PHYLOGENY OF ASCOMYCETES FROM PALMS

JIAN-KUI LIU

DOCTOR OF PHILOSOPHY
IN
BIOSCIENCES

SCHOOL OF SCIENCE
MAE FAH LUANG UNIVERSITY
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ABSTRACT

Palm fungi are a taxonomically diverse group, with more than 1770 described species (340 Basidiomycota and 1430 Ascomycota have been described from palm substrates), with representatives from almost all major fungal classes. The non-lichenized ascomycetes which have been described from palms are a very diverse assemblage with 1059 species distributed in 121 families and 436 genera, and their lifestyle ranges from saprobic, pathogenic, and endophytic to parasitic. A checklist of non-lichenized ascomycetes described from palms is provided. Most of the previous studies, only focused on morphology, and few phylogenetic studies have been carried out on palm fungi. Molecular phylogenetic studies of palm fungi are needed as the taxonomic placements of some genera/families are unresolved. By employing molecular approaches based on the ex-type and ex-epitype cultures, as well as the morphological studies of the type specimens, a better understanding of this group can be established.

In this study, phylogeny of Dothideomycetes was investigated. A class-wide phylogenetic assessment of Dothideomycetes was carried out based on the multi-gene (LSU, SSU, *TEF1* and *RPB2*) analysis in order to provide a natural classification. This involved selecting and clarifying types and ex-types of most genera in the class, making new collections from Europe and Thailand and using existing and novel sequence data. The phylogenetic tree presents 22 orders including 64 families (the current accepted families are 105) in Dothideomycetes, and it provides a working document for Dothideomycetes.

Type specimens of the genus *Astrosphaeriella* and families *Botryosphaeriaceae* and *Roussoellaceae* were examined; cultures were isolated from fresh collections. Phylogenetic and taxonomic studies of these taxa were carried out based on the multi-gene analysis and examination of types. The phylogenies showed that *Astrosphaeriella* was polyphyletic with species in *Fissuroma* and *Neoastrosphaeriella,* and *Astrosphaeriella*-like taxa clustering in four clades, two clades, including species with slit-like ostioles, clustered in *Aigialaceae*; the clade that includes the generic type clustered together with *Delitschia*; and *Astrosphaeriella afrocana*, which has striate ascospores, deviated from these three clades and had a basal position in the Pleosporales. With phylogenetic and morphological study, a natural classification of Botryosphaeriales is provided, and 29 accepted genera with 20 genera represented by molecular data were assigned to this order; the asexual and sexual morphs are linked to some genera. It is also suggests that there is more than one family in Botryosphaeriales; the phylogeny showed that the genera *Aplosporella*, *Melanops*, *Phyllosticta* and *Saccharata* formed distinct clades from *Botryosphaeriaceae* within Botryosphaeriales. In addition, the phylogeny showed that the *Roussoella*-like taxa formed a distinct clade within the *Pleosporales*; the *Roussoellaceae* clade can be distinguished into three well-supported sections, namely *Roussoella*/*Roussoellopsis*, *Roussoella* and *Neoroussoella*. Based on both morphology and phylogenetic analyses, and a new family *Roussoellaceae* was introduced to accommodate *Roussoella*, *Roussoellopsis* and *Neoroussoella*.

Keywords: Checklist/Dothideomycetes/Palm fungi/Phylogeny/Taxonomy/Types

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CHAPTER 1

INTRODUCTION

1.1 Introduction to Palms

The Palms (*Arecaceae*), though capable of reaching tree-like dimensions, differ from typical broad-leaved trees in profound ways that affect aspects of their cultivation. It belongs to the division of the flowering plants known as the monocots. Most monocot families consist of primarily herbaceous plants, that is, low-growing, soft-tissued plants, very few other species of monocots attain the size of many palms (Uhl & Dransfield, 1987). This is largely due to certain constraints placed on the development of the stems and monocots which in turn distinguish them from the second division of flowering plants.

The botanical family *Arecaceae* is the only family in the monocot order *Arecales*. Relative to many other large and economically important plant families, the *Arecaceae* has not been well studied taxonomically, largely due to the difficulty in preparing dried field specimens of palms, and the fact well over 90% of the palm family's diversity is found in the tropics. Uhl and Dransfield (1987) published the Genera Palmarum, which presented the first complete, modern system of classification for the palm family through the rank of genus, and 200 genera were recognized in the palm family with six subfamilies (defined by important characteristics shared by all the component genera). Recently, Dransfield et al. (2005) provided a new phylogenetic classification of the palm family with five subfamilies and sixteen tribes, and it has around 3000 recognized species in 219 genera (John et al., 2005), and most of them are restricted to tropical, subtropical, and warm temperate climates. They are among the best known and most extensively cultivated plant families, and they have been important to humans throughout much of history.

Many common products and foods are derived from palms, and palms are also widely used in landscaping for their exotic appearance, making them one of the most economically important plants.

Palms (*Arecaceae*) have greater morphological diversity than that of any other monocotyledonous family (Uhl & Dransfield, 1987). The group shares some features, such as a thick, woody trunk topped by a crown of large, fleshy leaves, with members of other families including the *Cycadaceae*, *Cyclanthaceae* and *Pandanaceae*, but these similarities are fairly superficial and the palms are a readily distinguishable and isolated group (Jones, 1984). Most palms are distinguished by their large, compound, evergreen leaves arranged at the top of an unbranched stem (Figs. 1.1 and 1.2). However, many palms are exceptions, and in fact exhibit an enormous diversity in physical characteristics. As well as being morphologically diverse, palms also inhabit nearly every type of habitat within their range, from rainforests to deserts (Sayan 2001).

Palms have basically the same structure as other flowering plants including roots, trunk(s), leaves, flowers and fruits (see Figs. 1.1 and 1.2). Most species have a prominent solitary trunk with a crown of leaves at its top, but a few have multiple stems, climbing stems, underground trunks or no trunk (Jones, 1984). Each stem or trunk has a single growing point (Moore, 1973). The *Pandanaceae* are arguably the most similar family in overall structure, differing from the *Palmae* chiefly in their ability to produce aerial, vegetative branches (Tomlinson, 1964). Both families produce only primary tissues (Tomlinson, 1964; Moore, 1973).

Palm leaves (fronds) are the most distinctive characters of palms and can be basically divided into two kinds, palmate or pinnate (Fig. 1.3). Fronds are composed of a sheath, petioles, a blade and a rachis and spirally arranged at the top of the stem. The leaves generally remain attached to the trunk for a long time, and the young leaves are called spear leaves as they usually arise vertically from the meristem. The basal woody structure that extends from the trunk to the first leaflet or segment is called the petiole. The petiole base, known as the sheathing base, leaf base or leaf sheath is expanded and clasps the trunk.

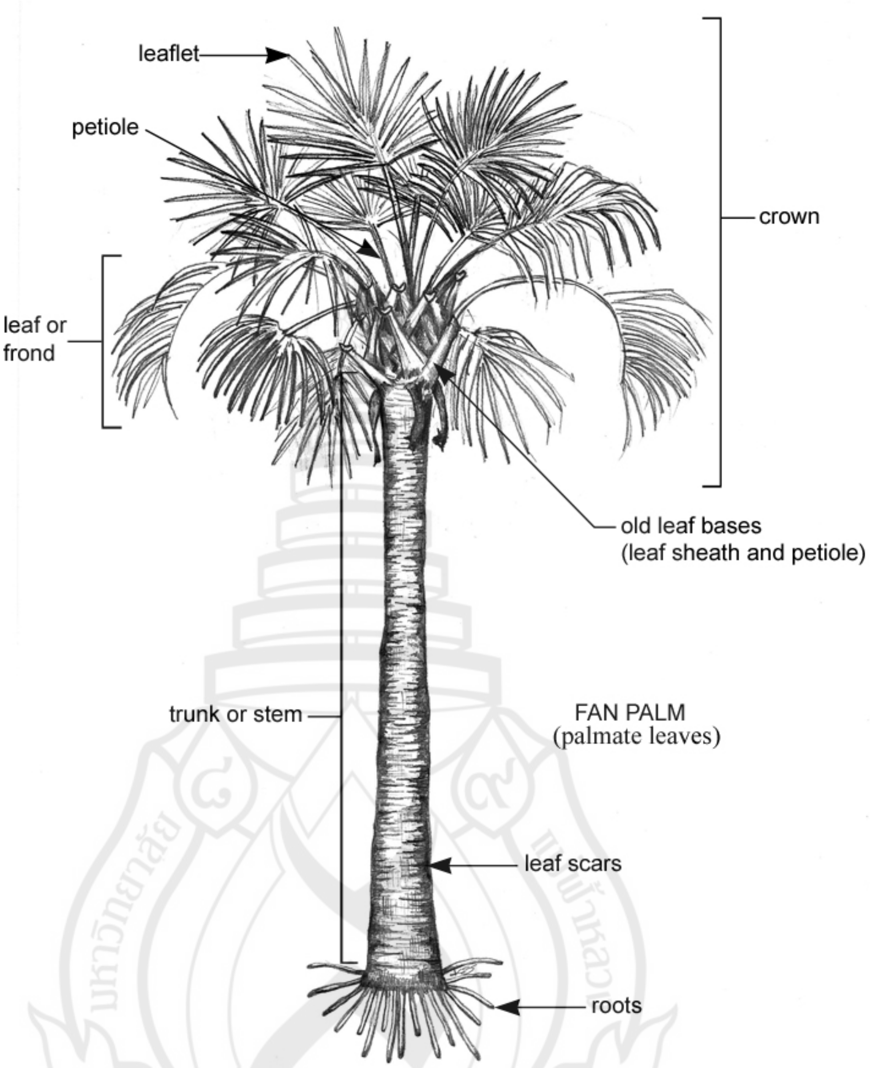


Figure 1.1 Basic structure of a fun palm. (Identifying Commonly Cultivated Palms: http://itp.lucidcentral.org/id/palms/palm-id/palm_morphology.html)

Figure 1.2 Palms in rainforest, roadside, mangrove and cultivate garden. a: *Calamus*.sp; b: *Phoenix*. sp; c: *Washingtonia*. sp; d: *Trachycarpus fortune*; e: *Borassus*. sp; f: *Arenga westerhoutii*.

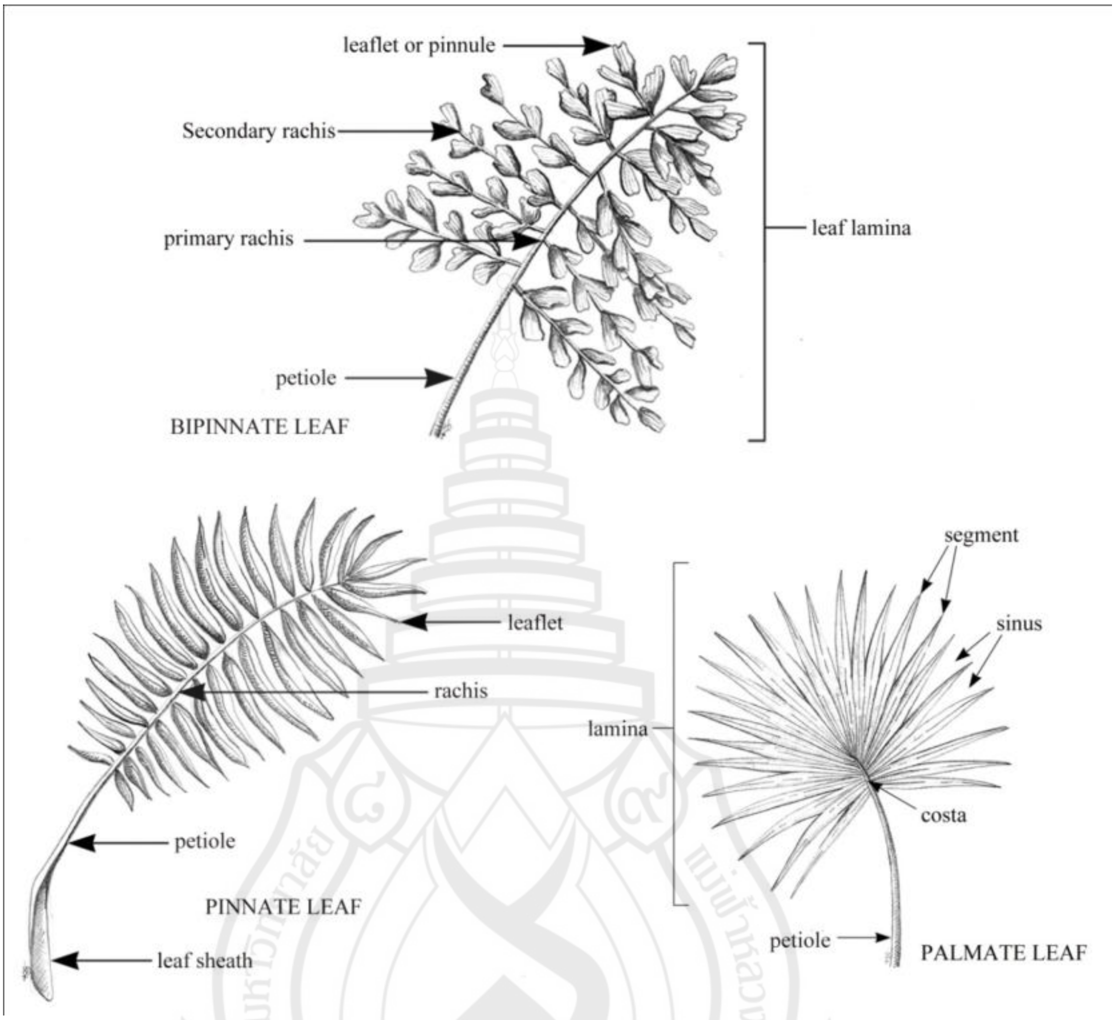


Figure 1.3 Major types of palm leaves and their structures

Palms generally have two methods of growth: solitary or clustered. The common representation is that of a solitary shoot ending in a crown of leaves. This monopodial character may be exhibited by prostrate, trunkless, and trunk-forming members. Some common palms are restricted to solitary growth include *Washingtonia* and *Roystonea* (Uhl & Dransfield, 1987). Palms may also grow in sparse though dense clusters. The trunk develops an axillary bud at a leaf node, usually near the base, from which a new shoot emerges. The new shoot, in turn, produces an axillary bud and a clustering habit results. Exclusively sympodial genera include many of the rattans, *Guihaia*, and *Rhapis*. Several palm genera have both solitary and clustering members.

1.2 Palm Fungi

1.2.1 Palm Ascomycetes: History

The term “palm fungi” we used in this study is defined as “any fungus which grows on palms”. In 1997, five-hundred and ninety-two species of non-lichenized ascomycetes had been described from collections made on palm tissues (Hyde et al., 1997). This number has increased to one thousand and twenty-nine in 2013 (Chapter 2), and there are three-hundred and eighty-five non-lichenized ascomycetes have been described between 1998 and 2013.

The first ascomycete species to be described from a palm (that has not subsequently been synonymised with a taxon described from a different substrate) was *Chaetomium globosum* Kunze (Mykologische Hefte 1, 16 (1817)). The species was described from decaying leaves of *Cocos nucifera* L. (i.e. coconut) in Argentina.

By the end of the 1870s, 19 species of ascomycetes had been described from palms. During the 1880s there was a dramatic increase with the publication of the first two volumes of P.A. Saccardo’s *Sylloge fungorum* omnium hucusque cognitorum (Fig. 1.4). Several other mycologists began to describe ascomycetes from palms during this period, including Spegazzini (1889) in Fungi Puiggariani, and Penzig and Saccardo (1897a, b, 1901) in the Diagnoses fungorum novorum in insula Java collectorum. Series secunda and Series tertia. Java has a rich palm flora, so it is not surprising that many palm fungi were described in these publications.

Hennings (1902, 1904, 1908) was another early worker who made a significant contribution to our knowledge of the palm mycobiota, and Rehm described about 23 species from palms from the Philippines (e.g. Rehm, 1913a,b,c, 1914, 1916). Interest in microfungi in general, and palm fungi in particular, remained high before, during, and after the First World War (Fig. 1.4) with a small number of relevant publications by a large number of mycologists (e.g. Theissen & Sydow, 1915; Sydow & Sydow, 1917; Spegazzini, 1921; Weedon, 1926).

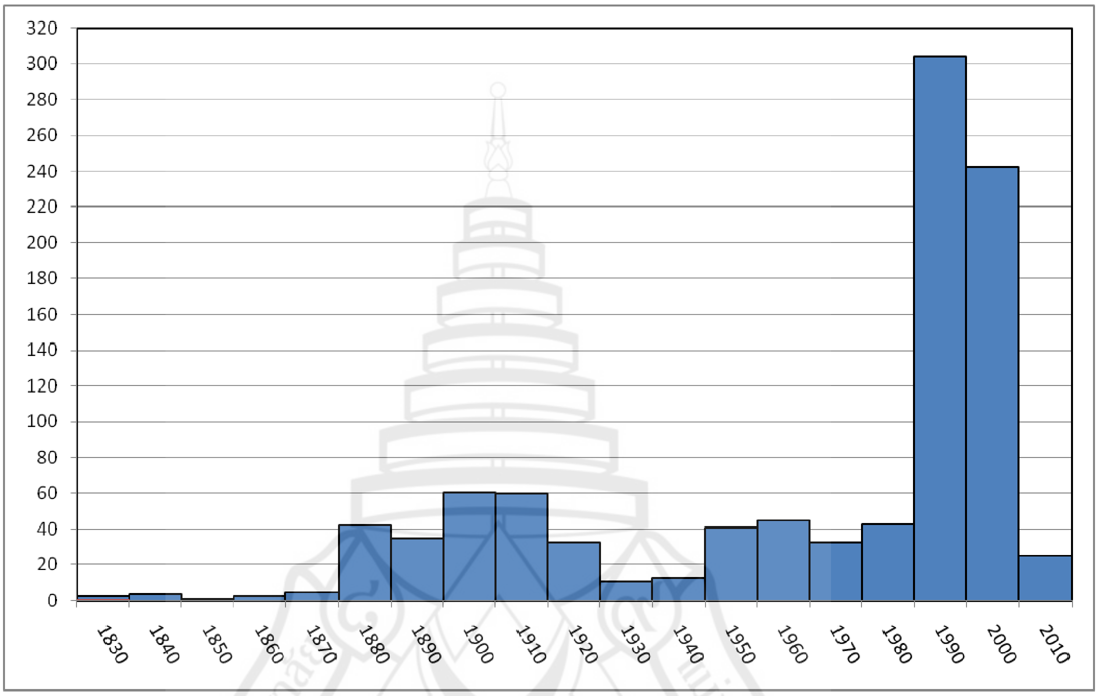


Figure 1.4 Palm ascomycetes publications frequency

The rate of publication of new ascomycetes descriptions from palms declined sharply during the depression and the Second World War, but increased and then remained steady during the 1950s to the 1980s (Fig. 1.4). There are no authors who particularly stand out during those four decades, with records from palms being incidental in publications relevant to particular regions (e.g. Chaudhury & Rao, 1964), to diseases of economically important palms (e.g. Brown, 1975; Forsberg, 1987; Coffey, 1988) or to particular taxonomic groups of fungi (e.g. Francis, 1975).

There was a dramatic increase in the number of ascomycetes described from palms during the 1990s (Fig. 1.4) when, for almost the first time, a mycologist began to look specifically at the microfungi on that substrate (refer to references by Hyde and co-workers). The publications by Hyde and co-workers include 407 palm ascomycetes names, and form the main literature base for fungi on palms. The only author to rival this contribution is Saccardo, whose name is associated with 110 palm ascomycetes.

Other recent contributions to our knowledge of palm ascomycetes have come from traditional sources i.e. studies of palm pathogens (Chase, 1992; Coffey, 1988; Deighton, 1985; Duff, 1989; Forsberg, 1985; Forsberg, 1987; Uchida, 1992; Crous et al., 2008; Fröhlich & Hyde, 2000; Taylor & Hyde, 2003) and taxonomic monographs (Hawksworth, 1985; Samuels, 1985; Hyde et al., 2000; Fröhlich & Hyde, 2000; Taylor & Hyde, 2003).

1.2.2 Palm Ascomycetes: Taxonomic Distribution

The ascomycetes which have been described from palms are a very diverse assemblage. The 1059 species are distributed in 121 families and 436 genera within the ascomycotina.

The *Xylariaceae* and *Amphisphaeriaceae* are the most represented families, with 118 species in thirteen genera, and 111 species in thirteen genera respectively. The *Hypocreaceae* is also represented by thirteen genera, but by substantially fewer species (27). The *Nectriaceae* and the *Phyllachoraceae* are the next most common families in terms of genera (ten each), but the *Meliolaceae*, which is the next species rich (26).

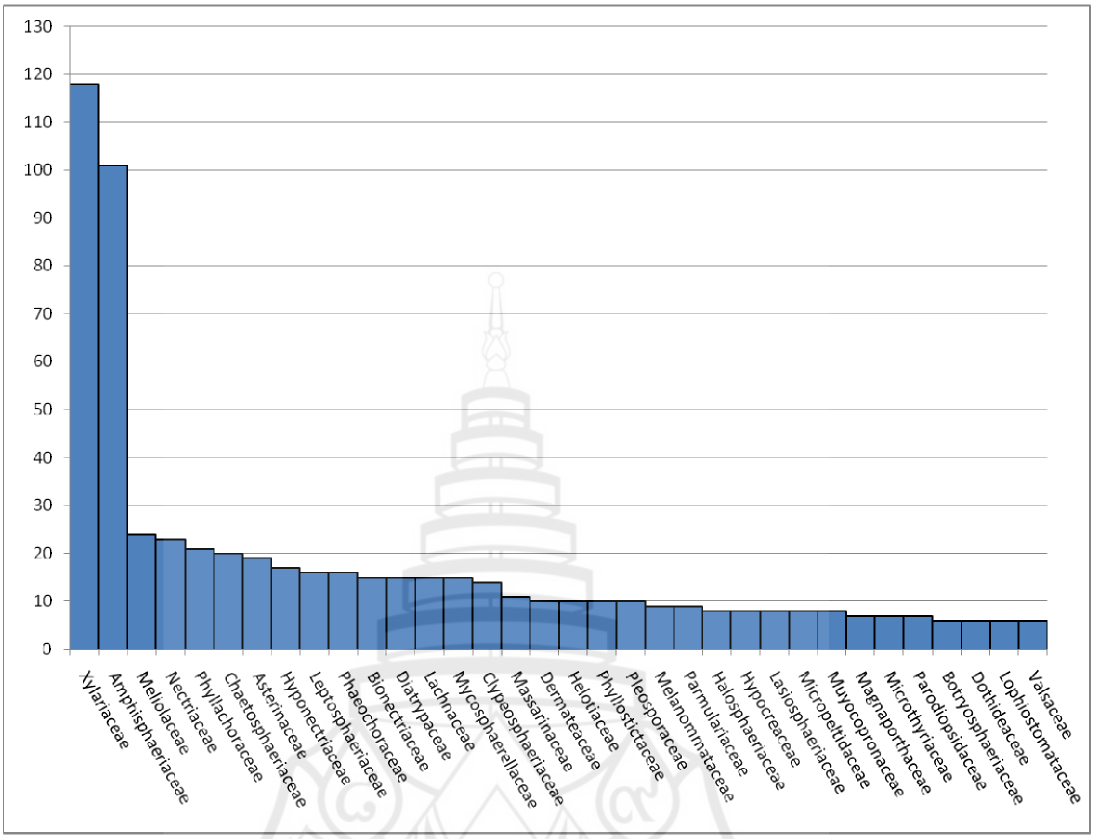


Figure 1.5 Families containing ≥ 5 ascomycetes species described from palms

The most common genus on palms is *Oxydothis* with 60 of its 65 species described from palm tissues (Fig. 1.6). This genus is known only from Palms, *Pandanus* (*Pandanaceae*), and bamboo (*Graminae*) and can confidently be described as a palm specialist. *Anthostomella* is the next most common genus with 38 species described from palms. It is difficult to establish what proportion of *Anthostomella* occur on palms, as there are over 250 species names in the genus. However, many of these are probably synonyms, and Hawksworth et al. (1995) give the number of *Anthostomella* species as 50, and Lu and Hyde (2000) accepted 86 species based on the examination of 2600 specimens from 35 herbaria. The taxon is found on a wide range of dicotyledenous, as well as monocotyledonous hosts.

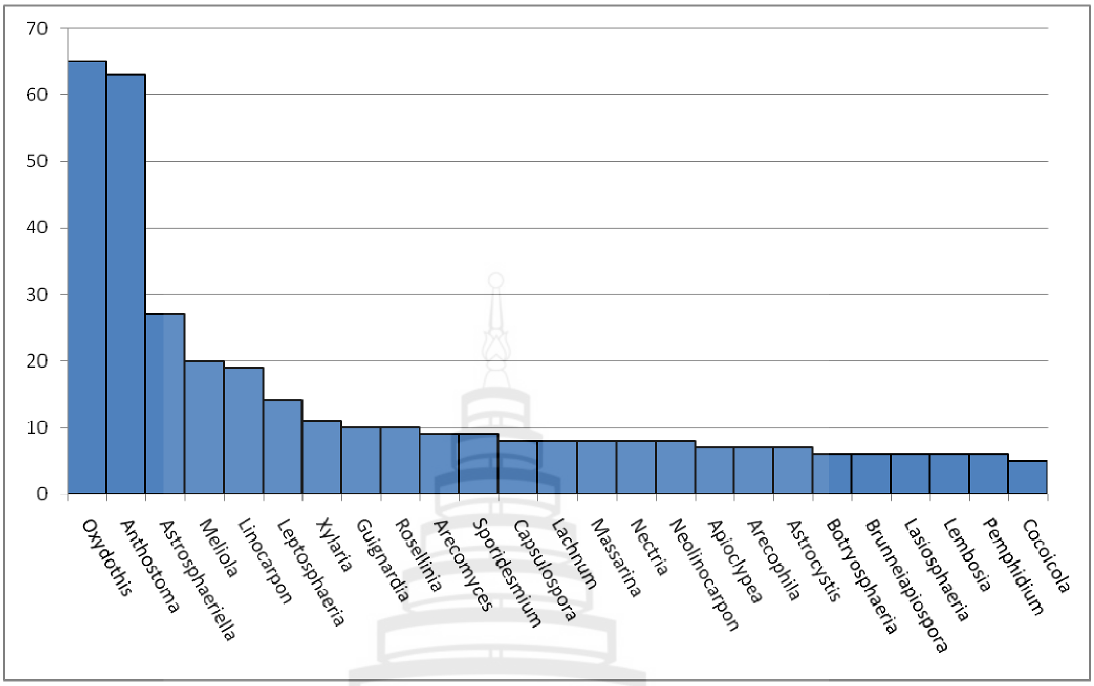


Figure 1.6 Genera containing ≥ 5 ascomycetes species described from palms

Meliola is a genus of sooty moulds which is very common in the tropics (Hyde et al., 1997) and has 22 species and six varieties described from palms. *Meliola* species are parasitic, but “the great majority have no appreciable effect upon their host plants” (Hansford, 1961). Individual species and/or varieties of *Meliola* are almost always limited to a narrow range of host plants, and rarely extend over more than a single family of phanerogamic hosts (Hansford, 1961). Consequently, although the genus as a whole does not specialise on palm hosts, individual species probably are limited to the *Palmae*.

The next most common genera are *Astrosphaeriella* (twenty-seven species), *Linocarpon* (nineteen species), *Astrosphaeriella* (thirteen species), *Leptosphaeria* (fourteen species), *Xylaria* (eleven species) and *Guignardia* (ten species) (Fig. 1.6).

1.2.3 Palm Ascomycetes: Host Distribution

The genera of palms from which the greatest numbers of ascomycetes have been described are shown in Fig. 1.7.

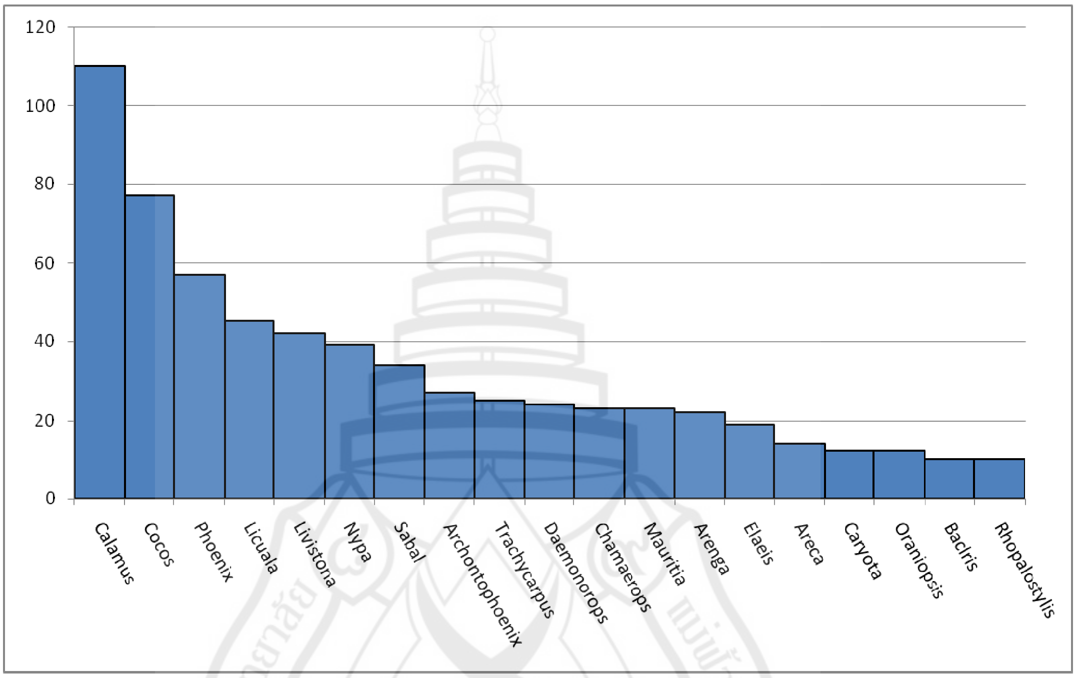


Figure 1.7 Host genera on which ≥ 5 ascomycetes species have been described

The genus *Calamus* is the richest source of ascomycetes yielding 110 new species. This may be due to due to the extraordinarily wide geographic distribution and high commercial importance. Personal experience with the rattans has suggested that they do have an unusually diverse mycobiota, and that this may also be due, at least in part, to the anatomy of rattans (see above). *Daemonorops* has been a less significant host to ascomycetes (twenty-four species), but this is not surprising as the ratio of *Calamus*: *Daemonorops* species is about 5:1, the latter genus has a narrower geographic distribution and many of its species are restricted to primary tropical rainforests (Uhl & Dransfield, 1987). Furthermore, unless they are fruiting, *Daemonorops* and *Calamus* species may be difficult to distinguish in the field (pers.

obs.) and it is likely that mycologists have misidentified the more rarely encountered *Daemonorops* species as *Calamus* species.

The monotypic genus *Cocos* has been the second rich source of palm ascomycetes with 77 new species described from it. This may be due to similar reasons to those given for *Calamus*, i.e. a wide geographic range, as well as economic importance of the species. Both factors would have ensured that *Cocos* was examined by a large number of mycologists!

The genus *Phoenix* is very widely distributed both naturally, and as an ornamental. The genus is “immensely important from an economic point of view” as it includes not only the date palm, which is a major crop of many Middle Eastern countries, but also many species used for starch, fibre and sugar (Uhl & Dransfield, 1987). Consequently, the mycobiota of the genus is relatively well known (57 species).

These remarks demonstrate that the numbers of fungi reported from a particular host are often a reflection of the distribution and economic significance of the palm rather than the biodiversity of its mycobiota. Consequently, it would be useful to look at the situation from the perspective of the fungus and to ask “which hosts are likely to be the most attractive as a substrate?”

1.2.4 Palm Ascomycetes: Tissue Specificity

Palms can conveniently be divided into eight parts: roots, trunks or stems, petioles, rachides, leaves, inflorescences, fruits and seeds. Not all mycologists have recorded the part of the palm from which their collections were taken, and inappropriate terms such as “bark” or “branch” or terms which encompass several tissues such as “frond” have sometimes been used. None-the-less, there is sufficient data available for some trends in specificity to be observed (Fig. 1.8).

The roots, seeds and fruits of palms have yielded very few ascomycetes records (Fig. 1.8). This may well be due to their temporal scarcity and/or physical inaccessibility. The petiole and rachis form a continuous tissue, and probably do not differ greatly in structure. Consequently, they will often be discussed as a single unit (petiole/rachis).

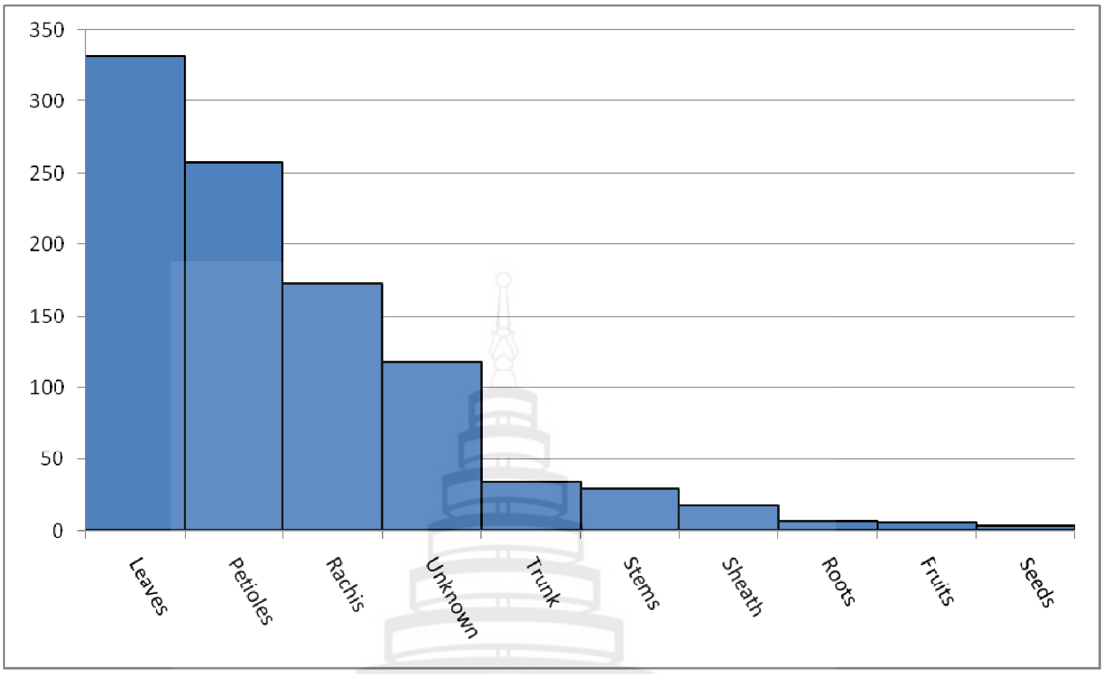


Figure 1.8 Palm ascomycetes: distribution by tissue type

As in the case of host specificity, tissue specificity can be expected to vary with a given fungus' ecology and taxonomy. Consequently, pathogens, endophytes, saprophytes, and the most common ascomycetes genera will be dealt with separately.

The majority of ascomycetes species described from palms (37.8%) have been recorded on leaves (Fig. 1.8). Most of the pathogenic ascomycetes were found on leaf tissues; however, not all palm pathogens are restricted to the leaves. Fungi which cause tar spots (*Phaeochoraceae* and *Phyllachoraceae*) often occur on both frond blades and petioles (Hyde & Cannon, 1997). During the research carried by Fröhlich and her co-workers (Fröhlich & Hyde, 2000), still they have never found an ascomycetes associated with localized tissue death on any palm tissue other than the leaf blade, and the tar spot fungi would appear to be an exception to a general tissue preference.

Palm saprophytes are found on all of the palm tissues. Of the 986 saprobic ascomycetes described from a particular palm tissue, 325 (32.9%) were collected on dead leaves, 252 (25.5%) were collected on petioles and 168 (17%) were collected on dead rachides (Fig. 1.8). The remaining 24.6% were found on the trunks/stems, reproductive parts, roots, “wood”, “bark”, spathes, culms and fibres.

The different palm tissues do seem to support different assemblages of saprophytic microfungi (Hyde et al., 1997; Fröhlich & Hyde, 2000; Taylor & Hyde, 2003). The few taxa described from inflorescences have not been found on other tissues, and leaf tissues often yield different taxa to the petioles and rachides, although there is some overlap.

1.3 Objectives of The Research

1. To provide a checklist of non-lichenized ascomycetes on palms.
2. To advance the understanding of phylogeny of ascomycetes (Dothideomycetes) and their asexual / sexual morphs.
3. To carry out phylogenetic studies on Dothideomycetes from palms and contribute to an understanding of their natural classification.
4. To document selected palm fungi from Thailand and describe any new taxa.

1.4 Organization of The Research

This thesis comprises seven main chapters, each chapter dealing with various aspects of the study of ascomycetes.

In Chapter 1, a brief introduction on the taxonomy and morphology of the palm hosts is given. A general overview of the ascomycetes associated with palms, their history and ecological aspects, such as host and tissue recurrences are provided. The objectives and organization of the research are explained.

In Chapter 2, a checklist of non-lichenized palm ascomycetes organized by genus in alphabetical order is given. The material examined for types, known hosts and distribution are given for each species. Notes are only provided for unclear species.

Chapter 3 is a phylogenetic chapter in which the arrangement of Dothideomycetes is discussed. A class-wide phylogenetic assessment of Dothideomycetes resulting from multi-gene (LSU, SSU, *TEF1* and *RPB2*) phylogenetic analyses is presented. The dataset was obtained from the ex-type, ex-epitype and fresh strains, representing each genus, family and order of Dothideomycetes. A discussion is provided for each existing order which includes the history and current information on taxonomy and phylogeny.

Chapter 4 is a taxonomic and phylogenetic study of Botryosphaeriales and provides a natural classification of the order. A general introduction to the taxonomy, phylogeny, sexual and asexual morphs is provided. There is a discussion for each genus, and then the generic description is given. The descriptions of sexual and asexual morphs for each genus or type species are provided if the data are available. A phylogenetic tree resulting from multi-gene (LSU, SSU, *TEF1* and β-tubulin) analyses is given. The dataset is obtained from the ex-type, ex-epitype and fresh strains, representing each genus.

In Chapter 5, a new family *Roussoellaceae* is introduced, and the aim of this chapter is to provide a better understanding of the taxonomy and phylogeny of *Roussoella*-like taxa within the order *Pleosporales*. The types of *Roussoella* and *Roussoellopsis* were examined, and then modified descriptions and notes are given. A phylogenetic tree resulting from multi-gene (LSU, *TEF1* and *RPB2*) analysis shows the relationship between *Roussoella*-like species and other families of Pleosporales. Suggestions for further research on this group are provided.

In Chapter 6, the palm genus *Astrosphaeriella* is detailed. A detailed description for the type species and novel species is given. A phylogenetic tree resulting from LSU and SSU combined data shows the relationship of *Astrosphaeriella*-like taxa with other families in Pleosporales. A discussion relating to the family placement of *Astrosphaeriella* is given.

Chapter 7 is an overall conclusion of this thesis, with suggestions for future work.

CHAPTER 2

Checklist of Non-Lichenized Palm Ascomycetes

2.1 Introduction

While fungi have been reported from palms since 1817 (Mykologische Hefte 1, 16 (1817), the study of palm fungi began by the end of 1870s (Actually the first palm fungi described was *Chaetomium globosum* Kunze). The publications on palm fungi increased during the 1880s, with the first two volumes of P.A. Saccardo's *Sylloge fungorum*, while Hennings was an early mycologist who made a significant contribution to our knowledge of the palm fungi. Other mycologist who worked on palm fungi is Saccardo, whose name is associated with 110 palm ascomycetes. However, few mycologists looked specifically at the microfungi on palms. During 1990s, Hyde, who described 407 palm ascomycetes, is the first mycologist began to work specifilly on this group. Since that time, interest in palm microfungi has increased dramatically, and studies of the palm fungi have taken place worldwide.

As knowledge of and interest in palm microfungi increased, there has been a corresponding need to summarize about these fungi. Several books and papers have been written which summarize this information. Hyde et al. (2000) published "Genera of Ascomycetes from Palms", which was the first monograph to provide detailed description and illustration of genera, and give a general discussion for each genus with literature which it is a main problems for most of the researcher on identification and classification of microfungi. "Palm Microfungi" and "Microfungi of Tropical and Temperate Palms" are the other two monographs published by Fröhlich and Hyde (2000) and Taylor et al. (2003). At the same time, many publications on palm ascomycetes have been published by Hyde and his co-workers (students or collaborators).

Here we present a checklist of non-lichenized palm ascomycetes; this checklist is a compilation of the known geographic and host distribution of these fungi as well as information about the substrate type and habitat.

2.2 Materials and Methods

I performed an extensive review of the literature on palm microfungi and attempted to review every publication on palm microfungi published before 2014, however, some papers were not available to me, and others likely were missed.

In preparing this checklist, palm fungi are defined as "the fungus that is found on palms and must have information regarding its morphology". The "Index of Fungi" published by CABI, UK is the reference to take the account of palm fungi. All the fungi would be included by searching "PALMAE" (*Arecaceae*) in Host section. Then I searched several literatures describing palm fungi and traced back to their original sources for their descriptions.

I document the following information, when they are available for each species: geographic distribution, host species, substrate type (dead trunk, living leaves, etc.) and its current placement (Order/Family).

2.3 The Checklist of Non-Lichenized Palm Ascomycetes

The complete list of palm ascomycetes and related information is presented below and organized by genus (placement of each genus based on the *Index Fungorum* (2014)) in alphabetical order.

Table 2.1 Checklist of Non-Lichenized Palm Ascomycetes

Taxa	Palm host	Substrate	Originally described	Order/Family
Achorella **(1)**				Dothideomycetes, *Incertae sedis*
A. attaleae	*Attalea cohune*	leaves	Panama	
Acremonium **(1)**				Hypocreales, *Incertae sedis*
A. macrocatenatum	—	—	Peru	
Amandinea **(1)**				Teloschistales, *Caliciaceae*
A. efflorescens var. *pseudohypopelidna*	*Cocos nucifera*, *Hibiscus tiliaceus*	—	Peru	
Amarenographium **(1)**				Pleosporales, *Incertae sedis*
A. sinense	*Trachycarpus fortune*	petioles	China	
Amphisphaeria **(2)**				Xylariales, *Amphisphaeriaceae*
A. cocos	*Cocos nucifera*	petioles	France	
A. phoenicis	*Phoenix dactylifera*	petioles	Tunisia	
Angatia **(2)**				*Incertae sedis*, *Saccardiaceae*
A. palmarum	—	—	Brazil	
A. rondoniensis	—	leaves	Brazil	
Anhellia **(1)**				Myriangiales, *Myriangiaceae*
A. calami	*Calamus*	leaves	Indonesia	
Aniptodera **(3)**				Microascales, *Halosphaeriaceae*
A. intermedia	*Nypa* sp.	petioles	Malaysia	
A. nypae	*Nypa fruticans*	rachis	Malaysia	
A. palmicola	*Raphia*	rachis	South Africa	
Annulatascus **(2)**				*Incertae sedis*, *Annulatascaceae*
A. citriosporus	*Licuala*	petioles	Brunei	
A. licualae	*Licuala*	petioles	Australia	
Anthostoma **(2)**				Xylariales, *Diatrypaceae*
A. phoenicis	*Phoenix sylvestris*	leaves	India	
A. tjibodense	*Plectocomia*	rachis	Indonesia	
Anthostomella **(61)**				Xylariales, *Xylariaceae*
A. acuminata	*Jubaeopsis*, *Phoenix reclinata*	stem	South Africa	
A. applanata	*Phoenix*	stem	South Africa	
A. arecae	*Areca catechu*	petioles	Philippines	
A. baileyi	*Licuala*, *Livistona*	rachis	Australia	
A. belalongensis	*Arenga*	rachis	Brunei	
A. bipileatus	*Calamus*	rachis	Australia	
A. birima	*Trachycarpus*	petioles	Australia	
A. bruneiensis	*Licuala*	rachis	Brunei	
A. caffrariae	*Corypha*, *Phoenix*	stem	Philippines	
A. calami	*Calamus*	—	Philippines	
A. calamicola	*Calamus, Licuala*	—	Australia	
A. capensis	*Phoenix dactylifera*	leaves	South Africa	
A. clypeosa	*Archontophoenix*	rachis	Australia	
A. cocoes	*Cocos nucifera*	petioles	Portugal	
A. cocoescapitatae	*Cocos nucifera*	leaves	Spain	
A. colligata	*Raphia*	stem	South Africa	
A. confluens	—	petioles	Sri Lanka	
A. consanguinea	*Chamaerops, Sabal, Serenoa*	leaves	Italy	
A. daemonoropis	*Daemonorop*	rachis	Brunei	
A. dilatata	*Butia, Cocos, Corypha*	petioles	Argentina	
A. francisiae	*Calamus*	rachis	Indonesia	
A. frondicola	—	—	Australia	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
A. grandispora	*Kentia*	leaves	Indonesia	
A. hemileuca	*Cocos nucifera*	leaves	Paraguay	
A. irregularispora	*Licuala*	leaves	Papua New Guinea	
A. leucobasis	*Sabal serrulata*	rachis	U.S.A.	
A. licualicola	*Licuala*	rachis	Malaysia	
A. livistonae	*Livistona chinensis*	leaves	Russia	
A. livistonicola	*Livistona*	rachis	Papua New Guinea	
A. lodhii	─	petioles	Pakistan	
A. lucens	*Arenga, Corypha*	petioles	Philippines	
A. meerensis	*Phoenix*	stem	South Africa	
A. microsticta	*Sabal serrulata*	petioles	U.S.A.	
A. mindorensis	*Arenga mindorensis*	rachis	Philippines	
A. mindorensis var. *verruculosa*	*Arenga*	petioles	Philippines	
A. molleriana	*Phoenix dactylifera*	petioles	Portugal	
A. nannorrhopsis	*Nannorrhops ritchieana*	rachis	Pakistan	
A. notabilis	*Cocos*	petioles	Australia	
A. nypae	*Nypa*	petioles	Brunei	
A. nypensis	*Nypa*	petioles	Malaysia	
A. nypicola	*Nypa*	petioles	Malaysia	
A. obtusispora	─	petioles	Indonesia	
A. oraniopsis	*Oraniopsis*	fronds	Australia	
A. palmae	*Phoenix*	stem	South Africa	
A. palmaria	*Cocos*	─	U.S.A.	
A. palmicola	*Chamaerops*	leaves	Italy	
A. pandani	*Arenga, Calamus, Cocos Livistona, Oncosperma*	rachis	Australia	
A. phoenicicola	*Borassus, Elaeis, Phoenix*	rachis	Argentina	
A. phoenicis	*Phoenix*	rachis	India	
A. pinangae	*Pinanga*	trunk	Brunei	
A. pisana	*Chamaerops*	rachis	Italy	
A. raphiae	*Raphia*	─	South Africa	
A. rattanicola	*Daemonorops*	rachis	Brunei	
A. sphaerotheca	*Sabal*	petioles	U.S.A.	
A. spiralis	*Phoenix*	stem	South Africa	
A. sulcigena	─	petioles	France	
A. trachycarpi	*Trachycarpus*	petioles	U.K	
A. uniseriata	*Calamus*	─	Brunei	
A. xuanenensis	*Cocos, Trachycarpus*	petioles	China	
A. zongluensis	*Phoenix*	rachis	Hong Kong, China	
***Apioclypea* (7)**				Xylariales, *Clypeosphaeriaceae*
A. apiosporioides	*Sabal*	petioles	U.S.A.	
A. cocoicola	*Cocos*	leaves	Malaysia	
A. indica	*Phoenix*	leaves	India	
A. livistonae	*Livistona*	rachis	Papua New Guinea	
A. nonapiospora	*Archontophoenix*	rachis	Hong Kong, China	
A. nypicola	*Nypa*	rachis	Malaysia	
A. phoenicicola	*Phoenix*	fronds	Hong Kong, China	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
***Apiospora* (1)**				*Incertae sedis*, *Apiosporaceae*
A. sinensis	*Trachycarpus*	petioles	China	
***Apiosporium* (1)**				Capnodiales, *Capnodiaceae*
A. australe	—	trunk	Argentina	
***Apiospora* (1)**				*Incertae sedis*, *Apiosporaceae*
A. australe	—	trunk	Argentina	
***Apogaeumannomyces* (1)**				Sordariomycetes, *Incertae sedis*
A. perplexus	—	fronds	Peru	
***Aposphaeria* (1)**				Pleosporales, *Melanommataceae*
A. martinii	*Sabal*	leaves	U.S.A.	
***Appendicospora* (2)**				*Incertae sedis*, *Apiosporaceae*
A. coryphae	*Corypha*	rachis	Philippines	
A. hongkongensis	*Livistona chinensis*	rachis	Hong Kong, China	
***Appendispora* (2)**				Pleosporales, *Didymosphaeriaceae*
A. australiensis	*Licuala*	rachis	Australia	
A. frondicola	*Oncosperma horridum*	rachis	Brune	
***Arachnopeziza* (1)**				Helotiales*, Hyaloscyphaceae*
A. rhopalostylidis	*Rhopalostylis*	leaves	New Zealand	
***Arecacicola* (1)**				Sordariomycetes, *Incertae sedis*
A. calami	*Calamus*	trunk	Indonesia	
***Arecomyces* (9)**				Xylariales, *Hyponectriaceae*
A. bruneiensis	*Daemonorops*	rachis	Brune	
A. calami	*Calamus*	—	Brune	
A. dicksonii	*Iriartia*	rachis	Ecuador	
A. epigeni	*Oraniopsis*	rachis	Australia	
A. frondicola	*Arenga*	rachis	Brune	
A. hedgeri	*Jessenia*	rachis	Ecuador	
A. licualae	*Licuala*	petioles	Brune	
A. sekoyae	*Jessenia*	rachis	Ecuador	
A. tetrasporus	*Phytelephas*	rachis	Ecuador	
***Arecophila* (7)**				Xylariales, *Amphisphaeriaceae*
A. calamicola	*Calamus*	rachis	Indonesia	
A. chamaeropis	*Chamaerops*	petioles	Spain	
A. eugeissonae	*Eugeissona*	rachis	Malaysia	
A. gulubiicola	*Gulubia*	trunk	Papua New Guinea	
A. notabilis	*Calamus*	rachis	Indonesia	
A. nypae	*Nypa*	leaves	Malaysia	
A. serrulata	*Serenoa*	petioles	U.S.A.	
***Arenaea* (1)**				Helotiales, *Lachnaceae*
A. javanica	*Plectocomia*	petioles	Indonesia	
***Argopericonia* (1)**				Pezizomycotina/ *Incertae sedis*
A. indirae	*Calamus*	—	India	
***Arthonia* (1)**				Arthoniales, *Arthoniaceae*
A. parantillarum	*Roystonea*	—	China	
***Arthrobotrys* (1)**				Orbiliales, *Orbiliaceae*
A. longiramulifera	—	petioles	Peru	
***Ascobolus* (1)**				Pezizales, *Ascobolaceae*
A. singeri	—	—	Germany	
***Ascotaiwania* (2)**				Sordariomycetes, *Incertae*

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
A. licualae	*Licuala*	petioles	Australia	
A. palmicola	*Iriartia*	rachis	Ecuador	
Asteridium **(2)**				Meliolales, *Meliolaceae*
A. ferrugineum	*Cocos*	leaves	Tanzania	
A. novum	*Phoenix*	leaves	Gallia	
Asterina **(4)**				Asterinales, *Asterinaceae*
A. arecacearum	*Calamus*	leaves	India	
A. bakeri	*Calamus, Daemonorops*	leaves	Philippines	
A. sabalicola	*Sabal*	leaves	U.S.A.	
A. subglobulifera	–	leaves	Indonesia	
Asterinella **(3)**				Microthyriales, *Microthyriaceae*
A. calami	*Calamus*	leaves	Philippines	
A. palawanensis	–	leaves	Philippines	
A. saginata	*Pinanga*	leaves	Philippines	
Asteromella **(1)**				Dothideomycetes, *Incertae sedis*
A. cocogena	*Cocos*	leaves	Tai Wan	
Astrocystis **(7)**				Xylariales, *Xylariaceae*
A. cocoes	*Cocos*	rachis	Philippines	
A. nypae	*Nypa*	fronds	Malaysia	
A. palmarum	–	petioles	Bermuda	
A. rachidis	*Cocos*	rachis	France	
A. rudis	*Korthalsia*	trunk	Papua New Guinea	
A. selangorensis	*Nypa*	rachis	Malaysia	
A. sinensis	*Trachycarpus*	petioles	China	
Astrosphaeriella **(27)**				Pleosporales, *Incertae sedis*
A. aequatoriensis	*Phytelephas*	petioles	Ecuador	
A. angustispora	*Licuala*	fronds	Brune	
A. aquatica	*Livistona*	petioles	Papua New Guinea	
A. australiensis	*Calamus*	stem	Australia	
A. bakeriana	*Livistona*	leaves	Singapore	
A. daemonoropis	*Daemonorops*	petioles	Hong Kong, China	
A. exorrhiza	*Iriartia*	roots	Venezuela	
A. fissuristoma	*Calamus*	petioles	Brune	
A. floridana	*Sabal*	petioles	U.S.A.	
A. frondicola	*Oraniopsis*	leaves	Australia	
A. immersa	*Archontophoenix*	petioles	Hong Kong, China	
A. lenticularis	*Geonoma*	petioles	Ecuador	
A. livistonicola	*Livistona*	petioles	Hong Kong, China	
A. lophiostomopsis	*Arenga*	rachis	Brunei	
A. malayensis	*Daemonorop*	–	Malaysia	
A. maquilingiana	*Calamus*	stem	Philippines	
A. mauritiae	*Mauritia*	petioles	Ecuador	
A. nipaecola	*Nypa*	petioles	Indonesia	
A. nypae	*Nypa*	petioles	Brunei	
A. samuelsii	–	petioles	Brazil	
A. splendida	–	petioles	Ecuador	
A. stellata	–	–	Mexico	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
A. striataspora	*Nypa*	petioles	Indonesia	
A. tornata	–	petioles	Surinam	
A. uberina	–	petioles	France	
A. vaginata	*Baclris*	–	Mexico	
A. vesuvius	–	petioles	Sri Lanka	
Asymmetricospora **(1)**				Pleosporales, *Melanommataceae*
A. calamicola	*Calamus*	stem	Australia	
Atrosetaphiale **(1)**				Pezizomycotina, *Incertae sedis*
A. flagelliformis	–	petioles	Peru	
Auerswaldia **(1)**				Dothideales, *Dothideaceae*
A. guilielmae	*Guilielmae*	–	Brazil	
Aulaxina **(1)**				Ostropales, *Gomphillaceae*
A. intermedia	*Calyptrogyne*	–	Costa Rica	
Aulographum **(2)**				Asterinales, *Aulographaceae*
A. atromaculans	–	petioles	Indonesia	
A. fimbriatum	*Daemonorops*	rachis	Philippines	
Bactrodesmium **(1)**				Dothideomycetes, *Incertae sedis*
B. palmicola	–	rachis	Mexico	
Bapalmuia **(1)**				Lecanorales, *Pilocarpaceae*
B. lineata	*Cryosophila*	leaves	Costa Rica	
Belonidium **(1)**				Helotiales, *Lachnaceae*
B. glaucofuligineum	–	–	Indonesia	
Berkleasmium **(2)**				Pleosporales, *Incertae sedis*
B. crunisia	*Calamus*	rachis	Thailand	
B. sinense	*Trachycarpus*	petioles	China	
Bharatheeya **(1)**				Pezizomycotina, *Incertae sedis*
B. mucoidea	*Calamus*	leaves	India	
Bionectria **(3)**				Hypocreales, *Bionectriaceae*
B. palmicola	*Mauritia*	rachis	Ecuador	
B. pseudochroleuca	–	fronds	France	
B. verrucispora	*Rhopalostylis*	–	New Zealand	
Blastophorum **(1)**				Pezizomycotina, *Incertae sedis*
B. fusarioides	–	petioles	Malaysia	
Boerlagiomyces **(1)**				Tubeufiales, *Tubeufiaceae*
B. velvutinus	*Plectocomia*	petioles	Indonesia	
Bondiella **(1)**				*Incertae sedis*, *Mesnieraceae*
B. palmicola	*Elaeis*	rachis	Tanzania	
Botryosphaeria **(6)**				Botryosphaeriales, *Botryosphaeriaceae*
B. archontophoenicis	*Archontophoenix*	rachis	Hong Kong, China	
B. arxii	*Caryota*	leaves	India	
B. brunneispora	*Trachycarpus*	petioles	China	
B. cocogena	*Cocos*	leaves	Brazil	
B. cocoicola	*Cocos*	rachis	Seychelles	
B. elaeidis	*Elaeis*	rachis	Sierra Leone	
Brachysporiopsis **(1)**				Pezizomycotina, *Incertae sedis*
B. chinensis	*Livistona*	rachis	Hong Kong, China	
Brobdingnagia **(1)**				Phyllachorales, *Phyllachoraceae*
B. nigeriensis	*Eremospatha*	leaves	Sierra Leone	
Brunneiapiospora **(6)**				Xylariales

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
B. aequatoriensis	*Geonoma*	trunk	Ecuador	
B. australiensis	*Calamus*	–	Australia	
B. daemonoropis	*Daemonorop*	rachis	Brunei	
B. deightoniella	*Elaeis*	rachis	Sierra Leone	
B. javensis	*Calamus*	rachis	Indonesia	
B. jesseniae	*Jessenia*	petiole	Ecuador	
Bulbocatenospora **(1)**				Pezizomycotina, *Incertae sedis*
B. complanata	*Bactris*	leaves	Venezuela	
Byssosphaeria **(1)**				Pleosporales, *Melanommataceae*
B. schiedermayeriana	*Sabal*	leaves	Germany	
Calonectria **(3)**				Hypocreales, *Nectriaceae*
C. dolichospora	–	leaves	Brazil	
C. ferruginea	*Geonoma*	leaves	Brazil	
C. spathiphylli	*Howea*	leaves	U.S.A.	
Camarops **(1)**				Boliniales, *Boliniaceae*
C. rickii	–	–	Brazil	
Camarotella **(2)**				Phyllachorales, *Phyllachoraceae*
C. acrocomiae	*Astrocaryum*	leaves	Brazil	
C. costaricensis	*Acrocomia*	leaves	Costa Rica	
Canariomyces **(1)**				Microascales, *Microascaceae*
C. notabilis	*Phoenix*	roots	Spain	
Cannonia **(1)**				Xylariales, *Amphisphaeriaceae*
C. australe	*Butia*	–	Argentina	
Capsulospora **(8)**				Xylariales, *Amphisphaeriaceae*
C. angustispora	*Licuala*	fronds	Brunei	
C. australiensis	*Licuala*	fronds	Australia	
C. bipolaris	*Calamus*	fronds	Brunei	
C. borneoensis	*Calamus conirostris*	fronds	Brunei	
C. brunneispora	*Daemonorops*	rachis	Brunei	
C. calamicola	*Calamus*	rachis	Indonesia	
C. frondicola	*Daemonorop*	rachis	Malaysia	
C. trachycarpa	*Trachycarpus*	petioles	China	
Carinispora **(2)**				Pleosporales, *Phaeosphaeriaceae*
C. nypae	*Nypa fruticans*	rachis	Brunei	
C. velatispora	*Oncosperma tigillarium*	rachis	Brunei	
Catabotrys **(1)**				*Incertae sedis*, *Catabotrydaceae*
C. deciduum	*Archontophoenix*	leaves	Australia	
Caudatispora **(1)**				Sordariomycetes, *Incertae sedis*
C. palmicola	*Phytelephas*	rachis	Ecuador	
Cenangina **(1)**				Helotiales, *Helotiaceae*
C. palmarum	–	leaves	Indonesia.	
Cenangiumella **(1)**				Helotiales, *Helotiaceae*
C. rattanicola	*Calamus conirostris*	sheath	Brunei	
Ceratocystis **(4)**				Microascales, *Incertae sedis*,
C. antennaroidospora	*Calamus maximus*	stem	Philippines	
C. asteroides	*Calamus maximus*	stem	Philippines	
C. filiformis	*Calamus maximus*	stem	Philippines	
C. radicicola	*Phoenix dactylifera*	trunk	U.S.A.	
Ceratostomella **(1)**				Sordariomycetidae, *Incertae sedis*

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
C. leptorrhyncha	*Chamaerops humilis*	–	Algeria	
***Cercophora* (2)**				Sordariales, *Lasiosphaeriaceae*
C. palmicola	–	trunk	Venezuela	
C. subambigua	–	stem	Brazil	
***Ceriospora* (1)**				Xylariales, *Amphisphaeriaceae*
C. arecae	*Areca catechu*	leaves	India	
***Ceuthocarpon* (1)**				Diaporthales, *Gnomoniaceae*
C. calamicolum	*Calamus*	stem	China (Hainan)	
***Ceuthospora* (1)**				Helotiales, *Phacidiaceae*
C. palmicola	*Trachycarpus*	petioles	Switzerland	
***Chaetomium* (2)**				Sordariales, *Chaetomiaceae*
C. fieberi	*Cocos yatay*	leaves	Argentina	
C. orientale	*Cocos nucifera*	–	Belize	
***Chaetopsina* (2)**				Hypocreales, *Nectriaceae*
C. alexandrae	*Archontophoenix*	rachis	Australia	
C. hongkongensis	*Phoenix*	petioles	Hong Kong, China	
***Chaetosphaeria* (4)**				Chaetosphaeriales, *Chaetosphaeriaceae*
C. arecacensis	*Licuala*	petioles	Brunei	
C. cubensis	–	trunk	Cuba	
C. hongkongensis	*Archontophoenix*	fronds	Hong Kong, China	
C. saltuensis	*Cocos*	petioles	Seychelles	
***Chalara* (2)**				
C. indica	*Areca*	leaves	India	
C. siamense	*Eleiodoxa*	stem	Thailand	
***Chilonectria* (1)**				Hypocreales, *Nectriaceae*
C. macrospora	–	–	Indonesia.	
***Ciboria* (1)**				Helotiales, *Sclerotiniaceae*
C. lilacina	–	petiole	Portugal	
***Ciliofusospora* (1)**				Sordariomycetes, *Incertae sedis*
C. oenocarpi	*Oenocarpus distichus*	leaves	Brazil	
***Circinotrichum* (1)**				Pezizomycotina, *Incertae sedis*
C. palmicola	*Trachycarpus*	petioles	Australia	
***Cirsosia* (3)**				Asterinales, *Asterinaceae*
C. arecacarum	*Calamus thwaitesii*	leaves	India	
C. hughesii	*Ancistrophyllum*	leaves	Ghana	
C. transversalis	–	leaves	Philippines	
***Cirsosiella* (1)**				Asterinales, *Asterinaceae*
C. nodulosa	*Calamus formosanus*	leaves	Taiwan	
***Cirsosina* (1)**				Microthyriales, *Microthyriaceae*
C. calami	*Calamus*	leaves	Bomeo	
***Cladonia* (1)**				Lecanorales, *Cladoniaceae*
C. palmicola	*Butia*	–	Brazil	
***Clonostachys* (2)**				Hypocreales, *Bionectriaceae*
C. pseudochroleuca	–	fronds	France	
C. verrucispora	*Rhopalostylis*	–	New Zealand	
***Coccomyces* (2)**				Rhytismatales, *Rhytismataceae*
C. cocoes	*Cocos nucifera*	leaves	Australia	
C. palmicola	–	leaves	Panama	
***Cocconia* (3)**				Asterinales, *Parmulariaceae*
C. astrocaryi	*Astrocaryum vulgare*	leaves	Ghana	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
C. palmae	–	leaves	Costa Rica	
C. sparsa	*Sabal palmetto*	leaves	U.S.A.	
Coccostromopsis **(3)**				Phyllachorales, *Phyllachoraceae*
C. chamaedoreae	*Chamaedorea bifurcata*	leaves	Costa Rica	
C. diplothemii	*Bactris*	leaves	Brazil	
C. palmicola	*Desmoncus littoralis*	leaves	Brazil	
Cochliobolus **(1)**				Pleosporales, *Pleosporaceae*
C. palmivora	*Livistona chinensis*	leaves	India	
Cocoicola **(5)**				Phyllachorales, *Phaeochoraceae*
C. californica	*Washingtonia filifera*	rachis	U.S.A.	
C. cylindrospora	*Cocos nucifera*	leaves	Papua New Guinea	
C. fusispora	*Cocos nucifera*	rachis	Malaysia	
C. livistonicola	*Livistona chinensis*	petioles	Hong Kong, China	
C. piperata	*Livistonicola*	petioles	Australia	
Coniochaeta **(2)**				Coniochaetales, *Coniochaetaceae*
C. caryotae	*Caryota urens*	rachis	India	
C. tilaki	*Phoenix sylvestris*	leaves	India	
Corallomyces **(1)**				Pezizomycotina, *Incertae sedis*
C. mauritiicola	*Mauritia flexuosa*	–	Brazil	
Corynespora **(2)**				Pleosporales, *Corynesporascaceae*
C. caryotae	*Caryota mitis*	rachis	Singapore	
C. rhapidis-humilis	*Rhapis humilis*	rachis	China	
Corynesporasca **(1)**				Pleosporales, *Corynesporascaceae*
C. caryotae	*Caryota urens*	leaves	Sri Lanka	
Cosmospora **(1)**				Hypocreales, *Nectriaceae*
C. purpureocolla	*Calamus australis*	petioles	Australia	
Costantinella **(1)**				Pezizales, *Morchellaceae*
C. palmicola	*Livistona chinensis*	petioles	Hong Kong, China	
Craspedodidymum **(4)**				Chaetosphaeriales, *Chaetosphaeriaceae*
C. licualae	*Licuala longecalycata*	trunk	Thailand	
C. microsporum	*Licuala longecalycata*	trunk	Thailand	
C. nigroseptatum	*Oncosperma horridum*	rachis	Brune	
C. siamense	*Licuala longecalycata*	trunk	Thailand	
Cryptodiscus **(1)**				Ostropales, *Stictidaceae*
C. pumilis	–	rachis	Guadeloupe	
Cryptovalsa **(1)**				Sordariomycetes, *Incertae sedis*
C. deusta	*Sabal serrulata*	petioles	U.S.A	
Curvatispora **(1)**				Sordariomycetes, *Incertae sedis*
C. singaporensis	*Livistona spinosa*	fronds	Singapore	
Curvularia **(1)**				Pleosporales, *Pleosporaceae*,
C. trachycarpi	*Trachycarpus fortunei*	leaves	China	
Custingophora **(1)**				Sordariomycetes, *Incertae sedis*
C. undulatistipes	*Eleiodoxa conferta*	petioles	Thailand	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
Cyanopulvis **(1)**				Xylariales, *Xylariaceae*
C. australiensis	*Calamus australis*	petioles	Australia	
Cyclodomus **(1)**				Phyllachorales, *Incertae sedis*
C. aequatoriensis	*Astrocaryum*	leaves	Ecuador	
Dactylaria **(3)**				Helotiales, *Incertae sedis*
D. flammulicornuta	*Nenga pumila*	petioles	Thailand	
D. palmae	*Nenga*	sheath	Thailand	
D. uliginicola	*Eleiodoxa conferta*	rachis	Thailand	
Dactylospora **(1)**				Lecanorales, *Dactylosporaceae*
D. imperfecta var. *stygiella*	*Serenoa serrulata*	–	U.S.A	
Dasyscypha **(1)**				Helotiales, *Lachnaceae*
D. aleuroides	–	petioles	India	
Dasyscyphus **(2)**				Helotiales, *Lachnaceae*
D. oncospermatis var. *oncospermatis*	*Oncosperma fasciculatum*	–	Sri Lanka	
D. oncospermatis var. *macrosporus*	–	petioles	Indonesia	
Davincia **(1)**				Helotiales, *Helotiaceae*
D. tenella	–	leaves	Indonesia	
Deightoniella **(1)**				*Incertae sedis*, *Magnaporthaceae*
D. arecae	*Areca*	leaves	China	
Dermatea **(2)**				Helotiales, *Dermateaceae*
D. palmicola	–	trunk	France	
D. sparsa	–	leaves	Brazil	
Diaporthe **(3)**				Diaporthales, *Diaporthaceae*
D. arctii	*Phoenix dactylifera*	petioles	Tunisia	
D. chamaeropina	*Chamaerops humilis*	petioles	Italy	
D. palmarum	*Trachycarpus*	petioles	China	
Diatrype **(4)**				Diaporthales, *Diaporthaceae*
D. euterpes	*Euterpe oleracea*	sheath	Brazil	
D. palmarum	*Unknown*	trunk	Brazil	
D. palmarum var. *rimosa*	*Unknown*	trunk	Brazil	
D. urticaria	*Unknown*	petioles	France	
Diatrypella **(4)**				Diaporthales, *Diaporthaceae*
D. borassi	*Borassus flabellifer*	petioles	India	
D. caryotae	*Caryota*	leaves	India	
D. palmicola	*Livistona australis*	rachis	Australia	
D. tuberculata	*Sabal serrulata*	–	U.S.A.	
Dictyochaeta **(1)**				Chaetosphaeriales, *Chaetosphaeriaceae*
D. minutissima	*Coccothrinacis miraguamae*	petioles	Cuba	
Dictyosporium **(4)**				Pleosporales, *Incertae sedis*
D. dkagarwalii	*Cocos nucifera*	leaves	India	
D. hughesii	*Rhopalostylis sapida*	leaves	New Zealand	
D. rhopalostylidis	*Rhopalostylis sapida*	leaves	New Zealand	
D. tetraseriale	*Livistona chinensis*	fronds	Hong Kong, China	
Dictyothyriella **(1)**				Microthyriales, *Micropeltidaceae*
D. guianensis	*Mauritae*	leaves	Trinidad	
Didymella **(4)**				Pleosporales, *Didymellaceae*
D. cocoicola	*Cocos nucifera*	leaves	Brazil	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
D. cocoina	*Cocos nucifera*	–	Madagascar	
D. cocos	*Cocos nucifera*	leaves	U.S.A.	
D. jaffueli	*Jubaea spectabilis*	leaves	Chile	
Didymobotryum **(1)**				Pezizomycotina, *Incertae sedis*
D. korthalsiae	*Korthalsia*	rachis	Singapore	
Didymosphaeria **(3)**				Pleosporales, *Didymosphaeriaceae*
D. calamicola	*Calamus*	rachis	Australia	
D. minor	*Sabal serrulata*	–	U.S.A.	
D. minutelloides	*Arenga*	petioles	Philippines	
Dimeriellopsis **(1)**				*Incertae sedis*, *Pseudoperisporiaceae*
D. cocoicola	*Cocos nucifera*	–	Brazil	
Dimerina **(1)**				*Incertae sedis*, *Pseudoperisporiaceae*
D. cyanophila	*Phoenix canariensis*	petioles	Algeria	
Dimerium **(1)**				*Incertae sedis*, *Parodiopsidaceae*
D. bactridicola	*Bactris*	leaves	Peru	
Dimerosporina **(1)**				*Incertae sedis*, *Parodiopsidaceae*
D. arecae	*Areca catechu*	–	India	
Diplochorella **(1)**				Botryosphaeriales, *Planistromellaceae*
D. indaie	*Cocos nucifera*	leaves	Brazil	
Diplochorina **(1)**				Dothideomycetes, *Incertae sedis*
D. naumovii	*Chamaerops humilis*	petioles	Russia	
Distocercospora **(1)**				Capnodiales, *Mycosphaerellaceae*
D. livistonae	*Livistona chinensis*	leaves	New Zealand	
Dothidella **(1)**				*Incertae sedis*, *Polystomellaceae*
D. diplothemii	*Diplothemium maritimum*	leaves	Brazil	
Durispora **(1)**				Diaporthales, *Valsaceae*
D. elaeidicola	*Elaeis guineensis*	rachis	Malaysia	
Dysrhychis **(1)**				
D. palmicola	*Elaeis guineensis*	leaves	Sierra Leone	
Echidnodes **(1)**				Asterinales, *Asterinaceae*
E. cocoes	*Cocos nucifera*	leaves	Philippines	
Ellisembia **(3)**				Sordariomycetes, *Incertae sedis*
E. atrobrunnea	–	rachis	Malaysia	
E. globulosa	–	rachis	China	
E. mucicola	–	rachis	China	
Ellisiodothis **(4)**				*Incertae sedis*, *Muyocopronaceae*
E. cocoicola	*Cocos nucifera*	leaves	Taiwan	
E. crustacea	*Cocos nucifera*	leaves	Paraguay	
E. inquinans	*Sabal palmetto*	leaves	U.S.A.	
E. pittierii	–	leaves	Venezuala	
Endomelanconium **(1)**				Helotiales, *Helotiaceae*
E. phoenicicola	*Phoenix*	petioles	Hong Kong, China	
Endosporoideus **(1)**				Pezizomycotina, *Incertae sedis*

