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Meliolales

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Abstract The order *Meliolales* comprises the families *Armatellaceae* and *Meliolaceae*. These are black mildews that grow on the surface of host plants, often regarded as minor plant pathogens. In this study, types or specimens of 17 genera of *Armatellaceae* and *Meliolaceae* were borrowed from herbaria and re-examined. *Armatella* is accepted in *Armatellaceae* and *Amazonia*, *Appendiculella*, *Asteridiella*, *Cryptomeliola*, *Endomeliola*, *Irenopsis* and *Meliola* are accepted in the family *Meliolaceae. Laeviomeliola* is synonymized under *Meliola. Ceratospermopsis*, *Ectendomeliola*, *Haraea*, *Hypasteridium*, *Leptascospora*, *Metasteridium*, *Ophiociliomyces*, *Ophioirenina*, *Ophiomeliola*, *Parasteridium*, *Pauahia*, *Pleomeliola*, *Pleomerium*, *Prataprajella*, *Ticomyces*, *Urupe* and *Xenostigme* are excluded from *Meliolaceae*, and are treated as doubtful genera or placed in ascomycetes genera incertae sedis. The type species of each genus is re-described and illustrated with photomicrographs. Notes are provided and comparisons made. Two new species of *Meliola* and one new species of *Irenopsis* are also introduced with molecular data and we provide the most populated phylogenetic tree of *Meliolomycetidae* to date. *Meliola thailandicum* was found on *Dimocarpus longan* (*Sapindales*) and *Acacia auriculiformis* (*Fabales*) and confirmed to be the same species in the molecular analyses. This has important implications as the several hundred *Meliola* species are recognized based on host associations. Thus the same species being recorded from two unrelated hosts sheds doubt on *Meliola* species being host-specific.

Keywords *Armatella* · *Armatellaceae* · Ascomycota · Black mildews · *Meliola* · *Meliolaceae* · *Meliolomycetidae* · *Sordariomycetes* · Morphology · Type · Species · Taxonomy

Introduction

Species of *Meliolales* are obligate, biotrophic, foliar pathogens, which occur as epiphytes on leaves, stems, branches, and sometimes on petioles of vascular plants (Hansford 1961; Hosagoudar 1994, 1996, 2008, 2013; Mibey and Hawksworth 1997; Old et al. 2003). They are commonly known as the "black mildews" or "dark mildews" based on their black colonies up to one cm diameter, produced on the surface of hosts, and are widely distributed especially in subtropical and tropical regions (Goos and Andersons 1974; Ainsworth 1963; Hosagoudar 1994, 1996, 2003a, 2008; Saenz and Taylor 1999; Mibey and Hawksworth 1997; Old

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et al. 2003; Justavino et al. 2015; Maharachchikumbura et al. 2015). They are believed to show a high degree of host specificity, and therefore it is necessary to identify the host before determining the mildew (Hansford 1961; Hirata 1971; Hosagoudar and Goos 1989). The extent of host association, however, has not yet been determined, and molecular studies are needed to establish that species are host-specific. Species of *Meliolales* are not pathogens in a strict sense and do not cause extensive damage to host plants (Sabulal et al. 2006; Hosagoudar et al. 1997), however, they may increase the temperature and respiration in areas covered by the fungus, and also reduce photosynthesis as in the family *Asterinaceae* (Hongsanan et al. 2014). Taxa of the order obtain nutrients by producing haustoria in host cells, and heavy infections result in a dirty appearance on plants and economic products (Fig. 1) and may reduce their value (Hosagoudar et al. 1997, 2012). Wellman (1972) noted that this group produces significant affects on crops, but has never been seriously studied (Hosagoudar and Riju 2013).

Species of *Meliolales* are often confused with sooty moulds because they coat fruits and leaves superficially with black colonies. Sooty moulds are saprobes which develop on leaf surfaces feeding on honeydew (Chomnunti et al. 2011, 2014). Species of *Meliolales* produce a variety of structures which can penetrate host cells for the uptake nutrients (Mibey and Hawksworth 1997; Saenz and Taylor 1999). This order is different from powdery mildews in morphology, but can develop in the same ecological habitats (Saenz and Taylor 1999).

The order *Meliolales* comprises the families *Armatellaceae* and *Meliolaceae*. The family *Meliolaceae* was proposed by Martin (1941) based on the generic type *Meliola* (Martin 1941; Hosagoudar 1994, 1996, 2008; Mibey and Hawksworth 1997; Old et al. 2003; Justavino et al. 2015; Maharachchikumbura et al. 2015). Members of the family are characterized by a biotrophic habitat, superficial dark hyphae, although sometimes the hyphae may be immersed in plant cells, with lateral hyphopodia and/or phialides. Superficial ascomata develop in the black, web-like colonies and are flattened or globose to subglobose, and have a dark peridium. Setae or appendages cover the ascomata and/or black mycelia in some genera. Asci are unitunicate, usually 3–4-spored, with brown, 3–4-septate ascospores (Mibey and Hawksworth 1997; Hosagoudar and Riju 2013). The asexual states of *Meliolaceae* species have been reported as phialides on hyphae, however, they are morphologically relatively poorly studied. Many characters of the family, such as types of hyphopodia, nature of phialides and structure of asci, are unclear, because various studies have provided different interpretations. The family *Armatellaceae* was established by Hosagoudar (2003b), with generic type *Armatella* Theiss. & Syd. Members of the family are characterized by superficial hyphae with hyphopodia, lacking phialides, ascomata which develop in the black colonies, cylindrical to subcylindrical asci, with 4–8-spores, and ascospores hyaline to brown at maturity, and 1-septate (Hosagoudar 2003b). The asexual morph is undetermined.

Because of their biotrophic lifestyles, species of *Meliolales* have yet to be grown in culture. Molecular data for species of *Meliolales* have therefore been obtained by directly extracting DNA from ascomata. Thite (1975) and Goos (1978) succeeded in germinating the ascospores, but growth following germination was limited and later ceased. We therefore focused on obtaining DNA and sequence data directly from the ascomata.

Taxonomic review

Superficial hyphae of *Meliolales* species are characterized by web-like colony formation on the host surface, usually branched, septate, and brown. Hyphopodia and setae are present in the genera *Cryptomeliola*, *Irenopsis*, and *Meliola* (Hansford 1961; Hosagoudar 1994, 1996, 2008, 2013; Mibey and Hawksworth 1997; Old et al. 2003). *Endomeliola* have intercellular hyphae which extend into the mesophyll (Hughes and Pirozynski 1994).

The nature of the hyphopodia is thought to be extremely important in identifying species in *Meliolales* (Hansford 1961), but this has never been proven by molecular evidence. The term hyphopodia was used by Gaillard (1891). Goos and Gessner (1975) noted that the hyphopodia is one kind of appressoria. Both terms hyphopodia and appressoria have been used in the literature, so Goos and Gessner (1975) suggested retaining usage of either. However, hyphopodia and appressoria are different because appressoria are produced on germ tubes, while hyphopodia are produced on hyphae (Emmett and Parbery 1975). These terms have been used interchangeably in many studies. As hyphopodia are produced on hyphae we recommend use of the term “hyphopodia” for the structures in *Meliolales* species. The hyphopodia are characterized by two cells, a short basal stalk cell bearing a single capitate hyphopodium. Hyphopodia may be alternate, opposite, or mixed alternate and opposite on hyphae depending on the species. Two kinds of hyphopodia are recognized in *Meliolales*, capitate and mucronate (Gaillard 1891). Capitate hyphopodia comprise a short stalk cell, bearing a single hyphopodia, which is the attachment and absorption organ. This later produces a single haustorium in the epidermal layer of host plants (Hansford 1961). Different species have differently shaped hyphopodia ranging from ovate, oblong, or angular to lobate. The capitate hyphopodia on the lower surface of leaves are mostly irregular in shape, while species found on the upper surface of leaves are globose to subglobose (Hansford 1961).

Mucronate hyphopodia were illustrated by Hughes (1981) and Mueller et al. (1991). Mucronate hyphopodia were

Fig. 1 *Meliolaceae* on various hosts. **a**, **b** *Dimocarpus longan*. **c**, **d** *Citrus maxima*. **e** *Litchi chinensis*. **f** *Mangifera indica*. **g** *Citrus reticulata*

interpreted as phialides and are conoid or ampuliform on hyphae, however they vary in shape in the same colony (Hansford 1961). Phialides produce conidia or phialoconidia (Hughes 1981, Mueller et al. 1991). There is however, no report to confirm that phialoconidia can develop into robust hyphae (Hughes 1981). Most species of *Meliolaceae* produce opposite phialides, or occasionally they are alternate or mixed with capitate hyphopodia on the hyphae. Some species in *Meliolaceae* lack phialides, but the apparent lack is probably due to the difficulty of observing such structures. Phialides appear to lack penetration or function (Hansford 1961; Goos 1974; Goos and Gessner 1975; Mueller et al. 1991). Species in *Armatellaceae* are characterized by hyphae without phialides, and the asexual morph is undetermined (Hosagoudar 2003b).

Ascomata are solitary or scattered on colonies of superficial hyphae and mostly develop at the centre of the colony. The ascomata is first flat, cells are radially arranged, and then become globose to subglobose, however a few genera (e.g., *Amazonia*), have flattened ascomata even at maturity. The wall of the ascomata comprises two strata, the outer strata having dark brown walls, and inner strata hyaline walls. A rounded pore is present at the apex of ascomata and is filled with hyaline periphyses and is covered by hyphal layers, and is thus hard to observe. The surface of ascomata is mostly verrucose. In *Asteridiella*, the surface has raised conoid cells, while conical appendages are present in *Appendiculella* species. The genus *Irenopsis* has setae on the surface of ascomata which are dark, smooth or rough, septate or aseptate, straight to coiled, with acute, rounded or hooked ends, and narrower than appendages in *Appendiculella*.

The asci of *Meliolales* have been reported differently in many studies. Müller and von Arx (1973) considered the asci of *Meliolales* species to be unitunicate. Eriksson (1981) introduced the term "Pseudoprototunicate" to describe the asci in *Meliolales*. A pseudoprototunicate ascus is characterized by thin walls, and is thought to have evolved from bitunicate asci, in which the endotunica is reduced. There is no opening mechanism, and they are evanescent at maturity (Eriksson 1981; Barr and Huhndorf 2001; Hofmann 2009). Hawksworth and Eriksson (1986) emended the description provided by Gäumann (1964) and concluded that *Meliolales* had bitunicate asci. However, Hosagoudar et al. (1997, 2012) used unitunicate to describe the asci of *Meliolales* species. We suggest using the term unitunicate asci to define the asci in *Meliolales* based on phylogeny, which place the species of *Meliolaceae* in *Sordariomycetes* (Maharachchikumbura et al. 2015).

The ascospores are very uniform in shape and septation in the family *Meliolaceae*. They are thick-walled, cylindrical to oblong, fusiform or obovoid, and slightly curved in some species. Some species have 3-septate ascospores, but in most they are 4-septate. In most species the central cells are widest and longest. The ascospores are more or less constricted at the septa, with smooth walls. The end cells are mostly rounded, but can rarely be conoid or apiculate (Hansford 1961; Mibey and Hawksworth 1997). All species in the family are hyaline when immature, and dark brown and thick-walled at maturity. However, some genera with two to multiseptate hyaline ascospores were included in *Meliolaceae* (Lumbsch and Huhndorf 2010). In this study, we only accept genera with 3–4-septate and brown ascospores in *Meliolaceae*. Ascospores in *Armatellaceae* are aseptate or 1-septate, hyaline to brown, and smooth or slightly rough-walled.

History of *Armatellaceae* and *Meliolaceae*

The family *Meliolaceae* was established by Martin (1941) without a Latin diagnosis but validated by Hansford (1946). Roger (1953) placed the *Meliolaceae* with nine other families in the order *Hypocreales*. This family has also been placed in the orders *Dothideales*, *Erysiphales*, *Meliolales*, *Myriangiales* and *Hypocreales* at various times (Martin 1941; Luttrell 1951, 1989; Roger 1953; Ainsworth et al. 1971; Müller and von Arx 1973; Yarwood 1973; Barr 1976; Eriksson 1981; Hawksworth et al. 1983). Monographs of the *Meliolaceae* were provided by Hansford (1961, 1963), with keys to the genera of the family based on morphology and host association (Hansford 1961). Ainsworth et al. (1971) and Eriksson and Hawksworth (1993) listed 50 genera in the family. This was reduced to 25 genera (Hawksworth et al. 1995) and later 22 genera (Kirk et al. 2008). A biogeographical distribution of *Meliolaceae* in India was provided by Hosagoudar (2006) and he included a key to the genera in the family. Lumbsch and Huhndorf (2010) placed *Meliolaceae* in the class *Sordariomycetes* with 26 genera. This was followed by Hyde et al. (2013) and Wijayawardene et al. (2014), who excluded *Meliolaceae* from *Dothideomycetes*. The family *Armatellaceae* was introduced by Hosagoudar (2003b). *Armatellaceae* contains a single monotypic genus (Table 1). Although *Basavamyces* Hosag. was included in *Armatellaceae* by Hosagoudar (2008), Hosagoudar et al. (2012) concluded that *Basavamyces* is not the member of *Armatellaceae* because of its 2-septate ascospores.

Saenz and Taylor (1999) directly sequenced DNA from ascomata and their phylogenetic tree indicated that *Meliolales* was a member of Pyrenomycetes, which are close to *Sordariales*. Pinho et al. (2012a) reported that the phylogenetic placement of members of *Meliolales* was uncertain because the phylogenetic analyses (28S rDNA) were not strongly supported, but this order is monophyletic within *Sordariomycetes*. Kirk et al. (2001) introduced a new subclass, *Meliolomycetidae* (*Sordariomycetes*) for members of *Meliolaceae*, but without a description or diagnosis. The placement of *Meliolomycetidae* in *Sordariomycetes* was confirmed by Justavino et al. (2015) based on their phylogenetic tree and Maharachchikumbura et al. (2015) validated the subclass. *Meliolales* species are biotrophic and cannot be cultured, thus there are few sequences for species in GenBank.

Ecology

The *Meliolales* are biotrophs, or pathogens of living leaves or occasionally dead leaves, and are common on scrubs in open park-lands and on inaccessible canopies of rainforest trees (Hansford 1961; Hosagoudar 2003b, 2008). Species of *Meliolales* are associated with a variety of plant substrates including living leaves, and occasionally petioles, twigs, and branches (Hansford 1961; Hosagoudar 1994, 1996, 2008; Hosagoudar and Riju 2013; Mibey and Hawksworth 1997; Old et al. 2003). Species of *Armatellaceae* and *Meliolaceae* have a worldwide distribution (Kirk et al. 2008). They are especially common in the tropics and have an extended distribution to sub-temperate to temperate regions, and are generally lacking in arid regions (Hansford 1961; Hosagoudar

Table 1 Genera included in *Armatellaceae* and *Meliolaceae* by different researchers

	Hosagoudar (2003b)	Hosagoudar (2008)	Hosagoudar et al. (2012)	This study		
Armatellaceae	*Armatella*	*Armatella* *Basavamyces*	*Armatella*	*Armatella*		
	Stevens 1925 (Meliolineae)	Hansford 1946 (Meliolineae)	Hansford (1961)	Boedijin (1961)	Lumbsch and Huhndorf (2010)	This study
Meliolaceae	*Actinodothis*	*Actinodothis*	*Amazonia*	*Amazonia*	*Amazonia*	*Amazonia*
	Amazonia	*Amazonia*	*Appendiculella*	*Appendiculella*	*Appendiculella*	*Appendiculella*
	Irene	*Appendiculella*	*Asteridiella*	*Armatella*	*Asteridiella*	*Asteridiella*
	Meliola	*Irene*	*Irenopsis*	*Asteridiella*	*Basavamyces*	*Cryptomeliola*
	Meliolina	*Irenina*	*Meliola*	*Irenopsis*	*Ceratospermopsis*	*Endomeliola*
	Meliolinopsis	*Irenopsis*		*Meliola*	*Cryptomeliola*	*Irenopsis*
		Meliola			*Ectendomeliola*	*Meliola*
					Endomeliola	
					Haraea	
					Hypasteridium	
					Irenopsis	
					Laeviomeliola	
					Leptascospora	
					Meliola	
					Metasteridium	
					Ophiociliomyces	
					Ophioirenina	
					Ophiomeliola	
					Parasteridium	
					Pauahia	
					Pleomeliola	
					Pleomerium	
					Prataprajella	
					Ticomyces	
					Urupe	
					Xenostigme	

1994, 1996, 2008, 2013; Saenz and Taylor 1999; Mibey and Hawksworth 1997; Old et al. 2003; Justavino and Piepenbring 2007; Kirk et al. 2008; Piepenbring et al. 2011; Pinho et al. 2012b, 2013; Justavino et al. 2015). Studies on the dispersal of ascospores in *Meliolales* are lacking (Hansford 1961; Hosagoudar 1996; Nayar et al. 1998). Dispersal of species of *Meliolaceae* probably occurs by rain splash, insects, or air (Nayar et al. 1998). *Meliolaceae* species can survive after the leaves have been shed. When new leaves grow during the next season they are colonized by *Meliolaceae* with spores from leaves on the ground (Nayar et al. 1998). *Meliolaceae* in forests are more abundant during the cool season in tropical to subtropical regions. Even though forests are burnt leaving only the perennial root stocks; this group of fungi still occurs during the next season (Nayar et al. 1998). There is no report concerning the dispersal of ascospores in species of *Armatellaceae*.

Life cycle of *Armatellaceae* and *Meliolaceae*

Species of *Meliolales* have different infection mechanisms and the life cycle is illustrated in Fig. 2. Thimmaiah et al. (2013) stated that colonization starts when a mature ascospore attaches to the host substrate (Fig. 2a). A primitive stalk-cell bearing a single capitate, angular or lobate hyphopodium is mostly produced from the terminal cell of the ascospore; this is likely to be an intermediate step before mature hyphopodia development (Fig. 2b) (Tucker et al. 2010, Hongsanan et al. 2014). The hyphopodium then forms an apoplastic complex which is called an interaction apparatus, based on a study of *Asteridiella callista* (Justavino et al. 2014). At the contact zone between epidermal cells and hyphopodia, the apoplastic interaction apparatus forms a penetration pore so that the haustorium can develop into the cytoplasmic membrane and epidermal cells, and rarely in deeper tissues. Nutrient uptake

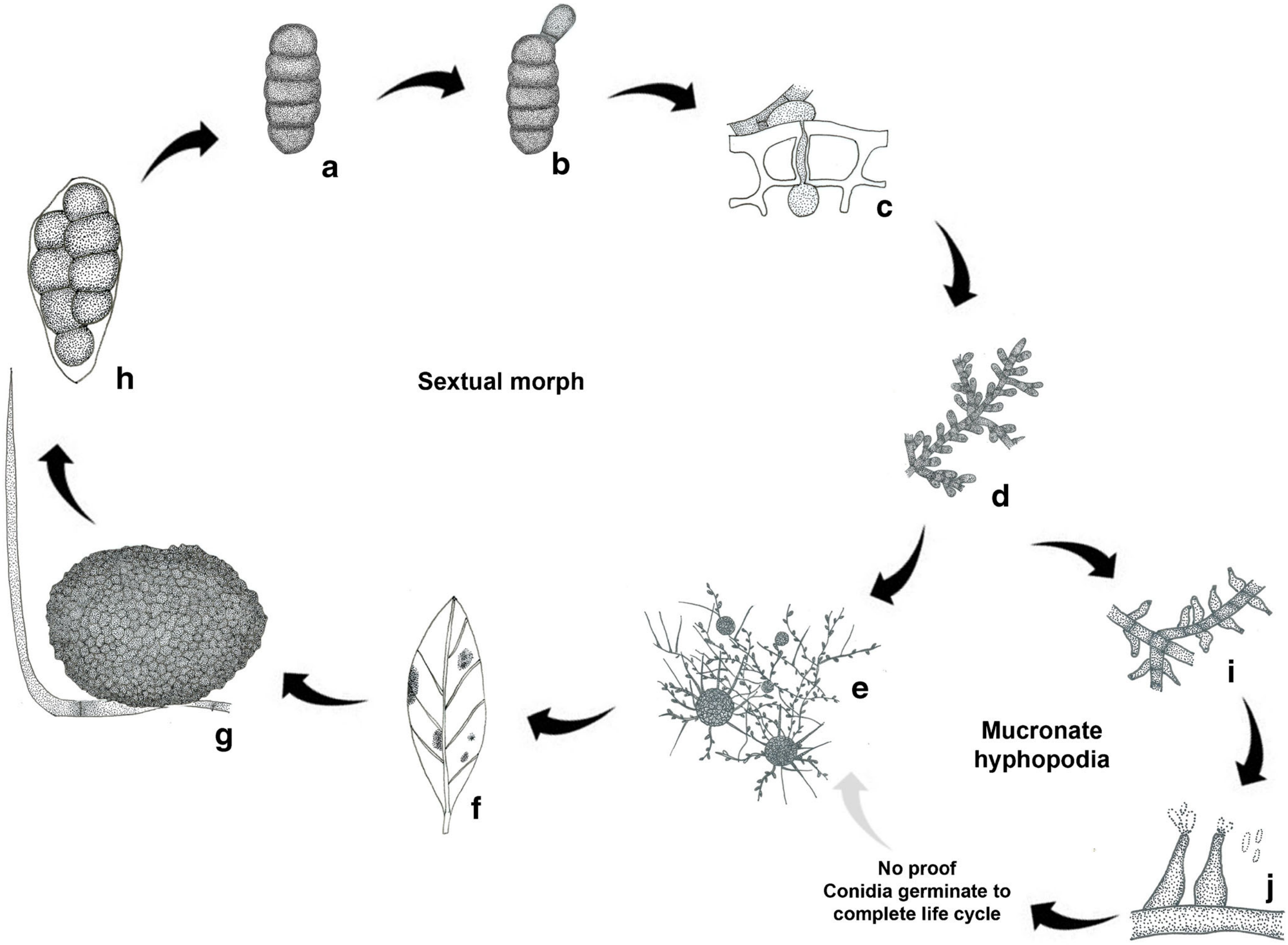


Fig. 2 Life cycle of *Meliola* sp. and its mucronate hyphopodia. **a** Ascospore. **b** Mature germinating ascospore. **c** Haustorium developing in epidermal cell. **d** Lateral hyphae forming superficially. **e** Colony formation. **f** Black spot of hyphae forming on the host surface. **g** Ascoma with hyphal setae. **h** Mature ascus. **i** Hyphopodia with phialides. **j** Phialoconidia

begins (Fig. 2c) and the other cells of the ascospores produce superficial hyphae with frequent branches, and then alternate or opposite lateral hyphopodia are formed on short stalks (Fig. 2d). Initial infection and web-like colony formation on the leaf surface follows (Fig. 2e, f). In *Meliola* species, superficial hyphae produce strong, dark setae. Ascomata are formed laterally on the hyphae, at first being flat, cells are radially arranged, and then becoming globose to subglobose at maturity (Fig. 2g). The genus *Amazonia* is the only genus with flattened ascomata. The ascomata are filled with sterile tissue and asci which are evanescent at maturity (Fig. 2h). Ascospores are produced within the 2–4-spored asci in *Meliolaceae* and 4–8-spored asci in *Armatellaceae*. The asexual morph of *Meliolaceae* develops from the hyphae, and form ampuliform hyphopodia which are called “phialides” (Fig. 2i). These structures developed on the same hyphae as the capitate hyphopodia or sometimes are found on separate hyphae, but lack penetration or apparent function (Mueller et al. 1991). Conidia, which are 1-celled, thin-walled and hyaline, are produced within the neck of phialides (Fig. 2j). The conidiogenous cells are probably present at the base of the phialides (Hughes 1981). It is unlikely that these small phialoconidia can develop into robust hyphae (Hughes 1981) and their function is unclear. There has been a lack of research to establish the asexual morph cycle. There is no reported asexual morph in *Armatellaceae*, and phialides are lacking.

Host specificity

Species in *Meliolales* are considered to have a high degree of host specificity because they are biotrophic on living leaves. Numerous studies have introduced new species based only on host association, even though taxa are morphologically identical (Hosagoudar 1987). Some species on different hosts are distinct in morphology and in penetration mechanisms (Fig. 3) (Hosagoudar 2003a; Justavino and Piepenbring 2007). Hence, most species of *Meliolales* species have been justified based on host association, and it is essential to establish the host

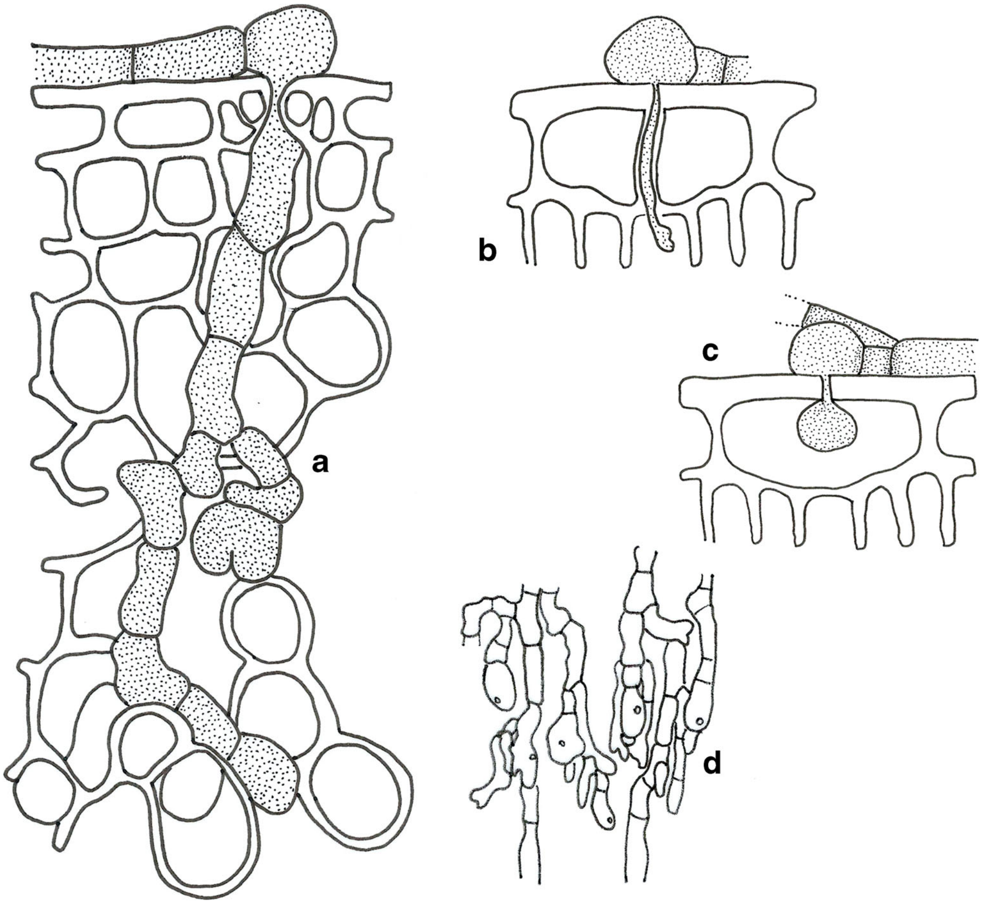


Fig. 3 Host penetration by *Meliolales* species (**a**–**c** redrawn and modified from Yamamoto 1954, **d** redrawn from Hughes and Pirozynski 1994). **a** Hyphopodium of *Meliolina octospora*. penetrating epidermis cells. **b** Hyphopodium of *Irenina rhaphiolepis* Yam. penetrating epidermis and mesophyll cells. **c** Hyphopodium of *Irenopsis coronata* var. *triumfettae* Stev. penetrating epidermis cell. **d** Hyphae with hyphopodia of *Endomeliola dingleyae* developing in epidermis and mesophyll cells

genus or family before identifying the fungal species. Whether *Meliolales* species are host specific needs verifying using molecular techniques.

Molecular phylogeny of *Meliolales*

The morphology of *Meliolales* species indicate that they belong to the class *Sordariomycetes* (Zhang et al. 2006). Pinho et al. (2012a) used sequence data of species in *Meliolaceae* and their phylogenetic tree confirmed the placement within *Sordariomycetes*. Justavino et al. (2015) mentioned a new subclass *Meliolomycetidae* based on their phylogenetic tree which was represented by a basal clade of *Meliolaceae* in *Sordariomycetes*. However, the phylogenetic placement of *Meliolaceae* members was uncertain within the clade because the phylogenetic analyses (28S rDNA) were not strongly supported, but monophyletic within *Sordariomycetes* (Pinho et al. 2012a). Maharachchikumbura et al. (2015) provided a backbone tree for *Sordariomycetes* based on LSU, SSU, TEF and RPB2 sequence data analysis, and their phylogenetic tree indicated that *Meliolomycetidae* is most closely related to *Sordariomycetidae* in *Sordariomycetes* as also found by Justavino et al. (2015). There are few sequences for the species of *Meliolaceae* as they are biotrophic and cannot be cultured (Maharachchikumbura et al. 2015). Most genera discussed here lack molecular data, however, the placements are based on morphological similarities and where possible phylogeny. No sequence data is available for any species of *Armatellaceae*.

Material and methods

Morphology

Type or other specimens of *Appendiculella*, *Asteridiella*, *Cryptomeliola*, *Endomeliola*, *Haraea*, *Irenopsis*, *Laeviomeliola*, *Leptascospora*, *Meliola*, *Ophiociliomyces*, *Ophioirenina*, *Ophiomeliola*, *Pauahia*, *Pleomeliola*, and *Pleomerium* were obtained from B, BPI, ILL, IMI, K(M), PDD, S, URM and ZT. Their morphology was observed under a stereomicroscope. Sections of ascomata were made freehand. Morphological characters were observed and photographed under a compound microscope (Nikon 80i).

Measurements were made using the Tarosoft (R) Image Frame Work v. 0.9.7.

Fresh specimens of *Meliolaceae* were collected in Thailand. Morphological characters were observed and photographed in the same way as herbarium specimens. Single spore isolation was performed following the method of Chomnunti et al. (2014) on PDA (potato dextrose agar) and MEA (malt extract agar), but was generally unsuccessful. Sequences were therefore obtained directly using dry fungal fruiting bodies.

