sterile tissue in the ascomata; 4): 1–2-celled ascospores and the presence/absence of a basal cells in the ascospores are inconsistent features which cannot be used to separate *Entopeltis* from *Vizella*. *Blasdalea* is also similar to the above genera. This monotypic genus was introduced by Saccardo and Sydow (1902) for *Blasdalea disciformis* and has remained monotypic. von Arx and Müller (1954) illustrated the type species which had cylindrical asci and abundant pseudoparaphyses and ascomata opening by a large ostiole. We were unable to find the sexual state in the holotype which was described in Rehm (1900). The same holotype specimens (S F793) was examined by J.K. Liu and S. Boonmee separately, who found one-celled brown conidia with a hyaline transverse band, some two-celled, hyaline to brown, with a medium lighter septum. *Blasdalea* may be related with *Fasciatispora* which has unitunicate asci but the nature of the asci in the illustration provided in von Arx and Müller (1954) is not clear. In this paper we treat *Mycerema* as a synonym of *Vizella*. *Blasdalea* is maintained as a distinct genus in *Vizellaceae* pending fresh collections and molecular studies.

The asexual states are unknown for most species in the family except three *Vizella* species and *Blasdalea disciformis*. Hughes (1953a) described a conidial form associated with *Vizella hendrickxii* (Hansf.) S. Hughes. He referred to the genus *Manginula* as apparently being the asexual state of an unknown *Vizella* species. However, Kirk et al. (2008) stated that the generic concept of *Manginula* is uncertain (i.e. *nom. dub.*). Swart (1971) introduced two new species to this genus from Australia with conidial states. The asexual state of *Blasdalea* is *Chrysogloeum* (Petrak 1953) and this is also illustrated here (from the type of *Blasdalea disciformis*) below. *Perizomella inquinans* Syd. has similar conidia (Sutton 1980).

Wijayawardene et al. (2012) listed the asexual states as *Chrysogloeum* and *Manginula*. *Chrysogloeum* was established to accommodate the coelomycetous asexual states of *Blasdalea* (as *Singeriella*). According to Sivanesan (1984) *Vizella* has *Manginula* or “*Manginula*”-like asexual states.

Type: *Vizella* Sacc., Syll. Fung. (Abellini) 2: 662 (1883), MycoBank: MB 5747

Possible synonyms:

Entopeltis Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 420 (1910)

Mycerema Bat. et al., Publicações Inst. Micol. Recife 392: 5 (1963)

For other possible synonyms see Index Fungorum

Colonies epiphyllous, developing under the cuticle. Sexual state: *Hyphae* ribbon-like consisting of hyaline cells alternating usually in pairs with much shorter dark cells or without thickened septa. *Ascostromata* disc-shaped with upper wall of irregularly arranged cells, scutate or crustose, roundish or elongate. *Hamathecium* comprising pseudoparaphyses in young ascostromata. *Asci* 8-spored, ovoid or saccate, short pedicellate or apedicellate, apically rounded with a inconspicuous ocular chamber, arranged radially around a central column. *Ascospores* biserial, one celled or with a small appendage-like basal cell, brown, with a light coloured band around the middle or just above the middle septum (the description follows Sivanesan 1984. Asexual state: *Pycnidia* disc-shaped with upper wall of irregularly arranged cells, scutate or crustose. *Conidiogenous cells* phialidic, hyaline, lining the inner cavity of the upper wall. *Conidia* ovoid, brown, with transverse hyaline band.

Notes: *Vizella* presently comprises 33 species all with light bands in the ascospores and three are linked to asexual states (Hughes 1953a, b; Swart 1971). The confusion between *Entopeltis* and *Vizella* is discussed in the family notes. The genus *Mycerema* was introduced by Batista et al. (1963) and is presently monotypic based on *M. vohysiacearum*. This species has ascospores that resemble *Vizella* in having a light band in the upper part of the ascospores, but with a small, brown basal cell (hyaline in *Vizella*) and similar pseudoparaphyses. The ascomata have thin walls as in *Entopeltis*. This

intermediate form between *Vizella* and *Entopeltis* further indicates they all three genera may be congeneric. *Vizella vochysiacearum* (New combination: *Vizella vochysiacearum* (Bat., J.L. Bezerra & Cavalc) J.K. Liu, R. Phookamsak & K.D. Hyde, comb. nov., basionym: *Mycerema vochysiacearum* Bat. et al., in Batista et al., Publicações. Instituto de Micologia da Universidade do Recife & Instituto Nacional de Pesquis 392: 7 (1963). MycoBank: MB 803658 is illustrated for this family (Fig. 133).

Type species: Vizella conferta (Cooke) Sacc., Syll. Fung. (Abellini) 2: 661 (1883), MycoBank: MB 207415 (Fig. 134) \equiv *Micropeltis conferta* Cooke, Grevillea 6: 118 (1878)

Other genera included

Blasdalea Sacc. & P. Syd., Syll. Fung. (Abellini) 16: 634 (1902), MycoBank: MB 592

Possible synonyms:

Singeriella Petr., Sydowia, 12: 252 (1959)

Chrysogloeum Petr., Sydowia 12: 254 (1959) [1958] (see Wijayawardene et al. 2013)

Sexual state: *Ascstromata* stromatic, with ring-like or linear loculus; subcuticular hyphae inconspicuous, scutate. *Peridium* composed of pigmented thick-walled cells of *textura angularis*. *Hamathecium* comprising hyaline, filiform pseudoparaphyses. *Asci* 8-spored, bitunicate, oblong to clavate, short pedicellate or apedicellate,



Fig. 133 *Vizella vochysiacearum* (Material examined: Ponta Negra, Manaus, Amazonas, on *Vochysiaceae* sp., 18 September 1961., URM 25844, holotype) **a** Herbarium material. **b** Ascostromata on substrate. **c** Squash of ascostromata. **d** Section of ascostroma. **e** Wall of ascostroma. **f**

Pseudoparaphyses. **g** Asci with immature ascospores. **h–i** Asci. **j, i–o** Ascospores. **k** Young ascus apex with an ocular chamber. Note **f, g, h, l, k** in lactolactophenol cotton blue. Scale bars: **c, d** = 20 μ m, **e–g** = 10 μ m, **h–j** = 5 μ m, **k–o** = 2 μ m



Fig. 134 *Vizella conferta* (Material examined: INDIA, Dinagepore, on upper surface of leaves of “Bhauri” (*Symplocos spicata*), IMI 174644, **holotype**) **a** Herbarium material. **b** Ascostromata on host substrate. **c**

Section of ascoma. **d** Peridium. **e–h** Asci. **i–m** Ascospores. Scale bars: **c**=100 μ m, **d–i**=20 μ m, **j–m**=10 μ m

apically rounded with a well-developed ocular chamber, not arranged in a ring surrounding a central column of sterile tissues. *Ascospores* hyaline, subglobose. Asexual state: *Pycnidia* up to 300 μ m diam., occurring on leaf surface, subglobose, dark brown to black, shiny, solitary, gregarious, papilla. *Conidiophores* up to 10 μ m long, hyaline. *Conidiogenous cells* hyaline, cylindrical, holoblastic. *Conidia* 9–12 \times 5–7 μ m, ellipsoidal or rarely subglobose, 1-celled, brown to dark brown, with colourless or light brownish band around median cell, smooth-walled (the sexual morph description follows Rehm 1900).

Type species: *Blasdalea disciformis* (Rehm) Sacc. & P. Syd., Syll. Fung. (Abellini) 16: 634 (1902), MycoBank: MB 144897 (Fig. 135)

\equiv *Vizella disciformis* Rehm, Hedwigia 39: 227 (1900)

Key to genera of *Vizellaceae*

1. Ascospores hyaline to brown, subglobose, with one to two cells; if asexual morphs present, with 1-celled, brown to dark brown, colorless or light brownish band around median cell conidia *Blasdalea*
2. Ascospores brown, fusiform to ellipsoidal, one to two-celled, with a light transverse band at the upper cell, sometimes with a small hyaline to brown basal cell *Vizella*

Zopfiaceae G. Arnaud ex D. Hawksw., Syst. Ascom. 11(1): 77 (1992), MycoBank: MB 81951



Fig. 135 *Blasdalea disciformis* (Material examined: BRAZIL, Serra do Itatiaia, on leaves of *Escallonia vaccinioides*, S F793, **holotype**, S F795, S F172050). **a** Herbarium material. **b, c** Conidiomata forming on the

leaves. **d** Section through conidioma. **e** Mycelium. **f–k** Conidiogenous cells and conidia. Scale bars: **d** = 50 μm , **e** = 30 μm , **f–k** = 10 μm

Saprobic usually on surface of roots or wood, terrestrial and marine, widespread. Sexual state: *Ascomata* cleistothecial or perithecial, relatively large, solitary or clustered, superficial or partially erumpent, subglobose rounded above, carbonaceous, dark brown to black, non-ostiolate and breaking on the top of ascomata at maturity, or ostiolate. *Peridium* thick-walled, 2-layered, comprised of cells of *textura angularis*, inner cells, hyaline to pale brown and outer cells, dark brown

to black and thick-walled. *Hamathecium* of numerous, septate, filamentous, hyaline, branched, anastomosing pseudoparaphyses, embedded in a gelatinous matrix dissolving at maturity. *Asci* 1–8-spored, bitunicate, fissitunicate, clavate to cylindrical, short or long pedicellate, dissolving at maturity. *Ascospores* crowded or partially overlapping, obovate to pyriform, hyaline, non-septate or 1-septate, mostly septate at the middle or upper cell broader than the lower

cell, with umbonate ends, constricted at the septum, smooth or slightly rough and colourless, yellow to brown when immature, smooth or slightly rough and completely black at maturity. Asexual state: “Cladosporium”-like (Wijayawardene et al. 2012)

Notes: *Zopfiaceae* was introduced by Arnaud (1913). This family is typified by *Zopfia rhizophila* Rabenh. Malloch (1970) suggested that *Zopfia* might be a loculoascomycete and *Zopfiaceae* should be used for taxa usually found on roots. von Arx and Müller (1975) recognized eight genera in *Zopfiaceae*, while Krus et al. (2006) and Zhang et al. (Zhang et al. 2012a, b) estimated there were 14 genera, with the combination of *Zopfiaceae* and *Testudinaceae*, but suggested that the family is likely to be polyphyletic. Zhang et al. (2013) revised their estimate to 11 genera with the transfer of *Halothia*, *Mauritiana* and *Pontoporeia* to the family *Halothiaceae*. In this paper we accept *Caryospora*, *Celtidia*, *Coronopapilla*, *Rechingeriella*, *Richonia*, *Zopfia* and *Zopfiofoveola* in *Zopfiaceae*.

In several studies, *Zopfiaceae* has been placed in *Pleosporales* (Ainsworth et al. 1971; Luttrell 1973; Hawksworth and Booth 1974; Malloch 1981; Barr 1987a, b). However, very few phylogenetic studies have been carried out on species of *Zopfiaceae* (Zhang et al. 2012a, b). Hence, a wider taxon and gene sampling is required to resolve the position of *Zopfiaceae* in *Dothideomycetes*.