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
E. pedicellatus	*Phoenix*	petioles	Hong Kong, China	
***Erinella* (1)**				Helotiales, *Lachnaceae*
E. nivea	*Calamus*	leaves	Indonesia	
***Euceramia* (1)**				Chaetothyriales, *Chaetothyriaceae*
E. palmicola	*Cocos nucifera*	leaves	Brazil	
***Euryachora* (1)**				Capnodiales, *Mycosphaerellaceae*
E. neowashingtoniae	*Neowashingtonia filifera*	–	U.S.A.	
***Eutypa* (1)**				Xylariales, *Diatrypaceae*
E. rattanicola	*Calamus moti*	–	Australia	
***Eutypella* (4)**				Xylariales, *Diatrypaceae*
E. arecae	*Areca catechu*	trunk	Philippines	
E. borassi	*Borassus flabellifer*	petioles	India	
E. cocoes	*Cocos*	–	–	
E. sabalina	*Sabal*	petioles	U.S.A.	
***Everhartia* (1)**				Pezizomycotina, *Incertae sedis*
E. phoenicis	*Phoenix hanceana*	leaves	Hong Kong, China	
***Farrowia* (1)**				Sordariales, *Chaetomiaceae*
F. malaysiensis	*Elaeis guineensis*	–	Malaysia	
***Fasciatispora* (5)**				Xylariales, Xylariaceae
F. bicincta	*Caryota*	rachis	Philippines	
F. melanosticta	*Sabal palmetto*	leaves	U.S.A.	
F. nypae	*Nypa fruticans*	rachis	Brunei	
F. petrakii	–	–	–	
F. sabalicola	*Sabal palmetto*	rachis	U.S.A.	
***Flammispora* (1)**				Hypocreomycetidae, *Incertae sedis*
F. bioteca	*Licuala*	leaves	Thailand	
***Fluviatispora* (2)**				Microascales, *Halosphaeriaceae*
F. reticulata	*Livistona*	petioles	Papua New Guinea	
F. tunicata	*Livistona*	petioles	Papua New Guinea	
***Frondicola* (1)**				*Incertae sedis*, *Annulatascaceae*
F. tunitricuspis	*Nypa fruticans*	rachis	Brune	
Frondisphaeria (2)				Sordariomycetes, *Incertae sedis*
F. joanneae	*Calamus*	petioles	Australia	
F. palmicola	*Eugeissona*	rachis	Brunei	
***Frondispora* (1)**				Xylariales, *Amphisphaeriaceae*
F. bicalcarata	*Chamaerops humilis*	petioles	Italy	
***Gaeumannomyces* (1)**				Magnaporthales, *Magnaporthaceae*
G. licualae	*Licuala*	petioles	Brunei	
***Gibbera* (1)**				Venturiales, *Venturiaceae*
G. syagri	*Syagrus pickelii*	–	Brazil	
***Gibberella* (1)**				Hypocreales, *Nectriaceae*
G. heterochroma	*Calamus*	leaves	Australia	
***Gilmania* (1)**				Chaetothyriales, *Chaetothyriaceae*

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
G. pulchra	–	leaves	Brazil	
Glomerella **(1)**				*Incertae sedis*, *Glomerellaceae*
G. arecae	*Areca catechu*	leaves	Philippines	
Gloniella **(2)**				Hysteriales, *Hysteriaceae*
G. fourcroyae	–	leaves	Sri Lanka	
G. palmarum	*Phoenix natalensis*	leaves	Indonesia	
Gloniopsis **(1)**				Hysteriales, *Hysteriaceae*
G. pulchra	–	leaves	Brazil	
Glomerella **(1)**				*Incertae sedis*, *Glomerellaceae*
G. arecae	*Areca catechu*	leaves	Philippines	
Gloniella **(2)**				Hysteriales, *Hysteriaceae*
G. fourcroyae	–	leaves	Sri Lanka	
G. palmarum	*Phoenix natalensis*	leaves	Indonesia	
Gloniopsis **(1)**				Hysteriales, *Hysteriaceae*
G. multiformis	*Copernicia cerifera*	petioles	Paraguay	
Glonium **(1)**				Mytilinidiales, *Gloniaceae*
G. palmincola	–	–	Brazil	
Gnomoniella **(1)**				Diaporthales, *Gnomoniaceae*
G. tubaeformis	*Roystonea oleracea*	–	Brazil	
Goidanichiella **(1)**				Pezizomycotina, *Incertae sedis*
G. fusiformis	*Oncosperma horridum*	rachis	Brune	
Graphina **(1)**				Ostropales, *Graphidaceae*
G. salazinica	–	stem	Australia	
Graphis **(1)**				Ostropales, *Graphidaceae*
G. palmicola	*Cocos*	stem	India	
Guestia **(1)**				Xylariales, *Xylariaceae*
G. gonetropospora	*Mauritia jlexuosa*	rachis	Ecuador	
Guignardia **(10)**				Botryosphaeriales, *Phyllostictaceae*
G. arecae	*Areca catechu*	leaves	Philippines	
G. arengae	*Arenga mindorensis*	leaves	Philippines	
G. astrocaryi	*Astrocaryum rostratum*	leaves	Brazil	
G. bispora	*Areca*	Leaves	Thailand	
G. calami	*Cocos nucifera*	leaves	Burma	
G. candeloflamma	*Pinanga*	leaves	Australia	
G. cocoes	*Cocos nucifera*	leaves	Solomon island	
G. cocogena	*Cocos nucifera*	leaves	Guyana	
G. ellipsoidea	*Caryota*	leaves	Thailand	
G. manokwaria	*Gulubia*	rachis	Indonesia	
G. migrans	*Arenga saccharifera*	leaves	Philippines	
G. ryukyuensis	*Arenga engleri*	leaves	Japan	
Gyalideopsis **(4)**				Ostropales, *Gomphillaceae*
G. epithallina	*Chamaedorea*	leaves	Costa Rica	
G. minutissima	*Calyptrogyne*	leaves	Costa Rica	
G. montana	–	leaves	Costa Rica	
G. pallida	–	leaves	Costa Rica	
Hansfordia **(1)**				Pezizomycotina, *Incertae sedis*
H. catalonica	–	rachis	Spain	
Haraea **(1)**				Meliolales, *Meliolaceae*
H. mauritiae	*Mauritia*	leaves	Trinidad	
Helicascus **(1)**				Pleosporales, *Morosphaeriaceae*
H. nypae	*Nypa fruticans*	fronds	Brunei	
Helicorhoidion **(1)**				Pezizomycotina, *Incertae sedis*
H. nypicola	*Nypa*	–	Brunei	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
Helminthosporium **(2)**				Pleosporales, *Massarinaceae*
H. constrictum	*Trachycarpus*	rachis	China	
H. subhyalinum	*Phoenix hanceana*	leaves	China	
Helotium **(2)**				Helotiales, *Helotiaceae*
H. blumenaviense	–	leaves	Brazil	
H. disseminatum	–	leaves	Brazil	
Hemicorynespora **(2)**				Chaetosphaeriales, *Chaetosphaeriaceae*
H. biconica	*Calamus rotang*	leaves	Singapore	
H. obclavata	*Calamus*	leaves	Singapore	
Hemisynnema **(1)**				Pezizomycotina, *Incertae sedis*
H. malayasianum	–	rachis	Malaysia	
Herpotrichia **(3)**				Pleosporales, *Melanommataceae*
H. calamicola	*Calamus*	petioles	Australia	
H. nypicola	*Nypa fruticans*	petioles	Malaysia	
H. palmicola	*Calamus caryotoides*	–	Australia	
Homostegia **(1)**				Dothideomycetes, *Incertae sedis*
H. lophiostomacea	*Arenga saccharifera*	petioles	Philippines	
Humaria **(1)**				Pezizales, *Pyronemataceae*
H. palmicola	–	–	Brazil	
Humicola **(1)**				Sordariales, *Chaetomiaceae*
H. siamensis	*Nypa fruticans*	–	Thailand	
Hyalocurreya **(1)**				*Incertae sedis*, *Cookellaceae*
H. palminicola	–	leaves	Brazil	
Hyaloderma **(1)**				Sordariomycetes, *Incertae sedis*
H. bakeriana	*Bactris major*	sheath	Brazil	
Hyaloscolecostroma **(1)**				Capnodiales, *Capnodiaceae*
H. rondoniensis	–	leaves	Brazil	
Hydropisphaera **(1)**				Hypocreales, *Bionectriaceae*
H. ciliata	*Archontophoenix alexandrae*	sheath	Australia	
H. calami	*Calamus*	sheath	Indonesia	
Hymenoscyphus **(1)**				Helotiales, *Helotiaceae*
H. sclerogenum	–	petioles	Cuba	
Hypocrea **(5)**				Hypocreales, *Hypocreaceae*
H. artocreas	–	petioles	Sri Lanka	
H. fusca	*Maximiliana regia*	petioles	France	
H. luteovirens	*Livistona subglobosa*	leaves	Japan	
H. palmicola	–	leaves	Sri Lanka	
H. protocitrinoides	–	leaves	Columbia	
Hypocrella **(4)**				Hypocreales, *Clavicipitaceae*
H. glaziovii	*Chamaedorea*	leaves	Brazil	
H. palmae	–	leaves	Suriman	
H. palmicola	–	–	Ma dagascar	
H. semen	*Chamaedorea*	leaves	Brazil	
Hypomyces **(2)**				Hypocreales, *Hypocreaceae*
H. arecae	*Areca madagascariensis*	leaves	Italy	
H. conviva	*Areca madagascariensis*	leaves	Italy	
Hypoxylon **(4)**				
H. arecarium	*Areca*	petioles	France	Xylariales, *Xylariaceae*
H. cocoinum	*Cocos nucifera*	petioles	Malaysia	
H. fragillimum	*Calamus*	–	Philippines	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
H. maculosum	*Livistona*	rachis	Indonesia	
Hysterium **(1)**				Hysteriales, *Hysteriaceae*
H. vulgare	*Chamaerops*	petioles	Algeria	
Hysterographium **(1)**				Dothideomycetes, *Incertae sedis*
H. cocoes	*Cocos alphonsei*	leaves	U.S.A.	
Hysterostomella **(1)**				Asterinales, *Parmulariaceae*
H. elaeicola	*Elaeis guineensis*	leaves	Guinea	
Hysterostomina **(4)**				Asterinales, *Parmulariaceae*
H. bakeri	*Astrocaryum*	leaves	Brazil	
H. palmae	–	leaves	Belize	
H. rhytismoides	*Bactris*	leaves	Brazil	
H. sabalicola	*Sabal palmetto*	leaves	U.S.A.	
Ijuhya **(1)**				Hypocreales, *Bionectriaceae*
I. hongkongensis	*Livistona chinensis*	petioles	Hong Kong, China	
Iodosphaeria **(1)**				Xylariales, *Amphisphaeriaceae*
I. hongkongensis	*Archontophoenix alexandrae*	petioles	Hong Kong, China	
Jahnula **(1)**				Jahnulales, *Aliquandostipitaceae*
J. appendiculata	*Licuala longecalycata*	trunk	Thailand	
Karschia **(1)**				Dothideomycetes, *Incertae sedis*
K. tjibodensis	–	rachis	Indonesia	
Kionochaeta **(1)**				Sordariomycetes, *Incertae sedis*
K. filamentosa	*Oraniopsis appendiculata*	rachis	Australia	
Koorchaloma **(1)**				Sordariomycetes, *Incertae sedis*
K. novojournalis	*Arenga engleri*	petioles	Hong Kong, China	
Kretzschmaria **(1)**				Xylariales, *Xylariaceae*
K. phoenicis	*Phoenix sylvestris*	leaves	India	
Lachnea **(1)**				Pezizales, *Pyronemataceae*
L. cocoes	*Cocos nucifera*	leaves	Tahiti	
Lachnellula **(1)**				Helotiales, *Hyaloscyphaceae*
L. rattanicola	*Calamus australis*	petioles	Australia	
Lachnum **(8)**				Helotiales, *Lachnaceae*
L. edwardsii	*Calamus conirostris*	fronds	Brunei	
L. euterpes	*Prestoea montana*	fronds	U.S.A.	
L. granulatum	*Calamus*	–	Hong Kong, China	
L. palmae	–	petioles	Belize	
L. pritzelianum	–	–	–	
L. pritzelianum var *longipilosum*	*Livistona*	fronds	China	
L. privum	–	–	China	
L. pseudocorreae	*Livistona*	leaves	China	
Laestadia **(1)**				Diaporthales, *Gnomoniaceae*
L. cocophila	*Cocos nucifera*	leaves	Guyana	
Lanzia **(1)**				Helotiales, *Rutstroemiaceae*
L. cantareirensis	–	–	Brazil	
Lasiobertia **(1)**				Xylariales, *Incertae sedis*
L. africana	–	stem	Ghana	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
***Lasionectria* (1)**				Hypocreales, *Bionectriaceae*
L. calamicola	*Calamus*	sheath	Australia	
***Lasiosphaeria* (6)**				Sordariales, *Lasiosphaeriaceae*
L. alexandrae	*Archontophoenix*	rachis	Australia	
L. alexandricola	*Archontophoenix*	sheath	Hong Kong, China	
L. chapmanii	*Mauritia flexuosa*	petioles	Ecuador	
L. jamaicensis	–	trunk	Jamaica	
L. rufula	–	–	Indonesia	
L. tephrocoma	–	petioles	Sri Lanka	
***Lecideopsella* (1)**				*Incertae sedis*, *Schizothyriaceae*
L. trinidadensis	*Mauritia*	leaves	Thailand	
***Leiosphaerella* (1)**				Xylariales, *Amphisphaeriaceae*
L. phoenicis	*Phoenix dactylifera*	rachis	West Pakistan	
***Lembosia* (6)**				Asterinales, *Asterinaceae*
L. cocoes	*Cocos nucifera*	leaves	Brazil	
L. diplothemii	*Diplothemium maritimum*	leaves	Brazil	
L. globulifera	*Calamus*	leaves	Tonkin	
L. microcarpa	*Calamus*	leaves	Philippines	
L. poasensis	*Chamaedorea bifurcata*	leaves	Costa Rica	
L. zalaccae	*Salacca edulis*	–	Indonesia	
***Lepteutypa* (2)**				Xylariales, *Amphisphaeriaceae*
L. hexagonalis	*Pinanga*	trunk	Ecuador	
L. sabalicola	*Sabal serrulata*	petioles	U.S.A.	
***Leptomeliola* (2)**				*Incertae sedis*, *Parodiopsidaceae*
L. cryptocarpa	*Mauritia martiana*	leaves	Brazil	
L. cymbisperma	*Bactris*	leaves	Peru	
***Leptosphaeria* (15)**				Pleosporales, *Leptosphaeriaceae*
L. algarbiensis	*Chamaerops humilis*	leaves	Portugal	
L. arecae	*Areca sapida*	leaves	Portugal	
L. batumensis	*Phoenix canariensis*	leaves	–	
L. briosiana	*Jubaea spectabilis*	leaves	Italy	
L. chamaeropis	*Chamaerops humilis*	leaves	Russia	
L. coccothrinacis	*Coccothrinax argentea*	leaves	Dominican	
L. cocoes	*Cocos romanzoffiana*	leaves	Portugal	
L. elaeidicola	*Elaeis guineensis*	fronds	Tanzania	
L. magnusiana	*Chamaerops humilis*	leaves	Italy	
L. molleriana	*Cocos romanzoffiana*	leaves	Portugal	
L. nypicola	*Nypa*	petioles	Malaysia	
L. phoenicis	*Phoenix dactylifera*	petioles	India	
L. phoenix	*Phoenix sylvestris*	leaves	China	
L. pruni	*Chamaerops*	leaves	Russia	
L. sabaligera	*Sabal*	leaves	U.S.A	
***Lignincola* (2)**				Microascales, *Halosphaeriaceae*
L. conchicola	*Phoenix paludosa*	fronds	Thailand	
L. nypae	*Nypa*	petioles	Malaysia	
***Linobolus* (1)**				Tubeufiales, *Tubeufiaceae*
L. ramosii	*Calamus*	leaves	Philippines	
***Linocarpon* (19)**				Sordariomycetes, *Incertae sedis*
L. angustatum	*Nypa*	petioles	Malaysia	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
L. apiculatum	–	petioles	Indonesia	
L. appendiculatum	*Nypa fruticans*	petioles	Brunei	
L. aquaticum	–	rachis	Australia	
L. australiense	*Licuala*	rachis	Australia	
L. bipolaris	*Nypa fruticans*	petioles	Brunei	
L. bruneiense	*Calamus*	petioles	Brunei	
L. calamicola	*Calamus*	–	Australia	
L. carinisporum	*Licuala*	rachis	Malaysia	
L. clavatum	*Pinanga*	rachis	Malaysia	
L. eccentricollum	*Mauritia*	petioles	Ecuador	
L. elaeidis	*Elaeis guineensis*	–	Sierra Leone	
L. livistonae	*Livistona*	petioles	Philippines	
L. longisporum	*Nypa fruticans*	petioles	Brunei	
L. luteocollum	*Archontophoenix*	rachis	Australia	
L. mauritiae	*Mauritia*	petioles	Ecuador	
L. nipae	*Nypa fruticans*	petioles	Philippines	
L. palmetto	*Sabal palmetto*	leaves	U.S.A	
L. verminosum	*Serenoa serrulata*	petioles	U.S.A.	
***Lithothelium* (2)**				Pyrenulales, *Pyrenulaceae*
L. insulare	*Cocos*	–	–	
L. microsporum	*Roystonea*	–	U.S.A.	
***Lockerbia* (1)**				Sordariales, *Incertae sedis*
L. palmicola	–	rachis	Australia	
***Lophiosphaera* (1)**				
L. tahitensis	*Cocos nucifera*	–	France	
***Lophiostoma* (2)**				Pleosporales, *Lophiostomataceae*
L. australiense	*Licuala*	petioles	Australia	
L. julii	*Phoenix*	trunk	France	
***Lophiotrema* (2)**				Pleosporales, *Lophiostomataceae*
L. phoenicis	*Phoenix*	trunk	France	
L. phyllophilum	*Phoenix*	leaves	Belgium	
***Lophodermium* (2)**				Rhytismatales, *Rhytismataceae*
L. borneoensis	*Licuala*	petioles	Brunei	
L. licualae	*Licuala*	petioles	Brunei	
***Lylea* (1)**				Pezizomycotina, *Incertae sedis*
L. palmicola	–	rachis	Cuba	
***Mackenziea* (1)**				Pezizomycotina, *Incertae sedis*
M. livistonae	*Oraniopsis*	rachis	Australia	
***Maculatifrondes* (1)**				Phyllachorales, *Phyllachoraceae*
M. aequatoriensis	*Astrocaryum*	leaves	Ecuador	
***Maculatipalma* (1)**				Diaporthales, *Valsaceae*
M. frondicola	*Linospadix*	leaves	Australia	
***Malthamyces* (2)**				
M. calamigena	*Calamus rudentum*	leaves	Sri Lanka	
M. coimbatorica	*Calamus rotang*	leaves	India	
***Mangrovispora* (1)**				Sordariomycetes, *Incertae sedis*
M. irregularis	*Phoenix*	rachis	Hong Kong, China	
***Manokwaria* (1)**				Xylariales, *Amphisphaeriaceae*
M. notabilis	–	rachis	Indonesia	
***Massaria* (1)**				Pleosporales, *Massariaceae*

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
M. bolivarii	*Chamaerops humilis*	leaves	Spain	
Massariella **(2)**				Xylariales, *Amphisphaeriaceae*
M. palmarum	*Chamaerops humilis*	leaves	Italy	
M. palmicola	–	trunk	Cameroons	
Massarina **(8)**				Pleosporales, *Massarinaceae*
M. albo-ostiolata	Livistona	petioles	Hong Kong, China	
M. corticola	*Cocos nucifera*	petioles	China	
M. desmonci	*Desmoncus*	leaves	Brazil	
M. frondisubmersa	*Livistona*	petioles	Papua New Guinea	
M. grandispora	Trachycarpus	petioles	China	
M. palmetta	*Sabal palmetto*	petioles	U.S.A.	
M. palmicola	Livistona	rachis	Malaysia	
M. sanguineo-ostiolata	Calamus	sheath	Brunei	
Massarinula **(1)**				Pleosporales, *Massarinaceae*
M. catharinae	–	leaves	Brazil	
Melanochaeta **(1)**				Chaetosphaeriales, *Chaetosphaeriaceae*
M. daemonoropis	*Daemonorops margaritae*	sheath	Hong Kong, China	
Melanographium **(2)**				Pezizomycotina, *Incertae sedis*
M. calami	Calamus	sheath	India	
M. palmicola	Archontophoenix	rachis	Hong Kong, China	
Melanomma **(2)**				Pleosporales, *Melanommataceae*
M. mindorense	*Arenga mindorensis*	–	Philippines	
M. penzigii	–	rachis	Indonesia.	
Meliola **(20)**				Meliolales, *Meliolaceae*
M. acristae	*Acrista monticola*	leaves	Puerto Rico	
M. acristae var. *coccothrinacis*	*Coccothrinax argentea*	leaves	Dominican	
M. acristae var. *cocoës*	*Cocos nucifera*	leaves	Brazil	
M. amadelpha	–	leaves	Philippines	
M. bactridis	*Bactris major*	leaves	Trinidad	
M. calami	*Calamus deeratus*	leaves	Seirra Leonne	
M. caryotae	*Caryota urens*	leaves	India	
M. decora	*Bactris*	leaves	Ecuador	
M. elaeis	–	leaves	Panama	
M. livistonae	*Livistona*	leaves	Philippines	
M. livistonae var. *boninensis*	*Livistona chinensis*	leaves	Japan	
M. mauritae	*Mauritia*	leaves	Trinidad	
M. melanococcae	*Elaeis melanococcae*	leaves	Peru	
M. morrowii	–	leaves	Panama	
M. palmicola	*Serenoa serrulata*	leaves	U.S.A.	
M. palmicola var. *africana*	*Phoenix reclinata*	leaves	South Africa	
M. palmicola var. *coperniciae*	*Copernicia australis*	leaves	Paraguay	
M. regia	*Roystonea regia*	leaves	San Domingo	
M. sparsipoda	–	leaves	Belize	
M. sparsipoda var. *longiseta*	*Copernicia pauciflora*	leaves	Cuba	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
Melomastia **(1)**				Sordariomycetes, *Incertae sedis*
M. calami	*Calamus*	petioles	Philippines	
Mendogia **(2)**				*Incertae sedis*, *Schizothyriaceae*
M. bambusina	–	leaves	Brazil	
M. philippinensis	–	leaves	Philippines	
Menisporopsis **(1)**				Chaetosphaeriales, *Chaetosphaeriaceae*
M. anisospora	*Wettinia praemosa*	petioles	Venezuela	
Metasphaeria **(5)**				Dothideales, *Dothioraceae*
M. chamaeropis	*Chamaerops humilis*	petioles	Italy	
M. jubaeae	*Jubaea spectabilis*	leaves	Chile	
M. palmetto var. *foliicola*	*Sabal palmetto*	petioles	U.S.A.	
M. rachidis	*Phoenix dactylifera*	leaves	Italy	
M. spegazzinii	*Cocos romanzoffiana*	–	Argentina	
Micropeltella **(1)**				Microthyriales, *Micropeltidaceae*
M. marginata	–	leaves	France	
Micropeltis **(5)**				Microthyriales, *Micropeltidaceae*
M. malayensis	*Salacca edulis*	leaves	Singapore	
M. palmarum	–	leaves	Belize	
M. schomburkianae	–	leaves	Brazil	
M. zalaccae	*Salacca edulis*	leaves	Singapore	
M. vagabunda var. *calamincola*	*calamus*	leaves	Philippines	
Mitopeltis **(1)**				Microthyriales, *Micropeltidaceae*
M. chilensis	*Jubaea spectabilis*	leaves	Chile	
Mollisia **(2)**				Helotiales, *Dermateaceae*
M. copelandi	*Caryota*	leaves	Philippines	
M. sabalidis	*Serenoa serrulata*	petioles	U.S.A.	
Monochaetia **(2)**				Xylariales, *Amphisphaeriaceae*
M. caryotae	*Caryota*	leaves	China	
M. salaccae	*Salacca*	leaves	China	
Monotosporella **(3)**				Sordariales, *Incertae sedis*
M. clavata	*Oraniopsis*	rachis	Australia	
M. palmicola	*Oraniopsis*	rachis	Australia	
M. sphaerica	*Oraniopsis*	rachis	Australia	
Montagnula **(2)**				Pleosporales, *Montagnulaceae*
M. palmacea	*Phoenix dactylifera*	leaves	Italy	
M. stromatosa	*Trachycarpus*	petioles	China	
Morenoella **(1)**				Asterinales, *Asterinaceae*
M. calami	*Calamus*	leaves	Indonesia.	
Morenoina **(1)**				Asterinales, *Asterinaceae*
M. palmicola	*Calamus australis*	–	Australia	
Muyocopron **(3)**				*Incertae sedis*, *Muyocopronaceae*
M. conjunctum	*Daemonorops*	leaves	Philippines	
M. hongkongense	*Archontophoenix*	petioles	Hong Kong, China	
M. palmarum	–	leaves	Brazil	
Mycogala **(1)**				Pezizales, *Pyronemataceae*
M. firmum	–	leaves	Russia	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
***Mycomicrothelia* (2)**				Trypetheliales, *Trypetheliaceae*
M. palmarum	*Cocos nucifera*	leaves	India	
M. palmicola	*Daemonorops*	petioles	Hong Kong, China	
***Mycosphaerella* (5)**				Capnodiales, *Mycosphaerellaceae*
M. chamaeropis	*Chamaerops humilis*	leaves	Italy	
M. cocoes	*Cocos*	leaves	Brazil	
M. palmae	–	leaves	Puerto Rico	
M. palmicola	*Cocos nucifera*	leaves	India	
M. serrulatae	*Acrocomia intumescens*	leaves	Brazil	
***Myelosperma* (1)**				Sordariomycetes, *Incertae sedis*
M. alata	*Lodoicea*	petioles	Seychelles	
***Myelosperma* (2)**				Sordariomycetes, *Incertae sedis*
M. parasitica	*Phoenix*	leaves	South Africa	
M. tumidum	*Cocos nucifera*	rachis	Sri Lanka	
***Myranginella* (1)**				
M. sabaleos	*Sabal palmetto*	leaves	U.S.A.	
***Naemacyclus* (1)**				Helotiales, *Incertae sedis*
M. palmarum	–	leaves	Bomeo	
***Nectria* (8)**				Hypocreales, *Nectriaceae*
N. botryosa	–	trunk	Brazil	
N. calamicola	*Calamus*	leaves	Indonesia	
N. chaetopsinae-polyblastiae	–	–	Venezuela	
N. euterpes	*Euterpes oleracea*	–	Brazil	
N. kera	*Cocos nucifera*	–	Sri Lanka	
N. palmicola	*Mauritia*	rachis	Ecuador	
N. pseudoflavoviridis	*Rhopalostylis sapida*	rachis	New Zealand	
N. suffulta	–	rachis	Cuba	
***Nectriella* (4)**				Hypocreales, *Bionectriaceae*
N. chamaeropis	*Chamaerops humilis*	–	Netherlands	
N. erythroclypea	*Licuala*	petioles	Australia	
N. jaczewskii	*Sabal blackbuniana*	sheath	Russia	
N. ptychospermatis	*Ptychosperma macarthurii*	–	Philippines	
***Nectriopsis* (1)**				Hypocreales, *Bionectriaceae*
N. lilliputia	–	–	Brazil	
***Nemania* (1)**				
N. saladerana	*Astrocaryum*	rachis	Ecuador	
***Neodeightonia* (2)**				Botryosphaeriales, *Botryosphaeriaceae*
N. palmicola	*Arenga westerhoutii*	leaves	Thailand	
N. phoenicum	*Phoenix*	–	Spain	
***Neolinocarpon* (8)**				Sordariomycetes, *Incertae sedis*
N. australiense	*Calamus*	–	Australia	
N. calami	*Calamus conirostris*	petioles	Brunei	
N. enshiense	*Trachycarpus*	petioles	China	
N. eutypoides	*Archontophoenix alexandrae*	rachis	Australia	
N. globosicarpon	*Nypa fruticans*	fronds	Brunei	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
N. inconspicuum	*Ancistrophyllum*	rachis	Australia	
N. nonappendiculatum	*Ancistrophyllum*	petioles	Australia	
N. nypicola	*Nypa*	petioles	Malaysia	
Netrocymbe **(1)**				
N. mauritiae	*Mauritia vinifera*	leaves	Brazil	
Niesslia **(2)**				Hypocreales, *Niessliaceae*
N. palmicola	*Cocos*	petioles	Seychelles	
N. taiwanensis	*Chrysalidocarpus lutescens*	sheath	Taiwan	
Nigromammilla **(1)**				Sordariomycetes, *Incertae sedis*
N. calami	*Daemonorops margaritae*	sheath	Hong Kong, China	
Nipicola **(3)**				Xylariales, *Xylariaceae*
N. carbonispora	*Nypa fruticans*	rachis	Brunei	
N. licualae	*Licuala*	petioles	Australia	
N. selangorensis	*Nypa fruticans*	rachis	Kuala Selangor	
Octospora **(1)**				Pezizales, *Pyronemataceae*
O. watersonii	*Livistona chinensis*	–	Bermuda	
Oletheriostrigula **(1)**				Strigulales, *Strigulaceae*
O. papulosa	*Chamaerops humilis*	leaves	Algeria	
Ophioceras **(1)**				Magnaporthales, *Magnaporthaceae*
O. palmae	*Calamus*	–	Philippines	
Ophiodothella **(3)**				Phyllachorales, *Phyllachoraceae*
O. arengae	*Arenga*	rachis	Taiwan	
O. calamicola	*Calamus rotang*	leaves	India	
O. palmicola	–	rachis	Guyana	
Ophionectria **(1)**				Hypocreales, *Nectriaceae*
O. calamicola	*Calamus*	petioles	Indonesia	
Orbilia **(2)**				Orbiliales, *Orbiliaceae*
O. loci-semiarum	–	–	Brazil	
O. trinacriifera	–	petioles	Peru	
Ornatispora **(3)**				Sordariomycetes, *Incertae sedis*
O. frondicola	*Mauriti*	petioles	Ecuador	
O. gamsii	*Calamus*	rachis	Brunei	
O. palmicola	–	rachis	Ecuador	
Oxodeora **(1)**				Phyllachorales, *Phyllachoraceae*
O. petrakii	*Roystonea regia*	petioles	Dominican	
Oxydothis **(65)**				Xylariales, *Amphisphaeriaceae*
O. acutata	*Orania*	leaves	Philippines	
O. alexandrarum	*Archontophoenix alexandrae*	petioles	Australia	
O. angustispora	*Licuala*	petioles	Australia	
O. asiatic	*Calamus*	–	Brunei	
O. asymmetrica	*Calamus*	petioles	Brunei	
O. australiensis	*Archontophoenix*	petioles	Australia	
O. batuapoiensis	*Daemonorops*	petioles	Brunei	
O. belalongensis	*Licuala*	petioles	Brunei	
O. bruneiensis	*Licuala*	petioles	Brunei	
O. calami	*Calamus*	trunk	Philippines	
O. cyrtospora	*Licuala*	petioles	Australia	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
O. cyrtostachicola	*Cyrtostachys*	petioles	Thailand	
O. daemonoropis	*Daemonorops*	petioles	Philippines	
O. daemonoropsicola	*Daemonorops*	rachis	Hong Kong, China	
O. dispariapicis	*Daemonorops*	petioles	Brunei	
O. elaeicola	*Elaeis guineensis*	petioles	Sierra Leone	
O. elaeidis	*Elaeis*	leaves	Zaire	
O. extensa	*Licuala*	petioles	Australia	
O. froehlichiae	*Calamus radicalis*	leaves	Australia	
O. frondicola	–	petioles	Australia	
O. gigantea	–	petioles	Indonesia	
O. grisea	*Calamus*	petioles	Indonesia	
O. hoehnelii	*Arenga*	petioles	Philippines	
O. hongkongensis	*Daemonorops*	petioles	Hong Kong, China	
O. ianei	*Trachycarpus*	petioles	China	
O. inaequalis	*Wallichia*	rachis	Thailand	
O. licualae	*Licuala spinosa*	petioles	Philippines	
O. licualicola	*Licuala*	petioles	Brunei	
O. linospadicis	*Linospadix microcarya*	leaves	Australia	
O. livistonae	*Livistona*	petioles	Philippines	
O. livistonica	*Livistona subglobosa*	petioles	Japan	
O. livistonicola	*Livistona*	petioles	Philippines	
O. luteaspora	*Calamus*	petioles	Australia	
O. maculosa	–	petioles	Indonesia	
O. magnicolla	*Calamus conirostris*	petioles	Brunei	
O. manokwariensis	–	–	Indonesia	
O. maquilingiana	*Daemonorops*	rachis	Philippines	
O. mauritiae	*Mauritia*	petioles	Ecuador	
O. megalospora	*Calamus*	petioles	Brunei	
O. nigra	*Licuala*	petioles	Malaysia	
O. nonamyloidea	*Livistona*	petioles	Indonesia	
O. nonspecifica	*Calamus pogonacanthus*	petioles	Brunei	
O. nontincta	*Licuala*	petioles	Brunei	
O. nypae	*Nypa fruticans*	petioles	Brunei	
O. nypicola	*Nypa fruticans*	petioles	Brunei	
O. obducens	*Linospadix microcarya*	leaves	Australia	
O. oedema	*Mauritia flexuosa*	petioles	France	
O. opaca	*Rhipogonium*	stem	New Zealand	
O. oraniopsis	*Oraniopsis appendiculata*	leaves	Australia	
O. parasitica	*Licuala ramsayi*	leaves	Australia	
O. parvula	*Orania*	petioles	Philippines	
O. perangusta	*Licuala*	petioles	Brunei	
O. poliothea	–	petioles	Venezuela	
O. pusillispora	*Licuala*	petioles	Brunei	
O. ragae	–	petioles	Indonesia	
O. rattanica	*Daemonorops*	sheath	Hong Kong, China	
O. rattanicola	*Calamus*	fronds	Hong Kong, China	
O. rimicolla	*Calamus*	–	Brunei	
O. rubella	*Calamus*	trunk	Australia	
O. sabalensis	*Sabal*	petioles	U.S.A.	
O. saltuensis	*Livistona*	petioles	Papua New Guinea	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
O. selenosporella	*Rhopalostylis sapida*	petioles	New Zealand	
O. tayabensis	*Calamus*	trunk	Philippines	
O. uniseriata	*Calamus radicalis*	–	Australia	
O. wallichianensis	*Wallichia*	leaves	Thailand	
***Palawania* (2)**				Microthyriales, *Microthyriaceae*
P. cocoes	*Cocos nucifera.*	–	Philippines	
P. grandis	*Calamus*	–	India	
***Palmicola* (4)**				Xylariales, *Incertae sedis*
P. archontophoenicis	*Archontophoenix alexandrae*	rachis	Australia	
P. australiensis	*Licuala ramsayi*	petioles	Australia	
P. bipolaris	*Archontophoenix*	petioles	Australia	
P. filiformis	*Jessenia*	rachis	Ecuador	
***Palmomyces* (1)**				Xylariales, *Clypeosphaeriaceae*
P. montaneus	*Oraniopsis*	rachis	Australia	
***Parahendersonia* (1)**				Pleosporales, *Leptosphaeriaceae*
P. trachycarpa	*Trachycarpus*	petioles	Switzerland	
***Paraphaeosphaeria* (1)**				Pleosporales, *Montagnulaceae*
P. hongkongensis	*Livistona*	fronds	Hong Kong, China	
***Parmeliella* (2)**				Peltigerales, *Pannariaceae*
P. allochroa	*Cocos*	–	India	
P. macrospora	*Cocos*	–	India	
***Parodiella* (2)**				*Incertae sedis*, *Parodiellaceae*
P. circumdata	–	leaves	–	
P. gloeosporidia	*Elaeis guineensis*	leaves	Zaire	
***Parodiopsis* (1)**				*Incertae sedis*, *Perisporiopsidaceae*
P. orbignyae	*Orbignya speciosa*	rachis	Brazil	
***Peltella* (1)**				*Incertae sedis*, *Muyocopronaceae*
P. palmarum	–	leaves	Brazil	
***Pemphidium* (6)**				Xylariales, *Amphisphaeriaceae*
P. australiense	*Calamus*	–	Australia	
P. calamicola	*Calamus*	–	Australia	
P. nitidum	*Maximiliana regia*	petioles	France	
P. palmicola	–	fronds	Indonesia.	
P. rattanicola	*Calamus*	–	Australia	
P. zonatum	–	rachis	Brazil	
***Penicilliopsis* (1)**				Eurotiales, *Trichocomaceae*
P. clavariaeformis	–	–	Brazil	
***Penzigia* (1)**				Xylariales, *Xylariaceae*
P. mauritanica	–	–	Maurita	
***Periconia* (1)**				Pleosporales, *Incertae sedis*
P. trachycarpicola	*Trachycarpus*	petioles	China	
***Pertusaria* (4)**				Pertusariales, *Pertusariaceae*
P. amnicola	–	–	Australia	
P. anomalospora	*Cocos*	–	Papua New Guinea	
P. karkarensis	*Cocos*	trunk	Papua New Guinea	
P. novae-guineae	*Cocos*	trunk	Papua New Guinea	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
Pestalosphaeria **(1)**				Xylariales, *Amphisphaeriaceae*
P. elaeidis	*Elaeis guineensis*	leaves	Nigeria	
Petrakina **(1)**				Asterinales, *Asterinaceae*
P. discoidea	–	leaves	Mexico	
Peziza **(1)**				Pezizales, *Pezizaceae*
P. palmicola	–	–	Cuba	
Pezizella **(2)**				Helotiales, *Hyaloscyphaceae*
P. avellanea	*Calamus*	sheath	Indonesia.	
P. isabellino-rufa	*Salacca*	petioles	Indonesia	
Phaeochora **(3)**				Phyllachorales, *Phaeochoraceae*
P. indaya	*Cocos petraea*	leaves	Brazil	
P. livistonae	*Livistona chinensis*	–	Japan	
P. steinheilii	*Chamaerops humilis*	leaves	Algeria	
Phaeochoropsis **(4)**				Phyllachorales, *Phaeochoraceae*
P. diplothemii	*Diplothemium*	leaves	Brazil	
P. mucosa	*Cocos australis*	leaves	Paraguay	
P. neowashingtoniae	*Neowashingtonia*	leaves	U.S.A.	
P. palmicola	*Thrinax ponceana*	leaves	Puerto Rico	
Phaeomonilia **(1)**				Pezizomycotina, *Incertae sedis*
P. pleiomorpha	–	petioles	Mexico	
Phaeonectria **(1)**				Hypocreales, *Nectriaceae*
P. olivacea	–	stem	Mexico	
Phaeophleospora **(1)**				Capnodiales, *Mycosphaerellaceae*
P. striae	*Trachycarpus*	petioles	Switzerland	
Phaeosphaeria **(3)**				Pleosporales, *Phaeosphaeriaceae*
P. japonica	*Livistona subglobosa*	leaves	Japan	
P. livistonae	*Livistona*	petioles	Hong Kong, China	
P. palmarum	*Cocos nucifera*	leaves	India	
Phialocephala **(1)**				Helotiales, *Vibrisseaceae*
P. vittalensis	*Caryota*	leaves	India	
Phomatospora **(4)**				Sordariomycetes, *Incertae sedis*
P. archontophoenicis	*Archontophoenix*	rachis	Australia	
P. kentiae	*Kentia balmoreana*	petioles	Argentina	
P. nypae	*Nypa fruticans*	leaves	Malaysia	
P. nypicola	*Nypa*	petioles	Malaysia	
Phragmospathula **(1)**				Pezizomycotina, *Incertae sedis*
P. parva	*Roystonea*	rachis	Cuba	
Phruensis **(1)**				Diaporthales, *Valsaceae*
P. brunneispora	*Licuala*	trunk	Thailand	
Phyllachora **(4)**				Phyllachorales, *Phyllachoraceae*
P. calami	*Calamus*	–	India	
P. palmicola	*Copernicia*	leaves	Brazil	
P. perisporiodes	*Phoenix*	leaves	Seychelles	
P. stearnii	*Phoenix*	leaves	Uganda	
Physalospora **(4)**				Xylariales, *Hyponectriaceae*
P. cocoes	*Cocos australis*	leaves	Spain	
P. palmicola	–	leaves	Tai Wan	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
P. rhacheophila	*Arenga mindorensis*	rachis	Philippines	
P. tecta	—	leaves	Brazil	
Pichia **(1)**				Saccharomycetales, *Pichiaceae*
P. chodatii var. *fermentans*	*Phoenix dactylifera*	—	Egypt	
Piricauda **(2)**				Pezizomycotina, *Incertae sedis*
P. longispora	—	petioles	Costa Rica	
P. mexicana	—	rachis	Veracruz	
Piricaudilium **(1)**				Pezizomycotina, *Incertae sedis*
P. holubovanum	*Scheelea*	rachis	Singapore	
Pirottaea **(2)**				Helotiales, *Dermateaceae*
P. palmicola	*Rhopalostylis*	fronds	New Zealand	
P. versicolor	*Salacca*	rachis	Indonesia	
Pithomyces **(2)**				Pleosporales, *Pleosporaceae*
P. arecastri	*Arecastrum*	leaves	China	
P. ellipticus	*Trachycarpus*	leaves	China	
Platypeltella **(1)**				Microthyriales, *Microthyriaceae*
P. angustispora	*Chamaedorea*	leaves	Mexico	
Platystomum **(1)**				Pleosporales, *Lophiostomataceae*
P. chamaeropis	*Chamaerops humilis*	petioles	Tunisia	
Pleogibberella **(1)**				Hypocreales, *Nectriaceae*
P. calamia	*Calamus fasciculati*	—	India	
Pleomassaria **(1)**				Pleosporales, *Pleomassariaceae*
P. phoenicis	*Phoenix*	trunk	India	
Pleomeliola **(1)**				Meliolales, *Meliolaceae*
P. hyphaenes	*Hyphaene*	leaves	Tanzania	
Pleosphaeria **(1)**				Sordariomycetes, *Incertae sedis*
P. xenochaeta	—	petioles	Indonesia	
Pleospora **(4)**				Pleosporales, *Pleosporaceae*
P. chamaeropis	*Chamaerops humilis*	leaves	Algeria	
P. excelsa	*Chamaerops excelsa*	leaves	Spain	
P. principis	*Phoenix dactylifera*	leaves	Italy	
P. herbarum var. *coryphae*	*Calamus australis*	leaves	Italy	
Podosordaria **(1)**				Xylariales, Xylariaceae
P. ingii	*Phoenix*	fronds	Canary	
Podosporium **(1)**				Pezizomycotina, *Incertae sedis*
P. biseptatum	*Cocos*	—	Seychelles	
Polybulbophiale **(1)**				Pezizomycotina, *Incertae sedis*
P. palmicola	*Licuala*	petioles	Brunei	
Polydesmus **(2)**				Pezizomycotina, *Incertae sedis*
P. oncospermatis	*Oncosperma*	rachis	Singapore	
P. scheeleae	*Scheelea*	rachis	Singapore	
Preussia **(1)**				Pleosporales, *Sporormiaceae*
P. aquilirostrata	*Phoenix*	leaves	Iraq	
Proliferodiscus **(1)**				Helotiales, *Hyaloscyphaceae*
P. caeruleoniger	*Archontophoenix*	stem	Australia	
Propoliopsis **(1)**				Ostropales, *Stictidaceae*
P. arengae	*Arenga saccharifera*	—	Philippines	
Protocreopsis **(2)**				Hypocreales, *Bionectriaceae*
P. palmicola	—	leaves	Papua New Guinea	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
P. viridis	*Prestoea*	leaves	U.S.A	
***Pseudocercospora* (3)**				Capnodiales, *Mycosphaerellaceae*
P. arecacearum	*Rhopalostylis*	leaves	New Zealand	
P. coperniciae	*Copernicia*	leaves	Brazil	
P. roystoneae	*Roystonea*	leaves	U.S.A.	
***Pseudographis* (1)**				Triblidiales, *Triblidiaceae*
P. cocoes	*Cocos romanzoffiana*	leaves	Brazil	
***Pseudohalonectria* (3)**				Magnaporthales, *Magnaporthaceae*
P. eubenangeensis	*Archontophoenix*	rachis	Australia	
P. palmicola	*Calamus*	–	Australia	
P. tayloriae	*Jessenia*	–	Ecuador	
***Pseudolignincola* (1)**				Microascales, *Halosphaeriaceae*
P. siamensis	*Nypa*	–	Thailand	
***Pseudomassaria* (3)**				Xylariales, *Hyponectriaceae*
P. huwerae	*Calamus*	rachis	Australia	
P. mauritiae	*Mauritia*	petioles	Ecuador	
P. megalospora	*Mauritia*	petioles	Ecuador	
***Pseudomicrodochium* (2)**				Hypocreales, *Incertae sedis*
P. angamosense	–	petioles	Peru	
P. triseptatum	–	petioles	Peru	
***Pseudospiropes* (1)**				Helotiales, *Helotiaceae*
P. arecacensis	*Licuala*	leaves	Australia	
***Pteridiospora* (1)**				Dothideomycetes, *Incertae sedis*
P. munkii	*Phoenix sylvestris*	leaves	India	
***Pulmosphaeria* (1)**				Sordariomycetes, *Incertae sedis*
P. archontophoenicis	*Archontophoenix*	petioles	Australia	
***Pulvinodecton* (1)**				Arthoniales, *Incertae sedis*
P. seychellensis	*Lodoicea sechellarum*	–	Seychelles	
***Pyricularia* (1)**				*Incertae sedis*, *Magnaporthaceae*
P. oncosperma	*Oncosperma*	rachis	Brunei	
***Rachidicola* (1)**				Xylariales, *Hyponectriaceae*
R. palmae	*Calamus*	rachis	Hong Kong, China	
***Ravenelula* (1)**				Pezizomycotina, *Incertae sedis*
R. gainesvillensis	*Sabal*	leaves	U.S.A.	
***Rhipidocarpon* (1)**				Asterinales, *Parmulariaceae*
R. javanicum	*Nypa fruticans*	leaves	Indonesia	
***Rhynchosphaeria* (2)**				Sordariomycetes, *Incertae sedis*
R. floridana	*Sabal palmetto*	petioles	U.S.A.	
R. phoenicis	*Phoenix sylvestris*	–	India	
***Rogergoosiella* (1)**				Pezizomycotina, *Incertae sedis*
R. roystoneicola	*Roystonea*	petioles	Cuba	
***Rosellinia* (11)**				Xylariales, *Xylariaceae*
R. ambigens	*Daemonorops*	–	Singapore	
R. calami	*Calamus*	stem	Australia	
R. capetribulensis	*Calamus*	rachis	Australia	
R. elaeicola	*Elaeis guineensis*	rachis	Cameroons	
R. euterpes	*Euterpe*	–	Brazil	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
R. lakshadweepensis	*Cocos*	–	India	
R. marginato-clypeata	–	rachis	Indonesia	
R. palmae	*Rhopalostylis*	rachis	New Zealand	
R. rachidis	*Cocos nucifera*	rachis	Tahiti	
R. rhopalostylidicola	*Rhopalostylis*	rachis	New Zealand	
R. sepulta	–	stem	Cuba	
Roussoella **(4)**				Pleosporales, *Roussoellaceae*
R. aequatoriensis	–	petioles	Ecuador	
R. calamicola	*Calamus*	petioles	Australia	
R. palmicola	*Calamus*	–	Brunei	
R. saltuensis	–	petioles	Ecuador	
Sabalicola **(1)**				Xylariales, *Xylariaceae*
S. sabalensioides	*Serenoa serrulata*	rachis	U.S.A.	
Sarcoscypha **(1)**				Pezizales, *Sarcoscyphaceae*
S. cocotina	*Cocos*	–	UK	
Schizoparme **(1)**				Diaporthales, *Schizoparmeaceae*
S. calamicola	*Daemonorops*	fronds	Hong Kong, China	
Schweinitziella **(1)**				Trichosphaeriales, *Trichosphaeriaceae*
S. palmigena	*Chamaedorea*	leaves	Costa Rica	
Scolionema **(1)**				*Incertae sedis*, *Parodiopsidaceae*
S. palmarum	–	leaves	Surinan	
Scorias **(1)**				Capnodiales, *Capnodiaceae*
S. brasiliensis	*Cocos nucifera*	leaves	Brazil	
Septoriella **(1)**				Dothideomycetes, *Incertae sedis*
S. trachycarpa	*Trachycarpus*	petioles	China	
Serenomyces **(4)**				Phyllachorales, *Phaeochoraceae*
S. mauritii	*Mauritia flexuosa*	petioles	French Guiana	
S. palmae	–	petioles	Venezuela	
S. phoenicis	*Phoenix*	petioles	France	
S. virginiae	*Phoenix*	rachis	U.S.A.	
Setella **(1)**				*Incertae sedis*, *Parodiopsidaceae*
S. coracina	*Mauritia vinifera*	leaves	Brazil	
Seynesia **(4)**				Xylariales, *Xylariaceae*
S. erumpens	–	petioles	Cuba	
S. livistonae	*Livistina*	petioles	Hong Kong, China	
S. nobilis	*Elaeis guineensis*	petioles	Angola	
S. palmicola	–	leaves	Brazil	
Sorokina **(1)**				Helotiales, *Dermateaceae*
S. frondicola	*Archontophoenix*	rachis	Australia	
Sorokinella **(2)**				Helotiales, *Dermateaceae*
S. appendicospora	*Livistona*	petioles	Hong Kong, China	
S. calamae	*Calamus*	rachis	Australia	
Spadicoides **(3)**				Sordariales, *Helminthosphaeriaceae*
S. arengae	*Arenga*	rachis	Brunei	
S. macroobovata	–	petioles	Peru	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
S. palmicola	*Licuala*	leaves	Brunei	
Sphaerella **(2)**				Capnodiales, *Mycosphaerellaceae*
S. sabaligena	*Sabal palmetto*	leaves	U.S.A. (Louisiana)	
S. washingtoniae	*Washingtonia brachypoda*	–	U.S.A. (California)	
Sphaeria **(4)**				Xylariales, *Xylariaceae*
S. columnaris	*Cocos nucifera*	trunk	Indonesia	
S. depolita	–	leaves	Japan	
S. palmarum	–	leaves	Brazil	
S. salzmanni	–	leaves	Brazil	
Sphaerochaetia **(1)**				Chaetothyriales, *Chaetothyriaceae*
S. belodesmia	–	leaves	Brazil	
Sphaerodothis **(2)**				Phyllachorales, *Phyllachoraceae*
S. arengae	*Arenga saccharifera*	leaves	Indonesia	
S. borassi	*Borassus flabellifer*	leaves	India	
Sphaerognomonia **(1)**				Sordariomycetes, *Incertae sedis*
S. elaeicola	*Elaeis guineensis*	leaves	Brazil	
Sphaerostilbe **(1)**				Hypocreales, *Nectriaceae*
S. wrightii	–	stem	Cuba	
Sphaerulina **(1)**				Capnodiales, *Mycosphaerellaceae*
S. phoenicis	*Phoenix panceana*	leaves	Taiwan	
Sporidesmiella **(1)**				Pleosporales, *Melanommataceae*
S. oraniopsis	*Oraniopsis*	rachis	Australia	
Sporidesmium **(9)**				Pleosporales, *Incertae sedis*
S. abortivum	–	petioles	Peru	
S. angamosense	–	petioles	Peru	
S. apiceinflatum	–	petioles	Peru	
S. aunstrupii	–	leaves	China	
S. calami	*Calamus*	rachis	Singapore	
S. coccothrinacis	*Coccothrinax*	leaves	Cuba	
S. malayasianum	–	rachis	Malaysia	
S. multiseptatum	–	rachis	China	
S. singaporense	*Korthalsia*	rachis	Singapore	
Stachybotrys **(1)**				Hypocreales, *Incertae sedis*
S. palmae	*Licuala*	rachis	Thailand	
Stanjehughesia **(1)**				Chaetosphaeriales, *Chaetosphaeriaceae*
S. fasciculata	*Roystonea*	rachis	Cuba	
Staurophoma **(1)**				Pezizomycotina, *Incertae sedis*
S. calami	*Calamus*	petioles	Hong Kong, China	
Stenella **(1)**				Capnodiales, *Mycosphaerellaceae*
S. caryotae-urensis	*Caryota*	leaves	India	
Stictis **(4)**				Ostropales, *Stictidaceae*
S. ecclesiensis	*Trachycarpus*	petioles	UK	
S. ramuligera	*Rhopalostylis sapida*	rachis	New Zealand	
S. serenoae	*Serenoa*	–	U.S.A.	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
S. stellata	*Daemonorops*	rachis	Philippines	
Stratiphoromyces **(2)**				Pezizomycotina, *Incertae sedis*
S. brunneisporus	*Licuala*	petioles	Brunei	
S. raghukumarensis	*Caryota*	leaves	India	
Strossmayeria **(2)**				Helotiales, *Helotiaceae*
S. australiensis	*Calamus*	rachis	Australia	
S. calamicola	*Calamus*	sheath	Australia	
Submersisphaeria **(2)**				*Incertae sedis*, *Annulatascaceae*
S. palmae	*Eleiodoxa*	rachis	Thailand	
S. rattanicola	*Calamus*	–	Australia	
Telemeniella **(1)**				Phyllachorales, *Phyllachoraceae*
T. elaeicola	*Elaeis guineensis*	leaves	Brazil	
Thyridaria **(1)**				Pleosporales, *Thyridariaceae*
T. calamincola	*Calamus*	–	Philippines	
Thyridium **(1)**				*Incertae sedis*, *Thyridiaceae*
T. chrysomallum	–	stem	Sri Lanka	
Tirisporella **(1)**				Dothideomycetes, *Incertae sedis*
T. beccariana	*Nypa fruticans*	rachis	Malaysia	
Trabutia **(1)**				Phyllachorales, *Phyllachoraceae*
T. mauritiae	*Mauritia flexuosa*	leaves	Brazil	
Trabutiella **(1)**				Phyllachorales, *Phyllachoraceae*
T. congregata	*Heterospathe*	leaves	Philippines	
Trematosphaeria **(2)**				Pleosporales, *Trematosphaeriaceae*
T. abuensis	*Phoenix sylvestris*	leaves	India	
T. canariensis	*Phoenix canariensis*	trunk	Spain	
Triadelphia **(3)**				Pezizomycotina, *Incertae sedis*
T. australiensis	*Archontophoenix*	rachis	Australia	
T. centroseptata	*Cocos*	rachis	India	
T. synnematofera	–	petioles	Peru	
Triblidium **(1)**				Triblidiales, *Triblidiaceae*
T. sabalidis	*Sabal palmetto*	leaves	U.S.A.	
Tribulatia **(1)**				Phyllachorales, *Phyllachoraceae*
T. appendicospora	*Archontophoenix*	rachis	Australia	
Trichobelonium **(1)**				Helotiales, *Dermateaceae*
T. virgineum	–	–	Brazil	
Trichocladium **(1)**				Sordariales, *Chaetomiaceae*
T. nypae	*Nypa*	–	Brunei	
Trichoderma **(1)**				Hypocreales, *Hypocreaceae*
T. stilbohypoxyli	–	leaves	Puerto Rico	
Trichopeziza **(1)**				Helotiales, *Lachnaceae*
T. melleo-rufa	–	petioles	Indonesia	
Trichosphaerella **(1)**				Hypocreales, *Niessliaceae*
T. arecae	*Areca catechu*	leaves	Philippines	
Trichosphaeria **(2)**				Trichosphaeriales, *Trichosphaeriaceae*
T. affinis	–	petioles	Indonesia	
T. regulinoides	*Arenga*	petioles	Philippines	
Trichosporium **(3)**				Capnodiales, *Piedraiaceae*

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
T. camptospora	*Corypha australis*	leaves	Russia	
T. palmicolum	*Cocos nucifera*	leaves	British	
Trichothyrium **(1)**				Microthyriales, *Trichothyriaceae*
T. iquitosense	–	leaves	Brazil	
Trinacrium **(1)**				Orbiliales, *Orbiliaceae*
T. angamosense	–	petioles	Peru	
Tubeufia **(1)**				Tubeufiales, *Tubeufiaceae*
T. palmarum	–	leaves	Congo	
Uleodothis **(1)**				Venturiales, *Venturiaceae*
U. coonoorensis	*Phoenix*	leaves	India	
Unisetosphaeria **(1)**				Trichosphaeriales, *Trichosphaeriaceae*
U. penguinoides	*Eleiodoxa*	petioles	Thailand	
Ustulina **(1)**				Xylariales, *Xylariaceae*
U. zonata	–	–	Indonesia	
Valsa **(3)**				Diaporthales, *Valsaceae*
V. chlorina	*Cocos nucifera*	–	Dominican	
V. cocoes	*Cocos nucifera*	–	Philippines	
V. tenebricosa	–	–	Sri Lanka	
Vanakripa **(1)**				Pezizomycotina, *Incertae sedis*
V. minutiellipsoidea	*Eleiodoxa*	petioles	Thailand	
Venturia **(2)**				Venturiales, *Venturiaceae*
V. elaeidis	*Elaeis guineensis*	leaves	Zaire	
V. sabalicola	*Sabal palmetto*	leaves	U.S.A.	
Venustisporium **(2)**				Pezizomycotina, *Incertae sedis*
V. chelyoforme	*Baclris*	leaves	Venezuela	
V. aequatorialis	–	petioles	Peru	
Vibrissea **(1)**				Helotiales, *Vibrisseaceae*
V. nypicola	*Nypa*	petioles	Malaysia	
Virgariella **(1)**				Pezizomycotina, *Incertae sedis*
V. ellipsospora	*Calyptronoma*	leaves	Cuba	
Virgatospora **(1)**				Pezizomycotina, *Incertae sedis*
V. natarajanensis	*Calamus*	leaves	India	
Waihonghopes **(1)**				Pezizomycotina, *Incertae sedis*
W. australiensis	*Oraniopsis*	rachis	Australia	
Wardina **(1)**				Asterinales, *Asterinaceae*
W. calami	*Calamus*	leaves	Philippines	
Wardomyces **(1)**				Microascales, *Microascaceae*
W. moseri	*Mauritia*	petioles	Colombia	
Wardomycopsis **(1)**				Microascales, *Microascaceae*
W. trachycarpicola	*Trachycarpus*	–	China	
Wettsteinina **(2)**				Dothideomycetes, *Incertae sedis*
W. phoenicis	*Phoenix sylvestris*	petioles	India	
W. sabalicola	*Sabal adansonii*	petioles	U.S.A.	
Xylaria **(11)**				Xylariales, *Xylariaceae*
X. copelandii	*Calamus*	trunk	Philippines	
X. frustulosa	*Corypha elata*	petioles	Philippines	
X. juruensis	–	stem	Brazil	
X. minuta	*Phoenix sylvestris*	rachis	India	
X. palmicola	–	fruit	Brazil	
X. ponapeana	*Metroxylon amicarum*	petioles	Micronesia	
X. queenslandica	*Archontophoenix*	rachis	Australia	
X. radicata	*Cocos*	–	Togo	

Table 2.1 (continued)

Taxa	Palm host	Substrate	Originally described	Order/Family
X. scabriclavula	*Thrinax radiata*	stem	Mexico	
X. striata	*Trachycarpus*	trunk	China	
X. trabuti	*Latania*	─	Algeria	
***Xylosphaeria* (1)**				Dothideomycetes, *Incertae sedis*
X. deviata	*Sabal palmetto*	petioles	U.S.A.	
***Yatesula* (1)**				Chaetothyriales, *Chaetothyriaceae*
X. calami	*Calamus*	leaves	Philippines	
***Zeuctomorpha* (1)**				Pleosporales, *Pleosporaceae*
Z. arecae	*Areca catechu*	leaves	India	
***Zignoëlla* (5)**				Chaetosphaeriales, *Chaetosphaeriaceae*
Z. arengae	*Arenga mindorensis*	petioles	Philippines	
Z. astrocaryi	*Astrocaryum*	petioles	Brazil	
Z. omphalostoma	*Livistona chinensis*	stem	Indonesia	
Z. palmicola	-	leaves	Cameroons	
Z. sabalina	*Sabal adansonii*	petioles	U.S.A.	
***Zukalia* (1)**				Chaetothyriales, *Chaetothyriaceae*
Z. stuhlmanniana	*Cocos nucifera*	leaves	Tanzania	

Note. "─" means data is not available.

2.4 Conclusion

In total, 1059 palm microfungi are listed in this checklist. They are distributed in 121 families and 436 genera within the ascomycotina.

The *Xylariaceae* and *Amphisphaeriaceae* are the best represented families, with 118 species in 13 genera, and 111 species in 13 genera respectively. The *Hypocreaceae* is also represented by 13 genera, but by substantially fewer species (27). The *Nectriaceae* and the *Phyllachoraceae* are the next most common families in term of genera (ten each).

The most common genus on palms is *Oxydothis* with 60 of its 65 species, and *Anthostomella* is the next most common genus with 38 species.

The genus *Calamus* is the richest source of ascomycetes yielding 110 new species; the next is the monotypic genus *Cocos*, with 77 species described from it, and the genus *Phoenix* is the third richest source with 57 species.

CHAPTER 3

THE PHYLOGENETIC ASSESSMENT OF DOTHIDEOMYCETES

3.1 Introduction

Dothideomycetes is the largest class of Ascomycota, with an estimated number of 19,000 species (Kirk et al., 2008). This class largely corresponds to what has historically been called the Loculoascomycetes (Nannfeldt 1932; Luttrell 1955; Janex-Favre 1971; Barr 1979a, b, 1983a, b, 2001; Eriksson 1981; Reynolds 1971; Tehler 1990, 1995; Letrouit-Galinou et al., 1994; Barr & Huhndorf, 2001; Liu & Hall, 2004), although several lineages previously assigned to that group, such as the Pyrenulales and Verrucariales , are now classified in subclass Chaetothyriomycetidae, class Eurotiomycetes (Lutzoni et al., 2004; Schmitt et al., 2005; Hibbett et al., 2007; Schoch et al., 2009a, b). On the other hand, Arthoniomycetes, which were usually considered to feature an intermediate type of ascoma development between ascolocular ascohymenial fungi (Choisy 1955; Henssen & Jahns, 1973; Eriksson 1994; Henssen & Thor, 1994; Tehler 1990, 1995), have been shown to be a sister group to Dothideomycetes and the two classes are united in superclass Dothideomyceta (Schoch et al., 2009a).

The most important morphological characters used to define groups in Ascomycota were the morphology and development of the ascoma, the type of ascus, as well as the septation, shape and color of ascospores. For Dothideomycetes, several morphological assessments were carried out by different mycologists. Luttrell described important development types of most tissues inside the ascoma (the centrum concept) and combined this with ascoma structure to define five orders in Dothideomycetes (Luttrell 1951, 1955). Eriksson (1981) refine Luttrell's ideas and introduced the concept of the hamathecium. Müller and von Arx (1962) focused on the morphology of ascoma opening and ascus shape. The most recent treatment was carried out by Barr (1979, 1987), and she determined the class based on centrum characters, including the absence, presence and types of hamathecial tissues.

The introduction of molecular phylogenies for Dothideomycetes (Berbee 1996) provided an opportunity to verify the significance of various morphological characters used in the aforementioned classifications. The studies based on DNA sequence phylogeny showed that the presence or absence of pseudoparaphyses is largely in agreement with the first orders proposed by Luttrell (Liew et al., 2000; Lumbsch & Lindemuth, 2001), while the shape of the pseudoparaphyses to define orders introduced by Barr was rejected by molecular phylogenies (Liew et al., 2000). Schoch et al. (2006) confirmed this by using more comprehensive analyses incorporating protein data, and the molecular data resulted in the definition of two subclasses, Pleosporomycetidae (pseudoparaphyses present) and the Dothideomycetidae (pseudoparaphyses absent).

Several studies based on molecular phylogeny have advanced our understanding of fungi (Lutzoni et al., 2004; Crous et al., 2006; James et al., 2006; Hibbett et al., 2007; McLaughlin et al., 2009; Hyde et al., 2013). In this study, I am studying the genera of Dothidoemycetes in order to provide a natural classification. This has involved making new collections from Europe and Thailand and using existing and novel sequence data in our phylogenies. This study will present an expanded multi-gene phylogeny for more than 400 isolates and 22 orders including 64 families (the current accepted families are 105) in Dothideomycetes. The relationships between asexual and sexual morphs will be linked for some groups, and finally present a multi-gene phylogeny that exposes the highly diverse of Dothideomycetes.