Type specimens of the *Meliolaceae* are deposited in the Mae Fah Luang University Herbarium (MFLU), Chiang Rai, Thailand. Faces of fungi numbers and Index fungorum numbers were obtained as in Jayasiri et al. (2015) and Index fungorum (2015).

DNA isolation, amplification and sequencing

DNA extraction was made directly from dry fungal fruiting bodies to obtain sequence data. Extraction was started by placing individual ascomata in 1.5 *ml* sterilized tubes and leaving overnight at −20 °C. DNA extraction was performed by E.Z.N.A® Forensic Genomic DNA Extraction Kit (OMEGA Bio-tek Norcross GA 2013), GoTaq® Hot start-Promega, Lysis Buffer for Microorganism to Direct PCR (TaKaRa); following the manufacturer‘s instructions.

For GoTaq® Hot start-Promega, amplification conditions were set up for initial denaturation of 3 min at 95 °C, followed by 35 cycles of 27 s at 94 °C, 60 s at 56 °C and 90 s at 72 °C, and a final extension period of 7 min at 72 °C. PCR-products were cleaned from excessive nucleotides and primers by adding 2 μl of 1:5 diluted ExoSAP-IT® (Affymetrix, ExoSAP-IT® For PCR Product Cleanup) to 5 μl of PCR-product. The mix was incubated in the thermocycler for 30 min at 37 °C, followed by 15 min at 80 °C, and sequencing was performed on a ABI 3130xl sequencer in the sequencing service in the faculty of biochemistry at the Ruhr-Universität Bochum. For the specimens which were performed by using Lysis Buffer for Microorganism to Direct PCR (TaKaRa) Kit and E.Z.N.A® Forensic Genomic DNA Extraction Kit, amplification conditions were set up for initial denaturation of 5 min at 95 °C, followed by 35 cycles of 45 s at 94 °C, 45 s at 52 °C and 90 s at 72 °C, and a final extension period of 10 min at 72 °C. PCR-products were checked on 1 % agarose electrophoresis gels stained with ethidium bromide. The purification and sequencing of PCR products were done by Majorbio Co., China.

Phylogenetic analysis

Sequences data were downloaded from GenBank to supplement the dataset (Supplementary Table 1). *Dothidea sambuci* was selected as outgroup taxon. The representative sequences included taxa from *Amplistromatales*, *Annulatascales*, *Boliniales*, *Chaetosphaeriales*, *Coniochaetales*, *Meliolales* and *Sordariales*, as well as some from tentatively placed lineages downloaded from GenBank (Supplementary Table 1), and aligned by using Bioedit v.7.0.1 (Hall 2004) and Clustal X 2.0.11 (Thompson et al. 1997).

RAxML (Maximum likelihood) analysis was performed by using raxmlGUIv.0.9b2 (Silvestro and Michalak 2012). The search strategy was set to rapid bootstrapping and the analysis using the GTRGAMMAI model. The number of replicates was inferred using the stopping criterion (Pattengale et al. 2009). Maximum likelihood bootstrap values equal or greater than 50 % are given as the first set of numbers above the nodes (Figs. 4 and 5). The model of evolution was performed by MrModeltest 2.2 (Nylander et al. 2008). Posterior probabilities (PP) were determined by Markov Chain Monte Carlo sampling (BMCMC) (Rannala and Yang 1996; Zhaxybayeva and Gogarten 2002) in MrBayes v3.1.2 (Huelsenbeck and Ronquist 2001). Six simultaneous Markov chains were run for 1,000,000 generations and trees were sampled every 100th generation and 10, 000 trees were obtained. The first 2000 trees, representing the burn-in phase were discarded, the remaining 8000 trees were used for calculating posterior probabilities (Cai et al. 2006, 2008). Bayesian posterior probabilities (BYPP) equal or greater than 0.80 are given as second set of numbers above the nodes (Figs. 4 and 5).

Results and discussion

Molecular phylogeny

Phylogenetic analyses used LSU (Fig. 4) and ITS sequence data (Fig. 5) and indicate that the *Meliolales* clade clusters in the class *Sordariomycetes*, subclass *Meliolomycetidae*. The *Meliolaceae* clade includes species of the family *Meliolaceae* with 100 % ML support and 1.0 PP support, and is sister to *Rimaconus coronatus* and *R. jamaicensis*; this is similar to the results of Maharachchikumbura et al. (2015). However, we are unable to clarify the placement of *Armatellaceae* because there is no sequence data from this family. *Irenopsis walsurae* clustered in the *Meliolaceae* clade and was closely related to other species of *Irenopsis* with relatively high bootstrap support (99 % ML, 1.0 PP support). *Meliola mucunicola* is placed within the genus *Meliola* in the clade of *Meliolaceae* and closely related to *M. centellae* (55 % ML support). Five strains of *Meliola thailandicum* clustered in the clade of *Meliolaceae* within the genus *Meliola* and are sister to *M. variaseta* (84 % ML, 0.9 PP support). Four strains of *Meliola thailandicum* which were found on *Dimocarpus longan* (MFLU15-0377,

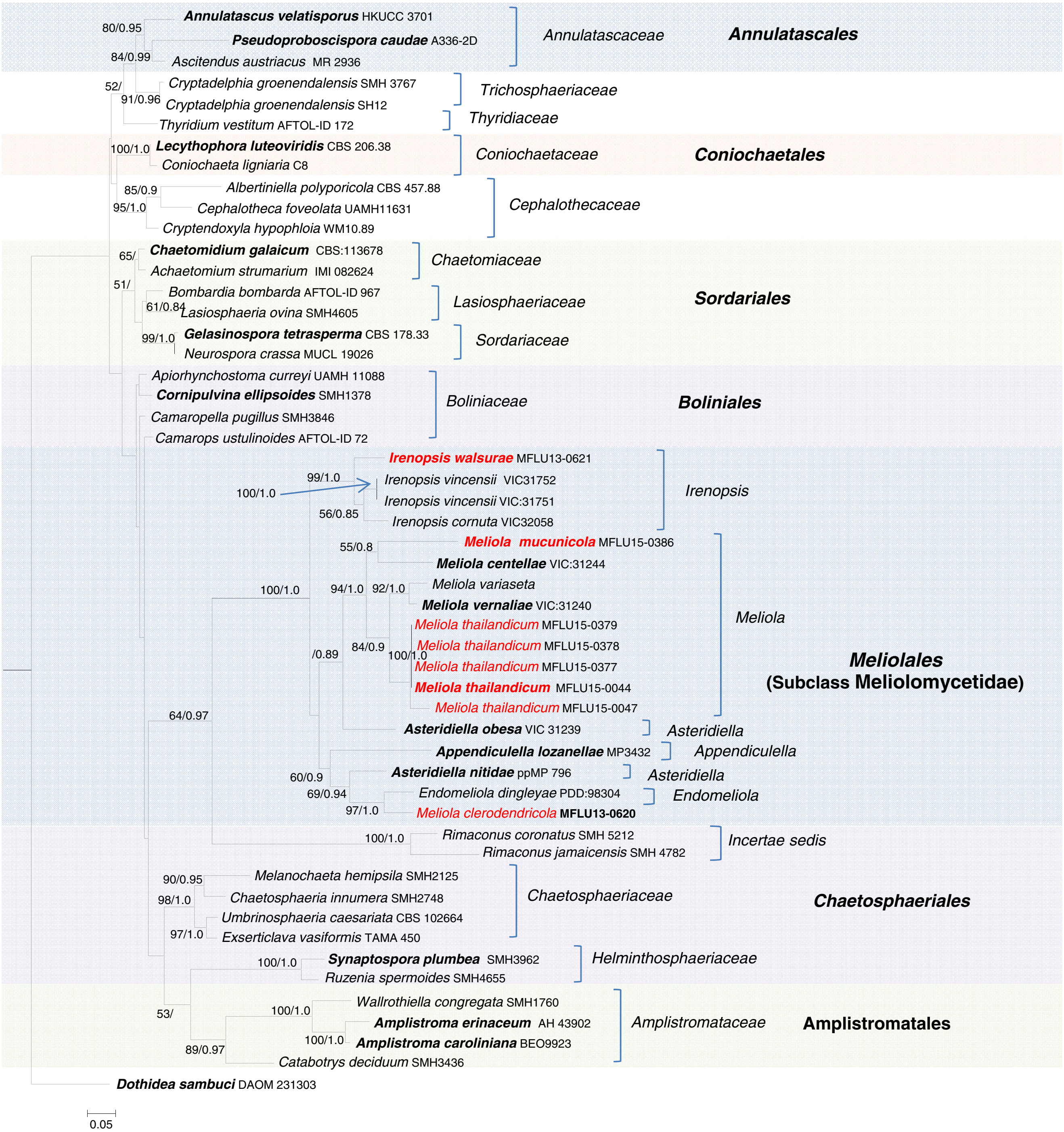


Fig. 4 RAxML maximum likelihood phylogenetic tree (LSU). The first set of numbers above the nodes are RAxML value expressed from 1000 repetitions with values above 50 % shown. The second set of numbers above the nodes are Bayesian posterior probabilities, with values above 0.8 shown. Strain numbers are indicated after species names. New sequence data are in red, types of the new species are in red bold, and other types are in black bold

MFLU15-0379, MFLU 15-0044, MFLU 15-0047) and one from *Acacia auriculiformis* (MFLU15-0378), are the same species in the LSU tree (100 % ML, 0.1 PP support), and in the ITS tree (100 % ML, 0.1 PP support). Polymorphic nucleotides from sequence data of the ITS show a few base pair differences between the four strains of *Meliola thailandicum* from *Dimocarpus longan* and one strain from *Acacia auriculiformis*, and are not significant to separate them (Table 2). Hence, we conclude that this species is not host-specific. *Appendiculella* was not closely related to *Asteridiella* contradicting the phylogenetic tree of Justavino et al. (2015), however, these authors noted that the two

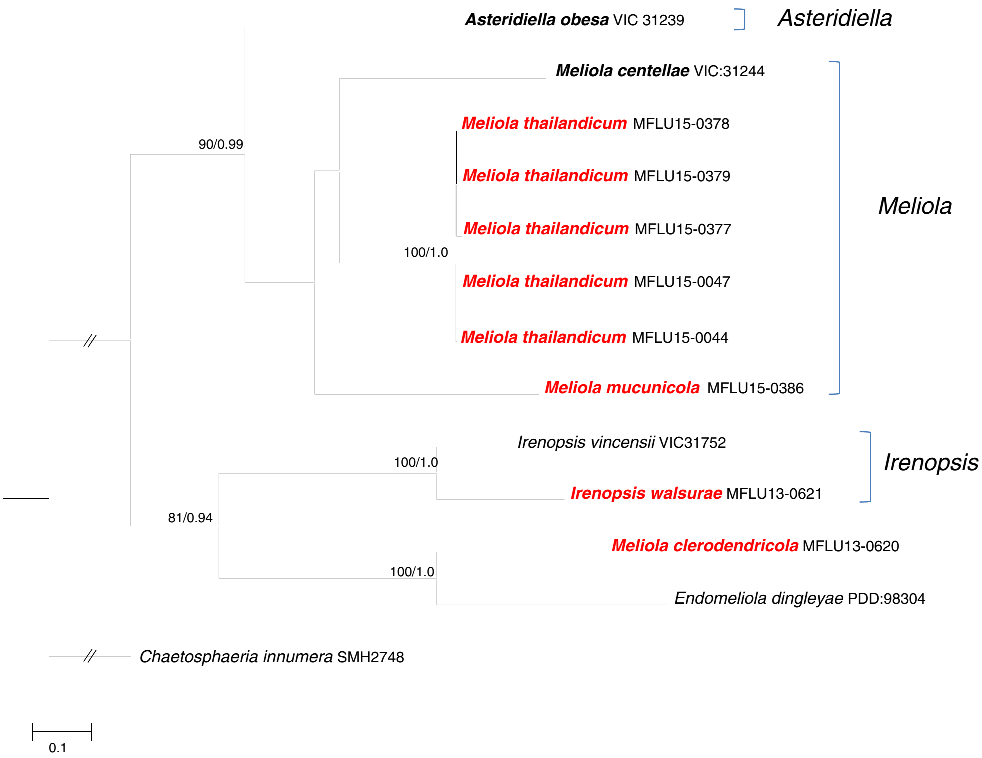


Fig. 5 RAxML maximum likelihood phylogenetic tree (ITS). The first set of numbers above the nodes are RAxML values expressed from 1000 repetitions with values above 50 % shown. The second set of numbers above the nodes are Bayesian posterior probabilities, with values above 0.8 shown. Strain numbers are indicated after species names. New sequence data of *Meliolaceae* are in red, types of the new species are in red bold, and other types are in black bold

species might be closely related as the conical appendages of *Appendiculella* could be homologous to the projecting conical cells on the ascoma wall in *Asteridiella*. Justavino et al. (2015), used LSU rDNA with 417 positions, and this may have resulted in a distinct separation of *Appendiculella* from *Asteridiella*. In the present study, the backbone tree used LSU sequence data with 635 positions and indicated that *Appendiculella lozanellae* is related to *Asteridiella nitidae* with 60 % ML and 0.9 PP support. *Asteridiella obese*, however, formed a distinct clade with *Meliola* species, and clustered in different subclades with *Asteridiella nitidae*, thus, more sequence data for *Appendiculella* and *Asteridiella* are needed to clarify their relationships. *Meliola clerodendricola* is sister to *Endomeliola dingleyae* (97 % ML, 1.0 PP support), however, these two stains are different in morphology. We suspect this may be wrong and needs to be verified in future, although host plants of *Endomeliola dingleyae* and *Meliola clerodendricola* belong to closely related orders in the euasterids (Jansen et al. 2007; Justavino et al. 2015). Some species have an uncertain placement, therefore, more gene and sequence data are needed to clarity the placement of the genera and species.

Table 2 Polymorphic nucleotides from sequence data of the ITS show a few base pair differences between the five strains of *Meliola thailandicum*. Polymorphisms unique to *Meliola thailandicum* are highlighted

Codes	Hosts	ITS											
		15	215	266	273	299	348	349	350	392	430	504	607
MFLU 15-0377	*Dimocarpus longan*	T	T	C	A	G	A	G	G	T	T	G	T
MFLU 15-0378	*Acacia auriculiformis*	G	G	C	A	G	A	G	G	T	T	G	T
MFLU 15-0379	*Dimocarpus longan*	G	G	C	A	G	A	G	G	T	T	G	T
MFLU 15-0044	*Dimocarpus longan*	G	G	C	A	G	A	G	G	T	T	G	A
MFLU 15-0047	*Dimocarpus longan*	G	G	C	A	G	A	G	G	T	T	G	A

Taxonomy

Key to genera of *Meliolales*

1. Hyphae with capitate hyphopodia, but without phialides	***Armatella*** (*Armatella*ceae)
1. Hyphae with capitate hyphopodia and phialides	2 (*Meliolaceae*)
2. Hyphae intercellular	***Endomeliola***
2. Hyphae superficial	3
3. Ascomata flattened	***Amazonia***
3. Ascomata globose to subglobose	4
4. Hyphae with dark brown to black setae	5
4. Hyphae without setae (setae may be present on ascomata)	6
5. Hyphal setae with bulbous tips, apical part curved, covering ascomata	***Cryptomeliola***
5. Hyphal setae simple, straight or sometimes slightly curved	***Meliola***
6. Ascomata with appendages or setae	7
6. Ascomata without appendages and setae, with raised conical cells on the ascoma wall	***Asteridiella***
7. Ascomata with larviform to cylindrical appendages	***Appendiculella***
7. Ascomata with long setae, mostly curved at the apex	***Irenopsis***

Armatellaceae Hosag., Sydowia 55(2): 165 (2003)

Facesoffunginumber: FoF00723

Epiphytes on the surface of leaves. *Superficial hyphae* dense, septate, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* capitate, alternate or opposite on hyphae, 2-celled, brown. **Sexual morph**: *Ascomata* superficial on the surface of hosts, globose to subglobose, flattened when immature, developing on hyphae, the surface verrucose, covered with tuberculate projections, ascomatal setae and appendages lacking. *Peridium* thick, comprising two strata, outer stratum amorphous and black, inner stratum thick, comprising reddish to brown, scleroparenchymatous cells of *textura angularis* to *globulosa. Hamathecium* with evanescent paraphyses. *Asci* 4–8-spored, unitunicate, subcylindrical to ovoid, or clavate, evanescent. *Ascospores* hyaline to brown, ellipsoidal to oblong, aseptate when immature, 1-septate at maturity, constricted at the septum, with rounded ends. **Asexual morph**: *Phialides* absent (Hansford 1946; Hosagoudar 2003b).

Notes: The family *Armatellaceae* differs from *Meliolaceae* by having aseptate to 1-septate, hyaline ascospores and a different peridial wall type. Phialides are lacking on the hyphae in *Armatellaceae*, but are found in *Meliolaceae*.

Type: ***Armatella*** Theiss. & Syd., Annls mycol. 13(3/4): 235 (1915)

= *Artallendea* Bat. & H. Maia, Atas Inst. Micol. Univ. Recife 1: 221 (1960)

Facesoffunginumber: FoF00722

Epiphytes on the surface of leaves. *Superficial hyphae* dense, septate, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* irregularly capitate, alternate or opposite on hyphae, 2-celled, brown. **Sexual morph**: *Ascomata* superficial on the surface of hosts, globose to subglobose, flattened when immature, developing on hyphae, surface verrucose, covered with tuberculate projections, ascomatal setae and appendages lacking. *Peridium* thick, comprising two strata, outer stratum amorphous and black, inner stratum thick, comprising reddish to brown, scleroparenchymatous cells of *textura angularis* to *globulosa. Hamathecium* with evanescent paraphyses. *Asci* 4–8-spored, unitunicate, subcylindrical to ovoid, or clavate, evanescent. *Ascospores* hyaline to brown, ellipsoidal to oblong, aseptate when immature, 1-septate at maturity, constricted at the septum, with rounded ends. **Asexual morph**: *Phialides* absent (Hansford 1946; Hosagoudar 2003b).

Notes: There is no sequence data for any species of this genus. Direct sequencing from fresh specimens is needed to clarify the phylogenetic placement.

Type species: ***Armatella litseae*** (Henn.) Theiss. & Syd., Annls mycol. 13(3/4): 235 (1915)

Facesoffunginumber: FoF00721

Epiphytes on the surface of leaves. *Superficial hyphae* 5–7 μm diam., ($\bar{x} = 7\ \mu m$, n=10), dense, branched, septate, brown to reddish, with hyphopodia, hyphal setae lacking. *Hyphopodia* 15–17 μm diam. ($\bar{x} = 16\ \mu m$, n=10), single stellate to sublobate on stalk cells, alternate on hyphae, 2-celled, brown to reddish. **Sexual morph**: *Ascomata* 210–235×174–192 μm ($\bar{x} = 226 \times 180\ \mu m$, n=10), superficial on surface of hosts, scattered, initially flattened, and becoming globose to subglobose, flattened when immature, developing on hyphae, surface verrucose, covered with tuberculate projections, ascomatal setae and appendages lacking. *Peridium* 43–59 *um*, thick, comprising two strata, outer stratum amorphous and black, inner stratum 29–37 *um*, thick, comprising reddish to brown, scleroparenchymatous cells of *textura angularis* to *globulosa. Hamathecium* with evanescent paraphyses. *Asci* 51–61×26–29 μm ($\bar{x} = 54 \times 27\ \mu m$, n=10), 4–8-spored, unitunicate, ovoid to clavate. *Ascospores* 33–35×10–11 μm ($\bar{x} = 34 \times 10\ \mu m$, n=10), 2–3-seriate, hyaline to light brown, ellipsoidal to oblong, aseptate when immature, 1-septate at maturity, constricted at the septum, rounded ends. **Asexual morph**: Undetermined.

Material examined JAPAN, Province Awa, Tokushima, Kigasumi, on *Litsea glauca* (Thunb.) Siebold (*Lauraceae*), 25 December 1897, S. Kusano (SF70331, **holotype**).

Notes: We re-examined the type specimen of *Armatella litseae*, and accept this as a separate family from *Meliolaceae* characterized by aggregated colonies on the surface of host, stellate hyphopodia, and ascomata covered with tuberculate projections which are amorphous and black in section, and a thick inner stratum, comprising reddish to brown scleroparenchymatous cells of *textura angularis* to *globulosa*, aseptate to 1-septate ascospores, and lacking phialides. However, the phylogenetic placement needs clarification (Fig. 6).

Meliolaceae W. Martin ex Hansf., Mycol. Pap. 15: 23 (1946)

Facesoffunginumber: FoF00741

Epiphytes or *pathogens* on leaves, occasionally on stems or branches, often forming web-like colonies. *Superficial hyphae* branched, septate, brown to dark brown, hyphal setae present or lacking, with hyphopodia. *Hyphal setae* developing from hyphae in *Cryptomeliola* and *Meliola*, septate, branched or unbranched at apex, or with bulbous apices or apical part in *Cryptomeliola*, brown to dark brown. *Hyphopodia* capitate on hyphae, variously shaped. **Sexual morph**: *Ascomata* superficial on surface of black, web-like colonies on host, mostly globose to subglobose, or flattened in the genus *Amazonia. Peridium* comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum of brown to dark brown cells, or with raised conoid cells, appendages or setae, inner stratum of hyaline to pale brown cells. *Hamathecium* with evanescent paraphyses. *Asci* 2–4-

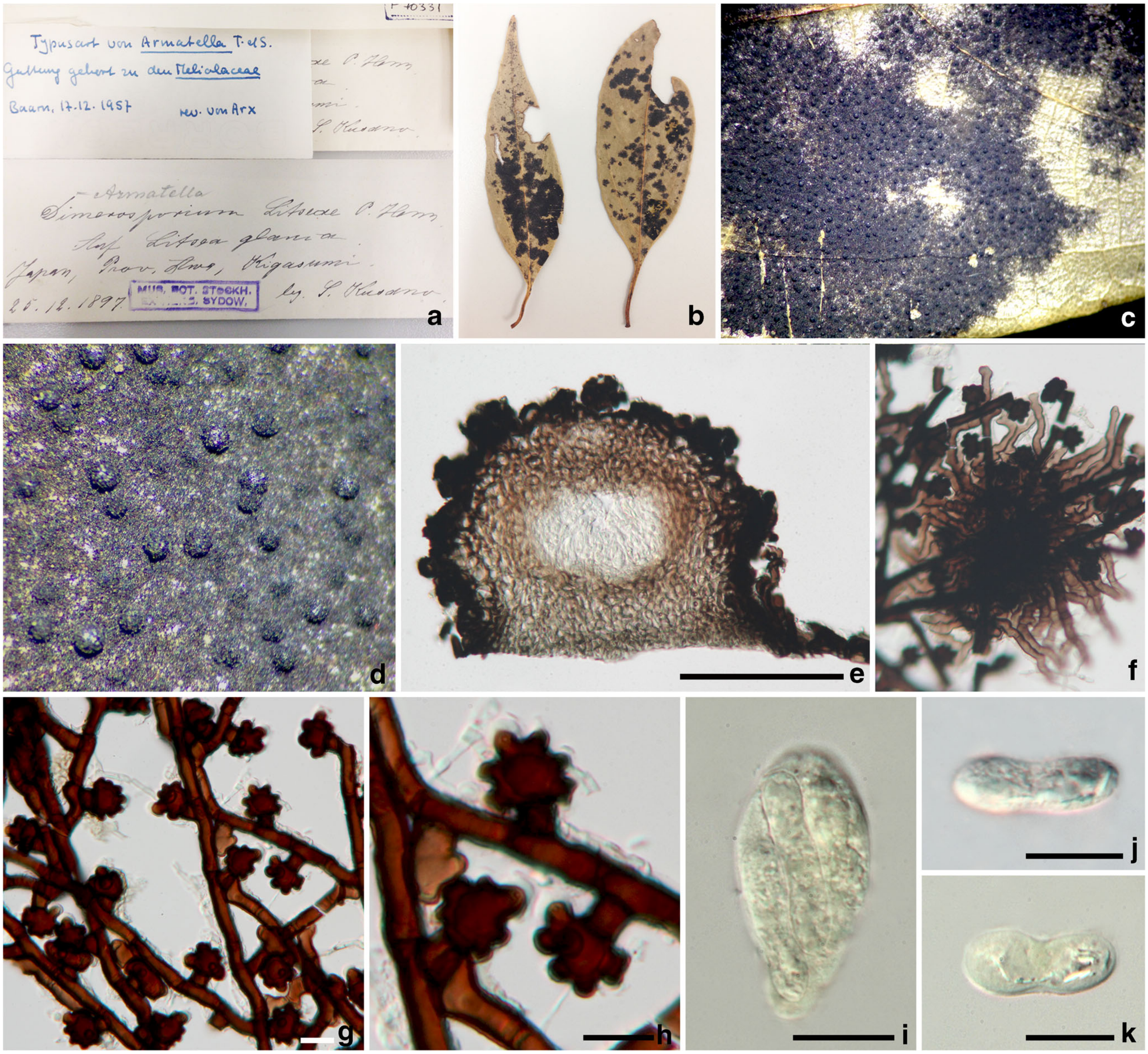


Fig. 6 *Armatella litseae* (holotype). **a** Herbarium packet. **b–d** Colonies on leaves. **e** Section through ascoma. **f** Upper cell walls of ascomata when viewed in squash mounts. **g**, **h** Hyphopodia on hyphae. **i** Immature ascus in Melzers' reagent. **j**, **k** Mature 1-septate ascospores in Melzer's reagent. Scale bars: **e**=100 μm, **i–k**=20 μm, **g**, **h**=10 μm

spored, unitunicate, subglobose to broadly clavate, lacking an opening mechanism. *Ascospores* 2–3-seriate, hyaline when immature, brown to dark brown at maturity, ellipsoid or cylindrical to ovoid, 3–4-septate. **Asexual morph**: *Phialides*, ampuliform or flask-shaped on hyphae. *Conidiogenous* cells formed directly from vegetative hyphae. *Conidia* unicellular, small and hyaline (from Cannon and Kirk 2007).

Type species: ***Meliola*** Fr., Syst. orb. veg. (Lundae) 1: 111 (1825)

Notes: Phylogenetic analyses place *Meliolaceae* species in the class *Sordariomycetes*, and they were therefore accommodated in a new subclass *Meliolomycetidae* (Liu et al. 2015; Justavino et al. 2015; Maharachchikumbura et al. 2015). In our phylogenies (Fig. 4), the subclass *Meliolomycetidae* is clearly supported.

Genera included in *Meliolaceae* are *Amazonia*, *Appendiculella*, *Asteridiella*, *Cryptomeliola*, *Endomeliola*, *Irenopsis* and *Meliola*. These genera are characterized by superficial hyphae with hyphopodia or intracellular hyphae with hyphopodia in *Endomeliola*, and forming lateral haustoria that may penetrate the epidermis or mesophyll cells. Hyphal setae are found in *Cryptomeliola* and *Meliola*. Ascomata are globose to subglobose except in *Amazonia* where they are flattened. Ascomatal setae are found in *Irenopsis* and ascomatal appendages are found in *Appendiculella*. Asci are unitunicate and ascospores brown to dark brown at maturity with 3–4 septa. *Basavamyces* was transferred to *Armatellaceae* based on having superficial hyphae without phialides, cylindrical to subcylindrical asci and 1–2-septa ascospores (Hosagoudar et al. 2012), but we treat the genus in *Sordariomycetes* genera, *incertae sedis* base on its morphology. *Ceratospermopsis*, *Ectendomeliola*, *Hypasteridium*, *Leptascospora*, *Metasteridium*, *Ophiociliomyces*, *Ophioirenina*, *Ophiomeliola*, *Prataprajella*, *Parasteridium*, *Pauahia*, *Pleomeliola*, *Pleomerium*, *Ticomyces*, *Urupe* and *Xenostigme* are excluded from *Meliolaceae*. This is based on morphology or because taxa are doubtful due to lack of good type specimens. *Hypasteridium*, *Metasteridium* and *Parasteridium* were introduced without species name and their application is uncertain (Eriksson and Hawksworth 1988). *Laeviomeliola* is synonymized under *Meliola* based on morphology.

Amazonia Theiss., Annls mycol. 11(6): 499 (1913)

Facesoffunginumber: FoF00718

Epiphytes on the surface of leaves. *Superficial hyphae* branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* capitate, alternate on hyphae, near to hyphal septa, 2-celled, brown to dark brown. **Sexual morph**: *Ascomata* superficial on surface of host, mostly gregarious, rarely solitary, circular, flattened, borne under radiating hyphae, branching at the rim, producing lateral hyphopodia, ascomatal setae and appendages absent. *Peridium* arranged radially when viewed in squash mounts, poorly developed at the base, with three strata, outer stratum comprising a dark brown to black amorphous layer, central stratum comprising flattened, thick-walled, brown cells of *textura angularis* and inner stratum of hyaline to reddish brown flattened cells. *Hamathecium* with evanescent paraphyses. *Asci* 2-spored, unitunicate, ellipsoid to obovoid, lacking an opening mechanism, short pedicellate or apedicellate, evanescent. *Ascospores* 2-seriate, hyaline to brown, ellipsoid to subcylindrical, 4-septate, constricted and darker at the septa, smooth-walled. **Asexual morph**: *Phialides* ampuliform, sometimes curved, alternate or opposite on hyphae, mixed with capitate hyphopodia, pale brown to brown. *Phialoconidia* rarely observed, hyaline.

Notes: The genus *Amazonia* was introduced by Theissen (1913), with the type species *Amazonia psychotriae* (Henn.) Theiss. *Amazonia* is typical of other members of *Meliolaceae* based on its unitunicate asci, and brown to dark brown, 4-septate ascospores. Höhnel (1918) noted this genus as transitional between *Meliola* and *Microthyriaceae* based on its flattened ascomata typical of species in *Microthyriaceae* (Wu et al. 2011), while asci and ascospores are typical of species in *Meliolaceae*. Molecular analyses place *Meliolaceae* in the class *Sordariomycetes*, while the family *Microthyriaceae* is placed in *Dothideomycetes* (Hyde et al. 2013; Maharachchikumbura et al. 2015).