Type: *Zopfia* Rabenh., Fungi europ. exsicc.: no. 1734 (1874), MycoBank: MB 5875

Saprobic on roots of *Asparagi radicibus* and other plants. Sexual state: *Ascomata* relatively large, thick-walled, solitary or clustered, superficial and partially erumpent, carbonaceous, dark brown to black, subglobose to globose, rounded above, dark brown to black, non-ostiolate, breaking on top of ascomata to release ascospores at maturity. *Peridium* thick, comprising two-layers, outer layer composed of pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Hamathecium* comprising numerous, filamentous, septate, branched, anastomosing, hyaline pseudoparaphyses, embedded in a gelatinous matrix. *Asci* 8-spored, thick-walled, bitunicate, globose or saccate, dissolving at maturity (Hawksworth and Booth 1974; Cannon and Kirk 2007). *Ascospores* 3–4-seriate, oblong to ellipsoid, hyaline or yellow, to brown when immature, completely black at maturity, 1-septate in the centre, constricted and dark at the septum, with umbonate ends, smooth-walled or slightly roughened.

Notes: There are 16 species epithets for *Zopfia* in Index Fungorum (2013) and as the genus stands now it is certainly polyphyletic. A strain of *Zopfia rhizophila* groups as a sister clade to three *Delitschia* species with weak/moderate support in a five gene phylogenetic study (Schoch et al. 2009a, b; Zhang et al. 2012a).

Type species: *Zopfia rhizophila* Rabenh. Fungi europ. exsicc.: no. 1734 (1874), MycoBank: MB 209329 (Fig. 136)

Other genera included

Caryospora De Not., Micr. Ital. Novi 9: 7 (1855)

Type species: *Caryospora putaminum* (Schwein.) De Not., Micr. Ital., Dec. 9: 7 (1855) *Celtidia* J.D. Janse, Ann. Jard. Bot. Buitenzorg 14(1): 202 (1897)

Type species: *Celtidia duplicispora* J.D. Janse, Ann. Jard. Bot. Buitenzorg 14(1): 202 (1897)

Coronopapilla Kohlm. & Volkm.-Kohlm., Mycol. Res. 94(5): 686 (1990)

Type species: *Coronopapilla avellina* Kohlm. & Volkm.-Kohlm., Mycol. Res. 94(5): 687 (1990)

Rechingeriella Petr., in Rechinger et al., Annln naturh. Mus. Wien 50: 465 (1940)

Type species: *Rechingeriella insignis* Petr., Annln naturh. Mus. Wien, Ser. B, Bot. Zool. 50: 465 (1940)

Richonia Boud., Revue mycol., Toulouse 7: 224 (1885)

Type species: *Richonia variospora* Boud., Revue mycol., Toulouse 7: 265 (1885)

Zopfiofoveola D. Hawksw., Can. J. Bot. 57(2): 98 (1979)

Type species: *Zopfiofoveola punctata* (D. Hawksw. & C. Booth) D. Hawksw., Can. J. Bot. 57(2): 98 (1979)

Key to genera of *Zopfiaceae*

1. Ascomata with stroma or clypeus2
1. Ascomata without stroma or clypeus4
2. Ascospore echinulate, granulate*Celtidia*
2. Ascospore not echinulate3
3. Ascospore uni-septate, ornamented, with undulating sheath, irregularly ridged at maturity*Richonia*
3. Ascospore 1–3-septate, not ornamented, constricted at the central of septum*Coronopapilla*
4. Ascomata superficial to partially erumpent5
4. Ascomata immersed to erumpent*Caryospora*
5. Ascospore 1-septate with swollen cells, ornamented*Rechingeriella*
5. Ascospore 1-septate without swollen cells, ornamented6
6. Ascospore large, dark, apiculate at both ends, elongate*Zopfia* (incl. “Cladosporium” -like)
6. Ascospore more elongate than in *Zopfia**Zopfiofoveola*

Excluded, doubtful and poorly known families

Acrocordiaceae Oxner ex M.E. Barr, Mycotaxon 29: 505 (1987)

Notes: In Nelsen et al. (2009) *Acrocordia subglobosa* clustered in *Monoblastiaceae*. The type species, *Acrocordia garovaglioii* A. Massal, however, has no molecular data.

Aspidotheliaceae Räsänen ex J.C. David & D. Hawksw., Syst. Ascom. 10(1): 13 (1991), MycoBank: MB 82007

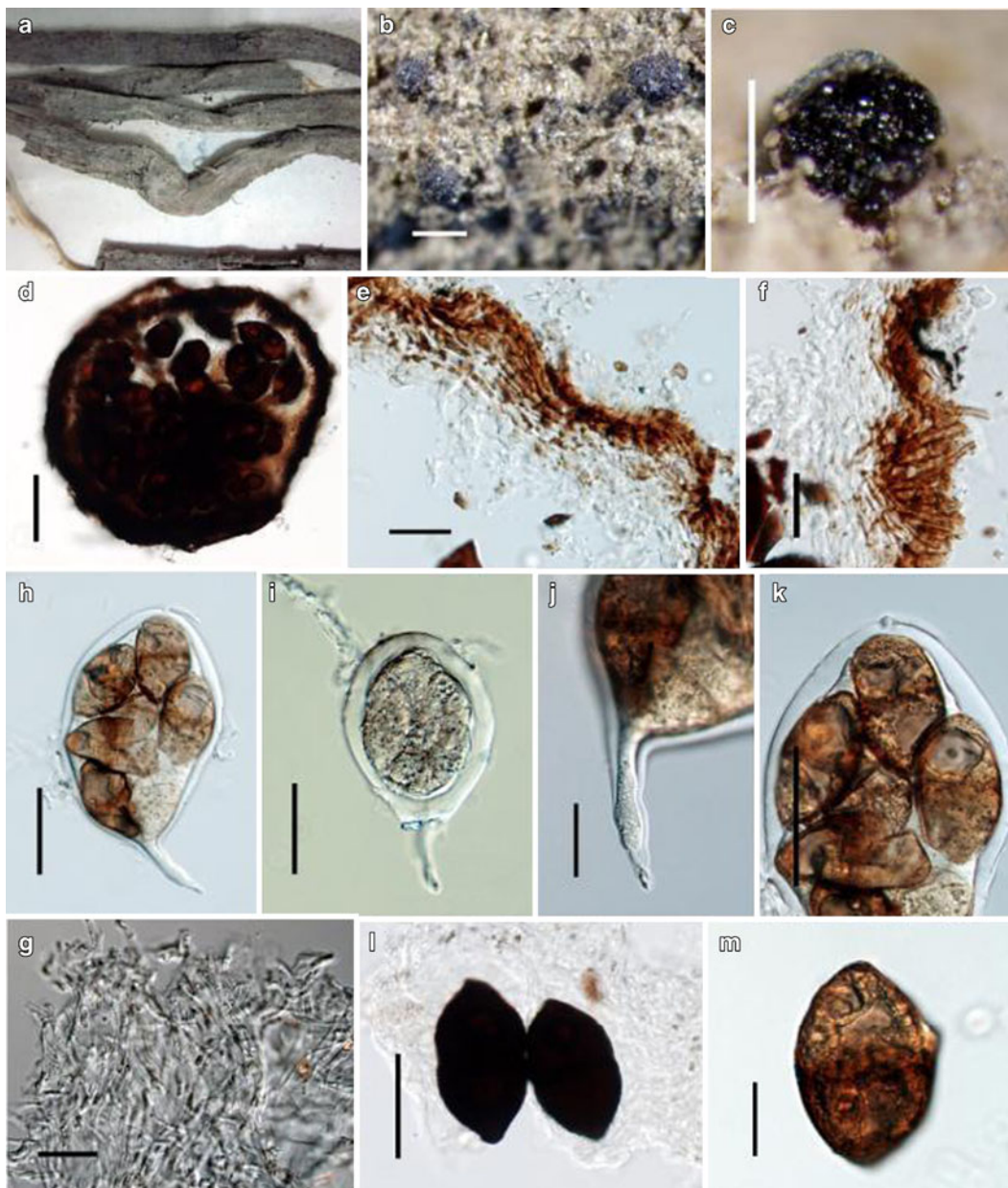


Fig. 136 *Zopfia rhizophila* (Material examined: GERMANY, on dry roots of *Asparagus officinalis*, 18 August 1874. Wilhelm Zopf, IMI 175866, **type**). **a** Habit, ascomata on the stem of host. **b**, **c** Black and

soft ascomata. **d** Section of ascoma. **e–f** Peridium. **h–k** Asci. **g** Pseudoparaphyses. **l**, **m** Mature ascospores. Scale bars: **b** = 300 μm , **c** = 400 μm , **d–f** = 100 μm , **h**, **i**, **k**, **l** = 50 μm , **j**, **m**, **g** = 20 μm

Lichenized with green algae, on leaves and bark. Sexual state: *Ascomata* solitary, scattered, sessile, \pm globose or slightly flattened, sometimes clypeate, the wall sometimes ornamented, with periphysate ostioles. *Asci* 2–8-spored, bitunicate?, fissitunicate, relatively large, clavate, persistent, with a short pedicel and very small ocular chamber not staining blue in iodine. *Ascospores* hyaline, transversely septate or muriform, with a mucilaginous sheath (Cannon and Kirk 2007; Eriksson 1981; David and Hawksworth 1991). Asexual state: pycnidial, conidiomata sessile or more or less

immersed, conidia aseptate, oblong, colorless (David and Hawksworth 1991).

Notes: This previously invalid family was formerly validated by David and Hawksworth (1991) and includes seven genera *Aspidothelium*, *Aspidopyrenium*, *Aspidotheliomyces*, *Patellonectria*, *Porinopsis*, *Secoligella*, *Aspidopyrenis*. *Aspidotheliaceae* is represented by *Aspidothelium* and this genus has been referred to *Strigulaceae* (Poelt 1974) along with *Phyllobathelium* (Eriksson 1981). Nelson et al. (in prep.) place this in Lecanoromycetes.

Type: Aspidothelium Vain., Acta Soc. Fauna Flora fenn. 7(no. 2): 190 (1890)

Mycobank: MB 401

Type species: Aspidothelium cinerascens Vain., Acta Soc. Fauna Flora fenn. 7(no. 2): 189 (1890)

Coccodiniaceae Höhn., ex O.E. Erikss., Op. bot. Soc. bot. Lund. 60: 42 (1981), MycoBank: MB 80615

Epiphytic or biotrophic sooty moulds on leaves and stems, dark globose hyphae covering the surface of the host, cells of ascostromata growing into the host tissue, with or without setae, surrounded by dark septate hyphae, constricted at the septum. Subiculum well-developed, especially at the ascomata base, surrounded by very loosely entangled dark hyphae, and superficial, blackish brown, effuse, subglobose or globose brown-walled cells, individual hyphae attached to the ascomata wall. Sexual state: Ascostromata developing on the surface of a mycelial pellicle which forms on a leaf or less commonly a stem or twig, scattered or gregarious, sessile on the subiculum or somewhat immersed, globose to subglobose, frequently cupulate when dry, brownish, uniloculate. Ostiole is centred in a slightly umbonate portion of the depressed area, well-developed with numerous periphyses. Hamathecium well-developed with numerous periphyses at the apex and pseudoparaphyses apparent in mature ascoma. Peridium thick-walled, inner cells flattened, hyaline to pale brown, outer cells angular, dark, outermost cells globose resembling subiculum cells. Asci 8-spored, bitunicate, fissitunicate, saccate, pedicellate, lacking a distinct ocular chamber, thick-walled. Ascospores 2–3-seriate, fusiform, ellipsoidal or clavate, with up to six transverse septa or muriform, hyaline when immature and brownish at maturity, slightly constricted at the septa, lacking a mucilaginous sheath. Asexual state: hyphomycetous (Crous et al. 2007a). Hyphal strands consisting of brown, globose cells, giving rise to indistinct phialidic loci, producing 1–3 conidia. Conidia fusoid-ellipsoidal to clavate, 3–5-septate, constricted at the transverse septa, apex obtuse, base subtruncate.