3.2 Materials and Methods

3.2.1 Molecular phylogeny

Sequences were obtained from GenBank following mostly previous publications (e.g. Schoch et al., 2006, 2009a, b; Suetrong et al., 2009, 2011a,b; Zhang et al., 2012; Li et al., 2012; Liu et al., 2012) and are listed in Table 3.1.

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

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

Maximum-parsimony analyses were performed by PAUP v. 4.0b10 (Swofford 2003) using the heuristic search option with 1000 random taxa addition and tree bisection and reconnection (TBR) as the branch swapping algorithm. All characters were unordered and of equal weight and gaps were treated as missing data. The Tree Length (TL), Consistency Indices (CI), Retention Indices (RI), Rescaled Consistency Indices (RC) and Homoplasy Index (HI) were calculated for each tree generated.

Maxtrees were unlimited, branches of zero length were collapsed and all multiple, equally parsimonious trees were saved. Clade stability was assessed using a bootstrap (BT) analysis with 1000 replicates, each with 10 replicates of random stepwise addition of taxa (Hillis & Bull, 1993). Maximum parsimony bootstrap values (MPBP) equal or greater than 50% are given above each node (Fig. 3.2).

Maximum likelihood (ML) analysis was performed at the CIPRES webportal (Miller et al., 2010) using RAxML v. 7.2.8 as part of the “RAxML-HPC2 on TG” tool (Stamatakis 2006; Stamatakis et al., 2008). A general time reversible model (GTR) was applied with a discrete gamma distribution and four rate classes. Fifty thorough maximum likelihood (ML) tree searches were done in RAxML v. 7.2.7 under the same model, with each one starting from a separate randomised tree and the best scoring tree selected with a final in value of −13974.356237. One thousand non parametric bootstrap iterations were run with the GTR model and a discrete gamma distribution. The resulting replicates were plotted on to the best scoring tree obtained previously. Maximum Likelihood bootstrap values (MLBP) equal or greater than 50 % are given above each node (Fig. 3.2).

Bayesian analyses (Larget & Simon, 1999): The model of evolution was estimated by using MrModeltest 2.2 (Nylander 2004). Independent Bayesian phylogenetic analyses were performed in MrBayes v. 3.1.2 (Huelsenbeck & Ronquist, 2001) using a uniform [GTR+I+G] model, lsetnst = 6 rates = invgamma; prsetstatefreqpr = dirichlet (1,1,1,1). Posterior probabilities (PP) (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) were determined by Markov Chain Monte Carlo sampling (BMCMC) in MrBayes v. 3.0b4 (Huelsenbeck & Ronquist, 2001). Six simultaneous Markov chains were run for 5000000 generations and trees were sampled every 100th generation (resulting in 10000 total trees). The first 5 000 trees were discarded as burn-in prior to convergence of the four chains. The remaining trees were used to construct a 50 % majority rule consensus tree and to calculate Bayesian Posterior Probabilities (BYPP) with those equal or greater than 0.90 given below each node (Fig. 3.2).

Phylogenetic trees were drawn using Treeview v. 1.6.6 (Page 2001) and MEGA 5 (Tamura et al., 2011).

Table 3.1 Isolates used in the study

Taxon	Isolates	GenBank accession numbers			
		LSU	SSU	*RPB2*	*TEF1*
Acanthostigma lignicola	MFLUCC 11-0378	KF301531	KF301539	–	–
Acanthostigma piniraiensis	MFLUCC 10-0116	KF301534	KF301542	–	–
Acanthostigma chiangmaiensis	MFLUCC 10-0125	JN865197	JN865185	–	–
Acanthostigma fusiforme	MFLUCC 11-0510	KF301537	KF301546	–	–
Acrocalymma aquatica	MFLUCC 11-0208	JX276952	JX276953	–	–
Acrocordiopsis patilii	BCC 28167	GU479773	GU479737	GU479812	–
Acrogenospora sphaerocephala	CBS 164.76	GU301791	GU296129	GU371748	GU349059
Acrospermum adeanum	M 133	EU940104	EU940031	EU940320	–
Acrospermum compressum	M 151	EU940084	EU940012	EU940301	–
Acrospermum graminum	M 152	EU940085	EU940013	EU940302	–
Aigialus grandis	BCC 18419	GU479774	GU479738	GU479813	GU479838
Aigialus mangrovis	BCC 33564	GU479777	GU479742	GU479816	GU479841
Aigialus parvus	BCC 32558	GU479779	GU479743	GU479818	GU479843
Aigialus rhizophorae	BCC 33572	GU479780	GU479745	GU479819	GU479844
Aliquandostipite khaoyaiensis	CBS 118232	GU301796	AF201453	FJ238360	GU349048
Aliquandostipite crystallinus	R 76 -1	EF175651	EF175630	–	–
Aliquandostipite siamensiae	SS 81.02	EF175666	EF175645	–	–
Alternaria alternata	CBS 916.96	DQ678082	DQ678031	DQ677980	DQ677927
Amniculicola immersa	CBS 123083	FJ795498	GU456295	GU456358	GU456273
Amniculicola parva	CBS 123092	FJ795497	GU296134	–	GU349065
Anisomeridium ubianum	94	GU327709	GU327682	–	–
Anteaglonium abbreviatum	GKM 1029	GQ221878	–	–	GQ221915
Anteaglonium globosum	ANM 925.2	GQ221879	–	–	GQ221925
Anteaglonium latirostrum	L100N 2	GQ221876	–	–	GQ221938
Anteaglonium abbreviatum	ANM 925a	GQ221877	–	–	GQ221924
Anteaglonium globosum	SMH 5283	GQ221911	–	–	GQ221919
Anteaglonium latirostrum	GKM 1119	GQ221874	–	–	GQ221937
Anteaglonium parvulum	SMH 5223	GQ221909	–	–	GQ221918
Anteaglonium parvulum	GKM 1218	GQ221880	–	–	GQ221922
Anteaglonium parvulum	GKM 219N	GQ221881	–	–	GQ221916
Apiosporina collinsii	CBS 118973	GU301798	GU296135	–	GU349057
Aplosporella prunicola	STE -U 6326	EF564377	–	–	–
Aquasubmersa mircensis	MFLUCC 11-0401	JX276955	JX276956	–	–
Ascochyta pisi	CBS 126.54	DQ678070	DQ678018	DQ677967	DQ677913
Ascocratera manglicola	BCC 9270	GU479782	GU479747	GU479821	GU479846
Asterina cestricola	TH 591	GU586215	GU586209	–	–

Table 3.1 (continued)

Taxon	**Isolates**	**GenBank accession numbers**			
		LSU	SSU	*RPB2*	*TEF1*
Asterina fuchsiae	TH 590	GU586216	GU586210	–	–
Asterina phenacis	TH 589	GU586217	GU586211	–	–
Asterina weinmanniae	TH 592	GU586218	GU586212	–	–
Asterina zanthoxyli	TH 561	GU586219	GU586213	–	–
Asteromassaria pulchra	CBS 124082	GU301800	GU296137	GU371772	GU349066
Astrosphaeriella aggregata	MAFF 239486	AB524591	AB524450	AB539092	AB539105
Astrosphaeriella bakeriana	CBS 115556	GU301801	–	–	GU349015
Astrothelium confusum	98	GU327710	GU327685	–	–
Auerswaldia dothiorella	MFLUCC 11-0438	JX646813	JX646829	–	–
Aulographina pinorum	CBS 174.90	GU301802	GU296138	GU371737	GU349046
Aureobasidium pullulans	CBS 584.75	DQ470956	DQ471004	DQ470906	DQ471075
Bagnisiella examinans	CBS 551.66	GU301803	GU296139	GU371746	GU349056
Bambusicola bambusae	MFLUCC 11-0614	JX442035	JX442039	–	–
Bambusicola irregulispora	MFLUCC 11-0437	JX442036	JX442040	–	–
Bambusicola massarinia	MFLUCC 11-0389	JX442037	JX442041	–	–
Bambusicola splendida	MFLUCC 11-0439	JX442038	JX442042	–	–
Barriopsis fusca	CBS 174.26	DQ377857	EU673182	–	–
Biatriospora marina	CY 1228	GQ925848	GQ925835	GU479823	GU479848
Bimuria novae-zelandiae	CBS 107.79	AY016356	AY016338	DQ470917	DQ471087
Botryobambusa fusicoccum	MFLUCC 11-0143	JX646809	JX646826		
Botryosphaeria dothidea	CBS 115476	DQ678051	DQ677998	DQ677944	DQ767637
Botryosphaeria tsugae	CBS 418.64	DQ767655	AF271127	DQ767644	DQ677914
Botryosphaeria agaves	MFLUCC 11-0125	JX646808	JX646825	–	–
Byssolophis sphaerioides	IFRDCC 2053	GU301805	GU296140	GU456348	GU456263
Byssosphaeria jamaicana	SMH 1403	GU385152	–	–	GU327746
Byssosphaeria rhodomphala	GKM L153N	GU385157	–	–	GU327747
Byssosphaeria salebrosa	SMH 2387	GU385162	–	–	GU327748
Byssosphaeria schiedermayeriana	GKM 1197	GU385161	–	–	GU327750
Byssosphaeria villosa	GKM 204N	GU385151	–	–	GU327751
Byssothecium circinans	CBS 675.92	AY016357	AY016339	DQ767646	GU349061
Capnobotryella renispora	CBS 215.9	GQ852582	AY220613	–	–
Capnodiales sp. Rock TRN	CBS 118294	GU323220	GU323193	GU371751	GU349088
Capnodiales sp. Rock TRN	CBS 118300	GU323973	GU323196	GU371750	–
Capnodiales sp. Rock TRN	CBS 118346	GU323976	GU323197	GU371752	–
Capnodium coffeae	CBS 147.52	DQ247800	DQ247808	DQ247788	DQ471089
Catenulostroma abietis	CBS 459.93	DQ678092	DQ678040	–	DQ677933

Table 3.1 (continued)

Taxon	Isolates	GenBank accession numbers			
		LSU	SSU	*RPB2*	*TEF1*
Cercospora beticola	CBS 116456	DQ678091	DQ678039	—	DQ677932
Chaetosphaeronema hispidulum	CBS 216.75	EU754144	EU754045	GU371777	—
Chlamydotubeufia cf. *huaikangplaensis*	MFLUCC 11-0512	KF301536	KF301545	—	—
Chlamydotubeufia huaikangplaensis	MFLUCC 10-0926	JN865198	JN865186	—	—
Chlamydotubeufia khunkornensis	MFLUCC 10-0117	JN865189	JN865177	—	—
Cladosporium cladosporioides	CBS 170.54	DQ678057	DQ678004	DQ677952	DQ677898
Cladosporium herbarum	CBS 399.80	DQ678074	DQ678022	DQ677971	DQ677918
Clohesyomyces aquaticus	MFLUCC 11 -0092	JX276950	JX276949	—	—
Cochliobolus heterostrophus	CBS 134.39	AY544645	AY544727	DQ247790	DQ497603
Cochliobolus sativus	DAOM 226212	DQ678045	DQ677995	DQ677939	—
Coleroa robertiani	CBS 458.64	JQ036231	—	—	—
Columnosphaeria fagi	CBS 171.93	AY016359	AY016342	DQ677966	
Condioxyphium gardeniorum	CPC 14327	GU301807	GU296143	GU371743	GU349054
Conidiocarpus asiana	MFLUCC 10-0062	JN832612	JN832597	—	—
Conidiocarpus betle	MFLUCC 10-0053	JN832606	JN832591	—	—
Conidiocarpus siamense	MFLUCC 10-0061	JN832607	JN832592	—	—
Conidiocarpus siamense	MFLUCC 10-0065	JN832610	JN832595	—	—
Coniothyrium palmarum	CBS 400.71	DQ767653	DQ678008	DQ677956	DQ677903
Cophinforma eucalypti	MFLUCC 11-0425	JX646817	JX646833	—	—
Corynespora cassiicola	CBS 100822	GU301808	GU296144	GU371742	GU349052
Corynespora olivacea	CBS 114450	GU301809	—	—	GU349014
Corynespora smithii	CABI 5649b	GU323201	—	GU371783	GU349018
Cucurbitaria berberidis	CBS 394.84	GQ387605	GQ387544	—	—
Davidiellaceae sp.	CBS 117950	GU323221	GU323200	GU371755	GU349086
Decaisnella formosa	BCC 25617	GQ925847	GQ925834	GU479824	GU479850
Decorospora gaudefroyi	CBS 332.63	EF177849	AF394542	—	—
Delitschia chaetomioides	SMH 3253.2	GU390656	—	—	GU327753
Delitschia winteri	CBS 225.62	DQ678077	DQ678026	DQ677975	DQ677922
Delphinella strobiligena	CBS 735.71	DQ470977	—	DQ677951	DQ471100
Dendryphiopsis atra	DAOM 231155	DQ678046	DQ677996	DQ677940	DQ677884
Devriesia strelitziae	CBS 122379	GU301810	GU296146	GU371738	GU349049
Didymella bryoniae	CBS 133.96	GU301863	—	GU371767	
Diplodia mutila	CBS 431.82	DQ678064	DQ678012	DQ677960	DQ677907

Table 3.1 (continued)

Taxon	Isolates	GenBank accession numbers			
		LSU	SSU	*RPB2*	*TEF1*
Dissoconium aciculare	CBS 204.89	GU214419	GU214523	–	–
Dissoconium aciculare	CBS 342.82	EU019266	GU214524	–	–
Dothidea hippophaes	CBS 188.58	DQ678048	U42475	DQ677942	DQ677887
Dothidea insculpta	CBS 189.58	DQ247802	DQ247810	AF107800	DQ471081
Dothidotthia aspera	CPC 12933	EU673276	EU673228	–	–
Dothidotthia symphoricarpi	CBS 119687	EU673273	EU673224	–	–
Dothiora cannabinae	CBS 737.71	DQ470984	DQ479933	DQ470936	DQ471107
Dothiora ellyptica	CBS 736.71	GU301811	–	–	GU349013
Dothiorella iberica	CBS 115041	AY928053	EU673155	–	–
Dothistroma septosporum	CBS 543.74	GU301853	–	GU371730	–
Elsinoe centrolobi	CBS 222.50	DQ678094	DQ678041	–	DQ677934
Elsinoe phaseoli	CBS 165.31	DQ678095	DQ678042	–	DQ677935
Elsinoe veneta	CBS 150.27	DQ767658	DQ767651	–	DQ767641
Endomelanconiopsis endophytica	CBS 120397	EU683629	–	–	–
Endomelanconiopsis microspora	CBS 353.97	EU683628	–	–	–
Entodesmium rude	CBS 650.86	GU301812	–	–	GU349012
Falciformispora lignatilis	BCC 21118	GU371827	GU371835	–	GU371820
Falciformispora lignatilis	BCC 21117	GU371826	GU371834	–	GU371819
Fissuroma maculans	MFLUCC 10-0886	JN846724	JN846734	–	–
Fissuroma aggregata	KT 984	AB524591	AB524450	AB539092	AB539105
Flavobathelium epiphyllum	67	GU327717	–		–
Floricola striata	JK 5678I	GU301813	GU296149	GU371758	–
Fusicladium africanum	CPC 12829	EU035424	–	–	–
Fusicladium africanum	CPC 12828	EU035423	–	–	–
Fusicladium intermedium	CBS 110746	EU035432	–	–	–
Fusicladium pini	CBS 463.82	EU035436	–	–	–
Gibbera conferta	CBS 191.53	GU301814	GU296150		GU349041
Gloniopsis praelonga	CBS 112415	FJ161173	FJ161134	FJ161113	FJ161090
Gloniopsis subrugosa	CBS 123346	FJ161210	FJ161170	FJ161131	–
Glonium stellatum	CBS 207.34	FJ161179	FJ161140	–	FJ161095
Guignardia bidwellii	CBS 237.48	DQ678085	DQ678034	DQ677983	–
Guignardia citricarpa	CBS 102374	GU301815	GU296151	–	GU349053
Guignardia gaultheriae	CBS 447.70	DQ678089	–	DQ677987	–
Halomassarina thalassiae	JK 5262D	GU301816	–	–	GU349011
Halomassarina thalassiae	JK 5385B	GU479804	–	–	GU479853

Table 3.1 (continued)

Taxon	**Isolates**	**GenBank accession numbers**			
		LSU	SSU	*RPB2*	*TEF1*
Halotthia posidoniae	BBH 22481	GU479786	GU479752	–	–
Helicascus nypae	BCC 36752	GU479789	GU479755	GU479827	GU479855
Helicoma fagacearum	MFLUCC 11-0379	KF301532	KF301540	–	–
Helicoma chiangraiense	MFLUCC 10-0115	JN865188	JN865176	–	–
Helicoma siamense	MFLUCC 10-0120	JN865192	JN865180	–	–
Helicomyces roseus	CBS 283.51	DQ678083	DQ678032	DQ677981	DQ677928
Herpotrichia diffusa	CBS 250.62	DQ678071	DQ678019	DQ677968	DQ677915
Herpotrichia juniperi	CBS 200.31	DQ678080	DQ678029	DQ677978	DQ677925
Herpotrichia macrotricha	GKM 196N	GU385176	–	–	GU327755
Hortaea werneckii	CBS 100496	GU301817	GU296152	GU371739	GU349050
Hysterium angustatum	CBS 236.34	FJ161180	GU397359	FJ161117	FJ161096
Hysterobrevium smilacis	CBS 114601	FJ161174	FJ161135	FJ161114	FJ161091
Hysteropatella clavispora	CBS 247.34	AY541493	DQ678006	DQ677955	DQ677901
Hysteropatella elliptica	CBS 935.97	DQ767657	EF495114	DQ767647	DQ767640
Jahnula bipolaris	SS 44	EF175658	EF175637	–	–
Jahnula bipileata	AF 220-1	EF175656	EF175634	–	–
Jahnula bipileata	F 49 -1	EF175657	EF175635	–	–
Jahnula seychellensis	SS 2113.1	EF175665	EF175644	–	–
Jahnula seychellensis	SS 2113.2	EF175664	EF175643	–	–
Jahnula sangamonensis	F 81 -1	EF175663	EF175641	–	–
Jahnula sangamonensis	A 482 -1B	EF175662	EF175640	–	–
Jahnula aquatica	R 68 -1	EF175655	EF175633	–	–
Jahnula sangamonensis	A 402 -1B	EF175661	EF175639	–	–
Julella avicenniae	BCC 18422	GU371823	GU371831	GU371787	GU371816
Julella avicenniae	BCC 20173	GU371822	GU371830	GU371786	GU371815
Kalmusia scabrispora	NBRC 106237	AB524594	AB524453	AB539094	AB539107
Karstenula rhodostoma	CBS 690.94	GU301821	GU296154	GU371788	GU349067
Katumotoa bambusicola	MAFF 239641	AB524595	AB524454	AB539095	AB539108
Keissleriella cladophila	CBS 104.55	GU301822	GU296155	GU371735	GU349043
Kellermania macrospora	CBS 131716	JX444874	JX444902	–	–
Kellermania yuccigena	CBS 131727	JX444883	JX444908	–	–
Kirschsteiniothelia lignicola	MFLUCC 10-0036	HQ441568	HQ441569	–	–
Kirschsteiniothelia aethiops	CBS 109.53	AY016361	AY016344	–	–
Lasiodiplodia theobromae	CBS 164.96	EU673253	EU673196	–	–
Lentithecium aquaticum	CBS 123099	GU301823	GU296156	GU371789	GU349068
Lentithecium arundinaceum	CBS 619.86	GU301824	GU296157	FJ795473	–
Lentithecium fluviatile	CBS 122367	GU301825	GU296158	–	GU349074

Table 3.1 (continued)

Taxon	**Isolates**	**GenBank accession numbers**			
		LSU	SSU	*RPB2*	*TEF1*
Lepidosphaeria nicotiae	CBS 101341	DQ678067	—	DQ677963	DQ677910
Leptosphaeria biglobosa	CBS 303.51	GU301826	—	—	GU349010
Leptosphaeria doliolum	CBS 505.75	GU301827	GU296159	—	GU349069
Leptosphaeria dryadis	CBS 643.86	GU301828	—	GU371733	GU349009
Leptosphaerulina argentinensis	CBS 569.94	GU301829	—	—	GU349008
Leptosphaerulina australis	CBS 317.83	GU301830	GU296160	GU371790	GU349070
Leptosphearia maculans	DAOM 229267	DQ470946	DQ470993	DQ470894	DQ471062
Leptoxyphium cacuminum	MFLUCC 10-0086	JN832604	JN832589	—	—
Leptoxyphium fumago	CBS 123.26	GU301831	GU214535	GU371741	GU349051
Lichenoconium aeruginosum	CBS 129239	HQ174269	HQ174268	—	—
Lichenoconium erodens	CBS 128704	HQ174267	HQ174266	—	—
Lichenoconium lecanorae	CBS 128024	HQ174263	HQ174262	—	—
Lichenoconium usneae	CBS 128020	HQ174265	HQ174264	—	—
Lichenothelia cf. *calcarea*	L 1323	KC015061	KC015081	—	—
Lichenothelia cf. *calcarea*	L 1324	KC015062	KC015082	—	—
Lichenothelia convexa	L 1606	KC015068	KC015083	—	—
Lichenothelia convexa	L 1607	KC015069	KC015084	—	—
Lichenothelia convexa	L 1608	KC015070	KC015085	—	—
Lichenothelia convexa	L 1609	KC015071	KC015086	—	—
Lichenothelia sp.	L 984	KC015074	KC015087	—	—
Lichenothelia sp.	L 985	KC015075	KC015088	—	—
Lichenothelia sp.	L 986	KC015076	KC015089	—	—
Lindgomyces breviappendiculata	HHUF 28193	AB521748	AB521733	—	—
Lindgomyces breviappendiculatus	KT 1399	AB521749	AB521734	—	—
Lindgomyces cinctosporae	R56 -1	AB522431	AB522430	—	—
Lindgomyces cinctosporae	R56 -3	GU266245	GU266238	—	—
Lindgomyces ingoldianus	ATCC 200398	AB521736	AB521719	—	—
Lindgomyces rotundatus	HHUF 27999	AB521740	AB521723	—	—
Lophiostoma arundinis	CBS 621.86	DQ782384	DQ782383	DQ782386	DQ782387
Lophiostoma caulium	CBS 623.86	GU301833	GU296163	GU371791	—
Lophiostoma compressum	IFRD 2014	GU301834	GU296164	FJ795457	—
Lophiostoma crenatum	CBS 629.86	DQ678069	DQ678017	DQ677965	DQ677912
Lophiostoma macrostomoides	GKM 1033	GU385190	—	—	GU327776
Lophiostoma quadrinucleatum	GKM 1233	GU385184	—	—	GU327760
Lophiostoma scabridisporum	BCC 22835	GQ925844	GQ925831	GU479830	GU479857

Table 3.1 (continued)

Taxon	**Isolates**	**GenBank accession numbers**			
		LSU	SSU	*RPB2*	*TEF1*
Lophiotrema brunneosporum	CBS 123095	GU301835	GU296165	—	GU349071
Lophiotrema lignicola	CBS 122364	GU301836	GU296166	—	GU349072
Lophiotrema nucula	CBS 627.86	GU301837	GU296167	GU371792	GU349073
Lophiotrema nucula	JCM 14132	AB619021	AB618703	—	—
Lophiotrema neohysterioides	MAFF 23945	AB619020	AB618702	—	—
Lophiotrema neohysterioides	JCM 17673	AB619019	AB618701	—	—
Lophiotrema neoarundinaria	MAFF 239461	AB524596	AB524455	—	—
Lophiotrema neoarundinaria	NBRC 106239	AB524598	AB524457	—	—
Lophiotrema neoarundinaria	NBRC 106238	AB524597	AB524456	—	—
Lophiotrema vagabundum	JCM 17674	AB619022	AB618704	—	—
Lophiotrema vagabundum	JCM 17675	AB619023	AB618705	—	—
Lophium mytilinum	CBS 269.34	DQ678081	DQ678030	DQ677979	DQ677926
Loratospora aestuarii	JK 5535B	GU301838	GU296168	GU371760	—
Macrophomina phaseolina	CBS 227.33	DQ678088	DQ678037	DQ677986	DQ677929
Macroventuria anomochaeta	CBS 525.71	GU456315	GU238208	GU456346	GU456262
Manglicola guatemalensis	BCC 20079	FJ743449	FJ747443	—	—
Manglicola guatemalensis	BCC 20157	FJ743450	FJ743444	—	—
Manglicola guatemalensis	BCC 20156	FJ743448	FJ743442	—	—
Manglicola guatemalensis	BCC 24217	FJ743447	FJ743441	—	—
Massaria anomia	CBS 591.78	GU301839	GU296169	GU371769	—
Massaria ariae	M 52	HQ599382	HQ599456	—	HQ599322
Massaria aucupariae	M 49	HQ599384	HQ599455	—	HQ599324
Massaria campestris	M 28	HQ599385	HQ599449	HQ599459	HQ599325
Massaria conspurcata	M 14	HQ599393	HQ599441	—	HQ599333
Massaria gigantispora	M 26	HQ599397	HQ599447	—	HQ599337
Massaria inquinans	M 19	HQ599402	HQ599444	HQ599460	HQ599342
Massaria lantanae	M 18	HQ599406	HQ599443	—	HQ599346
Massaria macra	M 3	HQ599408	HQ599450	—	HQ599348
Massaria mediterranea	M 45	HQ599417	HQ599452	—	HQ599357
Massaria platani	CBS 221.37	DQ678065	DQ678013	DQ677961	DQ677908
Massaria platanoidea	M 7	HQ599420	HQ599457	HQ599462	HQ599359
Massaria pyri	M 21	HQ599424	HQ599445	—	HQ599363
Massaria vindobonensis	M 27	HQ599429	HQ599448	HQ599464	HQ599368
Massaria vomitoria	M 13	HQ599437	HQ599440	HQ599466	HQ599375
Massarina arundinariae	NBRC 106238	AB524597	AB524456	AB539097	AB524818
Massarina cisti	CBS 266.62	FJ795447	FJ795490	FJ795464	—
Massarina eburnea	CBS 473.64	GU301840	GU296170	GU371732	GU349040

Table 3.1 (continued)

Taxon	**Isolates**	**GenBank accession numbers**			
		LSU	SSU	*RPB2*	*TEF1*
Massarina igniaria	CBS 845.96	GU301841	GU296171	GU371793	–
Massariosphaeria grandispora	CBS 613.86	GU301842	GU296172	GU371725	GU349036
Massariosphaeria phaeospora	CBS 611.86	GU301843	GU296173	GU371794	–
Massariosphaeria typhicola	CBS 123126	GU301844	GU296174	GU371795	–
Mauritiana rhizophorae	BCC 28866	GU371824	GU371832	GU371796	GU371817
Megalotremis verrucosa	104	GU327718	GU327694	–	–
Melanomma pulvis-pyrius	CBS 124080	GU456323	GU456302	GU456350	GU456265
Melanops tulasnei	CBS 116805	FJ824764	FJ824761	–	–
Microthyrium microscopicum	CBS 115976	GU301846	GU296175	GU371734	GU349042
Microxyphium citri	CBS 451.66	GU301848	GU296177	GU371727	GU349039
Microxyphium theae	CBS 202.30	GU301849	GU296178	–	GU349060
Misturatosphaeria aurantonotata	GKM 1280	GU385174	–	–	GU327762
Misturatosphaeria claviformis	GKM 1210	GU385212	–	–	GU327763
Misturatosphaeria kenyensis	GKM 1195	GU385194	–	–	GU327767
Misturatosphaeria minima	GKM 169N	GU385165	–	–	GU327768
Misturatosphaeria tennesseensis	ANM 911	GU385207	–	–	GU327769
Misturatosphaeria uniseptata	SMH 4330	GU385167	–	–	GU327770
Monascostroma innumerosum	CBS 345.50	GU301850	GU296179	–	GU349033
Monotosporella tuberculata	CBS 256.84	GU301851	–	–	GU349006
Montagnula opulenta	CBS 168.34	DQ678086	AF164370	DQ677984	–
Morosphaeria ramunculicola	JK 5304B	GU479794	GU479760	GU479831	–
Mycomicrothelia hemispherica	102	GU327719	GU327695	–	–
Mycomicrothelia miculiformis	101B	GU327720	GU327696	–	–
Mycomicrothelia obovata	95	GU327721	GU327697	–	–
Mycosphaerella eurypotami	JK 5586J	GU301852	–	GU371722	–
Mycosphaerella graminicola	CBS 292.38	DQ678084	DQ678033	DQ677982	–
Mycosphaerella punctiformis	CBS 113265	DQ470968	DQ471017	DQ470920	DQ471092
Myriangium duriaei	CBS 260.36	DQ678059	AY016347	DQ677954	DQ677900
Myriangium hispanicum	CBS 247.33	GU301854	GU296180	GU371744	GU349055
Mytilinidion acicola	EB O349	GU323209	GU323185	GU371757	
Mytilinidion andinense	CBS 123562	FJ161199	FJ161159	FJ161125	FJ161107
Mytilinidion mytilinellum	CBS 303.34	FJ161184	FJ161144	FJ161119	FJ161100
Mytilinidion scolecosporum	CBS 305.34	FJ161186	FJ161146	FJ161121	FJ161102
Natipusilla decorospora	AF236-1a	HM196369	HM196376	–	–
Natipusilla limonensis	AF286-1a	HM196370	HM196377	–	–

Table 3.1 (continued)

Taxon	**Isolates**	**GenBank accession numbers**			
		LSU	SSU	*RPB2*	*TEF1*
Natipusilla limonensis	PE3-2a	JX474861	JX474867	–	–
Natipusilla limonensis	PE3-2b	JX474862	JX474870	–	–
Natipusilla naponensis	AF217-1a	HM196371	HM196378	–	–
Natipusilla naponensis	AF217-1b	HM196372	HM196379	–	–
Natipusilla bellaspora	PE91-1a	JX474863	JX474868	–	–
Natipusilla bellaspora	PE91-1b	JX474864	JX474869	–	–
Neoastrosphaeriella krabiensis	MFLUCC 11-0025	JN846729	JN846739	–	–
Neodeightonia phoenicum	CBS 122528	EU673261	EU673205	–	–
Neodeightonia subglobosa	CBS 448.91	DQ377866	EU673202	–	–
Neodeightonia palmicola	MFLUCC 10-0822	HQ199222	HQ199223	–	–
Neofusicoccum ribis	CBS 115475	DQ678053	DQ678000	DQ677947	DQ677893
Neofusicoccum parvum	CMW 9081	AY928045	EU673151	–	–
Neomicrothyrium siamense	IFRDCC 2194	LR0R-LR5	NS1-NS4	–	–
Neophaeosphaeria filamentosa	CBS 102202	GQ387577	GQ387516	GU371773	GU349084
Neoscytalidium novaehollandiae	WAC 12691	EF585548	–	–	–
Neottiosporina paspali	CBS 331.37	EU754172	EU754073	GU371779	GU349079
Oedohysterium insidens	CBS 238.34	FJ161182	FJ161142	FJ161118	FJ161097
Oedohysterium sinense	CBS 123345	FJ161209	FJ161169	FJ161130	
Ophiosphaerella herpotricha	CBS 620.86	DQ678062	DQ678010	DQ677958	DQ677905
Ophiosphaerella sasicola	MAFF 239644	AB524599	AB524458	AB539098	AB539111
Paraconiothyrium minitans	CBS 122788	EU754173	EU754074	GU371776	GU349083
Paraphaeosphaeria michotii	CBS 591.73	GU456326	GU456305	GU456352	GU456267
Patellaria atrata	CBS 958.97	GU301855	GU296181	GU371726	GU349038
Phaeobotryon mamane	CPC 12440	EU673248	EU673184	–	–
Phaeobotryosphaeria eucalypti	MFLUCC 11-0579	JX646819	JX646835	–	–
Phaeocryptopus nudus	CBS 268.37	GU301856	GU296182	–	GU349034
Phaeodothis winteri	CBS 182.58	GU301857	GU296183	–	DQ677917
Phaeosclera dematioides	CBS 157.81	GU301858	GU296184	–	GU349047
Phaeosphaeria ammophilae	CBS 114595	GU301859	GU296185	GU371724	GU349035
Phaeosphaeria avenaria	CBS 602.86	AY544684	AY544725	DQ677941	DQ677885
Phaeosphaeria brevispora	NBRC 106240	AB524601	AB524460	AB539100	AB539113
Phaeosphaeria caricis	CBS 120249	GU301860	–	–	GU349005
Phaeosphaeria elongata	CBS 120250	GU456327	GU456306	GU456345	GU456261
Phaeosphaeria eustoma	CBS 573.86	DQ678063	DQ678011	DQ677959	DQ677906
Phaeosphaeria luctuosa	CBS 308.79	GU301861	–	–	GU349004

Table 3.1 (continued)

Taxon	Isolates	GenBank accession numbers			
		LSU	SSU	*RPB2*	*TEF1*
Phaeosphaeria nigrans	CBS 576.86	GU456331	–	GU456356	GU456271
Phaeosphaeria nodorum	CBS 259.49	GU456332	–	–	GU456285
Phaeosphaeria oryzae	CBS 110110	GQ387591	GQ387530	–	–
Phaeosphaeriopsis musae	CBS 120026	GU301862	GU296186	–	GU349037
Phaeotrichum benjaminii	CBS 541.72	AY004340	AY016348	DQ677946	DQ677892
Phoma betae	CBS 109410	EU754178	EU754079	GU371774	GU349075
Phoma complanata	CBS 268.92	EU754180	EU754081	GU371778	GU349078
Phoma cucurbitacearum	CBS 133.96	GU301863	–	GU371767	–
Phoma exigua	CBS 431.74	EU754183	EU754084	GU371780	GU349080
Phoma glomerata	CBS 528.66	EU754184	EU754085	GU371781	GU349081
Phaeosphaeria nigrans	CBS 576.86	GU456331	–	GU456356	GU456271
Phaeosphaeria nodorum	CBS 259.49	GU456332	–	–	GU456285
Phaeosphaeria oryzae	CBS 110110	GQ387591	GQ387530	–	–
Phaeosphaeriopsis musae	CBS 120026	GU301862	GU296186	–	GU349037
Phaeotrichum benjaminii	CBS 541.72	AY004340	AY016348	DQ677946	DQ677892
Phoma betae	CBS 109410	EU754178	EU754079	GU371774	GU349075
Phoma complanata	CBS 268.92	EU754180	EU754081	GU371778	GU349078
Phoma cucurbitacearum	CBS 133.96	GU301863	–	GU371767	–
Phoma exigua	CBS 431.74	EU754183	EU754084	GU371780	GU349080
Phoma glomerata	CBS 528.66	EU754184	EU754085	GU371781	GU349081
Phoma herbarum	CBS 276.37	DQ678066	DQ678014	DQ677962	DQ677909
Phoma radicina	CBS 111.79	EU754191	EU754092	–	GU349076
Phoma zeae-maydis	CBS 588.69	EU754192	EU754093	GU371782	GU349082
Phyllobathelium anomalum	242	GU327722	GU327698	–	–
Pleomassaria siparia	CBS 279.74	DQ678078	DQ678027	DQ677976	DQ677923
Pleospora herbarum	CBS 191.86	DQ247804	DQ247812	DQ247794	DQ471090
Polychaeton coartatum	MFLUCC 10-0066	JN832613	JN832598	–	–
Polychaeton coartatum	MFLUCC 10-0070	JN832615	JN832600	–	–
Polyplosphaeria fusca	CBS 125425	AB524607	AB524466	–	AB524822
Pontoporeia biturbinata	BBH 23338	GU479796	GU479763	GU479837	–
Preussia funiculata	CBS 659.74	GU301864	GU296187	GU371799	GU349032
Preussia lignicola	CBS 264.69	GU301872	GU296197	GU371765	GU349027
Preussia terricola	DAOM 230091	AY544686	AY544726	DQ470895	DQ471063
Prosthemium betulinum	CBS 127468	AB553754	AB553644	–	–
Prosthemium canba	JCM 16966	AB553760	AB553646	–	–
Prosthemium orientale	JCM 12841	AB553748	AB553641	–	–
Prosthemium stellar	CBS 126964	AB553781	AB553650	–	–

Table 3.1 (continued)

Taxon	Isolates	GenBank accession numbers			
		LSU	SSU	*RPB2*	*TEF1*
Protoventuria barriae	CBS 300.93	JQ036232	—	—	—
Pseudofusicoccum stromaticum	CBS 117448	DQ377931	EU673146	—	—
Pseudotetraploa curviappendiculata	CBS 125426	AB524610	AB524469	—	AB524825
Pseudotrichia guatopoensis	SMH 4535	GU385202	—	—	GU327774
Pseudoveronaea obclavata	CBS 132086	JQ622102	—	—	—
Psiloglonium araucanum	CBS 112412	FJ161172	FJ161133	FJ161112	FJ161089
Psiloglonium clavisporum	CBS 123338	FJ161197	FJ161156	FJ161123	
Psiloglonium simulans	CBS 206.34	FJ161178	FJ161139	FJ161116	FJ161094
Pyrenochaeta nobilis	CBS 407.76	DQ678096	—	DQ677991	DQ677936
Pyrenophora phaeocomes	DAOM 222769	DQ499596	DQ499595	DQ497614	DQ497607
Pyrenophora tritici-repentis	OSC 100066	AY544672	—	—	DQ677882
Quadricrura septentrionalis	CBS 125428	AB524617	AB524476	—	AB524832
Quintaria submersa	CBS 115553	GU301866	—	—	GU349003
Ramichloridium apiculatum	CPC 12310	GU214687	GU214687	—	—
Ramichloridium apiculatum	CBS 156.59	EU041848	GU296189	GU371770	—
Repetophragma ontariense	HKUCC 10830	DQ408575	—	—	DQ435077
Rhytidhysterium rufulum	CBS 306.38	FJ469672	GU296191	—	GU349031
Rimora mangrovei	JK 5246A	GU301868	GU296193	GU371759	—
Roussoella hysterioides	CBS 125434	AB524622	AB524481	AB539102	AB539115
Roussoella pustulans	MAFF 239637	AB524623	AB524482	AB539103	AB539116
Roussoellopsis tosaensis	MAFF 239638	AB524625	—	AB539104	AB539117
Saccardoella rhizophorae	JK 5456A	GU479799	GU479766	—	GU479860
Saccharata proteae	CBS 115206	GU301869	GU296194	GU371729	GU349030
Saccothecium sepincola	CBS 278.32	GU301870	GU296195	GU371745	GU349029
Salsuginea ramicola	KT 2597.1	GU479800	GU479767	GU479833	GU479861
Schismatomma decolorans	DUKE 47570	AY548815	AY548809	DQ883715	DQ883725
Scorias spongiosa	CBS 325.33	DQ678075	DQ678024	DQ677973	DQ677920
Scorias spongiosa	MFLUCC 10-0084	JN832601	JN832586	—	—
Setomelanomma holmii	CBS 110217	GU301871	GU296196	GU371800	GU349028
Spencermartinsia viticola	CBS 117009	DQ678087	DQ678036	DQ677985	—
Sporormiella minima	CBS 524.5	DQ678056	DQ678003	DQ677950	DQ677897
Stagonospora macropycnidia	CBS 114202	GU301873	GU296198	—	GU349026
Stylodothis puccinioides	CBS 193.58	AY004342	—	—	DQ677886
Sydowia polyspora	CBS 116.29	DQ678058	DQ678005	DQ677953	DQ677899
Sympoventuria capensis	CPC 12840	DQ885904	—	—	—

Table 3.1 (continued)

Taxon	**Isolates**	**GenBank accession numbers**			
		LSU	SSU	*RPB2*	*TEF1*
Sympoventuria capensis	CPC 12839	DQ885905	–	–	–
Teratosphaeria associata	CBS 112224	GU301874	GU296200	GU371723	GU349025
Tetraplosphaeria sasicola	MAFF 239677	AB524631	AB524490	–	–
Thaxteriella inthanonensis	MFLUCC 11-0003	JN865199	JN865187	–	–
Thaxteriellopsis lignicola	MFLUCC 10-0121	JN865193	JN865181	–	–
Thaxteriellopsis lignicola	MFLUCC 10-0123	JN865195	JN865183	–	–
Thyridaria rubronotata	CBS 419.85	GU301875	–	GU371728	GU349002
Trematosphaeria pertusa	CBS 122368	FJ201990	FJ201991	FJ795476	GU456276
Trematosphaeria pertusa	CBS 122371	FJ201992	FJ201993	GU371801	GU349085
Trichodelitschia bisporula	CBS 262.69	GU348996	GU349000	GU371802	GU349020
Trichodelitschia munkii	Kruys 201	DQ384096	DQ384070	–	–
Triplosphaeria maxima	MAFF 239682	AB524637	AB524496	–	–
Trypethelium eluteriae	111	GU327726	GU327704	–	–
Trypethelium tropicum	25	GU327730	GU327708	–	–
Tubeufia cerea	CBS 254.75	DQ470982	DQ471034	DQ470934	DQ471105
Tubeufia paludosa	CBS 120503	GU301877	GU296203	GU371731	GU349024
Tubeufia miscanthi	MFLUCC 11-0375	KF301533	KF301541	–	–
Tubeufia chiangmaiensis	MFLUCC 11-0514	KF301538	KF301543	–	–
Tubeufia khunkornensis	MFLUCC 10-0119	JN865191	JN865179	–	–
Tyrannosorus pinicola	CBS 124.88	DQ470974	DQ471025	DQ470928	DQ471098
Ulospora bilgramii	CBS 110020	DQ678076	DQ678025	DQ677974	DQ677921
Uwebraunia commune	CBS 132091	JQ622093	–	–	–
Uwebraunia commune	CBS 132092	JQ622101	–	–	–
Uwebraunia dekkeri	CBS 132093	JQ622104	–	–	–
Venturia inaequalis	CBS 815.69	GU301878	GU296204	–	GU349023
Veronaeopsis simplex	CBS 588.66	EU041877	–	–	–
Verruculina enalia	BCC 18401	GU479802	GU479770	GU479835	GU479863
Westerdykella angulata	CBS 610.74	DQ384105	DQ384067	–	GU371821
Westerdykella cylindrica	CBS 454.72	AY004343	AY016355	DQ470925	DQ497610
Westerdykella dispersa	CBS 508.75	DQ468050	U42488	–	–
Westerdykella ornata	CBS 379.55	GU301880	GU296208	GU371803	GU349021

Note. Abbreviations of isolates and culture collections: **AFTOL:** Assembling the Fungal Tree of Life; **ATCC:** American Type Culture Collection, Virginia, USA; **BCC:** BIOTEC Culture Collection, Bangkok, Thailand; **CBS:** Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands; **CMW:** Tree Pathology Co-operative Program, Forestry and Agricultural Biotechnology Institute, University of Pretoria, South Africa; **CPC:** Collection of Pedro Crous housed at CBS; **DAOM:** Plant Research Institute, Department of Agriculture (Mycology), Ottawa, Canada; **IFRDCC:** Culture Collection, International Fungal Research & Development Centre, Chinese Academy of Forestry, Kunming, China; **JCM**: the Japan Collection of Microorganisms, Japan; **MAFF**: Ministry of Agriculture, Forestry and Fisheries, Japan; **MFLUCC:** Mae Fah Luang University Culture Collection, ChiangRai, Thailand; **NBRC**: NITE Biological Resource Centre, Japan; **STE-U:** Culture collection of the Department of Plant Pathology, University of Stellenbosch, South Africa; **OSC**: Oregon State University Herbarium, U.S.A.; **ANM**: A.N. Miller; **GKM**: G.K. Mugambi; **JK**: J. Kohlmeyer; **KT**: K. Tanaka; **SMH**: S.M. Huhndorf.

3.3 Results and Discussion

The combined LSU, SSU, *TEF1* and *RPB2* gene data set consists of 414 taxa, with *Schismatomma decolorans* as the outgroup taxon. The dataset consists of 4584 characters after alignment, 1615 characters were constant, and 2303 characters were parsimony informative, while 666 variable characters are parsimony-uninformative. A heuristic search with random addition of taxa (1000 replicates) and treating gaps as missing characters generated six equally parsimonious trees. The best scoring RAxML trees are shown in Figs 3.1 and 3.2. Bootstrap support (BS) values of MP and ML (equal to or above 50 %) are shown on the upper branches. Values of the Bayesian posterior probabilities (PP) (equal to or above 90 %) from MCMC analyses are shown under the branches (TL = 39,381, CI = 0.140, RI = 0.617, RC = 0.086, Hi = 0.860).

In the phylogenetic trees (Figs. 3.1 and 3.2), the 414 strains of Dothideomycetes included in the analysis cluster into the two Dothideomycetes subclasses as previously described based on presence or absence of pseudoparaphyses (Schoch et al., 2006). Subclass Pleosporomycetidae includes *Pleosporales*, *Mytilinidiales*, and *Hysteriales* and is the same as in previous publications (School et al., 2009b; Boehm et al., 2009; Shearer et al., 2009; Suetrong et al., 2011a). However, the position of *Jahnulales* was not consist and clustered together with two newly introduced orders *Dyfrolomycetales* and *Strigulales*; and *Acrospermales* in this study. The second subclass Dothideomycetidae representing *Capnodiales*, *Dothideales* and *Myriangiales* is confirmed as well-supported.

Twenty-two orders (*Pleosporales*, *Mytilinidiales*, *Hysteriales*, *Acrospermales*, *Dyfrolomycetales*, *Strigulales*, *Jahnulales*, *Tubeufiales*, *Patellariales*, *Botryosphaeriales*, *Dothideales*, *Myriangiales*, *Capnodiales*, *Lichenoconiales*, *Phaeotrichales*, *Microthyriales*, *Natipusillales*, *Venturiales*, *Asterinales*, *Lichenotheliales*, *Monoblastiales* and *Trypetheliales*) within the class Dothideomycetes are supported in Figs 3.1. The order *Venturiales* was recently proposed (Zhang et al., 2011) with two families *Venturiaceae* and *Sympoventuriaceae* to accommodate the groups which have a parasitic or saprobic lifestyle, occurring on leaves or stems of dicotyledons; small to medium-sized ascomata, often with setae; deliquescing pseudoparaphyses; 8-spored, broadly cylindrical to obclavate asci; 1-septate, yellowish, greenish or pale brown to brown ascospores; and hyphomycetous asexual morphs (Zhang et al., 2011). The family *Tubeufiaceae* which was not placed in an order by Schoch et al. (2006, 2009a, b), is now accommodated in *Tubeufiales* (Boonmee et al., 2014, in press). The order *Tubeufiales* includes taxa with uni-loculate, superficial and pigmented (e.g. pale brown, brown, and dark brown to black) ascomata, and mostly multi-celled and hyaline relatively long ascospores and mostly produce helicosporous asexual states. Both *Venturiaceae* and *Tubeufiaceae* were traditionally assigned to *Pleosporales*, although they have diagnostic characters which readily distinguish them from other pleosporalean families. Phylogenetically, the core genera of *Venturiaceae* and *Tubeufiaceae* form monophyletic clades within Dothideomycetes, and represent separate sister lineages from the current orders. The nearest relatives of the *Tubeufiales* are *Botryosphaeriales*. The species-rich order Botryosphaeriales includes the single family *Botryosphaeriaceae* in Schoch et al. (2006, 2009b). With more extensive taxa sampling of diversity in this order, the *Planistromellaceae* was shown to cluster adjacent to the *Botryosphaeriaceae* (Minnis et al., 2012; Monkai et al., 2013), and *Phyllostictaceae* reinstated (Wikee et al., 2013). Three well-supported clades are representative of these families in *Botryosphaeriales* (Figs 3.1 and 3.2). *Saccharata protea* (Wakef.) Denman & Crous does not reside in any of the above clades, and is placed on early diverging branche of the order, representing *Saccharataceae* (Slippers et al., 2013). The monotypic genus *Melanops* (type = *Melanops tulasnei* Fuckel) clustered together with *Planistromellaceae*, but without strong support, and is placed in the *Melanopsaceae* by Slippers et al. (2013). In addition, the two asexual genera *Aplosporella* and *Pseudofusicoccum* did not cluster in any clade in this analysis. *Aplosporella* is placed in the *Aplosporellaceae* by Slippers et al. (2013).

Families with good support but not clustering in any known orders include *Kirschsteiniotheliaceae*, *Lichenoconiaceae*, *Lichenotheliaceae*, *Monoblastiaceae*, *Natipusillaceae*, *Phaeotrichaceae*, and *Strigulaceae* (Figs. 3.1 and 3.2). *Dyfrolomycetaceae* clustered together with *Acrospermaceae*, *Kirschsteiniotheliaceae* and *Strigulaceae* and formed a sister group with *Jahnulales*. *Monoblastiaceae* (lichenized fungi) formed a separate lineage comprising two species, *Megalotremis verrucosa* and *Anisomeridium ubianum* (Vain.) R.C. Harris with 100% bootstrap support and is closest to the lichen family *Trypetheliaceae* Zenker (1827). The recently introduced family *Kirschsteiniotheliaceae* (Boonmee et al., 2012) is also related to *Dyfrolomycesillaceae* and *Acrospermaceae*, however its placement is not stable in all phylogenetic analyses (Schoch et al., 2009; Suetrong et al., 2009b; Boonmee et al., 2012) and this will require further study. *Lichenoconiaceae*, a lichenicolous group of coelomycetous asexual morphs, is introduced as a new family by Hyde et al. (2013). *Natipusillaceae*, introduced by Huzefa et al. (2011) comprises freshwater species with unique characters (e.g. thin-walled, light-coloured, ascomata, subglobose asci and two-celled appendaged ascospores), and forms a distinct lineage (100% and 100% BS and 94% PP) in a clade with *Phaeotrichaceae*, *Microthyriaceae* and *Venturiales*. The poorly studied *Phaeotrichaceae* is a distinct lineage (100% and 100% BS and 100% PP) that clusters in a clade with *Asterinales*, *Microthyriales* and *Venturiales* (Figs. 3.1 and 3.2). The *Lichenotheliaceae* are lichenicolous or loosely associated with algae and form a separate clade without any close relatives. Based on their significant morphological characters and current phylogenetic studies, Hyde et al. (2013) introduced 7 orders, namely *Dyfrolomycetales* K.L. Pang, K.D. Hyde & E.B.G. Jones, *Lichenoconiales* Diederich, Lawrey & K.D. Hyde, *Lichenotheliales* K. Knudsen, Muggia & K.D. Hyde, *Monoblastiales* Lücking, M.P. Nelsen & K.D. Hyde, *Natipusillales*, Raja, Shearer, A.N. Mill. & K.D. Hyde, *Phaeotrichales* Ariyawansa, J.K. Liu & K.D. Hyde and *Strigulales* Lücking, M.P. Nelsen & K.D. Hyde.

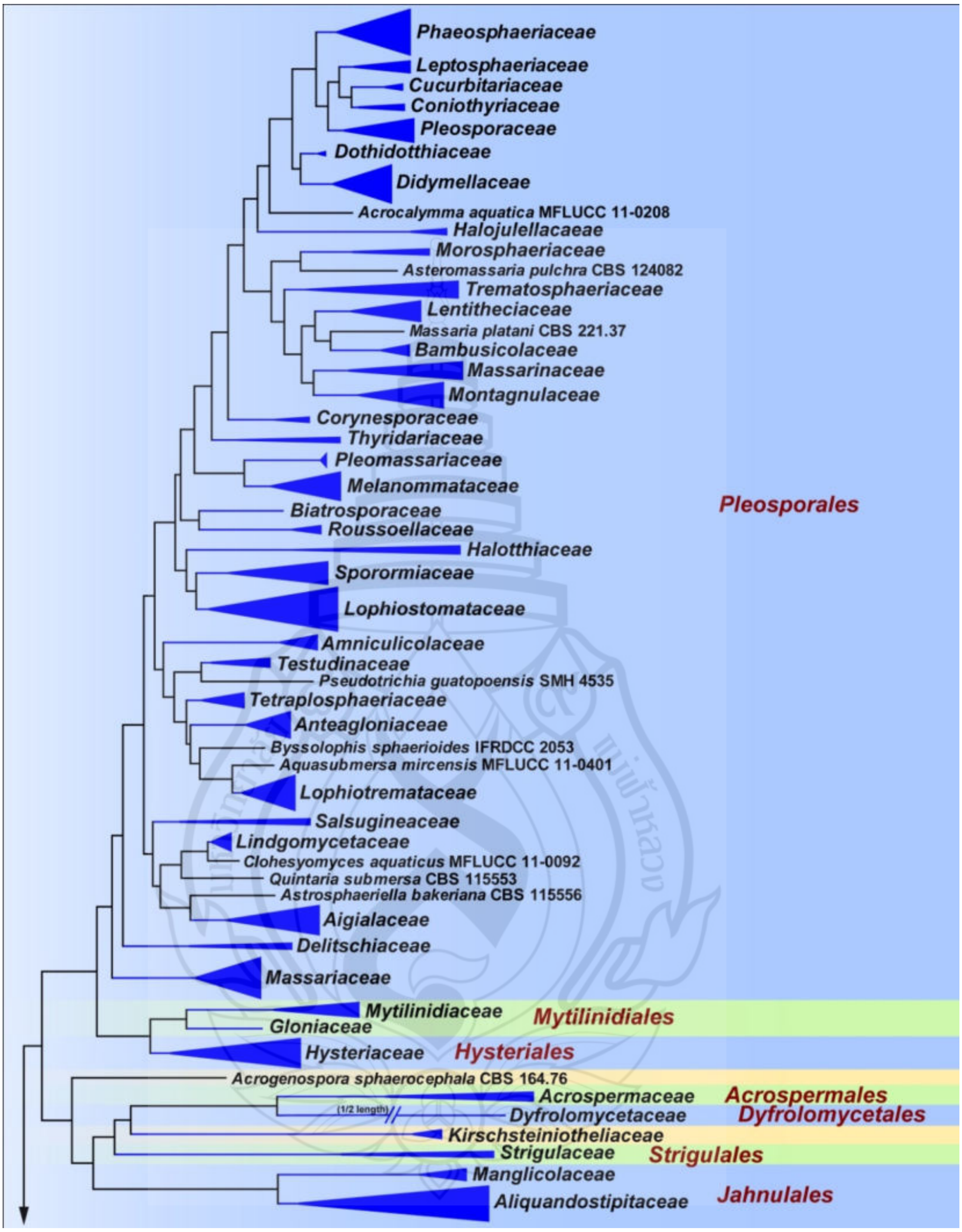
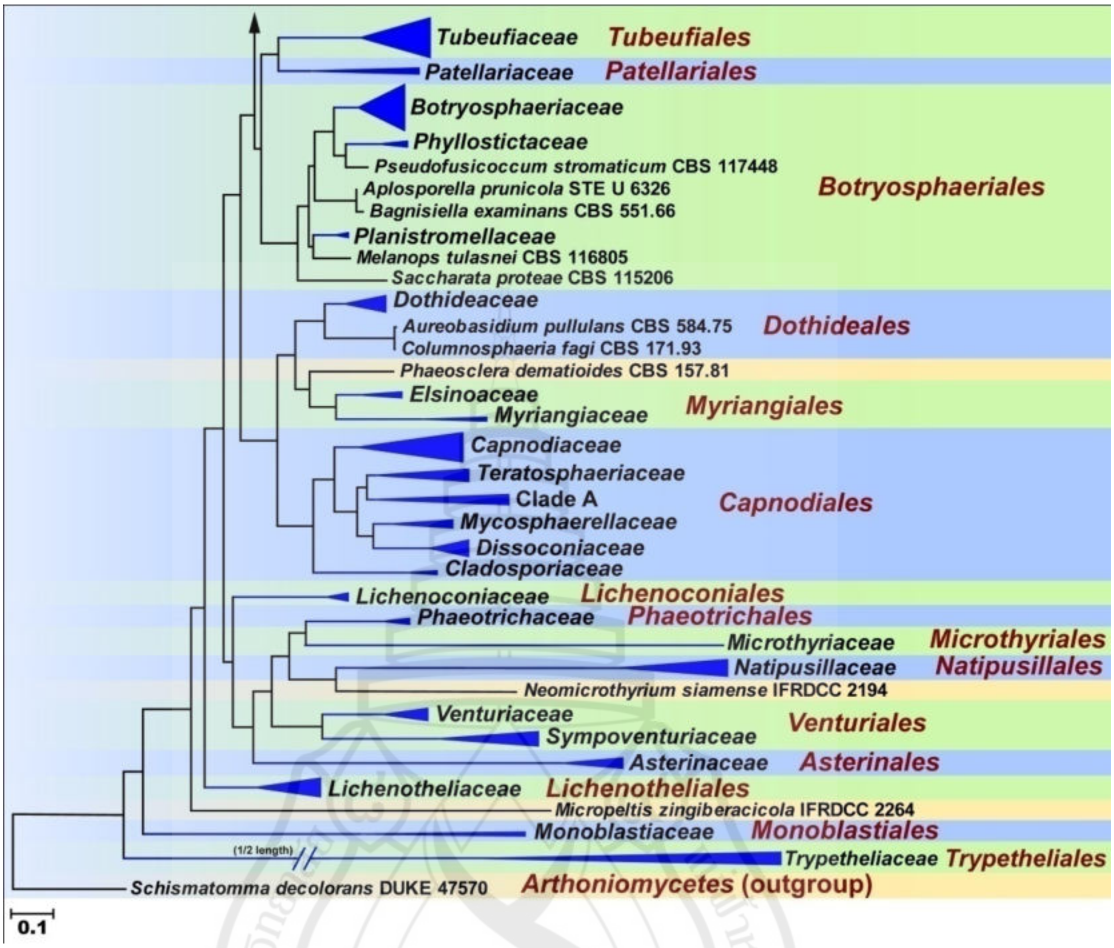


Figure 3.1 The phylogenetic tree of Dothideomycetes (compress overview tree) based on RAxML analysis



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

Figure 3.1 (continued)

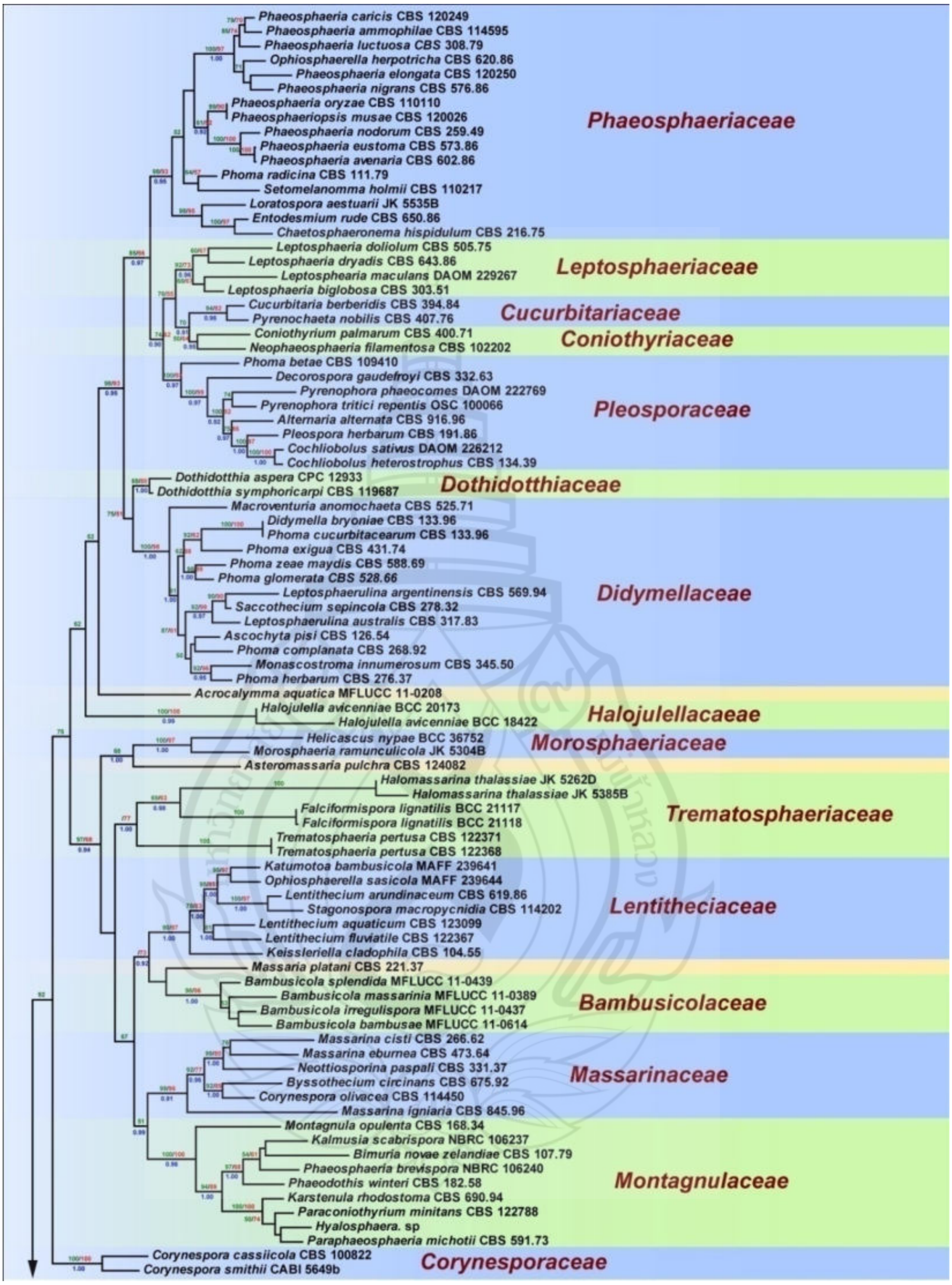


Figure 3.2 The phylogenetic tree of Dothideomycetes based on RAxML analysis

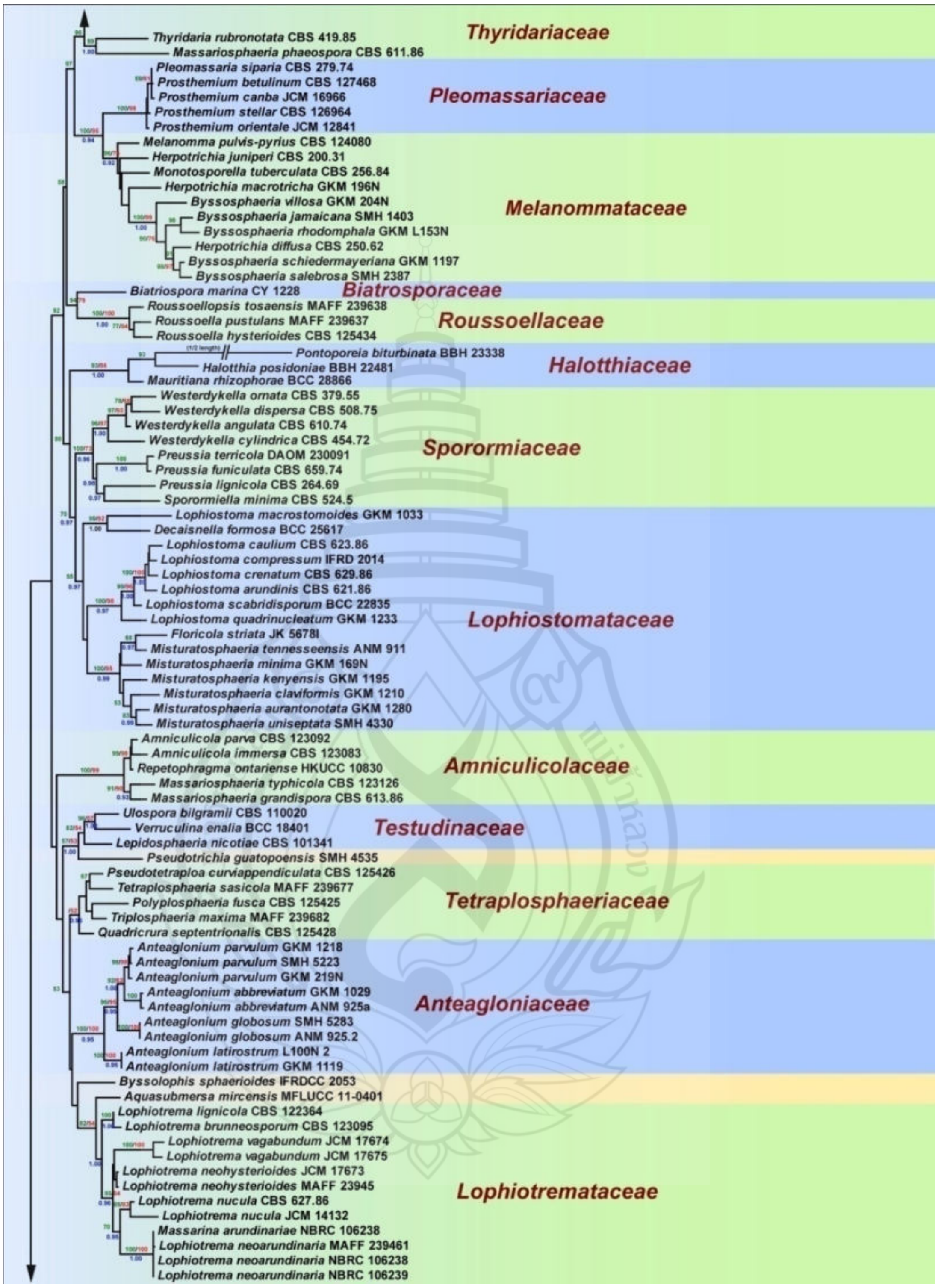


Figure 3.2 (continued)

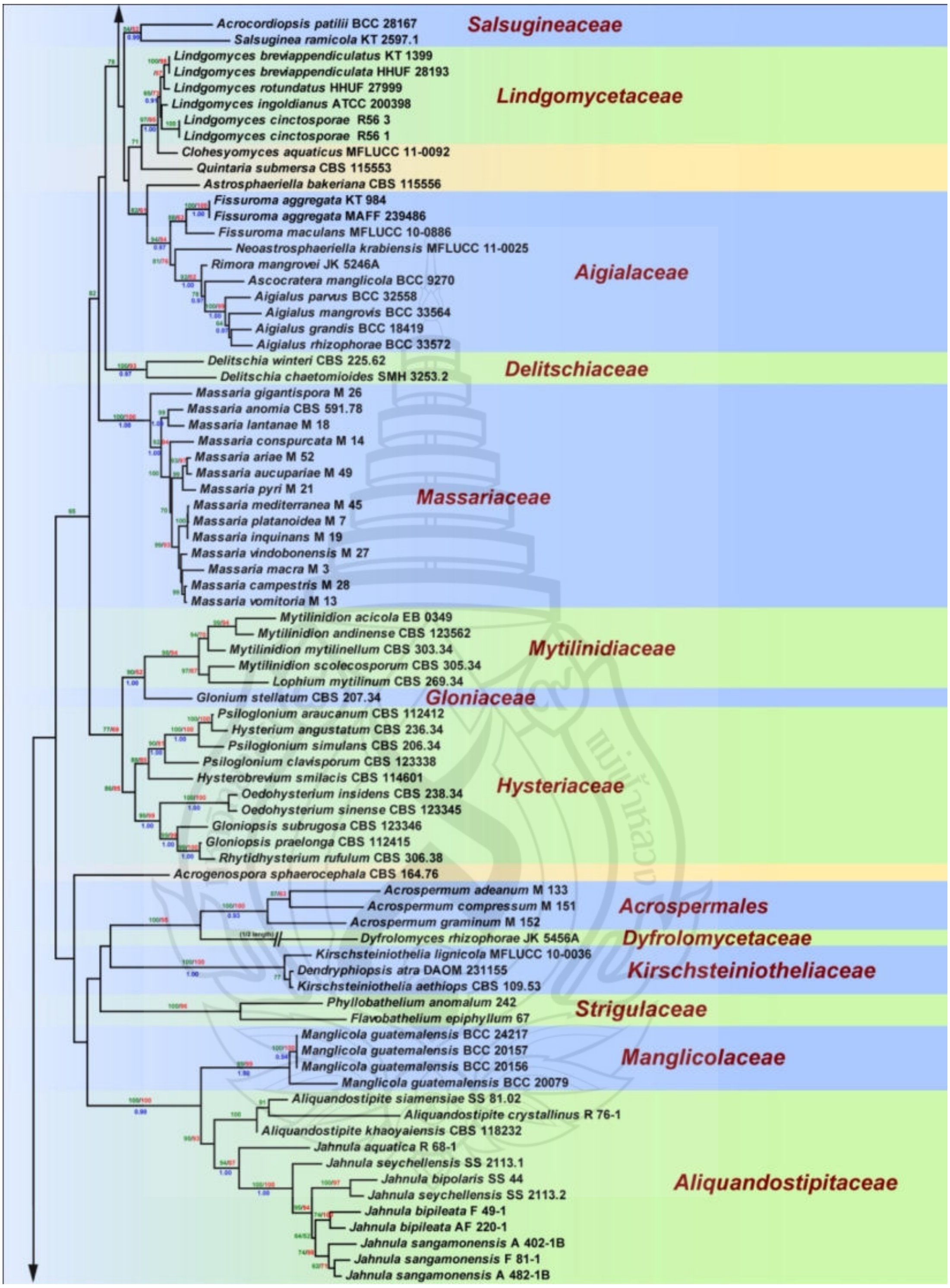


Figure 3.2 (continued)

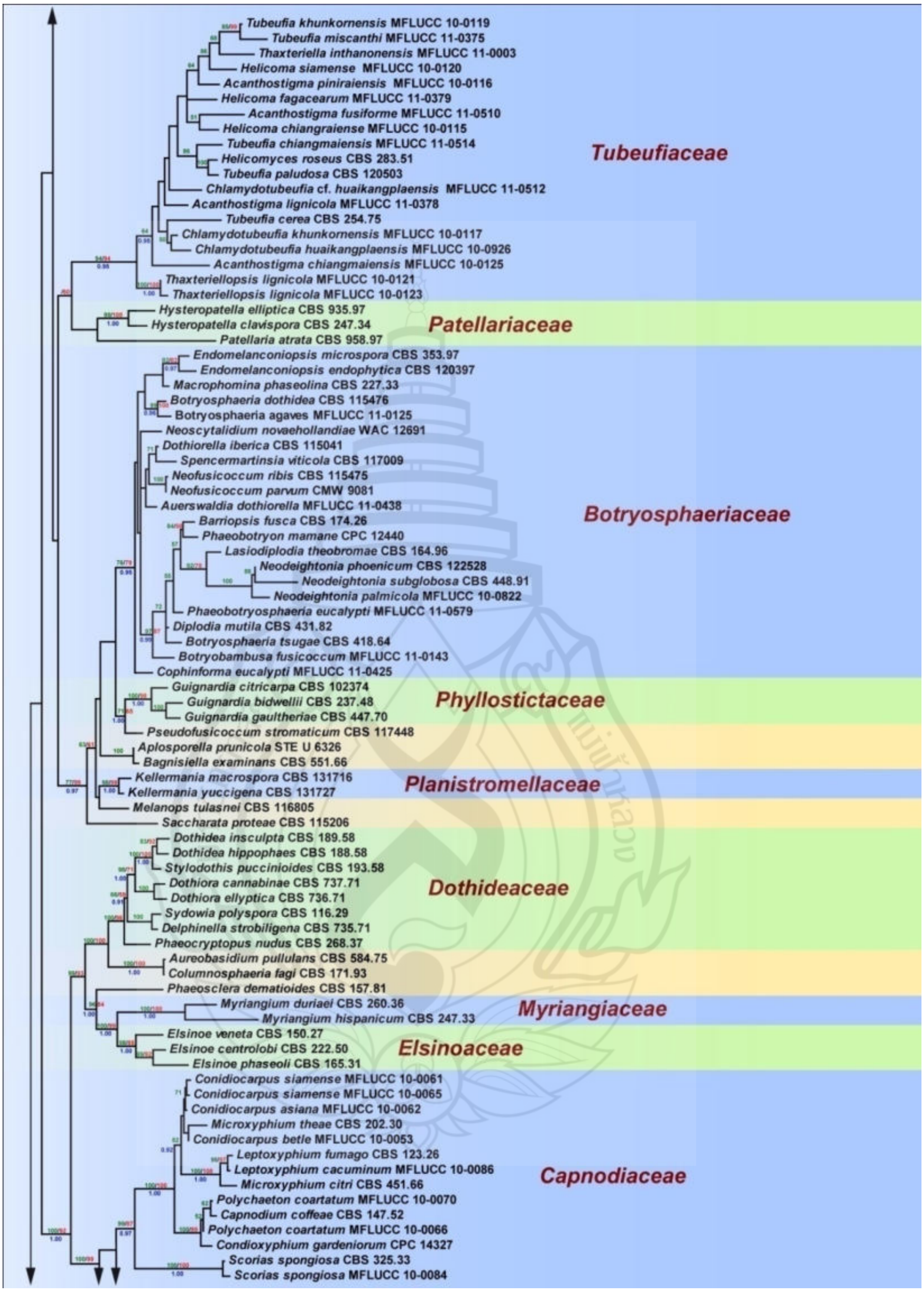
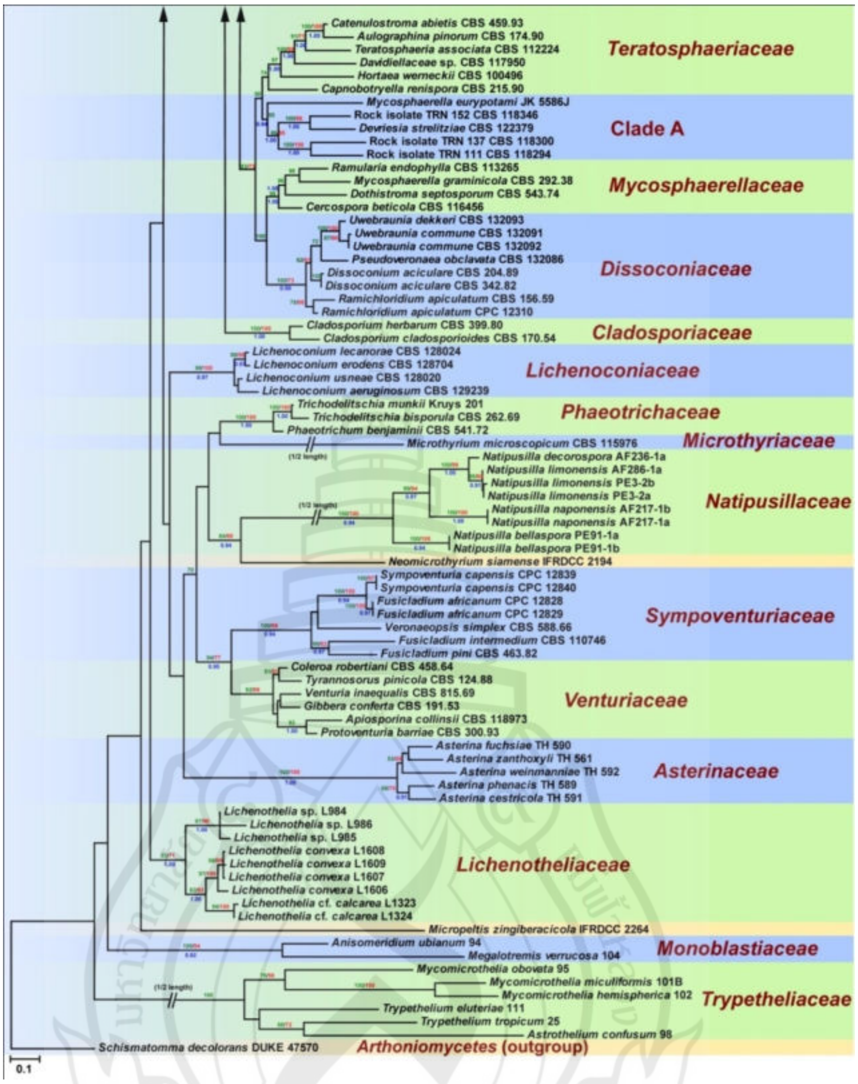


Figure 3.2 (continued)



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

Figure 3.2 (continued)

Pleosporomycetidae C.L Schoch, Spatafora, Crous and Shoemaker., *Mycologia* 98(6): 1048 (2007) [2006]

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

Pleosporales

The 23 or 27 families included in *Pleosporales* by Kirk et al. (2008) and Lumbsch and Huhndorf (2010) respectively, were previously grouped based on morphological characters. These families were recently resolved at molecular level, for example, Schoch et al. (2006, 2009a) found reasonable support for 7 to 23 families in a phylogeny generated from four genes. Subsequently, Zhang et al. (2012) accepted 28 families in this order based on both morphology and phylogeny (four genes). The analyses in Figs. 3.1 and 3.2 provided support for 33 family clades, which correspond to the suborders *Pleosporineae* with seven families and *Massarianeae* with six families. The other seven newly introduced families are *Anteagloniaceae*, *Bambusicolaceae*, *Biatriosporaceae*, *Halojulellacaeae*, *Roussoellaceae*, *Salsugineaceae* and *Thyridariaceae*, belong in *Pleosporales*, while *Bambusicolaceae* forms a clade within the suborder *Massarianeae*. *Lophiostomataceae* comprise two distinct clades *Lophiostoma*-clade (100%, 100% BS and 0.97 PP) and *Misturarosphaeria*-clade (100%, 95% BS and 0.99 PP) which may represent distinct families, however, we refrain from introducing a new family until more species are sequenced. *Roussoellaceae* (100%, 100% BS and 1.00 PP) and *Biatriosporaceae* are newly introduced families in Hyde et al. (2013). They form distinct clades (94% and 79% BS) which comprise morphologically and phylogenetically distinct families. The *Anteagloniaceae* (100%, 100% BS and 0.95 PP) is also introduced as a new family and is related to *Lophiotremataceae*. *Salsuginaceae* (54%, 52% BS and 0.99 PP) is also a distinct family introduced in Hyde et al. (2013) close to *Aigialaceae* and *Lindgomycetaceae*.