Type species: ***Amazonia psychotriae*** (Henn.) Theiss., Annls mycol. 11(6): 499 (1913)

≡ *Meliola asterinoides* var. *psychotriae* Henn., Hedwigia 43: 361 (1904)

≡ *Amazonia psychotriae* (Henn.) Theiss., Annls mycol. 11(6): 499 (1913) var. *psychotriae*

= *Amazonia psychotriae* var. *major* Hansf., Reinwardtia 3: 102 (1954)

Facesoffunginumber: FoF00716

Epiphytes on the surface of leaves. *Superficial hyphae* 4–5 μm diam., branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* 10–11 μm diam. ($\bar{x}$ = 10 μm, *n*=10), capitate, alternate on hyphae, near to hyphal septa, 2-celled, brown to dark brown. **Sexual morph**: *Ascomata* 440–495 μm diam. ($\bar{x}$ = 455 μm, *n*=5), superficial on surface of host, mostly gregarious, rarely solitary, circular, flattened, borne under radiating hyphae, branching at the rim, producing lateral hyphopodia, ascomatal setae and appendages absent. *Peridium* 20–26 μm thick, arranged radially when viewed in squash mounts, poorly developed at the base, with three strata, outer stratum comprising a dark brown to black amorphous layer, central stratum comprising flattened, thick-walled, brown cells of *textura angularis* and inner stratum of hyaline to reddish brown flattened cells. *Hamathecium* with evanescent paraphyses. *Asci*

45–50×23–28 μm ($\bar{x} = 47 \times 26\ \mu m$, n=10), 2-spored, unitunicate, ellipsoid to obovoid, lacking an opening mechanism, short pedicellate or apedicellate, evanescent. *Ascospores* 37–40×15–20 μm ($\bar{x} = 39 \times 19\ \mu m$, n=10), 2-seriate, hyaline to brown, ellipsoid to subcylindrical, 4-septate, constricted and darker at the septa, smooth-walled, with an evanescent sheath. **Asexual morph**: *Phialides* 7–8 μm ($\bar{x} = 8\ \mu m$, n=5), ampuliform, sometimes curved, alternate or opposite on hyphae, mixed with capitate hyphopodia, sometimes occurring on separate hyphae, pale brown to brown. *Phialoconidia* rarely observed, hyaline.

Material examined BRAZIL, Amazonas, Rio Negro, Manaus, on leaves of *Phychotria* sp. (*Rubiaceae*), March 1901, E. Ule No. 3152 (B700014752, **syntype**); BRAZIL, Amazonas, Rio Negro, Manaus, on leave of *Phychotria* sp. (*Rubiaceae*), 1901, E. Ule (B70001475).

Notes: *Amazonia* was introduced based on its flattened ascomata, with the type species as *A. psychotriae. Meliola asterinoides* var. *psychotriae* Henn. is a synonym of *A. psychotriae* Theissen (1913). We examined and illustrated the syntype of *A. psychotriae* from B (Figs. 7 and 8). Molecular data is lacking for this genus.

Appendiculella Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 128: 556 (1919)

Possibly synonyms (from Index Fungorum 2015):

≡ *Irenina* F. Stevens, Annls mycol. 25(5/6): 411 (1927)

≡ *Meliola* subgen. *Irenina* (F. Stevens) Cif., Annls mycol. 36(2/3): 203 (1938)

Facesoffunginumber: FoF00720

Epiphytes on the surface of leaves or stems. *Superficial hyphae* branched, septate, darker at the septa, with hyphopodia, hyphal setae lacking. *Hyphopodia* capitate, angular or lobate, alternate or opposite on hyphae, 2-celled, brown. **Sexual morph**: *Ascomata* superficial on surface of host, mostly gregarious on superficial hyphae, subglobose to globose, thick-walled, lacking ascomatal setae, but with raised conoid cells, which may extend to form larviform to cylindrical appendages. *Peridium* comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum of brown to dark brown cells of *textura angularis*, inner stratum of hyaline to pale brown flattened cells. *Hamathecium* with evanescent paraphyses. *Asci* 2–4-spored, unitunicate, oblong to obovoid, lacking an opening mechanism, short pedicellate or apedicellate, evanescent at maturity. *Ascospores* 2–3-seriate, hyaline to brown, fusiform to ellipsoid, 3–4-septate, slightly constricted and darker at the septa, smooth-walled. **Asexual morph**: *Phialides* ampuliform, alternate or opposite, mixed with capitate hyphopodia on hyphae, sometimes curved, brown. *Phialoconidia* not seen (Justavino and Piepenbring 2007).

Notes: The genus *Appendiculella* was introduced by Höhnel (1919) with the type species *A. calostroma* (Desm.) Höhn. and is characterized by conical appendages with transversely striate walls developing on the surface of the ascomata. This feature is similar to the conical ascomatal cells of *Asteridiella* (Justavino et al. 2015). *Appendiculella* species are distributed widely in the tropics (Kirk et al. 2008), with an 87 species epithets listed in Index Fungorum (2015). Most species were described based on host association. Justavino et al. (2015) provided the first sequence data for *Appendiculella lozanellae* (DQ508302), which grouped in the *Meliolaceae* clade in their phylogenetic tree. However, this relationship was weakly supported in the phylogenetic tree of Justavino et al. (2015). In this study, the phylogenies indicate a close relationship between *Appendiculella lozanellae* and *Asteridiella nitidae* (60 % ML support). However, the morphology of these two genera differs, and therefore we maintain these genera as distinct.

Type species: ***Appendiculella calostroma*** (Desm.) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 128: 556 (1919)

≡ *Sphaeria calostroma* Desm., Bull. Soc. bot. Fr. 4: 22 (1857)

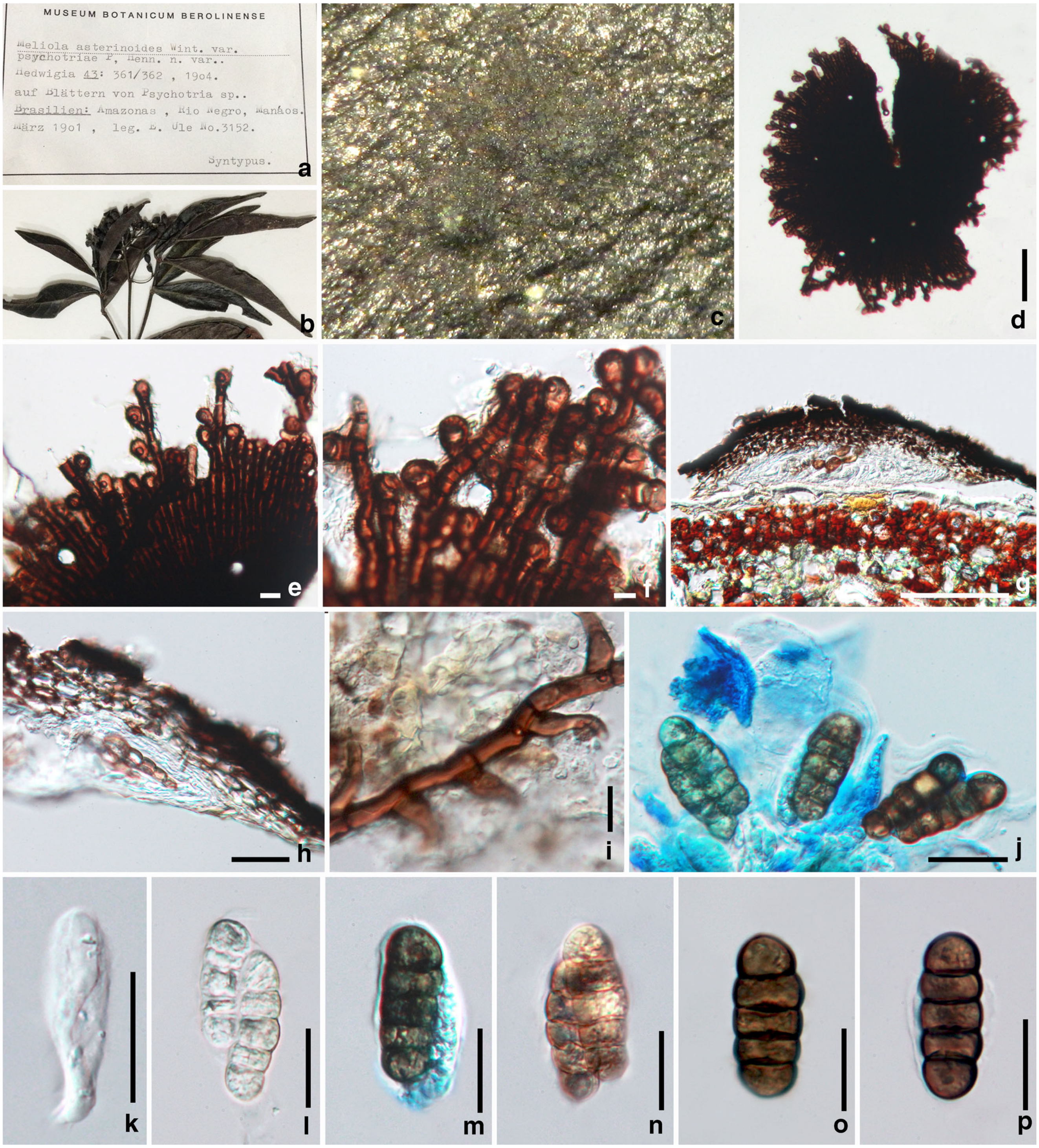
= *Chaetosphaeria calostroma* (Desm.) Sacc., Syll. fung. (Abellini) 2: 95 (1883)

= *Meliola calostroma* (Desm.) Höhn., Annls mycol. 15(5): 363 (1917)

Facesoffunginumber: FoF00719

Epiphytes on the surface of leaves. *Superficial hyphae* 5–6 μm diam. ($\bar{x} = 5\ \mu m$, n=10), branched, septate, darker at the septa, with hyphopodia, hyphal setae lacking. *Hyphopodia* 13–15 μm diam. ($\bar{x} = 14\ \mu m$, n=10), capitate, angular or lobate, alternate or opposite on hyphae, 2-celled, brown. **Sexual morph**: *Ascomata* 125–140 high×140–150 μm diam. ($\bar{x} = 125 \times 149\ \mu m$, n=5), superficial on surface of host, mostly gregarious on superficial hyphae, subglobose to globose, thick-walled, lacking ascomatal setae, but with raised conoid cells, which may extend to form larviform to cylindrical appendages. *Peridium* 28–34 μm ($\bar{x} = 30 \mu m$, n=5), comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum of brown to dark brown cells of *textura angularis*, inner stratum of hyaline to pale brown flattened cells. *Hamathecium* with evanescent paraphyses. *Asci* 42–57×24–33 μm ($\bar{x} = 45 \times 28 \mu m$, n=10), 2–4-spored, unitunicate, oblong to obovoid, lacking an opening mechanism, with short pedicellate or apedicellate, evanescent. *Ascospores* 35–37×12–13 μm ($\bar{x} = 36 \times 12\ \mu m$, n=10), 2–3-seriate, hyaline to brown, fusiform to ellipsoid, 3-septate, slightly constricted and darker at the septa, smooth-walled. **Asexual morph**: Undetermined.

Material examined CHILE, Bío-Bío, Concepción, on surface of leaves of *Geum chilense* Balb. (*Rosaceae*), 5 June 1895, F.W. Neger (SF5748).



MUSEUM BOTANICUM BEROLINENSE

Meliola asterinoides Wint. var.
psychotriae P, Henn. n. var..
Hedwigia 43: 361/362 , 1904.
auf Blättern von Psychotria sp..
Brasilien: Amazonas , Rio Negro, Manáos.
März 1901 , leg. E. Ule No.3152.

Syntypus.

Fig. 7 *Amazonia psychotriae* (syntype). **a**, **b** Herbarium packet and specimens. **c** Colony on substrate. **d** Ascoma viewed in squash mount. **e**, **f** Hyphopodia at rim of ascoma. **g** Section through ascoma. **h** Peridium. **i** Phialides. **j** Ascus in cotton blue reagent. **k**, **l** Immature asci. **m**, **n** Mature asci. **o**, **p** Ascospores with 4 septa. Note the thin sheath in p. Scale bars: **d**, **g**=100 μm, **e**, **f**, **i**=10 μm, **h**, **j**, **l**–**p**=20 μm, **k**=50 μm

Notes: *Appendiculella calostroma* was established by Höhnel (1919) and infects plant species in *Rosaceae* (Hansford 1961; Justavino et al 2015) (Figs. 9 and 10).

Asteridiella McAlpine, Proc. Linn. Soc. N.S.W. 22(1): 38 (1897)

Possible synonymy (from Index Fungorum 2015):

= *Irene* Theiss et al., Annls mycol. 15(3/4): 194 (1917)

= *Meliola* subgen. *Irene* (Theiss et al.) Cif., Annls mycol. 36(2/3): 203 (1938)

Fig. 8 *Amazonia psychotriae* (B70001475). **a**, **b** Herbarium packet and specimen. **c** Colony on substrate. **d** Ascoma borne under radiating hyphae viewed in squash mounts. **e** Wall comprising radiating cells. **f** Hyphae with capitate hyphopodia. **g** Hyphopodia at rim of ascoma. **h**, **i** Immature asci. **j** Mature ascus. **k**–**m** Mature ascospores. Scale bars: **d**=100 *µm*, **e**=50 *µm*, **f**, **g**=10 *µm*, **h**–**m**=20 *µm*

= *Parasteridiella* H. Maia, Publicações Inst. Micol. Recife 267: 25 (1960)

Facesoffunginumber: FoF00724

Epiphytes on the surface of leaves and stems. *Superficial hyphae* branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* capitate, alternate or opposite on hyphae, near to hyphal septa, 2-celled, brown. **Sexual morph**: *Ascomata* superficial on surface of host, mostly gregarious, rarely solitary on superficial hyphae, subglobose to globose, thick-walled, ascomatal setae and appendages absent. *Peridium* comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum of dark brown cells of *textura angularis*, with raised conical cells, acute or rounded at the apex, and inner stratum of hyaline cells of *textura porrecta*. *Hamathecium* with evanescent paraphyses. *Asci* 2–4-spored, unitunicate, oblong to cylindrical. *Ascospores* 2–4-seriate, hyaline to brown, subcylindrical to oblong, 4-septate, slightly constricted and darker at the septa, not constricted in some species, smooth-walled (description modified from Hansford 1961, 1963; Mibey and Hawksworth 1997 and own observations). **Asexual morph**: *Phialides* rarely observed on hyphae, ampuliform, alternate or opposite, sometimes curved, pale brown to brown. *Conidia* hyaline (Hansford 1961; Hosagoudar 2013).

Notes: *Asteridiella* was introduced by McAlpine (1897) and differs from *Meliola* species in lacking hyphal setae. Most of the genera in *Meliolaceae* have been separated previously by setae and appendages. These characters seem hardly sufficient to separate *Asteridiella* from other genera, molecular data however, show *Asteridiella* as a distinct clade in *Meliolaceae*, sister to *Appendiculella. Asteridiella* may well

Fig. 9 *Appendiculella calostroma* (S-F5748). **a**, **b** Herbarium packet and specimen. **c** Ascomata on surface of leaves. **d** Transverse section through ascoma. **e** Ascoma viewed in squash mount. **f** Peridium comprising cells of *textura angularis*. **g** Conical appendage on ascomata. **h** Hyphae with hyphopodia. **i** Immature ascus in Melzer's reagent. **j** Mature ascus. **k**, **l** Mature ascospores with 3 septa. Scale bars: **d**, **e**=50 *μm*, **f**, **g**, **i**–**l**=20 *μm*, **h**=10 *μm*

be a distinct genus in having conical cells raised from the ascomata and in lacking ascomatal setae or appendages (Justavino et al. 2015). Species in *Asteridiella* are differentiated based on host as they are thought to be host-specific (Hansford 1961; Hosagoudar 2013). Less significant differences can be seen in the size of ascomata, hyphopodia shape and arrangement, however this needs testing at the molecular level (Hansford 1961; Hosagoudar 2013). *Asteridiella* species are commonly found in the tropics (Mibey and Hawksworth 1997; Kirk et al. 2008), with around 300 species estimated in Kirk et al. (2008), and almost 450 species epithets listed in Index Fungorum (2015). Molecular evidence placed *Asteridiella nitidae* Rodr. Just. (EF094839) and *A. obesa* (Speg.) Hansf. (DQ508302) in *Meliolaceae* as a distinct clade, however, the two species clustered in different subclades (Justavino et al. 2015). Therefore, molecular data is needed to clarify the distinctiveness of this and other genera.

Type species: ***Asteridiella solani*** McAlpine, Proc. Linn. Soc. N.S.W. 22(1): 38 (1897)

= *Asteridiella solani* var. *kodaikanalensis* Hosagoudar et al., in Nithyatharani et al., Scientific Transactions in Environment and Technovation 4(4): 165 (2011)

Facesoffunginumber: FoF00725

Epiphytes on the surface of leaves and stems. *Superficial hyphae* branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* 10–14 *μm*

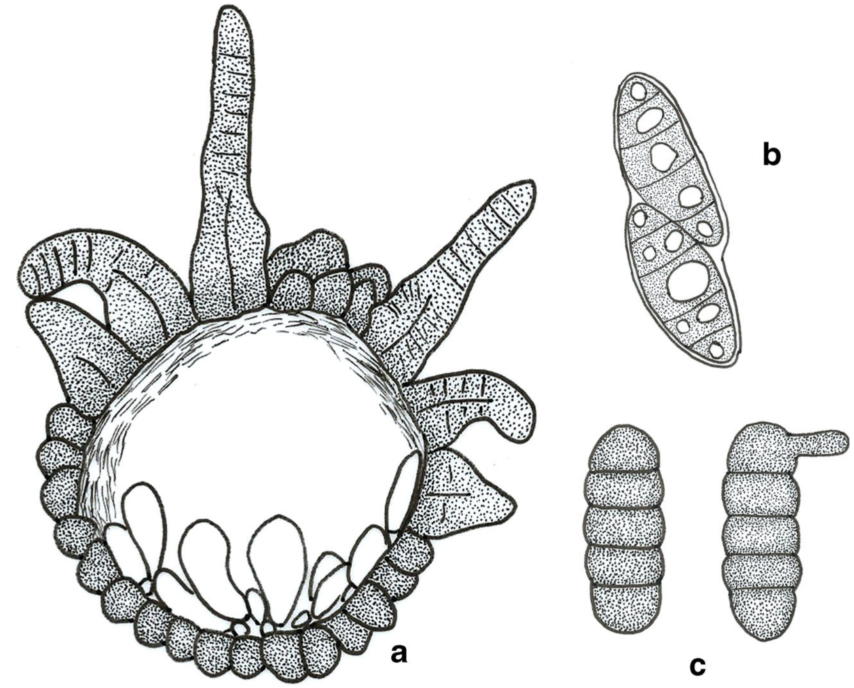


Fig. 10 *Appendiculella lozanellae* (redrawn from Justavino and Piepenbring 2007). **a** Transverse section through ascoma showing appendages on ascoma. **b** Ascus. **c** Ascospores with 4 septa

diam. ($\bar{x} = 13\ \mu m$, n=10), capitate, alternate or opposite on hyphae, near to hyphal septa, 2-celled, brown. **Sexual morph**: *Ascomata* 120–207 μm diam. ($\bar{x} = 198\ \mu m$, n=3), superficial on surface of host, mostly gregarious, rarely solitary on superficial hyphae, subglobose to globose, thick-walled, ascomatal setae and appendages absent. *Peridium* 35–46 μm thick, comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum of dark brown cells of *textura angularis*, with raised conical cells 35–70 μm long, acute or rounded at the apex, and inner stratum of hyaline cells of *textura porrecta. Hamathecium* with evanescent paraphyses. *Asci* 45–50×21–26 μm ($\bar{x} = 46\ \times\ 23\ \mu m$, n=3), 2–4-spored, unitunicate, oblong to cylindrical. *Ascospores* 37–42×15–19 μm ($\bar{x} = 38\ \times\ 18\ \mu m$, n=3), 2–4-seriate, hyaline to brown, oblong, 4-septate, slightly constricted and darker at the septa, sometimes not constricted, smooth-walled. **Asexual morph**: *Phialides* rarely observed on hyphae, ampuliform, alternate or opposite, sometimes curved, pale brown to brown. *Conidia* not seen (Hansford 1961; Hosagoudar 2013).

Material examined AUSTRALIA, on *Solanum viride* G. Forst. ex Spreng. (*Solanaceae*), 1896, V.H. Maiden (IMI 73840, glass slide from **ex-holotype**); PHILIPPINES, Benguet Province, Luzon, Mt. Santo Tomas, on leaf of *Solanum inaequilaterale* Merrill (*Solanaceae*), February 1925, Mary Strong Clemens 6410 (BPI 697764)

Notes: Part of the holotype specimen of this species is preserved as a glass slide at K (as IMI 73840), but we could not observe many characters (Fig. 11). However, a specimen (BPI 697764), and a redrawing of *Asteridiella solani* var. *kodaikanalensis* Hosag. et al. published by Hosagoudar (2013), and a redrawing from Hansford (1963) are provided here (Figs. 12, 13 and 14). Molecular data is lacking for *A. solani*.

Cryptomeliola S. Hughes & Piroz., Mycol. Pap. 174: 14 (1997)

Facesoffunginumber: FoF00727

Epiphytes on the surface of leaves, twigs, or petioles. *Superficial hyphae* branched, brown or dark-brown, with or without hyphopodia, hyphal setae present. *Hyphopodia* capitate, alternate or opposite on hyphae, near to hyphal septa, 2-celled, brown. *Hyphal setae* arising from hyphae, dense, septate, dark brown, curved, rounded or hooked at the apex. **Sexual morph**: *Ascomata* superficial on surface of host, solitary or gregarious, sometimes hidden amongst setae, subglobose to globose, carbonaceous, verrucose, ascomatal setae and appendages absent. *Peridium* comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum with dark brown to reddish cells of *textura globulosa* to *angularis*, and inner stratum with hyaline, flattened cells. *Hamathecium* with evanescent paraphyses. *Asci* 2–4-spored, unitunicate, ellipsoid to oval, evanescent. *Ascospores* 2-seriate, hyaline when immature and brown to dark brown at maturity, cylindrical to oblong, 4-septate, constricted and dark at septa, smooth-walled. **Asexual morph**: *Phialides* rarely seen, ampliform, interspersed between hyphal setae on hyphae (Mibey and Hawksworth 1997). *Conidia* unicellular, hyaline.

Notes: *Cryptomeliola* was raised to genus by Hughes & Pirozynski in Mibey and Hawksworth (1997). The genus

Fig. 11 *Asteridiella solani* (holotype). **a**, **b** Herbarium packet and extype slide. **c** Ascomata viewed in squash mount. **d** Hyphae with capitate hyphopodia. **e** Immature ascomata viewed in squash mount. **f–g** Ascospores with 4 septa. Scale bars: **c**=100 μm, **e**=50 μm, **f**, **g** =20 μm, **d**=5 μm

contains three species (Index Fungorum 2015). There is no sequence data for any species in *Cryptomeliola*.

Type species: ***Cryptomeliola orbicularis*** (Berk. & M.A. Curtis) S. Hughes & Piroz., in Mibey & Hawksworth, Mycol. Pap. 174: 15 (1997)

= *Meliola orbicularis* Berk. & M.A. Curtis, in Berkeley, J. Linn. Soc., Bot. 10(no. 46): 392 (1868) [1869]

= *Englerulaster orbicularis* (Berk. & M.A. Curtis) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 454 [62 repr.] (1910)

= *Meliolina orbicularis* (Berk. & M.A. Curtis) F. Stevens, Annls mycol. 25(5/6): 417 (1927)

Facesoffunginumber: FoF00726

Epiphytes on the surface of host. *Superficial hyphae* branched, brown or dark brown, with or without hyphopodia, hyphal setae present. *Hyphopodia* not seen. *Hyphal setae* 92–320 long×4–5 μm wide ($\bar{x} = 265 \times 5$, n=10), dense, septate, dark brown, curved and rounded, or hooked at the apex. **Sexual morph**: *Ascomata* 280–295 μm diam. ($\bar{x} = 288\ \mu m$, n=5), superficial on upper surface of host, solitary or gregarious, hidden amongst hyphae, subglobose to globose, carbonaceous, verrucose, ascomatal setae and appendages absent. *Peridium* 51–65 μm ($\bar{x} = 56 \mu m$, n=5), comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum with thick-walled, dark brown to reddish cells of *textura globulosa* to *angularis*, and inner stratum with hyaline, flattened cells. *Hamathecium* with evanescent paraphyses. *Asci* 60–71×37–49 μm ($\bar{x} = 67$–$43 \mu m$, n=10), 2−4-spored, unitunicate, ellipsoid to oval, evanescent. *Ascospores* 57–63×17–20 μm ($\bar{x} = 58 \times 19\ \mu m$, n=10), 2-seriate, hyaline when immature and brown to dark brown at maturity, cylindrical to oblong, 4-septate, constricted and dark at the septa, rounded ends, smooth-walled. **Asexual morph**: Undetermined.

Notes: *Cryptomeliola orbicularis*, the type species of *Cryptomeliola*, was introduced based on *Meliola orbicularis* Berk. & Curtis (Mibey and Hawksworth 1997). *Cryptomeliola orbicularis* differs from *Meliola* species as the hyphae are immersed in the outer layers of host tissue or sometimes superficial, and hyphal setae are crowded, curly, and apically rounded. We re-examined the holotype specimen and could not find ascomatal setae, although the original description illustrated the species with ascomatal setae (Fig. 15). However, other species in the genus *Cryptomeliola* do not have an

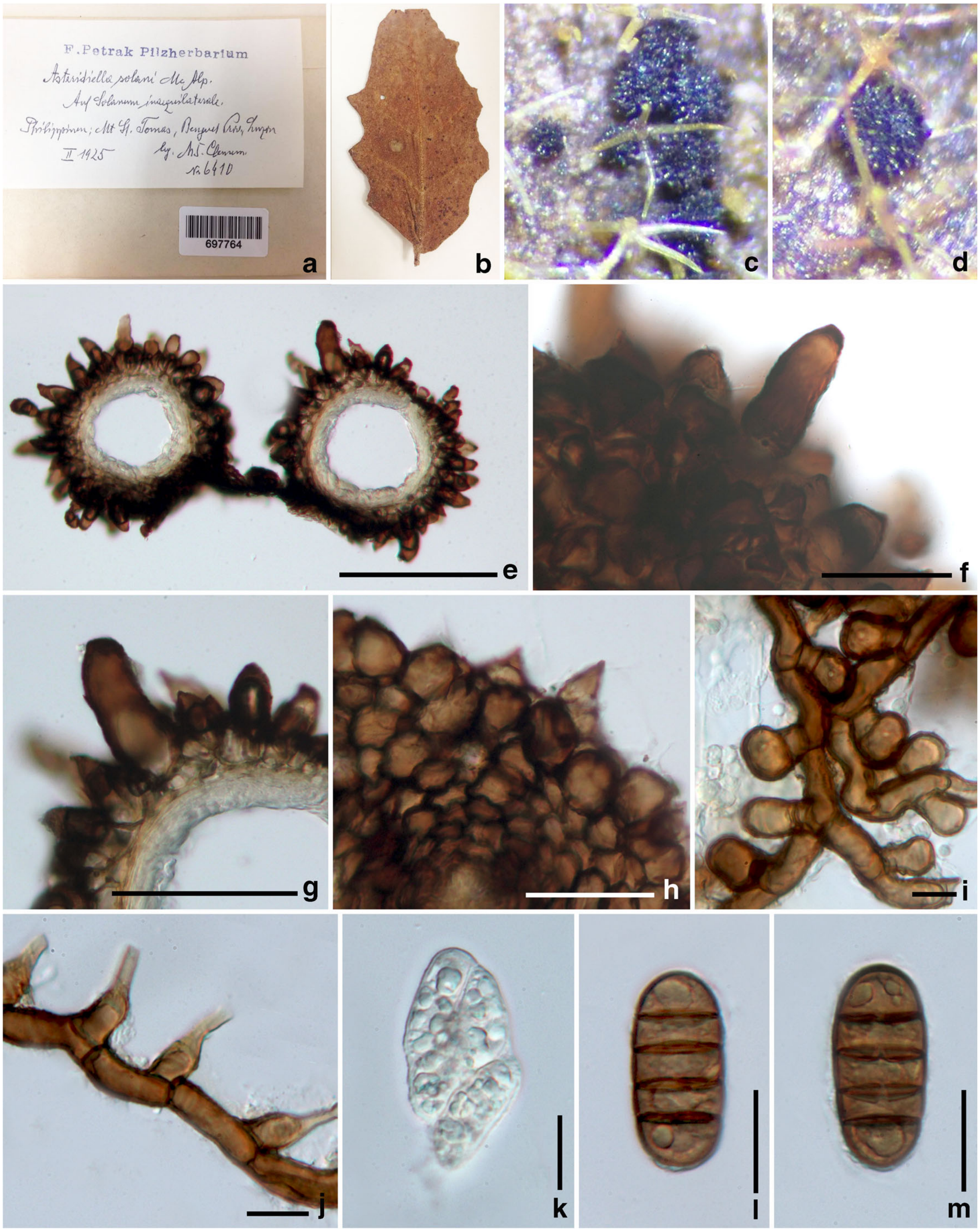


Fig. 12 *Asteridiella solani* (BPI 697764). **a**, **b** Herbarium packet and specimen. **c**, **d** Ascomata on host surface. **e** Section through ascomata. **f**, **g** Raised conical projections on ascomata. **h** Upper walled of ascoma viewed in squash mount. **i** Hyphae with capitate hyphopodia. **j** Hyphae with phialides. **k** Ascus when immature. **l**, **m** Ascospores with 4 septa. Scale bars: **e**=100 *μm*, **f**–h=50 *μm*, **i**, **j** =10 *μm*, **k**–**m**=20 *μm*

ascomatal setae, thus we illustrate *Cryptomeliola orbicularis* as lacking ascomatal setae base on the holotype specimen.

Material examined On bark of indet. host, C. Wright 557 comm, Curtis; ex herb. Berkeley (IMI 193125, **holotype**).