Notes: Coccodiniaceae is a family of sooty moulds. The honey-dew secreted by insects serves as nourishment for the hyphal mats. The family, described by Eriksson (1981), comprises three genera; *Coccodinium* A. Massal., as type species, *Dennisiella* Bat. & Cif. and *Limacinula* Höhn (Lumbsch and Huhndorf 2010), while Kirk et al. (2008) recognize five genera which include the asexual genera *Bisbyopeltis* Bat. & A.F. Vital and *Microxiphium* (Harv. ex Berk. & Desm.) Thüm. Hughes (1976) referred the sooty moulds to a number of families (i.e. *Antennulariellaceae*, *Capnodiaceae*, *Chaetothyriaceae*, *Euantennariaceae*, *Metacapnodiaceae* and *Triposporiopsidaceae*), but did not include the *Coccodiniaceae*.

Eriksson (1981) provided a Latin diagnosis for *Coccodiniaceae* thus validating the family which had been introduced as ‘Coccodiniaceen’ by von Höhnel (1918a, b). Eriksson (1981) also described the type species *Coccodinium* and distinguished it from *Naetrocymbe* which previous authors had incorrectly placed in this genus. Based on *Coccodinium bartschii* A. Massal., the family comprises taxa that grow on dark superficial hyphal mats that grow on honey-dew on plants (i.e. sooty molds).

According to Reynolds (1971) all true *Coccodinium*, *Dennisiella* and *Limacinula* species are characterized by limacinuloid ascomata. A limacinuloid ascomata is defined by Reynolds (1971) as “a dark brown collabent ascomata on living leaves and sometimes other plant parts, developing on a scanty or well-developed subiculum or darkened hyphae usually surrounded in its immediate vicinity by a very loose arrangement of hyphae which appear light to whitish macroscopically and which are individually connected as a component of the lower portion of the fruit body wall”. This type of subiculum and ascomata characterizes the family along with the hamathecium of pseudoparaphyses, bitunicate asci which open by a long rostrum, ascospores which are mainly transseptate and possibly the J+ reaction of the hymenium. Eriksson (1981) suggested that a restudy of the species are needed to establish if they are congeneric. The asexual states form on rosettes of phialidic conidiogenous cells from ascospores (Hughes 1976) or are hyphomycetous and described as *Microxiphium* (Barr 1987b). Schoch et al. (2006), Crous et al. (2007a) and Ruibal et al. (2009) showed species in *Microxiphium* to be members of *Capnodiaceae* in a phylogeny derived from molecular analysis indicating that *Microxiphium* is polyphyletic as it has already been linked to *Dennisiella* in *Coccodiniaceae*. *Strigopodia* was tentatively included in this family by Barr (1987a), but is now accommodated in *Euantennariaceae* (Lumbsch and Huhndorf 2010).

Winka et al. (1998) observed a culture of *Coccodinium bartschii* which is the type species of the genus, derived from a collection by S. Hughes (CANADA, Ontario, Ottawa, Central Experimental Farm), on branches of *Quercus macrocarpa* Michx., on the ground near the Carling Building, 19 July 1994 (UME30232). DNA was extracted from the culture and herbarium material and the 18S rDNA gene sequenced. In a phylogenetic tree, *C. bartschii* clustered with the *Dothideaceae* in the MP and NJ tree (<50 % and 72 %, respectively). In ML tree *Coccodinium* sequences are basal to the *Patellariales* and *Pleosporales*, while *Dothideaceae* is paraphyletic to these orders. Winka et al. (1998) concluded that *C. bartschii* is a member of *Coccodiniaceae* and not related to *Chaetothyriales*, and best accommodated in *Dothideales*. This implies that the pseudoparaphyses in *Coccodiniaceae* are not necessarily homologous with those in *Chaetothyriaceae* and *Herpotrichiellaceae*. In fact, similar structures occur in other

unrelated groups of ascomycetes, for instance *Verucariaceae* and *Hypocreaceae*. Crous et al. (2007a) sequenced fresh material of *C. bartschii* from Canada, and based on parsimony analysis of the LSU region, *C. bartschii* was distinguished from *Teratosphaeriaceae* and clustered with 100 % bootstrap support with *Herpotrichiellaceae* (*Chaetothyriales*). This result was supported by Liu and Hall (2004) based on *RPB2* protein sequences analysis, with *C. bartschii* clustering in the *Chaetothyriales*, which are typified by the presence of short apical sterile hyphal paraphyses. Winka et al. (1998) studied the morphology of *Coccodiniaceae* and found the asexual state resembled a *Capnodendron* species, which is a conidial state of sooty moulds in the family *Antennulariellaceae*. Therefore, the asexual morph of *Coccodiniaceae* may be related to the *Antennulariellaceae* according to its morphology. Colonies of *Coccodinium bartschii* on MEA are slow growing and form erumpent round, black colonies with sparse hyphal growth (Crous et al. 2007a). Further collections and sequence data is needed to sort out this confusion.

Possible asexual states which are hyphomycetous, with mycelium forming a setose pellicle, with aseptate hyphae, which are single celled with curved hyphal tips were noted by Reynolds (1971) and Reynolds and Gilbert (2005) as *Microxyphium* sp. and *Bisbyopeltis* sp. However, as with all sooty moulds one has to take great care in assigning asexual states based on their presence with the sexual state, as numerous species may occur in one sooty mould growth (Faull et al. 2002; Hughes 2003). *Microxyphium* sp. is characterised by the rosette of phialidic cells found in the mycelium or often as a cortex of hyphae surrounding the mycelial setae. Phylogenetic data indicate that *Microxyphium citri* is a member of *Capnodiaceae* (Chomnunti et al. 2011). *Bisbyopeltis* sp. is characterised by subpellicular areas producing triradiate, septate conidia, erect setae on hyphae encircled by a cortex of hyphae bearing terminal rosettes of subglobose, phialides which produce an abundance of hyaline conidia in a mucilaginous head (Reynolds 1971; Reynolds and Gilbert 2005). Furthermore, conidia of *C. bartschii* on MEA arise from indistinct phialidic loci on globose hyphal cells. Conidia are fusoid-ellipsoidal to clavate, 3–5-septate, constricted at the septa, apex obtuse, smooth, and widest in the upper third of the conidium (Crous et al. 2007a). We do not include the asexual states in the key nor do we synonymise them as the connections are not proven.

Type: Coccodinium A. Massal., Atti Inst. Veneto Sci. lett., ed Arti, Sér. 3 5: 336 (1860)

Epiphytic or *biotrophic* sooty moulds on the host surface and related with sap feeding insects using the secreted honey dew as a food source. Dark hyphal mats thick, superficial on surface of host. Sexual state: *Ascomata* sessile on a subiculum, or somewhat immersed, globose to subglobose, collapsed when dry and swelling after water is added, brownish, uniloculate, thick-walled, sometimes setose, with periphysate ostioles.

Peridium thick-walled, inner cells small, flattened, hyaline to pale brown, outer cells angular, somewhat flattened, dark, outermost cells globose, dark, resembling the cells of the subiculum. *Hamathecium* of well-developed and numerous periphyses. *Asci* 8-spored, bitunicate, fissitunicate, saccate, pedicellate, lacking a distinct ocular chamber, thick-walled. *Ascospores* irregularly arranged, ellipsoidal or clavate, fusiform, transversely septate or muriform, with 2–4 transverse septa, central segments with 1–2 longitudinal septa, end segments with 2 angular septa or sometimes with a longitudinal septum, somewhat constricted at septa, hyaline or dark brown, lacking a mucilaginous sheath. Asexual state: hyphomycetous (Crous et al. 2007a). *Hyphal strands* consisting of brown, globose cells, giving rise to indistinct phialidic loci, producing 1–3 conidia. Conidia fusoid-ellipsoidal to clavate, 3–5-septate, constricted at the transverse septa, apex obtuse, base subtruncate, guttulate, smooth, widest in the upper third of the conidium.

Notes: Coccodinium and *Naetrocymbe*. have been merged in earlier studies by many mycologists (Rabenhorst 1863; Arnold 1858; Stizenberger 1862; Körber 1865) who accepted *Naetrocymbe* which had priority, but a few still used *Coccodinium*. von Höhnel (1918a, b) realized that *Coccodinium* (1860) was validly published earlier than *Naetrocymbe* (1865). *Coccodinium bartschii* was transferred to *Cucurbitaria* by Batista and Ciferri (1957). Morphological characters of *Limacinula* and *Dennisiella* are similar to *Coccodinium*, as all have a hamathecium consisting of periphyses. *Limacinula* however has hyaline to pale brown ascospores, while in *Coccodinium* the ascospores are dark brown. This taxonomic arrangement needs testing at the molecular level. *Dennisiella* differs from *Limacinula* in having only transvers septate ascospores and setose hyphae. This genus may also be congeneric with *Limacinula* and *Dennisiella* (Eriksson 1981). In the key below we maintain all three genera in *Coccodiniaceae* with reservations, based on the above discussion.

Type species: Coccodinium bartschii A. Massal., Atti Inst. Veneto Sci. lett., ed Arti, Sér. 3 5: 336 (1860), MycoBank: MB 153614 (Fig. 137)

Other genera included

Dennisiella Bat. & Cif., Beih. Sydowia 3: 37 (1962)

Type species: Dennisiella babingtonii (Berk.) Bat. & Cif., Beih. Sydowia 3: 38 (1962)

Limacinula Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 116: 101 (1907)

Type species: Limacinula samoënsis Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 1200 [44 repr.] (1909)

Key to genera of Coccodiniaceae

1. Hyphae with setae, ascospores hyaline with transverse septa only *Dennisiella*
1. Hyphae without setae, ascospores mostly coloured, muriform 2



Fig. 137 *Coccodinium bartschii* (Material examined: CANADA, Ontario, Ottawa, Central Experimental Farm, near Carling Building. 45°23' N, 75°42' W. alt. c. 60 m, on dead corticated branches of *Quercus macrocarpa* Michx., on the ground, 31 August 1999, S. J. Hughes,

DAOM 226257). **a** Herbarium material. **b** Ascomata on bark. **c, d** Vertical section through ascomata with periphyses. **e** Peridium. **f–h** Asci. **i–n** Ascospores. Scale bars: **c, d** = 100 μm , **e–f** = 50 μm , **g–j** = 20 μm , **k–n** = 10 μm

2. Ascospores hyaline to pale brown *Limacinula*
 2. Ascospores dark brown *Coccodinium*

Diporotheaceae e Mibey & D. Hawksw., Syst. Ascom. 14(1): 27 (1995), MycoBank: MB 81976

Habitat Biotrophic or necrotrophic on the roots of *Solanum* species. **Mycelium** superficial, hyphae dark brown, septate, branched, non-setose, appressoria present; haustoria

originating from the terminal cells of the appressoria. Sexual state: **Ascomata** dark, supported by “hyphal struts”, very thin-walled, membranous, ostiole periphysate. **Peridium** comprising 2–5 layers of relatively large cells of *textura angularis*. **Asci** 8-spored, thin-walled, subglobose to obovoid, pedicellate, without apical structures, evanescent. **Ascospores** 2–3-seriate, ovate, dark brown, 2-septate, the septa near the apices, with a much larger central cell, with a separable perispore with

poroid ends (from Gordon and Shaw 1960; Mibey and Hawksworth 1995). Asexual state: Unknown (Mibey and Hawksworth 1995).