Hysteriales

Phylogenetic analyses indicate that the *Hysteriales* are closely related to the *Pleosporales* (Schoch et al., 2006, 2009; Boehm et al., 2009a). In addition, the shared morphological characters, such as the similar centrum confirms their close relationship. However, there is still strong branch support for its separation from *Pleosporales* (Boehm et al., 2009). Luttrell (1955) retained the *Hysteriales* based on the elongated hysteriaceouslocule, capable of relatively indeterminate linear growth which is distinct from the strict *Pleospora*-type centrum, defined as it is by constrained concentric growth. In contrast to the close association between the *Hysteriales* and the *Pleosporales*, the *Mytilinidiales* is a distant clade which is close to Pleosporales within the *Pleosporomycetidae* (Boehm et al., 2009).

Acrospermales

The order *Acrospermales* was established by Minter et al. (2007) to accommodate *Acrospermaceae* in which the asci and ascospores are more than 1000 µm. The phylogenetic studies of Stenroos et al. (2010) used five-gene analysis to show that this order belongs in Dothideomycetes. In our phylogenetic study, it is close to the other two orders *Dyfrolomycetales* and *Strigulales*. However, whether a subclass is required to accommodate this order requires further research.

Jahnulales

The order *Jahnulales* was introduced in Dothideomycetes based on molecular analysis of SSU nrDNA sequence data from *Aliquandostipite*, *Jahnula* and *Patescospora* (Pang et al., 2002). Most taxa in *Aliquandostipitaceae* are freshwater fungi occurring on woody substrata. Suetrong et al. (2011a) introduced a new family *Manglicolaceae* for the marine ascomycete *Manglicola guatemalensis* Kohlm. & E. Kohlm. In this study, *Aliquandostipitaceae* and *Manglicolaceae* taxa formed a well-supported clade related to the newly introduced orders *Dyfrolomycetales*, *Strigulales* and *Acrospermales*, and is close to *Hysteriales*, as was indicated in earlier studies (Schoch et al., 2009; Boehm et al., 2009, Shearer et al., 2009). Although in our trees (Figs. 3.1 and 3.2) these orders form a distinct clade, the results are not stable, and therefore we do not treat these orders as members of *Pleosporomycetidae*, nor do we introduce a new subclass.

Botryosphaeriales

The order *Botryosphaeriales* was introduced by Schoch et al. (2006), following molecular analysis, and comprised a single family *Botryosphaeriaceae*. Subsequent studies suggested that *Botryosphaeriales* most likely should accommodate additional families (Schoch et al., 2009a; Liu et al., 2012; Minnis et al., 2012; Monkai et al., 2013). Based on morphology and phylogeny (four genes), Liu et al., (2012) presented a classification of *Botryosphaeriales*, and two major clades representing *Botryosphaeriaceae* and *Phyllostictaceae* resulted from their analysis. Minnis et al. (2012) also included *Planistromellaceae* as a distinct family, in an unresolved position relative to other genera within *Botryosphaeriales*. In our phylogenetic analysis, these three families formed well-supported clades (Figs. 3.1 and 3.2). The placement of the monotypic genera *Saccharata* and *Melanops* were unresolved, *Saccharata proteae* being basal in the order and *Melanops tulasnei* clustering together with *Planistromellaceae* with low bootstrap support. Slippers et al. (2013) introduce the *Saccharataceae* and *Melanopsaceae* to accommodate these taxa. A strongly supported clade which included *Aplosporella prunicola* Damm & Crous and a putative strain of *Bagnisiella examinans* was formed between *Planistromellaceae* and *Phyllostictaceae*, for which Slippers et al. (2013) introduce the *Aplosporellaceae*. The asexual genus *Pseudofusicoccum* clustered together with *Phyllostictaceae* with good support, however, the position of the strain was not stable; we therefore do not include this genus in *Phyllostictaceae* in our study. The family *Botryosphaeriaceae* typified by *Botryosphaeria dothidea* (Moug. ex Fr.) Ces. & De Not and related genera formed a well-supported clade and includes most sexual and asexual genera presently placed in the family. An extensive taxon sampling is required to address the diversity in this order and there is still much research to be carried out with resolution of families and genera, linkage of sexual and asexual morphs and differentiation of cryptic species (Liu et al., 2012).

Dothideomycetidae P.M.Kirk, P.F.Cannon, J.C. David & J.A. Stalpers, ex C.L. Schoch, Spatafora, Crous and Shoemaker; *Mycologia* 98(6): 1048 (2007) [2006]

This subclass always comprises *Capnodiales*, *Dothideales* and Myr*i*angiales (Schoch et al., 2006, 2009b; Zhang et al., 2009; Boehm et al., 2009; Figs. 3.1 and 3.2)

Dothideales

The order *Dothideales* was introduced by Lindau (1897) to accommodate a single family *Dothideaceae*, but familes of *Dothideales* varied from author to author. The *Dothideales* previously comprised *Dothideaceae*, *Dothioraceae* and *Teratosphaeriaceae* (Lumbsch & Huhndorf, 2010). Morphological examination and multi-gene phylogenetic analysis indicate that the *Dothioraceae* should be combined under *Dothideaceae*, while *Aureobasidium*, *Selenophoma*, *Kabatiella* and *Columnosphaeria* may need a new family (Thambugala et al. in prep., Figs 3.1 and 3.2).

Myriangiales

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

Capnodiales

The order *Capnodiales* comprises six clades (Figs. 3.1 and 3.2) representing *Capnodiaceae*, *Cladosporiaceae*, *Dissoconiaceae*, *Mycosphaerellaceae* and *Teratosphaeriaceae* plus one unnamed clade comprising mostly rock inhabiting species. The *Teratosphaeriaceae* is recently included (Crous et al., 2009c), while the *Capnodiaceae* has been redefined (Chomnunti et al., 2011). The family *Dissoconiaceae* comprises several asexual genera of plant pathogens and has been studied by Li et al. (2012).

Microthyriales

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

Asterinales

The order *Asterinales* is represented by *Asterinaceae* in our phylogenetic analysis. Few molecular studies have been carried out on this group, which mostly focused on morphology. Hofmann et al. (2011) presented the first molecular hypothesis of the *Asterinaceae* within Dothideomycetes based on the LSU and SSU sequences. In our phylogenetic analysis, it is close to *Venturiales* and the newly introduced orders *Natipusillales* and *Phaeotrichales*.

Trypetheliales

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

3.4 Conclusion

In this study, 414 isolates, representing 64 families in Dothideomycetes were included for the multi-gene (LSU, SSU, *TEF1* and *RPB2*) analyses, the reconstructions resulted from the dataset provided a class-wide phylogenetic assessment of Dothideomycetes. Twenty two orders were recognized, which 7 *Dyfrolomycetales*, *Lichenoconiales*, *Lichenotheliales*, *Monoblastiales*, *Natipusillales*, *Phaeotrichales* and *Strigulales* are new to science and introduced as new orders. Ten families *Anteagloniaceae*, *Bambusicolaceae*, *Biatriosporaceae*, *Lichenoconiaceae*, *Muyocopronaceae*, *Paranectriellaceae*, *Roussoellaceae*, *Salsugineaceae*, *Seynesiopeltidaceae* and *Thyridariaceae* were also introduced and assigned to orders. The asexual and sexual morphs were also linked with the available data. This study also provides a backbone tree for Dothideomycetes and the strains and sequences data can be the reference data for the phylogenetic studies of Dothideomycetes.

CHAPTER 4

TOWARDS A NATURAL CLASSIFICATION OF BOTRYOSPHAERIALES

4.1 Introduction

Botryosphaeria was introduced by Cesati and De Notaris (1863). Saccardo (1877) emended the initial generic description and transferred the hypocreaceous species amongst them to *Gibberella* and *Lisea*. Because Cesati and De Notaris (1863) did not designate a type species, von Höhnel (1909) suggested *Botryosphaeria berengeriana* De Not., while Theissen and Sydow (1915) suggested *B. quercuum* (Schwein.) Sacc., which could be regarded as generic lectotype. Neither proposal was accepted because these species were not included in the original description of the genus (Cesati & De Notaris, 1863). Therefore, Barr (1972) proposed *B. dothidea* (Moug. : Fr.) Ces. & De Not, one of the species originally included by Cesati and De Notaris (1863), as the lectotype of this genus. This proposal has generally been accepted and Slippers et al. (2004b) proposed a neotype and epitype to stabilize the type species *B. dothidea* and provided a modern description of this genus based on these new types.

Species of *Botryosphaeria* are cosmopolitan in distribution and occur on a wide range of monocotyledonous, dicotyledonous and gymnosperm hosts; on woody branches, herbaceous leaves, stems and culms of grasses; and on twigs and in the thalli of lichens (Barr 1987; Denman et al., 2000; Mohali et al., 2007; Lazzizera et al., 2008a; Marincowitz et al., 2008). Taxa range in habit from saprobic to parasitic or endophytic (Smith et al., 1996; Denman et al., 2000; Phillips et al., 2006; Slippers & Wingfield, 2007; Huang et al., 2008; Pérez et al., 2010; Ghimire et al., 2011;

González & Tello, 2011), and cause die-back and canker diseases of numerous woody hosts (von Arx 1987; Damm et al., 2007a; Phillips et al., 2007; Slippers et al., 2007;Alves et al., 2008; Lazzizera et al., 2008b; Marincowitz et al., 2008; Zhou et al., 2008; Pérez et al., 2010; Adesemoye & Eskalen, 2011; Urbez-Torres et al., 2012). Species of *Botryosphaeria* have also been isolated from marine environments in sea grasses (Sakayaroj et al., 2010).

The *Botryosphaeriales* was introduced by Schoch et al. (2006), following molecular analysis, and comprises a single family *Botryosphaeriaceae*. This family however, has a rather varied past as can be seen from inclusion of genera by various authors (Table 4.1). Von Arx and Müller (1954) included 15 genera, but later reduced it to 14 genera by von Arx and Müller (1975). Barr (1987) was much more conservative and included only nine genera, mostly different from those of von Arx and Müller (1954), while Hawksworth et al. (1995) listed five genera and numerous synonyms of *Botryosphaeria*. With the use of molecular data it has been possible to add more new genera to the family *sensu* Hawksworth et al. (1995). Lumbsch and Huhndorf (2010) included 11 genera, while Hyde et al. (2011) and Wijayawardene et al. (2012) listed 20 asexual genera. Phillips and Alves (2009) restudied the botryosphaeriaceous *Melanops*, epitypifying the generic type. In the present study, we accept 29 genera based on molecular data and examination of generic types.

Botryosphaeriaceae has been well circumscribed, and can be defined as forming uni- to multilocular ascostromata with multi-layered walls, occurring singly or sometimes in botryose clusters or pulvinate stromata (e.g. *Auerswaldiella*), often united with conidiomata on a common basal stroma and embedded in the host and becoming partially erumpent at maturity (von Arx & Müller, 1954; Eriksson 1981; Sivanesan 1984). We follow the concept for "*Ascostromata*" given by Ulloa and Hanlin (2000) as follows: "ascostromata: A stromatic ascocarp resulting from ascolocular ontogeny, with the asci produced in locules or cavities, the walls of which consist only of stromal tissue. No separable wall is formed around them. If a single cavity is present it is a unilocular (uniloculate) ascostroma, and if several locules are formed it is a multilocular (multiloculate) ascostroma". This is not always clear, but we have tried to be consistent in using ascostromata even when only single locules are present and ascomata might therefore be more appropriate. Asci are bitunicate, fissitunicate, with a thick endotunica, and clavate, with a short or long pedicel and with a well-developed ocular chamber. The asci form in a basal hymenial layer, intermixed among hyaline, septate pseudoparaphyses that are often constricted at the septum. Pseudoparaphyses are frequently present in the centrum of immature ascostromata, but they gradually disappear as the asci develop and mature. Ascospores are hyaline, thin-walled, aseptate and vary from fusoid to ellipsoid or ovoid, bi- to triseriate and are irregularly biseriate in the ascus, mostly without a mucilaginous sheath or appendages, some with an apiculus at each end. Ascospores may turn brown and become septate and even slightly verruculose upon germination or with age and have projection or appendage at the ends (von Arx & Müller, 1954; Shoemaker 1964; Eriksson 1981; Sivanesan 1984; Hsieh & Chen, 1994; Denman et al., 2000; Alves et al., 2004; Slippers et al., 2004b; Phillips et al., 2005, 2008; Crous et al., 2006; Schoch et al., 2006; Phillips & Alves, 2009).

The asexual morphs of *Botryosphaeriaceae* have been assigned to several coelomycete genera, including *Aplosporella*, *Diplodia*, *Dothiorella*, *Fusicoccum, Macrophomina, Microdiplodia, Neofusicoccum, Neoscytalidium, Lasiodiplodia, Pseudofusicoccum* and *Sphaeropsis* (Crous & Palm, 1999; Denman et al., 2000; Crous et al., 2004, 2006; Pavlic et al., 2004, 2008, 2009a, b; Phillips & Pennycook, 2004; Slippers et al., 2004a; Phillips et al., 2005; Alves et al., 2006, 2008; Damm et al., 2007b; Lazzizera et al., 2008b). Denman et al. (2000) recognized only two of these, namely *Diplodia* and *Fusicoccum*. Recent studies on the taxonomy of *Botryosphaeria* have employed molecular methods to reveal phylogenetic relationships among species (Jacobs & Rehner, 1998) and to resolve species complexes (Smith et al., 2001; Phillips et al., 2002; Denman et al., 2003; Alves et al., 2004; Slippers et al., 2004c; Phillips et al., 2005). Two major clades corresponding to species with *Diplodia* and *Fusicoccum* asexual morphs were revealed based on the phylogenies resulting from ITS sequence analyses (Jacobs & Rehner, 1998; Denman et al., 2000). Later studies including additional species and a larger suite of DNA-based markers supported this grouping (Zhou & Stanosz, 2001; Alves et al., 2004; Slippers et al., 2004d). When Crous et al. (2004) described the species *Saccharata proteae* Denman & Crous (as *Botryosphaeria proteae* (Wakef.) Denman & Crous with *Fusicoccum* and *Diplodia* synanamorphs), this well supported grouping was questioned, as it is morphologically and phylogenetically distinct from representatives of the *Diplodia*-like and *Fusicoccum*-like groups. *Lasiodiplodia* Ellis & Everh. has been treated as a distinct genus from *Diplodia* Fr. by many authors due to its distinct phylogeny (usually ITS or *TEF1*) and morphology (striated or smooth conidia and presence or absence of pseudoparaphyses). Pavlic et al. (2004) employed morphological and phylogenetic data to separate *Lasiodiplodia* from *Diplodia*. Later, Phillips et al. (2005) broadened the concept by including *Dothiorella* within *Botryosphaeria*. *Dichomera* Cooke has been linked to *Botryosphaeria* species with *Fusicoccum* anamorphs by Barber et al. (2005). In a phylogenetic study based on 28S rDNA sequence data, Crous et al. (2006) recognised ten lineages within *Botryosphaeriaceae* corresponding to different genera. Subsequently, Damm et al. (2007b) added a further genus, *Aplosporella*, while Phillips et al. (2008) recognised five additional genera. Asexual genera for *Botryosphaeriaceae* were listed in Hyde et al. (2011) as *Aplosporella, Bahusutrabeeja, Barriopsis, Dichomera, Diplodia, Dothichiza, Dothiorella, Fusicoccum, Lasiodiplodia, Macrophomina, Microdiplodia, Neofusicoccum, Neoscytalidium, Phaeobotryon, Phyllosticta, Pseudofusicoccum* and *Sphaeropsis*, with *Camarosporium, Dichomera* and *Hendersonula* listed under *Botryosphaeriales incertae sedis*.

In this study, we present a systematic treatment of *Botryosphaeriaceae* and its related asexual morph genera based on type specimens sourced from various herbaria and a morphological study of 17 fresh specimens of botryosphaeriaceous taxa from northern Thailand as well as a molecular phylogenetic analysis of sequence data from four genes. Two monotypic genera and four new species are introduced, one in *Botryosphaeria*, one in *Phaeobotryosphaeria* and two in *Aeurswaldia*. These taxa are fully described and their taxonomy is discussed.

4.2 Materials and Methods

4.2.1 Examination of Herbarium Material and Fresh Specimens

The type specimens of *Auerswaldia*, *Auerswaldiella*, *Barriopsis*, *Botryosphaeria*, *Leptoguignardia*, *Melanops*, *Neodeightonia*, *Phaeobotryon, Phaeobotryosphaeria, Phyllachorella, Pyrenostigme, Saccharata*, *Sivanesania*, *Spencermartinsia* and *Vestergrenia* were obtained from BPI, K, IMI, LISE, LPS, PREM and S. Fresh material was collected from Chiang Mai, Chiang Rai, Lampang and Phayao provinces in Thailand. Seventeen freshly collected samples were grown on malt extract agar (MEA) and/or potato dextrose agar (PDA). Methods for examining the type material and isolation from fresh material were as in Boonmee et al. (2011), Chomnunti et al. (2011) and Liu et al. (2011). To increase the chances of sporulation 3–5 single ascospore cultures were placed around the Petri-dish so that mixing of mycelia occurred. Observations and photomicrographs were made from material mounted in water using a Nikon ECLIPSE 80i microscope. India ink was added to water mounts to detect the presence of gelatinous sheaths or ascospore appendages. Measurements were made with Tarosoft (R) Image Frame Work (Liu et al., 2010).

4.2.2 DNA Extraction, PCR Amplification and Sequencing

Fungal isolates were grown on PDA for one week at 28 °C in the dark. Genomic DNA was extracted from the fresh mycelium using the Biospin Fungus Genomic DNA Extraction Kit (BioFlux®) following the manufacturer's protocol (Hangzhou, P.R. China).

DNA amplification was performed by polymerase chain reaction (PCR). Primer pairs NS1 and NS4 (White et al., 1990) were used to amplify a region spanning of the nuclear ribosomal SSU gene. LROR and LR5 primer pairs (Vilgalys & Hester 1990) were used to amplify a segment of the large subunit r RNA. Primer pairs ITS4 and ITS5 (White et al., 1990) were used to amplify the internal transcribed spacers. Primers EF1-728F and EF1-986R (Carbone & Kohn, 1999) and Bt2a and Bt2b (Glass & Donaldson, 1995) were used to amplify and sequence part of the translation elongation factor 1-alpha (*TEF1*) gene and part of the β-tubulin gene respectively. Amplification and nucleotide sequencing of the EF1-α and β-tubulin genes were performed as described by Alves et al. (2006, 2008). The PCR products were checked on 1% agarose electrophoresis gels stained with ethidium bromide.

PCR products were purified using minicolumns, purification resin and buffer according to the manufacturer's protocols (Amersham product code: 27–9602–01). The sequences were carried out by Shanghai Sangon Biological Engineering Technology & Services (Shanghai, P.R. China). For each fungal strain, sequences obtained for the respective primers (ITS5 and ITS4, LROR and LR5, NS1 and NS4, EF1-728F and EF1-986R, Bt2a and Bt2b) were manually aligned to obtain an assembled sequence using Bioedit (Hall 1999). The reference nucleotide sequences of ITS, LSU, SSU, *TEF1*, β-tubulin regions of various taxa were obtained from GenBank (Table 4.1)

4.2.3 Phylogenetic Analysis

Sequences generated from different primers were analyzed with other sequences obtained from GenBank. A Blast search was performed to reveal the closest matches with taxa in *Botryosphaeriales*. In addition, fungal members from different genera of the *Botryosphaeriales* and close orders were also included in the analyses. Sequences were aligned using Bioedit (Hall 1999) and ClustalX v. 1.83 (Thompson et al., 1997). The alignments were checked visually and improved manually where necessary. Phylogenetic analyses were performed by using PAUP v. 4.0b10 (Swofford 2002) for Maximum-parsimony (MP) and MrBayes v. 3.0b4 (Ronquist & Huelsenbeck, 2003) for Bayesian analyses.

The analyses of Maximum likelihood (RAxML), Maximum Parsimony and Bayesian were performed as in Chapter3 (3.2.1).

Table 4.1 Accepted genera according to various treatments of *Botryosphaeriaceae*

Von Arx and Müller 1954	Barr 1987	Hawksworth et al., 1995	Lumbsch and Huhndorf 2010	Present study*
Auerswaldia	*Auerswaldia*	*Amarenomyces*	*Auerswaldiella*	*Aplosporella*
Auerswaldiella	*Auerswaldiella*	*Auerswaldiella*	*Barriopsis*	*Auerswaldia*
Bagnisiella	*Botryosphaeria*	*Botryosphaeria*	*Botryosphaeria*	*Auerswaldiella*
Botryosphaeria	*Discochora* (= *Guignardia*)	*Dothidotthia*	*Guignardia*	*Barriopsis*
Cleistosphaeria	*Dothidotthia*?	*Sivanesania*	*Leptoguignardia*	*Botryobambusa*
Ellisiodothis	*Homostegia*		*Neodeightonia*	***Botryosphaeria***/*Fusiccocum***
Guignardia	*Leptoguignardia*		*Phaeobotryon*	*Cophinforma*
Montagnellina	*Neodeightonia*		*Phaeobotryosphaeria*	*Endomelanconiopsis*
Microdothiella	*Phyllachorella*		*Saccharata*	*Diplodia*
Muyocopron			*Sivanesania*	*Dothiorella*
Parastigmatea				*Lasiodiplodia*
Pilgeriella				*Leptoguignardia*
Pyrenostigme				*Macrophomina*
Trabutia				*Macrovalsaria*
Vestergrenia				*Melanops*
				Neodeightonia
				Neofusicoccum
				Neoscytalidium
				Phaeobotryon
				Phaeobotryosphaeria/*Sphaeropsis****
				Phyllachorella
				Phyllosticta/*Guignardia*****
				Pseudofusicoccum
				Pyrenostigme
				Saccharata
				Sivanesania
				Spencermartinsia
				?*Tiarosporella*
				Vestergrenia

Note. *If two names are known for the genus both names are listed. The name that should be used following the introduction of the rule requiring a genus to have a single name is listed first and in bold.

**Botryosphaeria* is preferred over *Fusicoccum*, even though the latter is the older name because this name has been used against *Fusicoccum* in recent publications, it is the type of the order and family, it is more commonly recorded in publications and as a pathogen (e.g. Slippers et al., 2004b; Crous et al., 2006).

****Phaeobotryosphaeria* is preferred over *Sphaeropsis*; even through the latter is the older name because this name has been used against *Sphaeropsis* in recent publications (e.g. Phillips et al., 2008). *Sphaeropsis* is also likely to be polyphyletic.

****A case has already been presented for using *Phyllosticta* in Wikee et al., (2011a).

Table 4.2 Isolates used in this study

Taxon	Isolates	GenBank accession numbers				
		ITS	SSU	LSU	*TEF1*	β-tubulin
Amniculicola lignicola	CBS 123094	–	EF493863	EF493861	–	–
Aplosporella prunicola	STE-U 6327	–	–	EF564378	–	–
Aplosporella prunicola	STE-U 6326	EF564376	–	EF564377	–	–
Aplosporella yalgorensis	MUCC 512	EF591927	–	EF591944	EF591978	EF591961
Aplosporella yalgorensis	MUCC 511	EF591926	–	EF591943	EF591977	EF591960
Auerswaldia dothiorella	MFLUCC 11-0438	JX646796	JX646829	JX646813	JX646861	JX646844
Auerswaldia lignicola	MFLUCC 11-0435	JX646797	JX646830	JX646814	JX646862	JX646845
Auerswaldia lignicola	MFLUCC 11-0656	JX646798	JX646831	JX646815	JX646863	JX646846
Barriopsis fusca	CBS 174.26	EU673330	EU673182	DQ377857	EU673296	EU673109
Botryobambusa fusicoccum	MFLUCC 11-0143	JX646792	JX646826	JX646809	JX646857	–
Botryobambusa fusicoccum	MFLUCC 11-0657	JX646793	JX646827	JX646810	JX646858	–
Botryosohaeria melanops	CBS 118.39	FJ824771	FJ824763	DQ377856	FJ824776	FJ824782
Botryosphaeria agaves	MFLUCC 10-0051	JX646790	JX646824	JX646807	JX646855	JX646840
Botryosphaeria agaves	MFLUCC 11-0125	JX646791	JX646825	JX646808	JX646856	JX646841
Botryosphaeria corticis	CBS 119047	DQ299245	EU673175	EU673244	EU017539	EU673107
Botryosphaeria corticis	ATCC 22927	DQ299247	EU673176	EU673245	EU673291	EU673108
Botryosphaeria dothidea	CMW 8000	AY236949	EU673173	AY928047	AY236898	AY236927
Botryosphaeria dothidea	CBS 110302	AY259092	EU673174	EU673243	AY573218	EU673106
Botryosphaeria fusispora	MFLUCC 10-0098	JX646789	JX646823	JX646806	JX646854	JX646839
Botryosphaeria fusispora	MFLUCC 11-0507	JX646788	JX646822	JX646805	JX646853	JX646838
Capnodium coffeae	CBS 147.52	–	–	DQ247800	–	–
Cochliobolus heterostrophus	CBS 134.39	–	AY544727	AY544645	–	–
Cophinforma eucalyptus	MFLUCC 11-0425	JX646800	JX646833	JX646817	JX646865	JX646848
Cophinforma eucalyptus	MFLUCC 11-0655	JX646801	JX646834	JX646818	JX646866	JX646849
Dichomera eucalypti	MUCC 498	EF591913	–	EF591932	EF591966	EF591949
Didymella exigua	CBS 183.55	–	EU754056	EU754155	–	–
Diplodia corticola	CBS 112549	AY259100	EU673206	AY928051	AY573227	DQ458853
Diplodia corticola	CBS 112546	AY259090	EU673207	EU673262	EU673310	EU673117
Diplodia cupressi	CBS 168.87	DQ458893	EU673209	EU673263	DQ458878	DQ458861
Diplodia cupressi	CBS 261.85	DQ458894	EU673210	EU673264	DQ458879	DQ458862
Diplodia mutila	CBS 112553	AY259093	EU673213	AY928049	AY573219	DQ458850

Table 4.2 (continued)

Taxon	**Isolates**	**GenBank accession numbers**				
		ITS	**SSU**	**LSU**	***TEF1***	**β-tubulin**
Diplodia mutila	CBS 230.30	DQ458886	EU673214	EU673265	DQ458869	DQ458849
Diplodia scrobiculata	CBS 113423	DQ458900	EU673217	EU673267	DQ458885	DQ458868
Diplodia scrobiculata	CBS 109944	DQ458899	EU673218	EU673268	DQ458884	DQ458867
Dothidea insculpta	CBS 189.58	AF027764	DQ247810	DQ247802	–	–
Dothidea sambuci	DAOM 231303	DQ491505	AY544722	AY544681	–	–
Dothidotthia symphoricarpi	CPC 12929	–	EU673224	EU673273	–	–
Dothiorella iberica	CBS 115041	AY573202	EU673155	AY928053	AY573222	EU673096
Dothiorella iberica	CBS 113188	AY573198	EU673156	EU673230	EU673278	EU673097
Dothiorella sarmentorum	IMI 63581b	AY573212	EU673158	AY928052	AY573235	EU673102
Dothiorella sarmentorum	CBS 115038	AY573206	EU673159	DQ377860	AY573223	EU673101
Falciformispora lignatilis	BCC 21117	NG_016526	GU371834	GU371826	–	–
Falciformispora lignatilis	BCC 21118	–	GU371835	GU371827	–	–
Gloniopsis subrugosa	CBS 123346	–	FJ161170	FJ161210	–	–
Guignardia bidwellii	CBS 111645	FJ824766	EU673223	DQ377876	FJ824772	FJ824777
Guignardia citricarpa	CBS 102374	FJ824767	FJ824759	DQ377877	FJ538371	FJ824778
Guignardia philoprina	CBS 447.68	FJ824768	FJ824760	DQ377878	FJ824773	FJ824779
Herpotrichia juniperi	AFTOL-ID 1608	–	DQ678029	DQ678080	–	–
Hysterium angustatum	CBS 123334	–	FJ161167	FJ161207	–	–
Lasiodiplodia crassispora	CBS 110492	EF622086	EU673189	EU673251	EF622066	EU673134
Lasiodiplodia crassispora	CBS 118741	DQ103550	EU673190	DQ377901	EU673303	EU673133
Lasiodiplodia gonubiensis	CBS 115812	DQ458892	EU673193	DQ377902	DQ458877	DQ458860
Lasiodiplodia gonubiensis	CBS 116355	AY639594	EU673194	EU673252	DQ103567	EU673126
Lasiodiplodia parva	CBS 356.59	EF622082	EU673200	EU673257	EF622062	EU673113
Lasiodiplodia parva	CBS 494.78	EF622084	EU673201	EU673258	EF622064	EU673114
Lasiodiplodia pseudotheobromae	CBS 447.62	EF622081	EU673198	EU673255	EF622060	EU673112
Lasiodiplodia pseudotheobromae	CBS 116459	EF622077	EU673199	EU673256	EF622057	EU673111
Lasiodiplodia rubropurpurea	CBS 118740	DQ103553	EU673191	DQ377903	EU673304	EU673136
Lasiodiplodia theobromae	CBS 124.13	DQ458890	EU673195	AY928054	DQ458875	DQ458858

Table 4.2 (continued)

Taxon	Isolates	GenBank accession numbers				
		ITS	SSU	LSU	*TEF1*	β-tubulin
Lasiodiplodia theobromae	CBS 164.96	AY640255	EU673196	EU673253	AY640258	EU673110
Lasiodiplodia theobromae	CAA 006	DQ458891	EU673197	EU673254	DQ458876	DQ458859
Lasiodiplodia theobromae	MFLUCC 11-0508	JX646799	JX646832	JX646816	JX646864	JX646847
Leptosphaerulina australis	CBS 939.69	–	EU754068	EU754167	–	–
Macrophomina phaseolina	CBS 227.33	–	–	DQ377906	–	–
Macrophomina phaseolina	CBS 162.25	–	–	DQ377905	–	–
Macrophomina phaseolina	CPC 11108	–	–	DQ377912	–	–
Macrophomina phaseolina	CPC 11085	–	–	DQ377910	–	–
Macrophomina phaseolina	CPC 11106	–	–	DQ377911	–	–
Macrovalsaria megalospora	178150	–	FJ215707	FJ215701	–	–
Macrovalsaria megalospora	178149	–	FJ215706	FJ215700	–	–
Melanomma pulvis-pyrius	IFRD 002	–	FJ201985	FJ201984	–	–
Melanops tulasnei	CBS 116805	FJ824769	FJ824761	FJ824764	FJ824774	FJ824780
Melanops tulasnei	CBS 116806	FJ824770	FJ824762	FJ824765	FJ824775	FJ824781
Murispora rubicunda	IFRD 2017	–	GU456308	FJ795507	–	–
Mycosphaerella punctiformis	AFTOL-942	–	–	DQ470968	–	–
Neodeightonia palmicola	MFLUCC 10-0822	HQ199221	HQ199223	HQ199222	–	–
Neodeightonia palmicola	MFLUCC 10-0823	HQ199224	HQ199226	HQ199225	–	–
Neodeightonia phoenicum	CBS 169.34	EU673338	EU673203	EU673259	EU673307	EU673138
Neodeightonia phoenicum	CBS 122528	EU673340	EU673205	EU673261	EU673309	EU673116
Neodeightonia phoenicum	CBS 123168	EU673339	EU673204	EU673260	EU673308	EU673115
Neodeightonia subglobosa	MFLUCC 11-0163	JX646794	–	JX646811	JX646859	JX646842

Table 4.2 (continued)

Taxon	Isolates	GenBank accession numbers				
		ITS	SSU	LSU	*TEF1*	β-tubulin
Neodeightonia subglobosa	CBS 448.91	EU673337	EU673202	DQ377866	EU673306	EU673137
Neofusicoccum luteum	CBS 110299	AY259091	EU673148	AY928043	AY573217	DQ458848
Neofusicoccum luteum	CBS 110497	EU673311	EU673149	EU673229	EU673277	EU673092
Neofusicoccum mangiferum	CBS 118531	AY615185	EU673153	DQ377920	–	AY615172
Neofusicoccum mangiferum	CBS 118532	AY615186	EU673154	DQ377921	DQ093220	AY615173
Neofusicoccum parvum	MFLUCC 11-0184	JX646795	JX646828	JX646812	JX646860	JX646843
Neofusicoccum parvum	CMW 9081	AY236943	EU673151	AY928045	AY236888	AY236917
Neofusicoccum parvum	CBS 110301	AY259098	EU673150	AY928046	AY573221	EU673095
Neoscytalidium dimidiatum	CBS 251.49	FM211430	–	DQ377923	–	FM211166
Neoscytalidium dimidiatum	CBS 499.66	FM211432	–	DQ377925	EU144063	FM211167
Neoscytalidium novaehollandiae	WAC 12691	EF585543	–	EF585548	EF585574	–
Neoscytalidium novaehollandiae	WAC 12688	EF585542	–	EF585549	EF585575	–
Otthia spiraeae 1	CBS 114124	–	EF204515	EF204498	–	–
Otthia spiraeae 2	CBS 113091	–	EF204516	EF204499	–	–
Phaeobotryon mamane	CPC 12440	EU673332	EU673184	EU673248	EU673298	EU673121
Phaeobotryon mamane	CPC 12442	EU673333	EU673185	DQ377899	EU673299	EU673124
Phaeobotryon mamane	CPC 12443	EU673334	EU673186	EU673249	EU673300	EU673120
Phaeobotryon mamane	CPC 12444	EU673335	EU673187	DQ377900	EU673301	EU673123
Phaeobotryon mamane	CPC 12445	EU673336	EU673188	EU673250	EU673302	EU673122
Phaeobotryosphaeria citrigena	ICMP 16812	EU673328	EU673180	EU673246	EU673294	EU673140
Phaeobotryosphaeria citrigena	ICMP 16818	EU673329	EU673181	EU673247	EU673295	EU673141
Phaeobotryosphaeria eucalyptus	MFLUCC 11-0579	JX646802	JX646835	JX646819	JX646867	JX646850
Phaeobotryosphaeria eucalyptus	MFLUCC 11-0654	JX646803	JX646836	JX646820	JX646868	JX646851
Phaeobotryosphaeria porosa	CBS 110496	AY343379	EU673179	DQ377894	AY343340	EU673130
Phaeobotryosphaeria porosa	CBS 110574	AY343378	–	DQ377895	AY343339	–
Phaeobotryosphaeria visci	CBS 186.97	EU673325	EU673178	DQ377868	EU673293	EU673128
Phyllosticta brazilianiae	LGMF 330	JF343572	–	–	JF343593	–

Table 4.2 (continued)

Taxon	Isolates	GenBank accession numbers				
		ITS	SSU	LSU	*TEF1*	β-tubulin
Phyllosticta brazilianiae	LGMF 333	JF343574	–	–	JF343595	–
Phyllosticta brazilianiae	LGMF 334	JF343566	–	–	JF343587	–
Pleomassaria siparia	AFTOL-ID 1600	–	DQ678027	DQ678078	–	–
Pleospora herbarum	CBS 191.86	GU238232	DQ247812	DQ247804	–	–
Pseudofusicoccum adansoniae	WAC 12689	EF585534	–	EF585554	EF585567	–
Pseudofusicoccum adansoniae	WAC 12718	EF585533	–	EF585555	EF585568	–
Pseudofusicoccum stromaticum	CBS 117448	AY693974	EU673146	DQ377931	AY693975	EU673094
Pseudofusicoccum stromaticum	CBS 117449	DQ436935	EU673147	DQ377932	DQ436936	EU673093
Psiloglonium simulans	CBS 206.34	–	FJ161139	FJ161178	–	–
Pyrenophora phaeocomes	DAOM 222769	–	DQ499595	DQ499596	–	–
Saccharata capensis	CBS 122694	EU552129	–	EU552129	EU552094	–
Saccharata proteae	CBS 115206	AF452560	GU296194	DQ377882	GU349030	–
Spencermartinsia viticola	CBS 117006	AY905555	EU673166	EU673236	AY905562	EU673103
Spencermartinsia viticola	CBS 112870	AY343376	–	DQ377872	AY343337	–
Spencermartinsia viticola	CBS 117009	AY905554	EU673165	DQ377873	AY905559	EU673104
Trematosphaeria pertusa	CBS 122368	FJ201991	FJ201991	FJ201990	–	–
Trematosphaeria pertusa	CBS 122371	FJ201993	GU348999	FJ201992	–	–

Note. Abbreviations of isolates and culture collections: **AFTOL:** Assembling the Fungal Tree of Life; **ATCC:** American Type Culture Collection, Virginia, USA; **BCC:** BIOTEC Culture Collection, Bangkok, Thailand; **CAA:** A. Alves, Universidade de Aveiro, Portugal; **CBS:** Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands; **CMW:** Tree Pathology Co-operative Program, Forestry and Agricultural Biotechnology Institute, University of Pretoria, South Africa; **CPC:** Collection of Pedro Crous housed at CBS; **DAOM:** Plant Research Institute, Department of Agriculture (Mycology), Ottawa, Canada; **ICMP:** International

Collection of Micro-organisms from Plants, Landcare Research, New Zealand; **IFRDCC:** Culture Collection, International Fungal Research & Development Centre, Chinese Academy of Forestry, Kunming, China; **IMI:** International Mycological Institute, CABI-Bioscience, Egham, Bakeham Lane, U.K; **LGMF:** Culture Collection of Laboratory of Genetics of Microorganisms, Federal University of Parana, Curitiba, Brazil; **MFLUCC:** Mae Fah Luang University Culture Collection, ChiangRai, Thailand; **MUCC:** Murdoch University Algal Culture Collection, Murdoch, Western Australia; **STE-U:** Culture collection of the Department of Plant Pathology, University of Stellenbosch, South Africa; **WAC:** Department of Agriculture Western Australia Plant Pathogen Collection, South Perth, Western Australia.

4.3 Results and Discussion

4.3.1 DNA Sequencing - Combined LSU, SSU, *TEF1* and β-tubulin Gene Phylogenies

The combined 28S (LSU), 18S (SSU), elongation factor 1-α (*TEF1*) and β-tubulin gene data set consists of 126 taxa, with *Dothidea insculpta* and *D. sambuci* as the outgroup taxa. The dataset consists of 2582 characters after alignment, of which 1861 sites are included in the ML and MP analysis. Of the included bases, 946 sites (36.64%) are parsimony-informative. A heuristic search with random addition of taxa (1000 replicates) and treating gaps as missing characters generated six equally parsimonious trees. All trees were similar in topology and not significantly different (data not shown). The first of 1 000 equally most parsimonious trees is shown in Fig. 4.1. Bootstrap support (BS) values of MP and ML (equal to or above 50% based on 1,000 replicates) are shown on the upper branches. Values of the Bayesian posterior probabilities (PP) (equal to or above 90% based on 1,000 replicates) from MCMC analyses are shown under the branches.

An effort was made to use ITS sequences, but it was found not suitable to segregate the taxa at generic/species level. Therefore, ITS gene data are not included in the multi-genes analyses of this study, but deposited in GenBank as it is preferred loci for use in fungal phylogenetics.

In the phylogenetic tree (Fig. 4.1), the 114 strains of *Botyrosphaeriales* included in the analysis cluster into two major clades with 80%, 96% and 1.00 (MP, ML and BY) support, with Clade A containing the family type of *Botryosphaeriaceae*, and Clade B containing *Phyllosticta*, *Saccharata* and *Melanops* species. Clade B may represent one family and *Phyllostictaceae* Fr. (1849) could be used. In Clade A the taxa analyzed cluster in eight sub-clades named Clades A1-8. Clade A1 comprises three distinct subclusters corresponding to the genera *Diplodia* (*Diplodia* clade), *Neodeightonia* (*Neodeightonia* Clade) and *Lasiodiplodia* (*Lasiodiplodia* Clade). All genera have asexual morphs with hyaline spores which become brown at maturity. The sexual morph is only known for *Neodeightonia.* Clade A2 clusters into three groups representing *Phaeobotryosphaeria* (100%), *Phaeobotryon* (100%) and *Barriopsis* (94%). Clade A3 incorporates 17 strains that cluster into three well-supported genera *Dothiorella* (86%), *Spencermartinsia* (100%) and *Auerswaldia* (63%), while the position of the fourth genus *Macrophomina* is not stable. Clade A4 is a single lineage (100%) representing the new genus *Botryobambusa,* which is introduced below. Clade A5 is a well-supported subclade incorporating species of *Neofussicoccum* and one strain of *Dichomera* which may be a synonym. Clade A6 represents the type species of *Botryosphaeria* and three other *Botryosphaeria* species and two other genera, *Neoscytalidium* and *Cophinforma*. Clade A7 comprises two *Pseudofusicoccum* species and Clade A8 has two *Aplosporella* species.

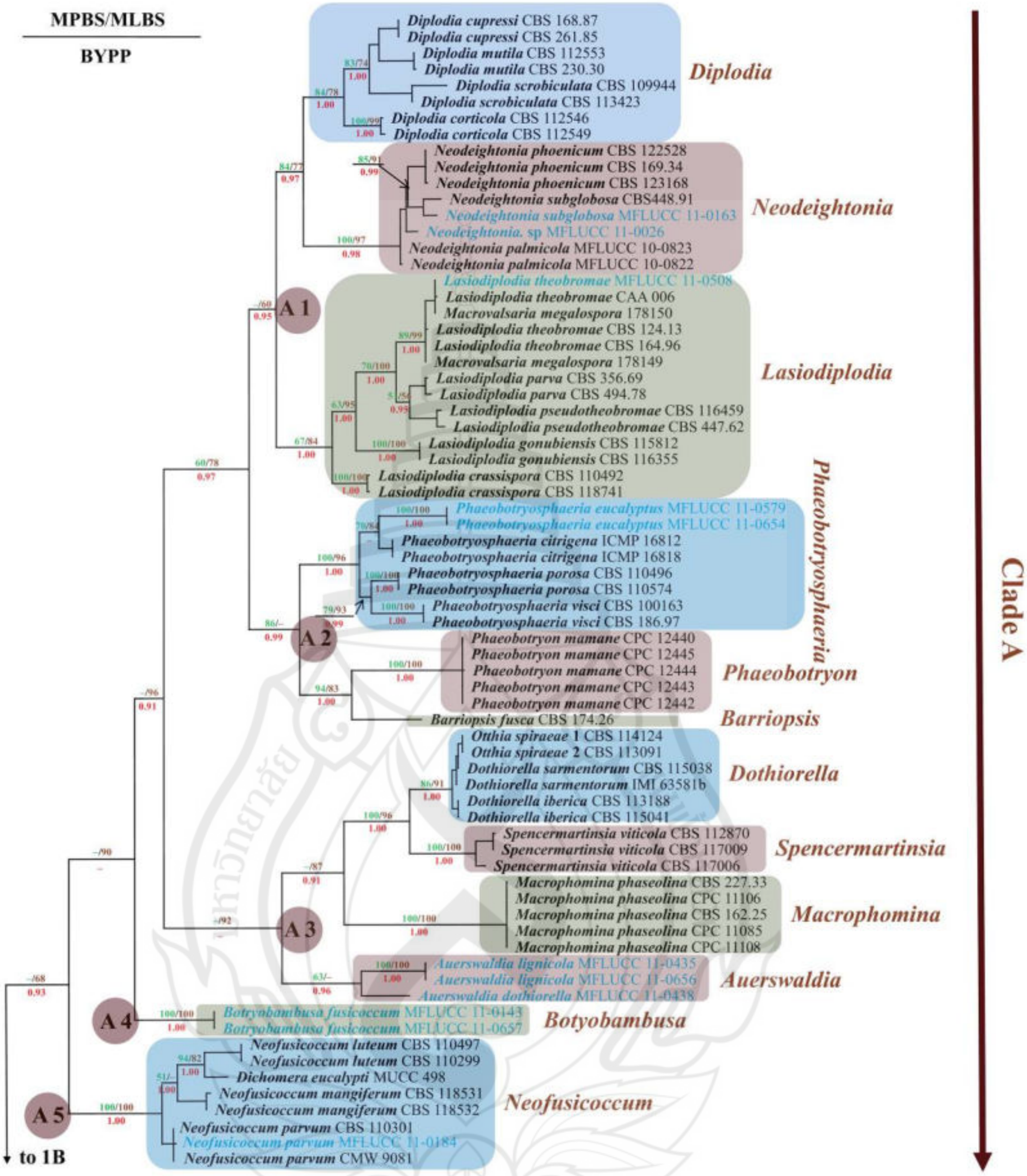
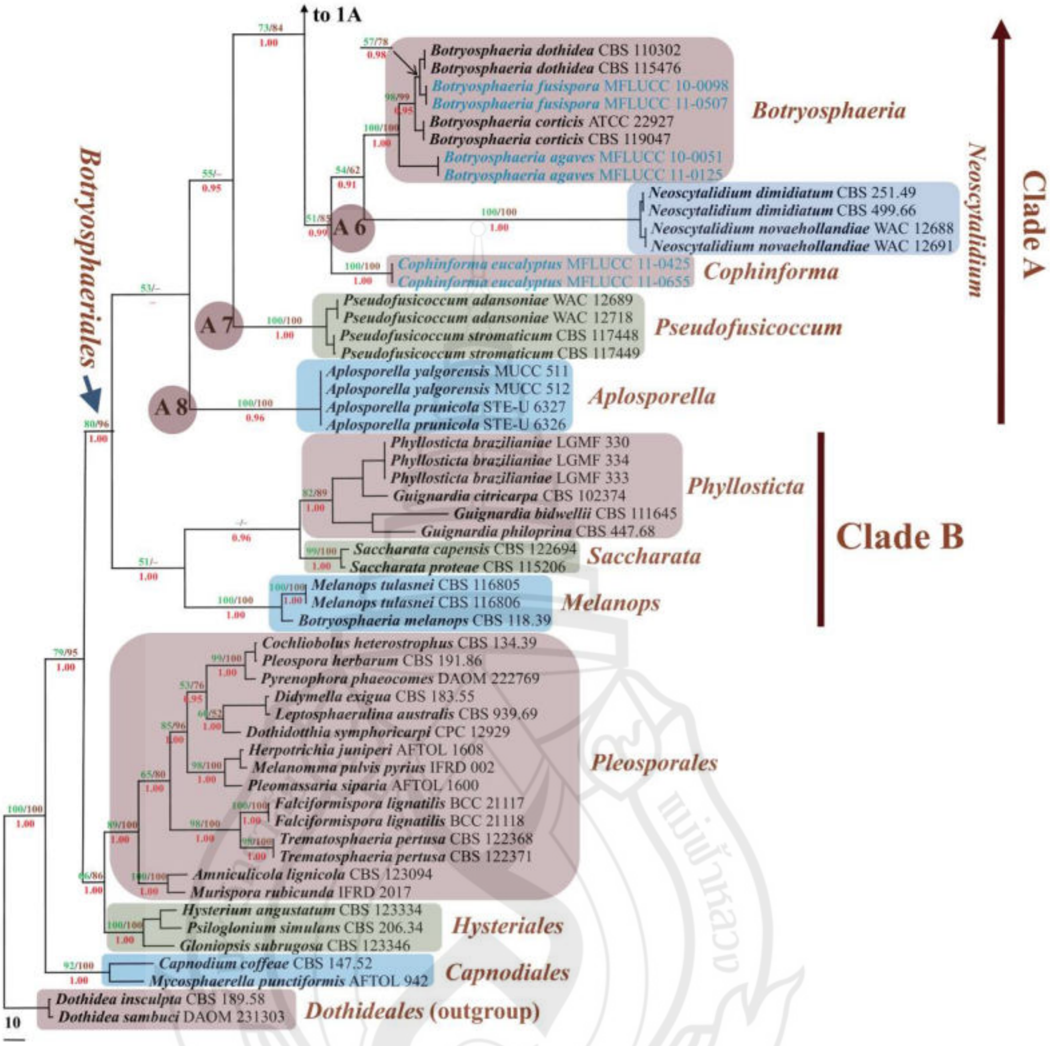


Figure 4.1 Phylogram generated from Maximum Parsimony Analysis



Note. The most parsimonious trees obtained the combined dataset of SSU, LSU EF1-α and β-tubulin sequences. Bootstrap support values for maximum parsimony (MP) and maximum likelihood (ML) greater than 50% above the nodes. The values below the nodes are Bayesian posterior probabilities above 0.95. Hyphen ("–") indicates a value lower than 50% (BS) or 0.90 (PP). The tree is rooted to *Dothidea insculpta* and *Dothidea sambuci.*

Figure 4.1 (continued)

4.3.2 Taxonomy

As a result of detailed morphological characterization and molecular analysis of taxa of *Botryosphaeriaceae*, two new genera, *Botryobambusa* and *Cophinforma* are introduced and compared with existing genera. Four species new to science are also described in existing genera *Auerswaldia lignicola*, *A. dothiorella, Botryosphaeria fusispora* and *Phaeobotryosphaeria eucalyptus*. The new taxa are differentiated by molecular phylogeny and morphology and are described and compared with similar taxa. A list of possible synonyms are given for genera and species, however this synonymy needs to be confirmed with molecular data as the order is now arranged mostly on the basis of molecular data. We also provide a list of unstudied genera and provide brief notes for these.

4.3.3 Taxonomic Treatment

Botryosphaeriales C.L. Schoch, Crous & Shoemaker

Ascostromata uni- to multiloculate, with dark brown to blackened walls, occurring singly or in clusters, often immersed, sometimes superficial or frequently embedded in stromatic tissues, or in ascostromata which form superficial cushion-like structures, exposed dry internal contents often white when cut. *Pseudoparaphyses* hyphae-like, frequently disappearing at maturity. Asci bitunicate, fissitunicate, pedicellate, clavate to cylindro-clavate. Ascospores hyaline to pigmented, septate or aseptate. *Asexual morphs* with uni to multilocular pycnidial conidiomata, frequently embedded in stromatic tissue, with hyaline, phialidic conidiogenous cells. *Conidia* hyaline to pigmented, mostly aseptate.

Botryosphaeriaceae Theiss. & P. Syd.

Ascostromata uni- to multilocular, with multi-layered walls, single or in clusters, with or without basal stroma, fully or partially erumpent at maturity, exposed dry internal contents often white when cut. *Pseudoparaphyses* hyphae-like, branched or unbranched, septate, constricted at the septum, frequently disappearing at maturity. *Asci* bitunicate, fissitunicate, with thick endotunica, short or long pedicellate, clavate to cylindro-clavate, apically rounded with an ocular chamber. *Ascospores* hyaline to brown, smooth to verrucose, thin-walled, aseptate to septate, fusoid to ellipsoid or ovoid, bi- to triseriate, with or without a mucoid sheath or rarely with appendages. *Asexual morphs* with uni to multilocular pycnidial conidiomata, frequently embedded in stromatic tissue, with hyaline, phialidic conidiogenous cells. *Conidia* hyaline to pigmented, thin to thick-walled conidia which sometimes have mucoid appendages or sheaths, striations, verrucose walls and germ slits.

Kirk et al. (2008) estimated that there are 26 genera and 1517 species in the family. Following this study we accept 29 genera (Table 4.1) and approximately 220 species (based on estimates for species in genera in Kirk et al. 2008). From our study, however we suspect that there are numerous undescribed species and several species complexes. *Macrovalsaria* Petr. and *Melanops* Nitschke ex Fuckel are newly placed in this family.

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

MycoBank: MB463

Saprobic on dead wood. *Ascostromata* black, superficial, gregarious, becoming erumpent at maturity, but still under host surface, flattened at the upper surface, globose to subglobose, with 4 to numerous locules, with individual ostioles, cells of ascostromata brown-walled *textura angularis*. *Peridium* of locules two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis. Pseudoparaphyses* not observed. *Asci* 6–8–spored, bitunicate, fissitiunicate, clavate to cylindro-clavate, with a short pedicel, apically rounded, with a small ocular chamber. *Ascospores* hyaline to brown, aseptate, oblong to ovate. *Conidiomata* pycnidial, immersed in the host tissue and becoming erumpent at maturity, globose, coriaceous, dark brown in the erumpent part. *Conidiomata wall* with brown to dark brown outer layers and hyaline to light brown inner layers, comprising several layers with cells of *textura angularis*. *Conidiophores* reduced to *conidiogenous cells*, holoblastic, discrete, hyaline, cylindrical to ellipsoidal, smooth, straight or curved, formed from cells lining the innermost later of the pycnidium. *Conidia* initially hyaline and aseptate, becoming brown at maturity, 1-septate, slightly constricted at the septa, oblong to ellipsoidal, ends rounded, with slight undulating striations on the surface, lower cell smaller.

Notes: *Auerswaldia* was established by Saccardo in 1883 with *A. chamaeropis* (Cooke) Sacc*, A. pringlei* (Peck) Sacc and *A. scabies* (Kalchbr. and Cooke) Sacc. Von Arx and Müller (1954) suggested that *Auerswaldia* differs from the similar genus *Auerswaldiella* by the number of locules (40–50) within the ascostroma and its larger brown ascospores; in *Auerswaldiella* ascostroma have only 4–6 locules and small, hyaline to light brown ascospores. In addition, the types of these two genera were found on different substrates (wood and leaves). Combined sequence analysis of our fresh collections of *Auerswaldia* shows this to be a well-supported and distinct genus in *Botryosphaeriaceae* (Fig. 4.1). There is no sequence data for *Auerswaldia* or *Auerswaldiella* in GenBank, however we treat both as distinct genera in *Botryosphaeriaceae*. Although fresh collections may show this to be incorrect. We have examined and illustrated the generic type of *Auerswaldia* although it is not in good condition. We also found two new species during collections in Thailand which are described below. One is the asexual morph which we link for the first time to *Auerswaldia.* Von Arx and Müller (1975) synonymised *Dothidea examinans* under *Bagnisiella*. I have examined the type material of *B. australis* Speg. (Fig. 4.2) which is immature, but does not appear to be *botryosphaeriaceous* based on the characters of the sunken ascostromata and cylindrical asci (Fig. 4.2). Schoch et al. (2009a) used a strain named *Bagnisiella examinans* (= *Auerswaldia examinans*) following the synonymy of von Arx and Müller (1975) in their phylogenetic tree, which placed this genus in *Botryosphaeriaceae.* However we believe that *Bagnisiella* is not the same as *Auerswaldia* and the former should be retained in *Dothideaceae* pending fresh collections.

Generic type: *Auerswaldia examinans* (Mont. & Berk.) Sacc.

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

MycoBank: MB165896 (Fig. 4.2)

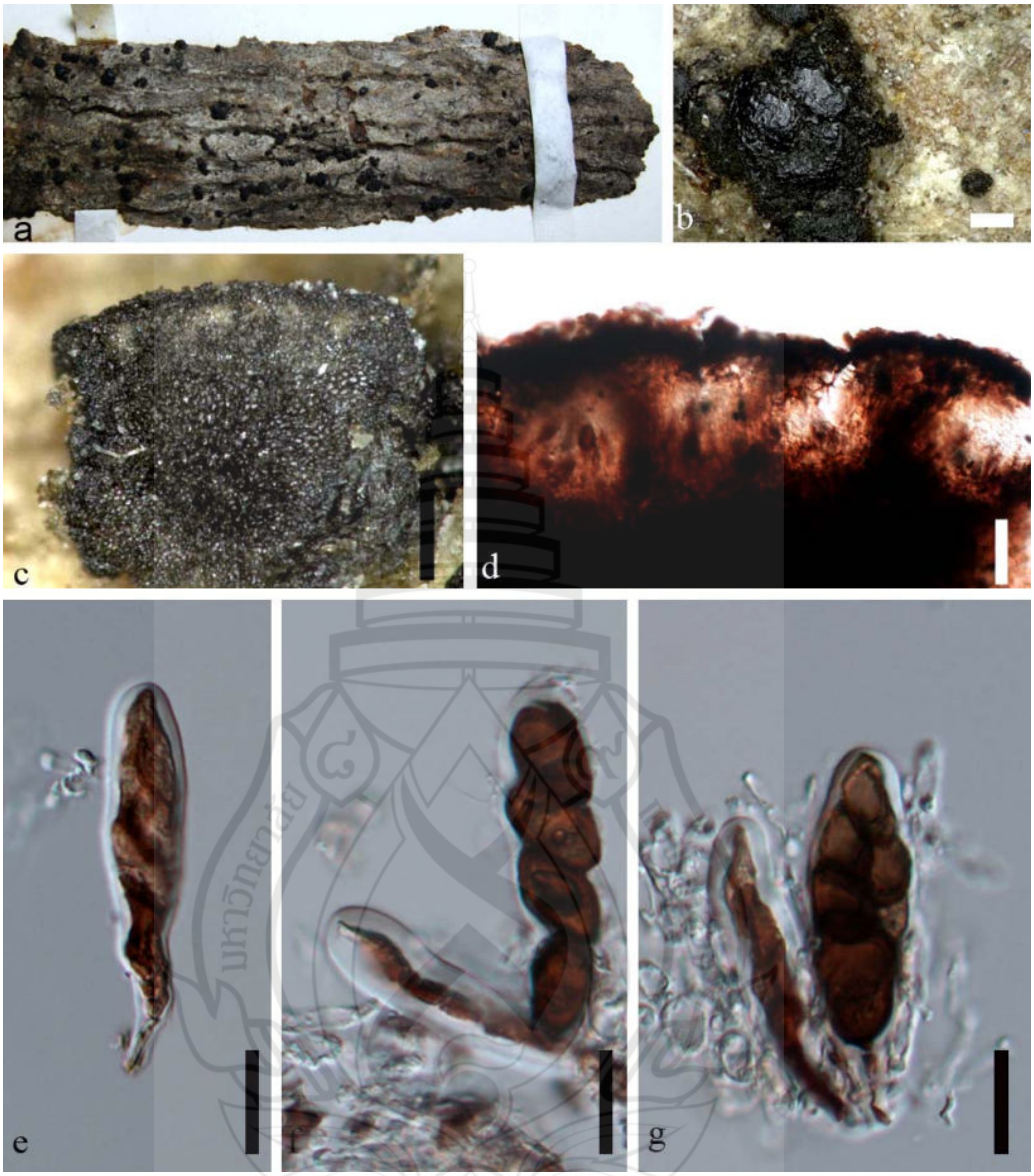
≡ *Dothidea examinans* Mont. & Berk., London J. Bot. 4:335 (1844)

≡ *Melogramma examinans* (Mont. & Berk.) Cooke, Grevillea 13(no. 68): 108 (1885)

≡ *Bagnisiella examinans* (Mont. & Berk.) Arx & E. Müll., Stud. Mycol. 9: 17 (1975)

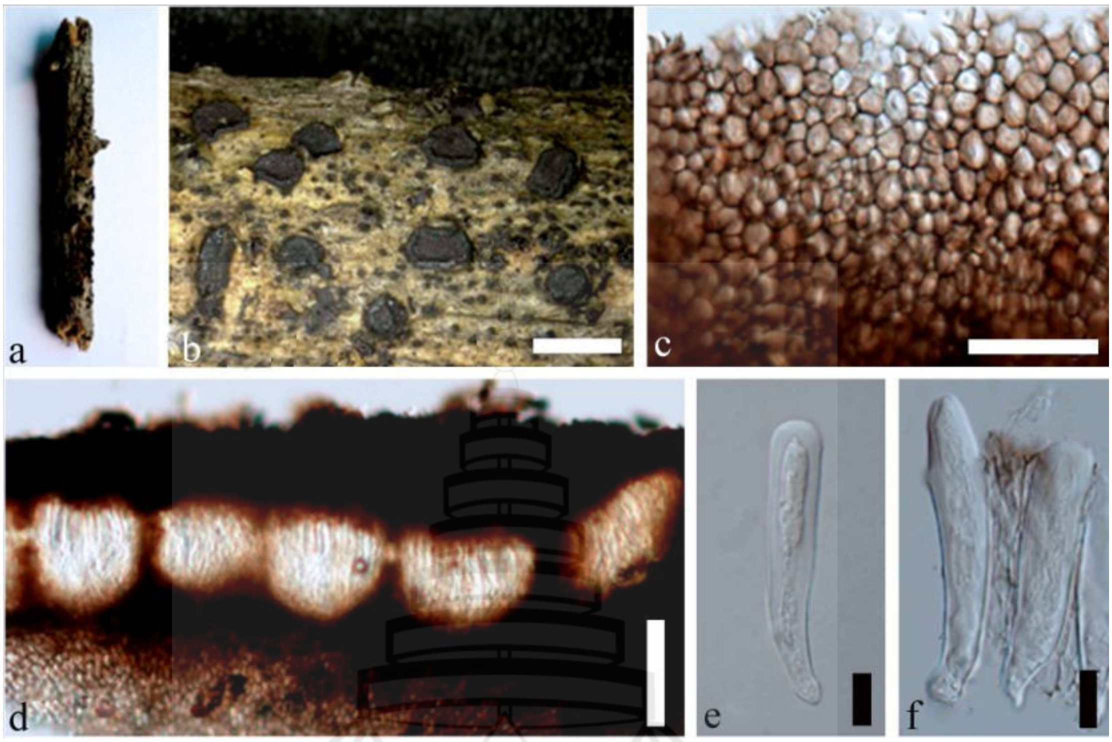
Saprobic on dead wood. *Ascostromata* 450-610 µm wide, black, gregarious, superficial, becoming erumpent, partially under the host surface, flattened at the upper surface, globose to subglobose, coriaceous, with numerous locules, with individual ostioles, cells of ascostromata brown-walled *textura angularis*. *Peridium* of locules 22–38 µm thick at the sides, two-layered, with outer layer composed of small heavily pigmented thick-walled cells *textura angularis*, with inner layer composed of hyaline thin-walled cells *textura angularis*. *Pseudoparaphyses* not observed. *Asci* 79–88 × 16–22 µm ($\bar{x}$ = 84 × 19 µm, n = 10), (4-)8–spored, bitunicate, fissitunicate, clavate to cylindro-clavate, with a short pedicel, apically rounded ,with a small ocular chamber. *Ascospores* 16–21 × 9–12 µm ($\bar{x}$ = 20 × 11 µm, n = 15), over-lapping 2–seriate, uniseriate near the base, brown, aseptate, oblong to ovate, smooth-walled. *Asexual state* not established.