Endomeliola S. Hughes & Piroz., N.Z. Jl Bot. 32(1): 53 (1994)

Facesoffunginumber: FoF00729

Epiphytes or *pathogens* on surface of leaves, developing on reddish-brown necrotic areas. *Intercellular hyphae* branched, septate, cylindrical, smooth, brown to pale

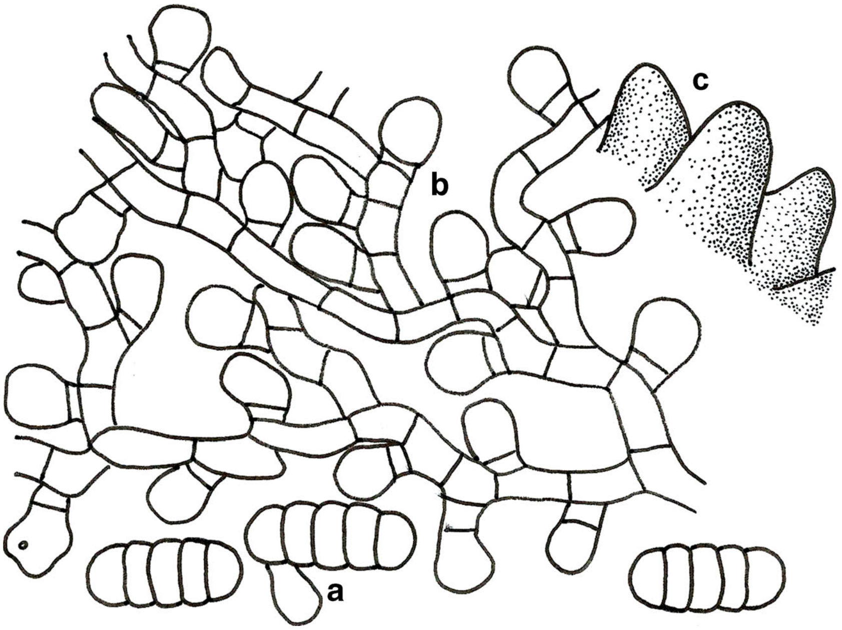


Fig. 13 *Asteridiella solani* (redrawn from Hansford 1963). **a** Ascospores. **b** Capitate hyphopodia on hyphae. **c** Raised conical projections on ascomata

brown, irregular, extending into the mesophyll, also penetrating between cells of the 2-layered palisade, with a single terminal hyphopodium. *Hyphopodia* irregular, mostly ellipsoidal to subglobose to ovoid to obovoid, occasionally angular or lobed in the mesophyll, generally with a short stalk cell, with hyaline pore at the centre of the head cell. **Sexual morph**: *Stromata* superficial on surface of host, solitary or gregarious, often discrete and then subglobose, somewhat flattened with a constricted base seated on the stromatic crust, black, comprising dark brown cells of *textura angularis* in transverse section, surface verrucose, with raised conical protuberant or ampuliform cells. *Peridium* comprising dark brown cells of *textura angularis* in transverse section, two strata, outer stratum of thick-walled, dark brown to reddish cells of *textura angularis*, and inner stratum of hyaline flattened

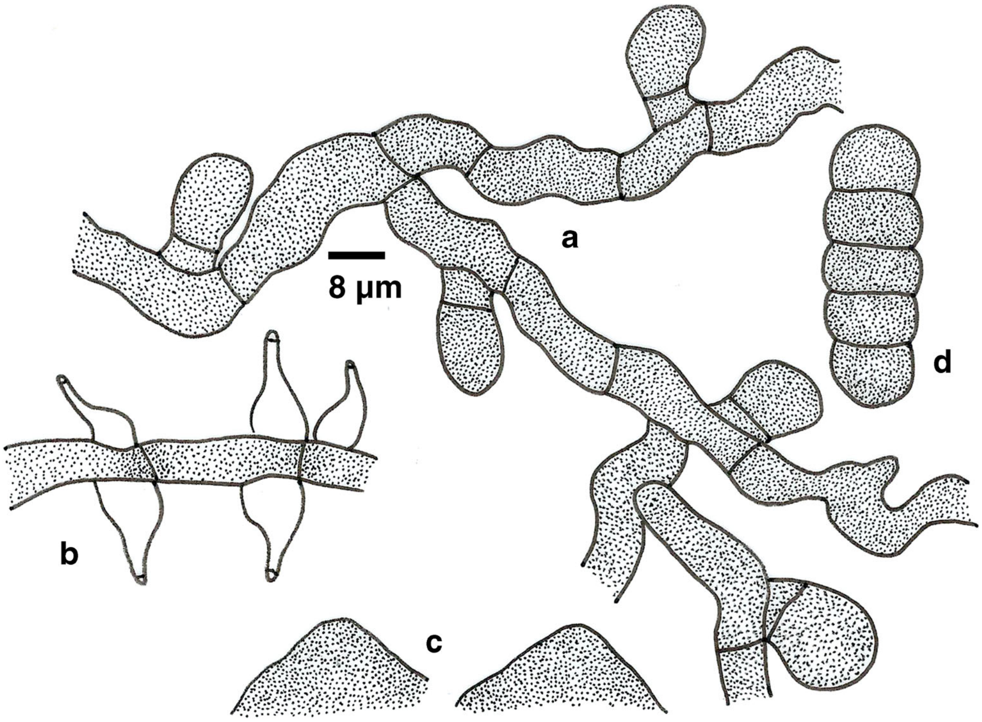


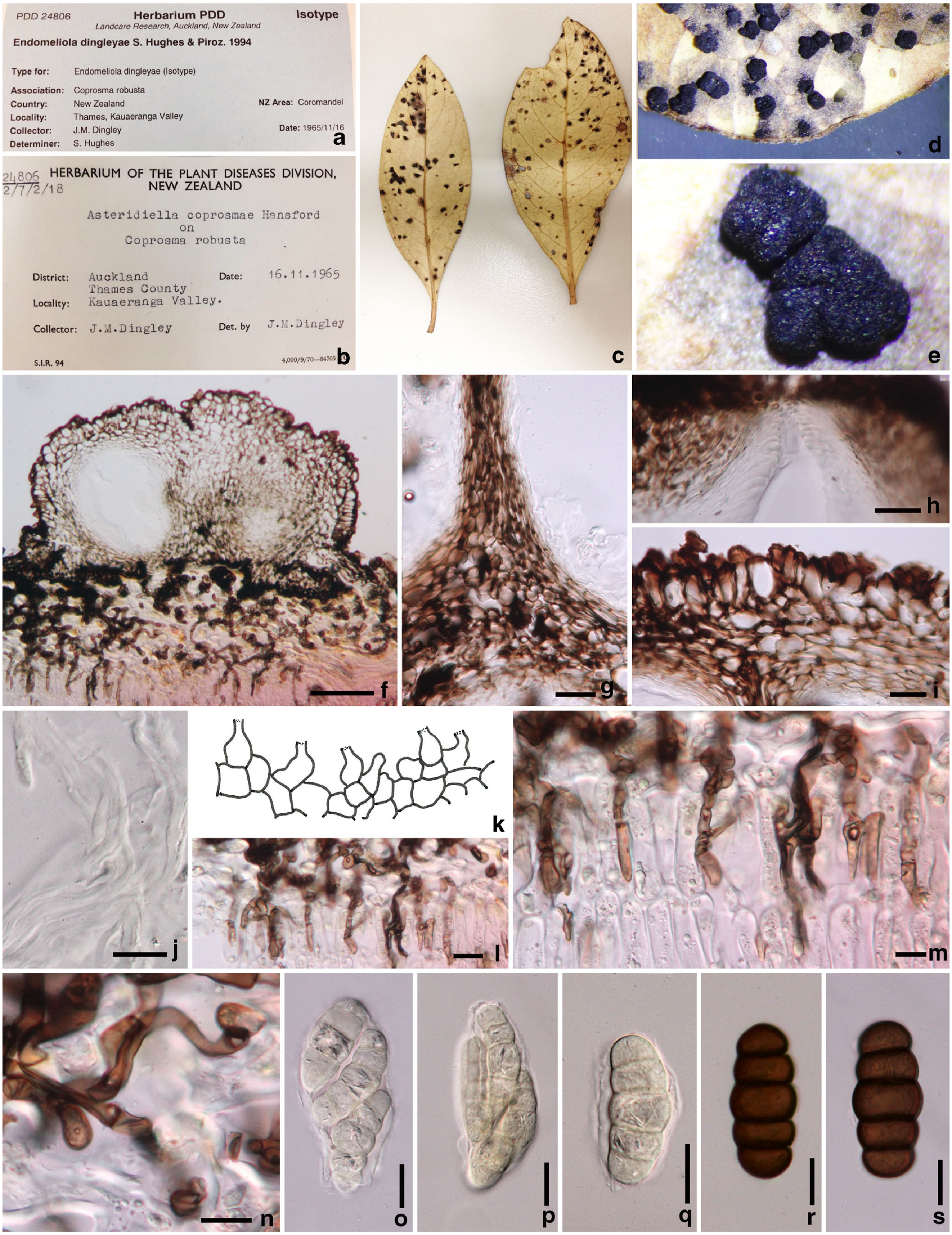
Fig. 14 *Asteridiella solani* var. *kodaikanalensis* (redrawn from Hosagoudar 2013). **a** Capitate hyphopodia on hyphae. **b** Phialides on hyphae. **c** Raised conical projections on ascoma. **d** Ascospore. Scale Bar: **a**=8 *μm*


K(M): 193125 HERB. HORT. BOT. REG. KEW
Cuba :
Meliola orbicularis Berk. & M.A. Curtis
sine loc.
on bark
Alt.(m):
Date:
Coll. C. Wrigth 557 (comm. Curtis; ex herb. Berkeley)
Add. info. ☑ Type: ☑
Det.
1.2.3.1

Fig. 15 *Cryptomeliola orbicularis* (holotype). **a**, **b** Herbarium packet, specimen and drawing. **c** Colony on host surface. **d** Ascomata on substrate. **e** Section through ascoma. **f** Projecting cells on outside of peridium. **g**, **i** Setae arising on hyphae. **h** Upper wall of ascoma in squash mount. **j** Immature ascus. **k**, **l** Mature ascospores. Scale bars: **e**, **f**=50 μm, **h**, **k**, **l**=20 μm, **g**, **i**, **j**=10 μm

cells. *Ascomatal locules* 1–4-locules in a pulvinate stroma, with central ostioles lined with periphyses. *Hamathecium* comprising cylindrical, hyaline, aseptate paraphyses. *Asci* 4-spored, unitunicate, ellipsoidal to clavate. *Ascospores* 2–3-seriate, hyaline when immature and brown to dark brown at maturity, broadly ellipsoidal to subcylindrical, 4-septate, slightly constricted and darker at the septa, the central cell sometimes longer than the others, smooth-walled. **Asexual morph**: *Phialides* solitary or gregarious on superficial ascostromata, occasionally on ascomatal walls, ampuliform or flask-shaped, brown to dark brown. *Conidia* ellipsoidal, hyaline (asexual morph redescribed from Hughes and Pirozynski 1994).

Notes: *Endomeliola* was introduced by Hughes and Pirozynski (1994), with type species *E. dingleyae*. The genus is distinguished by intercellular hyphae formed in the mesophyll layer of the plant. *Endomeliola* is a monotypic genus, lacking molecular data. However, the morphology is distinct from other genera in *Meliolaceae* (Fig. 16) and thus, we accept the genus in *Meliolaceae*.



PDD 24806 **Herbarium PDD** **Isotype**
Landcare Research, Auckland, New Zealand
Endomeliola dingleyae S. Hughes & Piroz. 1994

Type for: Endomeliola dingleyae (Isotype)
Association: Coprosma robusta
Country: New Zealand **NZ Area:** Coromandel
Locality: Thames, Kauaeranga Valley
Collector: J.M. Dingley **Date:** 1965/11/16
Determiner: S. Hughes

24806
2/7/2/18
HERBARIUM OF THE PLANT DISEASES DIVISION,
NEW ZEALAND

Asteridiella coprosmae Hansford
on
Coprosma robusta

District: Auckland Date: 16.11.1965
Thames County
Locality: Kauaeranga Valley.
Collector: J.M.Dingley Det. by J.M.Dingley

S.I.R. 94 4,000/9/70—84705

Fig. 16 *Endomeliola dingleyae* (isotype). **a**−**c** Herbarium packet and specimen. **d**–**e** Ascostromata on substrate. **f** Section through ascostromata. **g** Peridium between locules. **h** Periphyses. **i** Wall cells. **j** Paraphyses. **k** Phialides on surface of ascomata. **l**, **m** Intercellular hyphae. **n** Hyphopodia. **o**, **p** Asci. **q** Immature ascospore. **r**, **s** Mature ascospores. Scale bars: **e**, **f**=50 μm, **h**, **l**–**s**=20 μm, **g**, **i**, **j**=10 μm

Type species: ***Endomeliola dingleyae*** S. Hughes & Piroz., N.Z. Jl Bot. 32(1): 54 (1994)

Facesoffunginumber: FoF00728

Epiphytes, or *pathogens* on surface of leaves, developing on reddish brown necrotic areas. *Intercellular hyphae* 5–6 μm diam. ($\bar{x} = 5$ μm, n=10), branched, septate, cylindrical, smooth, brown to pale brown, irregular, extending into the mesophyll, also penetrating between cells of the 2-layered palisade, with a single terminal hyphopodium. *Hyphopodia* 6–8 μm diam. ($\bar{x} = 7$ μm, n=10), irregular, mostly ellipsoidal, subglobose, ovoid or obovoid, occasionally angular or lobed in the mesophyll, generally with a short stalk cell, with hyaline pore around the centre of the head cell. **Sexual morph**: *Stromata* 490–785 diam. × 255–575 μm high ($\bar{x} = 552 \times 345$ μm, n=10), superficial on surface of host, solitary or gregarious, often discrete and then subglobose, somewhat flattened with a constricted base seated on the stromatic crust, black, surface verrucose, with raised conical protuberant or ampuliform cells. *Peridium* 45–63 μm ($\bar{x} = 48$ μm, n=5), comprising dark brown cells of *textura angularis* in transverse section, with two strata, outer stratum of thick-walled, dark brown to reddish cells of *textura angularis*, and inner stratum of hyaline flattened cells. *Ascomatal locules* 1–4-locules in a pulvinate stroma, with central ostioles lined with periphyses. *Hamathecium* comprising cylindrical, hyaline, aseptate paraphyses. *Asci* 74–94×38–44 μm ($\bar{x} = 92 \times 41$ μm, n=10), 4-spored, unitunicate, ellipsoidal to clavate. *Ascospores* 65–67×29–32 μm ($\bar{x} = 66 \times 30$ μm, n=10), 2–3-seriate, hyaline when immature and brown to dark brown at maturity, broadly ellipsoidal to subcylindrical, 4-septate, slightly constricted and darker at the septa, the central cell sometimes longer than the others, smooth-walled. **Asexual morph**: Undetermined.

Notes: Molecular data indicate that *Endomeliola dingleyae* is a member of family *Meliolaceae*. The species is closely related to *Asteridiella intidae* with high bootstrap support (Justavino et al. 2015), but differs considerably in morphology and it is possible that the data is incorrect. Therefore, further gene and sequence data are needed to clarity the placement of the genus and species.

Material examined NEW ZEALAND, Auckland Province, Thames County, Kauaeranga Valley, on living leaves of *Coprosma robusta* Raoul. (*Rubiaceae*), 16 November 1965, J.M. Dingley (PDD 24806, **isotype**).

Irenopsis F. Stevens, Annls mycol. 25(5/6): 411 (1927)

≡ *Meliola* subgen. *Irenopsis* (F. Stevens) Cif., Annls mycol. 36(2/3): 203 (1938)

Facesoffunginumber: FoF00734

Epiphytes on the surface of leaves and stems. *Superficial hyphae* branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* capitate, angular or lobate, alternate or opposite on hyphae, near to hyphal septa, 2-celled, brown. **Sexual morph**: *Ascomata* superficial on the surface of hosts, solitary or gregarious on superficial hyphae, globose to subglobose, thick-walled, with raised long setae on the surface. *Ascomatal setae* curved or hooked at the apex, developing on the ascomata. *Peridium* comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 2–4-spored, unitunicate, obovoid to ovoid, evanescent. *Ascospores* 2-seriate, hyaline to brown, oblong to ovoid, 4-septate, constricted and darker at the septa, rounded ends, smooth-walled. **Asexual morph**: *Phialides* ampuliform, mixed with capitate hyphopodia, opposite or alternate, pale brown to brown. *Conidia* rarely observed, hyaline.

Notes: The genus *Irenopsis* was established by Stevens (1927). This genus is distinguished by having true setae on ascomata and lacking hyphal setae. *Irenopsis* comprises 180 species epithets in Index Fungorum (2015). Species were mainly introduced based on host association. Sequence data for *I. vincensii* places *Irenopsis* in *Meliolaceae* (Justavino et al. 2015).

Type species: ***Irenopsis tortuosa*** (G. Winter) F. Stevens, Annls mycol. 25(5/6): 439 (1927)

≡ *Meliola tortuosa* G. Winter, in Gaillard, Le Genre Meliola: 67 (1892)

≡ *Irenopsis tortuosa* (G. Winter) F. Stevens, Annls mycol. 25(5/6): 439 (1927) var. *tortuosa*

Possible synonym (from Index Fungorum 2015)

= *Meliola tonkinensis* var. *potomorphes* Cif., Annls mycol. 31(3): 149 (1933)

Facesoffunginumber: FoF00732

Epiphytes on the surface of leaves and stems. *Superficial hyphae* branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae lacking. *Hyphopodia* capitate, curved, alternate or opposite on hyphae, near to hyphal septa, 2-celled, brown. **Sexual morph**: *Ascomata* 175–215 μm diam. × 95–120 μm high ($\bar{x} = 208 \times 113$ μm, n=5), superficial on surface of hosts, solitary or gregarious on superficial hyphae, globose to subglobose, thick-walled, with raised long setae on the surface. *Ascomatal setae* 8–10×92–107 μm ($\bar{x} = 9 \times 102$ μm, n=5), curved or hooked at the apices, developing on the ascomata. *Peridium* 20–26 μm ($\bar{x} = 24$ μm,

n=5), comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 54–58×22–25 μm ($\bar{x}$ = 55 × 23 μm, n=5), 2–4-spored, unitunicate, obovoid to ovoid, evanescent. *Ascospores* 37–40×14–15 μm ($\bar{x}$ = 37 × 15 μm, n=10), 2-seriate, hyaline to brown, oblong to ovoid, 4-septate, or with 4 transverse septa and 2 longitudinal septa, constricted and darker at the septa, rounded ends, smooth-walled. **Asexual morph**: *Phialides* 16–17×7–8 μm ($\bar{x}$ = 16 × 7 μm, n=10), ampliform, mixed with capitate hyphopodia, opposite or alternate, pale brown to brown. *Conidia* not seen.

Material examined DOMINICAN REPUBLIC, on leaves of *Potomorpha umbellata* Mich. (*Piperaceae*), August 1929, R. Ciferri 2426 (SF5890, **holotype**); VENEZUELA, El Limon bei Puerto La Cruz, on leaves of *Piperis marginati* Jacq. (*Piperaceae*), 16 January 1928, H. Sydow (SF77640).

Notes: The type specimen was collected in Brazil (Stevens 1927), but we could not locate and examine the type. Therefore a collection of *Meliola tonkinensis* var. *potomorphes* from S was studied (Figs. 17 and 18). One ascospore was found with 4 transverse septa and 2 longitudinal septa in *Irenopsis tortuosa* (S-F5890).

Irenopsis walsurae X.Z. Zeng & K.D. Hyde, **sp. nov**.

Facesoffunginumber: FoF00733

Index Fungorum: IF551220

Etymology:— *walsurae* referring to the host on which the taxon was found.

Holotype: MFLU13-0621

Epiphytes on the surface of living leaves. *Superficial hyphae* 7 μm diam., radiating outwardly, branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae absent. *Hyphopodia* 14–19×9–13 μm ($\bar{x}$ = 16 × 11 μm, n=20), capitate, alternate on hyphae, near to hyphal septa, 2-celled, brown. **Sexual morph**: *Ascomata* up to 160 μm, superficial on surface of hosts, scattered, globose to subglobose, thick-walled, with long ascomatal setae. *Ascomatal setae* up to 170 μm long, raised on ascomata, and rounded at the apex. *Peridium* comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum a single layer of large, thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 2–3-spored, unitunicate, obovoid to ovoid, with short pedicel or apedicel, evanescent. *Ascospores* 33–39×12–18 μm ($\bar{x}$ = 36 × 14 μm, n=20), 2–3-seriate, hyaline to brown, oblong to ovoid, 3–4-septate, slightly constricted and darker at the septa, rounded ends, apical cell sometimes slightly longer, smooth-walled. **Asexual morph**: *Phialides* 16–21×8–10 μm ($\bar{x}$ = 18 × 9 μm, n=10), ampuliform, alternate to opposite, formed on separate hyphae, rarely mixed with capitate hyphopodia. *Conidia* undetermined.

Material examined THAILAND, Chiang Mai, Mae Taeng, Pa Pae, Bahn Pa Dheng, 128 Moo 3, Mushroom Research Centre, on the living leaves of *Walsura tubulata* Hiern. (*Meliaceae*), 22 November 2013, Xiangyu Zeng (MFLU 13-0621, **holotype**; **isotype**, KUN).

Notes: *Irenopsis walsurae* was found on living leaves of *Walsura tubulata* (*Meliaceae*). *Irenopsis* species known from this host family are *I. trichiliae* Hosag. & Riju, *I. chukrasiae* Hosag., *I. dysoxyli* Jana et al. and *I. indica* (Anahosur) Hosag. *Irenopsis walsurae* is most similar to *I. dysoxyli*, but differs in having longer ascospores and ascomatal setae, with smaller ascomata in *Irenopsis walsurae*. The new species is also similar to *I. trichiliae*, but differs in having opposite to unilateral phialides, separated from the hyphopodia in *Irenopsis walsurae*, while alternate to unilateral phialides, mixed with hyphopodia in *I. trichiliae*. There are no previous records of *Irenopsis* species reported on *Walsura*. Other genera in *Meliolaceae* known from *Walsura* are *Ectendomeliola walsurae* Hosag. & D.K. Agarwal, *Meliola walsurae* Hansf. and *M. walsuricola* Bagool & H. Biju, however, ascomatal setae are absent in these three species, while ascomatal setae are present in *Irenopsis walsurae*. *Ectendomeliola* is excluded from *Meliolaceae* in this study (Fig. 19).

Meliola Fr., Syst. orb. veg. (Lundae) 1: 111 (1825)

Possible synonyms (from Index Fungorum 2015):

Myxothecium Kunze, Syst. mycol. (Lundae) 3(1): 231 (1829)

Asterina subgen. *Asteridium* Sacc., Syll. fung. (Abellini) 1: 49 (1882)

Asteridium (Sacc.) Speg. ex Sacc., Syll. fung. (Abellini) 9: 435 (1891)

Facesoffunginumber: FoF00740

Epiphytes on the surface of leaves, stems or branches. *Superficial hyphae* branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae present. *Hyphopodia* capitate, alternate or opposite on hyphae, near to hyphal septa, 2-celled, brown. *Hyphal setae* arising from hyphae, forming around the base of the ascomata in some species, straight or curly, rounded or acute at the apex, or branches, septate or aseptate, brown to dark brown, smooth-walled. **Sexual morph**: *Ascomata* superficial on the surface of hosts, solitary to gregarious on superficial hyphae, globose to subglobose, thick-walled, ascomatal setae and appendages absent, surface of ascomata verrucose. *Peridium* comprising dark brown

Fig. 17 *Irenopsis tortuosa* (holotype). **a**–**c** Herbarium packet and specimen. **d** Ascomata on substrate. **e**, **f** Ascomata when viewed in squash mounts. **g** Section through ascoma. **h** Upper wall of ascomata. **i** Hyphae with phialides. **j** Hyphae with capitate hyphopodia. **k** Seta on ascoma. **l** Hamathecium. **m**, **n** Immature asci. **o**, **p** Ascospores with 4 septa. **q** Ascospore with 4 transverse septa and 2 longitudinal septa. Scale bars: **e**=200 μm, **f**, g=100 μm, **h**, **m**–**q**=20 μm, **i**, **j**=5 μm, **k**, **l**=10 μm

cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 2–4-spored, unitunicate, broadly clavate to oblong, evanescent. *Ascospores* 2–4-seriate, hyaline to brown, oblong to broadly cylindrical, 3–4-septate, constricted and darker at the septa, rounded ends, smooth-walled, verrucose when immature. **Asexual morph**: *Phialides* ampuliform, alternate or opposite on hyphae, sometimes curved, pale brown to brown. *Conidia* hyaline.

Notes: The genus *Meliola* was introduced by Fries (1825), and is the largest genus in the family *Meliolaceae*. *Meliola*

Fig. 18 *Irenopsis tortuosa* (S- F77640). **a**, **b** Herbarium packet and specimen. **c** Ascomata on host surface. **d** Ascoma when viewed in squash mounts. **e** Section through ascoma. **f** Peridium. **g** Upper wall of ascoma. **h** Phialides on hyphae. **i** Hyphae with capitate hyphopodia. **j** Young ascoma. **k** Seta on ascoma. **l**, **m** Immature asci. **n**–**p** Ascospores with 4 septa. Scale bars: **d**, **e**=50 μm, **f**, **g**, **j**–**p**=20 μm, **h**, **i**=10 μm

contains over 1200 species (Kirk et al. 2008). Most species were introduced based on host association. Molecular analysis of *Meliola* members were provided by Gregory and John (1999), Justavino et al. (2015) and Pinho et al. (2012a, 2014) and show their placement in *Meliolaceae*.

Type species: ***Meliola nidulans*** (Schwein.) Cooke, Grevillea 11(no. 57): 37 (1882)

≡ *Sphaeria nidulans* Schwein., Schr. naturf. Ges. Leipzig 1: 45 (1822)

≡ *Chaetosphaeria nidulans* (Schwein.) Rehm, Ascomyceten, fasc.: no. 287 (1875)

≡ *Meliola nidulans* (Schwein.) Cooke, Grevillea 11(no. 57): 37 (1882) var. *nidulans*

Facesoffunginumber: FoF00738

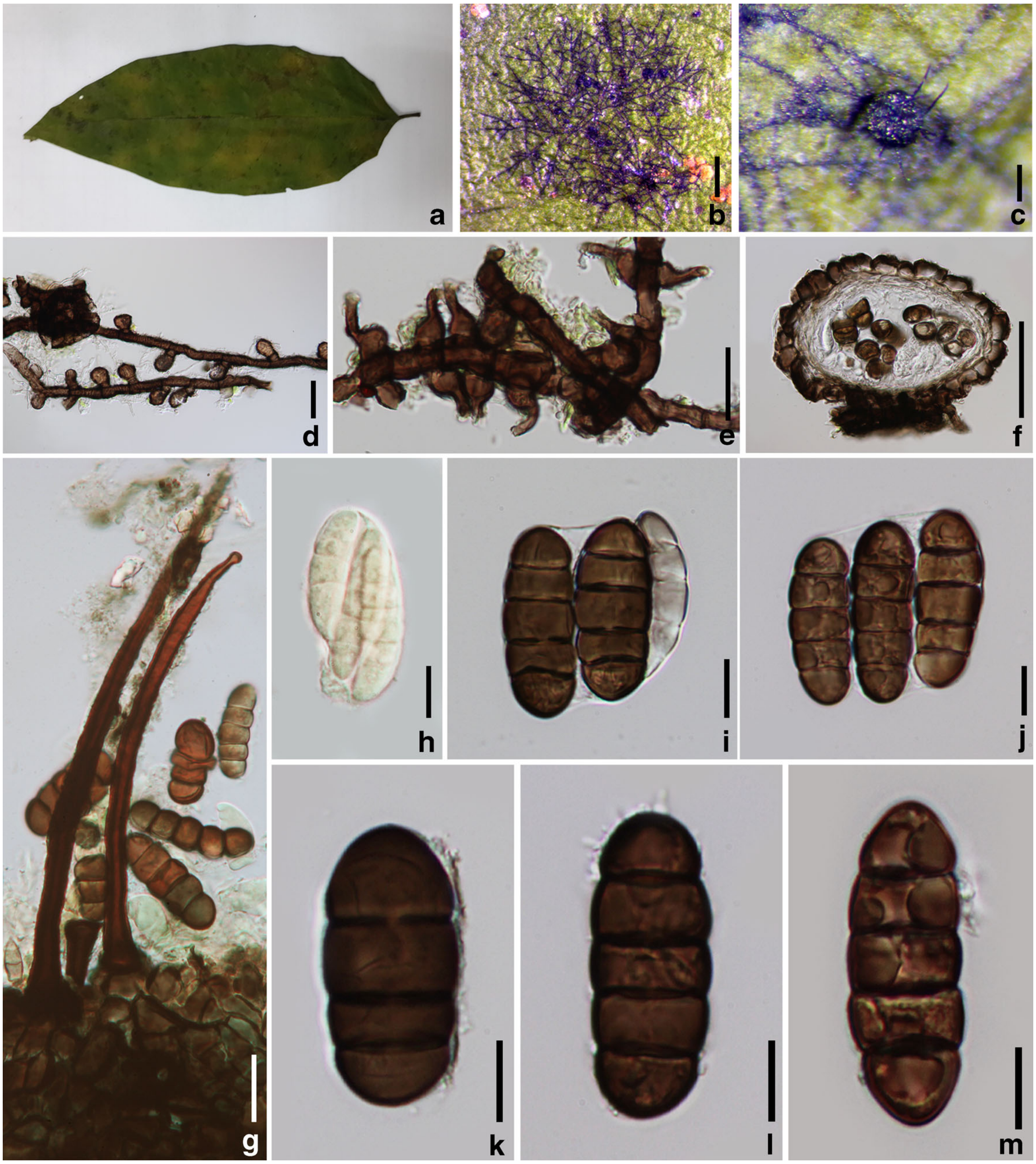


Fig. 19 *Irenopsis walsuri* (holotype). **a** Leaf specimen. **b** Colony on surface of leaves. **c** Ascoma on host substrate. **d** Hyphae with capitate hyphopodia. **e** Phialides on hyphae. **f** Section through ascoma. **g** Long setae forming on ascoma. **h** Immature ascus. **i–j** Mature asci. **k–m** Ascospores with 4 septa. Scale bars: **b**=500 μm, **c**=100 μm, **f**=50 μm, **d**, **e**, **g**=20 μm, **h–m**=10 μm

Epiphytes on the surface of leaves, stems or branches. *Superficial hyphae* branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae present. *Hyphopodia* not seen. *Hyphal setae* up to 350 μm, forming around the base of the ascomata in some species, straight or curly, rounded or acute at the apex or branches, septate or aseptate, brown to dark brown, smooth-walled. **Sexual morph**: *Ascomata* 235–345 μm diam. ($\bar{x}$ = 312 μm, n=5), superficial on the surface of hosts, solitary to gregarious on superficial hyphae, globose to subglobose, thick-walled, ascomatal setae and appendages absent, surface of ascomata verrucose. *Peridium* 53–62 μm diam. ($\bar{x}$ = 56 μm, n=5), comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum a single layer or multi-layered when immature, of large, thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 58–63×32–36 μm ($\bar{x}$ = 60 × 31 μm, n= 5), 2–4-spored, unitunicate, broadly clavate to oblong, evanescent. *Ascospores* 45–54×15–19 μm ($\bar{x}$ = 51 × 18 μm, *n*=5), 2–4-seriate, hyaline to brown, oblong to broadly cylindrical, 3–4-septate, constricted and darker at the septa, rounded ends, smooth-walled, verrucose when immature. **Asexual morph**: Undetermined.