Notes: *Diporotheaceae* was introduced by Mibey and Hawksworth (1995) to accommodate the single genus *Diporothea* and this genus has been referred to *Meliolaceae*. The family *Diporotheaceae* includes only one genus and a single species (Kirk et al. 2008). *Diporothea* is characterized by its black, superficial, pyriform to flask-shaped, paraphysate ascomata, with periphysate ostioles, and a peridium comprising 2–5 cell layers. *Asci* are 8-spored and unitunicate? According to Gordon and Shaw (1960), but Mibey and Hawksworth (1995) mentioned they are functionally unitunicate. Therefore it is not clear whether *Diporothea* should be placed in the class Dothideomycetes. Recollection and molecular studies are needed to establish whether this is a distinct family as molecular data is not available in GenBank.

Type: *Diporothea* C.C. Gordon & C.G. Shaw, *Mycologia* 52(2): 331 (1961) [1960]

Mycobank: MB 1635

Type species: *Diporothea rhizophila* C.C. Gordon & C.G. Shaw, *Mycologia* 52(2): 331 (1961) [1960]; Mycobank: MB 330113

Eoterfeziaceae G.F. Atk., Bot. Gaz. 34: 40 (1902), Mycobank: MB 80743

Fungicolous, parasitic on perithecia of *Sordaria*, *Podospora* and *Arniium* species. Sexual state: *Ascomata* small, cleistothecial, ± globose, non-ostiolate, with a thin membranous peridium either composed of coalescing hyphae or with a narrow layer of pseudoparenchymatous cells covered by a hyaline granular layer, interior sometimes divided into locules by radiating mycelia strands. *Asci* 8-spored, very thin walled, saccate, evanescent. *Ascospores* biseriate, ellipsoidal to elliptical-oblong, smooth, hyaline, aseptate. Asexual state: Unknown (Cannon and Kirk 2007; Atkinson 1902; Jeng and Cain 1976).

Notes: The family *Eoterfeziaceae* was introduced by Atkinson (1902) to accommodate the single genus *Eoterfezia* and this genus includes two species, the type *E. parasitica* and the recently introduced *E. perlucida* Jeng & Cain. *Eoterfezia parasitica* is characterized by its white, sessile, fleshy, subglobose to reniform, non-ostiolate ascomata which are closely attached to the ascomata of the host, elliptical-oblong *asci*, and, aseptate, smooth, biseriate, elliptical-oblong hyaline *ascospores*. *Eoterfezia perlucida* differs from *E. parasitica* in having a peridium composed of two layers, a hyaline, granular, non-cellular outer layer and a pseudoparenchymatous inner layer, numerous, globose *asci* which are associated with some hyaline septate filaments and relatively large *ascospores* (Jeng and Cain 1976; Atkinson 1902). Recollection and molecular and phylogenetic studies are needed as molecular data is not available in GenBank.

Type: *Eoterfezia* G.F. Atk., Bot. Gaz. 34: 40 (1902) Mycobank: MB 1844

Type species: *Eoterfezia parasitica* G.F. Atk., Bot. Gaz. 34: 40 (1902) Mycobank: MB 244212

Epigloeaceae Zahlbr., in Engler & Prantl, Nat. Pflanzenfam., Teil. I (Leipzig) 1*: 53 (1903), Mycobank: MB 80746

Parasitic on algae. Sexual state: *Ascomata* on a thin gelatinous algal film, perithecial, globose, dark green to black, superficial, composed of thin walled periclinally arranged hyphae immersed in a gelatinous matrix. *Hamathecium* consisting of thin, septate, rarely branched paraphyses. *Asci* cylindrical, persistent, at first thick-walled but becoming thin-walled, without apical structures, releasing *ascospores* through a vertical split, containing 8–50 *ascospores*. *Ascospores* hyaline, transversely 1–5-septate, thin-walled without a sheath but often with apical cilia. Asexual state: pycnidial (Döbbeler 1984; Cannon and Kirk 2007).

Notes: The family *Epigloeaceae* was introduced by Zahlbruckner (1903a) and this family includes three genera and 13 species (Döbbeler 1984, 1994; Aptroot 2003). The original three genera, *Epigloea*, *Epigloemyces* and *Vorarlbergia* are synonymized with *Epigloea* and the type is *Epigloea bactrospora*. According to Jaag and Thomas (1934), *Epigloea bactrospora* is a fungus parasitizing the algae, *Coccomyxa dispar* and Zúkal (1890) published it under *Hypocreaceae*, a family of unitunicate ascomycetes (Eriksson 1981). Later, Zahlbruckner (1903a) has removed it from *Hypocreaceae* and placed it under a new lichen family *Epigloeaceae* (Fink 1913; von Keissler 1934). Species of *Epigloea* are common in places with gelatinous algae, for instance dead stumps of trees. They occur mostly in temperate regions and are widespread; Döbbeler (1984) keys, describes and illustrates nine species from Central Europe and subantarctic regions (Marion islands), six of which occur in Great Britain (Smith et al. 2009), and eight species known from France are keyed out by Boissière and Montavont (1998). Molecular studies are needed to establish whether this is a distinct family as molecular data is not available in GenBank.

Type: *Epigloea* Zúkal, Verh. zool.-bot. Ges. Wien 39: 78 (1889) Mycobank: MB 1862

Possible synonyms:

Epigloemyces Cif. & Tomas., Atti Ist. bot. Univ. Lab. crittog. Pavia, Ser. 5 14: 6 (1957)

Vorarlbergia Grummann, Sydowia 22(1–4): 218 (1969)

Type species: *Epigloea bactrospora* Zúkal, Verh. zool.-bot. Ges. Wien 39: 78 (1889) Mycobank: MB 384895

Lautosporaceae Kohlm. et al., Bot. Mar. 38: 165 (1995), Mycobank MB 81975

Saprobic on wood and sea grasses in marine habitats. Sexual state: *Ascomata* perithecial, immersed, ellipsoidal with the long axis parallel to the host surface, ostiolate, with long neck, brown, coriaceous and single. *Peridium* composed of thick-walled scleroplectenchymatous cells. *Hamathecium* of simple, septate tapering paraphyses. *Asci* 4-spored, cylindrical to fusiform, short pedicel, thick-walled with a large ocular chamber, IKI negative. *Ascospores* uni- or biseriata, fusiform, muriform, distoseptate, hyaline, outer wall very thick, thinner at the apices, occasionally with small apical caps. Asexual states: Unknown.

Notes: The family *Lautosporaceae* was introduced by Kohlmeyer et al. (1995b) for two *Lautospora* species collected on driftwood of *Sonneratia griffithii* (*L. gigantea*) and culms of *Juncus roemerianus* (*L. simillima*) (Hyde and Jones 1989; Kohlmeyer et al. 1995b, respectively). The family was however not assigned to any order but referred to *Ascomycotina incertae sedis*. Jones et al. (2009a) referred the family to the *Dothideomycetidae incertae sedis*, based on the thick-walled nature of the ascus. However, spore discharge has not been observed in either species. A recent collection of *L. simillima* on mangrove wood in Thailand by S. Suetrong, enabled the extraction of DNA. LSU sequence analysis places the genus in the *Sordariomycetes*, in a basal clade to the orders *Diaporthales*, *Xylariales*, *Microascales* and an unnamed clade (Suetrong, unpublished data). *Lautospora simillima* grouped with the neotropical ascomycete *Mirannulata sameulsi* with weak support, and shares few morphological features with this genus (Huhndorf et al. 2003). The family *Lautosporaceae* is therefore excluded from the *Dothideomycetes*.

Type: *Lautospora* K.D. Hyde & E.B.G. Jones, Bot. Mar. 32: 479 (1989) Fig. 138

Type species: *Lautospora gigantea* K.D. Hyde & E.B.G. Jones, Bot. Mar. 32(3): 479 (1989)

Mastodiaceae Zahlbr., in Engler & Prantl, Nat. Pflanzenfam., Teil. I (Leipzig) 1*: 240 (1908), MycoBank: MB 80981

Lichenized with large marine algae. *Stromata* absent or reduced to a small clypeus-like structure. Sexual state: *Ascomata* perithecial, ± globose, black, thick-walled, weakly papillate with periphysate ostiole. *Hamathecium* comprising interascal tissue of simple paraphyses, sometimes evanescent, or of apical paraphyses. *Asci* 8-spored, clavate, thin-walled, persistent, without apical structures. *Ascospores* saccate, elongate ellipsoidal to cylindrical hyaline, simple or transversely septate, thin-walled, without a mucous sheath (Cannon and Kirk 2007; Kohlmeyer et al. 2004). Asexual state: *Conidiomata* solitary or gregarious, subglobose to lentiform, immersed, forming irregular chambers, coriaceous, dark brown above, hyaline at the base, ostiolate, epapillate. *Peridium* 12–24 μm wide, cells forming a *textura angularis*.

Conidiogenous cylindrical, lining the walls and lobes of the conidiomata locule. *Conidia* hyaline, subglobose to ellipsoidal, unicellular (Kohlmeyer et al. 2004).

Notes: The family *Mastodiaceae* was introduced by Zahlbruckner (1907) and is of uncertain phylogenetic position and includes the genera *Mastodia*, *Turgidosculum*, *Dermatomeris*, *Kohlmeyera* and *Leptogiopsis*. The type species *Mastodia tessellata* is a parasite on *Prasiola crispa* in Arctic and Antarctic regions and the algal component was described by Hooker and Harvey (1847) under the name of *Ulva tessellata*. Two years later, Hooker (1847) had found fungal components in *Ulva tessellata* and introduced the new genus *Mastodia* with the single species *Mastodia tessellata* (Eriksson 1981). *Mastodia tessellata* is characterized by solitary or gregarious, subglobose, immersed, epapillate, ostiolate ascomata which are dark brown above, and sides and base with irregular dark areas. The ostiole is schizogenous, periphysate, occluded by gelatinous, somewhat striate, turgescerent material. The paraphyses are absent in mature ascomata, but locule filled with gelatinous, faintly striate matrix; short periphysoids arise at the dome of the locule. *Asci* are clavate to sub-cylindrical, short pedicellate and the nature of the ascus is not certain (Kohlmeyer et al. 2004). According to Pérez-Ortega et al. (2010) asci are bitunicate which undergo gelification of the exotunica in the early states of development, conferring the appearance of unitunicate asci when viewed with a light microscope. *Ascospores* are elongate ellipsoidal to cylindrical, at maturity accumulating in the centrum (Kohlmeyer et al. 2004). *Prasiola crispa* subsp. *antarctica* has been considered the photobiont of *M. tessellata* and recent molecular analyses were carried out by Pérez-Ortega et al. (2010) for both the mycobiont and photobiont. They could not accurately determine the taxonomic position of the *M. tessellata* photobiont since the apical areas of the *Mastodia* photobiont blades consisted of several rows of algal cells, indicating a closer morphological resemblance to *P. borealis* (Reed 1902). Molecular analyses of the *Mastodia tessellata* mycobiont showed it to have phylogenetic affinities with members of the *Verrucariaceae* which is in *Chaetothyriomycetidae* and *Mastodia* clearly clustered with *Wahlenbergiella* Gueidan & Thüs, within the *Verrucariaceae* (Pérez-Ortega et al. 2010). The family *Mastodiaceae* is regarded as a *nomen dubium* as Zahlbruckner (1907) characterized the genus *Mastodia* as having unitunicate asci. Molecular data confirm its placement in the *Verrucariaceae* (*Verrucariales*, *Chaetothyriomycetidae*), therefore the family *Mastodiaceae* is superfluous (Pérez-Ortega et al. 2010).