Material examined: INDONESIA, Java, On decayed sticks bursting through the bark, collector Zollinger, n 520. (K 76513, type).



Note. a–c Appearance of ascostromata on the host substrate. d Vertical section through ascostroma. e–g Asci. Scale bars: b–c = 600 µm, d = 200 µm e–g = 20 µm

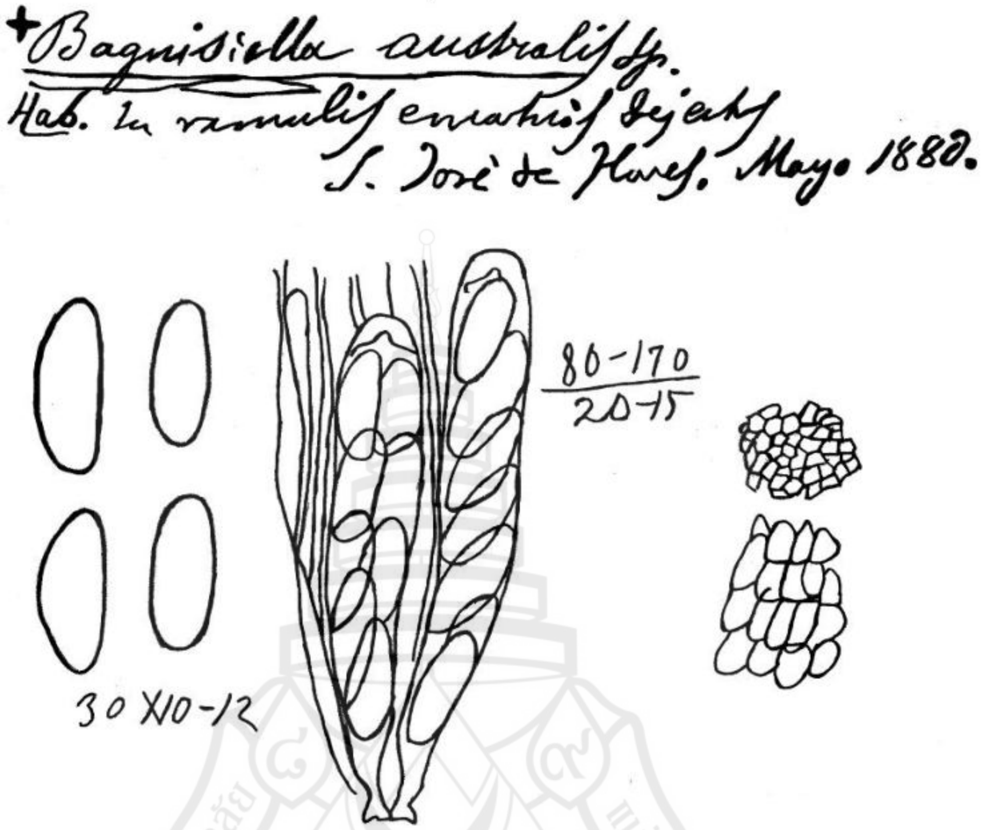
Figure 4.2 *Auerswaldia examinans* (K 76513, holotype).



Note. a Herbarium specimen. b Appearance of ascostromata on the host substrate. c Cells of ascostromata d Vertical section through ascostroma showing locules. e–f Cylindrical asci. Scale bars: b = 800 µm, c = 50 µm, d = 100 µm, e–f = 20 µm.

Figure 4.3 *Bagnisiella australis* (LPS 322, holotype)

Material examined: ARGENTINA, Buenos Aires, San José de Flores, on the branch of *Acacia bonariensis*, June 1880, C.L. Spegazzini, (LPS 322, holotype).



Note. Redrawing based on the original drawing

Figure 4.4 *Bagnisiella australis* (LPS 322, holotype)

Auerswaldia lignicola Ariyawansa, J.K. Liu & K.D. Hyde., Fungal Diversity **57**(1): 161 (2012)

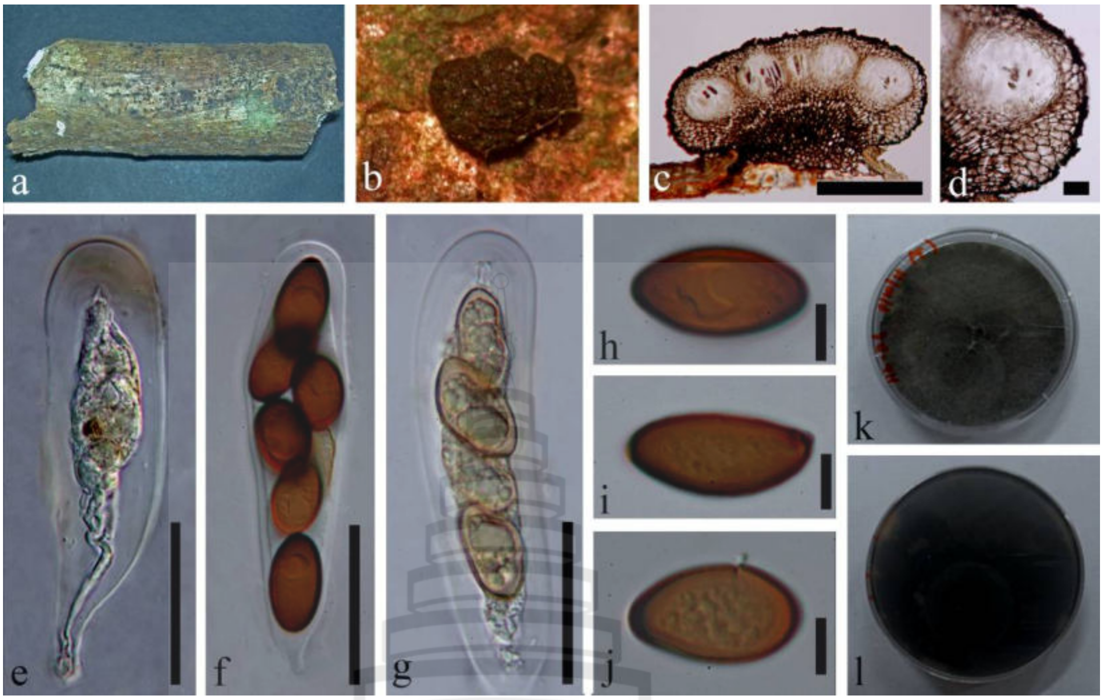
MycoBank: MB 801317 (Fig. 4.5)

Saprobic on dead wood. *Ascostromata* 0.5–0.75 mm diam, 0.75–1 mm high, dark brown to black, developing on host tissue, semi-immersed, globose to subglobose, coriaceous, multiloculate, with 4–5 locules, with individual ostioles, cells of ascostromata brown-walled *textura angularis*. *Locules* 100–130 µm diam × 110–130 µm high ($\bar{x}$ = 115 × 120 µm, n = 10), with individual papillate ostioles. *Peridium* of locules 30-60 µm diam ($\bar{x}$ = 50 µm, n = 10), thick-walled, wall composed of outer layers of thick-walled, dark brown cells of *textura angularis*, inner layers of thin-walled cells of *textura angularis*. *Pseudoparaphyses* not observed. *Asci* 80–90 × 15–25 µm ($\bar{x}$ = 85 × 20 µm, n = 20), bitunicate, fissitunicate, clavate to broadly clavate, with short and narrow pedicel, rounded at the apex with an ocular chamber. *Ascospores* 15–20 × 8–10 µm ($\bar{x}$ = 19 × 9 µm, n = 40), uniseriate or partially overlapping, reddish brown to dark brown, aseptate, fusiform to ellipsoid with narrowly rounded ends, smooth-walled. *Asexual state* not established.

Cultural characteristics: Ascospores germinating on WA within 18 h and producing germ tubes from each septum. Colonies growing slowly on MEA, reaching a diam of 3 mm after 5 d at 27°C, effuse, velvety, with entire to slightly undulate edge, dark brown to black. After 4 months, only superficial, branched, septate, smooth, brown mycelium produced, no asexual-morph produced on MEA and WA following incubation.

Material examined: THAILAND, Chiang Rai Province., Muang District, Bandu, on dead wood, 30 September 2011, A.D Ariyawansa, HA026 (MFLU 12–0750, holotype), ex-type living culture in MFLUCC11–0435; *Ibid*, living culture MFLUCC 11–0656.

Notes: The raised, pulvinate ascostromataof this taxon, isolated from wood, fit well with those of *Auerswaldia*. However, the species is distinct in producing short broad pedicellate asci with large brown ascospores. This fungus is phylogenetically most similar to *Auerswaldia dothiorella*, described below, (97% bootstrap support) based on *TEF1* gene sequence data. However, when multi-gene analyses were carried out, the species segregated into two distinct taxa. Liu et al. (2012) therefore introduced *A. lignicola* as a new species.



Note. a–b Ascostromata on host substrate. c Section of ascostromata showing 4-5 locules (TS). d Close up of peridium surrounding the locules comprising two cell layers and arrangement of cells in ascostromata. e–g Asci with 4–8 ascospores. h–j Immature and mature ascospores with smooth walls. k–l Colonies from above (k) and below (l). Scale bars: c = 350µm, d = 50µm, e–g = 30µm, h–j = 5µm. (Provided by Hiran Ariyawansha)

Figure 4.5 *Auerswaldia lignicola* (MFLU 12–0750, holotype)

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

MycoBank: MB454

Possible synonyms:

Dimeriellina Chardón, Bol. Soc. Venez. Cienc. Nat. 5(no. 40): 339 ('239') (1939)

Stichodothis Petr., Ann. Mycol. 25: 198 (1927)

Saprobic on leaves. *Ascostromata* black, solitary, scattered, superficial on lower side, globose, rough, papillate, pulvinate, multiloculate, cells of ascostromata brown-walled *textura angularis*. *Peridium* of locules two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, numerous, septate. *Asci* 8–spored, bitunicate, fissitunicate, cylindro-clavate, with a pedicel and an ocular chamber. *Ascospores* biseriate, hyaline to light brown, obovoid to ellipsoidal with rounded ends, smooth–walled. *Asexual state* not established.

Notes: *Auerswaldiella* presently comprises nine epithets (*Index Fungorum*) with the latest species being introduced by Farr (1989). This unusual genus forms raised ascostromata on the surface of leaves comprising four to six locules with densely packed asci and unicellular hyaline to light brown ascospores. The asci are typical of *Botryosphaeriaceae*, however, the raised, pulvinate ascostromata on leaves and large numbers of pseudoparaphyses are atypical; the minute ascospores also differentiate this from other genera in *Botryosphaeriaceae*.

Generic type: *Auerswaldiella puccinioides* (Speg.) Theiss. & Syd.

Auerswaldiella puccinioides (Speg.) Theiss. & Syd., Ann. Mycol. 12: 278 (1914)

MycoBank: MB155192 (Fig. 4.6)

≡ *Auerswaldia puccinioides* Speg., Anales Soc. Ci. Argent. 19: 247 (1885)

= *Phyllachora viridispora* Cooke, Grevillea. 13(no. 67): 65 (1885)

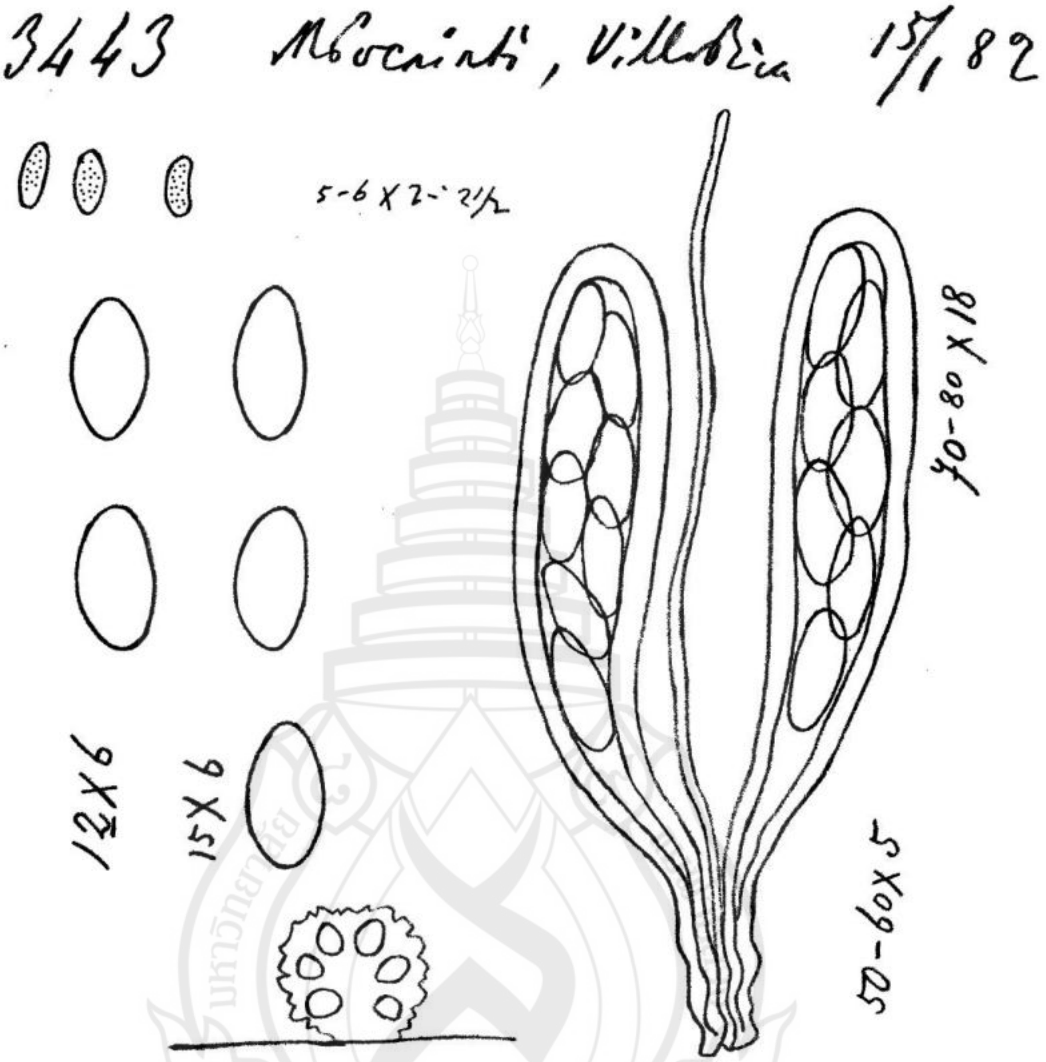
= *Dothidea viridispora* (Cooke) Berl. & Voglino, in Sacc., Syll. Fung. Addit. I-IV: 243 (1886)

= *Bagnisiella pruni* Henn., Hedwigia. 48: 6 (1908)

Saprobic on lower surface of leaves. *Ascostromata* 0.8–0.9 mm diam, 0.4–0.5 mm high, black, raised on host tissue, solitary, scattered, superficial, pulvinate, globose, rough, multiloculate, containing 4–6 locules, with individual papillate ostioles, cells of ascostromata brown-walled *textura angularis*. *Locules* 320–370 × 450–500 μm. *Peridium* of locules two-layered, up to 30–40 μm wide, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, septate, numerous. *Asci* 138–185 × 32–36 µm ($\bar{x}$ = 164× 35 µm, n = 15), 8–spored, bitunicate, fissitunicate, cylindro–clavate, with a long pedicel and wide shallow ocular chamber. *Ascospores* 9–12 × 3–6 µm ($\bar{x}$ = 11×5 µm, n = 30), biseriate, hyaline to light brown, obovoid to ellipsoidal, flattened in one plane, with rounded ends, smooth–walled. *Asexual state* not established.

Material examined: PARAGUAY, Villa Rica; Mbocaiaté, on leaves of *Prunus sclerocarpa*, 15 January 1882, B. Balansa No 3443 (LPS 281, holotype)

Notes: The type specimen examined is relatively immature and it was very hard to find asci and ascospores. This is a very distinctive fungus and should be recollected and epitypified. The smaller spores were not observed on the type specimen.



Note. Redrawing from the original type species drawing

Figure 4.6 *Auerswaldiella puccinioides* (LPS 281, holotype)

Barriopsis A.J.L. Phillips, A. Alves & Crous, Persoonia 21: 39 (2008)

MycoBank: MB511712

Saprobic on dead twigs. *Ascostromata* brown to black, immersed, aggregated or in clusters, scattered, erumpent at maturity, discoid to pulvinate or hemisphaerical, discrete, multiloculate. *Ostiole* central. *Pseudoparaphyses* hyphae-like, septate, embedded in gelatinous matrix. *Asci* 8–spored, bitunicate, clavate to sub-clavate, short stalked. *Ascospores* biseriate, brown to dark brown, aseptate, ellipsoid-oval, inequilateral, slightly curved, widest in the median to supramedian, smooth or verrucose, without sheath. *Asexual state* is *Lasiodiplodia*-like: *Conidiomata* stromatic, pycnidial, superficial, dark brown to black, multilocular, individual or aggregated, thick-walled, ostiolate. *Ostiole* central, circular, non-papillate. *Paraphyses* hyaline, thin-walled, usually aseptate, constricted at the septa, occasionally branched. *Conidiogenous cells* holoblastic, hyaline, thin-walled, cylindrical, with visible periclinal thickening. *Conidia* initially hyaline, oval, both ends broadly rounded, thick-walled, aseptate with longitudinal striations, striations visible on hyaline conidia even while attached to *conidiogenous cells*, becoming brown, aseptate or 1–3–septate, with prominent longitudinal striations (asexual morph description follows Stevens 1926; Abdollahzadeh et al., 2009).

Notes: *Barriopsis* was introduced as a monotypic genus by Phillips et al. (2008) based on *Physalospora fusca,* and a second species, *Barriopsis iraniana* Abdoll., Zare & A.J.L. Phillips, was added by Abdollahzadeh et al. (2009). *Barriopsis* accommodates species having brown, aseptate ascospores, which are lighter in the centre, without apiculi and with a *Lasiodiplodia*-like asexual morph (conidia initially hyaline, aseptate and thick-walled becoming dark brown and septate with irregular longitudinal striations, (20-)23–25(–28) × (11-)12–13(–16) µm) (Stevens 1926). It is listed as a member of *Dothidotthiaceae* in *Index Fungorum*, but Lumbsch and Huhndorf (2010) treated it as a member of *Botryosphaeriaceae*. Phillips et al. (2008) used phylogenetic data to confirm its identity as a member of the *Botryosphaeriaceae*. This is confirmed in the phylogenetic tree (Fig. 4.1).

Generic type: *Barriopsis fusca* (N.E. Stevens) A.J.L. Phillips, A. Alves & Crous.

Barriopsis fusca (N.E. Stevens) A.J.L. Phillips, A. Alves & Crous, Persoonia 21: 39 (2008)

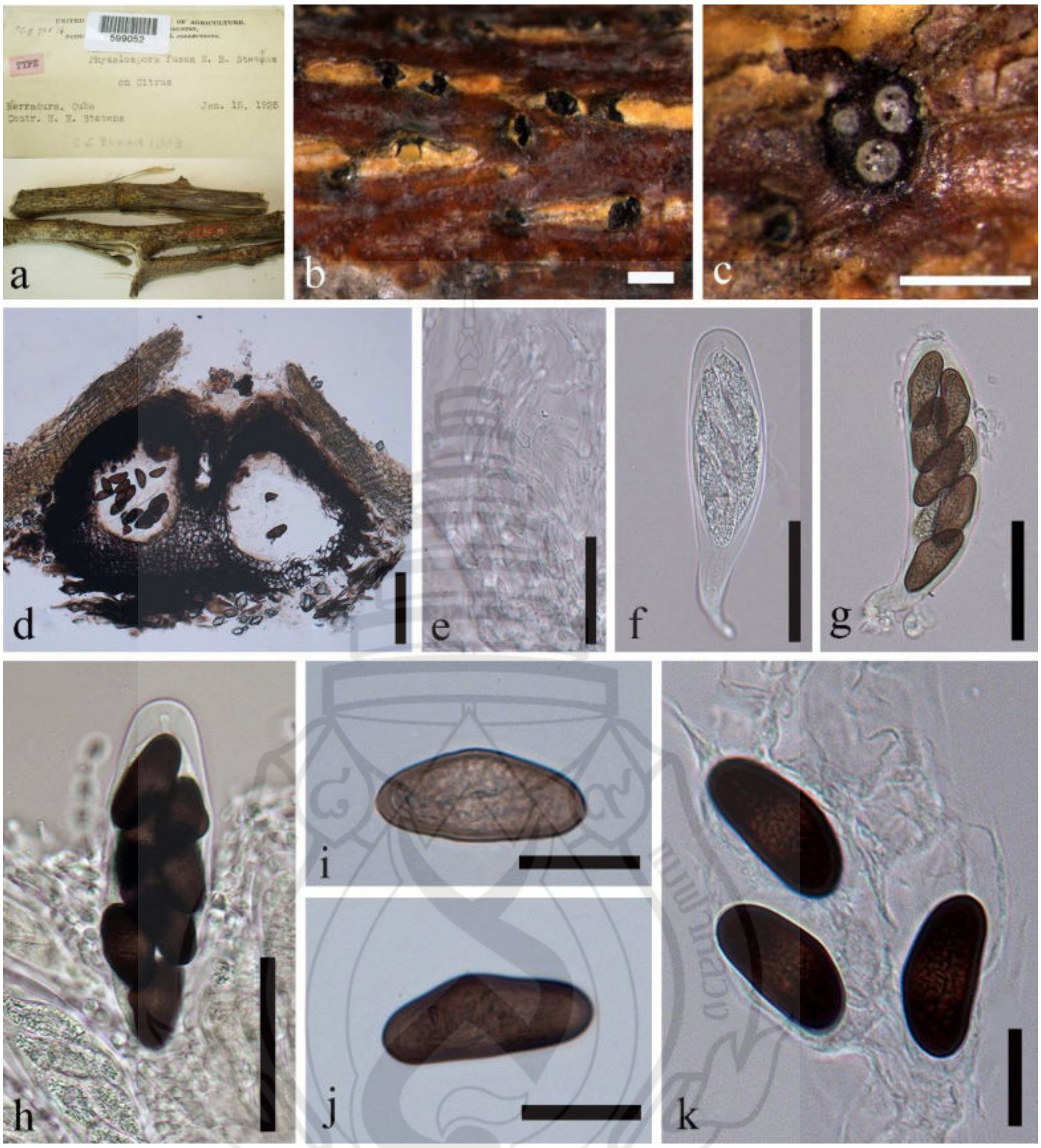
MycoBank: MB511713 (Fig. 4.7)

≡ *Physalospora fusca* N.E. Stevens, Mycologia 18: 210 (1926)

= *Phaeobotryosphaeria fusca* (N.E. Stevens) Petr., Sydowia 6: 317 (1952)

Saprobic on dead twigs. *Ascostromata* (430-)546.5–520 µm diam × 328–349 µm high ($\bar{x}$ = 520 × 338 µm), black, immersed, aggregated or some clustered, scattered, composed of one or up to three ascomata in each ascostroma, developing in the substrate and erumpent through the bark at maturity, discoid to pulvinate or hemisphaerical, discrete or wide-spreading with surface slightly convex, with thickened peridium. *Pseudoparaphyses* (3-)4–4.5 µm wide, hyphae-like, septate, embedded in a gelatinous matrix. *Asci* (109-)124–154.5(-166) × 32–39(-41) µm ($\bar{x}$= 139 × 36 µm), 8–spored, bitunicate, fissitunicate, clavate to sub-clavate, broad, with a short pedicel and apically rounded with an ocular chamber. *Ascospores* (29.5-)31–34 × (13-)15–15.5 µm ($\bar{x}$= 31.5 × 15 µm), biseriate, brown to dark brown, aseptate, ellipsoid-oval, inequilateral, slightly curved, widest in the median to supramedian, ends rounded, light brown in the centre, smooth or verrucose, without a gelatinous sheath. *Conidiomata* stromatic, pycnidial, dark brown to black, superficial, mostly multilocular, individual or aggregated, thick-walled, ostiolate. *Ostiole* central, circular, non-papillate. *Paraphyses* hyaline, usually aseptate, sometimes becoming up to 2–3–septate, not constricted at the septa, thin-walled, tip rounded, occasionally branched. *Conidiogenous cells* 7–12 × 3–5 µm, holoblastic, hyaline, cylindrical, thin-walled, smooth, proliferating at the same level, with visible periclinal thickening. *Conidia* (20-)23–25(-28) × (11-)12–13(-16) µm, initially hyaline, aseptate and thick-walled becoming dark brown and septate with irregular longitudinal striations (asexual morph description follows Stevens 1926; Abdollahzadeh et al., 2009).

Material examined: CUBA, Herradura, on twigs of *Citrus* sp., 15 January 1925, N. E. Stevens (BPI599052, holotype).



Note. a Herbarium material. b–c Ascostromata forming beneath the bark of substrate, note the cross section in surface view in c. d Section through erumpent ascostromata and peridium. e Pseudoparaphyses. f–h Ascus with ocular chamber at apex and containing young and mature ascospores. i–k Immature and mature ascospores. Scale bars: b–c = 500 µm, d = 100 µm, e = 20 µm, f–h = 50 µm, i–k = 20 µm.

Figure 4.7 *Barriopsis fusca* (BPI 599052, holotype)

Notes: The asexual morph was not observed in the type and the ex-type culture which was isolated more than 80 years ago and has lost its ability to sporulate. The second species *Barriopsis iraniana* was introduced with only an asexual morph as no sexual stage was formed in culture. The morphological characters (the conidia are striate at an early stage of development and the striations are clearly visible in young, hyaline conidia) confirmed that the asexual morph of *Barriopsis* is linked to a *Lasiodiplodia*-like morph. *Barriopsis fusca* differs from *B. iraniana* by its distinctly smaller conidia (23–25 × 12–13 µm vs. 24–30 × 14–18 µm) (Abdollahzadeh et al., 2009; Stevens 1926).

Botryobambusa R. Phookamsak, J.K. Liu & K.D. Hyde., Fungal Diversity 57: 166 (2012)

MycoBank: MB 801313

Saprobic on dead bamboo. *Ascostromata* dark brown to black, immersed under epidermis to erumpent, gregarious, visible as minute black dots or papilla on the host tissue, multiloculate, locules individual globose to subglobose or fused, coriaceous, vertical to the host surface, with a central ostiole. *Neck* central, papillate, periphysate. *Asci* 8–spored, bitunicate, fissitunicate, clavate to cylindro-clavate, pedicellate, with well-developed ocular chamber. *Ascospores* hyaline, velvety, aseptate, ellipsoidal to obovoid, smooth and thick-walled, surrounded by a mucilaginous sheath. *Pycnidia* developing in stromatic clusters, fused, multiloculate, individually globose to subglobose. *Peridium* comprising several layers of *textura angularis*, broader at the base, outer layers dark to dark-brown and thick-walled, inner layers hyaline and thin-walled. *Conidiogenous cells* holoblastic, hyaline, cylindrical to ellipsoidal, smooth. *Conidia* hyaline, aseptate, cylindrical to cylindro-clavate, thin-walled.

Notes: *Botryobambusa* is introduced as a monotypic genus for *B. fusicoccum* (Liu et al., 2012) which is characterized by multiloculate *ascostromata*, clavate, short pedicellate, fissitunicate asci and velvety, thick-walled, hyaline, aseptate, sheathed ascospores. It is so far only known from bamboo. The ascomata are tightly clustered under the bamboo host surface and can be considered as ascostromatic in a broad sense. This is obvious in culture where the pycnidia are clearly stromatic. The genus can be distinguished from the closely similar *Botryosphaeria* by its smaller asci, aseptate, velvety, hyaline, sheathed ascospores and *Fusicoccum*-like asexual stage with large conidia. Phylogenetically, these two genera are markedly distinguished.

Generic type: *Botryobambusa fusicoccum* R. Phookamsak, J.K. Liu & K.D. Hyde

Botryosphaeria Ces. & De Not., Comm. Soc. Crittog. Ital. 1: 211 (1863)

Mycobank: MB635

Possible synonyms

Amerodothis Theiss. & Syd., Ann. Mycol. 13: 295 (1915)

Apomella Syd., Ann. Mycol. 35: 47 (1937)

Caumadothis Petr., Sydowia 24): 276 (1971) [1970]

Coutinia J.V. Almeida & Sousa da Câmara, Revta agron., Lisb. 1: 392 (1903)

Creomelanops Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 129: 146 (1920)

Cryptosphaeria Ces. & De Not., Comm. Soc. Crittog. Ital. 1(4): 231 (1863)

Cryptosporina Höhn., Öst. Bot. Z. 55: 54 (1905)

Desmotascus F. Stevens, Bot. Gaz. 68: 476 (1919)

Epiphyma Theiss., Verh. Zool.-bot. Ges. Wien 66: 306 (1916)

Fusicoccum Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 2: 111 (1829)

Rostrosphaeria Tehon & E.Y. Daniels, Mycologia 19: 112 (1927)

Thuemenia Rehm, in Thümen, Mycoth. Univ., cent.: no. 971 (in sched.) (1878)

Hemibiotrophic or *saprobic* on leaves and wood. *Ascostromata* 300–500 mm diam., often erumpent through the bark, comprising a botryose aggregate, sometimes solitary, globose, brown to black, individual locules, with a central ostiole, papillate or not, cells of ascostromata having dark brown walls and arranged in a *textura angularis*. *Peridium* of locules two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, wide, septate. *Asci* 8–spored, bitunicate, fissitunicate, clavate, short pedicellate, apically rounded with a small ocular chamber. *Ascospores* biseriate, hyaline, aseptate, fusoid to ovoid, often with tapered ends, smooth-walled, with granular contents, with or without a mucilaginous sheath. *Conidiomata* pycnidial in nature. *Conidiogenous cells* holoblastic, hyaline, subcylindrical, proliferating percurrently with 1–2 proliferations and periclinical thickening. *Conidia* hyaline, aseptate, narrowly fusiform, or irregularly fusiform, base subtruncate to bluntly rounded, rarely forming a septum before germination, smooth with granular contents (asexual morph description follows Slippers et al., 2004b).

Notes: As the type of *Botryosphaeriaceae*, *Botryosphaeria* was introduced with type species *B. dothidea* by Cesati and De Notaris (1863). In the original description, Mougeot (in Fries 1823, as *Sphaeria dothidea*), did not designate any type specimen but the collection from fallen branches of *Fraxinus* sp was listed in the reference. However, the only material under this name available in the Fries herbarium was described from *Rosa* sp. As no type material existed, Slippers et al. (2004b) designated a neotype for the remaining *S. dothidea* sample from the Fries collection. The material, however, was immature as noted by von Arx and Müller (1954), and thus does not bear characteristics that would make it possible to clearly define the name. In order to stabilize the name, Slippers et al. (2004b) epitypified the type species *Botryosphaeria dothidea* based on morphology and phylogeny (combined multi-gene, ITS, *TEF1* and β-tubulin). Numerous species have been described in the genus *Botryosphaeria*, but later transferred to other genera (Crous et al., 2004, 2006; Phillips & Pennycook, 2004; Phillips et al., 2005, 2008; Phillips & Alves, 2009**)**. Crous et al. (2006) restricted the use of *Botryosphaeria* to *B. dothidea* and *B. corticis*. In our phylogenetic trees, two additional species, namely *B. agaves* (which we have epitypified) and *B. fusispora* clustered in this clade. The asexual morphs of *Botryosphaeria* were reported as *Dichomera*, *Diplodia*, and *Fusicoccum* (Crous & Palm, 1999; Slippers et al., 2004b; Crous et al., 2006).

Generic type: *Botryosphaeria dothidea* (Moug. : Fr.) Ces. & De Not.

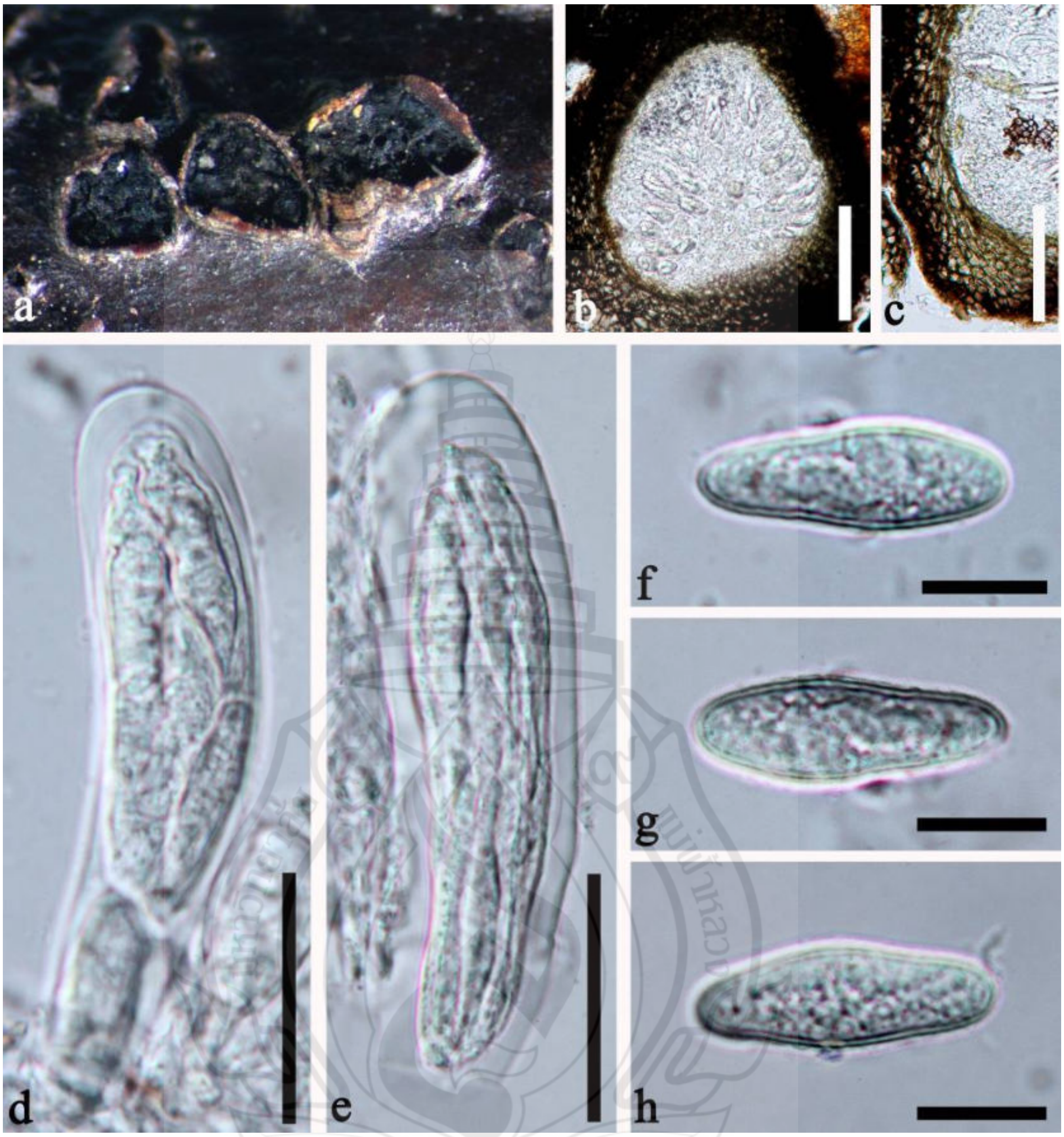
Botryosphaeria dothidea (Moug. : Fr.) Ces. & De Not., Comment Soc. crittog. Ital. 1:212 (1863).

MycoBank: MB183247 (Fig. 4.8)

= *Fusicoccum aesculi* Corda in Sturm, Deutschl. Fl., Abth. 3, 2:111 (1829)

Hemibiotrophic or *saprobic* on leaves and wood. *Ascostromata* erumpent through the bark, 300–500 mm diam., comprising a botryose aggregate, sometimes solitary, globose, brown to black, individual locules, with a central ostiole, papillate or not. *Peridium* of locules two-layered, outer layer composed of dark brown or brown thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis* lining the locule. *Pseudoparaphyses* 2–4 µm wide, hyphae-like, septate. *Asci* 63–125 × 16–20 µm, 8–spored, bitunicate, fissitunicate, clavate, short pedicellate, apically rounded with a small ocular chamber. *Ascospores* 20–25 ×7–9 µm, biseriate, hyaline, aseptate, fusoid to ovoid, sometimes with tapered ends giving a spindle shaped appearance, smooth with granular contents. *Conidiomata* pycnidial in nature. *Conidiogenous cells* 6–20 × 2–5 µm, holoblastic, hyaline, subcylindrical, proliferating percurrently with 1–2 proliferations and periclinical thickening. *Conidia* (17-)18–20(-22) × 4–5 µm ($\bar{x}$ = 19.5 × 4.8 µm, n = 35), hyaline, aseptate, narrowly fusiform, or irregularly fusiform, base subtruncate to bluntly rounded, rarely forming a septum before germination, smooth with granular contents (asexual morph description follows Slippers et al., 2004b).

Material examined: SWITZERLAND, Ticino, Crocifisso, *Prunus* sp., October 2000, B. Slippers (PREM57372, epitype)



Note. a Ascostromata on host substrate b Section through ascostromata. c Peridium. d–e Asci. f–h Ascospores. Scale Bars: b–c = 100 µm, d–e = 30 µm, f–h = 10 µm.

Figure 4.8 *Botryosphaeria dothidea* (PREM57372, epitype)

Botryosphaeria fusispora Boonmee, J.K. Liu & K.D. Hyde., Fungal Diversity 57: 171 (2012)

MycoBank: MB 801319 (Figs. 4.9, 4.10)

Hemibiotrophic or *saprobic* on leaves and wood. *Ascostromata* 137.5–210 µm high × 160–230 µm diam, dark-brown to black, immersed under epidermis in host tissue, becoming erumpent, clustered, gregarious, or scattered, coriaceous, subglobose, with indistinct ostiole. *Peridium* up to 22.5–37.5 µm thick, comprising 3–4 (-5) layers of dark brown cells of *textura angularis*. *Pseudoparaphyses* 2.5–5 µm wide, hyphae-like, aseptate, dense, embedded in a gelatinous matrix. *Asci* 77.5–112.5 × 20–25 µm ($\bar{x}$= 99.5 × 22 µm), 8–spored, bitunicate, fissitunicate, broadly cylindrical, ellipsoidal, short-pedicellate, apically rounded with an ocular chamber, up to 1 µm wide at the thickened gelatinous apex. *Ascospores* 20–27.5 × 10–12.5 µm ($\bar{x}$ = 24.6 × 11.5 µm), biseriate, partially overlapping, hyaline, aseptate, ellipsoidal to fusiform, smooth-walled. *Conidiomata* 140–180 × 160–210 µm. ($\bar{x}$= 165 × 180 µm), pycnidia, solitary, semi-immersed to immersed, dark brown to black walls, composed of thick–walled dark brown cells of *textura angularis*, becoming hyaline towards the inner region. *Conidiophores* 2–4.5µm wide ($\bar{x}$= 3 µm), hyaline, septate, cylindrical, smooth. *Conidiogenous cells* holoblastic, hyaline, cylindrical, integrated, proliferating, producing a single apical conidium. *Conidia* 16–22 × 4–5.5µm wide ($\bar{x}$= 20 × 5 µm, n = 20), hyaline, aseptate, fusiform to ellipsoidal, sometimes irregular ellipsoidal, smooth, apex obtuse, base subtruncate or bluntly round, granular.

Culture characters: Ascospores germinating from one or both ends. Colonies on MEA growing rapidly, reaching 9 cm diam in a week, at room temperature. Aerial mycelium at first white and later becoming dark-grey to black, and no sporulating structures were produced in cultures within 3 months.

Material examined: THAILAND, Chiang Rai, Doi Tung, on dried bark of *Entada* sp., 10 June 2009, Saranyaphat Boonmee (MFLU 10–0028, holotype), ex-type culture MFLUCC 10–0098; Chiang Mai, Chiang Mai University, on dead leaves of *Caryota* sp., 15 April 2010, Ratchadawan Cheewangkoon, JKC009, living culture MFLUCC 11–0507.

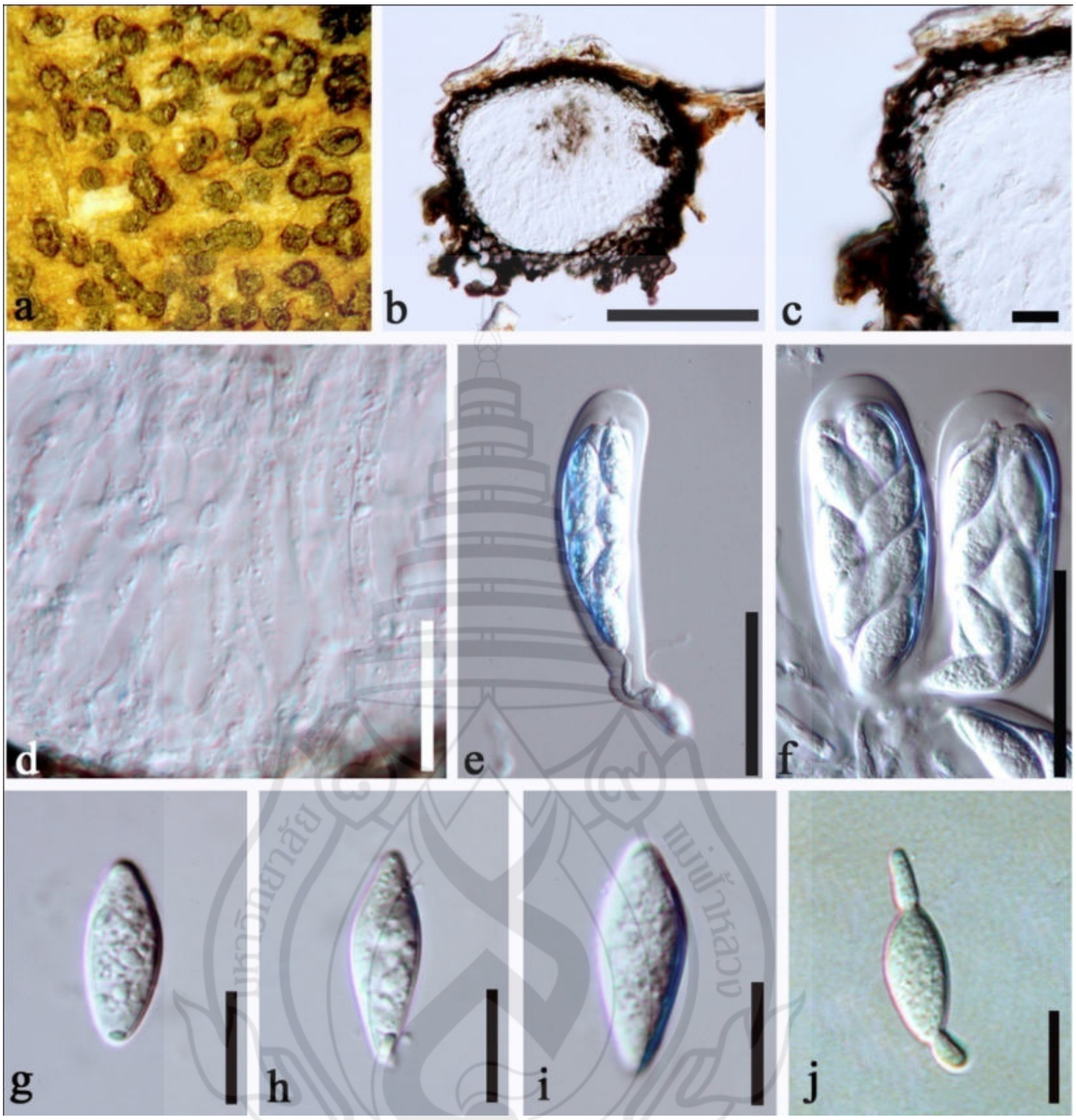
Notes: *Botryosphaeria fusispora* was found on dried bark of *Entada* sp. It is characterised by clusters or gregarious ascostromata, scattered, darkbrown to black, immersed under epidermis and erumpent at maturity on the bark of the host substrate. The ascospores are aseptate, ellipsoid to fusiform, hyaline and smooth and lacking sheaths. The asexual stage was also founded on palms and is “Fusicoccum”-like. This species phylogenetically belongs to *Botryosphaeria sensu stricto* (Crous et al., 2006). *Botryosphaeria fusispora* was introduced based on morphology and phylogeny (Liu et al., 2012). The combined gene sets (LSU, SSU, *TEF1* and β-tubulin and *TEF1* and β-tubulin) indicate this species is a typical *Botryosphaeria* with strong bootstrap support values (Fig. 4.1).

Cophinforma Doilom, J.K. Liu & K.D. Hyde., Fungal Diversity 57: 174 (2012)

MycoBank: MB 801315

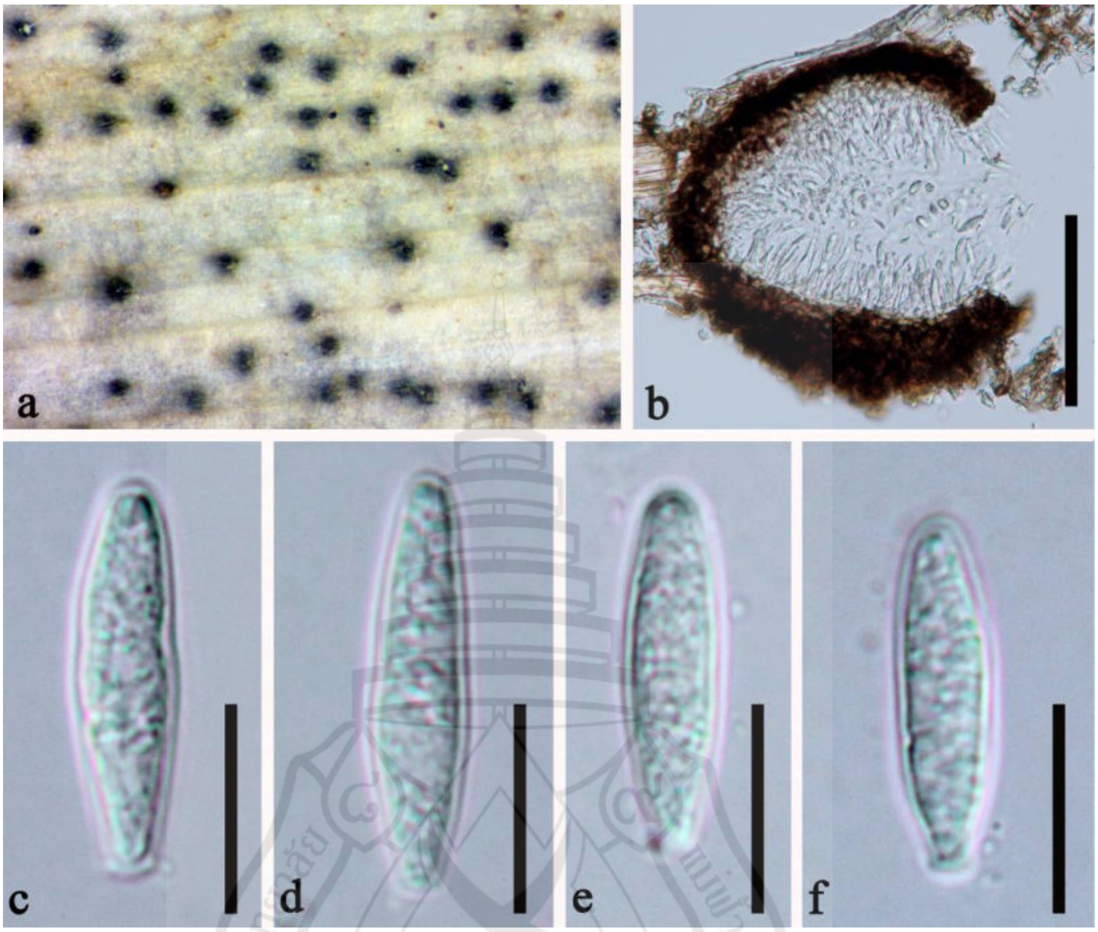
Saprobic on recently fallen wood. *Ascostromata* initially immersed under host epidermis, becoming semi-immersed to erumpent, breaking through cracks in bark, gregarious and fused, uniloculate, globose to subglobose, membraneous, visible white contents distinct when cut, ostiolate. *Ostiole* central, papillate, pale brown, relatively broad, periphysate. *Peridium* broader at the base, comprising several layers of relatively thick-walled, dark brown to black-walled cells, arranged in a *textura angularis*. *Pseudoparaphyses* hyphae-like, numerous, embedded in a gelatinous matrix. *Asci* 8–spored, bitunicate, fissitunicate, clavate to cylindro-clavate, pedicellate, apex rounded with an ocular chamber. *Ascospores* overlapping, uniseriate to biseriate, hyaline, aseptate, ellipsoidal to obovoid, slightly wide above the centre, smooth-walled. *Asexual state* not established.

Notes: We introduce this new genus based mainly on the molecular phylogeny, which shows that this is a distinct genus. The most similar genus is *Botryosphaeria*. *Cophinforma* has morphologically unique ascospores which are hyaline and aseptate.



Note. a Ascostromata on the tissue. b Section through ascostromata. c Peridium. d Pseudoparaphyses. e–f Asci with 8-spores and short stalk. g–i Ascospores. j Germinating ascospore. Scale bars: b = 100 μm, c = 20 μm, d–f = 40 μm, g–j = 10 μm.

Figure 4.9 *Botryosphaeria fusispora* (MFLU 10–0028, holotype)



Note. a Conidiomata on dead leaves of *Caryota* sp. b Section through conidioma. c–f Conidia. Scale bars: b = 100 µm, c–f = 10 µm

Figure 4.10 Asexual morph of *Botryosphaeria fusispora*

Generic type: *Cophinforma eucalypti* Doilom, J.K. Liu & K.D. Hyde.

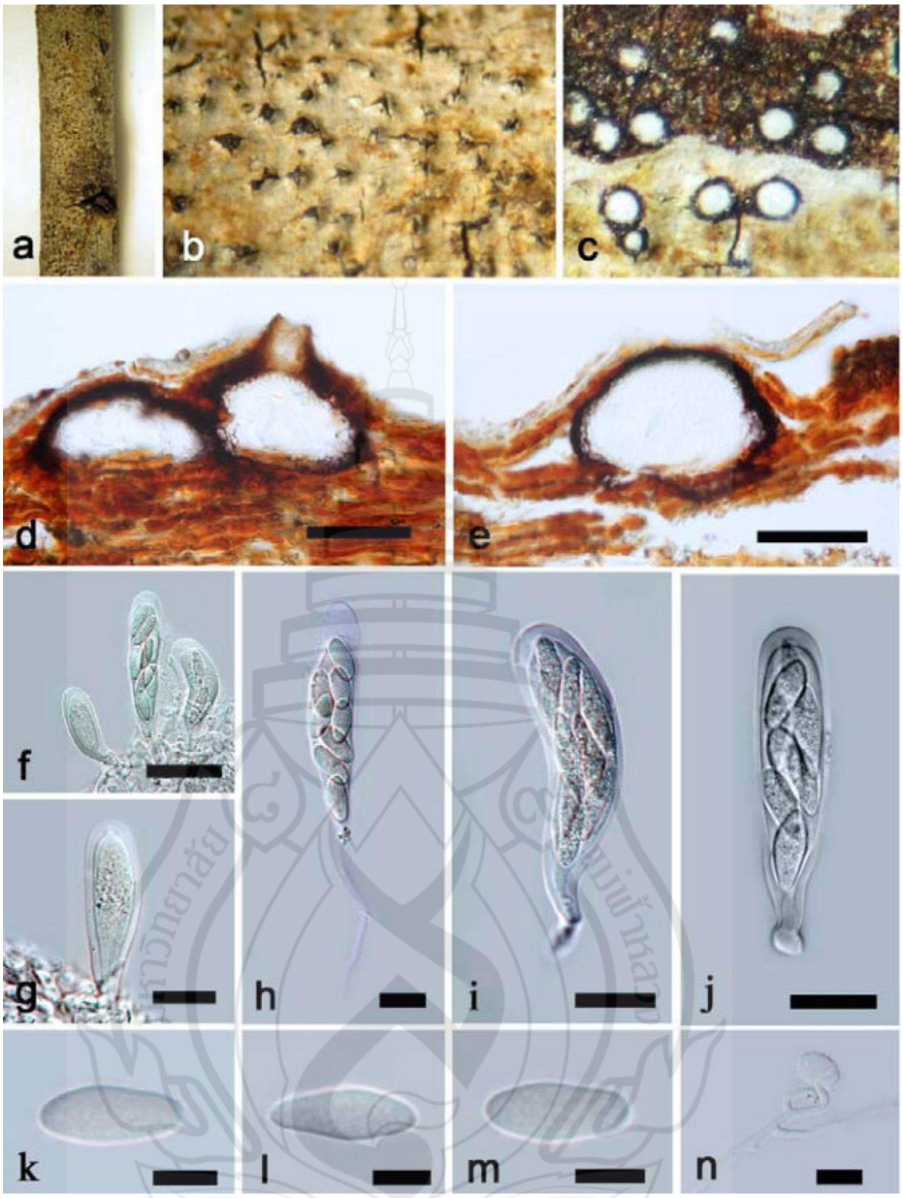
Cophinforma eucalypti Doilom, J.K. Liu & K.D. Hyde., Fungal Diversity 57: 174 (2012)

MycoBank: MB 801316 (Fig. 4.11)

Saprobic on recently fallen wood. *Ascostromata* (88-)112–125(-130) µm high × (135-)172–185(-195) µm wide ($\bar{x}$ = 112 × 165 µm, n = 10), initially immersed under host epidermis, becoming semi-immersed to erumpent, breaking through cracks in bark, gregarious and fused, uniloculate, globose to subglobose, membraneous, visible white contents distinct when cut, ostiolate. Ostiole (33-)43–52 µm high, (31-)40–48 µm wide, central, papillate, pale brown, relatively broad, periphysate. *Peridium* (13-)28–34 µm wide, broader at the base, comprising several layers of relatively thick-walled, dark brown to black-walled cells arranged in a *textura angularis*. *Pseudoparaphyses* hyphae-like, numerous, embedded in a gelatinous matrix. *Asci* 74–90 (-123) × 17–23 µm ($\bar{x}$ = 89 × 20 µm, n = 10), 8-spored, bitunicate, fissitunicate, clavate to cylindro-clavate, sometimes short pedicellate, mostly long pedicellate, apex rounded with an ocular chamber. *Ascospores* 21–26 × 8–11 µm ($\bar{x}$ = 23.5× 9 µm, n = 20), overlapping uniseriate to biseriate, hyaline, aseptate, ellipsoidal to obovoid, slightly wide above the centre, minutely guttulate, smooth-walled. *Asexual state* not established.

Culture characteristics: Ascospores germinating on PDA within 8–15 h. Germ tubes produced from both ends of the ascospore. Colonies growing on PDA 80 mm diam after 3 d at 25–30 ˚C, fast growing; fimbriate, flat or effuse, dense, initially white after a few days becoming pale grey starting form the centre, finally dark grey to black, convex with papillate surface, reaching the edge the Petri dish after 4 d.

Material examined: THAILAND, Chiang Rai Province, Muang District, Thasud Sub District, on dead branch of *Eucalyptus* sp., 5 October 2011, M. Doilom, (MFLU 12–0752, holotype), ex-type living culture MFLUCC 11–0425; *Ibid.*, living culture MFLUCC 11–0655.



Note. a-b. Ascostromata on dead twigs of *Eucalyptus* sp. c. Ascostromata cut horizontally showing the white contents. d–e. Vertical section through ascostromata. f. Immature asci and mature asci. g. Immature ascus. h–j. Asci. k–m. Ascospores. n. Germinated ascospore. Scale bars: d– e = 100µm, f = 50µm, g–j, n = 20µm, k–m = 10µm (Provided by Mingkhuan Doilom).

Figure 4.11 *Cophinforma eucalypti* (MFLU 12–0752, holotype)

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

MycoBank: MB8708

Saprobic on recently dead wood, often attached to tree, and *endophytic. Sexual morph* link not equivicoally proven. *Conidiomata* dark brown to black, uniloculate, immersed in the host becoming erumpent when mature. *Paraphyses* hyaline, septate, cylindrical, ends rounded. *Conidiogenous cells* hyaline, cylindrical, holoblastic. *Conidia* initially hyaline and aseptate, subovoid to ellipsoid-ovoid, with granular content, apex broadly rounded, remaining hyaline for a long time, becoming dark brown, 1–septate, thick-walled, base truncate or round, with longitudinal striations from apex to base.

Notes: *Lasiodiplodia* was introduced by Clendenin (1896) with *L. tubericola* Ellis & Everh. as the type species; the current name is *L. theobromae*. Alves et al. (2008) provide a recent description of the species which is widespread on many hosts. With the large number of hosts and its known morphological variability (Punithalingam 1980), it is possible that *L. theobromae* comprises a number of cryptic species (Alves et al., 2008). The type strain has questionably been linked to *Botryodiplodia rhodina* (Cooke) Arx, but this link has not been equivicoally proven (Alves et al., 2008; Phillips et al., 2008). Further work is required to establish the characters of the sexual morphs of *Lasiodiplodia sensu stricto* species, especially with the large number of potential cryptic species. Therefore no characters are given in the generic description; however, these are likely to be “Botryosphaeria”-like. The asexual morph can be distinguished by its distinctive striate brown conidia and numerous long paraphyses (Alves et al., 2008). It is hard to distinguish between species in this genus solely by morphology and analysis of *TEF1*, β-tubulin and *RPB2* gene sequences (Alves et al., 2008; Abdollahzadeh et al., 2010) or Genealogical Sorting Index (GSI), which has been used to resolve the asexual morph of *Neofusicoccum* (Sakalidis et al., 2011), is needed to resolve species.

Generic type: *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl.

Lasiodiplodia theobromae (Pat.) Griffon & Maubl., Bull. Soc. Mycol. Fr. 25: 57 (1909)

MycoBank: MB188476 (Fig. 4.12)

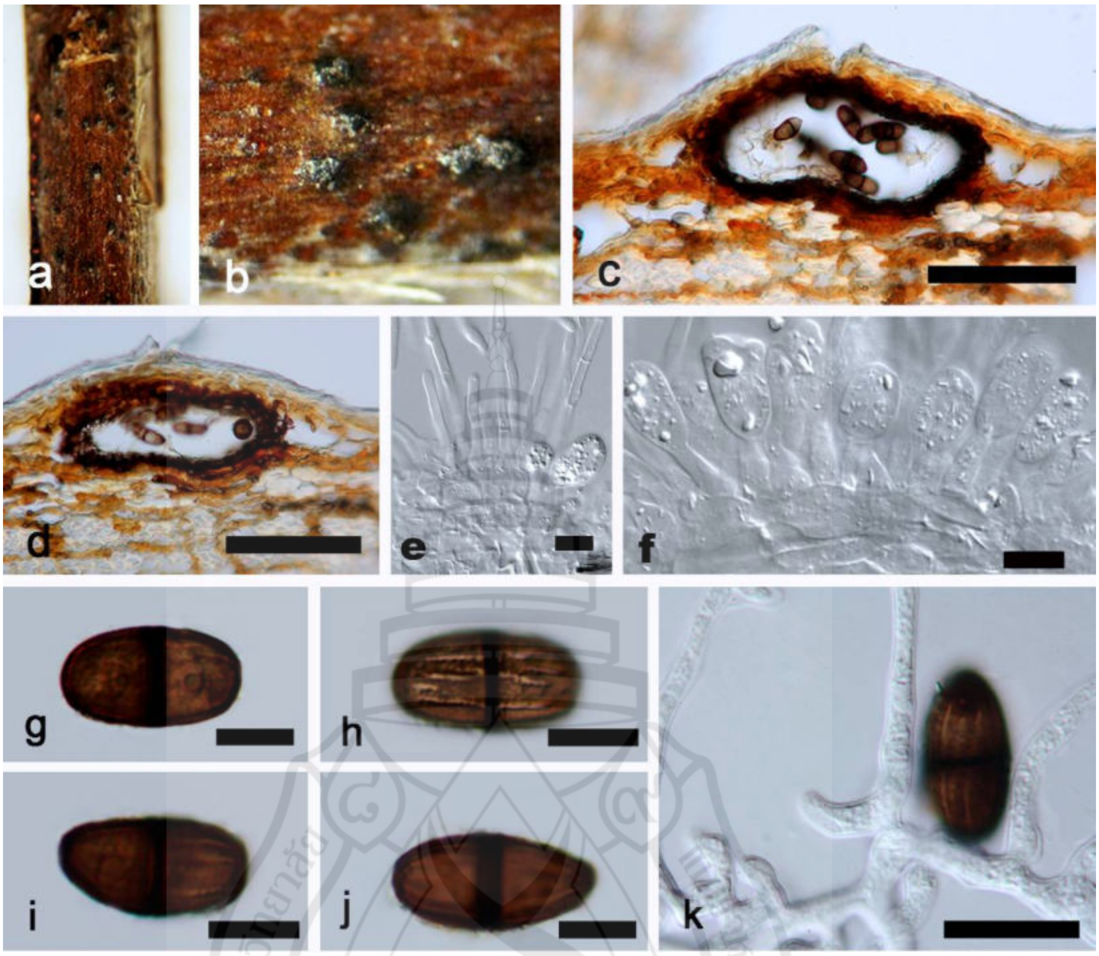
≡ *Botryodiplodia theobromae* Pat., Bull. Soc.Mycol. Fr. 8: 136 (1892)

= *Diplodia gossypina* Cooke, Grevillea 7: 95(1879)

For other possible synonyms see *Index Fungorum*

Saprobic on recently dead wood, often attached to tree, and endophytic. *Sexual state* not established. *Conidiomata* dark brown to black, uniloculate, immersed in the host becoming erumpent when mature. *Paraphyses* hyaline, septate, cylindrical, ends rounded, up to 40 µm long, 3–4 µm wide. *Conidiogenous cells* hyaline, cylindrical, holoblastic. *Conidia* (17-)21–27(-31) ×12.5–15.5 µm ($\overline{x}$ = 23 × 13 µm, n = 15), initially hyaline and aseptate, subovoid to ellipsoid-ovoid, with granular content, apex broadly rounded, remaining hyaline for a long time, finally becoming dark brown, 1–septate, thick-walled, base truncate or round, with longitudinal striations from apex to base.

Material examined: THAILAND, Chiang Rai Province., Muang District, Thasud Sub District, on dead twig of *Eucalyptus* sp., 8 August 2011, M. Doilom (MFLU 12–0760), living culture MFLUCC 11–0508.



Note. a-b. Conidiomata on dead twigs. c-d. Section through conidioma. e Paraphyses. f Conidiogenous cells and young conidia. g-j. Mature conidia in two different focal planes to show the longitudinal striations. k. Spore germinated. l-m. Culture on PDA. Scale bars: c-d = 100μm, e-j = 10μm, k = 30μm.

Figure 4.12 *Lasiodiplodia theobromae*

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

MycoBank: MB2971

Saprobic on dead twigs, leaf rachis, wood, bamboo and culms of a wide range of hosts. *Ascostromata* dark brown to black, immersed to erumpent, solitary to a few in a group, oblate, sphaeroid to subsphaerical, with a central ostiole. *Peridium* comprising brown and small-celled *textura angularis. Asci* 8–spored, bitunicate, fissitunicate, cylindro-clavate, with a short fine pedicel, apically rounded with a small ocular chamber. *Ascospores* uniseriate to irregularly uniseriate, 1–septate, brown, elliptical-fusoid, slightly constricted at septum, surface smooth to spinulose. *Asexual state* not established.

Notes: *Macrovalsaria* is a monotypic genus with a circumglobal distribution in the tropics. Sivanesan (1975) examined type material of *M. megalospora* (≡ *Sphaeria megalospora* Mont.) and several other species including *M. leonensis* (Deighton) Petr., the generic type, and synonymised them all under *Macrovalsaria megalospora* which is the oldest epithet. The brown, uniseptate ascospores that are constricted at the septum and the skull cap-like germ apparatus at the base are diagnostic features for the genus (Sivanesan 1975; Hyde et al., 2000). Cultures were obtained from material sampled from Hianan Province, China (Li & Zhuang, 2009). Phylogenetic analysis based on sequence analyses of 18S rDNA showed the genus to be related to *Botryosphaeriales* (Li & Zhuang, 2009). No asexual morph was observed in the collection. The two strains of *M. megalospora* clustered in the *Lasidodiplodia* clade (Fig. 4.1, Clade A1) and based on our data we might place *Macrovalsaria* in *Botryosphaeriaceae*. However, LSU and SSU sequence data is only available for the two strains of *Macrovalsaria* and thus it cannot be conclusively shown that *Macrovalsaria* is a synonym of *Lasiodiplodia*.

Generic type: *Macrovalsaria leonensis* (Deighton) Petr.