Notes: The species *Meliola nidulans* was established by Cooke (1882), and was based on *Sphaeria nidulans* Schwein. We examined the type specimen of *M. nidulans* and could not obtain good photographs of the superficial hyphae, hyphopodia, and phialides because the specimen is not in good condition (Fig. 20).

Material examined USA, Pennsylvania, New Garden, on branches of *Cornus* sp. (*Cornaceae*), Michener Collection 711 (BPI 800359, holotype of *Sphaeria nidulans*).

Meliola clerodendricola Henn., Hedwigia 37: 288 (1898)

Facesoffunginumber: FoF00736

Epiphytes on surface of living leaves. *Superficial hyphae* 7 *μm* diam. radiating outwardly, straight to substraight, branched, septate, darker at the septa, brown, with hyphopodia, hyphal setae present. *Hyphopodia* 13–17 × 9–13 *μm* ($\bar{x}$ = 15 × 11 *μm*, *n*=20), capitate, unilateral on hyphae, near to hyphal septa, 2-celled, brown. *Hyphal setae* long, straight, acute at the apex, septate, brown, and smooth-walled. **Sexual morph**: *Ascomata* up to 160 *μm* diam., superficial on surface of host, dense, globose to subglobose, thick-walled, ascomatal setae and appendages absent. *Peridium* comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum a single layer of large, thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 2–4-spored, unitunicate, obovoid to ovoid, with short pedicel, evanescent. *Ascospores* 31–35 × 10–13 *μm*, ($\bar{x}$ = 33 × 12 *μm*, *n*=20), 2–4-seriate, hyaline to light brown, oblong to ellipsoid, 3–4-septate, constricted and darker at the septa, rounded ends, apical cell sometimes slightly larger, smooth-walled. **Asexual morph**: Undetermined.

Material examined THAILAND, Chiang Mai, Mushroom Research Centre, Mae Taeng, Pa Pae, Bahn Pa Dheng, 128 Moo 3, on the living leaves of *Clerodendrum* sp. (*Lamiaceae*), 22 November 2013, Xiangyu Zeng (MFLU 13-0620; KIB, **reference specimen designated here**).

Notes: *Meliola clerodendricola* (MFLU 13-0620) was found on living leaves of *Clerodendrum* sp. (*Lamiaceae*). The morphology of MFLU13-0620 is most typical of *Meliola clerodendricola* based on host association and size of hyphal setae, ascomata, and ascospores. We were unable to locate the holotype material of *Meliola clerodendricola*, but an isotype is preserved in S (F8150) (Fig. 21). However, DNA cannot be extracted from the type specimen, consequently, we designate this as a reference specimen (Ariyawansa et al. 2014). *Meliolaceae* species known from *Clerodendrum* sp. are *Asteridiella clerodendricola* Hosag. and *A. vivekananthanii* Hosag., however, hyphal setae are absent in these species, but are found in *M. clerodendricola*. In addition, *Asteridiella clerodendricola* can produce a pathogenic effect on the host, while there is no pathogenic effect with *Meliola clerodendricola*. Molecular analyses place *M. clerodendricola* in the *Meliolaceae* clade, with a putatively named specimen of *Endomeliola dingleyae* (97 % ML support and 1.0 PP support). This result is strange as *Meliola clerodendricola* has superficial hyphae and hyphal setae, while *Endomeliola dingleyae* has intercellular hyphae without hyphal setae. *Meliola clerodendricola* was found on a host in the order *Lamiales* and *Endomeliola dingleyae* was found on host in the order *Gentianales*; their hosts belong in closely related orders in the euasterids (Jansen et al. 2007; Justavino et al. 2015). The identification of *Endomeliola dingleyae* may be incorrect and although the sequence has been placed in GenBank it does not appear to be linked to a voucher specimen.

Meliola thailandicum Hongsanan & K.D. Hyde, **sp. nov.**

Facesoffunginumber: FoF00739

Index Fungorum: IF551218

Etymology:—from Latin *thailandicum* meaning Thailand, referring to the location where the fungus was found.

Holotype: MFLU15-0044

Epiphytes on the surface of living leaves. *Superficial hyphae* 6 *μm* diam., radiating outwardly, branched, septate, darker at the septa, brown to dark brown, with hyphopodia. *Hyphal setae* up to 300 *μm* long, septate, darker at the septa, 1–3 forked at the apex. *Hyphopodia* 7 *μm* diam., capitate, mostly alternate or sometimes opposite on hyphae, near to hyphal septum, 2-celled, brown. **Sexual morph**: *Ascomata* 185–200 *μm* diam. × 120–180 *μm* high ($\bar{x}$ = 190 × 134 *μm*, *n*=10), superficial on surface of host, mostly scattered or solitary, globose to subglobose, thick-walled, ascomatal setae and appendages absent. *Peridium* 18–20 *μm* ($\bar{x}$ = 20 *μm*, *n*=10), comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum a single layer of large, thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 59–60 × 26–28 *μm* ($\bar{x}$ = 60 × 27 *μm*, *n*=10), 2–4-spored, unitunicate, obovoid to ovoid, or broadly clavate, with short pedicel, sessile at maturity, evanescent. *Ascospores* 39–41 × 14–16 *μm* ($\bar{x}$ = 40 × 15 *μm*, *n*=20), 2–4-seriate, hyaline to brown, oblong to cylindrical, 4-septate, constricted and darker at the septa, rounded ends, with thin sheath when immature, smooth-walled. **Asexual morph**: *Phialides* 7–8 *μm* ($\bar{x}$ = 7 *μm*, *n*= 10), ampuliform, alternate to opposite, formed on separate hyphae, mixed with capitate hyphopodia. *Conidia* undetermined.

Material examined THAILAND, Chiang Rai, Amphoe Thoeng, on the living leaves of *Dimocarpus longan*

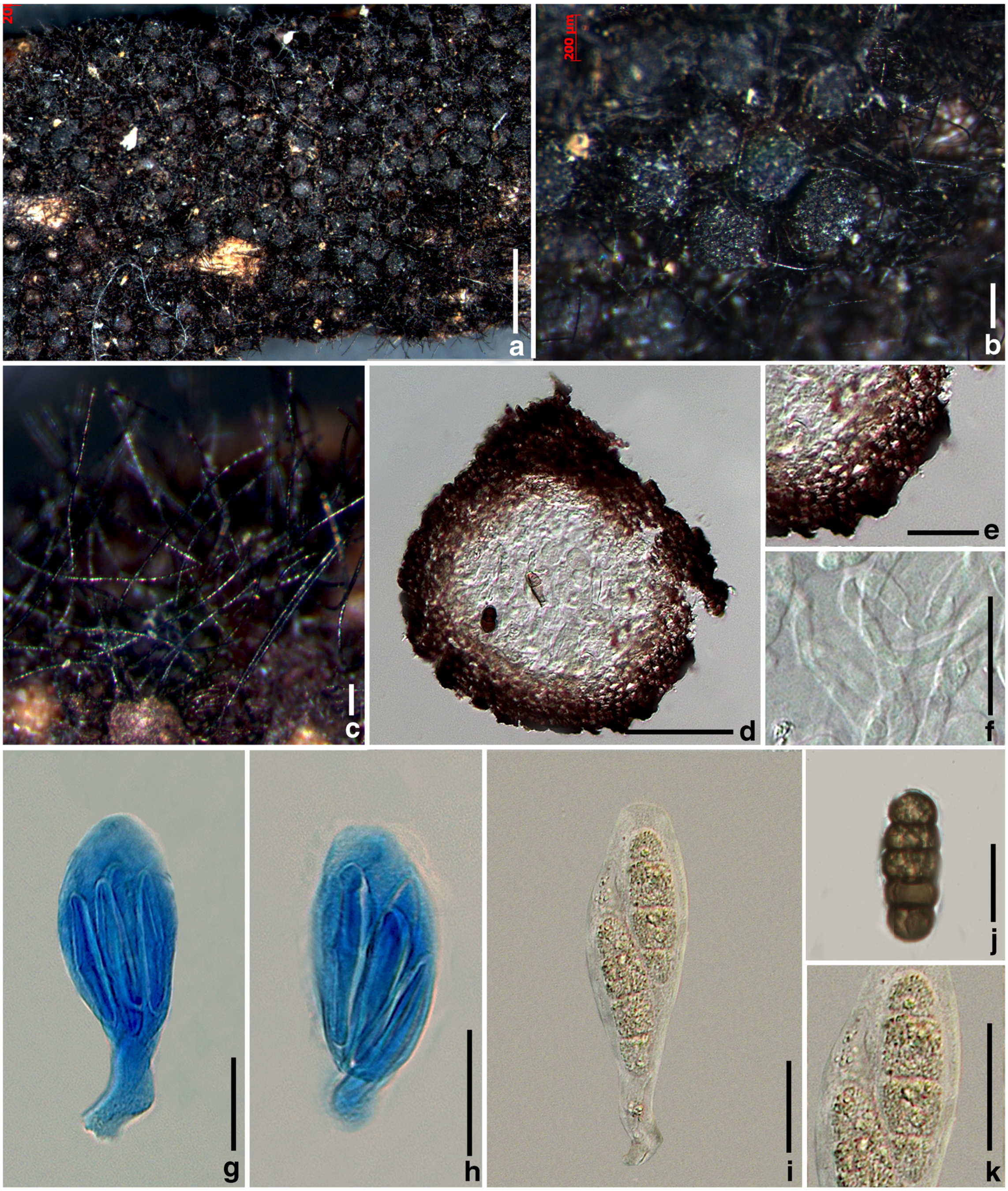


Fig. 20 *Meliola nidulans* (holotype) **a**, **b** Ascomata on host substrate **c** Long setae developed from hyphae. **d** Section through ascoma. **e** Peridium. **f** Paraphyses. **g**, **h** Immature asci in cotton blue reagent. **i** Immature ascus in Melzer's reagent. **j** Mature ascospore with 4 septa and rounded ends. **k** Immature ascospores in Melzer's reagent with verrucose surface. Scale bars: **a**=1000 μm, **b**=200 μm, **e**=50 μm, **c**, **f**–**k**=20 μm, **d**=100 μm

Lour. (*Sapindaceae*), 18 January 2015, S. Hongsanan (MFLU15-0044 **holotype**; KIB, **isotype**); Chiang Rai, Mueang, Rai Chun Tawan Meditation Centre, on the living leaves of *Dimocarpus longan* (*Sapindaceae*), 3 January 2015, S. Hongsanan (MFLU15-0047); Chiang Rai, Mueang, Tasud, on the living leaves of *Dimocarpus longan* (*Sapindaceae*), 11 February 2015, S. Hongsanan (MFLU15-0377); Chiang Rai, Mueang, Agricultural research center, on living leaves of *Acacia auriculiformis* A.Cunn. ex Benth. (*Fabaceae*), 23 January 2015, S. Hongsanan (MFLU15-0378); Chiang Rai, Mueang, Mae Fah Luang University, on the living leaves of *Dimocarpus longan* (*Sapindaceae*), 12 February 2015, S. Hongsanan (MFLU15-0379).

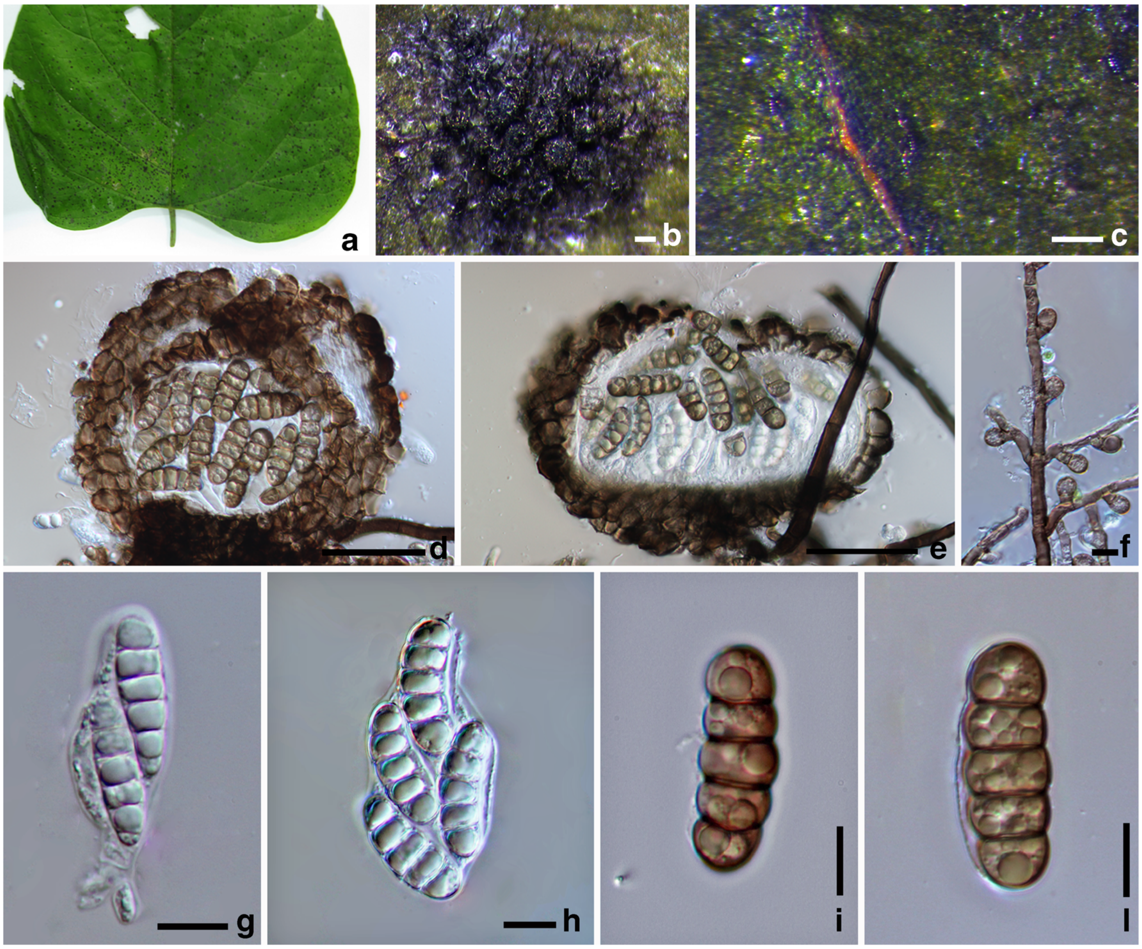


Fig. 21 *Meliola clerodendricola* (MFLU13-0620). **a** Leaf specimen. **b** Colony on surface of leaves. **c** Ascomata on host substrate. **d**, **e** Section through ascomata. **f** Hyphae with capitate hyphopodia. **g**, **h** Immature asci. **i**, **j** Ascospores with 4 septa. Scale bars: **b**, **c**=100 μm, **d**, **e**=50 μm, **f**–**l**=10 μm

Notes: *Meliola thailandicum* is common on living leaves of *Dimocarpus longan* in northern Thailand. *Meliola capensis* (Kalchbr. & Cooke) Theiss. and *M. dimocapi* Hosag. & T.K. Abraham are also known from *Dimocarpus longan*, however, they differ in having apically acute hyphal setae, and ascospores without a thin-sheath, while *M. thailandicum* has longer hyphal setae with 1 to many branches at the apex, and ascospores with thin-sheath when immature and that may be present at maturity (Figs. 22 and 23). *Meliola thailandicum* was also collected on *Acacia auriculiformis*. *Meliola* species known from this host genus are *M. acaciarum* Speg., *M. acaciae-binervatae* Hansf., *M. acaciae-confusae* Sawada, *M. acaciicola* Hansf. and *M. acaciorum* Speg., however, all species differ from *M. thailandicum* in having shorter hyphal setae, acute or rounded at the apex, and ascospores lacking a sheath. In *M. thailandicum* hyphal setae are longer and branched at the apex, and ascospores have thin sheaths when immature and sometimes when mature. Molecular analyses indicate that *M. thailandicum* from *D. longan* and *A. auriculiformis* are the same species which belong in *Meliolaceae* within the genus *Meliola* (100 % ML support and 1.0 PP support). Hence, we conclude that the species is not host-specific. This may have important implications on the numbers of *Meliolaceae* species, as most taxa were introduced based on host occurrence.

Meliola mucunicola Hongsanan & K.D. Hyde, **sp. nov.**

Facesoffunginumber: FoF00737

Index Fungorum: IF551219

Etymology:— *mucunicola* referring to the host on which the taxon was found.

Holotype: MFLU15-0386

Epiphytes on the surface of *Mucuna* living leaves. *Superficial hyphae* 5–8 μm ($\bar{x} = 6$ μm, $n=10$), radiating outwardly, branched, septate, darker at the septa, brown to dark brown, with hyphopodia. *Hyphal setae* 167–195 × 8–10 μm ($\bar{x} = 185 \times 9$ μm, $n=10$), rounded to acute at the apex. *Hyphopodia* 10–13 μm ($\bar{x} = 12$ μm, $n=10$), capitate, mostly alternate or sometimes opposite on hyphae, near to hyphal septa, 2-celled, brown. **Sexual morph**: *Ascomata* 120–145 μm diam. × 90–105 μm high ($\bar{x} = 122 \times 96$ μm, $n=10$), superficial on surface of hosts, mostly scattered or solitary, globose to subglobose, thick-walled, ascomatal hyphae or appendages

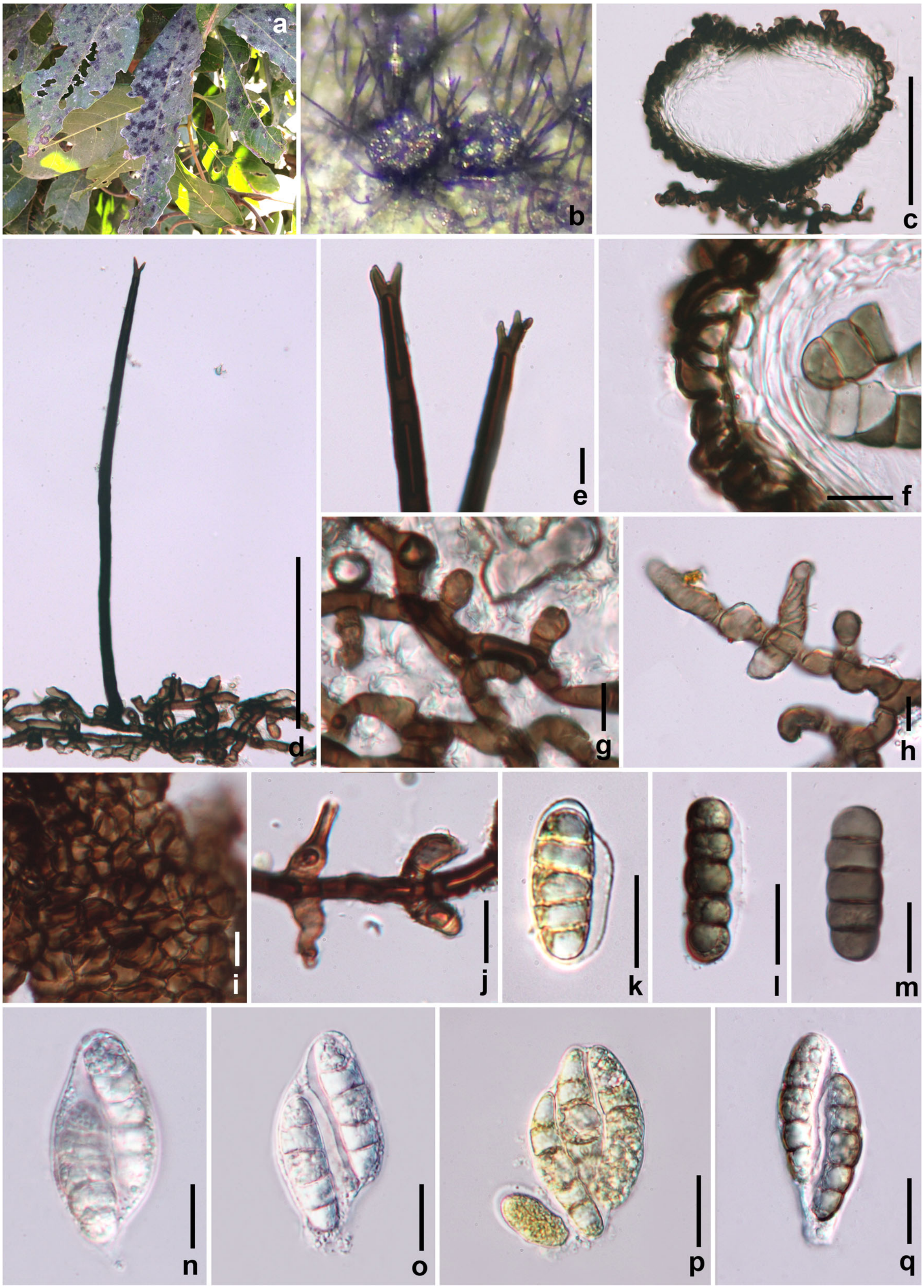


Fig. 22 *Meliola thailandicum* (holotype). **a** Leaf specimens. **b** Ascomata on host substrate. **c** Section through ascoma. **d** Hyphal seta. **e** Hyphal setae with forked apices. **f** Peridium. **g** Hyphae with capitate hyphopodia. **h** Terminal hyphae. **i** Upper wall of ascoma. **j** Phialides. **k** Immature ascospore in Melzer's reagent. **l**, **m** Mature ascospores. **n**, **o**, **q** Immature asci. **p** Immature ascus in Melzer's reagent. Scale bars: **c**, **d**= 100 *μm*, **e**, **f**=20 *μm*, **g**–**j**=10 *μm*, **k**–**q**=20 *μm*

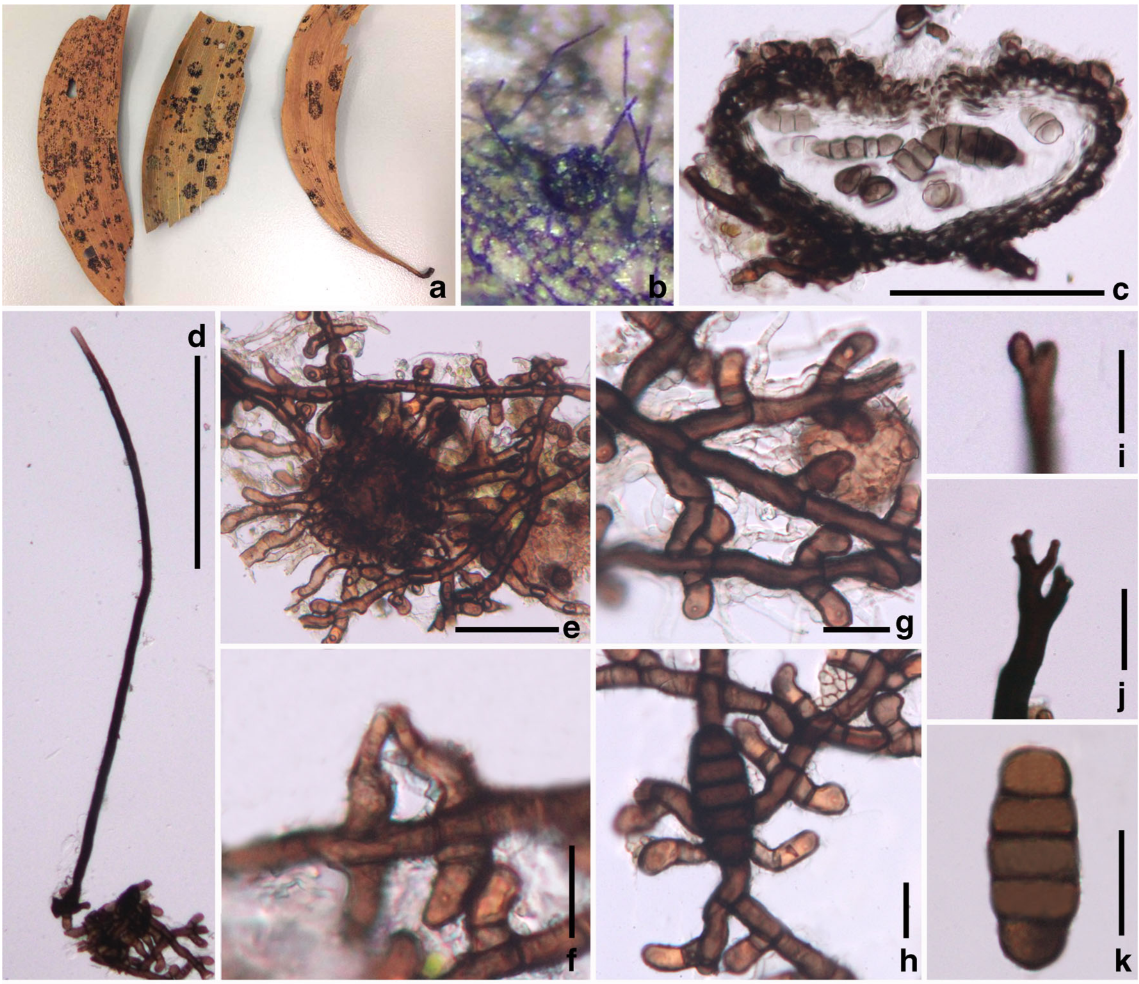


Fig. 23 *Meliola thailandicum* (from *Acacia auriculiformis*, MFLU 15-0378). **a** Leaf specimens. **b** Ascoma on host substrate. **c** Section through ascoma. **d** Hyphal seta. **e** Young ascoma. **f** Phialides on hyphae. **g** Capitate hyphopodia on hyphae. **h** Germinated ascospore. **i**, **j** Hyphal setae with branches at apex. **k** Mature ascospore with 4 septa. Scale bars: **c**=100 *μm* **d**=200 *μm* **e**=50 *μm*, **f**–**k**=20 *μm*

lacking. *Peridium* 15–19 *μm* ($\bar{x}$ = 17 *μm*, *n*=10), comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum a single layer of large, thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses. *Asci* 44–53×22–23 *μm* ($\bar{x}$ = 48 × 23 *μm*, *n*=10), 2-spored, unitunicate, oblong to cylindrical, with short pedicel, sessile at maturity, evanescent. *Ascospores* 37–41×12–15 *μm* ($\bar{x}$ = 39 × 13 *μm*, *n*=20), 2-seriate, hyaline to brown, oblong to cylindrical, 4-septate, constricted and darker at the septa, rounded ends, with thin sheath when immature, smooth-walled. **Asexual morph**: *Phialides* 7–9 *μm* ($\bar{x}$ = 8 *μm*, *n*=10), ampuliform, alternate to opposite on hyphae, mixed with capitate hyphopodia. *Conidia* undetermined.

Material examined THAILAND, Chiang Rai, Mueang, Agricultural Research Center, on the living leaves of *Mucuna pruriens* (L.) DC. (*Fabaceae*), 23 March 2015, S. Hongsanan (MFLU15-0386, **holotype**; KIB, **isotype**).

Notes: *Meliola mucunicola* was found on living leaves of *Mucuna pruriens*. *Meliola* species known from this host genus are *M. mucunae* Hansf. and *M. mucunae-acuminatae* Hansf. The new species is most typical of *M. mucunae-acuminatae* in terms of morphology and host association, as *M. mucunae-acuminatae* can be found on the same host species. *Meliola mucunicola* differs from *M. mucunae-acuminatae* in having ascomata surrounded by many short setae (Fig. 24), while in *M. mucunae-acuminatae* ascomata are surrounded by a few long setae. Moreover, phialides of *Meliola mucunicola* are larger than those of *M. mucunae-acuminatae*. Molecular analyses place *Meliola mucunicola* in the *Meliolaceae* clade close to *Meliola centellae* Pinho & O.L. Pereira with 55 % ML support and 0.8 PP support.

Genera / species synonymized under *Meliola*

Laeviomeliola Bat., Atas Inst. Micol. Univ. Recife 1: 224 (1960)

Fig. 24 *Meliola mucunicola* (holotype). **a** Leaf specimen. **b** Ascomata and hyphal setae on host substrate. **c** Section through ascoma. **d** Hyphal setae. **e** Peridium. **f** Phialides on hyphae. **g** Hyphae with capitate hyphopodia. **h** Rounded apex of hyphal seta. **i** Upper wall of young ascoma. **j** Immature ascus. **k** Immature ascus in Melzer's reagent. **l** Upper wall of ascoma when viewed in squash mounts. **m**, **n** Mature ascospores with 4 septa. Scale bars: **c**, **d**=50 μm, **e**, **i**–**k**, **m**, **n**=20 μm, **f**–**h**, **l**=10 μm

≡ *Laeviomeliola psidii* Bat., Atas Inst. Micol. Univ. Recife 1: 225 (1960)

Meliola psidicola Hongsanan & K.D. Hyde, **nom. nov.**

Facesoffunginumber: FoF00847

Index Fungorum: IF551222

Epiphytes on the surface of leaves. *Superficial hyphae* 6–7 μm diam. ($\bar{x} = 6$ μm, n=10), branched, septate, darker at the septa, brown, with hyphopodia. *Hyphal setae* 260–284×5–7 μm ($\bar{x} = 277 \times 7$ μm, n=10), rounded to acute at the apex. *Hyphopodia* 8–10 μm diam. ($\bar{x} = 9$ μm, n=10), capitate, cylindrical to subcylindrical, alternate on hyphae, near to hyphal septa, brown, 2-celled. **Sexual morph**: *Ascomata* 158–182 μm diam. ($\bar{x} = 163$, n=5), superficial on upper surface of leaves, solitary or gregarious on superficial hyphae, globose to subglobose, thick-walled, lacking ascomata setae and appendages. *Peridium* 22–25 μm ($\bar{x} = 23$ μm, n=5), comprising dark brown cells of *textura angularis* when viewed in squash mounts, with two strata, outer stratum a single layer of large, thick-walled, dark brown cells of irregular *textura angularis*, and inner stratum of flattened, hyaline cells. *Hamathecium* with evanescent paraphyses (Batista and da Silva 1960). *Asci* 37–43×16–22 μm ($\bar{x} = 41 \times 19$ μm, n=3), 2-spored, unitunicate, clavate to obovoid, evanescent. *Ascospores* 44–52×15–16 μm ($\bar{x} = 46 \times 15$ μm, n=10), 2-seriate, hyaline when immature, brown at maturity, ellipsoid to fusiform, 4-septate, not constricted when immature, slightly constricted and darker at the septa at maturity, acute ends, smooth-walled. **Asexual morph**: Undetermined.