Type: *Mastodia* Hook. f. & Harv., in Hooker, Bot. Antarc. Voy. Erebus Terror 1839–1843: 499 (1847), MycoBank: MB 3022

Type species: *Mastodia tessellata* (Hook. f. & Harv.) Hook. f. & Harv., in Hooker, Bot. Antarc. Voy. Erebus Terror 1839–1843: 499 (1847), MycoBank: MB 395110

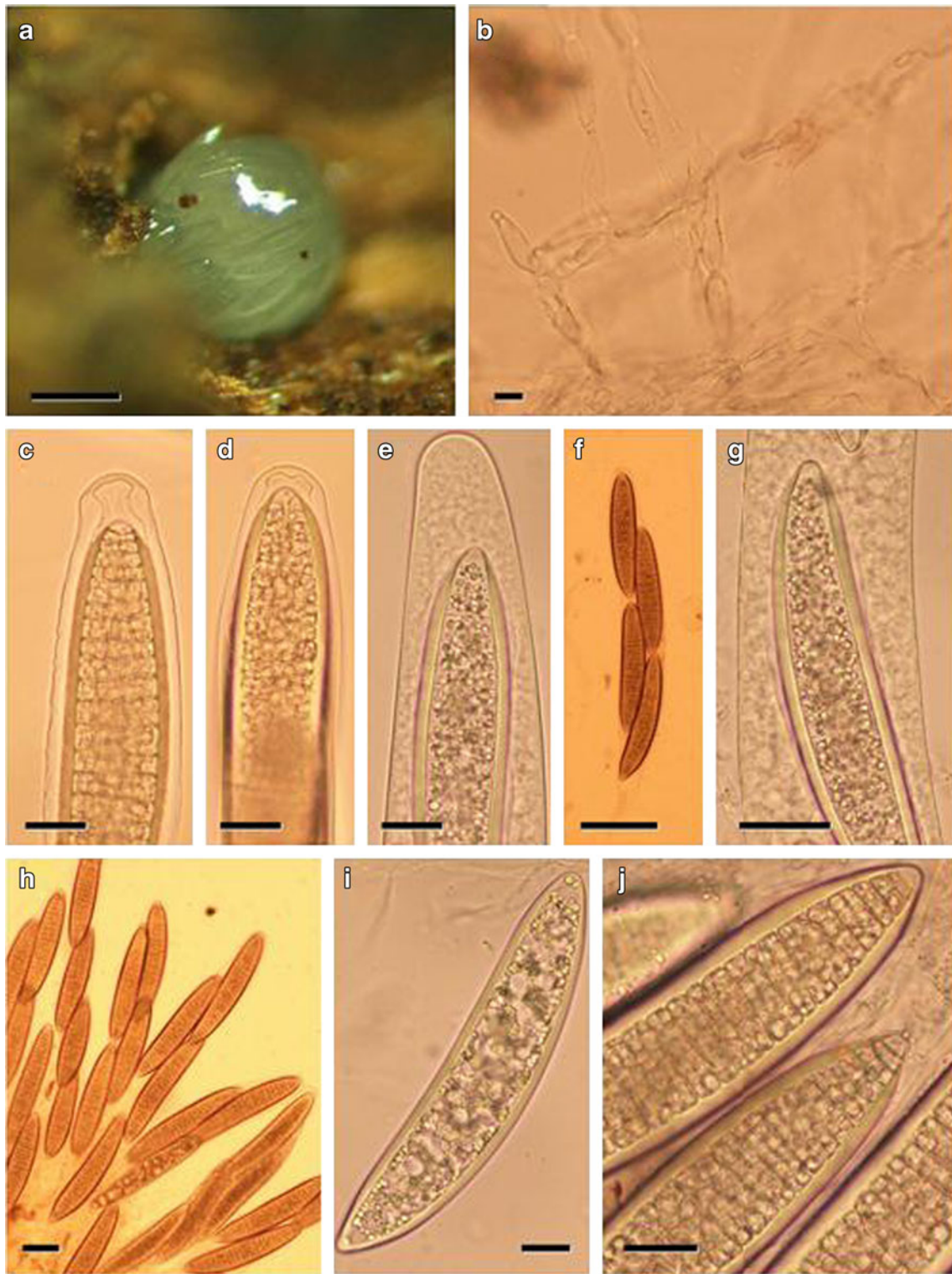


Fig. 138 *Lautospora simillima* (Material examined: *Lautospora simillima*. THAILAND, Champorn Province, on mangrove wood, S. Suetrong, 2012, BBH 31841). **a** Immersed ascoma with discharge of asci. **b** Septate paraphyses. **c, d** Apical region of ascus with ocular

chamber. **e** Ascus with immature thick-walled ascospores. **f, h** Four mature ascospores per ascus. **i** Immature ascospores with thick lateral wall. **j** Mature ascospores with transverse and longitudinal septa. Scale bar; **a** = 200 μm , **b** = 10 μm , **c–e, i–j** = 25 μm , **f–h** = 50 μm

≡ *Ulva tessellata* Hook. f. & Harv. [as ‘tesellata’], J. Bot., Lond. 4: 297 (1845)

Meliolaceae G.W. Martin ex Hansf., Mycol. Pap. 15: 23 (1946)

The family *Meliolaceae* was established by Martin (1941). However, no Latin diagnosis was provided and Hansford (1946) validated this family with a Latin diagnosis. The history of the family has been unsettled being placed in *Dothideales*, *Erysiphales*, *Meliolales*, *Myriangiales* and *Hypocreales* at various times (Martin 1941; Rogers 1953; Ainsworth et al. 1971; Muller and von Arx 1973; Yarwood 1973; Barr 1976; Eriksson 1981; Hawksworth et al. 1983). Eriksson (1981) provides a thorough discussion on the family which comprised two conflicting classifications. Recently, Lumbsch and Huhndorf (2010) accepted two families in *Meliolales*, *Armatellaceae* (1 genus) and *Meliolaceae* (26 genera) and placed it in the *Sordariomycetes*, orders *incertae sedis*. Thus we do not discuss this family further.

Meliolinaceae S. Hughes, Mycol. Pap. 166: 176 (1993), MycoBank: MB 81959.

Foliar epiphytes or parasites on leaves of *Agonis longifolia*, tropical. Colonies hypophyllous, velvety, black, comprising superficial, brown hyphae. Sexual state: *Ascomata* perithecioid solitary, superficial on hyphae, subglobose to globose, flattened, with ostiole. *Peridium* thin. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate?, broadly clavate, or saccate, pedicellate, lacking an ocular chamber, evanescent. *Ascospores* 2–4-overlapping seriate, cylindrical with somewhat flattened ends, light brown, becoming brown at maturity, 3-septate, strongly constricted at all septa with dark brown bands, ends cells possibly wider than central cells, with roughened walls.

Notes: Hughes (1993) established the family *Meliolinaceae* and revised the genus *Meliolina* and gave account of 38 species. Presently there are 59 names listed in Index Fungorum (2013). Kirk et al. (2008) listed the anamorph of *Meliolinaceae* as *Briania*. Pirozynski (1974) listed the asexual state of *Meliolinaceae* as similar to *Phialophora* sect. *Catenulatae*, but the conidiophores are very darkly pigmented, thick-walled and dichotomously branched (Sivanesan 1984). *Meliolina* is similar to *Meliola* but has distantly septate hyphae, and dichotomously branched phialophores. This genus resembles taxa in *Meliolales* in having superficially ascomata borne on black hyphal colonies, dark brown hyphae with capitates hyphopodia, broadly clavate, or saccate asci lacking an ocular chamber and brown 4-septate ascospores. We therefore transfer the genus to *Meliolales*.

Type: Meliolina Syd. & P. Syd., Annl. mycol. 12 (6): 553 (1914), MycoBank: MB 3105

Type species: Meliolina cladotricha (Lév.) Syd. & P. Syd., Annl. mycol. 12(6): 553 (1914), MycoBank: MB 120177

≡ *Meliola cladotricha* Lév., Annl. Sci. Nat., Bot., sér. 3 5: 266 (1846) (Fig. 139)

Microtheliopsidaceae O.E. Erikss., Op. bot. Soc. bot. Lund 60: 97 (1981), MycoBank: MB 81007

Possible synonym:

Gloeophragmiaceae Räsänen, Acta bot. fenn. 33: 31 (1943)

Foliicolous in undergrowth of tropical rain forest. *Thallus* crustose, thin, ecorticate, associated with *Phycopeltis*-type algae. Sexual state: *Ascomata* perithecia, small, c. 0.1–0.3 mm diam., solitary, often concentrically arranged, covered by the algal layer, but easily visible from above, lenticular to conical, rounded or radially elongate, black when dry, dark brown when wet, top rounded, with dark brown, conical involucrellum below the algal layer and dark brown, membranous involucrellum (peridium) surrounding the subglobose nucleus, without apparent ostiole. *Peridium* thin, composed of brown, septate hyphae more or less conglutinated into *textura epidermoidea* to *intricata*, *Hamathecium* gelatinous, I+ red (Lugol solution), KI+ blue, *Pseudoparaphyses* lacking. *Asci* 8-spored, fissitunicate, obclavate, without an ocular chamber, I-negative. *Ascospores* 3-seriate to irregularly arranged in asci, fusiform, pale grayish brown, 1-septate to submuriform, smooth-walled, ends rounded, without endospore, without perispore. Asexual state: Unknown.

Notes: The family *Microtheliopsidaceae* was introduced by Eriksson (1981) for taxa with a crustose, ecorticate thallus, with simple, solitary, immersed, conical, black ascomata, 8-spored, bitunicate, clavate asci and fusiform, pale grayish brown, 3-septate ascospores without a perispore. This family includes a single genus containing three species according to Lücking (2008). The genus is typical of *Chaetothyriales* and there is excluded from *Dothideomycetes*.

Type: Microtheliopsis Müll. Arg., Flora, Jena 73: 195 (1890), MycoBank: MB 3200

Notes: Microtheliopsis includes three species according to Lücking (2008).

Type species: Microtheliopsis uleana Müll. Arg., Flora, Jena 73: 195 (1890), MycoBank: MB 395632 (Fig. 140)

Moriolaceae Zahlbr., in Engler & Prantl, Nat. Pflanzenfam., Teil. I (Leipzig) 1*: 52 (1903), MycoBank: MB 81028

Parasitic on algae. Sexual state: *Ascomata* on a thin gelatinous algal film, perithecial, globose, black, superficial, composed of thick walled periclinally arranged hyphae. *Hamathecium* absent or consisting of thin, septate, rarely branched paraphyses. *Asci* cylindrical, persistent, at first thick-walled but becoming thin-walled, without apical structures, containing 8 ascospores. *Ascospores* hyaline or brown, transversely 3–5-septate or submuriform, thin-walled without a sheath. Asexual state: Unknown von Keissler (1934).