Macrovalsaria megalospora (Mont.) Sivan., Trans. Br. Mycol. Soc. 65: 400 (1975)

MycoBank: MB317110 (Fig. 4.13)

≡ *Sphaeria megalospora* Mont., Annls Sci. Nat., Bot., sér. 2, 14: 324 (1840)

≡ *Amphisphaeria megalospora* (Mont.) Sacc., Syll. Fung. 1: 724 (1882)

≡ *Melogramma megalospora* (Mont.) Cooke, Grevillea 13(no. 68): 109 (1885)

= *Amphisphaeria bambusina* Sydow, Philipp. Jour. Sci. 8: 247 (1913)

= *Valsaria leonensis* Deighton, Sydowia 6: 321 (1952)

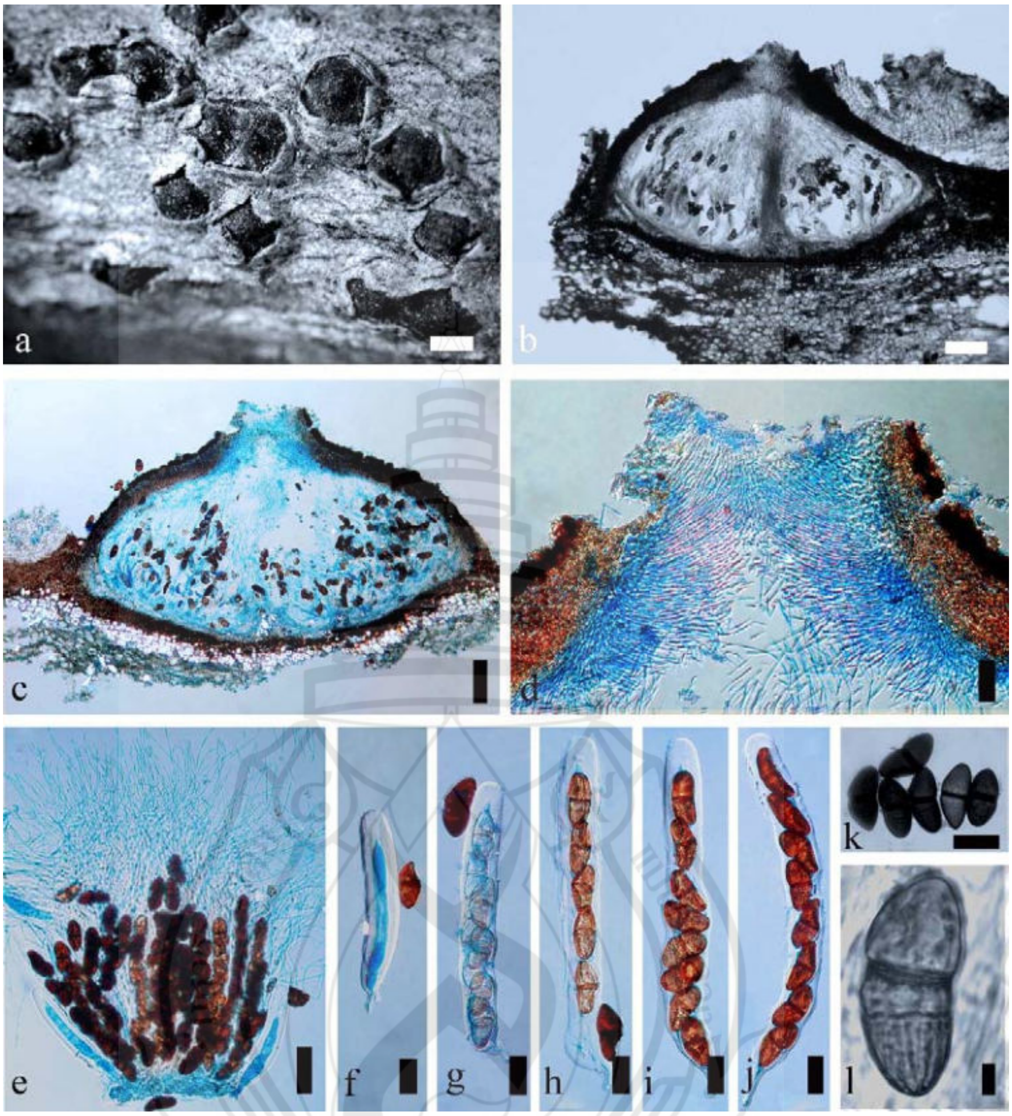
≡*Macrovalsaria leonensis* (Deighton) Petr., Sydowia 15: 300 (1961)

= *Amphisphaeria lantanae* K. Ramakr., Proc. Ind. Acad. Sci. 42: 249 (1955)

Saprobic on dead twigs, leaf rachis, wood, bamboo and culms of a wide range of hosts. *Ascomata* 706–1064 ×538–728 µm ($\bar{x}$ = 887 × 600 µm, n = 10), on the dead twigs and branches of shrubs, immersed to erumpent, solitary to a few in a group, oblate spheroid to subsphaerical, dark brown to black, with a central ostiole. *Peridium* 41–75 µm thick, consisting of brown and small-celled *textura angularis*, ostiole periphysate. *Asci* 135–206 × 22–30 µm ($\bar{x}$ = 171 × 26.3 µm, n = 20), 8–spored, bitunicate, fissitunicate, cylindrical-clavate, with a short fine pedicel at base, apically rounded with a small ocular chamber. *Ascospores* 36.5–45.5 × 15.7–21 µm ($\bar{x}$ = 42.2 × 18.2 µm, n = 25), uniseriate, brown, 1–septate, broadly subfusoid, constricted at septum, with skull cap-like germ apparatus at the lower end, surface smooth, granular to verrucose. *Asexual state* not established.

Culture characteristics: On PDA, colonies appeared woolly, fast growing, colonies 90 mm diam. at 25ºC after 3 d, greyish brown to black, reverse becoming dark brown with age, aerial mycelium greyish brown, optimum growth temperature 25–28ºC. *Conidia* not observed.

Material examined: CHINA, Hainan, Sanya, alt. 300 m, on dead twigs, 21 September 2006, W.Y. Li 7441, 7443, 7447, 7511, HMAS 178153, 178152, 178149, 178150; Hainan, Ledong, alt. 1100 m, on dead twigs, 22 September 2006, W.Y. Li 7475, HMAS 178151.



Note. a Ascostromata on host substrate. b, c Section showing structure of ascostroma. d Ostiole with periphyses. e Asci associated with pseudoparaphyses. f–j Ascus at different stages of development. k Ascospores. l An ascospore at higher magnification. Note skull cap-like germ apparatus. Scale bars: a = 0.5 mm, b–c = 100 μm, d = 25 μm, e = 50 μm, f–k = 25 μm, l = 5 μm

Figure 4.13 *Macrovalsaria megalospora* (HMAS 178149)

Melanops Nitschke, in Fuckel., Jahrb. Nassauischen Vereins Naturk. 23–24: 225 ('1869-70')

MycoBank: MB3078

Saprobic on dead wood. *Ascostromata* black, immersed, erumpent at maturity, multiloculate, thick-walled, wall composed of thick-walled *textura angularis*. *Peridium* of locules two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis. Pseudoparaphyses* hyphae-like, septate, constricted at the septa. *Asci* 8–spored, bitunicate, fissitunicate, clavate, pedicellate, apically rounded with an ocular chamber. *Ascospores* hyaline, ellipsoid to rhomboid, aseptate, with a persistent mucilaginous sheath. *Conidiomata* often found in the same ascostroma. *Paraphyses* hyphae-like, arising from between the conidiogenous cells. *Conidiogenous cells* cylindrical, hyaline, branched or unbranched, discrete. *Conidia* hyaline, aseptate, fusiform, with sheath.

Notes: *Melanops* Nitschke ex Fuckel was introduced by Fuckel (1870) to accommodate *Melanops tulasnei*, which was described as *Dothidia melanops* by Tulasne (1856) and *M. mirabilis* Fuckel. Later, a new combination *Botryosphaeria melanops* (Tul.) G. Winter was made to accommodate *D. melanops* by Winter (1887). Von Arx and Müller (1954) synonymised *B. melanops* under their broad concept of *B. quercuum*. Phillips and Pennycook (2004) detailed the taxonomy of *M. tulasnei*, the present type species of the genus and accepted this as a member of *Botryosphaeria*, but suggested that the correct name is *B. melanops* with designation of a neotype. Recently, Phillips and Alves (2009) epitypified the type species *Melanops tulasnei* and retained *Melanops* as a separate genus in the *Botryosphaeriaceae* based on morphology and phylogeny. They suggested that the large ascomata and conidiomata that occur within the same stroma and the sheath surrounding the ascospores and conidia are unique in the *Botryosphaeriaceae*.

Generic type: *Melanops tulasnei* Nitschke ex Fuckel

Melanops tulasnei Nitschke ex Fuckel, Jahrb. Nassauischen Vereins Naturk. 23–24: 225 ('1869-70').

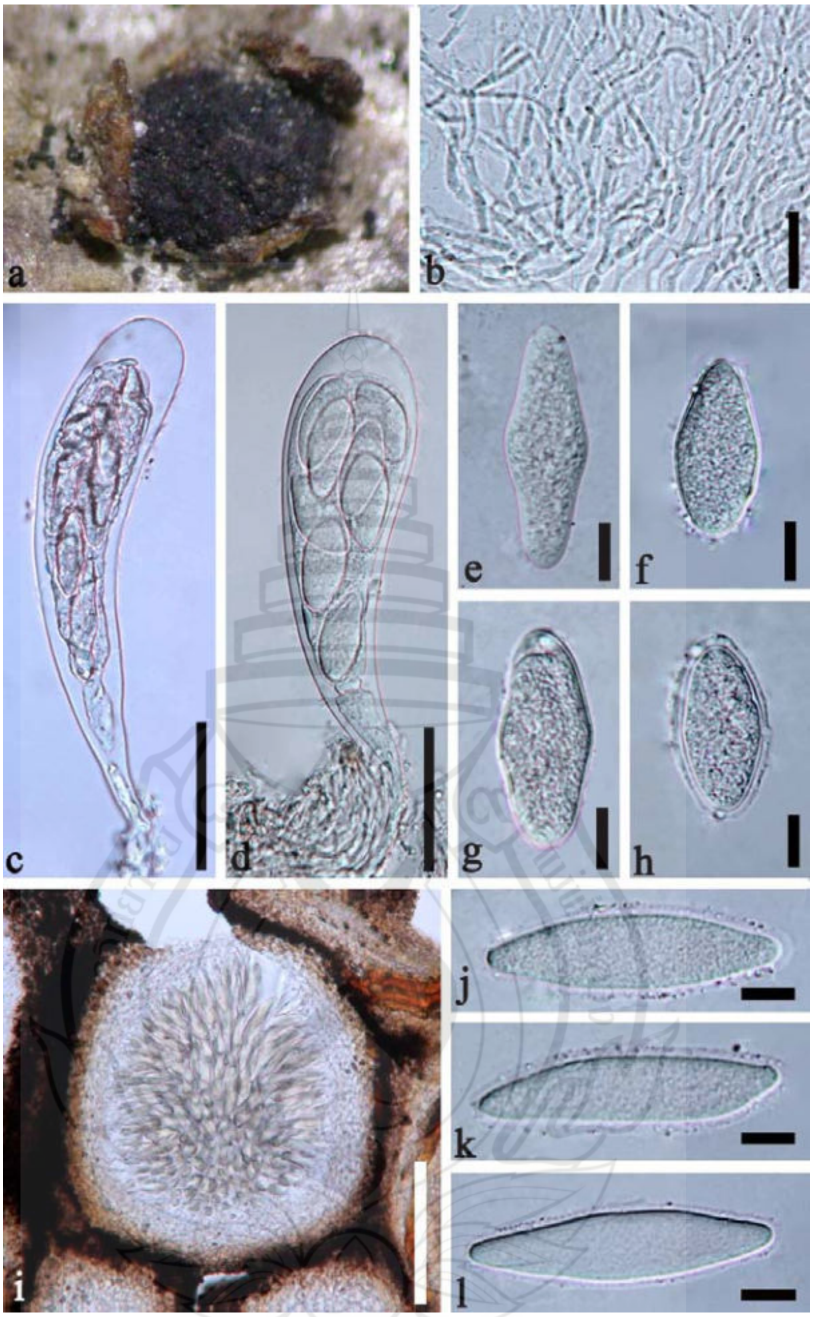
MycoBank: MB150956 (Fig. 4.14)

= *Dothidea melanops* Tul. & C. Tul., Annls Sci. Nat., Bot., sér. 4 5: 116 (1856)

≡ *Botryosphaeria melanops* (Tul. & C. Tul.) G. Winter, Rabenh. Krypt.-Fl. Ed. 2, 1: 800 (1886) [1887]

Saprobic on dead wood. *Ascostromata* black, immersed, erumpent at maturity, multilocular, thick-walled, composed of thick-walled, brown cells of *textura angularis*. *Locules* 150–300 µm diam, globose to subglobose. *Ostioles* central on each locule and circular. *Peridium* of locules two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, up to 3–4 µm, septate, constricted at the septum. *Asci* 130–245 × 26– 42 µm, 8–spored, bitunicate, fissitunicate, clavate, pedicellate, apically rounded with an ocular chamber. *Ascospores* 35–43 × 14–17 µm, irregularly biseriate in the ascus, hyaline, aseptate, ellipsoid to rhomboid, smooth, thin-walled, widest in the middle, with a mucilaginous sheath. *Conidiomata* often found in the same ascostroma. *Paraphyses* hyphae-like, branched, arising between the conidiogenous cells. *Conidiogenous cells* hyaline, cylindrical, sometimes branched at the base, discrete. *Conidia* 42–47(-55) × 8.5–12.5 µm, hyaline, aseptate, fusiform, widest in the middle, apex acute, base truncate with a minute marginal frill, surrounded by a mucilaginous sheath.

Material examined: GERMANY, Bavaria, Munich, English Garden, on dead twigs of *Quercus robur*, 8 July 2004, A.J.L. Phillips (LISE 95179, epitype).



Note. a–c Ascostromata on host substrate b Pseudoparaphyses. c–d Asci. e–h Ascospores. i Section through conidioma. j–l Conidia. Scale Bars: b = 30 µm, c–d = 50 µm, e–f = 10 µm, i = 100 µm, j–l = 10 µm

Figure 4.14 *Melanops tulasnei* (LISE 95179, epitype)

Neodeightonia C. Booth, in Punithalingam, Mycol. Pap. 119: 17 (1970) [1969]

Saprobic on dead wood and leaves of monocotyledons. *Ascostromata* brown to dark brown, uniloculate, immersed to erumpent, globose to subglobose. *Ostiole* circular, central. *Peridium* of dark brown-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, septate, constricted at the septa. *Asci* 8−spored, bitunicate, fissitunicate, clavate to cylindrical-clavate, apically rounded with an ocular chamber. *Ascospores* uniseriate or irregularly biseriate, hyaline, aseptate, ellipsoidal-fusiform or fusiform, surrounded or not surrounded by a complex sheath. *Pycnidia* uniloculate or multilocular, semi-immersed, solitary, globose, covered by mycelium, wall composed of dark brown thick-walled *textura angularis*, becoming thin-walled and hyaline toward the inner region. *Conidiogenous cells* holoblastic, hyaline, aseptate, cylindrical to subcylindrical. *Conidia* initially hyaline, aseptate, ellipsoid to obovoid, thick-walled with granular content, rounded at apex, occasionally truncate at base. Aged conidia becoming cinnamon to sepia, and 1−septate, brown to dark brown.

Notes: *Neodeightonia* was introduced by Booth (Punithalingam 1969). However, von Arx and Müller (1975) transferred the type of the genus, *N. subglobosa,* to *Botryosphaeria*, reducing *Neodeightonia* to synonymy. Phillips et al. (2008) reinstated this genus which is distinguishable from *Botryosphaeria* morphologically (based on the dark, 1−septate ascospores) and phylogenetically (Phillips et al., 2008; Abdollahzadeh et al., 2009) and described a new species *N. phoenicum*. Liu et al. (2010) added the fourth species, *N. palmicola* based on studies on morphology of the sexual and asexual morphs and phylogenetic data.

Generic type: *Neodeightonia subglobosa* C. Booth

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

MycoBank: MB318601

Saprobic on dead bamboo. *Ascostromata* 140–200 µm high, 210–360 µm diam, dark brown, uniloculate, semi-immersed in host tissue, with protruding papilla or erumpent, developing under raised, dome-shaped regions. *Ostiole* 45–75 × 50–80 µm, central, papillate. *Peridium* 15–40 µm wide, comprising several layers of dark brown-walled cells of *textura angularis*. *Pseudoparaphyses* up to 3–5 µm wide, hyphae-like, cellular, numerous, embedded in a hyaline gelatinous matrix. *Asci* (70-)81.5–100(-117) × 18–22.5(-23) μm ($\bar{x}$ = 89.2 × 20.7 μm, n = 20), 8-spored, bitunicate, fissitunicate, clavate to cylindro-clavate, with a short rounded pedicle, apically rounded with an ocular chamber (2.5–4.5 μm wide, n = 5). *Ascospores* (19.5-)21–26(-28) × (6.5-)7.5–9.5(-10) μm ($\bar{x}$ = 23.4 × 8.5 μm, n = 30), uniseriate at the base, biseriate at the apex, hyaline, aseptate, ellipsoidal to fusiform, usually widest in the middle, rough-walled, with bipolar germ pores, surrounded by distinctive structured mucilaginous sheath. *Pycnidia* 150–200 μm diam., brown to black, solitary or aggregated sometimes intermixed amongst ascostromata, unilocular or multilocular, spherical to globose, wall stromatic, composed of several layers of laterally compressed brown cells. *Conidia* (*phialospores*) 9–12 × 6–9 μm, mature ones light brown to dark brown, spherical to subglobose (asexual morph description follows Punithalingam 1969).

Material examined: SIERRA LEONE, Njala (Kori), on dead culms of *Bambusa arundinacea*, 17 August 1954, F.C. Deighton (IMI 57769 c, holotype); THAILAND, Lampang Province., Jae Hom District, Mae Yuag Forestry Plantation, on dead culms of *Bambusa* sp., 19 August 2010, R. Phookamsak, RP0079 (MFLU 11–0199), living culture MFLUCC 11–0163.

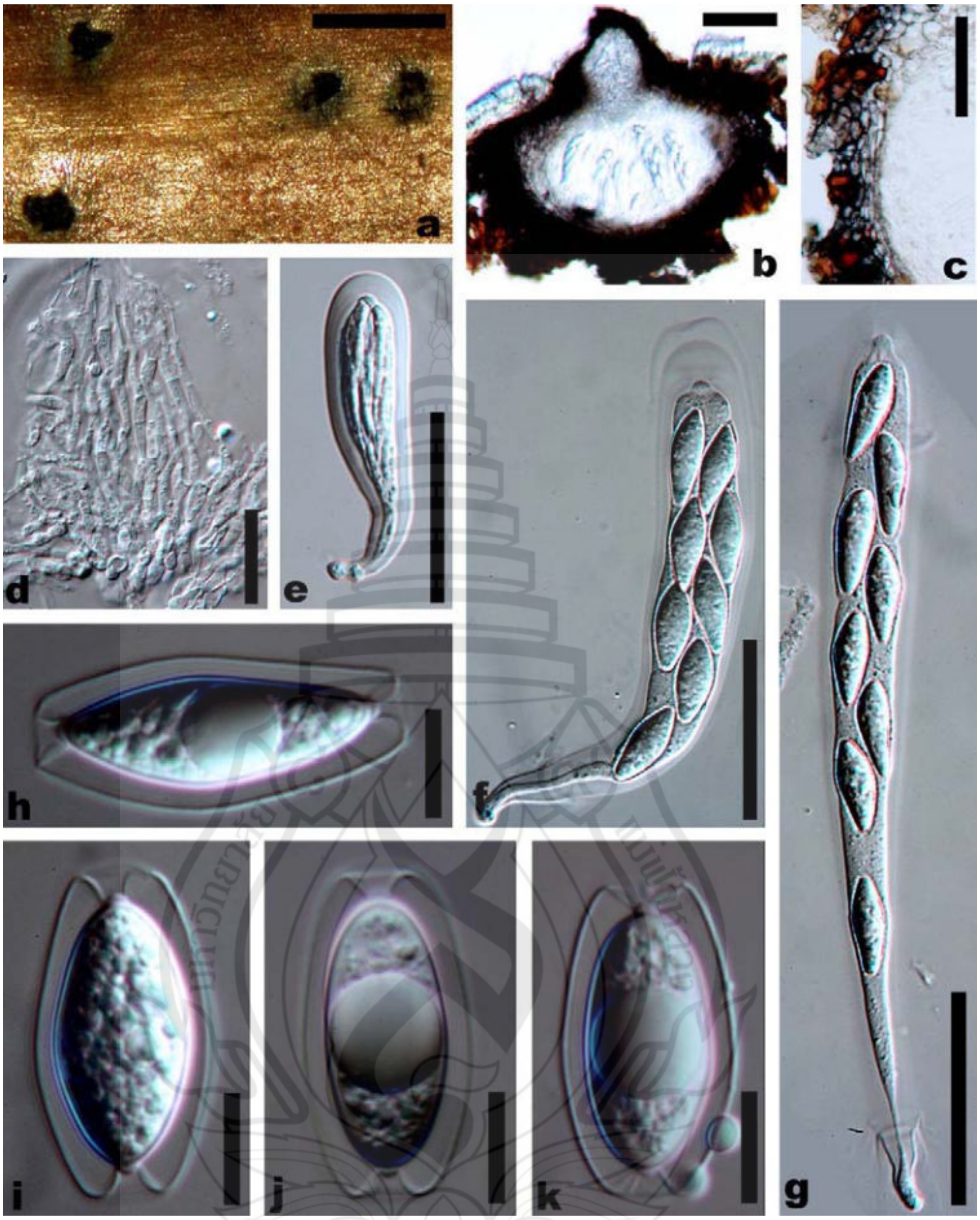
Notes: MFLU 11–0199 is a fresh collection of *Neodeightonia subglobosa* from *Bambusa* sp., and is similar to *N. palmicola*, which also has hyaline, aseptate ascospores surrounded by a wing-like hyaline sheath. However, MFLU 11–0199 differs from *N. palmicola* in having smaller asci and ascospores lacking bipolar germ pores. The original description of *N. subglobosa* reported that the ascospores become 1–septate, and brown to dark brown when mature, and this was not observed in *N. palmicola* and no asexual morph was formed in culture. In Fig. 4.1 the new isolate clustered together with a strain of *N. subglobosa* (CBS 448.91). This new collection is tentatively named *N. subglobosa*.

Neodeightonia palmicola J.K. Liu, R. Phookamsak and K.D. Hyde. Sydowia. 62: 268 (2010)

MycoBank: MB518804 (Figs. 4.15, 4.16)

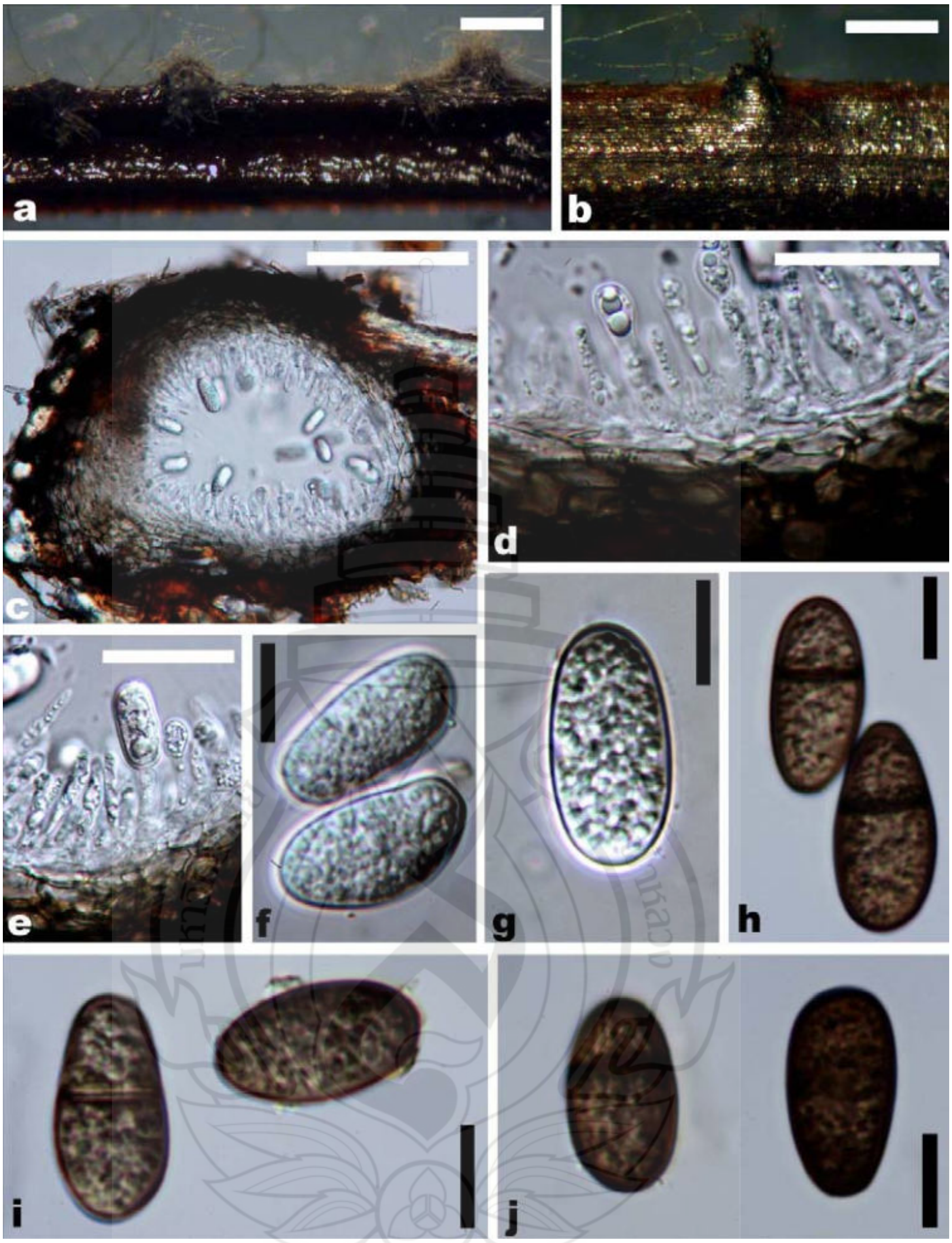
Saprobic on dead leaves. *Ascostromata* 180−230 µm high, 270−420 µm diam., uniloculate, immersed to erumpent in host tissue, globose to subglobose, brown to dark brown, rounded at the base. *Ostiole* circular, central. *Peridium* 26−55 µm wide, comprising several layers of brown-walled cells, the outer stratum of 1−3 cells comprising thick, dark brown walls *textura angularis*, the inner layer comprising pale brown to hyaline, thin-walled cells *textura angularis. Pseudoparaphyses* up to 3−5 µm wide, hyphae-like, frequently septate, often constricted at the septa. *Asci* (80-)110−210 (-225) × 17−22.5(-24) µm, 8−spored, bitunicate, fissitunicate, clavate to cylindro-clavate, pedicellate, apically rounded, with a well developed ocular chamber. *Ascospores* 23−31.5 × 8.5−12.5 µm ($\bar{x}$= 27 × 10 µm), obliquely uniseriate or irregularly biseriate, hyaline, aseptate, ellipsoidal or fusiform, widest in the middle, both ends obtuse, smooth and thin-walled, with bipolar germ pores, surrounded by a wing-like hyaline sheath. *Pycnidia* uniloculate, semi-immersed, solitary, globose, covered by mycelium, up to 240 µm wide, wall 4−8 cell layers thick, composed of dark brown thick-walled *textura angularis*, becoming thin-walled and hyaline toward the inner region. *Paraphyses* hyaline, cylindrical. *Conidiogenous cells* 9−20 × 3−6 µm, holoblastic, hyaline, aseptate, cylindrical to subcylindrical. *Conidia* 17.5−24.5 × 9.5−12.5 µm ($\bar{x}$= 21.5 × 11 µm), initially hyaline, aseptate, ellipsoid to obovoid, thick-walled with granular content, rounded at apex, occasionally truncate at base. Aged conidia becoming cinnamon to sepia, and 1–septate.

Material examined: THAILAND, Chiang Rai Province., Muang District, Khun Korn Waterfall, on dead leaves of *Arenga westerhoutii*., 18 Dec 2009, J.K. Liu, JKA0022 (MFLU 10–0407, holotype).



Note. a Appearance of ascostromata on host substrate. b Section of ascostroma. c Section of peridium comprising a few cells layers of *textura angularis*. d Pseudoparaphyses. e−g Asci. h−k Ascospores with a wing-like sheath. Scale bars: a = 1 mm, b−c = 100 μm, d−g = 30 μm, h−k = 10 μm

Figure 4.15 *Neodeightonia palmicola* (MFLU 10–0407, holotype)



Note. a−b Conidiomata on pine needles. c Section of conidioma. d−e Conidiogenous cells. f−g Young conidia. h−i. Mature conidia with septa. Scale bars: a−b = 500 µm, c = 100 µm, d−e = 30 µm, g−j = 10 µm.

Figure 4.16 Asexual morph of *Neodeightonia palmicola* (MFLU 10–0407)

Neofusicoccum Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 247 (2006)

Synonym

Nattrassia B. Sutton & Dyko, Mycol. Res. 93: 483 (1989)

MycoBank: MB500870

Saprobic on dead wood. *Ascostromata* visible as minute black dots or papilla on host tissue, semi-immersed to erumpent under epidermis, individually globose to subglobose, solitary or clustered, longitudinal axis vertical to the host surface. *Ostiole* central, circular, papillate. *Peridium* of locules two-layered, outer layer composed of brown to dark brown, thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis. Pseudoparaphyses* hyphae-like, numerous, septate, slightly constricted at septum. *Asci* 8−spored, bitunicate, fissitunicate, clavate to cylindro-clavate, short pedicellate, apically rounded with an ocular chamber. *Ascospores* hyaline, aseptate, ellipsoidal to fusiform, thick-walled. Pycnidial aggregates morphologically indistinguishable from ascomatal aggregates. *Pycnidia* globose and non-papillate to pyriform, with a short, acute papilla; pycnidium a locule created within stromal tissue; pycnidial wall not differentiated from surrounding tissue. *Conidiogenous cells* holoblastic, hyaline, subcylindrical, proliferating percurrently with 1–2 proliferations and periclinical thickening. *Conidia* ellipsoidal with apex round and base flat, hyaline, aseptate, becoming light brown and 1–2 septate with age (asexual morph description follows Pennycook and Samuels 1985).

Notes: *Neofusicoccum* was introduced for an asexual morph which occurs with a “Dichomera”-like synanamorph by Crous et al. (2006). They considered that the name is more informative of the morphological state. Most of the species of the genus had previously been treated as *Fusicoccum*, and Crous et al. (2006) proposed new combinations for 13 species based on the sequence data from cultures. Pennycook and Samuels (1985) listed *Fusicoccum parvum* as the asexual morph when they described *Botryosphaeria parvum* (= *Neofusicoccum parvum*). In the present study we found the sexual morph of *Neofusicoccum parvum*, the type species of the genus, on a branch of *Linum usitatissimum*. The isolate clustered with the type strain of *N. parvum* with 100% bootstrap support (Fig. 4.1). Morphologically our collection is identical to the original description of *N. parvum.*

Generic type: *Neofusicoccum parvum* (Pennycook & Samuels) Crous, Slippers & A.J.L. Phillips

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

MycoBank: MB3892

Saprobic on dead wood. *Ascostromata* black, immersed to erumpent, subglobose to ovoid, multilocular. *Ostiole* opening with a pore. *Peridium* consisting of layers of dark brown-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, septate, constricted at septa. *Asci* 8−spored, bitunicate, fissitunicate, clavate to cylindrical-clavate, short-pedicellate, apically rounded with an ocular chamber. *Ascospores* hyaline to brown, 2–septate, ellipsoid to broad fusiform, with or without an apiculus at each end, surrounded by a mucilaginous sheath. *Conidiomata* pycnidial, black, ostiolate, separate or aggregated, immersed to erumpent, unilocular or multilocular, ostiolate. *Ostiole* central, circular, non-papillate. *Paraphyses* hyaline, thin-walled, usually aseptate, sometimes becoming up to 2−septate. *Conidiogenous cells* holoblastic, hyaline, cylindrical to doliiform, smooth. *Conidia* brown, ellipsoid to oblong or obovoid, moderately thick-walled, ends rounded, 1(–2)–septate, mostly 2–septate, not constricted at septa (asexual morph description follows Phillips et al., 2008; Abdollahzadeh et al., 2009). Asexual morph is “Dothiorella”-like, but having conidia with up to two transverse septa.

Notes: *Phaeobotryon* was introduced by Theissen and Sydow (1915) to accommodate *Dothidea cercidis.* This taxon was considered to belong to a distinct genus due to its pale brown to brown, 2−septate ascospores which were reported as hyaline in the original description. Using a broader concept for *Botryosphaeria*, von Arx and Müller (1954, 1975) treated *Phaeobotryon* as a synonym of *Botryosphaeria*. However, Phillips et al. (2008) reinstated *Phaeobotryon* as they found it to be morphologically and phylogenetically distinct from other genera in the *Botryosphaeriaceae.* Phillips et al. (2008) considered the 2–septate, brown ascospores with a conical apiculus at each end, were characteristic of the genus and further described two new species, *P. mamane* Crous & A.J.L. Phillips and *P. quercicola* (A.J.L. Phillips) Crous & A.J.L. Phillips. Subsequently, Abdollahzadeh et al. (2009) introduced an endophytic species, *P. cupressi* Abdollahzadeh, Zare & A.J.L. Phillips, isolated from stems of *Cupressus sempervirens*. Molecular sequence data is available for *P. mamane* and *P. cupressi*. Asexual morphological characters and conidial dimensions are used to distinguish the species. However, the remaining species *P. cercidis*, *P. disruptum* (Berk. & M.A. Curtis) Petr. & Syd and *P. euganeum* (Sacc.) Höhn., were described based on the morphology of the sexual stage only and no asexual characters have been reported. Presently there are seven species listed in the genus (*Index Fungorum*, MycoBank).

Generic type: *Phaeobotryon cercidis* (Cooke) Theiss. & Syd.

Phaeobotryosphaeria Speg., Ann. Inst. Rech. Agron. 17, 10: 120. 1908

Synonym

Sphaeropsis Sacc., Michelia 2(no. 6): 105 (1880)

Other possible synonyms

Botryosphaerostroma Petr. & Syd., Beih. Reprium nov. Spec. Regni veg. 42: 126 (1926) [1927]

Botrysphaeris Clem. & Shear, Gen. Fung., Edn 2: 361 (1931)

Catosphaeropsis Tehon, Mycologia 31: 542 (1939)

Granulodiplodia Zambett. ex M. Morelet, Bull. Soc. Sci. nat. Arch. Toulon et du Var 203: 12 (1973)

Gyratylium Preuss, Linnaea 26: 722 (1855)

Macrophoma (Sacc.) Berl. & Voglino, Atti Soc. Veneto-Trent. Sci. Nat. 10(1): 172 (1886)

Macroplodia Westend., Bull. Acad. R. Sci. Belg., Cl. Sci., sér. 2 2: 562 (1857)

Neosphaeropsis Petr., Ann. Mycol. 19: 67 (1921)

Phoma subgen. *Macrophoma* Sacc., Syll. Fung. 3: 66 (1884)

Phomatosphaeropsis Ribaldi, Annali Sper. Agr., n.s. 7(3): 847 (1953)

Sphaeropsis Lév., in Demidov, Voyage dans la Russie Meridionale et la Crimeé, par la Hongrie, la Valachie et la Moldavie 2: 112 (1842)

MycoBank: MB3893

Saprobic on dead wood. *Ascostromata* erumpent, irregularly scattered or multiloculate in groups, fusiform. *Locules* in a single layer, flask-shaped, with short neck, composed of dark brown-walled cells of *textura angularis*. *Pseudoparaphyses* abundant, hyphae-like, septate. *Asci* 8–spored, bitunicate, fissitunicate, clavate, short or long pedicellate, apically rounded with an ocular chamber. *Ascospores* brown, aseptate, elliptical to ovoid, navicular, rhomboid when young, thick walled, with a hyaline apiculus at either end. *Conidiomata* pycnidial, immersed to erumpent, thick-walled, wall composed of several layers of dark brown *textura angularis*, eustromatic, unilocular. *Ostiole* central, papillate. *Paraphyses* hyaline, aseptate, thin-walled. *Conidiogenous cells* hyaline, discrete, proliferating internally to form periclinal thickenings. *Conidia* hyaline, becoming brown to dark brown, aseptate, oval, oblong or clavate, straight, thick-walled (asexual morph description follows Phillips et al., 2008).

Notes: *Phaeobotryosphaeria* was introduced as a monotypic genus by Spegazzini (1908) represented by *P. yerbae*, from *Ilex paraguayensis* collected from Argentina. Von Arx and Müller (1954) considered *Phaeobotryosphaeria* as a synonym of *Botryosphaeria* Ces. & De Not. However, Phillips et al. (2008) reinstated it showing that it is morphologically and phylogenetically distinct from *Botryosphaeria* in the *Botryosphaeriaceae*.

Generic type: *Phaeobotryosphaeria yerbae* Speg

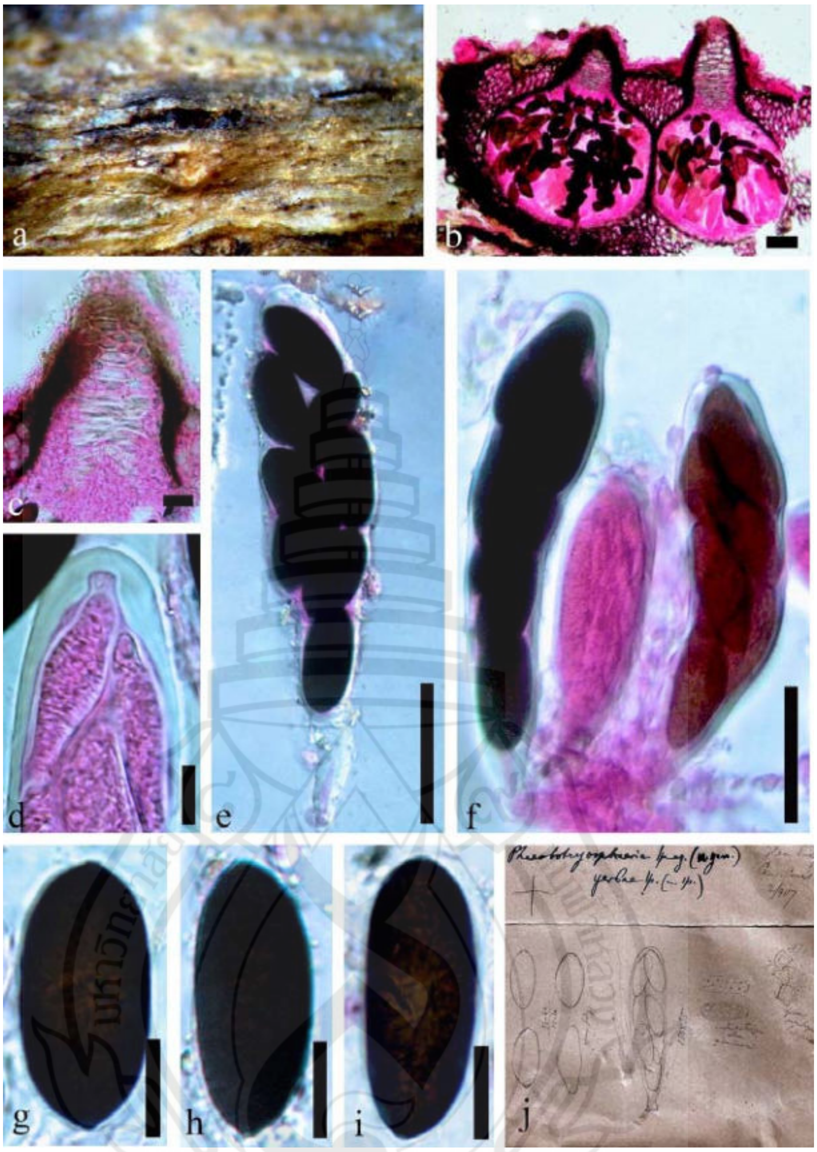
Phaeobotryosphaeria yerbae Speg., Anales del Museo Nacional de Historia Natural de Buenos Aires 17: 120 (1908)

MycoBank: MB182015 (Fig. 4.17)

Saprobic on dead branch. *Ascostromata* erumpent, irregularly scattered or multiloculate in groups (up to 6), fusiform. *Locules* in a single layer, flask-shaped, 200−290 × 300−350 µm, with a short neck 80−140 µm long. *Peridium* of locules single layer, composed of dark brown-walled cells of *textura angularis*. *Pseudoparaphyses* abundant, hyphae-like, septate, constricted at septa. *Asci* 180−200 × 30−35 µm, 8–spored, bitunicate, fissitunicate, clavate, with a 30−50 µm long pedicel, apically rounded with an ocular chamber. *Ascospores* 30−45(-50) × 14−17 µm, brown to dark brown, aseptate, elliptical to ovoid, navicular, rhomboid when young, thick-walled, smooth, brown, with a hyaline apiculus at either end. *Asexual state* not established.

Material examined: ARGENTINA, Misiones, Campo de las Cuias, on branches of *Ilex paraguayensis*, February 1907, C. Spegazzini, (LPS 2926 lectotype designated here); Departamento Iguazú, Parque Nac. Iguazú, on fallen unidentified branches, 17 March 1993, Carmarán 222 (BAFC33591 − identified as *Botryosphaeria ingiae* Kar & Maity).

Notes: The type material at LPS comprises four collections (LPS 2923, 2924, 2925, and 2926) under the name *Phaeobotryosphaeria yerbae,* all collected from the same place on the same date and are thus syntypes. Phillips et al. (2008) examined one collection (LPS 2926) and interpreted this as the holotype. We also studied LPS 2926 and designate this as the lectotype. Romero and Carmarán (1997) reported *Botryosphaeria ingae* A.K. Kar & Maity also from Argentina, but we have studied the material kept at BAFC Fungi Collection (BAFC33591) and it is identical to *Phaeobotryosphaeria yerbae*.



Note. a Ascostromata immersed in the substrate. b Longitudinal section of ascostromata. c Longitudinal section through neck. d Young ascus apex with an ocular chamber. e Ascus. f Three asci in different stages of development. g–h Ascospores. j Original drawings by Spegazzini (LPS 2926) on the envelope. Scale Bars: a = 0.5 mm, b = 50 µm; c = 20 µm, d, g –i = 10 µm, e–f = 50 µm

Figure 4.17 *Phaeobotryosphaeria yerbae* (LPS 2926, lectotype)

Phyllachorella Syd., Ann Mycol. 12: 489 (1914)

MycoBank: MB4050

Epiphytes on the host leaf surface, forming conspicuous ascostromata. *Ascostromata* gregarious, with numerous ascomata clustering together forming black, superficial, velvety patches. *Peridium* of locules laterally, thinner at the apex and the base, coriaceous, two-layered, outer layer composed of small heavily pigmented thick-walled cells *textura angularis*, inner layer composed of hyaline thin-walled cells *textura angularis*. *Pseudoparaphyses* not observed. *Asci* 8−spored, bitunicate, cylindrical to clavate, with a short narrow twisted pedicel, apically rounded; with a small ocular chamber. *Ascospores* irregularly arranged to uniseriate near the base, hyaline, septate, deeply constricted at the septum, oblong to ovate, with broadly to narrowly rounded ends, the upper cell often broader than the lower one, smooth, guttulate. *Asexual state* not established.

Notes: *Phyllachorella* was formally established by Sydow (1914) in "Phyllachoracearum" as a monotypic genus represented by *P. micheliae*. The genus is characterized by its "phyllachorae stroma" on the host surface. Kar and Maity (1971) recorded the type species of this genus in India and gave a full description of this genus based on its "hypophyllous, 2−3 sometimes coalescing stromata and cylindro-clavate, pedicellate asci".

We have re-examined the type specimen of this genus, which has hyaline ascospores as recorded in the protologue (Sydow 1914). According to Kar and Maity (1971) ascospore are brown inside the asci. It is not clear whether their collection was *Phyllachorella.*

There has been no phylogenetic study of this genus, however many of its characters (ascostromata, thick wall of relatively thick-walled brown-cells *textura angularis/globulosa*, characteristic asci and aseptate ascospores), suggest it should be included in *Botryosphaeriaceae*.

Generic type: *Phyllachorella micheliae* Syd.

Pyrenostigme Syd., Ann. Mycol. 24: 370 (1926)

MycoBank: MB4602

Parasitic on living leaves of *Siparunea patelliformis*. *Ascomata* black to dark brown, semi-immersed to superficial, scattered, globose to subglobose, thick-walled. *Peridium* composed of brown to black, darkly pigmented, small, thick-walled cells of *textura angularis*. *Pseudoparaphyses* not observed. *Asci* 8–spored, bitunicate, fissitunicate, clavate to broadly-clavate, with a short, narrow, furcate pedicel, and with an ocular chamber. *Ascospores* biseriate, hyaline, aseptate, fusiform to ellipsoid. *Asexual state* not established.

Notes: This genus is clearly typical of *Botryosphaeriales* and appears to be distinct from other genera in the order. We accept it in this study but it should certainly be recollected and sequenced to confirm its uniqueness as a genus.

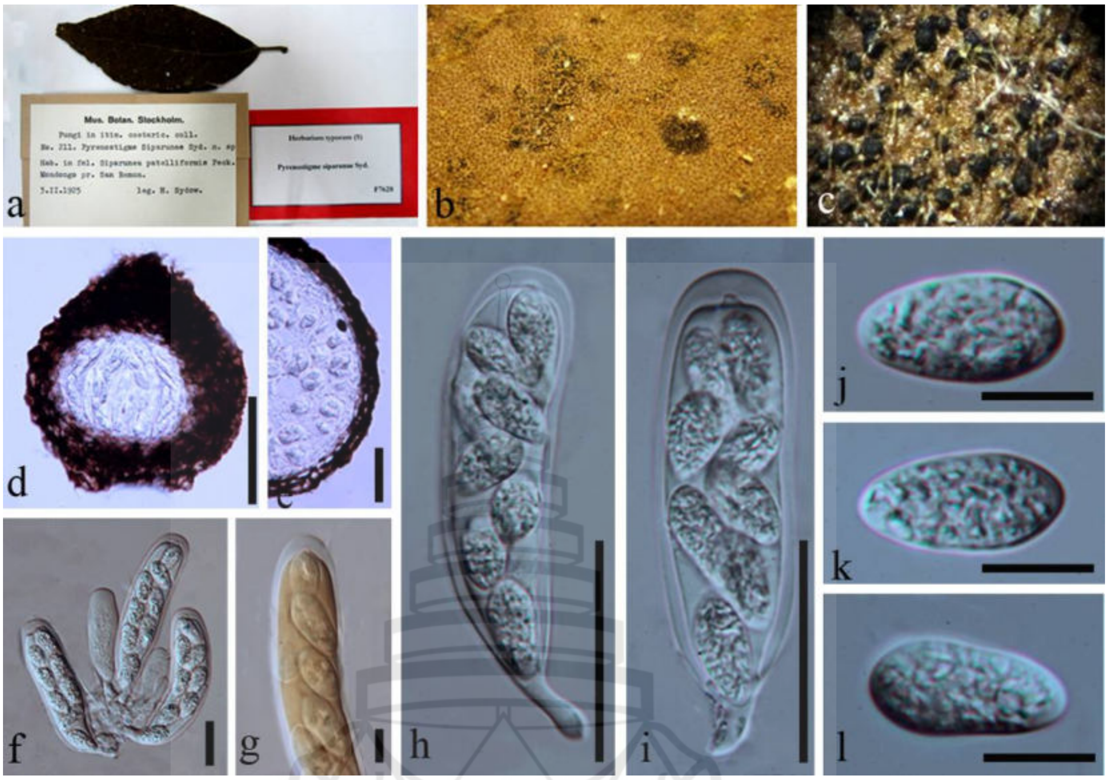
Generic type: *Pyrenostigme siparunae*

Pyrenostigme siparunae Syd., Ann. Mycol. 24: 370 (1926)

MycoBank: MB278247 (Fig. 4.18)

Parasitic on living leaves of *Siparunea patelliformis*. *Ascomata* 130−170 µm high, 150−180 µm wide ($\bar{x}$ = 156 ×169 µm, n=10), semi-immersed to superficial, scattered, globose to subglobose, black to dark brown, thick-walled, apex usually widely porate, papillate. *Peridium* up to 15−40 µm wide ($\bar{x}$ = 21µm, n=10), 3−10 layered, composed of brown to black, darkly pigmented, small, thick-walled cells *textura angularis*, with outer peridial wall fused with the host cells. *Pseudoparaphyses* not observed. *Asci* 60−90 × 13−20 µm ($\bar{x}$ = 75 × 20 µm, n=20), 8−spored, bitunicate, fissitunicate, clavate to broadly-clavate, with a short, narrow, furcate pedicel, rounded at apex with a 3−5 µm high ocular chamber. *Ascospores* 15−20 × 7−10 µm ($\bar{x}$ = 17 × 8 µm, n = 40), biseriate or distichously arranged, partially overlapping, hyaline, aseptate, fusiform to ellipsoid, straight or somewhat curved, with verrucose spore wall. *Asexual state* not established.

Material examined: COSTA RICA, Alajuela, near Mondongo, on living leaves of *Siparunea patelliformis* Peck, 3 February 1925, San Ramon, H. Sydow 211, (S−F7628, lectotype designated here)



Note. a Herbarium packet b–c Ascostromata on host substrate. d Section of ascostroma (TS). e. Section of peridium comprising a few layers of cells. f–i Asci. j–l Ascospores. Scale bars: d = 80 µm, e = 50 µm, f–g = 20 µm, h–I = 50 µm, j–l = 10 µm. (Provided by Hiran Ariyawansha).

Figure 4.18 *Pyrenostigme siparunae* (S–F7628, lectotype)

Saccharata Denman & Crous, CBS Diversity Ser. 2: 104 (2004)

MycoBank: MB28918

Saprobic on dead leaves. *Ascomata* black, erumpent, solitary, scattered, subglobose to ovoid, rough-walled, papillate. *Papilla* central, with a short neck. *Peridium* composed of brown pseudoparenchymatous cells of *textura globulosa*. *Pseudoparaphyses* hyphae-like, anastomosing mostly above the asci. *Asci* 8–spored, bitunicate, fissitunicate, cylindrical to fusiform, pedicellate, apically rounded with an ocular chamber. *Ascospores* uniseriate, hyaline, aseptate, guttulate, ellipsoidal, clavate, fusiform to broad fusiform, tapering to obtuse ends, smooth-walled. *Conidiomata* pycnidial, dark brown, eustromatic, immersed, subepidermal, separate, uni− to multilocular, walls consisting of dark brown *textura angularis*, ostiolate. *Fusicoccum* asexual morph: *Conidiophores* hyaline, smooth, branched, subcylindrical, 1−3 septate, formed from the inner layer of the locule, intermingled with hyaline, septate paraphyses. *Conidiogenous cells* enteroblastic, phialidic, hyaline, smooth, cylindrical, discrete or intergrated. *Conidia* hyaline, aseptate, smooth, clavate, thin-walled, apex subobtuse, base truncate. The *microconidial state* occurs in the same or in separate conidiomata to the *Fusicoccum* asexual morph. *Microconidiophores* hyaline, cylindrical, 1−3 septate, smooth, branched. *Microconidiogenous cells* phialidic, hyaline, smooth, cylindrical, discrete or integrated. *Microconidia* brown, aseptate, subcylindrical to narrowly ellipsoid with rounded ends, thick-walled, finely verruculose, guttulate. The *spermatial state* occurs in conidiomata with the *Fusicoccum* asexual morph, or in separate *spermatogomia*. *Spermatiophores* hyaline, 1−3 septate, cylindrical, smooth, branched. *Spermatiogenous cells* hyaline, cylindrical, discrete or integrated, smooth. *Spermatia* hyaline, aseptate, rod−shape with rounded ends, smooth (asexual morph description follows Denman et al., 1999).

Notes: *Saccharata* was introduced as a monotypic genus based on *S. proteae* (≡ *Phyllachora proteae* Wakef) by Crous et al. (2004) to accommodate species having unilocular, immersed ascomata, as well as a “Fusicoccum”-like asexual morph, with a “Diplodia”-like synanamorph with brown, narrowly ellipsoidal, thick-walled, conidia. Doidge (1942) suggested that *Botryosphaeria* would possibly be a better genus to place *Phyllachora proteae* (Wakefield 1922) based on the ascomatal wall being continuous with and smaller in structure to the clypeus. Denman et al. (1999) observed a “Fusicoccum”-like asexual morph which was formed in culture and proposed a new combination in *Botryosphaeria proteae* for *Phyllachora proteae* based on its bitunicate asci and ascospore morphology. By employing ITS DNA molecular sequence data, Denman et al. (2000) recognized two correlating clades of *Botryosphaeria*, namely *Diplodia* and *Fusicoccum*. However, *B. proteae* was not congeneric with these two clades. Recent phylogenetic studies using single and combined genes (Crous et al., 2006; Schoch et al., 2009a) showed *Saccharata* to be a distinct genus that is basal in the *Botryosphaeriales*. In this study, *Saccharata* clustered together with *Phyllosticta* and formed a clade with *Melanops* at the base of the *Botryosphaeriales*. This basal clade may be a distinct family in *Botryosphaeriales*.

Generic type: *Saccharata proteae* (Wakef.) Denman & Crous

Sivanesania W.H. Hsieh & Chi Y. Chen, Mycol. Res. 100: 1106 (1996)

MycoBank: MB26498

Pathogenic on stems and petioles of *Rubi kawakamii*. *Ascostromata* immersed, erumpent, becoming superficial, scattered, multilocular, subcuticular to subepidermal, pulvinate, cells of ascostromata of brown-walled cell of *textura globulosa* to *angularis*. *Locules* numerous, globose to compressed, forming in a single layer. *Ostioles* inconspicuous. *Peridium* composed of dark brown cells. *Pseudoparaphyses* hyphae-like, septate, branched. *Asci* 8–spored, bitunicate, fissitunicate, clavate, short pedicellate, apically rounded and thickened, with an inconspicuous ocular chamber. *Ascospores* hyaline to brown when old, ovoid, with a hyaline, filiform, simple appendage. *Asexual state* not established.

Notes: *Sivanesania* was introduced as a monotypic genus by Hsieh and Chen (1994) based on *Sivanesania rubi* W.H. Hsieh & Chi Y. Chen which is pathogenic on stems and petioles of *Rubi kawakamii.* The morphological characters of the fungus such as immersed, erumpent, multilocular ascostromata, hyaline, septate pseudoparaphyses and hyaline to brown, aseptate ascospores with an appendage fit well with *Botryosphaeriaceae*. It is most similar to *Botryosphaeria*, *Phyllosticta* and *Saccharata*, but differs by its multilocular ascostromata (*Phyllosticta* and *Saccharata* have uni-locular ascostromata) and aseptate ascospores with a basal filiform, hyaline, simple appendage. No asexual morph has been reported for this genus. No molecular sequence data is available, and therefore fresh collections are needed to confirm the phylogeny. In this study, we accept this genus in *Botryosphaeriaceae* based on morphology.

Generic type: *Sivanesania rubi* W.H. Hsieh & Chi Y. Chen

Spencermartinsia A.J.L. Phillips, A. Alves & Crous, Persoonia 21: 51 (2008)

MycoBank: MB511762

Saprobic or *endophytic* on plants. *Ascostromata* black, multilocular, solitary or in botryose clusters, immersed, erumpent, with four to numerous locules, with individual ostioles, cells of ascostromata of brown-walled *textura angularis*. *Peridium* of locules two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, septate, constricted at septa. *Asci* 8–spored, bitunicate, fissitunicate, clavate, pedicellate, with an ocular chamber. *Ascospores* hyaline to brown, uniseptate with an apiculus at each end. *Conidiomata* stromatic. *Conidiogenous cells* lining inner surface of conidiomata, cylindrical to broadly lageniform, holoblastic. *Conidia* hyaline to brown, oblong to subcylindrical, septate, constricted at the septum, thick-walled, often with a truncate base.

Notes: Phillips et al. (2008) introduced *Spencermartinsia* as a monotypic genus for *S. viticola* (A.J.L. Phillips & J. Luque) A.J.L. Phillips, A. Alves & Crous. It is close to *Botryosphaeria iberica* and *B. sarmentorum* due to the similar morphology of asexual morph “Dothiorella”. However, they can be distinguished by their ascospores as in *S. viticola* ascospores have a rounded projection at the tip and base. When the new genus *Spencermartinsia* was introduced, *Dothiorella viticola* was reclassified as *S. viticola* (Phillips et al., 2008). Subsequently, Pérez et al. (2010) described the second species, an endophyte, *Spencermartinsia uruguayensis* C.A. Pérez, R.A. Blanchette, B. Slippers & M.J. Wingfield, based on the phylogeny and morphology of the asexual morph formed in culture. *Spencermartinsia* formed a complex group with *Dothiorella* and as it is difficult to distinguish them based on asexual-morphs, a combined gene phylogenetic analysis has thus been used to differentiate these genera. In this study, *Dothiorella* and *Spencermartinsia* have been shown to be distinct genera in *Botryosphaeriaceae* (Fig. 4.1).

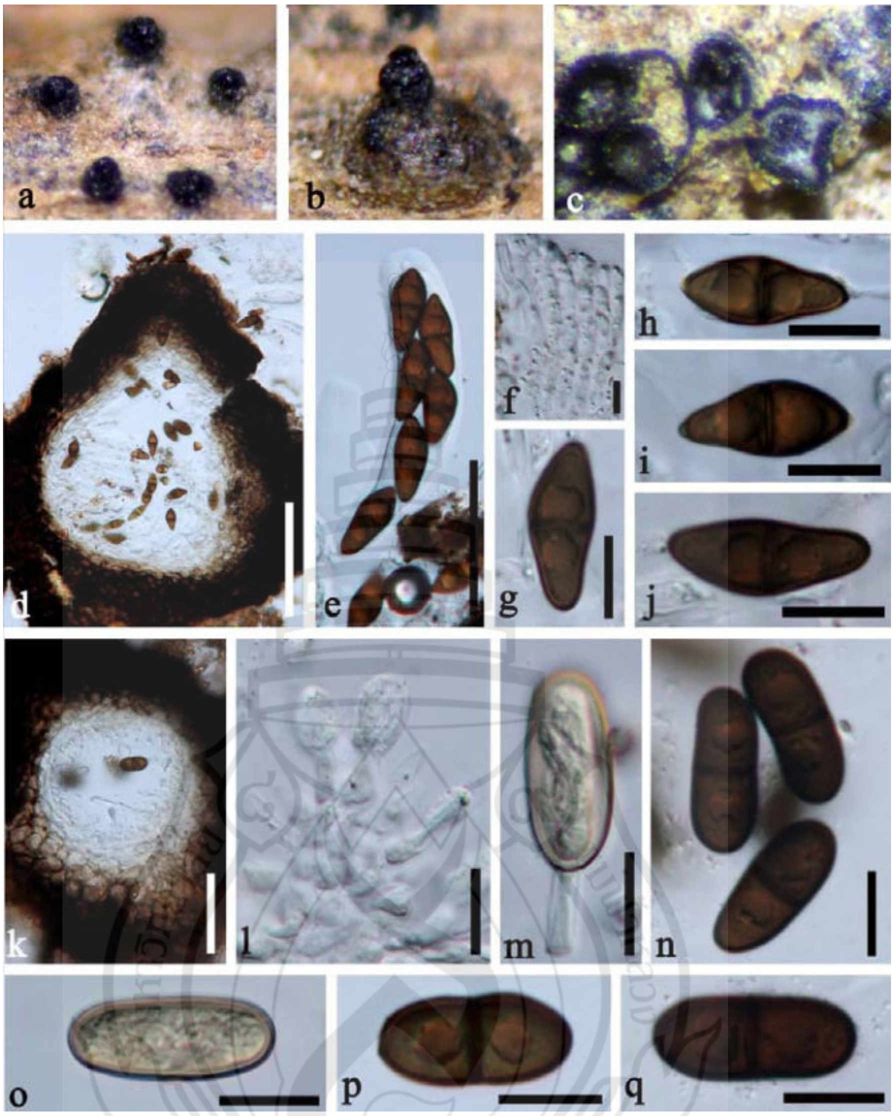
Spencermartinsia viticola (A.J.L. Phillips & J. Luque) A.J.L. Phillips, A. Alves & Crous, Persoonia 21: 51 (2008)

MycoBank: MB511763 (Fig. 4.19)

Saprobic on canes of *Vitis*. *Ascostromata* black, pseudothecial, solitary or in botryose clusters, initially immersed in host, erumpent at maturity, multilocular, with four to numerous locules, with individual ostioles, *Ostiole* circular, central, papillate;

up to 40 µm thick, dark brown comprising cells of thick-walled *textura angularis*, cells of ascostromata brown-walled *textura angularis*. *Peridium* of locules two-layered, outer layer composed of small heavily pigmented thick-walled cells of *textura angularis*, inner layer composed of hyaline thin-walled cells of *textura angularis*. *Pseudoparaphyses* hyphae-like, septate, slightly constricted at septum, up to 3−4 µm wide. *Asci* 100–110 × 25–30 µm, 8–spored, bitunicate, fissitunicate, clavate, pedicellate, with a well-developed ocular chamber, arising from base of the ascoma. *Ascospores* irregularly biseriate, 21−24 × 9−11.5 µm, 1–septate, brown to dark brown, ovate to subclavate, slightly constricted at septum, thick-walled, often with a small rounded projection at the apex and base, with basal cell tapering into an obtuse base. *Conidiomata* pycnidial, black, separate or aggregated into botryose clusters, immersed, then erumpent, spherical to globose, unilocular, thick-walled, wall of three layers of dark brown cells *textura angularis*. *Ostiole* single, central, circular. *Conidiophores* hyaline, cylindrical. *Conidiogenous cells* discrete or integrated, holoblastic, hyaline, smooth, cylindrical to broad lageniform. *Conidia* 17−21 × 9−10 µm brown, oblong to sub-cylindrical, septate, slightly constricted at septum, thick-walled, often with a truncate base.

Material examined: SPAIN, Catalonia, Vimbodí, near the Monastery of Poblet, on pruned canes of *Vitis vinifera* cv. Garnatxa Negra, 12 Aug. 2004, J. Luque & S. Martos, (LISE 95177, holotype).



Note. a–c Ascostromata on host substrate, note the cross section in surface view in c. d Section through ascostromata and peridium e Ascus. f Pseudoparaphyses. g–j Ascospores. k Section through conidioma. l–m Conidiogenous cells and developing conidia. n–q Dark brown conidia with 1–septa and light brown young aseptate conidia. Scale Bars: d = 100 µm, e = 50 µm, f–j = 10 µm, k = 50 µm, l–q = 10 µm

Figure 4.19 *Spencermartinsia viticola* (LISE 95177, holotype)

Vestergrenia Rehm, Hedwigia 40: 101 (1901)

MycoBank: MB5733

Saprobic on leaves. *Ascostromata* solitary, scattered, or in small groups, especially forming on leaf veins, superficial, subglobose or globose, black, coriaceous. *Peridium* composed of a single stratum, comprising 3–4 layers of brown pseudoparenchymatous cells of *textura angularis/globulosa*. *Pseudoparaphyses* not observed*.* *Asci* 8–spored, bitunicate, broadly clavate to ovoid, with a long pedicel, apically rounded with an ocular chamber. *Ascospores* irregularly 2–3–seriate, hyaline, aseptate, ellipsoidal-ovoid. *Asexual state* not established.

Notes: This appears to be a poorly studied genus with the last species, *Vestergrenia ixorae* C. Ramesh, being described in 1988 (Ramesh 1988). The genus has 23 epithets (*Index Fungorum*, MycoBank). *Vestergrenia* was introduced by Rehm (1901) in the "Sphaeriaceae" as a monotypic genus represented by *V. nervisequia*. Luttrell (1973) transferred this genus into *Dothideaceae* based on separate ascomata, broad-clavate to ovoid asci which lie in long, slender stalks of varying lengths and standing at differing heights in the locule and unicellular ascospores. There has been no phylogenetic study of this genus to confirm its taxonomic placement in *Dothideaceae*. However, the generic type is completely different to generic type of *Dothidea* where superficial pulvinate ascostromata contain numerous locules in an outer layer, and ascospores are 2-celled (Schoch et al., 2009a) The genus is more typical of *Botryosphaeriaceae* in having unicellular ascospores, widely clavate asci with distinct pedicels and ascomata with brown, relatively thick-walled cells of *textura angularis/globulosa*. We tentatively include *Vestergrenia* in *Botryosphaeriaceae* until fresh collections are made and this can be verified with phylogenetic analysis. The other species in the genus need examining to check their placement.

Generic type: *Vestergrenia nervisequia* Rehm.

Genera not studied

Aplosporella Speg., Anales Soc. Ci. Argent. 10: 157 (1880)

Possible synonyms

Epicyta Syd., Ann. Mycol. 24: 413 (1926)

Haplosporella subgen. *Pleosphaeropsis* (Died.) Petr. & Syd., Beih. Reprium nov. Spec. Regni veg. 42: 103 (1926)

Microhaplosporella Sousa da Câmara, Agron. lusit. 11: 63 (1949)

Pleosphaeropsis Died., Ann. Mycol. 14: 203 (1916)

Podosporium Bonord., Handb. Allgem. Mykol. 227 (1851)

Podosporium Sacc. & Schulzer, (1884)

Notes: A new species of *Aplosporella* was described by Damm et al. (2007b) and was shown to belong in *Botryosphaeriaceae.* Two species of *Aplosporella* cluster in *Botryosphaeriaceae* in Fig. 4.1 in this study. The genus appears to have no designated generic type and its 330 epithets are likely to be polyphyletic (Damm et al., 2007b) and thus the genus requires further study.

Dichomera Cooke, Nuovo G. Bot. Ital. 10: 24 (1878)

Notes: This genus has 48 epithets and has also been recorded as a synanamorph of some genera of *Botryosphaeriaceae* and requires a modern treatment.

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

Possible synonyms

Cryptosphaeria Grev., Scott. Crypt. Fl. 1: pl. 13 (1822)

Holcomyces Lindau, Verh. Bot. Ver. Prov. Brandenb. 45: 155 (1904)

Notes: This is a well-supported genus in *Botryosphaeriaceae* (Fig. 4.1). It has 1245 epithets and seriously needs a modern treatment. The type has been studied by Alves et al. (2004) and is characterized by erumpent conidiomata in which hyaline conidia develop which become pale brown (dark brown in some species) and 1–septate at maturity. The generic type *Diplodia mutila* Fr. has a "Botryosphaeria stevensii" sexual state.

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

Possible synonym

Macrophomopsis Petr., Ann. Mycol. 22: 108 (1924)

Notes: This is a well-supported genus in *Botryosphaeriaceae* (Phillips et al., 2005 and Fig. 4.1 in this study). The generic type is *Dothiorella pyrenophora* Berk. ex Sacc., Michelia 2(no. 6): 5 (1880) and the genus has 362 epithets and seriously needs a modern treatment. Jami et al. (2012) described two new species in the genus. There may be some confusion over the generic type which is listed under *Diplodia* in *Index Fungorum* and does not appear to have been recently treated or have sequence data.

Endomelanconiopsis E.I. Rojas & Samuels, Mycologia 100: 770 (2008)

Notes: This new genus was described as a distinct lineage of *Botryosphaeriaceae* based on multigene analysis of LSU, ITS and *TEF1*. The taxon was isolated as an endophyte from leaves of *Theobroma cacao* and a second species combined *Endomelanconium microsporum* Verkley & van der Aa (Rojas et al., 2008). The genus is distinct in having small brown ellipsoidal to limoniform conidia which are dark brown with a single longitudinal slit three-quarters of the length of the conidia when mature and hyaline microconidia.

Macrophomina Petr., Ann. Mycol. 21: 314 (1923)

Notes: Based on eight isolates of *Macrophomina phaseolina* (Tassi) Goid. This is a well-supported genus in *Botryosphaeriaceae* (Crous et al., 2006, Fig. 4.1 in this study). The generic type is *Macrophomina philippinensis* Petr. and has not been subjected to phylogenetic study. The genus has seven epithets and needs a modern treatment.

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

Possible synonyms

Microbotryodiplodia Sousa da Câmara, Agron. Lusit. 13: 206 (1951)

Syndiplodia Peyronel, Mem. R. Accad. Sci. Torino, Ser. 2 66(10): 35 (1915)

Notes: This genus is likely to be polyphyletic; the generic type *Microdiplodia conigena* Allesch. is linked to *Botryosphaeriaceae* in *Index Fungorum*. With 382 epithets this genus needs a modern treatment.

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

Notes: This is a well supported genus which has two species (Crous et al., 2006, Fig. 4.1 in this study) and a “Scytalidium”-like synanamorph (Pavlic et al., 2008; Madrid et al., 2009).

Pseudofusicoccum Mohali, Slippers & M.J. Wingf., Stud. Mycol. 55: 249 (2006)

Notes: This is a well-supported genus in *Botryosphaeriaceae* with six species (Crous et al., 2006, Pavlic et al., 2008, Fig 4.1 this paper).

Tiarosporella Höhn., Mitt. Bot. Inst. Tech. Hochsch. Wien 1(3): 82 (1924)

Notes: Jami et al., (2012) described one new species of *Tiarosporella* which is resolved in *Botryosphaeriaceae.* The generic type *Tiarosporella paludosa* (Sacc. & Fiori ex P. Syd.) Höhn. is, however, listed as an asexual state of *Darkera* (Helotiales) in *Index Fungorum*; and thus the four *Tiarosporella* species (Jami et al., 2012) in *Botryosphaeriaceae* may need a new genus to accommodate them depending on the placement of *Tiarosporella paludosa*.