Material examined BRAZIL, Pernambuco, Caruaru, on leaves of *Psidium guajavae* Linnaeus (*Myrtaceae*), 9 March 1958, Dr. Epaminondas de Barros Correia (URM 12749, **holotype**).

Notes: The genus *Laeviomeliola* is monotypic and was introduced by Batista and da Silva (1960), with the type species *L. psidii*. We re-examined the type specimen and concluded that the morphology of *Laeviomeliola* is quite similar to *Meliola* based on its hyphal setae. *Laeviomeliola psidii* differs in having fusiform ascospores with tapering ends, while in *Meliola* the ends are rounded (Fig. 25). Thus, *Laeviomeliola* should be synonymized under *Meliola*. As *Meliola psidii* is already in use, we provide a new name *Meliola psidiicola*. Fresh collection and molecular data are needed to confirm the position of the genus.

Doubtful genera within *Meliolales*

Ceratospermopsis Bat., Mycopath. Mycol. appl. 5: 165 (1951)

Notes: *Ceratospermopsis* was established by Batista (1951), and comprises two species, *C. cupaniae* Bat. and *C. xylopiae* Bat. The type species was not mentioned (Batista 1951; Index Fungorum 2015). We were unable to examine either species which are kept in URM, Brazil despite several requests. *Ceratospermopsis* is characterized by hyphal setae, lack of hyphopodia on the hyphae, globose to subglobose, membranous ascomata, 8-spored, subglobose asci, and muriform, slightly olivaceous, cylindrical to fusoid ascospores, with hyaline appendages (Batista 1951). We suggest that *C. xylopiae* should be the type species of the genus *Ceratospermopsis* based on its morphology. There is no sequence data to clarify the placement of the genus, which is poorly known and appears to lack herbarium material, thus we treat it as doubtful.

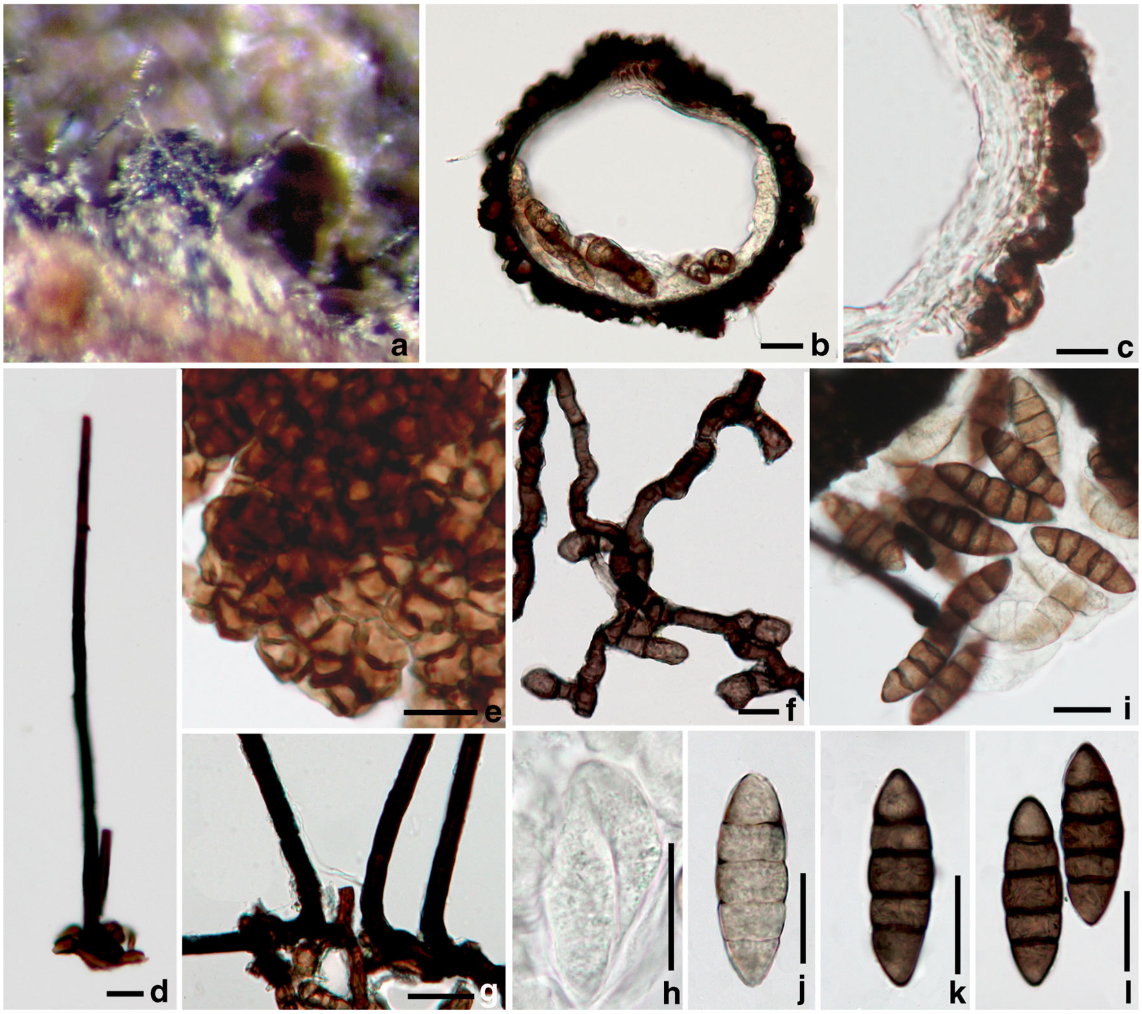


Fig. 25 *Meliola psidiicola* (holotype). **a** Ascoma on substrate. **b** Section through ascoma. **c** Section through peridium. **d** Hyphal seta. **e** Wall of ascoma in a squash mount. **f** Hyphae with capitate hyphopodia. **g** Hyphal setae on superficial hyphae. **h** Ascus when immature. **i**–**l** Ascospores with 4 septa. Scale bars: **b**, **d**, **e**, **g**–**l**=20 μm, **c**, **f**=10 μm

Type species: ***Ceratospermopsis xylopiae*** Bat., Mycopath. Mycol. appl. 5: 166 (1951)

Ectendomeliola Hosag. & D.K. Agarwal, Indian Phytopath. 59(1): 99 (2006)

≡ *Ectendomeliola walsurae* Hosag. & D.K. Agarwal, Indian Phytopath. 59(1): 99 (2006)

Notes: *Ectendomeliola* was established by Hosagoudar and Agarwal (2006) with the type species *E. walsurae*. This genus is characterized by 2-celled, ovate to subcylindrical hyphopodia on the hyphae, straight to curly hyphal setae, acute or rounded at the apex, and oblong to cylindrical ascospores, with 4 septa, and constricted at the septa (Figs. 26 and 27). *Ectendomeliola* is most typical of *Meliola* based on its hyphal setae, but differs in having hyphopodia immersed in host epidermal cells. This genus is also similar to *Endomeliola*, however the hyphopodia form in the epidermal layer, while hyphopodia extend into the mesophyll layer in *Endomeliola*. There are two species placed in the genus, *E. walsurae* from *Walsura trifolia* (A. Juss.) Harms. and *E. otonephelii* from *Otonephelium stipulaceum* (Bedd.) Radlk. (the latter species has longer hyphal setae than *E. walsurae*).

Haraea Sacc. & P. Syd., in Saccardo, Annls mycol. 11(3): 312 (1913)

Facesoffunginumber: FoF00731

Epiphytes on the surface of leaves, stems, and straw. *Superficial hyphae* branched, septate, aggregated, hyphopodia and hyphal setae lacking. **Sexual morph**: *Ascomata* superficial on surface of hosts, gregarious or solitary, globose to subglobose, flattened when immature, membranous to subcarbonaceous, brown to dark brown, and with aggregated hyphae at the margin, ascomatal setae and appendages absent. *Peridium* comprising dark brown of radially arranged cells when immature, with two strata, outer stratum of dark brown cells of *textura angularis*, and inner stratum of hyaline, flattened cells. *Hamathecium* with paraphyses. *Asci* 4–8-spored, rounded at the apex, with thick pedicel (Saccardo 1913). *Ascospores* 2–4-seriate, pale brown to brown, or reddish, oblong to fusoid, 3-septate, slightly constricted at the septa, smooth-walled. **Asexual morph**: Undetermined.

Notes: The genus *Haraea* was established by Saccardo (1913) with type species *H. japonica* Sacc. & P. Syd. It is a good genus but its placement is doubtful because hyphopodia are lacking, and asci were not illustrated. Hence, *Haraea* should be place as a doubtful genus until molecular data are available to verify the placement of this genus. Five species are listed in Index Fungorum (2015).

Type species: ***Haraea japonica*** Sacc. & P. Syd., Annls mycol. 11(3): 312 (1913)

Faces of fungi number: FoF00730

Epiphytes on the surface of leaves, stems, and straw. *Superficial hyphae* branched, septate, aggregate, hyphopodia and hyphal setae lacking. **Sexual morph**: *Ascomata* 100–140 μm diam. × 85–100 μm high ($\bar{x} = 135 \times 95\ \mu m$, n=5), superficial on surface of hosts, gregarious or solitary, globose to subglobose, flattened when immature, membranous to subcarbonaceous, brown to dark brown, and aggregated hyphae at the margin, ascomatal setae and appendages absent. *Peridium* 25–34 μm diam. ($\bar{x} = 31\ \mu m$, n=5), comprising dark brown radially arranged cells when immature, with two strata, outer stratum of thick-walled, dark brown cells of *textura angularis*,

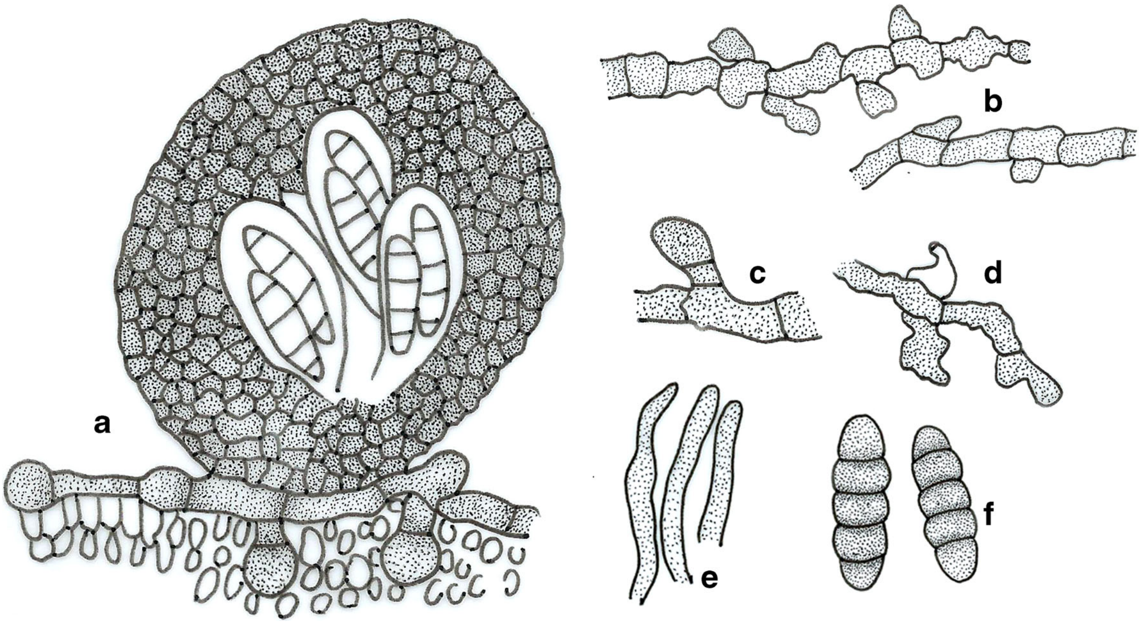


Fig. 26 *Ectendomeliola walsurae* (holotype, redrawn from Hosagoudar and Agarwal 2006). **a** Ascoma on the surface of host (notes: not sectioned and only showing ascoma shape and asci arrangement). **b** Septate hyphae. **c** Capitate hyphopodia on hyphae. **d** Phialides on hyphae. **e** Apex of the hyphal setae. **f** Ascospores with 4 septa

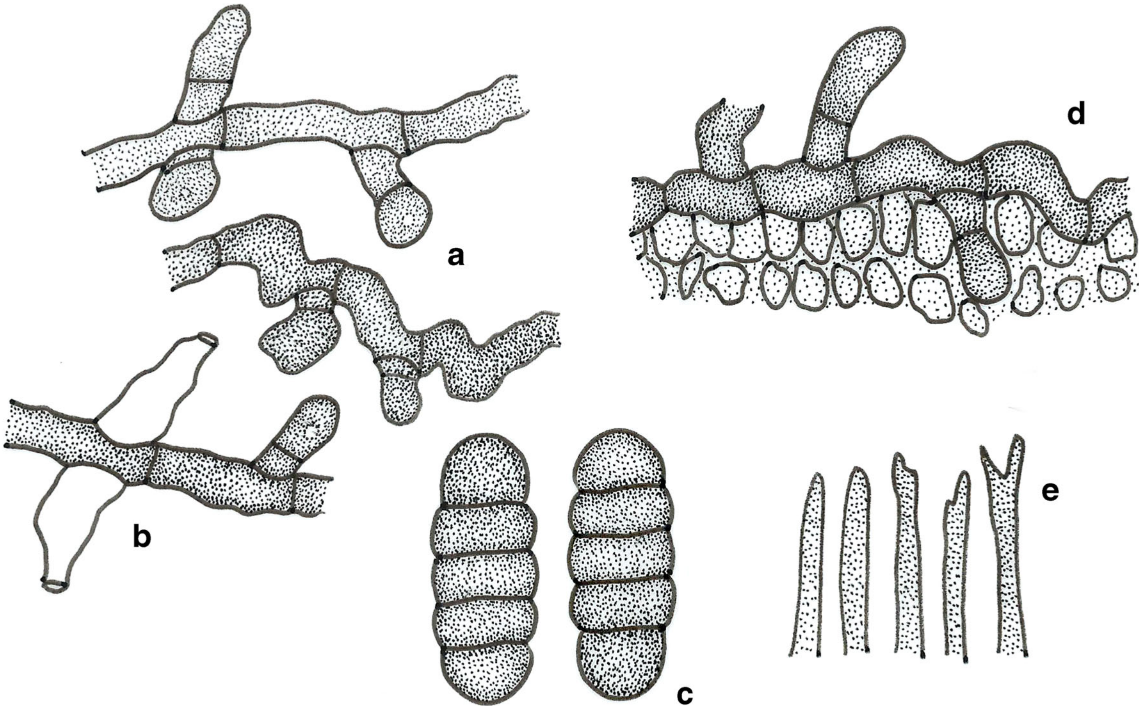


Fig. 27 *Ectendomeliola otonephelii* (holotype, redrawn from Hosagoudar and Archana 2013). **a** Capitate hyphopodia on hyphae. **b** Phialides on hyphae. **c** Ascospores with 4 septa. **d** Hyphopodia immersed in host epidermal cells. **e** Apex of the hyphal setae

and inner stratum of hyaline, flattened cells. *Hamathecium* with paraphyses. *Asci* 4–8-spored, rounded at the apex, with thick pedicel (Saccardo 1913). *Ascospores* 39–40 × 12–14 μm ($\bar{x} = 39 \times 14\ \mu m$, n=5), 2–4-seriate, pale brown to brown, somewhat reddish, oblong to fusoid, 3-septate, slightly constricted at the septa, smooth-walled. **Asexual morph**: Undetermined.

Material examined JAPAN, Prov. Mino, Kawauye-mura, on straw of *Sasa paniculata* (*Poaceae*), January 1913, K. Hara 97 (F10662, **holotype**).

Note: The holotype specimen of *Haraea japonica* is not in good condition. In this study, we could not find the characters to illustrate the asci and hamathecium (Fig. 28). This genus is also typical of *Iodosphaeria* Samuels et al. based on dark brown ascomatal setae, arising from cells at the ascomata surface with a stellate arrangement (Senanayake et al. 2015). Thus, *H. japonica* may be an over mature collection of *Iodosphaeria*, however, many characters were not seen in the type specimen. Hence, a new collection with sequence data are needed to illustrate its morphology and to clarify its placement in phylogenetic tree.

Hypasteridium Speg., Boln Acad. nac. Cienc. Córdoba 26(2-4): 349 (1921)

Notes: The genus was introduced with *Metasteridium* Speg. and *Parasteridium* Speg by Spegazzini (1921). However, no species name was mentioned, and the publication was noted as uncertain by Eriksson and Hawksworth (1988). Thus, we treat the three genera as doubtful until the original publication or herbarium specimens can be examined and emended.

Leptascospora Speg., Physis, Rev. Soc. Arg. Cienc. Nat. 4(no. 17): 284 (1918)

Facesoffunginumber: FoF00735

Epiphytes on the surface of leaves. *Superficial hyphae* branched at the base of ascomata. **Sexual morph**: *Ascomata* superficial, globose to subglobose, flattened above, with colorless appendages. *Hamathecium* with paraphyses. *Asci* 8-spored, cylindrical, rounded at the apex, narrowed at the base. *Ascospores* linear, multiseptate, rounded ends, hyaline, smooth-walled (Raciborski 1909). **Asexual morph**: Undetermined.

Notes: The monotypic genus *Leptascospora* was introduced by Spegazzini (1918), with the type species *L. uredinis*.

Type species: ***Leptascospora uredinis*** (Racib.) Speg., Physis, Rev. Soc. Arg. Cienc. Nat. 4(no. 17): 284 (1918)

Material examined INDONESIA, Java Bogor, on the lower surface of leaves of *Mucuna* sp. (*Fabaceae*), M. Raciborski (ZT Myc 24176, **holotype**).

Notes: *Leptascospora uredinis* was predated as *Hyaloderma uredinis* Racib. We re-examined the holotype material and it is in poor condition, thus, we treat

Fig. 28 *Haraea japonica* (holotype). **a**, **b** Herbarium packet and specimen. **c** Ascomata on host substrate. **d**, **e** Section through ascomata. **f** Hyphae at the base of ascomata. **g** Upper wall of ascoma. **h** Hyphae with septa. **i**–**k** Conidia. Scale bars: **e**=500 μm, **f**–**g**=100 μm, **h**–**m**=10 μm

Leptascospora as doubtful until it can be recollected and sequenced.

Metasteridium Speg.

Notes: *see* under *Hypasteridium* Speg.

Ophiociliomyces Bat. & I.H. Lima, Anais Soc. Biol. Pernambuco 13(2): 29 (1955)

Facesoffunginumber: FoF00743

Epiphytes or *saprobes* on leaves of *Bauhinia*. *Superficial hyphae* and *hyphopodia* lacking. **Sexual morph**: *Ascomata* superficial on the surface of leaves, solitary, globose, collapsing when dry. *Peridium* dark brown, comprising interwoven cells when viewed in squash mounts, darker at rim, with two strata, outer stratum of thick-walled, dark brown cells, and inner stratum of hyaline to pale brown cells. *Asci* 8-spored, bitunicate, clavate to ovoid, or subglobose, apedicellate, apically rounded, without ocular chamber. *Ascospores* fasciculate, hyaline to greyish, fusiform-clavate, 10–13-septate, not constricted at septa, straight to slightly curved, smooth-walled. **Asexual morph**: Undetermined.

Notes: *Ophiociliomyces bauhiniae* is the type species of *Ophiociliomyces* and has different morphology from the members of *Meliolaceae*. Thus, this genus is placed as doubtful. Four species are listed in Index Fungorum.

Type species: ***Ophiociliomyces bauhiniae*** Bat. & I.H. Lima, Anais Soc. Biol. Pernambuco 13(2): 30 (1955)

Facesoffunginumber: FoF00742

Epiphytes or *saprobic* on leaves of *Bauhinia raddiana*. *Superficial hyphae* and *hyphopodia* lacking. **Sexual morph**: *Ascomata* 185–240 μm diam. ($\bar{x} = 211$ μm, $n=5$), superficial on the surface of leaves, solitary, globose, collapsing when dry. *Peridium* 18–27 μm, dark brown, comprising interwoven cells when viewed in squash mounts, darker at rim, with two strata, outer stratum of thick-walled, dark brown cells, and inner stratum of hyaline to pale brown cells. *Hamathecium* lacking pseudoparaphyses. *Asci* 46–67.5 × 13–32 μm ($\bar{x} = 55.5 \times 21$ μm $n=10$), 8-spored, bitunicate, clavate to ovoid, or subglobose, apedicellate, apically rounded, without ocular chamber. *Ascospores* 52–77 × 5–9.5 μm ($\bar{x} = 63.5 \times 7$ μm, $n=20$), fasciculate, hyaline to greyish, fusiform-clavate, 10–13-septate, not constricted at septa, straight to slightly curved, smooth-walled. **Asexual morph**: Undetermined.

Material examined BRAZIL, Pernambuco; Recife, Dois Irmãos., on leaves of *Bauhinia raddiana* Bong. (*Fabaceae*), 5 February 1955, Osvaldo Soares da Silva, (URM 1235, **holotype**).

Notes: The type specimen was re-examined and lacked superficial hyphae, had bitunicate asci and multi-septate, hyaline ascospores (Fig. 29). We therefore treat this genus as doubtful within *Meliolales*.

Ophioirenina Sawada & W. Yamam., in Imazeki et al., Special Publication College of Agriculture, National Taiwan University 8: 35 (1959)

Facesoffunginumber: FoF00745

Epiphytes on the surface of leaves. *Superficial hyphae* branched, septate, with 1-celled hyphopodia. **Sexual morph**: *Ascomata* superficial on surface of leaves, solitary or gregarious, globose to subglobose, glabrous, dark brown to black, central ostiole at maturity. *Peridium* thick, comprising two strata, outer stratum of thick-walled, brown to dark brown cells of *textura angularis* to *globulosa*, inner stratum of hyaline to pale brown, scleroparenchymatous cells of *textura angularis* to *globulosa*. *Hamathecium* aparaphysate. *Asci* 8-spored, unitunicate, clavate, short pedicellate or sometimes apedicellate, ocular chamber absent. *Ascospores* fasciculate, hyaline to brown, clavate to narrowly fusiform, 4–6-septate, not constricted at septa, slightly darker at septa at maturity, smooth-walled. **Asexual morph**: Undetermined.

Notes: *Ophioirenina* was introduced and placed in *Meliolaceae* by Sawada and Yamamoto (in Sawada 1959) based on its superficial hyphae with hyphopodia, and globose ascomata developing in black colonies (Lumbsch and Huhndorf 2010; Patil and Mahamulkar 1999). *Ophioirenina* differs from *Meliolales* species in having 1-celled hyphopodia on the hyphae, papilla with a narrow pore or opening via a rupture, a peridial wall comprising two strata of scleroparenchymatous cells of *textura angularis* and hyaline ascospores. The genus is most typical of *Leptosphaeriaceae* species because of its scleroplectenchyma cells. We treat *Ophioirenina* as *Dothideomycetes* genera, *incertae sedis* until molecular data available.

Type species: ***Ophioirenina theae*** Sawada & W. Yamam., Special Publication College of Agriculture, National Taiwan University 8: 36 (1959)

Facesoffunginumber: FoF00744

Epiphytes on the surface of leaves. *Superficial hyphae* branched, septate, with 1-celled hyphopodia. **Sexual morph**: *Ascomata* 170–220 μm diam. ($\bar{x} = 197\ \mu m$, n=5), superficial on surface of leaves, solitary or gregarious, globose to subglobose, glabrous, dark brown to black, central ostiole at maturity. *Peridium* 43–52 μm ($\bar{x} = 46\ \mu m$, n=5), thick, comprising two strata, outer stratum of thick-walled, brown to dark brown cells of *textura angularis* to *globulosa*, inner stratum of hyaline to pale brown, scleroparenchymatous cells of *textura angularis* to *globulosa*. *Asci* 78–81 × 18–20 μm ($\bar{x} = 80 \times 18\ \mu m$, n=10), 8-spored, unitunicate, clavate, short pedicellate or sometimes apedicellate, ocular chamber absent. *Ascospores* 50–62 × 5–6 μm ($\bar{x} = 58 \times 5\ \mu m$, n=10), fasciculate, hyaline to brown, clavate to narrowly fusiform, 4–6-septate, not constricted at the septa, slightly darker at each septum at maturity, smooth-walled. **Asexual morph**: Undetermined.

Material examined TAIWAN, Shin-Chu, Formosa, on leave of *Camellia sinensis* (L.) Kuntze (*Theaceae*), 11 November 1925, K. Sawada (BPI 698821)

Notes: We found ascomata developing in the black colonies which are quite similar to *Meliolales* species, but differ based on their 1-celled hyphopodia, ascoma wall, and ascospore septation (Fig. 30).

Ophiomeliola Starbäck, Bih. K. svenska VetenskAkad. Handl., Afd. 3 25(no. 1): 22 (1899)

Facesoffunginumber: FoF00747

Epiphytes or *pathogens* on surface of living leaves. *Superficial hyphae* septate, dark brown, without hyphopodia. **Sexual morph**: *Ascomata* superficial on surface of leaves, solitary, subglobose to ovoid, covered with aerial hyphae, with apical, papillate ostiole. *Peridium* comprising two strata, outer stratum of thick-walled, dark brown to black cells of *textura globulosa*, and inner stratum of hyaline to pale brown cells, scleroparenchymatous cells of *textura globulosa* to *angularis*. *Hamathecium* comprising filiform paraphyses embedded in a gelatinous matrix. *Asci* 8-spored, unitunicate, clavate to cylindrical, with long pedicel. *Ascospores* fasciculate, hyaline, cylindrical to narrowly fusiform, 7-septate, not constricted at septa, slightly curved, tapering toward the ends, smooth-walled. **Asexual morph**: Undetermined.

Notes: *Ophiomeliola* was introduced by Starbäck (1899), with the type species *Ophiomeliola lindmanii*. Four species are listed for this genus in Index Fungorum and all lack molecular data. This genus cannot be placed in *Meliolaceae* based on its fusiform, 7-septate, hyaline ascospores, but it may belong to *Lasiosphaeriaceae* based on its ascomata wall. However, we treat this as *Sordariomycetes* genus *incertae sedis* until molecular data becomes available.