Notes: The family *Moriolaceae* was introduced by Zahlbruckner (1903a) and this family includes two genera and 13 species (von Keissler 1934). They are fungi parasitizing various algae, thought to be bitunicate ascomycetes (Eriksson 1981), but probably related or partly identical with



Fig. 139 *Meliolina cladotricha* (Material examined: AUSTRALIA, Queensland, Cape York Peninsula, on leaves of *Agonis longifolia*, L.J. Brass, 25 August 1948, K(M) 176503). **a** Herbarium package. **b**, **c** Ascomata on the host surface. **d**, **h** Squash mount of ascomata. **e–g**

Hyphae with dichotomously branched phialophores. **i**, **j** Asci. **k–m** Ascospores. Scale bars: **c**=400 μm , **d**, **h**=100 μm , **c–e**, **k–m**=10 μm , **e–f**=50 μm , **g**, **i–j**=20 μm

the genus *Merismatium* (in an extended sense) classified in the unitunicate *Verrucariaceae* (Triebel 1989). Most species are only reported from their types, which were all collected by Norman in the 19th century either Norway or Tirol. Only one species was recollected since and reported in the 20th century, from France (Bricaud et al. 1993). Molecular studies are needed to establish whether this is a distinct family as molecular data is not available in GenBank.

Eriksson (1981) provides a long discussion on the lectotype for this genus, proposing that *Moriola pseudomyces* (Norm.) Norm. is probably a better choice, rather than *M. descensa* Norm. as proposed by Clements and Shear (1931). We borrowed specimens of *M. descensa* and *M. pseudomyces* from TRH and TROM. However, from the type specimens we can not sure which fungus is the *M. descensa* or *M. pseudomyces* depends on the original descriptions. Hence we keep *M.*

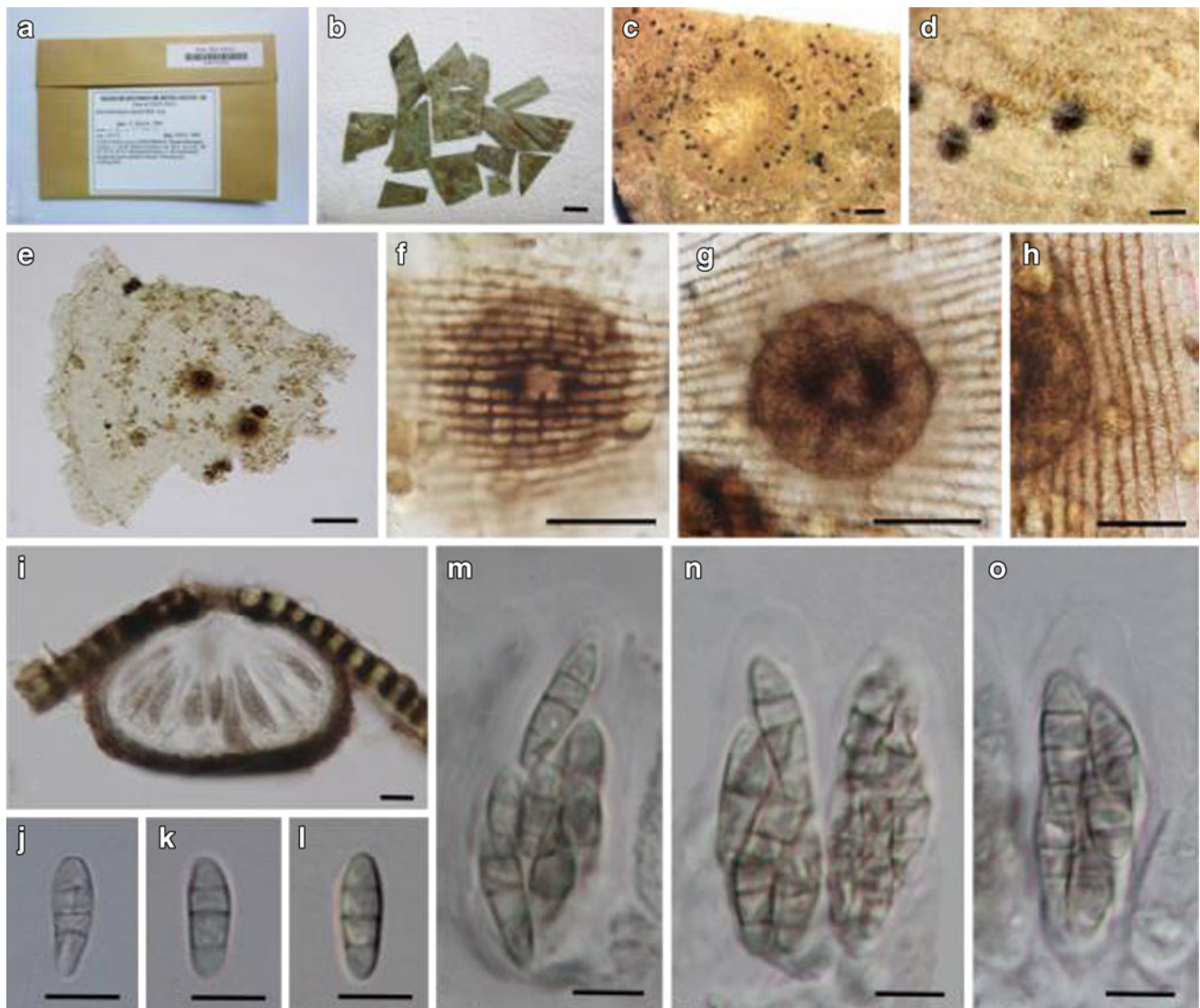


Fig. 140 *Microthelopsis uleana* (Material examined: COSTA RICA, Puntarenas Province, Reserva Biológica Carara, c. 15 km SSW of Orotina, Alt. m. 50 m. Co-ord.: 84° 37' W; 9° 47' N. Disturbed primary, c. 40 m tall forest, along trail near warden's house, foliicolous in undergrowth, 20 November 1988, H. Sipman & P. Döbbeler, B 60 0178769). **a, b** Herbarium material. **c** Thallus on leaf host. **d** Black to dark brown ascomata. **e** Shed thallus from host surface. **f** Brown ascoma immersed

below alga cells. **g** Rounded ascoma. **h** Dark brown hyphae around ascoma (involucrellum). **i** Section of ascoma showing pore in algal layer, subglobose involucrum and conical involucrellum below the cellular algal layer. **j–l** Ascospores with three septa. **m–o**. Asci with ascospores. Scale bars: **b**=20 mm, **c**=1 mm, **d, e**=200 μ m, **f–h**=50 μ m, **i–o**=5 μ m

pseudomyces as the type species until new collections to clarify them.

Type: Moriola Norm., Bot. Notiser: 13 (1872) MycoBank: MB 3273

Type species: Moriola pseudomyces Norm., Bot. Notiser: 13 (1872) MycoBank: MB 384937

Myxotrichaceae Locq. ex Currah, Mycotaxon 24: 103 (1985), MycoBank: MB 81054

Cellulotic, occurring on paper, straw or mycorrhizal, associated with roots of *Ericaceae* and *Epacariaceae*. Sexual state: *Ascomata* rose, deep reddish or greenish

brown often black, \pm globose reticuloperidium of asperulate, cleistothecial, not stiptate and peridium composed of a loose network of septate hyphae, often with complex thick-walled appendages. *Asci* globose or subglobose, evanescent, small, thin-walled, ephemeral, hyaline, probably originating from crosiers. *Ascospores* irregularly arranged, partially overlapping, ellipsoid to fusoid, long-striate, pigmented, hyaline to pale yellow to rose, \pm fusiform, smooth without a gelatinous sheath. Asexual state: *Geomyces*, *Malbranchea*, *Oidiodendron*. Hyphomycetous, arthric, with simple, thick-walled, conidia derived directly from short side branches or

intercalary cells of vegetative hyphae (Currah 1985; Cannon and Kirk 2007).

Notes: Loquin (1974) proposed the family *Myxotrichaceae* but did not validly publish the name so Currah (1985) included the family *Myxotrichaceae* within the order *Onygenales*. Genera are cellulolytic ascomycetes, having reddish to dark brown peridial hyphae, fusoid ascospores, and arthroconidial asexual states. Later, Currah (1994) suggested that the *Myxotrichaceae* do not belong to *Onygenales* and molecular analysis of Hambleton et al. (1998) placed the hypomycete genus *Oidiodendron* as a group member in *Myxotrichaceae*, closely related to *Bysoascus* and *Myxotrichum*. The inferred phylogeny showed a marked divergence *Myxotrichum* and *Bysoascus* between other genera, *Gymnostellatospora* and *Pseudogymnoascu* in the family *Myxotrichaceae* (Hambleton et al. 1998). Vidal et al. (2000) excluded the family *Myxotrichaceae* from the *Onygenales* based on molecular analysis of the SSU rDNA sequences and they have showed that two *Chrysosporium* species, *C. pseudomerdarium* and *C. filiforme* Sigler et al., are closely related to the *Myxotrichaceae*. Recent molecular phylogenetic studies now place the family in an isolated position and closer to members of the *Leotiales* (Sigler et al. 2000).

Type: Myxotrichum Kunze, in Kunze & Schmidt, Mykologische Hefte (Leipzig) 2: 108 (1823), MycoBank: MB 3405

Type species: Myxotrichum chartarum Kunze, in Kunze & Schmidt, Mykologische Hefte (Leipzig) 2: 108 (1823), MycoBank: MB 224500

Phaneromycetaceae Gamundí & Spinedi, Sydowia 38: 112 (1985), MycoBank: MB 81636

Saprobic on dead wood. *Stroma* absent. Sexual state: *Ascomata* brown or orange, apothecial, erumpent, flat to cupulate, with an outer wall of gelatinized hyphae with crystalline intrusions; hymenium not bluing in iodine. Interascal tissue of simple, filiform, paraphyses. *Asci* cylindrical-clavate, bitunicate (Gamundí and Spinedi 1985) sometimes fissitunicate. *Ascospores* hyaline, multiseptate (Cannon and Kirk 2007). Asexual state: Unknown.

Notes: *Phaneromycetaceae* was introduced by Gamundí and Spinedi (1985) to accommodate the single genus *Phaneromyces* by Spegazzini (1889b) with the single species *P. macrospores*. Later a second species *Phaneromyces plantensis* Speg. was added by Spegazzini (1909), but according to Gamundí and Spinedi (1985) *P. macrospores* and *P. plantensis* are conspecific. *Phaneromyces macrospores* is characterized by apothecia at first erumpent, then superficial, emerging from the wood, patelliform. External surface and margin is covered by an irregular, crystalline, white crust that shows now and then a dull ochraceous, glabrous surface. Margin is inflexed, thick. Hymenium is

concave, dark, olivaceous when dry, chestnut brown when soaked in water. Paraphyses are abundant, gelatinous, filiform, profusely branched at the top, hyaline with gelatinized walls. *Asci* are usually 8-spored, sometimes with 3–4 spores, with a very thick and refringent wall, claviform, tapering at the base. *Ascospores* are uniseriate, hyaline, smooth, fusoid, multiseptate, filled with small guttules in the young state, later with thick lateral walls. Excipulum is well developed, highly gelified and totally of “*textura intricata*” is formed by hyphae with gelified walls. Lumen is 1–3 μm ; 120–150 μm thick at the base, where some of the hyphae penetrate the xylem and medullary rays to a good extent; 50–80 μm thick at the lateral surface, incrustated with compound crystals of probably calcium carbonate all over except the margin (Gamundí and Spinedi 1985). Recollection and molecular studies are needed to establish whether this is a distinct family as molecular data is not available in GenBank.