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

Possible synonyms

Thyrostromella Syd., Ann. Mycol. 22: 406 (1924)

Wilsonomyces Adask., J.M. Ogawa & E.E. Butler, Mycotaxon 37: 283 (1990)

Notes: This genus comprises 22 epithets mostly linked to *Dothidotthia.* No generic type is presently listed and the genus needs a modern treatment.

Phylogenetic resolution of Botryosphaeriales

The 28S rRNA gene (LSU) has been shown to be suitable for distinguishing many ascomycetes at the generic level due to its relatively conserved nature (Crous et al., 2006; Schoch et al., 2006; Hibbett et al., 2007). By choosing comparisons of sequences of LSU, Crous et al. (2006) recognized ten lineages within the *Botryosphaeriaceae* and accepted several genera, including those genera with sexual and/or asexual morphs. Separate names were not introduced for morphs of the newly proposed genera when sexual and asexual morphs were known. With the addition of *TEF1* and β-tubulin genes, and molecular data being available for more botryosphaeriaceous taxa, it is now possible to use combined multi-gene data to resolve complex groups such as *Diplodia/Lasiodiplodia*, *Phaeobotryon/Barriopsis* and *Dothiorella/Spencermartinsia* which have yet to be resolved. In addition, new asexual genera and cryptic species have been introduced (Alves et al., 2008; Sakalidis et al., 2011). By combining *TEF1* and β-tubulin genes with ITS, Phillips et al. (2005, 2008) reinstated the genus *Neodeightonia* in the *Diplodia/Lasiodiplodia* complex and also showed that the latter asexual genera are morphologically and phylogenetically distinct.

ITS sequence data have been used to distinguish the species within the genera of *Botryosphaeriales* (Denman et al., 2000, 2003; Denman et al., 2003; Alves et al., 2004; Barber et al., 2005). However, it has not been possible to apply ITS alone in resolving species in this study, because *Botryosphaeriaceae* embodies species complexes. It is evident that at the generic level, the combined *TEF1* and β-tubulin gene analysis is best for delimiting genera of *Botryosphaeriaceae*, as well as the species in several genera of *Botryosphaeriales*. It has also been recommended that the *RPB2* gene should be considered in similar multi-combined genes analyses of genus and species levels of *Botryosphaeriales* (Pavlic et al., 2009a, b) and that some new approaches might be used for complex groups, such as Genealogical Sorting Index (GSI), which has been used to resolve the asexual morph of *Neofusicoccum* (Sakalidis et al., 2011).

Maximum Parsimonious (MP), Randomized Axelerated Maximum Likelihood (RAxML) and Mr. Bayes are models for generating phylogenetic trees and were used in this study. Most phylograms were similar when using different models, however the bootstrap values differed. RAxML and Mr. Bayes have been shown to be suitable models for phylogeny at higher taxonomic levels (class, order and family) and large data analysis (Hibbett et al., 2007; Schoch et al., 2009a, b; Suetrong et al., 2009; Liu et al., 2011; Zhang et al., 2012). Felsenstein (2004) suggested that the Bayesian methods are closely related to the likelihood methods, differing only in the use of a prior distribution of the quantity being inferred, which would typically be the tree. Maximum parsimony analysis has been shown to be a better method for establishing taxonomy at the family, genus and species levels. In the molecular data analysis, some of the new species taxonomic positions were not consistent when using the different methods. For example *Auerswaldia lignicola* clustered in the *Diplodia / Lasiodiplodia* clade in both Mr. Bayes and RAxML analysis, but with the *Dothiorella/Spencermartinsia* clade when using the Maximum Parsimony (MP) method. Furthermore, this only occurred in the combined multi-gene (LSU, SSU, *TEF1* and β-tubulin) analyses; however when combined *TEF1* and β-tubulin analysis was carried out they always clustered in the *Dothiorella / Spencermartinsia* clade. Maximum Parsimony may therefore be a better method for resolving the phylogeny and taxonomy in

Botryosphaeriales. We also recommend that LSU, *TEF1*, β-tubulin and *RPB2* genes should be sequenced for differentiating genera, while the latter three genes can resolve cryptic species.

Von Arx and Müller (1954) included 15 genera in *Botryosphaeriaceae* (Table 4.1). This study suggests that *Auerswaldia*, *Auerswaldiella*, *Botryosphaeria*, *Pyrenostigme* and *Vestergrenia* were correctly placed in the family, indicating that von Arx and Müller (1954) were remarkably astute in their understanding and observations. Many of the genera that von Arx & Müller (1954) included were subsequently removed from *Botryosphaeriaceae* by various researchers (Table 4.1) and in Lumbsch and Huhndorf (2010) only 11 genera were listed for the order. *Bagnisiella* is presently included in *Dothideaceae* (Lumbsch & Huhndorf 2010) as discussed above under *Auerswaldia*. *Cleistosphaeria* as represented by *C. macrostegia* Syd. & P. Syd. is presently included in *Parodiopsidaceae* (Lumbsch & Huhndorf, 2010). The ascospores are unicellular and typical of *Botryosphaeriaceae,* whereas the asci are unusual in being widely clavate and ascomata have a peridium comprising a single cell layer (S. Boonmee, pers. obs.). *Montagnellina* is now considered a synonym of *Phyllosticta* (= *Guignardia*) (Wikee et al., 2011a; Wong et al., 2012). *Muyocopron* is typical of *Botryosphaeriaceae* but the almost thyriothecoid ascomata are atypical and molecular data of Wu et al. (2011) exclude this genus. *Ellisiodothis* is treated as a synonym of *Muyocopron* in *Index Fungorum*, while *Microdothella* as represented by *M. culmicola* Syd. & P. Syd. is also probably a synonym. *Trabutia* is a synonym of *Phyllachora* (Barr 1987), while we have not been able to examine *Pilgeriella.* In the present study, we include 29 genera in *Botryosphaeriales*; this includes several genera (i.e. *Dothiorella* and *Phyllosticta*) whose name were previously based on the sexual morphs and thus not treated by von Arx & Müller (1954). *Planistromella* A.W. Ramaley*, Planistroma* A.W. Ramaley, *Mycosphaerellopsis* Höhn., and *Comminutispora* A.W. Ramaley with their asexual states appear to belong in *Botryosphaeriaceae* (J. Monkai et al., pers. comm.).

Otthia (Cooke 1871, 1890; Massee 1887; Stevens 1936; Bisby & Mason, 1940) which was introduced from *Ulmus* sp., with six species, but without a generic type being named (Fuckel 1870), might be considered for inclusion in *Botryosphaeriaceae.*

Booth (1958) selected a lectotype in *O. spiraeae* and considered *Diplodia sarmentorum* (Fr.) Fr. to be the asexual morph. Phillips et al. (2005) redescribed and illustrated *Otthia spiraeae* and placed *Diplodia sarmentorum* in a new species named *Botryosphaeria sarmentorum* A.J.L. Phillips, Alves & Luque. They considered the holotype of *Otthia spiraeae* and the specimen illustrated by Booth (1958) to be from different genera, with *O. spiraeae* having cylindrical asci with a thin endotunica, while Booth's specimen (Fig. 4.1 in Booth 1958) had clavate asci with a thick endotunica more typical of *Botryosphaeriaceae.* Schoch et al. (2009a) sequenced two strains named *Otthia spiraeae* from CBS (isolated from *Ulmus glabra* by K. & L. Holm in 1987, Sweden, Herbarium, UPS) and these clustered in *Botryosphaeriaceae* (see Fig. 4.1). However, it is not clear whether the strains used in Schoch et al. (2009a) were correctly identified and therefore the placement of *Otthia* (synonym = *Otthiella* (Sacc.) Sacc. & D. Sacc., Syll. Fung. (Abellini) 17: 662 1905) in *Botryosphaeriaceae* cannot be confirmed until fresh collections identical to the holotype are made and sequenced. It is evident however, that the *Dothiorella* Clade (Fig. 4.1, Clade A6) in our study, which includes the sequences from putative *Otthia* species, is a distinct genus.

The asexual morphs of *Botryosphaeriaceae* include species with brown, unicellular or bi-celled conidia (*Aplosporella*, *Diplodia*, *Dothiorella*, *Macrophomina*, *Neoscytalidium* and *Lasiodiplodia*) and species with hyaline conidia (*Fusicoccum*, *Neofusicoccum* and *Pseudofusicoccum*). In Table 4.1 we list the sexual morph against the asexual morph and provid an argument for which name should be used now that only a single name is available for each genus and taxon. Each plate was inoculated with more than three (generally five) single ascospores, derived cultures. We ensured this primarily to obtain secondary or dikaryotic mycelium, which enhanced the formation of sexual or asexual morphs.

It is evident that several groups of botryosphaeriaceous taxa are species complexes and these need to be resolved using multi-gene sequence analysis which should include protein genes. For example, the genus *Lasiodiplodia* is likely to comprise several species complexes (Burgess et al., 2006; Alves et al., 2008; Abdollahzadeh et al., 2010). Other genera which may also comprise species complexes are *Aplosporella, Botryosphaeria, Dothiorella, Neofusicoccum* and *Spencermartinsia*

(Phillips et al., 2005; Crous et al., 2006; Damm et al., 2007b; Pavlic et al., 2009a, b; Sakalidis et al., 2011). Cryptic species have also been resolved in several other pathogenic genera using multigene analysis including *Colletotrichum, Fusarium* and *Phyllosticta* (Hyde et al., 2010; Summerell et al., 2010, 2011; Cai et al., 2011; Ko-Ko et al., 2011; Wikee et al., 2011a, b; Damm et al., 2012a, b).

The data analysis indicates that the order *Botryosphaeriales* may comprise more families than the presently accepted *Botryosphaeriaceae* (Lumbsch & Huhndorf, 2010). Clades B could be represented by *Phyllostictaceae,* while Clade A splits into three major clades, A1-A3. Clade A1 comprises *Diplodia*, *Neodeightonia* and *Lasiodiplodia* and is characterized by dark brown, septate, striate conidia. Clade A2 comprises *Barriopsis*, *Phaeobotryon* and *Phaeobotryosphaeria*, and characterized by dark to dark brown, aseptate or 2-septate ascospores, with or without an apiculus. Clade A3 includes *Auerswaldia*, *Dothiorella* and *Spencermartinsia*. In these genera the ascospores become brown inside the asci, while the conidia become brown when still attached to the conidiogenous cells. Clade A6 (*Botryosphaeriaceae*) which includes the family type (*Botryosphaeria dothidea*) is characterized by hyaline, aseptate ascospores. We refrain from introducing new families for these clades at this stage until a larger dataset can confirm this.

4.4 Conclusion

In this study, the type specimens of 15 genera of *Botryosphaeriales* have been re-examined, 124 strains, representing 20 genera of *Botryosphaeriaceae* with sequence data to derive a modern treatment for the order, and 29 genera were assigned to the family *Botryosphaeriaceae*. Five new species *Auerswaldia dothiorella A. lignicola*, *Botryobambusa fusicoccum*, *Botryosphaeria fusispora*, *Cophinforma eucalypti* collected from Thailand were introduced. The type sepcies of each genus was described with the type materials and fresh collection, the asexual and sexual morphs were linked for available genera. This study advanced the understanding of *Botryosphaeriales* and provided a natural classification of the order. The results of this study also suggested that there is, however, still much research to be carried out with resolution of families and genera, linkage of sexual and asexual morphs and differentiation of cryptic species in the Botryosphaeriales.

CHAPTER 5

Roussoellaceae, A NEW PLEOSPORALEAN FAMILY TO ACCOMMODATE THE GENERA *Neoroussoella* *Roussoella* AND *Roussoellopsis*

5.1 Introduction

The *Pleosporales* is the largest order in the class *Dothideomycetes*, including 43 families, 332 genera and more than 4700 species (Kirk et al., 2008; Lumbsch & Huhndorf, 2009; Schoch et al., 2009a, b; Hyde et al., 2013). Most taxa were previously included in *Dothideomycetes* based on morphology. Many important taxonomic studies on this large and difficult group of *Ascomycota* incorporating molecular phylogeny have been published (Crous et al., 2006, 2009, 2012; Zhang et al., 2008, 2009a, 2009b, 2012, 2013; Schoch et al., 2009a, 2009b; Tanaka et al., 2009; Gruyter et al., 2010, 2012; Boonmee et al., 2011; Chomnunti et al., 2011; Liu et al., 2011, 2012; Manamgoda et al., 2011; Hyde et al., 2013; Woudenberg et al., 2013). However, several groups are not well-resolved because of few collections, lack of recent studies, and most importantly lack of molecular sequence data.

Roussoella was introduced with the type species *R. nitidula* Sacc. & Paol., recorded from the bamboo in Malacca (Saccardo & Paoletti, 1888). Rick (1906) described a second species, *R. amphigena* Rick, which was then synonymised under *Systremma amphigena* (Rick) Theiss. & Syd. (Thiessen & Sydow, 1915). Höhnel (1919) proposed *Roussoella hysterioides* as the type species of *Roussoella* as an earlier name was found in *Dothidea hysterioides*; this combination was accepted by Müller and von Arx (1962). The latter authors assigned *Roussoella* to *Amphisphaeriaceae*, a family characterized by broad, cylindrical, unitunicate asci, immersed ascostromata, and two-celled, brown ascospores. Aptroot (1995a) described the asci in *Roussoella* as unitunicate and transferred three species to this genus. Aptroot (1995b), however, modified his concept of *Roussoella* and considered the asci to be bitunicate.

Ascomycetes on bamboo and palms are commonly observed with immersed ascomata containing long, cylindrical, thin asci and brown, 1-septate, ornamented ascospores; this might have caused the above confusion. Hyde et al. (1996) discussed these, and two groups with these characteristics were commonly observed, the first group (*Roussoella*) the ascomata form under a darkened raised dome-shaped stroma, while the asci appear to be bitunicate in structure, but lacking fissitunicate dehiscence and a blue staining ring; while paraphyses are also narrow (Hyde et al., 1996). In the second group (*Amphisphaeria*-like) the ascomata are immersed under disk-like clypei, while the asci are also thin-walled, but with a blue staining ring; the paraphyses are relatively wide, irregular and embedded in a gelatinous matrix. However, in both groups the ascospores are very similar; collections of taxa from both groups have probably been considered as *Roussoella*.

Based on the examination of type species material of *Roussoella*, Eriksson (1984) placed the genus in *Didymosphaeriaceae* and this assignment was followed in the *Outline of the Ascomycota* 2009 (Lumbsch & Huhndorf, 2010). Hyde et al. (1996) examined the type material of *Dothidea hysterioides* and used *R. hysterioides* as the type species; and included an account of *Roussoella*, and its asexual morph *Cytoplea.* The asexual state formed in culture and both states were found on the host. Aptroot (1995b) also found the asexual morph *Cytoplea* formed in a culture of *Roussoella hysterioides*. Ju et al. (1996) introduced two new species and three new combinations and provided a key to the genus. Subsequently, Hyde (1997) reviewed the genus and provided a modified key for *Roussoella* species. *Roussoellopsis* was introduced by Hino and Katumoto (1965), typified by *Ro. japonica* (I. Hino & Katum.) I. Hino & Katum., and there are currently three species in this genus all of which were transferred from *Didymosphaeria* (Hino & Katumoto, 1954, 1965). Schoch et al. (2009a) and Tanaka et al. (2009) presented the first molecular data to show that *Roussoella* and *Roussoellopsis* clustered together with *Arthopyreniaceae* in *Dothideomycetes*, but these studies did not place the genera in any family.

This study re-evaluated the taxonomic and phylogenetic status of *Roussoella* and *Roussoellopsis* species and their phylogenetic relationships with other genera or families of *Pleosporales* using multi-locus sequence data. A new family is proposed to accommodate the genera *Neoroussoella*., *Roussoella* and *Roussoellopsis,* and the type species *Roussoella nitidula* of the genus is epitypified, *Neoroussoella bambusae*, *R. chiangraina*, *R. japanensis*, *R. neopustulans*, *R. siamensis*, *R. thailandica* and *R. verrucispora* are described as new species and *R. intermedia*, *R. pustulans*, *R. scabrispora*, *Ro. japonica*, *Ro. macrospora* and *Ro. tosaensis* are redescribed.

5.2 Materials and Methods

5.2.1 Collection and Examination of Specimens

Fresh materials of eight species were collected from bamboo and palms in northern Thailand during 2009 to 2012, and returned to the laboratory in paper envelopes or plastic bags. In most cases, ascomata were collected directly from natural substrates without incubation. The samples were processed and examined following the methods described by Taylor and Hyde (2003). The specimens were observed and examined under a Motic SMZ 168 Series stereomicroscope. Micro-morphological images were captured using a Nikon ECLIPSE 80i compound microscope with a Canon EOS 550D digital camera. Indian ink was added to water mounts to detect the presence of gelatinous sheaths or ascospore appendages. Measurements were made with the Tarosoft (R) Image Frame Work version 0.9.7 (Liu et al., 2010). Herbarium specimens were loaned from PAD and YAM.

Isolations were made from single ascospores. Ascomata were cut horizontally and the contents transferred to a drop of sterile water on a flamed microscope slide. A portion of this was taken and spread over a few square centimeters of a Petri dish containing 2% water agar (WA) and then incubated at 25 °C overnight. The next day individual germinating spores were transferred to fresh PDA media (Alves et al., 2006). The holotypes are deposited at the herbaria of Mae Fah Luang University (MFLU), Chiang Rai, Thailand and Hirosaki University (HHUF), Japan. Fungi isolated in our study were deposited at Mae Fah Luang University Culture Collection (MFLUCC), the Japan Collection of Microorganisms (JCM), and the National Biological Resources Center, Japan (NBRC).

5.2.2 DNA Extraction, PCR Amplification and Sequencing

Total genomic DNA was extracted from fresh fungal mycelium grown on MEA/PDA media agar at 25-27 °C. The Biospin Fungus Genomic DNA Extraction Kit (BioFlux®, Hangzhou, and P.R. China) was used to extract DNA according to the manufacturer's instructions.

DNA amplification was performed by polymerase chain reaction (PCR). Four partial gene portions were used in this study: the large subunits of the nuclear ribosomal RNA genes (LSU), the internal transcribed spacers (ITS) and two protein coding genes, namely the translation elongation factor 1-alpha gene (*TEF1*) and the partial RNA polymerase second largest subunit (*RPB2*). The primers used were LROR and LR5 (Vilgalys & Hester, 1990) for LSU, ITS5 and ITS4 (White et al., 1990) for ITS, EF1-983F and EF1-2218R (Rehner 2001) for *TEF1* and fRPB2-5F and fRPB2-7cR (Liu et al., 1999) for *RPB2*. The PCR thermal cycle program for ITS, LSU and *TEF1α* amplification were as follows: initially 94 °C for 3 mins, followed by 35 cycles of denaturation at 94 °C for 30 seconds, annealing at 55 °C for 50 seconds, elongation at 72 °C for 1 mins, and final extension at 72°C for 10 mins. The PCR thermal cycle program for the partial RNA polymerase second largest subunit (*RPB2*) was followed as initially 95 °C for 5 mins, followed by 40 cycle of denaturation at 95 °C for 1 mins, annealing at 52 °C for 2 mins, elongation at 72 °C for 90 seconds, and final extension at 72°C for 10 mins.

PCR products were then purified using minicolumns, purification resin and buffer according to the manufacturer's protocols (Amersham product code: 27–9602–01). The sequences were carried out by Shanghai Sangon Biological Engineering Technology and Services Co., Ltd (Shanghai, P.R. China).

5.2.3 Phylogenetic Analysis

Sequences generated from different primers were analyzed with other sequences obtained from GenBank. A Blast search was performed to reveal the closest matches with taxa in *Pleosporales*. Sequences were aligned using Bioedit (Hall 1999) and ClustalX v. 1.83 (Thompson et al., 1997). The alignments were checked visually and improved manually where necessary. Phylogenetic analyses were performed by using PAUP v. 4.0b10 (Swofford 2002) for Maximum-parsimony (MP) and MrBayes v. 3.0b4 (Hambleton et al., 2003, Ronquist & Huelsenbeck 2003) for Bayesian analyses.

The analyses of Maximum likelihood (RAxML), Maximum Parsimony and Bayesian were performed as in Chapter3 (3.2.1).

Table 5.1 Fungal isolates of *Pleosporales* used in this study

Taxon	**Isolates**	**GenBank accession numbers**			
		ITS	**LSU**	***TEF1***	***RPB2***
Aigialus grandis	BCC 18419		GU479774	GU479838	GU479813
Aigialus mangrovis	BCC 33564		GU479777	GU479841	GU479816
Alternaria alternata	CBS 916.96		DQ678082	DQ677927	DQ677980
Bambusicola massarinia	MFLUCC 11-0389		JX442037		
Bambusicola splendida	MFLUCC 11-0439		JX442038		
Biatriospora marina	CY 1228		GQ925848	GU479848	GU479823
Bimuria novae-zelandiae	CBS 107.79		AY016356	DQ471087	DQ470917
Byssothecium circinans	CBS 675.92		AY016357	GU349061	DQ767646
Cochliobolus heterostrophus	CBS 134.39		AY544645	DQ497603	DQ247790
Cucurbitaria berberidis	CBS 394.84		GQ387605		
Decaisnella formosa	BCC 25617		GQ925847	GU479850	GU479824
Dothidea insculpta	CBS 189.58		DQ247802	DQ471081	AF107800
Dothidotthia aspera	CPC 12933		EU673276		
Dothidotthia symphoricarpi	CBS 119687		EU673273		
Entodesmium rude	CBS 650.86		GU301812	GU349012	
Fissuroma aggregata	KT 984		AB524591	AB539105	AB539092
Fissuroma maculans	MFLUCC 10-0886		JN846724		
Halojulella avicenniae	BCC 18422		GU371823	GU371816	GU371787
Halojulella avicenniae	BCC 20173		GU371822	GU371815	GU371786
Halotthia posidoniae	BBH 22481		GU479786		
Helicascus nypae	BCC 36752		GU479789	GU479855	GU479827
Herpotrichia diffusa	CBS 250.62		DQ678071	DQ677915	DQ677968
Herpotrichia juniperi	CBS 200.31		DQ678080	DQ677925	DQ677978
Kalmusia scabrispora	NBRC 106237		AB524594	AB539107	AB539094
Karstenula rhodostoma	CBS 690.94		GU301821	GU349067	GU371788
Keissleriella cladophila	CBS 104.55		GU301822	GU349043	GU371735
Lentithecium aquaticum	CBS 123099		GU301823	GU349068	GU371789
Lentithecium fluviatile	CBS 122367		GU301825	GU349074	
Leptosphaeria biglobosa	CBS 303.51		GU301826	GU349010	
Leptosphaerulina australis	CBS 317.83		GU301830	GU349070	GU371790
Leptosphearia maculans	DAOM 229267		DQ470946	DQ471062	DQ470894
Lophiostoma macrostomoides	GKM 1033		GU385190	GU327776	
Massarina eburnea	CBS 473.64		GU301840	GU349040	GU371732
Mauritiana rhizophorae	BCC 28866		GU371824	GU371817	GU371796
Melanomma pulvis-pyrius	CBS 124080		GU456323	GU456265	GU456350
Montagnula opulenta	CBS 168.34		DQ678086		DQ677984
Morosphaeria ramunculicola	JK 5304B		GU479794		GU479831
Neoroussoella bambusae	MFLUCC 11-0124	KJ474827	KJ474839	KJ474848	KJ474856
Paraphaeosphaeria michotii	CBS 591.73		GU456326	GU456267	GU456352
Phaeodothis winteri	CBS 182.58		GU301857	DQ677917	
Phaeosphaeria oryzae	CBS 110110		GQ387591		

Table 5.1 (continued)

Taxon	Isolates	GenBank accession numbers			
		ITS	LSU	*TEF1*	*RPB2*
Phoma exigua	CBS 431.74		EU754183	GU349080	GU371780
Phoma herbarum	CBS 276.37		DQ678066	DQ677909	DQ677962
Pleomassaria siparia	CBS 279.74		DQ678078	DQ677923	DQ677976
Pleospora herbarum	CBS 191.86		DQ247804	DQ471090	DQ247794
Polyplosphaeria fusca	CBS 125425		AB524607	AB524822	
Preussia lignicola	CBS 264.69		GU301872	GU349027	GU371765
Pseudotetraploa curviappendiculata	CBS 125426		AB524610	AB524825	
Pyrenochaeta nobilis	CBS 407.76		DQ678096	DQ677936	DQ677991
Pyrenophora phaeocomes	DAOM 222769		DQ499596	DQ497607	DQ497614
Phoma exigua	CBS 431.74		EU754183	GU349080	GU371780
Phoma herbarum	CBS 276.37		DQ678066	DQ677909	DQ677962
Pleomassaria siparia	CBS 279.74		DQ678078	DQ677923	DQ677976
Pleospora herbarum	CBS 191.86		DQ247804	DQ471090	DQ247794
Polyplosphaeria fusca	CBS 125425		AB524607	AB524822	
Preussia lignicola	CBS 264.69		GU301872	GU349027	GU371765
Pseudotetraploa curviappendiculata	CBS 125426		AB524610	AB524825	
Pyrenochaeta nobilis	CBS 407.76		DQ678096	DQ677936	DQ677991
Pyrenophora phaeocomes	DAOM 222769		DQ499596	DQ497607	DQ497614
Quadricrura septentrionalis	CBS 125428		AB524617	AB524832	
Rimora mangrovei	JK 5246A		GU301868		GU371759
Roussoella chiangraina	MFLUCC 10-0556	KJ474828	KJ474840	KJ474849	KJ474857
Roussoella intermedia	NBRC 106245	KJ474831	AB524624		
Roussoella japanensis	MAFF 239636	KJ474829	AB524621	AB539114	AB539101
Roussoella neopustulans	MFLUCC 11-0609	KJ474833	KJ474841	KJ474850	
Roussoella nitidula	MFLUCC 11-0634	KJ474834	KJ474842	KJ474851	KJ474858
Roussoella nitidula	MFLUCC 11-0182	KJ474835	KJ474843	KJ474852	KJ474859
Roussoella pustulans	MAFF 239637	KJ474830	AB524623	AB539116	AB539103
Roussoella scabrispora	MFLUCC 11-0624	KJ474836	KJ474844	KJ474853	KJ474860
Roussoella siamensis	MFLUCC 11-0149	KJ474837	KJ474845	KJ474854	KJ474861
Roussoella thailandica	MFLUCC 11-0621	KJ474838	KJ474846		
Roussoella verrucispora	CBS 125434	KJ474832	AB524622	AB539115	AB539102
Roussoellopsis macrospora	MFLUCC 12-0005		KJ474847	KJ474855	KJ474862
Roussoellopsis sp	NBRC 106246		AB524626		
Roussoellopsis tosaensis	MAFF 239638		AB524625	AB539117	AB539104
Setomelanomma holmii	CBS 110217		GU301871	GU349028	GU371800
Sporormiella minima	CBS 524.5		DQ678056	DQ677897	DQ677950
Tetraplosphaeria sasicola	MAFF 239677		AB524631		
Trematosphaeria pertusa	CBS 122368		FJ201990	GU456276	FJ795476
Trematosphaeria pertusa	CBS 122371		FJ201992	GU349085	GU371801
Triplosphaeria maxima	MAFF 239682		AB524637		
Versicolorisporium triseptatum	JCM 14775	AB365596	AB330081		

Note. Abbreviations of isolates and culture collections. **BCC:** BIOTEC Culture Collection, Bangkok, Thailand; **CBS:** Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands; **CMW:** Tree Pathology Co-operative Program, Forestry and Agricultural Biotechnology Institute, University of Pretoria, South Africa; **CPC:** Collection of Pedro Crous housed at CBS; **DAOM:** Plant Research Institute, Department of Agriculture (Mycology), Ottawa, Canada; **JCM**: the Japan Collection of Microorganisms, Japan; **MAFF**: Ministry of Agriculture, Forestry and Fisheries, Japan; **MFLUCC:** Mae Fah Luang University Culture Collection, ChiangRai, Thailand; **NBRC**: NITE Biological Resource Centre, Japan; **GKM**: G.K. Mugambi; **JK**: J. Kohlmeyer; **KT**: K. Tanaka.

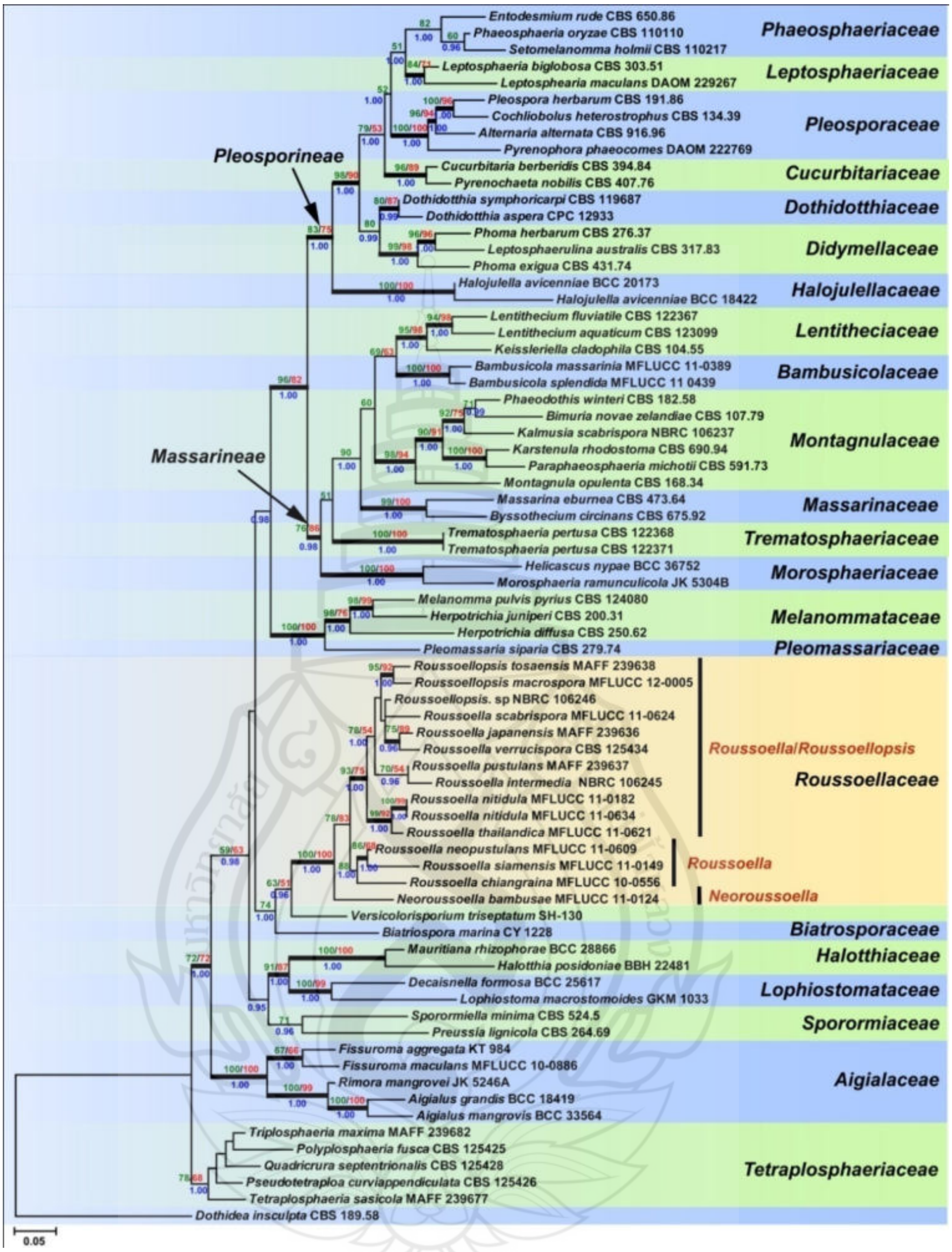
5.3 Results and Discussion

5.3.1 Phylogenetic Analysis

The combined LSU, *TEF1* and *RPB2* data set comprises 73 taxa with *Dothidea insculpta* as the outgroup taxon. The dataset comprises 3,101 characters after alignment, 1,750 characters were constant, and 1,062 characters were parsimony informative, while 289 variable characters are parsimony-uninformative. Bayesian, RAxML and Maximum parsimony (MP) analysis of the combined dataset resulted in phylogenetic reconstructions with largely similar topologies, and the best scoring RAxML tree is shown in Fig. 5.1. The most parsimony tree resulted from ITS sequences of 12 *Roussoella*-like taxa is shown in Fig. 5.2.

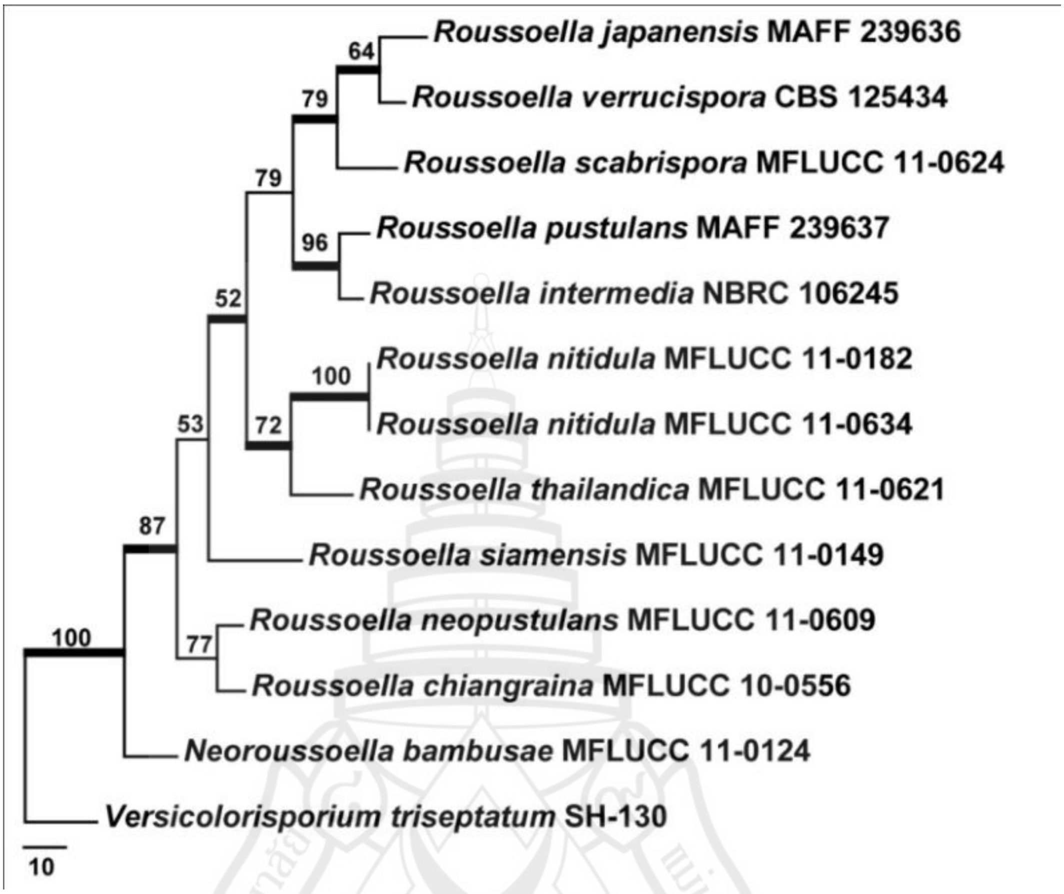
Most of the core families of *Pleosporales* (Hyde et al., 2013) are included in our phylogenetic analysis (Fig. 5.1), and two suborders *Massarineae* and *Pleosporineae* are represented with well-supported clades. Our eight strains of *Neoroussoella*, *Roussoella* and seven referenced sequences of *Roussoella* and *Roussoellopsis* from previous studies (Schoch et al., 2009a; Tanaka et al., 2009; Phookamsak et al., 2014 in press) formed a well-supported clade (100% BS/1.00 PP) named *Roussoellaceae*. They show a close relationship with *Versicolorisporium triseptatum* and *Biatriosporaceae*; the latter family was introduced for the monotypic genus *Biatriospora* (Hyde et al., 2013). The recently introduced bambusicolous fungal families *Bambusicolaceae* and *Tetraplosphaeriaceae* (Tanaka et al., 2009; Hyde et al., 2013) were also included in the phylogenetic analysis to understand the phylogenetic relationships between these bambusicolous fungi; however the phylogenetic reconstructions based on the combined datasets analysis showed that *Bambusicolaceae* clustered in the suborder *Massarineae* and *Tetraplosphaeriaceae* appeared as a basal lineage of the main families of *Pleosporales*, and did not show any close relationship with *Roussoellaceae*.

Three main clades could be distinguished within the *Roussoellaceae* corresponding to section *Roussoella*/*Roussoellopsis* (93% BS/1.00 PP), *Roussoella* (88% BS/1.00 PP) and *Neoroussoella* respectively. The *Roussoella*/*Roussoellopsis* clade formed two well-supported subclades. The first subclade includes five species of *Roussoella* and three species of *Roussoellopsis*. The second subclade comprised



Note. RAxML tree based on a combined LSU, *TEF1* and *RPB2* sequence dataset. Bootstrap support values for maximum likelihood, maximum parsimony and Bayesian posterior probabilities are given above and below the nodes respectively.

Figure 5.1 Phylogram generated from RAxML analysis



Note. The most parsimony tree obtained from a heuristic search with 1000 random taxon additions of ITS sequences alignment (524bp) using PAUP v. 4.0b10. The scale bar shows 10 changes. Bootstrap support values for maximum parsimony (MP) greater than 50 % are indicated above the nodes, and Bayesian posterior probabilities greater than 0.95 are thickness.

Figure 5.2 Phylogram generated from Maximum Parsimony analysis

Roussoella nitidula, the type species of *Roussoella*, plus a new species introduce herein, and this subclade is always stable in all phylogenetic reconstructions based on both the individual single gene (LSU, *TEF1* and *RPB2*) and combined gene (LSU, *TEF1* and *RPB2*) datasets analyses. The *Roussoella* clade includes three species and all of them are introduced herein; they share similar morphology but have distinct phylogenetic resolution. The *Neoroussoella* clade is monotypic with *N. bambusae*. Individual analysis of LSU, *TEF1* and *RPB2* data sets showed two main phylogenetically distinct clades, the *Roussoella*/*Roussoellopsis* and *Roussoella* clades. Bayesian, RAxML and Maximum parsimony analyses of individual LSU and *TEF1* datasets (trees not shown) did not show *Neoroussoella bambusae* to be a distinct taxon within the *Roussoellaceae*, where it clustered in the *Roussoella* clade. The ITS and *RPB2* gene dataset however, strongly supported *Neoroussoella* as a monotypic genus in the *Roussoellaceae,* as did combined datasets. The phylogenetic reconstructions resulted from Maximum parsimony and Bayesian analyses based on ITS gene sequences of 12 *Roussoella*-like taxa strongly supported the identifications of the fresh and referenced specimens.

5.3.2 Taxonomy

Roussoellaceae J.K. Liu, Phookamsak, D.Q. Dai & K.D. Hyde., Fungal Diversity 63: 225 (2013)

MycoBank MB 804651

Type genus: *Roussoella* Sacc.

Saprobic on decaying bamboo culms or palm branches. *Ascostromata* semi-immersed or immersed, forming under darkened, slightly raised, somewhat linear or dome-shaped ascostroma, with a flush intra-epidermal papilla, solitary or gregarious; in vertical section subglobose with a flattened base, with a clypeus. *Peridium* comprising several layers of elongate cells with interdispersed brown melanin particles, dark brown at the outside. *Hamathecium* comprising numerous, hypha-like, septate, straight pseudoparaphyses, narrowing towards the ends, anastoming above the asci and embedded in a gelatinous matrix. *Asci* 4 to 8-spored, bitunicate, cylindrical to clavate, with a short or long knob-like pedicel, often relatively thin-walled, apically rounded, with or without an ocular chamber. *Ascospores* overlapping uniseriate or biseriate, fusiform-ellipsoidal, straight, 2-celled, constricted at the septum, brown to dark brown, ornamented and surrounded by a wide mucilaginous sheath. *Asexual state* is linked to *Cytoplea* and *Melanconiopsis* or “Neomelanconium”-like. *Conidiomata* pycnothyrial, semi-immersed, subglobose, dark-brown to black, multilocular, locules separated by vertical columns of darkly pigmented pseudoparenchyma. *Peridium* comprising several layers of brown to dark brown cells of *textura angularis*. *Conidiophores* reduced to *conidiogenous cells*, annellidic to holoblastic, discrete, hyaline, cylindrical to ellipsoidal, smooth, formed from cells lining the innermost later of the pycnidium. *Conidia* globose, oblong or ellipsoidal, base truncate, narrower towards the apex, aseptate or septate, often biguttulate, hyaline, brown or black, thick-walled, smooth-walled, minutely warty, sometimes surrounded by an entire gelatinous material.

Notes: *Roussoellaceae* includes three genera, namely *Neoroussoella, Roussoella* and *Roussoellopsis*. This family is characterized as having semi-immersed to immersed, solitary or gregarious, clypeate ascostromata containing trabeculate pseudoparaphyses embedded in a gel matrix, long cylindrical to clavate bitunicate asci with or without obvious fissitunicate dehiscence and brown, 2-celled ornamented ascospores. All the strains of *Roussoellaceae* formed a well-supported (100% BS/1.00 PP) clade within the order *Pleosporales*. The phylogenetic relationship between three genera of *Roussoellaceae* is still not completely resolved and an extensive taxon sampling is required to address the diversity in this family.

Roussoella Sacc., Atti dell´Istituto Veneto Scienze, 6: 410, 1888.

Type species. *Roussoella nitidula* Sacc. & Paol.

Saprobic on decaying bamboo culms or palms branches. *Ascostromata* semi-immersed to immerse under a clypeus darkened, slightly raised, somewhat liner or dome-shaped ascostroma, with a flush intra-epidermal papilla on host surface, gregarious; in vertical section subglobose with a flattened base. *Peridium* comprising several layers of elongate cells with interdispersed brown melanin particles, dark brown at the outside. *Hamathecium* 1-2 µm diam., comprising numerous, anastoming, hypha-like, septate, straight, cellular pseudoparaphyses, narrowing towards the ends, branching at the apex, embedded in a gelatinous matix. *Asci* 4 to 8-spored, bitunicate, cylindrical, apically rounded, with a distinct ocular chamber. *Ascospores* overlapping uniseriate, fusiform-ellipsoidal, straight, 2-celled, constricted at the septum, brown, ornamented and surrounded by a wide mucilaginous sheath. *Asexual state* is linked to *Cytoplea* (Hyde et al., 1996). *Conidiomata* pycnothyrial, superficial or semi-immersed, subglobose, dark-brown to black, multilocular, locules separated by vertical columns of darkly pigmented pseudoparenchyma. *Peridium* comprising several brown to dark brown layers with cells of *textura angularis*. *Conidiophores* reduced to *conidiogenous cells*, holoblastic discrete, hyaline, cylindrical to ellipsoidal, smooth, formed from cells lining the innermost later of the pycnidium. *Conidia* oblong ellipsoidal, narrower towards the apex, brown, thick-walled, often biguttulate, minutely warty.

Notes: *Roussoella* is a genus occurring on monocotyledons (mainly palms and bamboo), with 12 accepted species (Ju et al., 1996; Hyde 1997; Hyde et al., 1999; Zhou et al., 2003), and is characterized by immersed, gregarious, clypeate ascostromata containing trabeculate pseudoparaphyses embedded in a gel matrix, long cylindrical bitunicate asci without obvious fissitunicate dehiscence and brown, 2-celled ornamented ascospores (Saccardo & Paoletti, 1888; Höhnel 1919; Müller & Arx, 1962; Hyde et al., 1996,1999; Zhou et al., 2003). There is confusion concerning the type species of *Roussoella* (Saccardo & Paoletti, 1888; Höhnel 1919; Müller & Arx, 1962). The genus was introduced by Saccardo and Paoletti (1888) with *R. nitidula* as the type species. Höhnel (1919) found an earlier name in *Dothidea hysterioides* Ces., and transferred it to *Roussoella hysterioides* (Ces.) Höhn. Later authors (Müller & Arx, 1962; Eriksson 1984; Hyde et al., 1996; Hyde 1997; Aptroot 1995b; Tanaka et al., 2009; Hyde et al., 2013) followed this treatment and listed *R. hysterioides* as the type of *Roussoella*. However, *Index Fungorum* (2013) correctly lists the type as *R. nitidula*.

In this study I observed the type of *R. nitidula* (Fig. 5.4), but was unable to examine the type of *Dothidea hysterioides*, because PAD will no longer loan specimens for taxonomic study. When redescribing *Roussoella*, Hyde et al. (1996) examined the type materials of *Dothidea hysterioides* and *Roussoella nitidula* and listed them as synonyms using the earlier name *Roussoella hysterioides* as with most previous authors. The asci and ascospore sizes of the type material of *Dothidea hysterioides* or *R. nitidula* were not given in the study of Hyde et al. (1996). Measurements were mainly based on fresh collections. In this study, our collection of *R. nitidula* has smaller ascospores (17.5–21 × 5.5–8 µm), while Hyde et al. (1996) list ascospores of *R. hysterioides* as being 18–34 × 6–8 µm. As we cannot confirm that *Dothidea hysterioides* is identical to *R. nitidula* we refer to the latter name to represent the genus type, we also epitypify *R. nitidula* with a fresh collection. The status of *R. hysterioides* is presently unclear.

Cytoplea, Neopycnodothis and *Roussoella* are probably synonymous. The type of *Cytoplea*, *C. arundinicola* Bizz. & Sacc. was described from *Arundo donax* (grass, *Graminae*) from Italy and Sutton (1980) illustrated it under the earlier name *C. arundinacea* (Sacc.) Petr. & Syd. Sutton's account is typical of asexual *Roussoella*; however, in the protologue of *C. arundinicola*, conidia are described as 1-septate (Sutton 1980). *Cytoplea arundinicola* therefore needs to be restudied, recollected, epitypified and subjected to phylogenetic analysis before this genus can be used to accommodate *Roussoella* species. For this reason we use *Roussoella* rather than *Cytoplea* to represent the genus. *Neopycnodothis* is monotypic and was described from *Phyllostachys edulis* (Carrière) J.Houz (bamboo, *Graminae*) and appears to be a species of *Roussoella.*

Roussoella nitidula Sacc. & Paol., Atti Ist. Veneto Sci., 6:410. 1888; (Fig. 5.3)

Saprobic on decaying bamboo culms or palms branches. *Ascostromata* 0.3–0.5 mm high, 1.5–2.4 mm diam, immersed under a clypeus, raised, visible as black dome-shaped on host surface, multilocular, solitary to gregarious, coriaceous. *Locules* 150–300 µm high, 240–720 µm diam, subglobose to lenticular or quadrilateral to dome-shaped, clustered, black, ostiolate. *Peridium* 10–21 µm wide, composed of several layers of cells of *textura angularis* to *prismatica*, thick-walled, brown to dark brown. *Hamathecium* 1.5–2 µm wide, comprising numerous, anastomosing, narrowly cellular pseudoparaphyses, branching at the apex, smooth-walled, and embedded in a gelatinous matrix. *Asci* (87–)110–150(–200) × (8–)9–10(–11) µm ($\bar{x}$= 122 × 9.8 µm, n = 30), 8-spored, bitunicate, cylindrical, short pedicellate, apically rounded with an ocular chamber. *Ascospores* (15–)16–18(–19) × (5.5–)6–7 µm ($\bar{x}$= 17 × 6.5 µm, n = 30), uni-seriate, ellipsoidal to fusiform, 2-celled, constricted at the septum, initially pale brown, becoming brown to dark brown, rough-walled, at maturity with longitudinally ribbed. *Ascospores* germinated within 12 hours, initially from one cell, hyaline hyphae. *Asexual morph* produced on bamboo pieces on WA cultures after 2 months. *Conidiomata* 620-760 µm high, 865-1000 µm diam, superficial, visible as black slimy on hyphae which covered the bamboo pieces, pycnidium, globose or dome-shaped, thickened the basal of pycnidium, solitary, scattered or gregarious, indistinctly ostiolate. *Pycnidial wall* 13–80 µm wide, composed of several layers of cells of *textura intricata*, dark brown to black. *Conidiophores* arising from the basal cavity around conidiomata, unbranched or branched, 2–3 septa. *Conidiogenous cells* (2.5–)6–11(–16) × (1.5–)2–2.5(–3) µm ($\bar{x}$ = 8.5 × 2.5 µm, n = 10), phialidic, integrated, cylindrical or cylindric-clavate or irregular swollen cell, hyaline, 1−2-septate, smooth-walled. *Conidia* (6–)7–8 × 3–4 µm ($\bar{x}$ = 7.5 × 3.5 µm, n = 30), oblong to ellipsoidal, initially hyaline, becoming brown to yellowish brown, aseptate with two guttules, thick-walled, rough-walled, verrucose.

Specimen examined: MALAYSIA, Malacca, on culms of *Bambusa*, 1885, *B. Scortechini* (PAD 2484, holotype); THAILAND, Chiang Rai, Muang District, Khun Korn Waterfall, on dead culms of *Bambusa*. 17 Dec. 2010, *R. Phookamsak*, RP0098 (MFLU 11-0218, epitype designated here), ex-epitype living culture MFLUCC 11-0182; THAILAND, Uttaradit Province, on dead culms of *Bambusa*. 02 Nov. 2011, *D.Q. Dai*, DDQ218 (MFLU 13-0642), culture MFLUCC 11-0634).

Notes: The type material of *Roussoella nitidula* was examined, and two fresh collections (on culms of *Bambusa* from Thailand) were observed and isolated. They have superficial morphological similarities, such as black dome-shaped *ascostromata*; hypha-like, septate, numerous, narrow *pseudoparaphyses*; cylindrical, relatively thin-walled *asci* and two-celled dark brown ornamented *ascospores*. In addition, the size of asci and ascospores are similar, except the asci and ascospores in type material of *R. nitidula* are slightly larger than the fresh collections (asci 123–220 × 7–11 µm vs. 110–200 × 8–11 µm; ascospores 17.5–21 × 5.5–8 µm vs. 16–19 × 5.5–7 µm). Although there is a small variation between these fresh collections and the type material of *R. nitidula*, we consider them to represent one species and epitype the type of *Roussoella* (*R. nitidula*) in this study. The isolated strain *R. nitidula* (MFLUCC

Note. a. Appearance of the ascostromata on host surface; b. Asci and pseudoparaphyses; c. Ascospores with longitudinal striations; d. Pseudoparaphyses; e–g. Asci; h–k. Ascospores; ─ Scale Bars: a = 3 mm; b = 60 µm; c, d = 10 µm; e–g = 30 µm; h–k = 10 µm.

Figure 5.3 *Roussoella nitidula* (from PAD 2484, holotype)

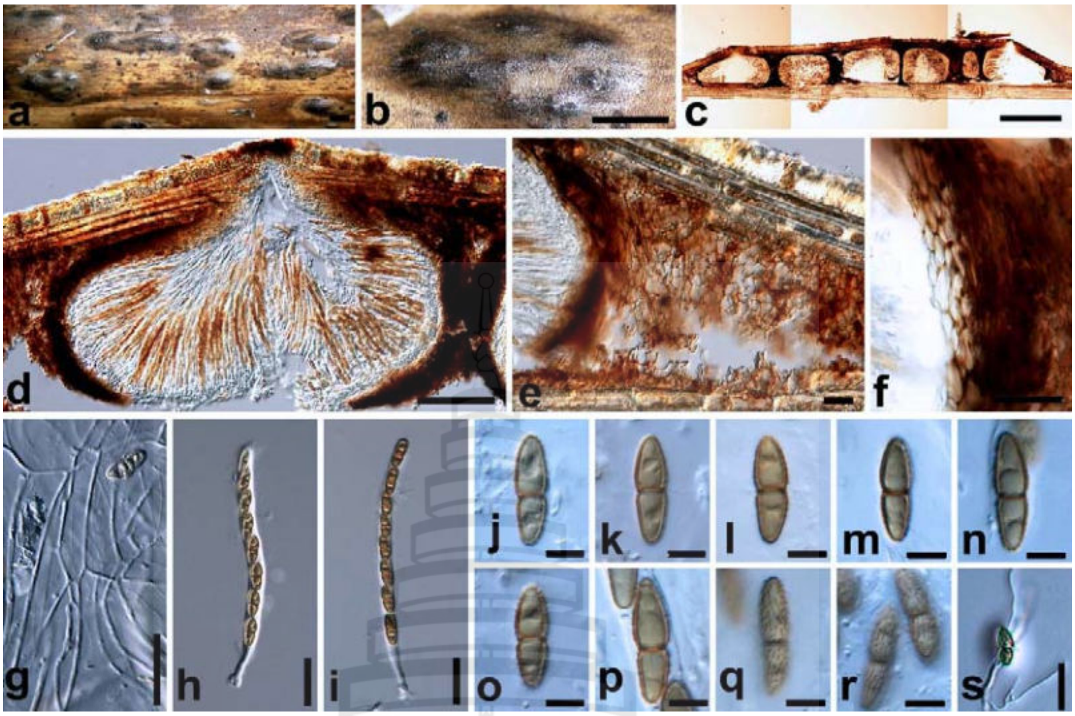
11–0182) formed the *Cytoplea* asexual morph in culture; it is similar with *C. hysterioides* (asexual morph of *Roussoella hysterioides*) as described by Hyde et al., (1996), but differ in having smaller conidia (7–8 × 3–4 µm vs. 7–10(–13) × 4–5(–6) µm).

Roussoella intermedia Y.M. Ju, J.D. Rogers & Huhndorf, Mycotaxon 58: 447 (1996). Fig. 5.4

Saprobic on decaying bamboo culms. *Ascostromata* 0.8–1.6 mm wide, 1.7–4.9 mm long, immersed under a clypeus, raised, visible, black, dome-shape areas on host surface, uni-biloculate. *Locules* 280–400 µm high, 450–630 µm diam, subglobose to lenticularis with a flattened base, solitary to clustered, black, centrally ostiolate. Beak short papillate, 75–95 µm high, 60–80 µm wide. *Peridium* 17–25 µm thick at sides, composed of polygonal flattened cells (5–12.5 × 1.5–5 µm), surrounded by wedge-shaped stromatic region (350–600 µm wide at sides) composed of rectangular to subglobose cells (5–20 × 2–15 µm). *Hamathecium* 1–2 µm wide, comprising numerous, anastomosing cellular pseudoparaphyses, branching, rough-walled, and embedded in a gelatinous matrix. *Asci* (86–)92–117(–130) × 6–8 µm ($\bar{x}$= 104.5 × 6.5 µm, n = 20), 8−spored, bitunicate, cylindrical, short pedicellate(12.5–29 µm long). *Ascospores* 12–18 × 4–5 µm ($\bar{x}$= 14.8 × 4.5, n = 50), uni-seriate, fusiform to cylindrical, with a median septum, 2-celled, brown, with irregular longitudinal striations. *Asexual morph* did not form in culture.

Specimen examined: JAPAN, Hokkaido, Isl. Rishiri, Oniwaki mountain trail, on twigs of *Sasa kurilensis*, 29 July 2007, *K. Tanaka* & *G. Sato*, KT 2303 (= HHUF 30025), culture NBRC 106245.

Notes: *Roussoella intermedia* is similar to *R. pustulans*, but differ in having larger asci and ascospores (asci 92–117 × 6–8 vs. 68–83 × 6.5–8.5 µm; ascospores 12–18 × 4–5 vs. 10–16 ×4–5 µm). The combined sequences phylogenetic tree (Fig. 5.1) indicates that these two species could be probably the same fungus. However, the ITS sequences analysis confirms that they are phylogenetically distinct species (Fig.5.2).



Note. a, b. Ascostromata on host surface; c, d. Section of ascoma; e. Wedge-shaped stromatic region; f. Peridium; g. Pseudoparaphyses; h, i. Asci; j–r. Ascospores; s. Germinating ascospore. ─ Scale bars: a, b = 1 mm; c = 500 µm; d = 100 µm; e–i, s = 20 µm; j–r = 5 µm. (Provided by Dr. Kazuaki Tanaka)

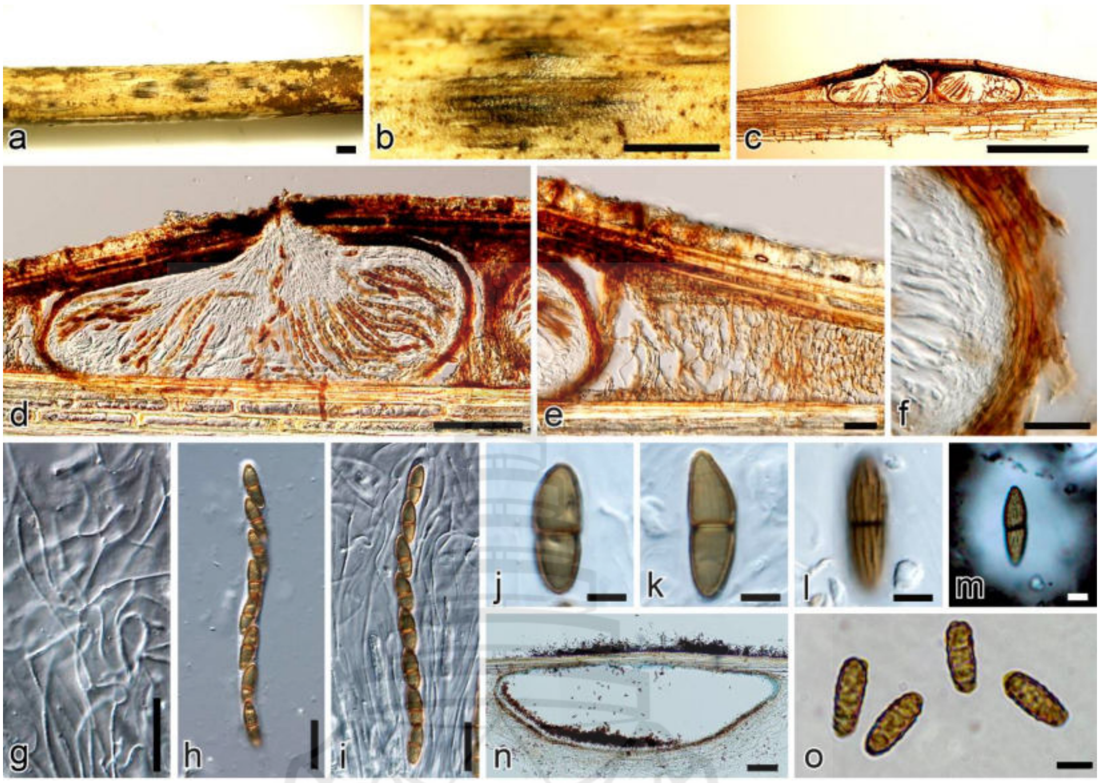
Figure 5.4 *Roussoella intermedia* (HHUF 30025)

Roussoella japanensis Kaz. Tanaka, J.K. Liu & K.D. Hyde., Phytotaxa. Fig. 5.5

Saprobic on decaying bamboo culms. *Ascostromata* 0.5–2 mm diam., immersed under a clypeus, raised, visible, black, dome-shape areas on host surface, uni-biloculate. *Locules* 190–210 µm high, 500–560 µm diam, depressed globose with a flattened base, single or 2–3 grouped, ostiolate. Beak short papillate, 38–50 µm high, 50–85 µm wide. *Peridium* 10–15 µm thick at sides, composed of 3–5 layers of polygonal flattened cells (3.5–12.5 × 1.5–2.5 µm), surrounded by wedge-shaped stromatic region (450–800 µm wide at sides) composed of rectangular to polygonal cells (3.5–15 × 4–10 µm). *Hamathecium* 1–1.5 µm wide, comprising numerous, anastomosing, cellular pseudoparaphyses, branching, rough-walled, and embedded in a gelatinous matrix. *Asci* 107–132 × 8–9.5 µm, 8-spored, bitunicate, cylindrical, short pedicellate (10–13 µm). *Ascospores* 16–22 × 5.5–7 µm ($\bar{x}$ = 19 × 6.5 µm, n = 50), uniseriate, fusiform to ellipsoidal, with a median septum, 2-celled, brown, covered with longitudinal striations and surrounded by an entire sheath of 0.5–4 µm wide. *Conidiomata* in culture, 300–550 µm high, 900–2000 µm diam, depressed globose, single to grouped, immersed. *Peridium* 7–12.5 µm wide. *Conidiophores* absent. *Conidiogenous cells* phialidic, ampulliform. *Conidia* 9.5–13 × 4–5 µm, oblong-ellipsoidal, yellowish brown, warty.

Specimen examined: JAPAN, Kanagawa, Yokohama, Nakaku, Sankei-garden, on twigs of *Sasa veitchii* var. *veitchii*; 9 Mar 2004; *K. Tanaka* & *Y. Harada*, KT 1651 (holotype HHUF 29217, ex-type living cultureJCM 13126 = MAFF 239636).

Notes: Although *Roussoella japanensis* produced an asexual morph similar to that of *R. hysterioides*, the asci and ascospores are considerably smaller than those of *R. hysterioides* (asci 107–132 × 8–9.5 µm vs. 140–210 × 8–11 µm; ascospores 16–22 × 5.5–7 µm vs. 18–34 × 6–8 µm). Tanaka et al. (2009) identified two *Roussoella* specimens (HHUF 26988 and KT 1651) as *R. hysterioides*, but sequence similarity between these fungi is very low (ca. 90.6%) in their ITS regions (Tanaka, unpublished data).



Note. a, b. Ascostromata on host surface; c, d. Section of ascostromata; e. Wedge-shaped stromatic region; f. Peridium; g. Pseudoparaphyses; h, i. Asci; j–m. Ascospores (m in indian ink); n. Section of conidioma; o. Conidia; a–m from KT 1651 (= HHUF 29217); n, o from culture JCM 13126 = MAFF 239636. — Scale bars: a, b = 1 mm; c = 500 µm; d, n = 100 µm; e–i = 20 µm; j–m, o = 5 µm. (Provided by Dr. Kazuaki Tanaka)

Figure 5.5 *Roussoella japanensis* (HHUF 29217, holotype)

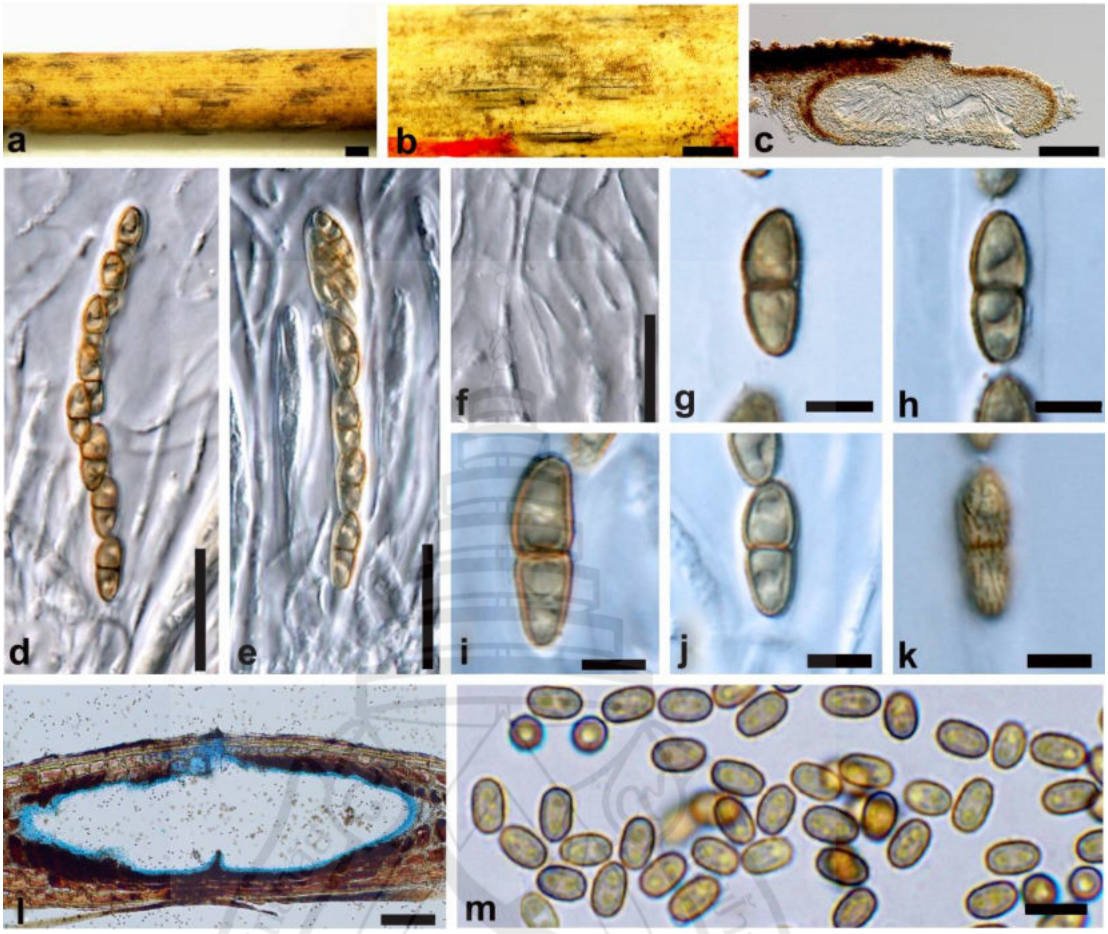
Roussoella pustulans (Ellis & Everh.) Y.M. Ju, J.D. Rogers & Huhndorf, Mycotaxon 58: 448 (1996); Fig. 5.6

≡ *Diatrype pustulans* Ellis & Everh., J. Mycol. 4(8): 80 (1888)

Saprobic on decaying bamboo culms or palms branches. *Ascostromata* 1 mm diam., immersed under a clypeus, raised, visible, black, dome-shape areas on host surface, uni-biloculate, scattered to grouped. *Locules* 150–170 µm high, 300–430 µm diam, depressed globose with a flattened base, single or grouped, ostiolate. *Peridium* 12–17 µm thick at sides, composed of polygonal to subglobose cells (3.5–15 × 3.5–5 µm), surrounded by wedge-shaped stromatic region composed of hyphal cells. *Hamathecium* 1–2 µm wide, comprising numerous, anastomosing, cellular pseudoparaphyses, branching at the apex, rough-walled, and embedded in a gelatinous matrix. *Asci* 68–83 × 6.5–8.5 µm, 8-spored, bitunicate, cylindrical, with a short stipe (15–18 µm long). *Ascospores* 10–16 × 4–5 µm ($\bar{x}$ = 12.5 × 4.5 µm, n = 50), fusiform to ellipsoidal, with a median septum, 2-celled, brown, covered with irregular longitudinal striations. *Conidiomata* produced in culture, 200–300 µm high, 300–1100 µm diam, subglobose, single to gregarious. *Conidiophores* absent. *Conidiogenous cells* 5–13 × 2–4 µm ($\bar{x}$ = 8.5 × 2.5 µm, n = 25), phialidic, ampulliform. *Conidia* 4–5 × 2–3 µm ($\bar{x}$ = 4.6 × 2.6 µm, n = 50), ellipsoidal, yellowish brown, smooth.

Specimen examined: JAPAN, Hokkaido, Sapporo, on twigs of *Sasa kurilensis*, 6 June 2004, *K. Tanaka*, KT 1709 (= HHUF 29229, culture JCM 13127 = MAFF 239637).

Notes: This species is similar to *R. pustulans* described by Ju et al. (1996) and Hyde (1997), but the ascospores are slightly narrower. The asexual morph formed in culture was unusual from *Cytoplea* in having smooth-walled, conidia and is similar with the asexual morph of *R. chiangraina*. However, these taxa are phylogenetically distinct (Figs. 5.1 and 5.2).