Type species: ***Ophiomeliola lindmanii*** Starbäck, Bih. K. svenska VetenskAkad. Handl., Afd. 3 25(no. 1): 22 (1899)

Facesoffunginumber: FoF00746

Epiphytes or *pathogens* on surface of living leaves. *Superficial hyphae* septate, dark brown, without hyphopodia. **Sexual morph**: *Ascomata* 310–345 μm high × 270–345 μm diam. ($\bar{x} = 334 \times 295\ \mu m$, n=3), superficial on surface of leaves, solitary, subglobose to ovoid, covered with aerial

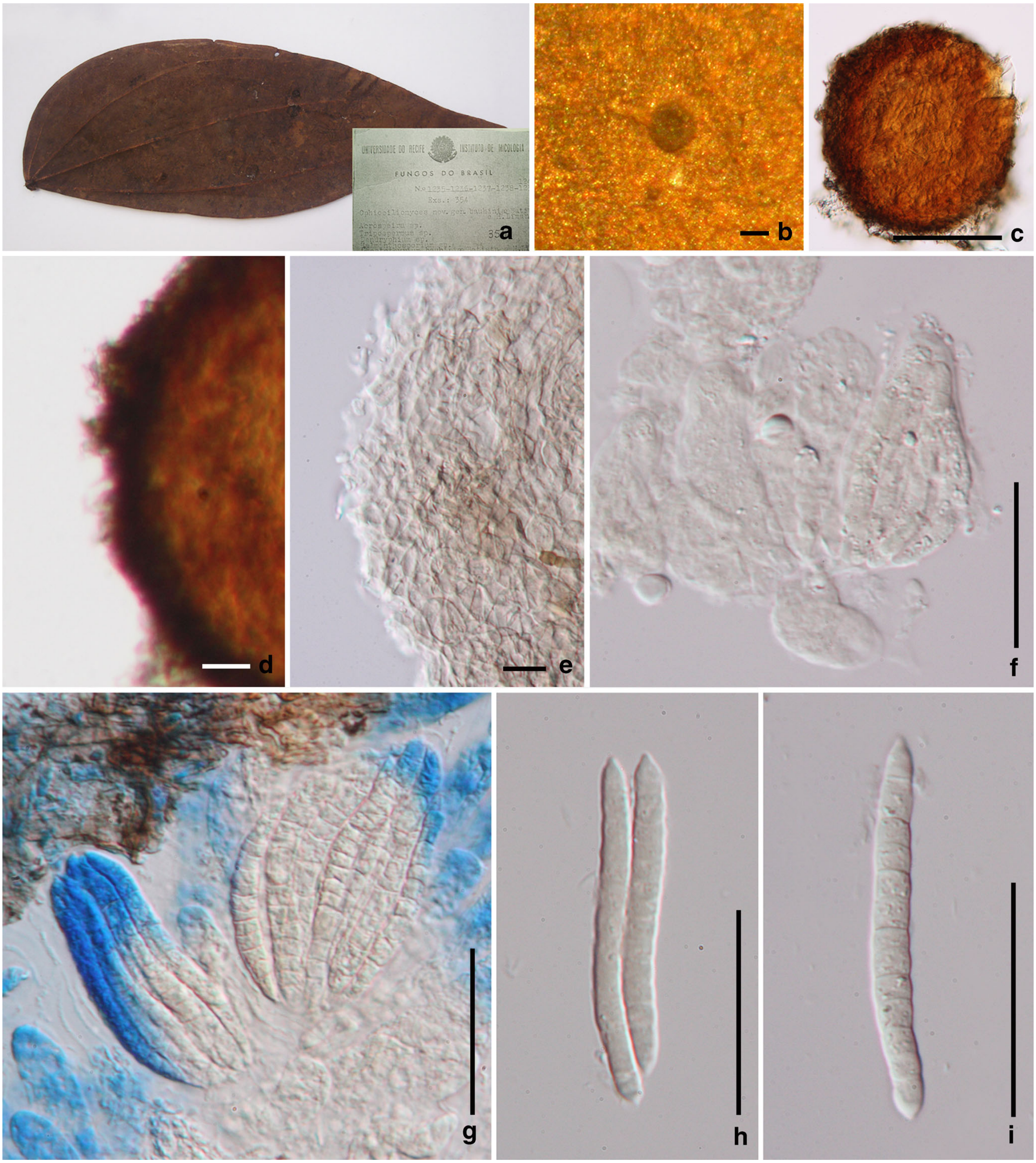


Fig. 29 *Ophiociliomyces bauhiniae* (holotype). **a** Herbarium material and specimen. **b** Ascoma on substrate. **c** Squash mount of ascoma. **d**, **e** Peridium and ascoma wall. **f**, **g** Asci at young and mature stages (**g** mounted in cotton blue reagent). **h**, **i** Ascospores. Scale bars: **b**, **c** =100 μm, **d**=20 μm, **e**=10 μm, **f**–**i**=40 μm

hyphae, with apical, papillate ostiole. *Peridium* 35–40 μm, comprising two strata, outer stratum of dark brown to black cells of *textura globulosa*, and inner stratum of hyaline to pale brown, scleroparenchymatous cells of *textura globulosa* to *angularis*. *Hamathecium* comprising filiform paraphyses embedded in a gelatinous matrix. *Asci* 121–141 × 17.5–20 μm ($\bar{x} = 135 \times 19$ μm, n=15), 8-spored, unitunicate, clavate to cylindrical, with long pedicel. *Ascospores* 88–125 × 3–6 μm

Fig. 30 *Ophioirenina theae* (holotype). **a**, **b** Herbarium packet and specimen. **c**, **d** Ascomata on substrate. **e** Section through ascomata. **f** Peridium and ascoma wall. **g** Ascoma when immature. **h** Hyphae with 1-celled appressoria. **i**, **j** Asci with 8-spores. **k**, **l** Ascospores. Scale bars: **e**=50 μm, **f**–**l**=20 μm

($\overline{x}$ = 109 × 5 μm, n=20), fasciculate, hyaline, cylindrical to narrowly fusiform, 7-septate, not constricted at septa, slightly curved, tapering toward the ends, smooth-walled. **Asexual morph**: Undetermined.

Material examined BRAZIL, Rio Grande do Sul, Hamburgerberg pr Porto Alegre, on leaves of *Myrtacea cujusdam* (*Myrtaceae*), September 1892, C.A.M. Lindman No. 37 (SF10033, **holotype**).

Notes: *Ophiomeliola lindmanii* is typical of species in *Lasiosphaeriaceae* in having aerial hyphae, a peridium comprising two strata, with the outer strata of dark brown to black cells of *textura globulosa* to *angularis*, unitunicate asci, and hyaline, multi-septate ascospores (Fig. 31). Molecular data is needed to clarify the placement.

Parasteridium Speg., Boln Acad. nac. Cienc. Córdoba 26(2-4): 349 (1921)

Notes: *see* under *Hypasteridium* Speg.

Pauahia F. Stevens, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 17 (1925)

Facesoffunginumber: FoF00749

Epiphytes on the surface of *Sideroxylon*. *Superficial hyphae* and *hyphopodia* absent. **Sexual morph**: *Ascostromata* superficial or erumpent at the base, pseudostromata, solitary, subglobose or irregular, thick-walled. *Locules* immersed in ascostromata, 1–multi-loculate. *Peridium of locules* comprising two strata, outer stratum of dark brown cells of *textura angularis*, and inner stratum of hyaline to pale brown, flattened cells. *Hamathecium* with paraphyses. *Asci* 2-spored, bitunicate, broadly clavate to oval, with short pedicel, evanescent. *Ascospores* 2-seriate, hyaline to brown, oblong to cylindrical, 3-septate, constricted and darker at the septa, terminal cells markedly smaller and slightly lighter than the others, thin sheath present at maturity, smooth-walled. **Asexual morph**: Undetermined.

Notes: The genus *Pauahia* was established within the family *Dothideaceae* in the section *Leveillelleae* by Stevens (1925). *Pauahia* is monotypic with *Pauahia sideroxyli* as its type species. We re-examined the type specimen of *P. sideroxyli* and found that the species differs from other genera in *Meliolaceae* in having pseudostromata, and lacking superficial hyphae.

Type species: ***Pauahia sideroxyli*** F. Stevens, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 17 (1925)

Facesoffunginumber: FoF00748

Epiphytes on the surface of *Sideroxylon*. *Superficial hyphae* and *hyphopodia* absent. **Sexual morph**: *Ascostromata* 700–1200 μm diam. × 353–410 μm high ($\bar{x} = 1000 \times 365\ \mu m$, $n=2$), superficial or erumpent at the base, solitary, pseudostromata, subglobose or irregular, thick-walled. *Locules* 200–235 × 165–219 μm ($\bar{x} = 208 \times 179\ \mu m$, $n=5$), immersed in ascostromata, 1–multi-loculate. *Peridium of locules* comprising two strata, outer stratum of dark brown cells of *textura angularis*, and inner stratum of hyaline to pale brown, flattened cells. *Hamathecium* with paraphyses. *Asci* 46–82 × 25–45 μm ($\bar{x} = 70 \times 36\ \mu m$, $n=5$), 2-spored, bitunicate, broadly clavate to oval, with short pedicel, evanescent. *Ascospores* 20–23 × 62–77 μm ($\bar{x} = 22 \times 65\ \mu m$, $n=5$), 2-seriate, hyaline to brown, oblong to cylindrical, 3-septate, constricted and darker at the septa, terminal cells markedly smaller and slightly lighter than the others, thin sheath present at maturity, smooth-walled. **Asexual morph**: Undetermined.

Notes: *Pauahia sideroxyli* is a single species in the genus *Pauahia*. We re-examined the type specimen which is very small and in poor condition, and found that *Pauahia sideroxyli* differs from *Meliolales* species in having a large pseudostromata, erumpent in host epidermal cells, and bitunicate asci (Fig. 32). Molecular data is lacking, so we cannot clarify the placement of this genus. Therefore, *Pauahia sideroxyli* is placed as *Dothideomycetes* genera, *incertae sedis* until it can be recollected and sequenced.

Material examined USA, Hawaii, Maui, Nahiku, on *Planchonella sandwicensis* (A.Gray) Pierre (*Sapotaceae*), January 1909, Lyon H. L. no. 61 (ILL00011484, **holotype**; BISH 499038, **isotype**).

Pleomeliola (Sacc.) Sacc., Syll. fung. (Abellini) 14(1): 17 (1899)

≡ *Meliola* subgen. *Pleomeliola* Sacc., Syll. fung. (Abellini) 1: 70 (1882)

Notes: *Pleomeliola* contains three species which are listed in Index Fungorum (2015) with the type species as *Pleomeliola fenestrata* (Cooke & Ellis) Sacc. The genus is characterized by subglobose, membranacous, reddish brown ascomata, 8-spored, ovoid asci, and cylindrical or clavate, muriform, 4–5-septate, hyaline to brown ascospores. We could not found any ascomata or hyphae on the holotype specimen. Hansford examined this specimen in 1952, and noted on the packet "This specimen is not *Meliola*" (Fig. 33) . We also exclude this genus from *Meliolales*. There is no molecular data available for this genus.

Type species: ***Pleomeliola fenestrata*** (Cooke & Ellis) Sacc., Syll. fung. (Abellini) 14(1): 17 (1899)

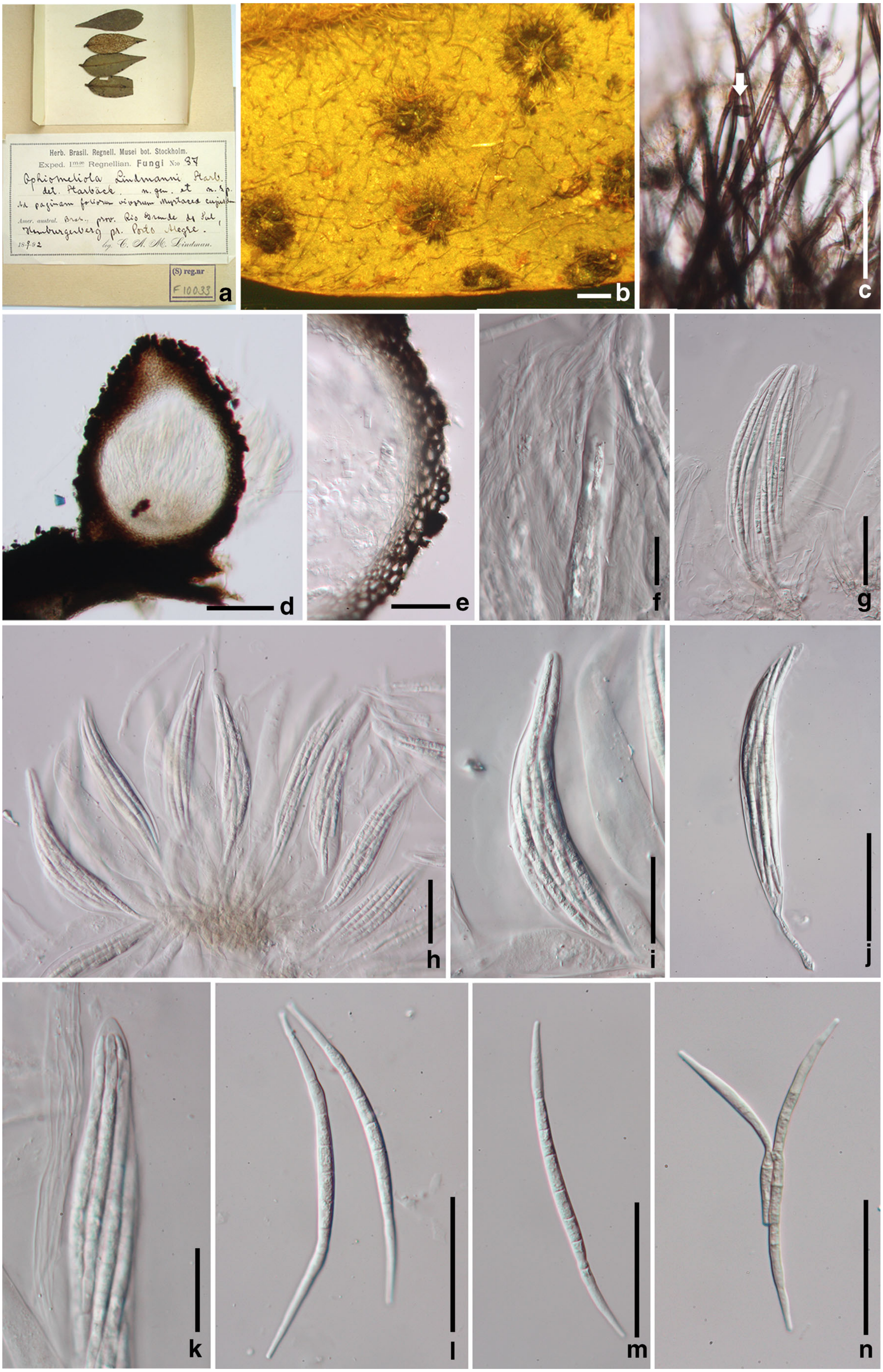
Material examined USA, New Jersey, on scales of pine cones (*Pinaceae*), MC. Cooke 2465 ex herb. (K(M) 193124, **holotype**).

Pleomerium Speg., Physis, Rev. Soc. Arg. Cienc. Nat. 4(no. 17): 284 (1918)

Facesoffunginumber: FoF00751

Epiphytes on the lower surface of leaves. *Superficial hyphae* branched, septate, darker at each septum, brown, lacking hyphopodia and hyphal setae. **Sexual morph**: *Ascomata* superficial, solitary on superficial hyphae, easily removed, subglobose to globose, surrounded and covered by hyphae,

Fig. 31 *Ophiomeliola lindmanii* (holotype). **a** Herbarium packet and material. **b**. Ascomata on substrate. **c** Aerial hyphae. **d** Vertical section of ascoma. **e** Peridium. **f** Paraphyses. **g**–**k** Unitunicate asci. **i**–**n** Ascospores. Scale bars: **b**=1 mm, **c**, **d**, **g**–**n**=50 μm, **e**=40 μm, **f**=20 μm ▶


Herb. Brasil. Regnell. Musei bot. Stockholm.
Exped. I^me Regnellian. Fungi N:o 37
Ophiomeliola Lindmanni Starb.
det. Starbäck. n. gen. et n. sp.
Ad paginam foliorum vivorum Myrtaceæ cujusdam
Amer. austral. Bras., prov. Rio Grande do Sul,
Hamburgerberg pr. Porto Alegre.
1892
leg. C. A. M. Lindman.
(S) reg.nr
F10033
a
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l
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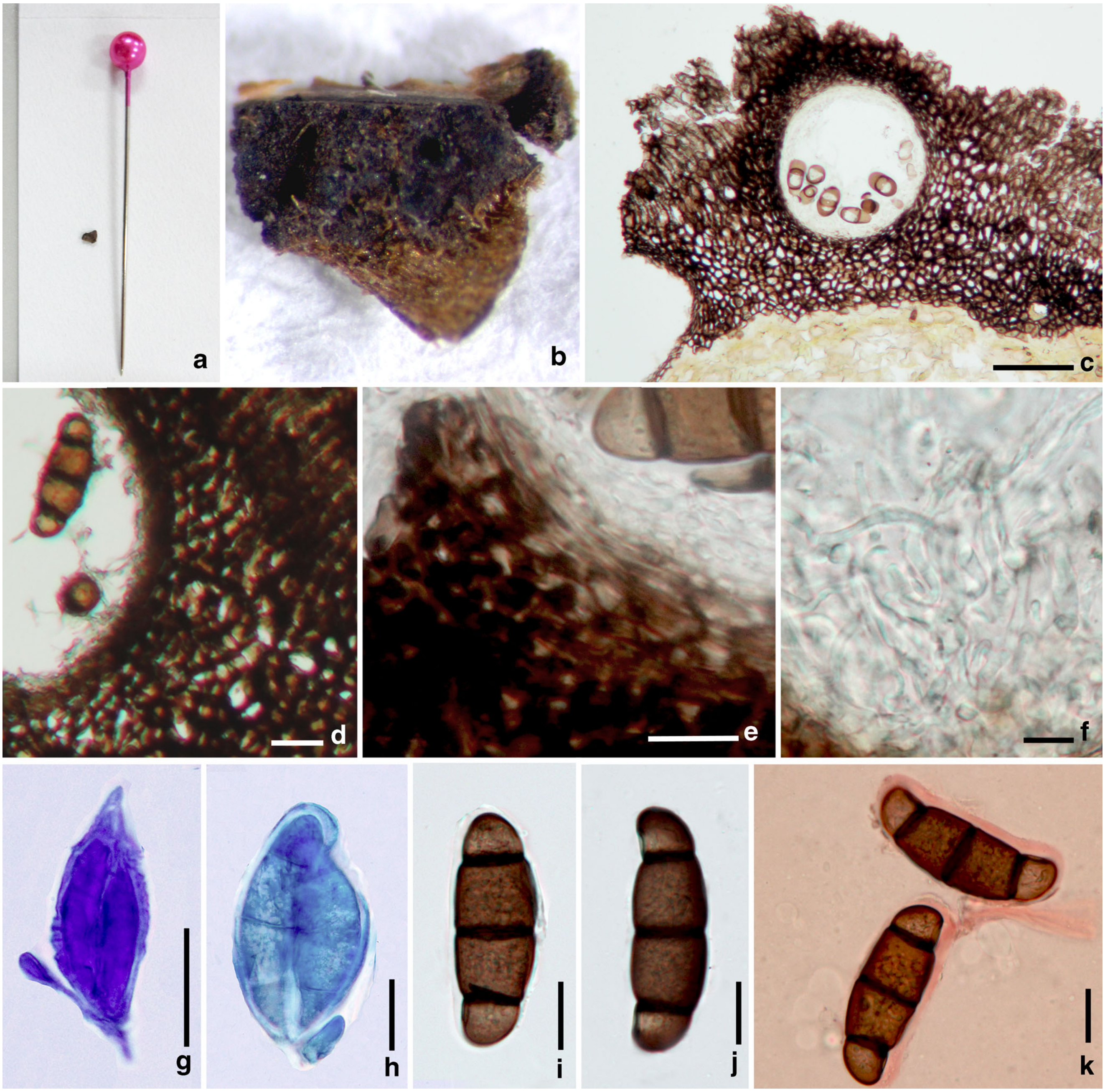


Fig. 32 *Pauahia sideroxyli* (holotype). **a** Specimen. **b** Ascostromata on substrate. **c** Section through ascostromata showing locule. **d**, **e** Peridium of ascostromata. **f** Hamathecium. **g**, **h** Asci with 2-spores in cotton blue reagent. **i**, **j** Ascospores with 3 septa and lighter end cells. **k** Ascospores in congo red reagent. Scale bars: **c**=100 μm, **d**, **e**, **g**–**k**=20 μm, **f**=10 μm

thin-walled. *Peridium* thin, membranous, comprising brownish to dark brown, interwoven cells when viewed in squash mounts. *Hamathecium* lacking pseudoparaphyses. *Asci* 8-spored, bitunicate, obovoid to subglobose, short pedicel or absent, ocular chamber not well developed. *Ascospores* 3–4-seriate, hyaline to brown, oblong to fusiform, muriform, 4–8 transverse septa, 1–2 longitudinal septa, not constricted but darker at septa, surrounded and covered by mucilage, smooth-walled. **Asexual morph**: *Conidia* oblong, 1-celled (Rehm 1901).

Notes: The monotypic genus *Pleomerium* was established within the family *Englerulaceae* by Spegazzini (1918). This genus differs from *Meliolales* species in having superficial hyphae without hyphopodia, bitunicate asci, and muriform ascospores. Molecular data is not available in GenBank. Hence, we suggest that the genus should be placed as *Dothideomycetes* genera, *incertae sedis*, until sequence data can clarify its placement.

Type species: ***Pleomerium fuscoviridescens*** (Rehm) Speg., Physis, Rev. Soc. Arg. Cienc. Nat. 4(no. 17): 284 (1918)


229/4
HOLOTYPE

K(M): 193124 HERB. HORT. BOT. REG. KEW
USA : [New Jersey]
Meliola fenestrata Cooke & Ellis
sine loc.
on scales of pine cones
Alt.(m): Date:
Coll. 2465 (ex herb. M.C. Cooke)
Add. info. ☐ Type: ☑
Det. 1.2.3.1

Meliola fenestrata Cke
HERB. MYCOL. M. C. COOKE. 1885.
2465 on scales of pine cones with the previous no.

Not a Meliola!
C. G. Hansford 4.9.1952.

Fig. 33 *Pleomeliola fenestrata* (holotype). **a**–**d** Herbarium packet and specimen

≡ *Limacinia fuscoviridescens* Rehm, Hedwigia 40: 168 (1901)

≡ *Naetrocymbe fuscoviridescens* (Rehm) Bat. & Cif., Saccardoa 2: 159 (1963)

Facesoffunginumber: FoF00750

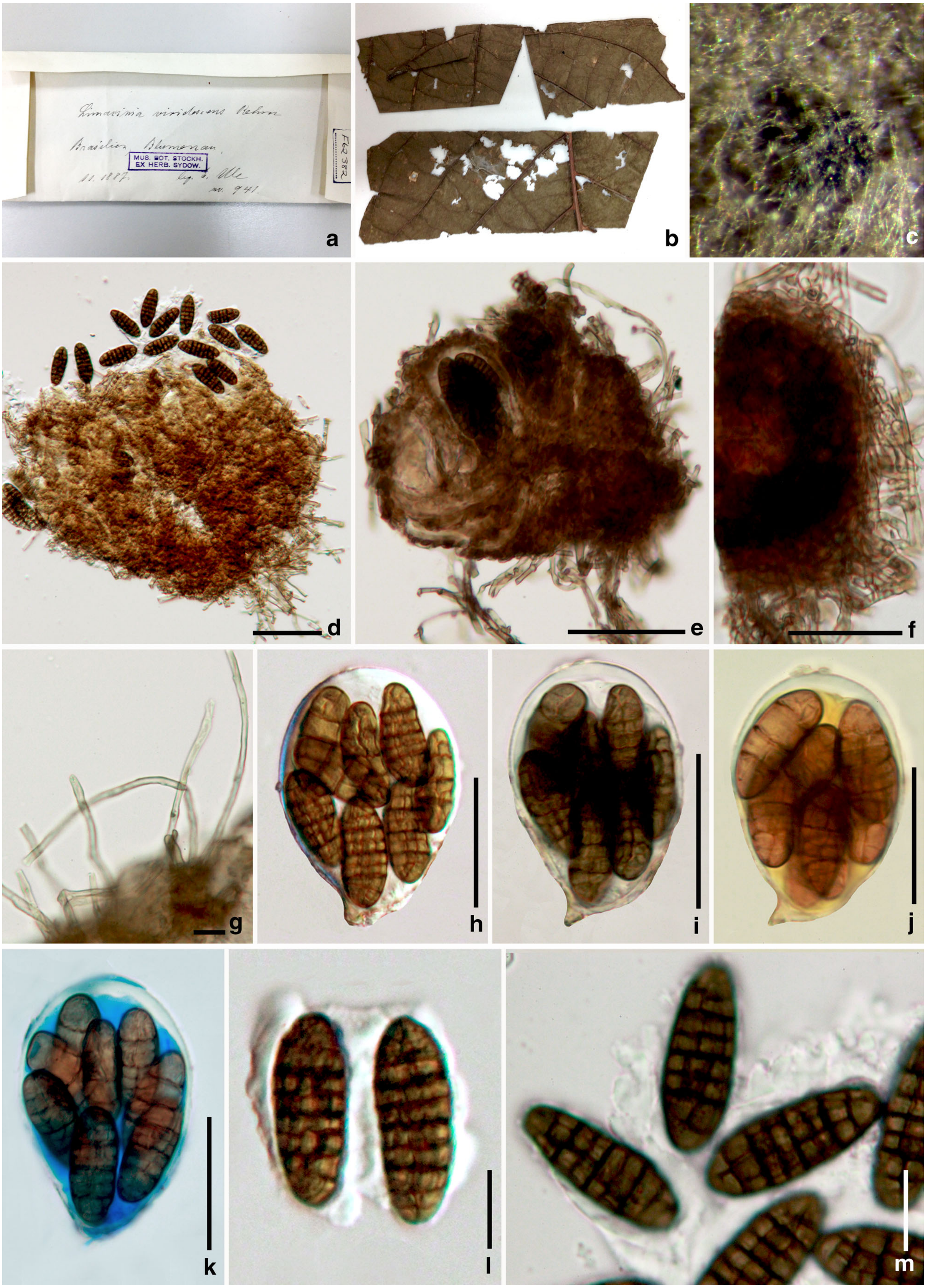
Epiphytes on the lower surface of leaves. *Superficial hyphae* branched, septate, darker at septa, brown, lacking hyphopodia and hyphal setae. **Sexual morph**: *Ascomata* 280–350 μm diam. ($\bar{x}$ = 312 μm, n=5), superficial, solitary on superficial hyphae, easily removed, subglobose to globose, surrounded and covered by hyphae, thin-walled. *Peridium* thin, membranous, comprising brownish to dark brown, interwoven cells when viewed in squash mounts. *Hamathecium* lacking pseudoparaphyses. *Asci* 84–96 × 58–63 μm ($\bar{x}$ = 87 × 60 μm, n=5), 8-spored, bitunicate, obovoid to subglobose, short pedicel or absent, ocular chamber not well-developed. *Ascospores* 44–47 × 16–17 μm ($\bar{x}$ = 45 × 16 μm, n=10), 3–4-seriate, hyaline to brown, oblong to fusiform, muriform, 4–8 transverse septa, 1–2 longitudinal septa, not constricted but darker at septa, surrounded and covered by mucilage, smooth-walled. **Asexual morph**: Undetermined.

Notes: *Pleomeliola fuscoviridescens* was introduced as *Limacinia fuscoviridescens* by Rehm (1901). We re-examined the holotype specimen of *P. fuscoviridescens* and found that it differs from other species in *Meliolales* (Fig. 34) This genus may belong in *Englerulaceae* because of its membranous ascomata, containing few asci, lack of ostiole, and dissolving at centre to release bitunicate asci. However, molecular data is needed to clarify its placement.

Material examined BRAZIL, Santa Catarina, Blumenau, on leaves of undetermined host, November 1887, E. Ule 941 b (SF7084, **holotype** of *Limacinia fuscoviridescens* Rehm).

Prataprajella Hosag., Nova Hedwigia 55(1-2): 224 (1992)

Notes: *Prataprajella* was introduced by Hosagoudar (1992). The type species was found on leaves of *Turpinia malabarica*, and was deposited in HCIO, which will not loan


Limacinia viridescens Rehm
Brasilien Blumenau
11. 1887. leg. E. Ule
n. 941
MUS. BOT. STOCKH.
EX HERB. SYDOW.
F62382
a
b
c
d
e
f
g
h
i
j
k
l
m

◀ **Fig. 34** *Pleomerium fuscoviridescens* (holotype). **a**, **b** Herbarium packet and specimen. **c** Ascoma on substrate. **d** Ascoma viewed in squash mount. **e** Section through ascoma. **f** Upper wall cells of young ascoma. **g** Mycelium. **h** Ascus with 8-spores. **i** Ascus in 70 % lactic acid. **j** Ascus in Melzer's reagent. **k** Ascus in cotton blue reagent. **l**–**m** Ascospores at maturity. Scale bars: **d**, **e**=100 *μm*, **f**, **h**–**k**=50 *μm*, **g**, **l**=20 *μm*

specimens outside India. Therefore, a re-drawing from Hosagoudar (2006) is provided here (Fig. 35). *Prataprajella* is characterized by superficial hyphae with globose to stellate hyphopodia, hyphal setae lacking, globose to subglobose ascomata, with raised ascomatal setae, and conical appendages, brown, 3-septate ascospores (Hosagoudar 2006). We treat *Prataprajella* as a doubtful genus until the type specimen can be re-examined, or fresh collection can be collected and sequenced.

Type species : ***Prataprajella turpiniicola*** (Hosag.) Hosag., Nova Hedwigia 55(1-2): 225(1992)

Ticomyces Toro, J. Agric. Univ. Puerto Rico 36: 48 (1952)

Possible synonyms

= *Tonduzia* F. Stevens, Illinois Biol. Monogr. (Urbana) 11(2): 16 (1927)

= *Dontuzia* L.D. Gómez, Brenesia 2: 21 (1973)

Notes: *Ticomyces* was predated as *Tonduzia* Stevens in the family *Perisporiaceae* (Stevens 1927), with the type species *T. psychotriae* Stevens. Toro (1952) introduced *Ticomyces* in *Meliolaceae* (Kirk et al. 2008). However, the genus differs from other species in *Meliolales* in having superficial aseptate hyphae without hyphopodia. Ascospores are hyaline with several septa (Batista 1951). There is no molecular data available for this genus, thus we treat *Ticomyces* in *Sordariomycetes* genera, *incertae sedis*.

Type species: ***Ticomyces psychotriae*** (F. Stevens) Toro, J. Agric. Univ. P. Rico 36: 49 (1952)

Tonduzia psychotriae F. Stevens, Illinois Biol. Monogr. (Urbana) 11(2): 168 (1927)

Dontuzia psychotriae (F. Stevens) L.D. Gómez, Brenesia 2: 21 (1973)

Material examined COSTA RICA, Columbiana, on *Psychotria brachiate* Sw. (*Rubiaceae*), 19 July 1923, F.L. Stevens 570 (ILL00011485, glass slide from **holotype**).

Notes: We re-examined the type specimen of *Ticomyces psychotriae* but could not see asci and ascospores (Fig. 36). Therefore, new fresh collection and sequence data are needed to clarify placement of the genus.