Type: Phaneromyces Speg. & Har., in Spegazzini, Revue mycol., Toulouse 11: 93 (1889), MycoBank: MB 3976

Type species: Phaneromyces macrosporus (Boud.) Speg., Revue mycol., Toulouse 11: 93 (1889), MycoBank: MB 219128

≡ *Niptera macrospora* Boud., in Hariot, : 193 (1883) [1882–1883]

Phillipsiellaceae Höhn. [as ‘Phillipsielleae’], Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 118: 361 [87 repr.] (1909), MycoBank: MB 81148

Saprobic or *epiphytic* on leaves, sometimes associated with leaf hairs. Sexual state: *Ascomata* small, apothecial, scutate to pulvinate, greenish-black, circular in outline, emarginated, sometimes surrounded by weakly developed mycelium. *Peridium* scarcely developed, of a few rows of pseudoparenchymatous cells, pseudoparaphyses which are enlarged at the apex to form an epithecium-like layer. *Asci* 8-spored, ellipsoidal, saccate, sessile, with a wide ocular chamber. *Ascospores* discontinuously arranged, fusiform to ellipsoid, hyaline to brown, simple, transversely septate or muriform. Asexual state: Unknown (Cannon and Kirk 2007).

Notes: *Phillipsiellaceae* was introduced by von Höhnelt (1909a) and this family includes the genera *Bactridiopsis*, *Phillipsiella* and *Microphyma*. The type species *Phillipsiella atra* is characterized by its apothecial, granular, hymenium hyaline, fleshy to gelatinous ascomata. Pseudoparaphyses are 1–2 μm wide, septate, hyaline, branching extending above asci to form a thin, irregular epithecium, 3–8 μm thick, of black, granular, inflated hyphal ends; exciple thin, hyphal, extending from basal tissue and continuous with epithecium. Pseudoparaphyses and asci developed from pseudoparenchymatous basal stroma (Rossman et al. 1994). *Asci* are broadly clavate to short-cylindric, slightly flattened at apex, bitunicate

and the ectotunica is invisible in lower part of ascus and probably restricted to a large apical dome with wide ocular chamber. Ascospores are fusiform to ellipsoid, one septate, smooth, hyaline with rounded ends and without a gelatinous sheath. The family *Phillipsiellaceae* is usually placed in the *Schizothyriaceae*, *Dothideales* (Rossman et al. 1994; Eriksson 1981), but the familial placement is not confirmed yet as no sequence data is available. Recollection and molecular studies are needed to establish whether this is a distinct family.

Type: Phillipsiella Cooke, Grevillea 7(no. 42): 48 (1878) MycoBank: MB 3996

Possible synonyms:

Bactridiopsis Gonz. Frag. & Cif., Boln Real Soc. Españ. Hist. Nat., Biologica 27: 330 (1927)

Microphyma Speg., Boln Acad. nac. Cienc. Córdoba 11(4): 551 (1889)

Type species: Phillipsiella atra Cooke, Grevillea 7(no. 42): 48 (1878), MycoBank: MB 205237

Polystomellopsidaceae Bat. et al., Nova Hedwigia 2: 472 (1960)

The reasons for invalidity are discussed by DL Hawksworth & JC David (“Family Names” [Index of Fungi Supplement] 1989)

Pseudeurotiaceae Malloch & Cain, Can. J. Bot. 48: 1815 (1970), MycoBank: MB 81222

Saprobic on woody tissue and rotting vegetation, often isolated from soil. Sexual state: *Ascomata* cleistothecial, formed from coiled initials, brown to black, the peridium pseudoparenchymatous., thin-walled, not cephalothecoid in structure. *Asci* 8-spored, globose, scattered, thin-walled, evanescent, without apical structure. *Ascospores* sphaerical to ellipsoidal, distichously arranged, partially overlapping hyaline or brown, usually aseptate, smooth walled without germ pores. Asexual state: *Teberdinia*, morphologically simple, hyphomycetous, conidia produced from phialides or by sympodial proliferation of the conidiogenous cells in some cases (Cannon and Kirk 2007; Takashi et al. 2006).

Notes: The family *Pseudeurotiaceae* was introduced by Malloch and Cain (1971) to accommodate the genera which were referred to *Cephalothecaceae* and includes *Connersia*, *Leuconeurospora*, *Pleuroascus*, *Pseudeurotium*, *Teberdinia* and *Pseudogymnoascus*. Hawksworth et al. (1995) placed *Pseudeurotiaceae* and *Cephalothecaceae* in the *Eurotiales*. According to the recent molecular and phylogenetic analyses by Suh and Blackwell (1999) members of *Pseudeurotiaceae* and *Cephalothecaceae* are excluded from the *Eurotiales* and some species of *Pseudeurotiaceae* show well-supported close relationships to perithecial taxa in *Hypocreales*, *Ophiostomatales*, *Sordariales* and *Xylariales* while others to discomycetes and Dothideomycetes. *Cephalotheca sulfurea*, the type of *Cephalothecaceae* formed a

monophyletic group with species of *Pseudeurotiaceae* now placed in the *Sordariales* (Suh and Blackwell 1999).

Type: Pseudeurotium J.F.H. Beyma, Zentbl. Bakt. ParasitKde, Abt. II 96(20–23): 415 (1937), MycoBank: MB 4408

Possible synonym:

Levispora Routien, Mycologia 49: 189 (1957)

Type species: Pseudeurotium zonatum J.F.H. Beyma, Zentbl. Bakt. ParasitKde, Abt. II 96(20–23): 411 (1937), MycoBank: MB 282361

Pyrenothrichaceae Zahlbr. Nat. Pflanzenfam., Edn 2 (Leipzig) 8: 91 (1926), MycoBank: MB 515946

Sexual state: *Thallus* corticolous or foliicolous, composed of densely arranged, but not conglutinated, appressed filaments, filaments formed by unbranched or falsely branched photobiont threads wrapped in a sheath of fungal hyphae; hyphae branched and anastomosing, formed by elongate, often strongly curved and terminally inflated, pale brownish cells. *Ascomata* perithecioid, sessile or immersed between thallus filaments, globose to pear-shaped with short neck or only with ostiole, glabrous. *Excipulum (peridium)* thin, paraplectenchymatous, grayish brown. *Hamathecium* paraphysate (but empty asci resembling paraphyses often present). *Asci* 8-spored, bitunicate, broadly clavate to saccate, pedicellate. *Ascospores* transversally septate to muriform, pale to dark grayish brown. Asexual state: Unknown.

Notes: The family *Pyrenothrichaceae* (as *Pyrenothricaceae*) was established to accommodate *Pyrenothrix* (the type) and *Cyanoporina* Groenh by Zahlbruckner (1926). Based on the type species producing perithecia, Henssen (1964) placed *Pyrenothrichaceae* in *Pleosporales*. Eriksson (1981) suggested this taxon is close to *Coccodiniaceae*, sooty molds placed in *Capnodiales*. Eriksson et al. (2004) listed *Pyrenothrichaceae* under Chaetothyriomycetes and Dothideomycetes *incertae sedis*, but Lumbsch and Huhndorf (2010) listed the family in Dothideomycetes *incertae sedis*. Recent phylogenetic studies have shown that Dothideomycetes and Chaetothyriomycetes are not closely related, with Chaetothyriomycetes clustering together with Eurotiomycetes and Lecanoromycetes, while Dothideomycetes are basal Pezizomycotina. Morphologically, *Chaetothyriales* and *Verrucariales* are the most likely two orders to place *Pyrenothrichaceae*, as they share a typically hemiamyloid, rarely amyloid hamathecium lacking paraphyses, usually producing long periphysoids. However, *Verrucariales* are mainly lichenized, and *Chaetothyriales* are mostly non-lichenized. There are no molecular data for lichenized fungi currently placed in *Chaetothyriales* to confirm this placement. Herrera-Campos et al. (2005) suggested placing *Pyrenothrichaceae* within Chaetothyriales based on the simple perithecial wall characteristic of *Pyrenothrix*. *Cyanoporina* was introduced as a

monotypic genus by Groenhart (1951) for *Cyanoporina granulosa* Groenh. This genus is presently monotypic. Although it seems unlikely that this genus is related to *Pyrenothrix* we include it in the *Pyrenothrichaceae* for convenience of keying out.

Type: Pyrenothrix Riddle. Bot. Gaz. 64: 513 (1917), MycoBank: MB 4608

Possible synonym:

Lichenothrix Henssen, Ber. dt. bot. Ges. 77: 318 (1964)

Sexual state: *Thallus* corticolous or foliicolous, composed of densely arranged, but not conglutinated, appressed filaments, up to 100 µm, filaments formed by unbranched or falsely branched photobiont threads wrapped in a sheath of fungal hyphae; hyphae branched and anastomosing, formed by elongate, often strongly curved and terminally inflated, pale brownish cells. *Ascomata* solitary or in botryose clusters, dark greyish brown to black, coriaceous, with individual ostioles. *Ostiole* circular, central, papillate, periphyses absent from ostiolar channel. *Peridium* paraplectenchymatous, grayish brown, inner most 2–3 layers composed of narrow, thin-walled and periclinally elongate, almost hyaline cells, median 1–2 layers composed of broader, rather large, thick-walled and strongly pigmented cells, and outer most 2–3 layers composed of isodiametric to irregular, thin-walled and paler cells. *Hamathecium* of hypha-like, septate, pseudoparaphyses, which are slightly constricted at septum, rather long, hyaline periphysoids reaching down from below ostiolar channel into perithecial chamber. *Asci* 8-spored, bitunicate, fissitunicate, clavate, pedicellate. *Ascospores* 2–3-seriate, fusiform to clavate, muriform with (3–)5 transverse and 0–1 longitudinal septa per segment, brown to dark brown, slightly constricted at septum, terminal cells paler to almost hyaline, wall smooth. Asexual state: not established.

Notes: Pyrenothrix was introduced as a monotypic genus by Riddle (1917) based on *P. nigra*. This lichen fungus is characterized by perithecioid ascomata and an appressed filamentous thallus with cyanobacterial photobiont (*Scytonema*). Henssen (1964) re-studied the type *Pyrenothrix* and described two new species namely, *Lichenothrix riddlei* A. Henssen as filamentous lichen and *Pleosphaeria lichenothricis* A. Henssen as parasymbiotic fungus, and suggested the type species *P. nigra* to be composed of two distinct elements: a filamentous, sterile lichen resembling a *Cystocoleus*, and a pyrenocarpous, parasymbiotic fungus. Eriksson (1981) synonymized both *Lichenothrix riddlei* and *Pleosphaeria lichenothricis* under *Pyrenothrix nigra* based on all the elements which are originally assigned to *P. nigra*. Herrera-Campos et al. (2005) examined the types with designating a lectotype, and introduced a new species *Pyrenothrix mexicana* Herrera-Campos, Huhndorf & Lücking. A modern treatment based on molecular data is required for this family.

Type species: Pyrenothrix nigra Riddle, Bot. Gaz. 64: 513 (1917), MycoBank: MB 403162 (Fig. 141)

Other genus accepted

Cyanoporina Groenh., Reinwardtia 1: 198 (1951)

Type species: Cyanoporina granulosa Groenh., Reinwardtia 1: 198 (1951)

Notes: Cyanoporina was introduced as monotypic genus for *C. granulosa* by Groenhart (1951), from the original description; this likely is a *Psoroglaena* (*Verrucariaceae*). We were unable to examine the type, however this is most unlikely a Dothideomycete.