Urupe Viégas, Bragantia 4(1-6): 125 (1944)

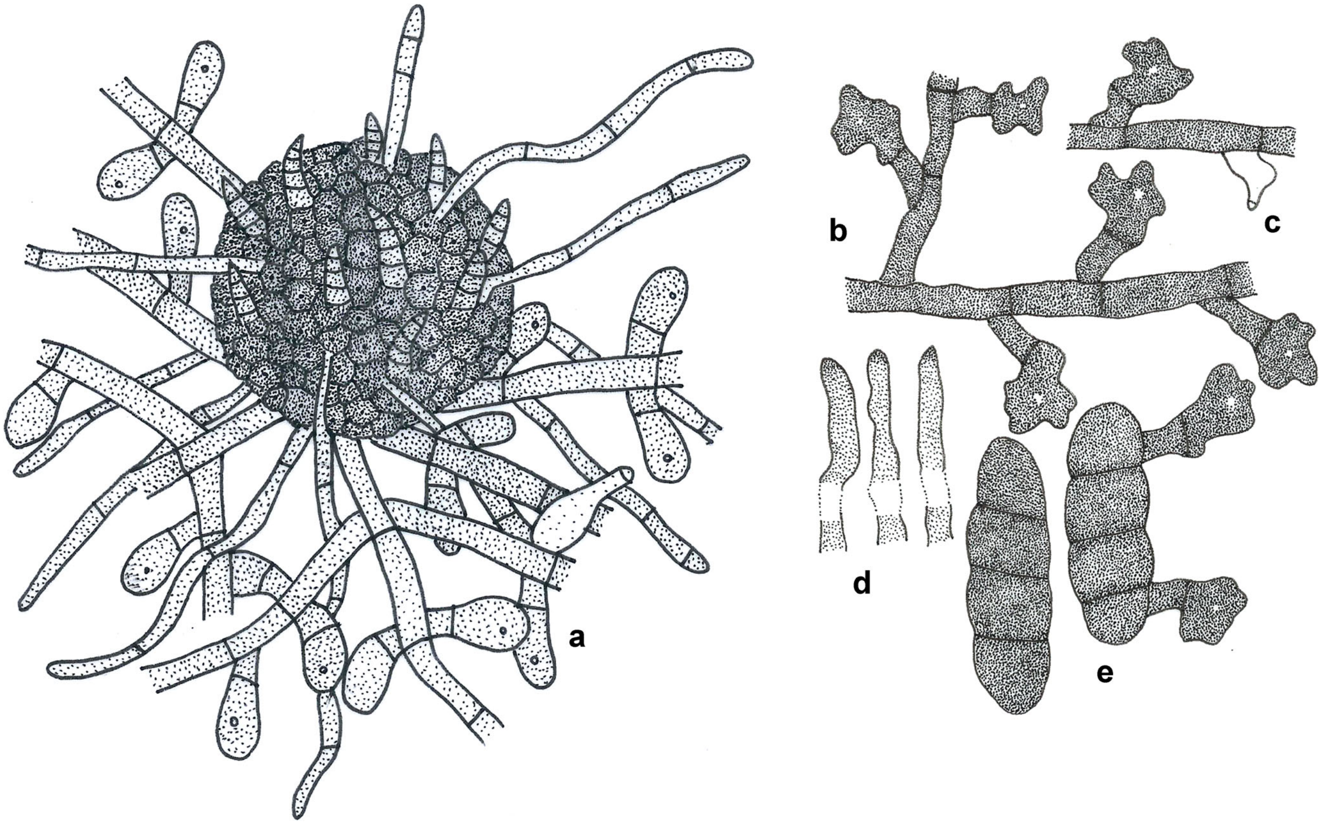
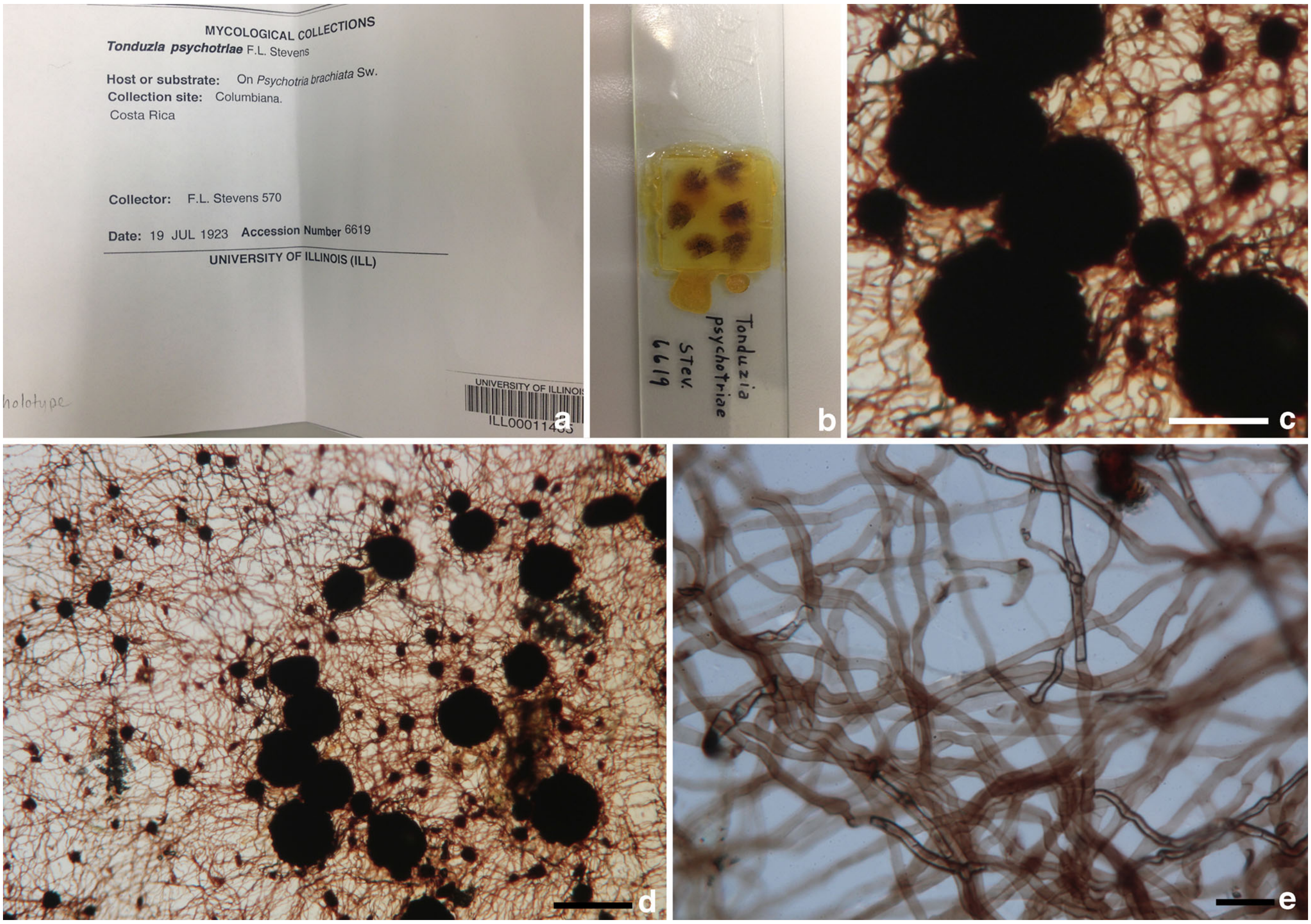


Fig. 35 *Prataprajella* sp. (**a** redrawn from Hosagoudar 2006), ***Prataprajella turpiniicola*** (**b**–**e** redrawn from Hosagoudar and Riju 2013). **a** Ascoma with appendages and setae surrounded by septate hyphae with capitate hyphopodia and phialides. **b** Stellate hyphopodia on hyphae. **c** Stellate hyphopodia mixed with phialides on hyphae. **d** Setae with rounded ends. **e** Ascospores with 3 septa and germinated ascospore



MYCOLOGICAL COLLECTIONS
Tonduzia psychotriae F.L. Stevens
Host or substrate: On *Psychotria brachiata* Sw.
Collection site: Columbiana.
Costa Rica
Collector: F.L. Stevens 570
Date: 19 JUL 1923 Accession Number 6619
UNIVERSITY OF ILLINOIS (ILL)

Fig. 36 *Ticomyces psychotriae* (holotype). **a** Herbarium packet. **b** Glass slide. **c**, **d** Ascomata developed on hyphae. **e** Hyphae without hyphopodia

Notes: *Urupe* was introduced by Viégas (1944) and is a monotypic genus. The genus is characterized by intercellular hyphae, reddish ascomata, clavate asci with 8-spores, and hyaline, 3-septate ascospores (Viégas 1944). We were unable to borrow the type species, therefore, we treat *Urupe* as *Sordariomycetes* genera, *incertae sedis* based on morphology as illustrated in Viégas (1944).

Type species: ***Urupe guaduae*** Viégas, Bragantia 4(1-6): 125 (1944)

Xenostigme Syd., Annls mycol. 28(5/6): 434 (1930)

Notes: *Xenostigma* was established by Sydow (1930) with the type species *X. trichophila* Syd. The genus is monotypic and differs from *Meliolales* species in having slimy ascomata at maturity, with light grey cells, asci with 8-spores, and dark brown to black, 1-septate ascospores (Sydow 1930). We were unable to locate type material of *Xenostigme trichophila*. Thus, we place *Xenostigme* as *Sordariomycetes* genera, *incertae sedis* until molecular data is available.

Type species: ***Xenostigme trichophila*** Syd., Annls mycol. 28(5/6): 434 (1930)

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References

Ainsworth GC (1963) Ainsworth and Bisby's dictionary of the fungi, 5th edn. Commonwealth Mycological Institute, Kew, p 547

Ainsworth GC, James PW, Hawksworth DL (1971) Ainsworth & bisby's dictionary of the fungi, 6th edn. CAB, Kew

Ariyawansa HA, Hawksworth DL, Hyde KD, Jones EBG, Maharachchikumbura SSN, Manamgoda DS, Thambugala KM, Udayanga D, Camporesi E, Daranagama A, Jayawardena R, Liu JK, McKenzie EHC, Phookamsak R, Senanayake IC, Shivas RG, Tian Q, Xu JC (2014) Epitypification and neotypification: guidelines with appropriate and inappropriate examples. Fungal Divers 69(1):57–91

Barr ME (1976) Perspectives in the ascomycotina. Mem New York Bot Gard 28:1–8

Barr ME, Huhndorf SM (2001) *Loculoascomycetes*. Mycota 7A:283–305

Batista AC (1951) Alguns fungos de fumagina de Pernambuco. Mycopathol Mycol Appl 5(2–3):147–172

Batista AC, da Silva MH (1960) Dois novos gêneros de fungos Meliolaceae. Atas do Inst de Micol da Univ do Recife 1:221–227

Boedijin KB (1961) Notes on the *Meliolales*. Persoonia 1(4):393–404

Cai L, Jeewon R, Hyde KD (2006) Phylogenetic investigations of *Sordariaceae* based on multiple gene sequences and morphology. Mycol Res 110:137–150

Cai L, Guo XY, Hyde KD (2008) Morphological and molecular characterization of a new anamorphic genus *Cheirosporium*, from freshwater in China. Persoonia 20:53–58

Cannon PF, Kirk PM (2007) Fungal families of the world. CABI Bioscience, Wallingford

Chomnunti P, Schoch CL, Aguirre-Hudson B, KoKo TW, Hongsanan S, Jones EBG, Kodsub R, Chukeatirote E, Bahkali AH, Hyde KD (2011) *Capnodiaceae*. Fungal Divers 51:103–134

Chomnunti P, Hongsanan S, Hudson BA, Tian Q, Peršoh D, Dhami MK, Alias AS, Xu J, Liu X, Stadler M, Hyde KD (2014) The sooty moulds. Fungal Divers 66:1–36

Cooke MC (1882) The *Perisporiaceae* of Saccardo's sylloge fungorum. Grevillea 11(57):35–38

Emmett RW, Parbery DG (1975) Appressoria. Ann Rev Phytopathol 13: 147–165

Eriksson OE (1981) The families of bitunicate ascomycetes. Nord J Bot 1(6):800–800

Eriksson OE, Hawksworth DL (1988) Notes on ascomycete systematics – nos 552–732. Syst Ascomycetum 7(1):59–101

Eriksson OE, Hawksworth DL (1993) Notes on ascomycete systematics – nos 1530–1610. Syst Ascomycetum 12(1–2):23–50

Fries E (1825) Systema orbis. Vegetabilis 2:1–373

Gaillard A (1891) Les hyphopodies myceliennes des Meliola. Bull Trimest Soc Mycol Fr 7:99–101

Gäumann E (1964) Die Pilze. Brikhäuser, Basel

Goos RD, Andersons JH (1974) The meliolaceae of Hawaii. Sydowia 26: 73–80

Goos RD, Gessner RV (1975) Hyphal modifications of *Sphaerulina pedicellata*: appressoria or hyphopodia? Mycologia 67:1035–1038

Goos RD (1974) A scanning electron microscope and in vitro study of *Meliola palmicola*. Proc Lowa Acad Sci 81:23–27

Goos RD (1978) Field and laboratory studies of meliolaceous fungi in Hawaii. Mycologia 70:996–1006

Gregory SS, John WT (1999) Phylogenetic relationships of *Meliola* and *Meliolina* inferred from nuclear small subunit rRNA sequences. Mycol Res 103(8):1049–1056

Hall TA (2004) BioEdit. Ibis Therapeutics, Carlsbad, CA, 92008, USA. (http://www.mbio.ncsu.edu/BioEdit/bioedit.html). 18 March 2005

Hansford CG (1946) The foliicolous Ascomycetes and their parasites and associated fungi. Mycol Pap 15:1–240

Hansford CG (1961) The *Meliolaceae* a monograph. Sydowia Beih 2:1–806

Hansford CG (1963) Iconographia meliolinearum. Sydowia Beih 5:285

Hawksworth DL, Eriksson OE (1986) The names of accepted orders of ascomycetes. Syst Ascomycetum 5(1):175–184

Hawksworth DL, Sutton BC, Ainsworth GC (1983) Ainsworth and Bisby's dictionary of the fungi, 7th edn. Commonwealth Mycological Institute, Kew

Hawksworth DL, Kirk PM, Sutton BC, Pegler DN (1995) Ainsworth and Bisby's dictionary of the fungi, 8th edn. CAB International, Wallingford

Hirata K (1971) Host range and geographic distribution of *Erysiphaceae* as viewed from the families of Angiosperms, and comparison with *Meliolineae*. Sydowia 25:100–118

Hofmann TA (2009) Plant parasitic *Asterinaceae* and *Microthyriaceae* from the Neotropics (Panama). PhD thesis. 408pp. The faculty of biological sciences at the J.W.Goethe-University Frankfurt am Main, Germany

Hongsanan S, Li YM, Liu JK, Hofmann T, Piepenbring M, Bhat JD, Boonmee S, Doilom M, Singtripop C, Tian Q, Mapook A, Zeng XY, Bahkali AH, Xu JC, Mortimer PE, Wu XH, Yang JB, Hyde KD (2014) Revision of genera in asterinales. Fungal Divers 68:1–68

Hosagoudar VB (1987) *Meliolaceae* of S.India, 1. Eeon Tax Bot 11(1): 157–160

Hosagoudar VB (1992) *Prataprajella*, a new genus of the family *Meliolaceae*. Nova Hedwigia 55:223–226

Hosagoudar VB (1994) *Meliolales* of India. J Econ Taxon Bot 18(2):253–265

Hosagoudar VB (1996) *Meliolales* of India. Botanical Survey of India, Calcutta, p 363

Hosagoudar VB (2003a) *Meliolaceae* of Kerala, India– XVIII New species, varieties and records. Zoo's Print J 999–1002

Hosagoudar VB (2003b) *Armatellaceae*, a new family segregated from the *Meliolaceae*. Sydowia 55:162–167

Hosagoudar VB (2006) Additions to the fungi of Kerala II. Zoos Print J 21:2412–2416

Hosagoudar VB (2008) *Meliolales* of India. Vol. II. Botanical Survey of India, Calcutta, p 390

Hosagoudar VB (2013) *Meliolales* of India. vol. III. J Threatened Taxa 5(6):3993–4068

Hosagoudar VB, Agarwal DK (2006) *Ectendomeliola*, a new genus of the family *Meliolaceae*. Indian Phytopathol 59:98–100

Hosagoudar VB, Archana GR (2013) A new species of the genus *Ectendomeliola* (*Meliolaceae*) from Kerala, India. J Threatened Taxa 2(8):1092–1095

Hosagoudar VB, Goos RD (1989) *Meliolaceous* fungi from the state of Kerala, India I. Mycotaxon 36(1):221–247

Hosagoudar VB, Riju MC (2013) Foliicolous fungi of Silent Valley National Park, Kerala, India. J Threatened Taxa 5(3):3701–3788

Hosagoudar VB, Abraham TK, Pushpangadan P (1997) The *Meliolineae* a supplement. The Director TBG and RI, Pal ode, Thiruvananthapuram, 20

Hosagoudar VB, Dhivaharan V, Nithyatharani R (2012) Foliicolous fungi of kodaikanal in Tamil Nadu. Bull Basic Appl Plant Biol 2(1):94

Huelsenbeck JP, Ronquist F (2001) MRBAYES: Bayesian inference of phylogenetic trees. Bioinformatics 17(8):754–755

Hughes SJ (1981) Mucronate hyphopodia of *Meliolaceae* are phialides. Can J Bot 59:1514–1517

Hughes SJ, Pirozynski KA (1994) *Endomeliola dingleyae*, a new genus and new species of *Meliolaceae*. New Zealand J Bot 32:53–59

Hyde KD, Jones EBG, Liu JK, Ariyawansa H, Boehm E, Boonmee S, Braun U, Chomnunti P, Crous PW, Dai DQ, Diederich P, Dissanayake A, Doilom M, Doveri F, Hongsanan S, Jayawardena R, Lawrey JD, Li YM, Liu YX, Lücking R, Monkai J, Muggia L, Nelsen MP, Pang KL, Phookamsak R, Senanayake I, Shearer CA, Suetrong S, Tanaka K, Thambugala KM, Wijayawardene NN, Wikee S, Wu HX, Zhang Y, Aguirre-Hudson B, Alias SA, Aptroot A, Bahkali AH, Bezerra JL, Bhat DJ, Camporesi E, Chukeatirote E, Gueidan C, Hawksworth DL, Hirayama K, Hoog SD, Kang JC, Knudsen K, Li WJ, Li XH, Liu ZY, Mapook A, McKenzie EHC, Miller AN, Mortimer PE, Phillips AJL, Raja HA, Scheuer C, Schumm F, Taylor JE, Tian Q, Tibpromma S, Wanasinghe DN, Wang Y, Xu JC, Yan JY, Yacharoen S, Zhang M (2013) Families of *Dothideomycetes*. Fungal Divers 63:1–313

Index Fungorum (2015) http://www.indexfungorum.org/Names/Names.asp

Jansen RK, Cai Z, Raubeson LA, Daniell H, dePamphilis CW, Leebens-Mack J, Müller KF, Guisinger-Bellian M, Haberle RC, Hansen AK, Chumley TW, Lee SB, Peery R, McNeal JR, Kuehl JV, Boore JL (2007) Analysis of 81 genes from 64 plastid genomes resolves relationships in angiosperms and identifies genomes cale evolutionary patterns. PNAS 104:19369–19374

Jayasiri SC, Ariyawansa HA, Liu JK, Jones EBG, Hyde KD (2015) The faces of fungi database: fungal names linked with morphology, molecular and human attributes. Fungal Divers (In press)

Justavino DR, Piepenbring M (2007) Two new species of *Appendiculella* (*Meliolaceae*) from Panama. Mycologia 99(4):544–552

Justavino DR, Velásquez JC, Sánchez COM, Rincón R, Oberwinkler F, Bauer R (2014) The interaction apparatus of *Asteridiella callista* (*Meliolaceae*, Ascomycota). Mycologia 106(2):216–223

Justavino DR, Kirschner R, Piepenbring M (2015) New species and new records of *Meliolaceae* from Panama. Fungal Divers 70(1):73–84

Kirk PM, Cannon PF, David JC, Stalpers JA (2001) Ainsworth & Bisby's dictionary of the fungi, 9th edn. CABI, Wallingford

Kirk PM, Cannon PF, Minter DW, Stalpers JA (2008) Dictionary of the fungi. 10th ed. CAB International, 784

Liu JK, Hyde KD, Jones EBG, Ariyawansa HA, Bhat DJ, Boonmee S, Maharachchikumbura SSN, McKenzie EHC, Phookamsak R, Phukhamsakda C, Shenoy BD, Abdel-Wahab MA, Buyck B, Chen J, Chethana KWT, Singtripop C, Dai DQ, Dai YC, Daranagama DA, Dissanayake AJ, Doilom M, D'souza MJ, Fan XL, Goonasekara ID, Hirayama K, Hongsanan S, Jayasiri SC, Jayawardena RS, Karunarathna SC, Li WJ, Mapook A, Norphanphoun C, Pang KL, Perera RH, Peršoh D, Pinruan U, Senanayake IC, Somrithipol S, Suetrong S, Tanaka K, Thambugala KM, Tian Q, Tibpromma S, Udayanga D, Wijayawardene NN, Wanasinghe D, Wisitrassameewong K, Zeng XY, Abdel-Aziz FA, Adamčík S, Bahkali AH, Boonyuen N, Bulgakov T, Callac P, Chomnunti P, Greiner K, Hashimoto A, Hofstetter V, Kang JC, Lewis D, Li XH, Liu XZ, Liu ZY, Matsumura M, Mortimer PE, Rambold G, Randrianjohany E, Sato G, Sri-Indrasutdhi V, Tian CM, Verbeken A, von Brackel W, Wang Y, Wen TC, Xu JC, Yan JY, Zhao RL, Camporesi E (2015) Fungal diversity notes 1–110: taxonomic and phylogenetic contributions to fungal species. Fungal Divers 72(1):1–197

Lumbsch HT, Huhndorf SM (2010) Life and earth sciences. Part one. Outline of Ascomycota 2009. Myconet volume 14. Field Museum of Natural History 1–40

Luttrell ES (1951) Taxonomy of the pyrenomycetes. Univ Missouri Stud 24:1–120

Luttrell ES (1989) Morphology of *Meliola floridensis*. Mycologia 81: 192–204

Maharachchikumbura SSN, Hyde KD, Jones EBG, McKenzie EHC, Huang SK, Abdel-Wahab MA, Daranagama DA, Dayarathne M, D'souza MJ, Goonasekara ID, Hongsanan S, Jayawardena RS, Kirk PM, Konta S, Liu JK, Liu ZY, Norphanphoun C, Shang KLQ, Shenoy BD, Xiao Y, Bahkali AH, Kang J, Somrothipol S, Suetrong S, Wen T, Xu J (2015) Towards a natural classification and backbone tree for Sordariomycetes. Fungal Divers 72:199–301

Martin GW (1941) Outline of the fungi. Stud Nat Hist Univ Iowa 18:192–204

McAlpine D (1897) New South Wales fungi. Proc Linn Soc New South Wales 22:38

Mibey RK, Hawksworth DL (1997) *Meliolaceae* and *Asterinaceae* of the Shimba Hills. Kenya Mycol Pap 174:1–108

Mueller WC, Goos RD, Quainoo J, Morgham AT (1991) The structure of the phialides (mucronate hyphopodia) of the Meliolaceae. Can J Bot 69:803–807

Müller E, von Arx J (1973) Pyrenomycetes: *Meliolales*, *Coronophorales*, *Sphaeriales*. In: Ainsworth G, Sparrow F, Sussman A (eds) The fungi IV. Academic, New York, pp 87–132

Nayar TS, Hosagoudar VB, Prakashkumar R, Jothish S, Thripthy KM (1998) The occurrence of *Meliolaceae* ascospores in the air of Kerala, India. Grana 37:253–254

Nylander JAA, Wilgenbusch JC, Warren DL, Swofford DL (2008) AWTY (are we there yet?): a system for graphical exploration of MCMC convergence in Bayesian phylogenetics. Bioinformatics 24: 581–583

Old KM, Wingfield MJ, Yuan ZQ (2003) A manual of diseases of eucalypts in South-East Asia, 106

Patil MS, Mahamulkar SH (1999) Studies on *Meliolaceae* of India-IV. Indian Phytopath 52(3):245–253

Pattengale ND, Alipour M, Bininda-Emonds ORP, Moret BME, Stamatakis A (2009) How many bootstrap replicates are necessary? LNCS 5541:184–200

Piepenbring M, Hofmann TA, Kirschner R, Mangelsdorff R, Perdomo O, Justavino DR, Trampe T (2011) Diversity patterns neotropocal plant parasitic microfungi. Ecotropica 17:27–40

Pinho DB, Firmino AL, Ferreira-junior WG, Pereira OL (2012a) An efficient protocol for DNA extraction from *Meliolales* and the description of *Meliola centellae* sp. nov. Mycotaxon 122:333–345

Pinho DB, Pereira OL, Firmino AL, Silva M, Ferreira-Junior WG, Barreto RW (2012b) New *Meliolaceae* from the Brazilian Atlantic Forest 1. Species on hosts in the families *Asteraceae*, *Burseraceae*, *Euphorbiaceae*, *Fabaceae* and *Sapindaceae*. Mycologia 104:121–137

Pinho DB, Firmino AL, Ferreira-Júnior WG, Pereira OL (2013) New *Meliolaceae* from the Brazilian Atlantic Forest 2: species on host families *Annonaceae*, *Cecropiaceae*, Meliaceae, Piperaceae, Rubiaceae, Rutaceae and Tiliaceae. Mycologia 105:697–711

Pinho DB, Junior JH, Firmino AL, Junior BTH, Mizubuti ESG, Pereira OL (2014) Reappraisal of the black mildews (*Meliolales*) on *Hevea brasiliensis*. Trop Plant Pathol 39(1):89–94

Raciborski M (1909) Parasitische und epiphytische Pilze Javas. Bull Int de l'Acad des Sci de Cracovie Classe des Sci Math et Nat 3:346–394

Rannala B, Yang Z (1996) Probability distribution of molecular evolutionary trees: a new method of phylogenetic inference. J Mol Evol 43:304–311

Rehm H (1901) Beiträge zur Pilzflora von Südamerika. XIII. *Xylariaceae*. Hedwigia 40:141–170

Roger L (1953) Phytopathologie des pays Chauda. In: Encyclopedia mycologique 1638–1653

Sabulal B, Hosagoudar VB, Pradeep NS, Dan M, George V (2006) Chemical composition and antimicrobial activity of *Meliola toddaliae* infected leaf oil of *Pamburus missionis*. J Mycopathol Res 44:237–242

Saccardo PA (1913) Notae mycologicae. Series XVI. Ann Mycol 11(4): 312–325

Saenz GS, Taylor JW (1999) Phylogenetic relationships of *Meliola* and *Meliolina* inferred from nuclear small subunit rRNA sequences. Mycol Res 103:1049–1056

Sawada K (1959) Descriptive catalogue of Taiwan (Formosan) fungi. Part XI. Spec Publ Coll Agric Nat Taiwan Univ 8:1–268

Senanayake IC, Maharachchikumbura SSN, Hyde KD, Bhat JD, Dai DQ, Daranagama DA, Dayarathne MC, Konta S, Li WJ, Wijayawardene NN, Xiao YP, Wen TC, Norphanphoun C, Li QR, Liu XZ, Bahkali AH, Jones EBG, Kang JC, Wang Y, Camporesi E (2015) Towards unraveling relationships in *Xylariomycetidae* (Sordariomycetes). Fungal Divers 73(1):73–144

Silvestro D, Michalak I (2012) RaxmlGUI: a graphical front-end for RAxML. Org Divers Evol 12:335–337

Spegazzini C (1918) Notas micologicas. Physis 4:281–295

Spegazzini C (1921) Boln Acad nac Cienc Córdoba 26(2–4):349

Starbäck K (1899) Ascomyceten der ersten Regnell'schen expedition. I. Bihang till kungliga svenska. Vetenskaps-Akademiens Handlingar 25(1):1–68

Stevens FL (1925) Hawaiian fungi. Bernice P Bishop Mus Bull 19:1–189

Stevens FL (1927) The *Meliolineae*. I Ann Mycol 25:405–469

Sydow H (1930) Novae fungorum species - XX. Ann Mycologici 28(5–6):432–447

Theissen F (1913) Uber einige mikrothyriaceen. Ann Mycol 11:499

Thimmaiah CJ, Hosagoudar VB, Jayashankar M (2013) Black mildews of Kodagu, Karnataka. J Threatened Taxa 5(16):5021–5180

Thite AN (1975) Ascospore germination in *Meliola jasminicola*. Indian Phytopathol 28:94–96

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG (1997) The CLUSTAL X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Res 25:4876–4882

Toro RA (1952) Study of the tropical American black-mildews. J Agric Univ P R 36:24–87

Tucker SL, Besi MI, Galhano R, Franceschetti M, Goetz S, Lenhert S, Osbourn A, Sesmaa A (2010) Common genetic pathways regulate organ-specific infection-related development in the rice blast fungus. Plant Cell Prev, www.aspb.org

Viégas AP (1944) Alguns fungos do Brazil. II. Ascomicetos. Bragantia 4: 1–392

von Höhnel F (1918) Fragments Zur mycologie mitteil. Ibid 128:556

von Höhnel F (1919) Fragmente zur Mykologie. XXIII Mitteilung, Nr. 1154 bis 1188. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Math.-naturw. Klasse Abt. I. 128:535–625

Wellman FL (1972) Tropical American plant disease. The Scarcccrow Press, Metuchen, p 989

Wijayawardene NN, Crous PW, Kirk PM, Hawksworth DL, Boonmee S, Braun U, Chomnunti P, Dai DQ, D'souza MJ, Diederich P, Dissanayake A, Doilom M, Hongsanan S, Jones EBG, Groenewald JZ, Jayawardena R, Lawrey JD, Liu JK, Lücking R, Madrid H, Manamgoda DS, Muggia L, Nelsen MP, Phookamsak R, Suetrong S, Tanaka K, Thambugala KM, Wikee S, Zhang Y, Aptroot A, Ariyawansa HA, Bahkali AH, Bhat JD, Gueidan C, De Hoog GS, Knudsen K, McKenzie EHC, Miller AN, Mortimer PE, Wanasinghe DN, Phillips AJL, Raja HA, Slippers B, Shivas RS, Taylor JE, Wang Y, Woudenberg JHC, Piątek M, Cai L, Jaklitsch WM, Hyde KD (2014) Naming and outline of *Dothideomycetes*–2014. Fungal Divers 69(1):1–55

Wu X, Schoch CL, Boonmee S, Bahkali AH, Chomnunti P, Hyde KD (2011) A reappraisal of *Microthyriaceae*. Fungal Divers 51(1):189–248

Yamamoto W (1954) Studies on the parasitism of sooty mould fungi. Phytopathol Soc Japan 18(3–4):102–106

Yarwood CE (1973) Pyrenomycetes: erysiphales. In: Ainsworth GC, Sparrow FK, Sussman AS (eds) The fungi: an advanced treatise. Vol. IVA. Academic, New York, pp 71–86

Zhang N, Castlebury LA, Miller AN, Hundorf SM, Schoch CL, Seifert KA, Rossman AY, Rogers JD, Kohlmeyer J, Volkmann-Kohlmeyer B, Sung G-H (2006) An overview of the systematics of the Sordariomycetes based on a four-gene phylogeny. Mycologia 98: 1076–1087

Zhaxybayeva O, Gogarten JP (2002) Bootstrap, Bayesian probability and maximum likelihood mapping: exploring new tools for comparative genome analyses. BMC Genomics 3:4