Roesleriaceae Y.J. Yao & Spooner, Kew Bull. 54(3): 684 (1999), MycoBank: MB 82089

Hypogeous on plant roots, *parasitic* but sometimes becoming *saprobic*. Sexual state: *Ascomata* apothecial, stipitate, capitates, generally lacking an excipulum or sometimes with a very reduced hyaline excipulum as the extension of the outer layer of the stipe. Interascal tissue composed of narrow hypha-like paraphyses, sometimes interwoven and protruding beyond the hymenium. *Asci* 8-spored, cylindrical, without apical structure, evanescent, not bluing in iodine. *Ascospores* uniseriate, lenticular to discoid, smooth, sometimes septate, hyaline or grayish and ascospores released in to a mazaedium over the top of ascomata Asexual state: Unknown (Cannon and Kirk 2007; Yao and Spooner 1999).

Notes: The family Roesleriaceae was introduced by Yao and Spooner (1999) and includes two genera of discomycetes, *Roesleria* and *Roeslerina*. *Roesleriaceae* was formally referred to *Caliciales*, an order in which the mazaediate discomycetes were placed. The type *Roesleria* was published by von Thümen (1877) to accommodate a single species of ascomycetes, *Roesleria hypogaea* on roots of vines. *Roesleria* has been referred to *Geoglossaceae* by Nannfeldt (1932), although this genus was considered to be related to the lichenized genus *Coniocybe* by the same author. Arnaud (1931) considered *Roesleria* as synonymous with *Coniocybe* and *R. hypogaea* with *C. nivea* (Yao and Spooner 1999). Phylogenetic analyses by Kirchmair et al. (2008) indicate that *Roesleria* is closely related to *Hymenoscyphus* (*Helotiales*). *Roesleria* differs from the other members of the *Helotiales* since the ascospores of *Roesleria* are passively released, and a distinct apical apparatus cannot be observed by light microscope. Also electron microscope investigations have not explicated whether the asci of *Roesleria* are equipped with a rudimentary apical apparatus or not. The passive release of the ascospores is considered as an apomorphic character that evolved as adaptation to a hypogeous living (Kirchmair et al. 2008).

Type: Roesleria Thüm. & Pass., Öst. bot. Z. 27: 270 (1877), MycoBank: MB 4777

Possible synonym:

Paracudonia Petr., Annl. mycol. 25(3/4): 246 (1927)

Type species: Roesleria hypogaea Thüm. & Pass., in Thümen, Symb. mycol. austr. 1: no. 1 (1877), MycoBank: MB 152286



Fig. 141 *Pyrenothrix nigra* (FH, lectotype, USA Florida, West Palm Beach, on shrub oaks, December 1897, Thaxter s.n.) **a** Herbarium material **b** Appressed filamentous thallus with perithecia **c** Ascoma **d**

Section of ascoma **e** Peridium **f–h** Ascospores Scale bars: **b** = 500 μm , **c–d** = 100 μm , **e–f** = 50 μm , **g–h** = 10 μm

Seuratiaceae Vuill. ex M.E. Barr, Mycotaxon 29: 501 (1987), MycoBank: MB 81841

Possible synonym:

Atichiaceae Racib. [as 'Atichiae'], Parasit. Alg. Pilze Java's (Jakarta) 3: 41 (1900)

Saprobic and *epiphytic* on leaves, often found on honey dew and mixed with sooty molds. Sexual state: *Stromata* superficial or absent. *Ascomata* crustose, dark, irregular in outline, the upper part deliquescing to

expose the asci. *Peridium* consisting of pale chain of cells in a gelatinous matrix. Interascal tissue poorly developed, consisting of irregular interthelial strands and arising from budding croziers or by their abortion and from persistent sterile tissue. *Asci* 8-spored, globose to subglobose, scattered or in small groups, saccate, fissitunicate with a distinct stipe. *Ascospores* irregularly arranged, inequilateral, clavate, hyaline to brown, 1-septate, without a sheath. Asexual state: "Atichia"

multicellular, torulose or holoblastic conidia originating from superficial layers of the colonies. The variation of the conidia arises from indeterminate but ecologically limited growth (Meeker 1975; Cannon and Kirk 2007; Eriksson 1981).

Notes: The family *Seuratiaceae* was introduced by Barr (1987a) and includes *Atichia*, *Seuratia* and *Seuratiopsis*. The *Seuratiaceae* agree with *Arthoniaceae*, but have a more gelatinous thallus and conidia of a type not found in the *Arthoniaceae*. The tissue between the asci is built exactly as in the rest of the thallus and they are never lichenized but often found on honey-dew and intermixed with sooty moulds. Mangin and Patouillard (1913) and Batista (1957) have recognized a separate order, *Atichiales* for this family (Eriksson 1981), which probably has an earlier name in *Atichiaceae*.

However, Eriksson (1981) stated that the family should be named *Seuratiaceae*, because the correct name is the earliest name typified by the sexual morph (ICBN, Art 59). Recollection and molecular studies are needed to establish whether this is a distinct family as molecular data is not available in GenBank.

Type: *Seuratia* Pat., Bull. Soc. mycol. Fr. 20(3): 136 (1904), MycoBank: MB 5015

Type species: *Seuratia coffeicola* Pat., Bull. Soc. mycol. Fr. 20(3): 136 (1904), MycoBank: MB 164016 [Current name: *Seuratia millardetii* (Racib.) Meeker, Can. J. Bot. 53: 2485 (1975)]

Thryptosporaceae Petr., Sydowia 1(1–3): 54 (1947)

This is an invalid name (Eriksson 1981)



Fig. 142 *Triposporiopsis spinigera* (Material examined: SAMOA, on living leaf of *Sterculia populnea*, 1905, K. Reehinger FH 00290340, **holotype**) **a** Herbarium packet. **b** Sooty mould on host. **c** Ascostromata.

d, e Vertical section of ascostroma. **f** Peridium. **g** Hyphae. **h** Conidia. **i, j** Bitunicate asci. **k, l** Ascospores. Scale bars: **c** = 100 μ m, **d–j** = 20 μ m, **k–l** = 10 μ m

Triposporiopsidaceae S. Hughes, Mycologia 68(4): 712 (1976), MycoBank: MB 81600

Sooty moulds on leaf and stem surface. Sexual state: *Thallus* comprising septate mycelium. *Hyphae* superficial, cylindrical, septate, constricted or not at the septum, or with relatively inconspicuous septa, light brown to brown, smooth-walled or slightly roughened, a loose extensive network or somewhat dense stratum. *Ascstromata* arise from the mycelial subiculum, soft, sessile, brown, uniloculate, ostiole central, bearing numerous, setose, brown to dark brown, erect, straight or curved hyphal appendages, which are septate or lack septa. *Pseudoparaphyses* not present at maturity. *Peridium* thin-walled, comprising several layers of pale brown to brown cells of *textura angularis*. *Asci* apparently bitunicate, cylindrical to clavate, with an apical ring. *Ascospores* overlapping 2–3-seriate, hyaline, fusiform or ellipsoidal, round at ends, 2–3-septate, slightly constricted or not constricted at the septum, without a mucilaginous sheath. Asexual state: *Tripopermium* sp., mycelium forms brown, effuse, superficial colonies composed of branched and anastomosing smooth, septate, brown hyphae, which are slightly constricted at the septum. *Conidiogenous cells* phialidic, scattered, relatively long, subhyaline to pale brown, producing stauroconidia. *Mature conidia* typically tetradiate with a short basal stalk cell, cylindrical with a rounded base, brown, hyaline to pale brown at the apex, smooth or roughened, up to 6-septate, slightly constricted at the septa, wide at the base and tapering to a rounded apex, of various sizes. Occasionally with three or four short arms. Germinating conidia, hyphae and ascostromata initials frequently bear more or less subulate or narrowly flask-shaped phialides or phialide-like structures, erect on the repent hyphae and often crowded, one to each cell, along considerable lengths of the particular hyphae. Phialides produce hyaline, ellipsoidal to broadly ellipsoidal phialoconidia (Hughes 1976).

Notes: *Triposporiopsidaceae* was described by Hughes (1976) based on the genus *Triposporiopsis* and linked to the asexual state *Tripopermium*. von Arx and Müller (1975) classified *Triposporiopsis* in *Capnodiaceae*. Colonies of sooty moulds are often mixtures of species from different families and it is difficult to isolate and identify them. Hughes and Seifert (2012) have summarized hyphal morphologies and synanamorphic patterns of sooty moulds in *Metacapnodiaceae*, *Euantennariaceae* and *Triposporiopsidaceae*. Hyphae of *Triposporiopsidaceae* are cylindrical, slightly constricted, and medium brown, in *Metacapnodiaceae* hyphae are monilioid, deeply constricted, and dark brown, while in *Euantennariaceae* hyphae are brick-like, slightly constricted and brown or dark brown Chomnunti et al. (2011) re-examined *Trichomerium* which has similar morphology to *Triposporiopsis* and was shown to belong in *Chaetothyriales* based on molecular data.

Therefore *Triposporiopsis* is transferred to *Trichomeriaceae* in this paper (*Chaetothyriales*).

Type: ***Triposporiopsis*** W. Yamam., Pap. Dedic. Tochinai & Fukushi Commem. 60th Birthdays: 52–56 (1955), MycoBank: MB 5609

Notes: Hughes (1976) observed many type collections of sooty moulds (*Parapodia*, *Vitalia*, *Trichomerium coccolobae* Bat. & Cif. and *Trichomerium stuhlmanianum* (Henn.) Bat. & Cif. var. *biseptatum* Bat. & Cif.) and found them to be typical of *Triposporiopsis* bearing *Tripopermium* conidia with characteristic phialides, thus he considered they should all belong to *Triposporiopsidaceae*. Hyphae of *Aithaloderma* and *Triposporiopsis* are similar to each other in being septate, cylindrical and slightly constricted at the septum, but they can be distinguished as *Triposporiopsis* hyphae produce *Tripopermium* conidia on typical hyphae and bear phialides (Hughes 1976). Hyde et al. (2011) reported that *Tripopermium* sp. is the asexual state of *Trichomerium* sp. Chomnunti et al. (2011) described and illustrated *Trichomerium* in the new family *Trichomeriaceae* (*Chaetothyriales*). This introduction was supported by morphology and molecular analysis. A matching asexual state was referred to *Tripopermium* sp., but this link lacked morphological and molecular data. Ruibal et al. (2009) stated that *Devriesia strelitziae*, *Mycosphaerella eurypotami* and *Tripopermium myrti* are leaf-colonizing species. A maximum likelihood analysis of the combined nucLSU, nucSSU and mtSSU show that these species cluster within *Teratosphaeriaceae* with unknown species of *Capnodiaceae*, the lichen species *Cystocoleus ebeneus* and 20 undescribed rock inhabiting strains. Therefore, the sexual and asexual state of *Triposporiopsidaceae* remains unclear.

Type species: ***Triposporiopsis spinigera*** (Höhn.) W. Yamam., Pap. Dedic. Tochinai & Fukushi Commem. 60th Birthdays: 52–56 (1955), MycoBank: MB 3077143

≡ *Limacinia spinigera* Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. I 116: 100 (1907) (Fig. 142)

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