Note. a, b. Ascostromata on host surface; c. Section of ascostroma; d, e. Asci; f. Pseudoparaphyses; g–k. Ascospores; l. Section of conidioma (in lactophenol cotton blue); m. Conidia; a–k from KT 1709 (= HHUF 29229); l, m from culture JCM 13127 = MAFF 239637. ─ Scale bars: a, b = 1 mm, c = 500 µm; d, n = 100 µm; e–i = 20 µm; j–m, o = 5 µm. (Provided by Dr. Kazuaki Tanaka)

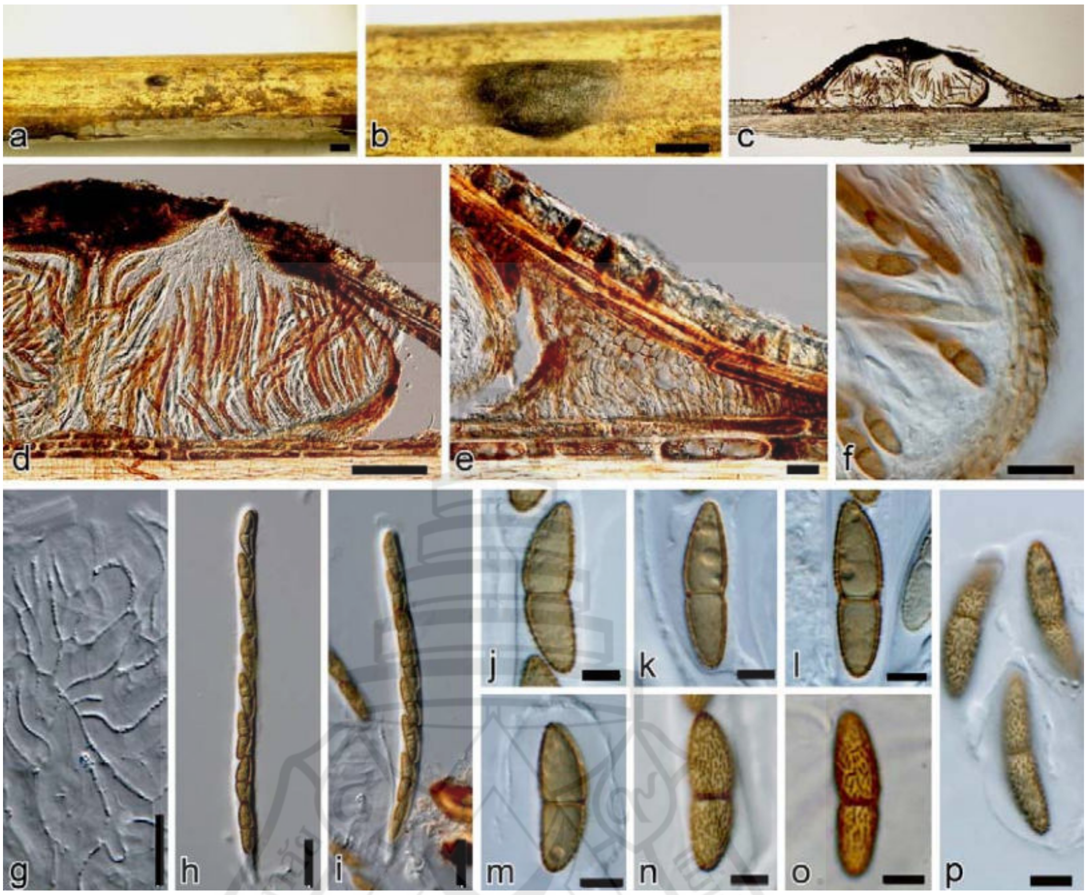
Figure 5.6 *Roussoella pustulans* (HHUF 29229)

Roussoella verrucispora Kaz. Tanaka, J.K. Liu & K.D. Hyde., *Phytotaxa*

Saprobic on decaying bamboo culms. *Ascostromata* 1.3–4.8 mm diam., semi-immersed or immersed under a clypeus, raised, visible, black, dome-shape areas on host surface, scattered to gregarious. *Locules* 280–320 µm high, 400–430 µm diam., depressed globose with a flattened base, 2–3 grouped, ostiolate. Beak short papillate, 50–75 µm high, 55–75 µm wide. *Peridium* 12.5–17.5 µm thick at sides, composed of 4–6 layers of rectangular flattened cells (3.5–18 × 1.5–4.5 µm), surrounded by wedge-shaped stromatic region (210–240 µm wide at sides) composed of polygonal to subglobose cells (3.5–18 × 4–15 µm). *Hamathecium* 1–2 µm wide, comprising numerous, anastomosing, cellular pseudoparaphyses, branching, rough-walled, and embedded in a gelatinous matrix. *Asci* 135–160 × 8–10 µm ($\bar{x}$= 150 × 9 µm, n = 18), 8-spored, bitunicate, cylindrical, short-stalked (12–20 µm long). *Ascospores* 18–24.5 × 5.5–7 µm ($\bar{x}$= 21.5 × 6.2 µm, n = 50), uniseriate, fusiform to ellipsoidal, 2-celled, constricted at the septum, brown, verrucose wall, covered with irregular longitudinal short striations and surrounded by an entire sheath of 1–5 µm wide.

Specimen examined: JAPAN, Aomori, Shimokita, Yagen, on twigs of *Sasa kurilensis*, 18 Nov 2001, *Y. Ooki* et al., (holotype HHUF 26988, ex-type living cultureliving CBS 125434).

Notes: *Roussoella verrucispora* is similar to *R. hysterioides*, but the asci and ascospores are considerably smaller (asci 135–160 × 8–10 µm vs. 140–210 × 8–11 µm; ascospores 18–24.5 × 5.5–7 µm vs. 18–34 × 6–8 µm) than those of *R. hysterioides* (Hyde et al., 1996). In addition, the ornamentation of ascospores in *R. verrucispora* is verrucose, while those of *R. hysterioides* are linear and full length. This species was named as "*R. hysterioides*" (HHUF 26988) in Tanaka et al. (2009). *Roussoella verrucispora* is also morphologically similar to *R. japanensis*, but differs in having slightly larger asci and ascospores (asci 135–160 × 8–10 µm vs. 107–132 × 8–9.5 µm; ascospores 18–24.5 × 5.5–7 µm vs. 16–22 × 5.5–7 µm). The ascospores of *R. verrucispora* have verrucose ornamentation, while those of *R. japanensis* are striate. Phylogenetic analysis also distinguished these species (Figs. 5.1 and 5.2).



Note. a, b. Ascostromata on host surface; c, d. Section of ascostroma; e. Wedge-shaped stromatic region; f. Peridium; g. Pseudoparaphyses; h, i. Asci; j–p. Ascospores. Scale bars: a, b = 1 mm; c = 500 µm; d = 100 µm; e–i = 20 µm; j–p = 5 µm. (Provided by Dr. Kazuaki Tanaka)

Figure 5.7 *Roussoella verrucispora* (HHUF 26988, holotype)

Neoroussoella J.K. Liu, Phookamsak & K.D. Hyde., Phytotaxa

Type species: *Neoroussoella bambusae* Phookamsak, J.K. Liu & K.D. Hyde

Saprobic on decaying bamboo culms. *Ascostromata* immersed under a clypeus or epidermis, raised, visible as black dome-shaped or flattened ovoid areas on host surface, coriaceous, solitary to gregarious, black, centrally ostiolate. *Peridium* composed of 2–3 layers of light brown to brown, thin-walled cells of *textura* *angularis*, with flattened base. *Hamathecium* comprising numerous, anastomosing, cellular pseudoparaphyses, branching at the apex, often constricted at the septum, embedded in a gelatinous matrix. *Asci* 8-spored, bitunicate, cylindrical, short to long pedicellate, apically rounded with an ocular chamber. *Ascospores* uni-biseriate or overlapping, ellipsoidal to fusiform, 2-celled, constricted at the septum, pale brown to brown or yellowish brown, rough-walled, longitudinally ribbed, surrounded by mucilaginous sheath. *Asexual morphs* produced on bamboo pieces on WA cultures after 2 months. *Conidiomata* superficial to immersed, pycnidium, uni-multiloculate, globose to subglobose or irregular shape, scattered or clustered, solitary or gregarious, indistinctly ostiolate. *Pycnidial wall* composed of several layers of cells of *textura angularis*. *Conidiophores* arising from the basal cavity around conidiomata, unbranched, aseptate. *Conidiogenous cells* annellidic, unbranched, ampulliform or lageniform or cylindrical or cylindric-clavate, hyaline, aseptate, smooth-walled. *Conidia* oblong to ellipsoidal, hyaline, aseptate with two guttules, smooth-walled.

Roussoellopsis I. Hino & Katum., J. Jap. Bot. 40: 86 (1965)

Type species: *Roussoellopsis japonica* (I. Hino & Katum.) I. Hino & Katum

Saprobic on decaying bamboo culms. *Ascostromata* immersed under a clypeus or epidermis raised, black, dome-shaped on host surface, solitary to gregarious, centrally ostiolate, multiloculate, cells of ascostromata of brown-walled *textura angularis*. *Peridium* composed of 2–3 layers of cells of *textura angularis*, light brown to brown thin-walled, flattened at the base. *Hamathecium* comprising numerous, anastomosing, hyphae-like, cellular pseudoparaphyses, branching at the apex, often constricted at the septum, and embedded in a gelatinous matrix. *Asci* 8–spored, bitunicate, fissitunicate, clavate, short to long pedicellate with shallow ocular chamber. *Ascospores* uni-biseriate, fusiform, thick-walled, 2-celled, constricted at the septum, hyaline, pale brown or yellowish brown. *Asexual state Melanconiopsis* or "Neomelanconium"-like. *Conidiomata* pycnothyrial, superficial to semi-immersed, subglobose, dark-brown to black, unilocular or multilocular, if unilocular, locules separated by vertical columns of lightly pigmented pseudoparenchyma; *Peridium* comprising several brown to dark brown layers with cells of *textura angularis*. *Conidiophores* reduced to annellidic *conidiogenous cells*, hyaline, cylindrical, smooth, formed from cells lining the inner most layer of the pycnidium. *Conidia* almost globose, black, aseptate, thick-walled surrounded by an entire gelatinous material.

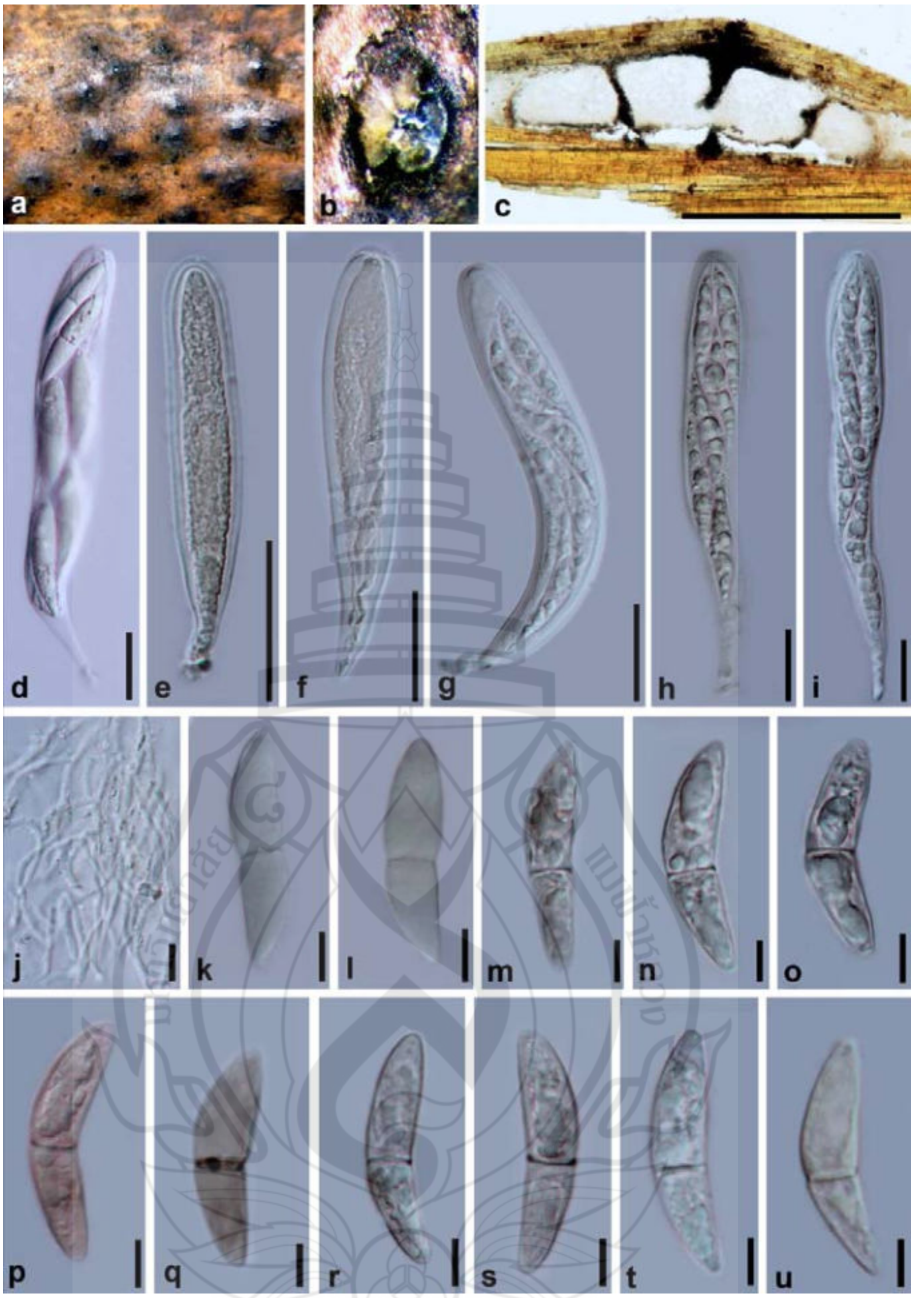
Notes: *Roussoellopsis* was introduced by Hino and Katumoto (1965), typified by *Ro. japonica* (I. Hino & Katum.) I. Hino & Katum, and currently comprises three species, with all being transferred from *Didymosphaeria* by Hino and Katumoto (1965). *Roussoellopsis* is similar to *Roussoella*, but differs in having clavate asci and large fusiform ascospores which are strongly constricted at the submedian septum. In addition, *Roussoellopsis* has *Melanconiopsis* or "Neomelanconium"-like asexual morphs with annellidic conidiogenous cells, and aseptate, almost globose, black, thick-walled conidia (Tanaka et al., 2009).

Roussoellopsis japonica (I. Hino & Katum.) I. Hino & Katum., J. Jap. Bot. 40: 86 (1965); Fig. 5.8

Saprobic on decaying bamboo culms. *Ascostromata* 0.4–0.5 mm high, 1.2–2 mm diam, immersed under a clypeus or epidermis, visible as black raised, dome-shaped on host surface, solitary to gregarious, centrally ostiolate, multiloculate, containing 4–6 locules, cells of ascostromata brown-walled *textura angularis*. *Locules* 300–400 × 400–450 µm. *Peridium* up to 8.5–16.5 µm wide, composed of 2–3 layers of cells of *textura angularis*, light brown to brown thin-walled with flattened at the base. *Hamathecium* 1–1.5 µm wide, comprising numerous, anastomosing, hyaphae-like, cellular pseudoparaphyses, smooth-walled, branching at the apex, often constricted at the septum, and embedded in a gelatinous matrix. *Asci* (130–)155–220× 22–27(–30) µm ($\bar{x}$= 183 × 26 µm, n = 20), 8-spored, bitunicate, fissitunicate, clavate, short to long pedicellate, apically rounded with an ocular chamber. *Ascospores* (43–)48–55 × 8–12(–13.5) µm ($\bar{x}$= 51 × 10.5 µm, n = 30), biseriate, fusiform, 2-celled, constricted at the septum, thick-walled, hyaline when immature, pale brown to brown or yellowish brown when mature. *Asexual morphs* not established.

Specimen examined: JAPAN, Nagato Province, on dead culms of *Phyllostachys bambusoides*, 16 May 1954, *K. Katumoto* (holotype in YAM).

Notes: We examined the type material of *Roussoellopsis japonica,* it matches well with the original description and we here give a detailed description.



Note. a. Appearance of ascostromata on the host; b. Ascostromata cut horizontally showing the contents; c. Vertical section through ascostromata; d–i Acsi; j. Pseudoparaphyses; k–u. Ascospores. ─ Scale bars: c = 500 μm; d–i = 30 μm; j–u = 10 μm.

Figure 5.8 *Roussoellopsis japonica*

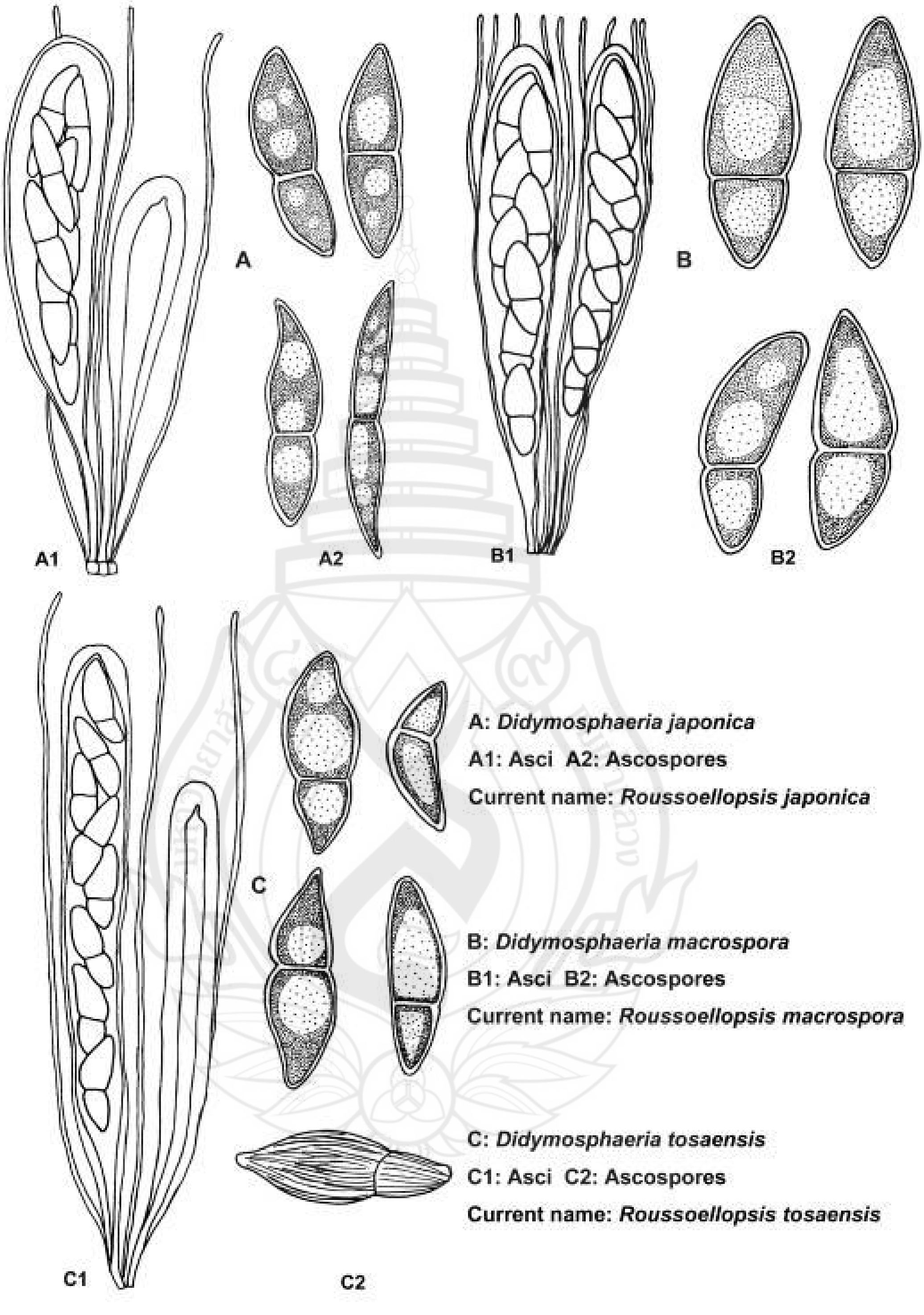


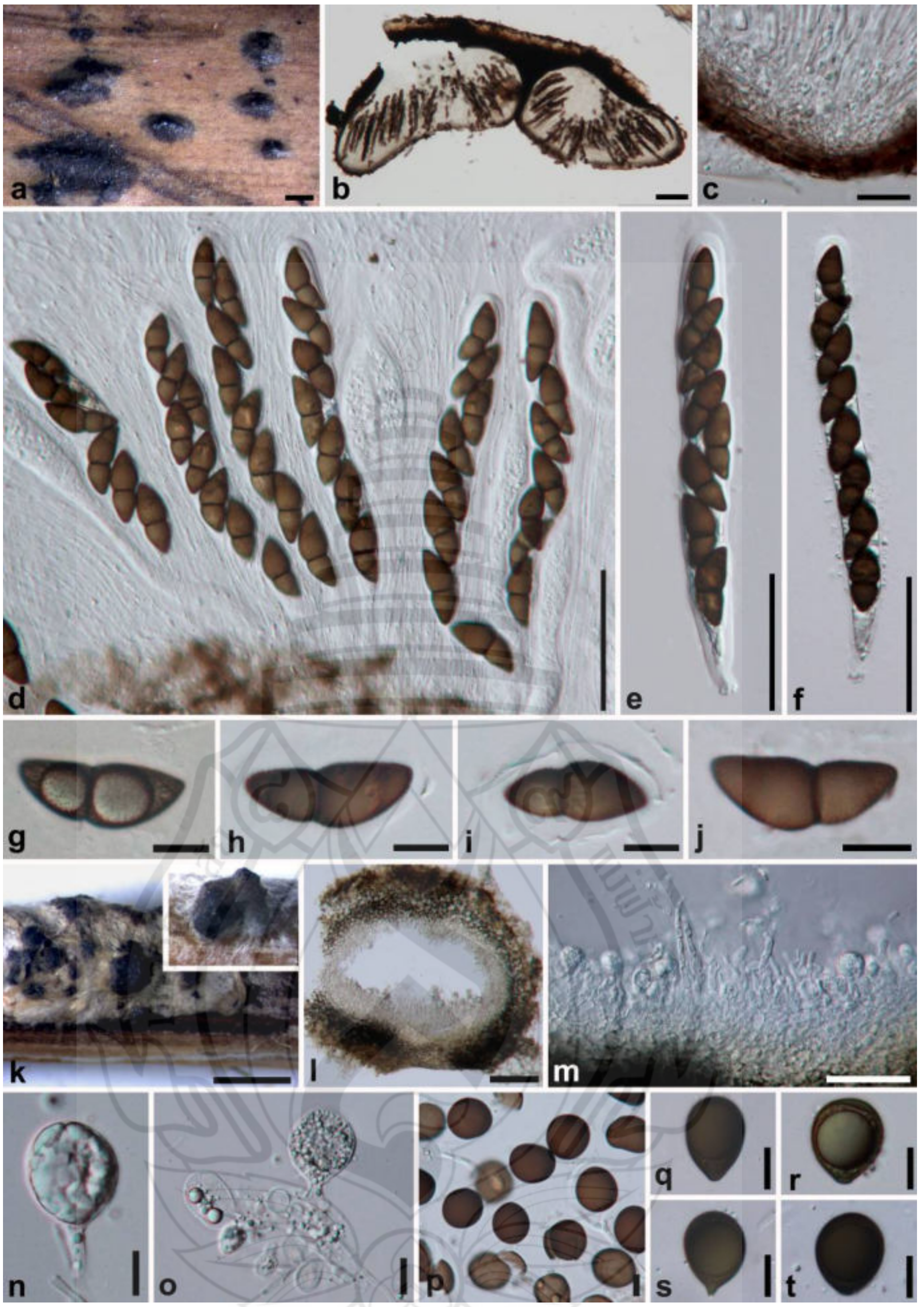
Figure 5.9 Redrawing of *Roussoellopsis japonica*, *Ro. macrospora* and *Ro. tosaensis* based on the original drawing (Hino 1961)

Roussoellopsis macrospora (I. Hino & Katum.) I. Hino & Katum., J. Jap. Bot. 40(3): 87 (1965); Fig. 5.10

Saprobic on decaying bamboo culms, *Ascostromata* 0.3–0.6 mm high, 1.2–2.3 mm diam., immersed under a clypeus, raised, visible as black, dome-shaped areas on host surface, solitary to gregarious. *Locules* 210–280 µm high, 540–720 µm diam, depressed globose with a flattened base, single to grouped, with a central ostiole. *Peridium* 7–18 µm thick at sides, composed of small compressed cells, surrounded by wedge-shaped stromatic region. *Hamathecium* 1–2 µm wide, comprising numerous, anastomosing, hyphae-like cellular pseudoparaphyses, branching at the apex, wall rough, and embedded in a gelatinous matrix. *Asci* 165–220 × (17–) 20.5–25 µm ($\bar{x}$= 192 × 22.5 µm, n = 30), 8–spored, bitunicate, clavate, rarely cylindrical, short to long pedicellate, apically rounded with an ocular chamber. *Ascospores* (27–)30–35 × 10.5–14 µm ($\bar{x}$= 32.2 × 12.2 µm, n = 30), uni-biseriate, broadly fusiform, 2-celled, with a submedian septum, strongly constricted at the septum, brown, surrounded by mucilaginous sheath. *Asexual morphs* produced in culture, a "Melanconiopsis" or "Neomelanconium"-like conidial state is produced. *Conidiomata* (individual locules) 225–385 µm high, 300–430 µm diam, depressed globose, single or gregarious, immersed to erumpent, papillate at the apex. *Peridium* 35–70 µm thick at sides, composed of dark brown cells. *Conidiophores* septate, unbranched. *Conidiogenous cells* 13–30 × 3–6 µm, doliform to cylindrical, annellidic. *Conidia* 19–24.5 ×19–23 µm ($\bar{x}$= 22.5 × 21.5 µm, n = 30), globose to subglobose, slightly truncate at the base, hyaline when immature, becoming black to dark brown when mature, thick-walled, smooth-walled.

Specimen examined: THAILAND, Chiang Rai Province, Muang District, Khun Korn Waterfall, on living stem of bamboo, 21 June 2011, *R. Phookamsak*, RP0126, MFLU 11–0244, culture MFLUCC 12–0005.

Notes: The above material matches the original description of *Didymosphaeria macrospora* (Hino & Katumoto, 1955).



Note. a. Ascostromata on host surface; b. Section of ascostromata; c. Peridium; d–f. Asci; g–j. Ascospores; k. Conidiomata on pine; l. Section of Conidioma; m. Conidiophores; n, o. Conidiogenous cells and conidia; p–t. Conidia. ─ Scale bars: a, k = 1 mm; b, l = 100 µm; d–e, m = 50 µm; c, g–j, n–t = 10 µm.

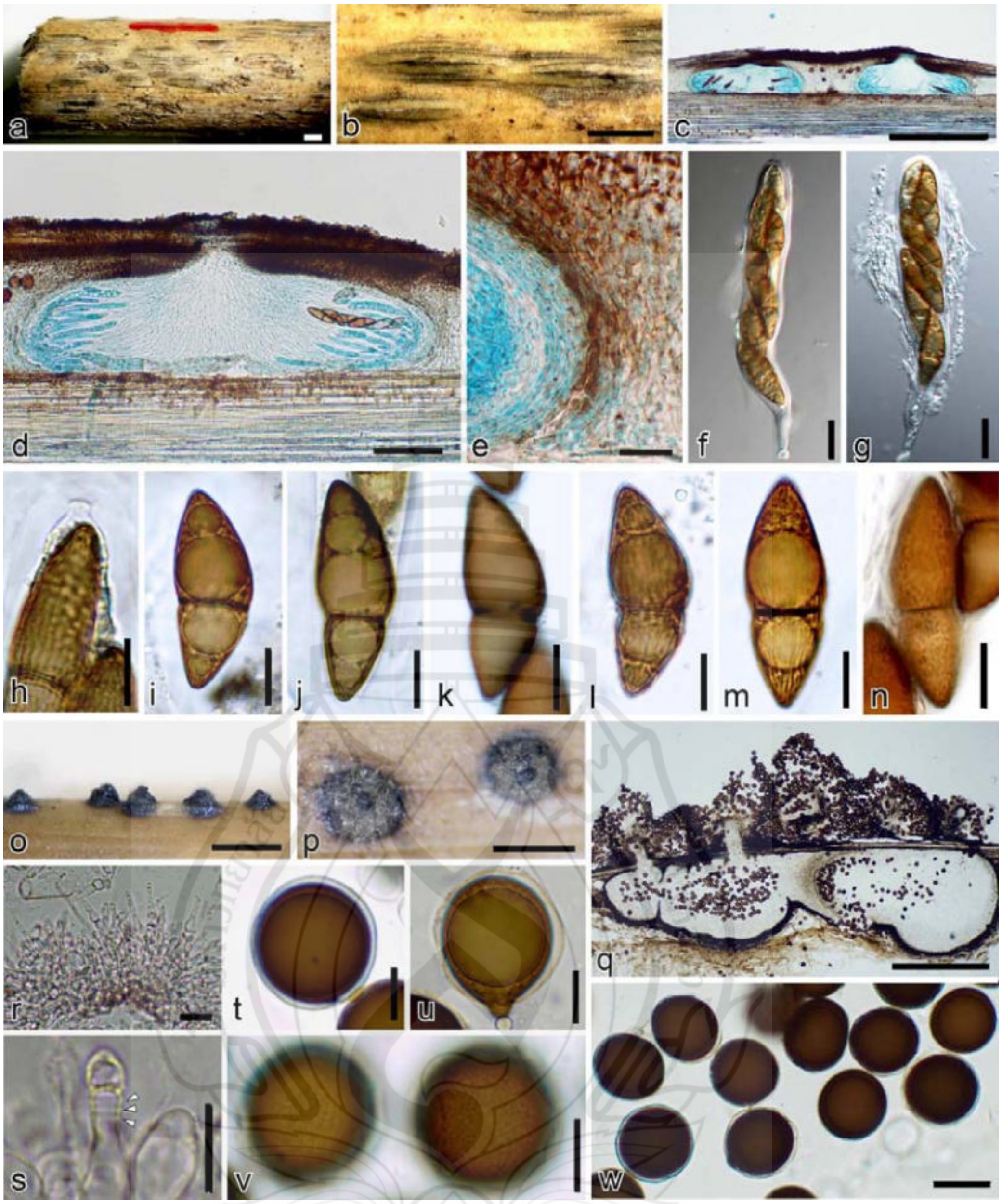
Figure 5.10 *Roussoellopsis macrospora* (MFLU 11–0244, epitype)

Roussoellopsis tosaensis (I. Hino & Katum.) I. Hino & Katum., J. Jap. Bot. 40(3): 87 (1965); Fig. 5.11

Saprobic on decaying bamboo culms. *Ascostromata* 0.3–0.8 mm wide, 1.4–2.5 mm long., immersed under a clypeus, raised, visible, black, dome-shape areas on host surface. *Locules* 220–260 µm high, 560–630 µm diam, depressed globose with a flattened base, single to grouped, with a central ostiole. Beak short papillate, 60–90 µm high, 60–100 µm wide. *Peridium* 12.5–25 µm thick at sides, composed of small compressed cells, surrounded by wedge-shaped stromatic region. *Hamathecium* 1–2 µm wide, comprising numerous, anastomosing, cellular pseudoparaphyses, branching at the apex, rough-walled, and embedded in a gelatinous matrix. *Asci* 154–190 × 21.5–26 µm, 8-spored, bitunicate, clavate, short-stalked (23–40 µm long). *Ascospores* (33–)36–43(–53) × 12–17 µm ($\bar{x}$ = 40.3 × 14.6 µm, n = 23), biseriate, broadly fusiform with acute ends, 2-celled, with a submedian septum, brown, with irregular longitudinal striations. *Asexual morphs* produced in culture, a “Melanconiopsis” or “Neomelanconium”-like conidial state is formed. *Conidiomata* (individual locules) 200–500 µm high, 550–950 µm diam, depressed globose, single or grouped, immersed to erumpent, papillate at the apex. *Peridium* 15–30 µm thick at sides, composed of compressed dark brown cells. *Conidiophores* septate, unbranched. *Conidiogenous cells* 10–20 × 4–8 µm, doliform to cylindrical, annellidic. *Conidia* 20.5–30 µm diam ($\bar{x}$ = 23.5 µm, n = 50), globose to subglobose, slightly truncate at the base, black to dark brown, thick-walled, verrucose, with irregular gelatinous sheath (1 µm thick).

Specimen examined: JAPAN, Tokyo, Isl. Ooshima, Motomachi, on twigs of bamboo, 19 Mar 2004, *K. Oota*, KT 1659 (HHUF 29234, culture JCM 13128 = MAFF 239638).

Notes: The above material matches the original description of *Didymosphaeria tosaensis* (Hino & Katumoto, 1955).



Note. a. Ascostromata on host surface; b. Section of ascostromata; c. Peridium; d–f. Asci; g–j. Ascospores; k. Conidiomata on pine; l. Section of Conidioma; m. Conidiophores; n, o. Conidiogenous cells and conidia; p–t. Conidia. ─ Scale bars: a, k = 1 mm; b, l = 100 μm; d–e, m = 50 μm; c, g–j, n–t = 10 μm. (Provided by Dr. Kazuaki Tanaka)

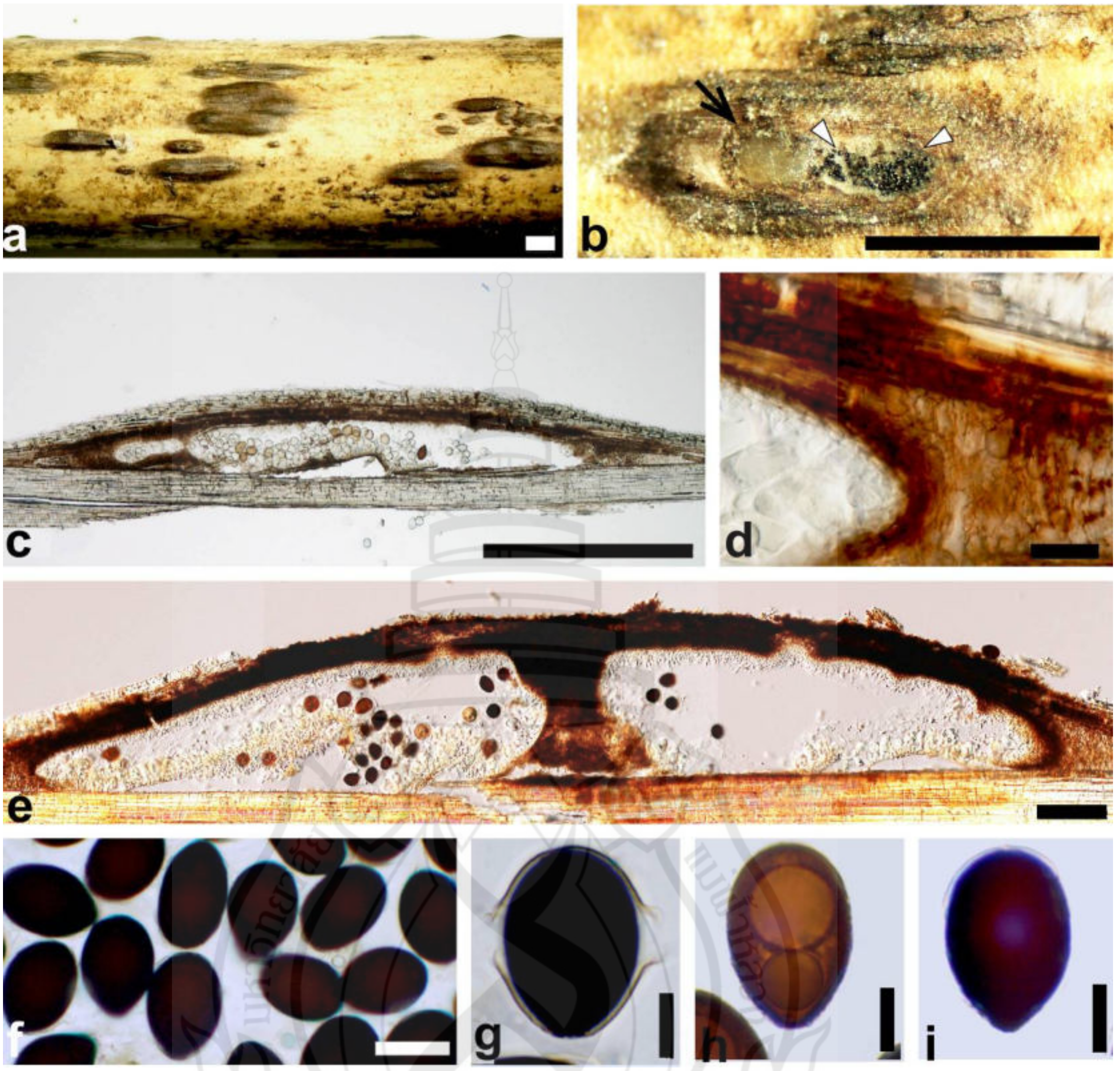
Figure 5.11 *Roussoellopsis tosaensis* (HHUF 29234)

Roussoellopsis sp.

Saprobic on decaying bamboo culms. *Conidiomata* 1.4–3.4 × 0.5–1.5 mm, forming under black, dome-shape areas of on host surface; individual locules in section 150–250 µm high, 250–750 µm diam, depressed globose with a flattened base, immersed under a clypeus, single to grouped, with a central ostiole. *Peridium* 7.5–12.5 µm thick at sides, composed of small polygonal cells (6–10 × 1.5–3.5 µm), surrounded by wedge-shaped stromatic region (130–300 µm wide at sides) composed of rectangular cells (5–15 × 3.5–7.5 µm). *Conidiogenous cells* 10–20 × 4–6 µm, doliform to cylindrical. *Conidia* 25–31(–34) × 17–25.5(–27.5) µm ($\bar{x}$= 29.0 × 21.3 µm, n = 60), subglobose to obovoid, black to dark brown, with an entire sheath of 1–2 µm thick.

Specimen examined: JAPAN, Hokkaido, Sapporo, near Maruyama-park, on twigs of *Sasa kurilensis*, 6 June 2004, *K. Tanaka*, KT 1710 (HHUF 30026, culture NBRC 106246).

Notes: The asexual state strongly suggests that it is a species of *Roussoellopsis*, and the molecular analyses also showed that this strain (NBRC 106246) clusterred into the *Roussoella*/*Roussoellopsis* section (Fig. 5.1). This fungus is characterized by its unique ovoid conidia, while other species in this genus have almost globose conidia, it appears to be new. Possibly it maybe a same species with *Ro. japonica*, but the asexual morph of the latter has not been yet observed, the molecular data for *Ro. japonica* is also not available.



Note. a, b. Conidiomata on host surface (b, arrowheads indicate conidiomata; arrow indicates immature ascoma); c, d. Section of conidiomata; e. Peridium; f–i. Conidia; a–e from KT 1710 (= HHUF 30026); f–i from culture NBRC 106246. — Scale bars: a, b = 1 mm; c = 500 µm; d = 100 µm; e, f = 20 µm; g–i = 10 µm. (Provided by Dr. Kazuaki Tanaka)

Figure 5.12 *Roussoellopsis* sp (HHUF 30026)

Roussoella was placed in *Didymosphaeriaceae* by Lumbsch and Huhndorf (2010). However, recent molecular data did not support this and *Roussoella* clustered together with *Arthopyreniaceae* (Schoch et al., 2009a; Tanaka et al., 2009; Zhang et al., 2012). Most taxa in *Arthopyreniaceae* have hemispherical ascostromata containing cellular pseudoparaphyses, fissitunicate asci and mostly hyaline ascospores (Eriksson 1981; Cannon & Kirk, 2007) and these taxa are clearly unrelated. The two strains of *Arthopyrenia salicis*, which were included in the phylogenetic analysis (Schoch et al., 2009a; Tanaka et al., 2009; Zhang et al., 2012) may be wrongly named or may differ from the type (*Arthopyrenia cerasi*). We also included these two strains (*Arthopyrenia salicis*) in our analysis (not in the final analysis) and they clustered in the *Roussoella*/*Roussoellopsis* clade, as in Schoch et al. (2009a), Tanaka et al. (2009) and Zhang et al. (2012). Further studies may be warranted, with the newly added data from the fresh collections and isolations, a new family *Roussoellaceae* is introduced to accommodate this group.

Roussoellopsis could not be differentiated from *Roussoella* in our phylogenetic analyses, as *Ro. tosaensis*, *Ro. macrospora* and *Roussoellopsis* sp (NBRC 106246) grouped together with *Roussoella*. However, the genera are morphologically distinct. *Roussoellopsis* has clavate asci and large fusiform ascospores which are strongly constricted at the septum and *Melanconiopsis* or "Neomelanconium"-like asexual morphs, while *Roussoella* has cylindrical asci with *Cytoplea* asexual morphs. This indicates that *Roussoellopsis* is a distinct genus, even though the present molecular analysis does not support this. Tanaka et al. (2009) also suggested that *Roussoellopsis* might be a synonym of *Roussoella* based on the topology of the phylogenetic analysis, but stated that careful consideration must be given to the treatment. This topology may result from too few taxa in the tree. Therefore, we refrain from synonymizing the morphologically distinct *Roussoellopsis* whose three species share similar morphological characters under *Roussoella* pending further study with a larger dataset. In addition, *Roussoellopsis* species were considered as *Didymosphaeria* by Hino and Katumoto (1965). Recently, the genus *Didymosphaeria* has been reexamined by Ariyawansa et al. (2014, in press) based on type material and fresh collections of the type species *D. epidermidis*. Their results showed that *Didymosphaeria* clustered into the family *Montagnulaceae*. We also included core genera of *Montagnulaceae* in our phylogenetic analysis (Fig. 5.1), and confirm that *Roussoellopsis* and *Didymosphaeria* are distinct genera and distally related.

5.4 Conclusion

In this study, nine fresh strains of *Roussoella*-like taxa were collected from bamboo and palms in northern Thailand during 2009 to 2012 and 6 reference strains from previous studies, totally 15 target strains with multi-gene (ITS, LSU, *TEF1* and *RPB2*) were included for the phylogenetic analysis, as well as the examination of generic type. The 15 target strains formed a well supported clade in Pleosporales, a new family *Roussoellaceae* (in *Pleosporales*) was introduced to accommodate these three genera based on morphological examination (type specimens) and phylogenetic analyses (15 target strains). 14 *Roussoella*-like taxa were named properly and six previous study strains in GenBank were also clarified. This study also suggested that more sampling is needed to give a better understanding of the relationship between *Roussoella* and *Roussoellopsis*.

CHAPTER 6

Astrosphaeriella IS POLYPHYLETIC WITH SPECIES IN *Fissuroma* AND *Neoastrosphaeriella*

6.1 Introduction

The *Pleosporales* is the largest order in the class *Dothideomycetes*, including 23 families, 332 genera and more than 4700 species (Kirk et al., 2008; Zhang et al., 2012). The taxa range in habit from being saprobic on dead leaves or stems in terrestrial or aquatic environments (Camara et al., 2002; Ramesh 2003; Kodsueb et al., 2008; Suetrong et al., 2009; Zhang et al., 2008b; 2009a, b; 2012) or on animal dung (Kruys et al., 2006; Kruys & Wedin, 2009), parasitic on green leaves or stems (Wetzel et al., 1999; Solomon et al., 2006; Morin et al., 2010), endophytes or epiphytes (Sánchez Márquez et al., 2008, 2010; Albrectsen et al., 2010; Pérez et al., 2010) or found to occur in association with sea grasses (Sakayaroj et al., 2010) and marine sponges (Paz et al., 2010). Some genera are known as important plant pathogens, these include such examples as *Cochliobolus*, *Fusarium* and *Pyrenophora* (*Pleosporaceae*) which cause leaf spot and blight disease (Luttrell 1973; White 1999; Summerell et al., 2010, 2011; Manamgoda et al., 2011), *Phaeosphaeria* (anamorph *Stagonospora*) and *Phaeosphaeriopsis* (*Phaeosphaeriaceae*) which cause wheat glume blotch (Crous 2006; Vergnes et al., 2006); *Didymella* (*Didymellaceae*) which cause *Ascochyta* blight of pea (Chilvers et al., 2009) and *Leptosphaeria* (*Leptosphaeriaceae*) which cause stem canker on *Brassica*. In recent years, many important taxonomic studies on this large and difficult group of *Ascomycota* have been published using molecular phylogeny (Zhang et al., 2008a, b; 2009a, b; 2012; Schoch et al., 2009a; Suetrong et al., 2009; Tanaka et al., 2009). However, some taxa are still not completely well-resolved, such as *Anteaglonium* Mugambi & Huhnforf;

Ascorhombispora L. Cai & K. D. Hyde, *Astrosphaeriella* Syd. & P. Syd, *Atradidymella* Davey & Currah, *Ostropella* (Sacc.) Höhn., and *Tingoldiago* K. Hiray. & Kaz. Tanaka (Lumbsch & Huhndorf, 2010).

Astrosphaeriella was originally introduced with the type species *A. fusispora* Syd. & P. Syd., recorded from bamboo stems in Japan in 1912 (Sydow & P. Sydow, 1913). Subsequently, Scheinpflug (1958) introduced three additional species, all of which occurred on dicotyledonous hosts in temperate regions. Müller and von Arx (1962) transferred all the species of Scheinpflug, together with two other species previously described in *Astrosphaeriella*, to *Microthelia* Körber. When von Arx and Müller (1975) reviewed the genera of bitunicate pyrenomycetes, they followed the arrangement proposed by Müller and von Arx (1962) and kept *Astrosphaeriella* as a synonym of *Microthelia*. Hawksworth (1981) reintroduced and emended the genus by accommodating four loculoascomycetous species with characteristic hemispherical to conical ascomata and treated *Astrosphaeriella stellata* (Pat.) Sacc., as an earlier name for *A. fusispora*, which is the type species of the genus. He also circumscribed *Astrosphaeriella* as an exclusively tropical genus occurring on bamboo or palms. The generic concept was subsequently extended to include six additional species and a key to these ten known species was provided (Hawksworth & Boise, 1985). Subsequently, numerous species of *Astrosphaeriella* have been described and reported (Yue & Eriksson, 1986; Barr 1990; Hyde 1992, 1994a, b; Aptroot 1995a; Frohlich & Hyde, 1995). Hyde and Fröhlich (1998) reviewed the genus *Astrosphaeriella*, including all 31 published species which characteristically occurred on the petioles of terrestrial palms, bamboo culms, and stout grasses. Some species are also reported from freshwater (Hyde 1994a; Tsui et al., 2001; Cai et al., 2003) or brackish water habitats (Hyde 1992). Hyde et al. (2000a) expanded the concept of *Astrosphaeriella* to include species with slit-like ostioles, and three new species and three new combinations were reported. With this broad genetic concept, Tanaka and Harada (2005) transferred *Melanopsamma aggregata* I. Hino & Katum to *Astrosphaeriella aggregata* (I. Hino & Katum.) Kaz. Tanaka & Y. Harada. More recently, a number of new species and combinations have been reported (Rogers & Barr, 2003; Zhou et al., 2003; Chen & Hsieh, 2004; Wang et al., 2004; Tanaka & Harada, 2005; Chen & Huang, 2006;

Aptroot 2009), the latest data show that there are 60 epithets for *Astrosphaeriella* in *Index Fungorum* (April 2014) and an estimated 51 species in Krik et al. (2008).

The placement of *Astrosphaeriella* at the family level has received some attention. Hara (1913) established the new family *Astrocystidiaceae* Hara (as '*Asterocystidiaceae*') to include the two genera *Astrocystis* and *Astrosphaeriella*. Even though there is a strong superficial similarity between some species of these genera, they are not closely allied, with the former being a unitunicate *Pyrenomycete* (Hawksworth 1981). The family *Platystomaceae* Schröter was re-introduced by Barr (1987) in her *Prodromus* to the *Loculoascomycetes*, and *Astrosphaeriella* was included in this family, together with *Platystomum, Pseudotrichia, Thyridaria* and *Trematosphaeria*. *Javaria* was also later included (Barr 1990). Hawksworth and Ainsworth (1995) however, had different suggestions concerning the familial placement of *Astrosphaeriella*, referring the genus to *Melanommataceae incertae cedis*. When Hyde et al. (2000a) described new *Astrosphaeriella* species with slit-like ostioles (previously described as *Lophiostoma*); they followed the treatment proposed by Hawksworth and Ainsworth (1995) and placed *Astrosphaeriella* in *Melanommataceae*. Species of *Astrosphaeriella* were considered to be different from species of *Lophiostoma* as the former have narrow, trabeculate pseudoparaphyses and a dense, carbonaceous peridium, while the latter have wide, cellular pseudoparaphyses and a cellular peridium (Hyde et al., 2000a). This treatment has been followed in most subsequent publications (Cai et al., 2006a; Cannon & Kirk, 2007; Lumbsch & Huhndorf, 2007; Kirk et al., 2008), but no phylogenetic study has been conducted. Tanaka et al. (2009) indicated that *Astrosphaeriella* is not a genus in the *Melanommataceae*, and the monophyletic status of this genus was also rejected. Similar results were also reported by Schoch et al. (2009a) and Zhang et al. (2009b). However, the placement of *Astrosphaeriella* with respect to its proper family is not resolved in any of the previous studies. Currently, *Astrosphaeriella* was treated as a genus of *Pleosporales* family *incertae sedis* in Lumbsch and Huhndorf (2010).

The purpose of this study is to re-evaluate the taxonomic and phylogenetic status of *Astrosphaeriella* species using combined gene sequence data and to investigate the phylogenetic relationships with other genera or families of *Pleosporales*. Two new genera are proposed to accommodate some species excluded from *Astrosphaeriella*.

6.2 Materials and Methods

6.2.1 Collection and Examination of Specimens

Ten fresh species were collected from bamboo and palms in Thailand during 2008 to 2010, and returned to the laboratory in paper envelopes or plastic bags. In most cases, ascomata were collected directly from natural substrates without incubation. The samples were processed and examined following the method described in Hyde et al., (2000b) and Taylor & Hyde (2003). Observations and photographs were made from material mounted in water using a Nikon ECLIPSE 80i microscope. India ink was added to water mounts to detect the presence of gelatinous sheaths or ascospore appendages. Measurements were made with the Tarosoft (R) Image Frame Work (Liu et al., 2010). Herbarium specimens were obtained on loan from the Swedish Museum of Natural History (S) and the New York Botanical Garden (NY).

Isolations were made from single ascospores as in Chapter 4 (4.2.1).

6.2.2 DNA Extraction, PCR Amplification and Sequencing

Follow Chapter 4 (4.2.2). The reference nucleotide sequences of LSU and SSU regions of various taxa were obtained from GenBank (Table 6.1).

6.2.3 Phylogenetic Analysis

Sequences generated from different primers were analyzed with other sequences obtained from the GenBank. A Blast search was performed to reveal the closest matches with taxa in *Pleosporales*. In addition, fungal members from different families of the *Pleosporales* and related orders were also included in the analyses. Sequences were aligned using Bioedit (Hall 1999) and ClustalX v. 1.83 (Thompson et al., 1997). The alignments were checked visually and improved manually where necessary. Phylogenetic analyses were performed by using PAUP v. 4.0b10 (Swofford 2002) for Maximum-parsimony (MP) and MrBayes v. 3.0b4 (Ronquist & Huelsenbeck 2003) for Bayesian analyses.

The analyses of Maximum likelihood (RAxML), Maximum Parsimony and Bayesian were performed as in Chapter3 (3.2.1).

6.3 Results and Discussion

6.3.1 DNA Sequencing - Combined LSU and SSU rDNA Phylogenies

The combined 28S (LSU) and 18S (SSU) rDNA data set consists of 79 taxa, with *Dothidea insculpta, D. sambuci* and *Myriangium hispanicum* as the outgroup taxa. The dataset consists of 1894 characters after alignment, of which 1861 sites are included in the ML and MP analysis. Of the included bases, 483 sites (25.95%) are parsimony-informative. A heuristic search with random addition of taxa (1000 replicates) and treating gaps as missing characters generated six equally parsimonious trees. All trees were similar in topology and not significantly different (data not shown). A best scoring RAxML tree is shown in Fig. 6.1. Bootstrap support (BS) values of ML and MP (equal to or above 50% based on 1,000 replicates) are shown on the upper branches. Values of the Bayesian posterior probabilities (PP) (equal to or above 95% based on 1,000 replicates) from MCMC analyses are shown under the branches.

The phylogenetic trees obtained from maximum likelihood, Bayesian and maximum parsimony analyses gave similar results relating to family relationships and were similar to previous studies based on maximum likelihood (Schoch et al., 2009a; Suetrong et al., 2009; Zhang et al., 2009a, 2012). Eleven new *Astrosphaeriella* strains are shown to be polyphyletic within *Pleosporales* and cluster in four clades: Clade C representing the generic type *A. stellata* with *A. bakeriana* and species of *Delitschia*; Clades A and B in *Aigialaceae* representing the new genera *Fissuroma* and *Neoastrosphaeriella* (species with slit-like ostioles in ascomata) which are introduced in this paper; and *A. africana* (Clade D) with striate ascospores which deviated from these three clades and is basal in *Pleosporales*. The new taxa are described based on support in all three computational methods.

Morphologically, *Astrosphaeriella* fits well in *Pleosporales*, but cannot be accommodated under any of the current families. *Astrosphaeriella* has been provisionally assigned to *Melanommataceae*, *Pleosporales* (Lumbsch & Huhndorf 2007), a placement rejected by recent phylogenetic results (Tanaka et al., 2009). Phylogenetically, *Astrosphaeriella stellata*, the type of the genus, separated from

Herpotrichia juniperi, a representative species of the *Melanommataceae* (Zhang et al., 2008a), and was basal to other families of *Pleosporales* (Tanaka et al., 2009). In our study, eleven new strains of *Astrosphaeriella* have been sequenced and analyzed with other members of the *Pleosporales*; the results show that *Astrosphaeriella* is polyphyletic.

Table 6.1 Fungal isolates of *Pleosporales* included in this study

Taxon	**Source**	**GenBank accession numbers**		
		LSU	**SSU**	**ITS**
Aigialus grandis	BCC 18419	GU479774	GU479738	
Aigialus grandis	BCC 20000	GU479775	GU479739	
Aigialus grandis	JK 5244A	GU301793	GU296131	
Aigialus mangrovis	BCC 33563	GU479776	GU479741	
Aigialus mangrovis	BCC 33564	GU479777	GU479742	
Aigialus parvus	BCC 18403	GU479778	GU479743	
Aigialus parvus	BCC 32558	GU479779	GU479744	
Aigialus rhizophorae	BCC 33572	GU479780	GU479745	
Aigialus rhizophorae	BCC 33573	GU479781	GU479746	
Amniculicola lignicola	CBS 123094	EF493861	EF493863	
Ascocratera manglicola	HHUF 30032	GU479783	GU479748	
Ascocratera manglicola	BCC 09270	GU479782	GU479747	
Ascocratera manglicola	JK 5262C	GU301799	GU296136	
Astrosphaeriella africana	MFLUCC 10-0553	JN846721	JN846731	JN846717
Astrosphaeriella bakeriana	CBS 115556	GU301801		
Astrosphaeriella bakeriana	MFLUCC 11-0027	JN846730	JN846740	JN846716
Astrosphaeriella sp	A70	GU205213	GU205233	
Astrosphaeriella stellata	KT 998	AB524592	AB524451	
Astrosphaeriella stellata	MFLUCC 10-0095	JN846720	JN846741	JN846709
Astrosphaeriella stellata	MFLUCC 10-0555	JN846723	JN846733	JN846719
Bimuria novae-zelandiae	CBS 107.79	AY016356	AY016338	
Chaetosphaeronema hispidulum	CBS 216.75	EU754144	EU754045	
Cochliobolus heterostrophus	CBS 134.39	AY544645	AY544727	
Cochliobolus sativus	DAOM 226212	DQ678045	DQ677995	
Delitschia didyma	UME 31411	DQ384090	AF242264	
Delitschia winteri	CBS 225.62	DQ678077	DQ678026	
Didymella cucurbitacearum	IMI 373225	AY293792	AY293779	
Didymella exigua	CBS 183.55	EU754155	EU754056	
Didymocrea sadasivanii	CBS 438.65	DQ384103	DQ384066	
Dothidea insculpta	CBS 189.58	DQ247802	DQ247810	
Dothidea sambuci	DAOM 231303	AY544681	AY544722	
Entodesmium rude	CBS 650.86	GU301812		
Falciformispora lignatilis	BCC 21118	GU371827	GU371835	
Falciformispora lignatilis	BCC 21117	GU371826	GU371834	
Fissuroma aggregata	KT 767	AB524590	AB524449	
Fissuroma aggregata	KT 984	AB524591	AB524450	
Fissuroma aggregata	MFLUCC 10-0554	JN846722	JN846732	JN846718
Fissuroma maculans	MFLUCC 10-0886	JN846724	JN846734	JN846710
Fissuroma maculans	MFLUCC 10-0887	JN846725	JN846736	JN846712
Fissuroma maculans	MFLUCC 10-0888	JN846726	JN846737	JN846713

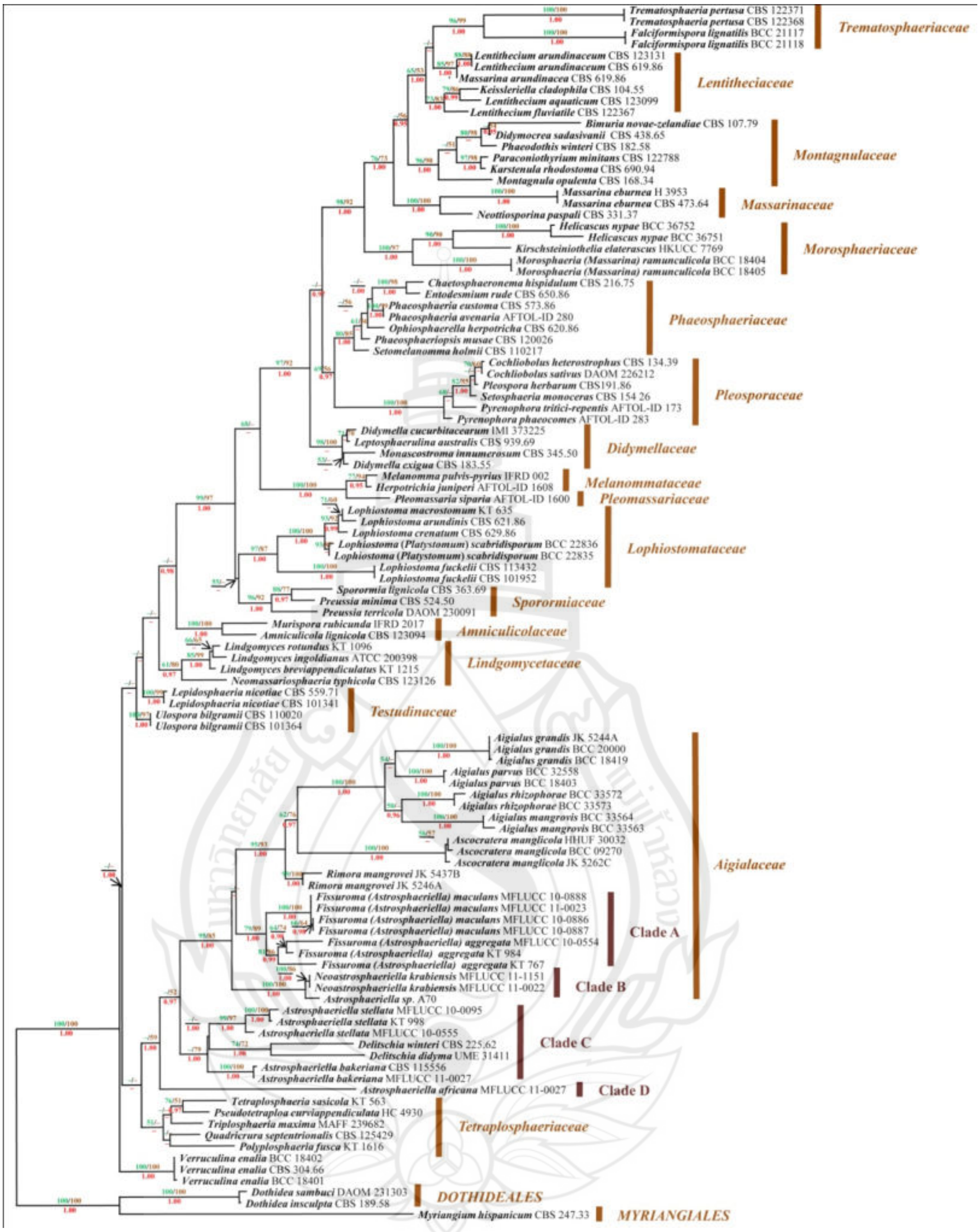
Table 6.1 (continued)

Taxon	Source	GenBank accession numbers		
		LSU	SSU	ITS
Fissuroma maculans	MFLUCC 11-0023	JN846728	JN846738	JN846714
Helicascus nypae	BCC 36751	GU479788	GU479754	
Helicascus nypae	BCC 36752	GU479789	GU479755	
Herpotrichia juniperi	AFTOL-ID 1608	DQ678080	DQ678029	
Karstenula rhodostoma	CBS 690.94	GU301821	GU296154	
Keissleriella cladophila	CBS 104.55	GU301822	GU296155	
Kirschsteiniothelia elaterascus	HKUCC 7769	AY787934	AF053727	
Lentithecium aquaticum	CBS 123099	GU301823	GU296156	
Lentithecium arundinaceum	CBS 123131	GU456320	GU456298	
Lentithecium arundinaceum	CBS 619.86	GU301824	GU296157	
Lentithecium fluviatile	CBS 122367	GU301825	GU296158	
Lepidosphaeria nicotiae	CBS 559.71	DQ384106	DQ384068	
Lepidosphaeria nicotiae	CBS 101341	DQ678067		
Leptosphaerulina australis	CBS 939.69	EU754167	EU754068	
Lindgomyces breviappendiculata	KT 1215	AB521748	AB521733	
Lindgomyces ingoldianus	ATCC 200398	AB521736	AB521719	
Lindgomyces rotundatus	KT 1096	AB521740	AB521723	
Lophiostoma scabridisporum	BCC 22835	GQ925844	GQ925831	
Lophiostoma scabridisporum	BCC 22836	GQ925845	GQ925832	
Lophiostoma arundinis	CBS 621.86	DQ782384	DQ782383	
Lophiostoma crenatum	CBS 629.86	DQ678069	DQ678017	
Lophiostoma fuckelii	CBS 113432	EU552139		
Lophiostoma fuckelii	CBS 101952	DQ399531		
Lophiostoma macrostomum	KT 635	AB433273	AB521731	
Massarina eburnea	CBS 473.64	FJ795449	GU296170	
Massarina eburnea	H 3953	AB521735	AB521718	
Monascostroma innumerosum	CBS 345.50	GU301850	GU296179	
Montagnula opulenta	CBS 168.34	DQ678086	AF164370	
Morosphaeria ramunculicola	BCC 18405	GQ925854	GQ925839	
Morosphaeria ramunculicola	BCC 18404	GQ925853	GQ925838	
Murispora rubicunda	IFRD 2017	FJ795507	GU456308	
Myriangium hispanicum	CBS 247.33	GU301854	GU296180	
Neoastrosphaeriella krabiensis	MFLUCC 11-0022	JN846727	JN846735	JN846711
Neoastrosphaeriella krabiensis	MFLUCC 11-0023	JN846729	JN846739	JN846715
Neomassariosphaeria typhicola	CBS 123126	FJ795504	GU296174	
Neottiosporina paspali	CBS 331.37	EU754172	EU754073	
Ophiosphaerella herpotricha	CBS 620.86	DQ678062	DQ678010	
Paraconiothyrium minitans	CBS 122788	EU754173	EU754074	
Phaeodothis winteri	CBS 182.58	DQ678073	DQ678021	
Phaeosphaeria avenaria	AFTOL-ID 280	AY544684	AY544725	
Phaeosphaeria eustoma	CBS 573.86	DQ678063	DQ678011	

Table 6.1 (continued)

Taxon	Source	GenBank accession numbers		
		LSU	SSU	ITS
Phaeosphaeriopsis musae	CBS 120026	GU301862	GU296186	
Pleomassaria siparia	AFTOL-ID 1600	DQ678078	DQ678027	
Pleospora herbarum	CBS 191.86	DQ247804	DQ247812	
Polyplosphaeria fusca	KT 1616	AB524604	AB524463	
Preussia minima	CBS 524.50	DQ678056	DQ678003	
Preussia terricola	DAOM 230091	AY544686	AY544726	
Pseudotetraploa curviappendiculata	HC 4930	AB524608	AB524467	
Pyrenophora phaeocomes	AFTOL-ID 283	DQ499596	DQ499595	
Pyrenophora tritici-repentis	AFTOL-ID 173	AY544672	AY544716	
Quadricrura septentrionalis	CBS 125429	AB524615	AB524474	
Rimora mangrovei	JK 5246A	GU301868	GU296193	
Rimora mangrovei	JK 5437B	GU479798	GU479765	
Setomelanomma holmii	CBS 110217	GU301871	GU296196	
Setosphaeria monoceras	CBS 154.26	AY016368	AY016352	
Sporormia lignicola	CBS 363.69	DQ384098	DQ384087	
Tetraplosphaeria sasicola	MAFF 239677	AB524631	AB524490	
Tetraplosphaeria yakushimensis	KT 1906	AB524632	AB524491	
Trematosphaeria pertusa	CBS 122371	FJ201992	FJ201993	
Trematosphaeria pertusa	CBS 122368	FJ201990	FJ201991	
Triplosphaeria maxima	MAFF 239682	AB524637	AB524496	
Ulospora bilgramii	CBS 101364	DQ678076	DQ678025	
Ulospora bilgramii	CBS 110020	DQ384108	DQ384071	
Verruculina enalia	CBS 304.66	DQ678079	DQ678028	
Verruculina enalia	BCC 18401	GU479802	GU479770	
Verruculina enalia	BCC 18402	GU479803	GU479771	
Paraconiothyrium minitans	CBS 122788	EU754173	EU754074	
Phaeodothis winteri	CBS 182.58	DQ678073	DQ678021	
Phaeosphaeria avenaria	AFTOL-ID 280	AY544684	AY544725	
Phaeosphaeria eustoma	CBS 573.86	DQ678063	DQ678011	

Note. Abbreviations of isolates and culture collections as in Chapter 3 (Table 3.1).



Note. RAxML tree based on a combined dataset of SSU (957bp) and LSU (888bp) nrDNA sequences. The tree was rooted to *Dothidea insculpta, Dothidea sambuci* and *Myriangium hispanicum.*

Figure 6.1 Phylogram generated from RAxML analysis

6.3.2 Taxonomy

Two new genera, *Fussiroma* and *Neoastrosphaeriella* in the family *Aigialaceae* typified by *Fussiroma maculans* and *Neoastrosphaeriella krabiensis*, are established in Liu et al. (2011). All of the new taxa are differentiated by molecular phylogeny results and their morphology was described in detail.

Astrosphaeriella Syd & P. Syd., Ann. Mycol. 11: 260. 1913.

Synonymy: *Asterella* (Sacc.) Sacc., Syll Fungorum. 9: 393 (1891).

Leptosphaeria sec. *Astrosphaeria* Höhnel, Sitzungsberichte der Akademie der Wissenschaften Wien, Math. Nat. Kl., Abt. I. 118: 327 (1909).

Ascomata dark brown to almost black, unilocular, hemispherical to conical, scattered, or rarely clustered, with 2-3 occasionally clustering at the base, immersed at first and initially subepidermal, mainly becoming superficial with the base attached to the host, or covered by epidermis except for the ostiolar region, or rupturing the host tissue with tissue remaining as scales around the base with a stellate appearance from above, base flattened, ostiolate. *Ostiole* usually black, mammiform or occasionally elongated. *Peridium* strongly carbonaceous and relatively thick, composed of thick-walled red-brown to dark angular or relatively compressed pseudoparenchymatous cells. *Pseudoparaphyses* trabeculate, numerous, narrow, persistent, filiform, septate, anastomosing and branched, embedded in a gelatinous matrix. *Asci* 8−spored, bitunicate, fissitunicate, cylindrical, cylindric-clavate, pedicellate, with an ocular chamber and some with a faint ring. *Ascospores* 2-3−seriate, elongate-fusiform, hyaline or reddish brown, smooth-walled, mostly straight, 1-5 septate, sometimes constricted at the septa, concolourous, or with striations, often with a mucilaginous sheath.

Type species: *Astrosphaeriella fusispora* Syd. & P. Syd.

Known hosts: Bamboo, palms.

Notes: *Astrosphaeriella* was neatly circumscribed by Hawksworth (1981) and Hawksworth and Boise (1985). *Astrosphaeriella stellata* was treated as an earlier name for *A. fusispora* which has been accepted by most mycologists (Hyde & Fröhlich, 1998; Chen & Huang, 2000; Hyde et al., 2000a; Chen & Hsieh, 2004; Tanaka & Harada, 2005; Tanaka et al., 2009). We follow this treatment in the present study. Species of *Astrosphaeriella* are comparable to species of *Caryospora* and

Trematosphaeria in the structure of their ascomata, but *Astrosphaeriella* is distinguished by the shape and structure of the ascospores or the hosts. In *Caryospora* the ascospores differ as they have thick walls and germ pores at the ends of ascospores. Species of *Trematosphaeria* differ from *Astrosphaeriella* in having ascospores with lighter extremities and also in the fact that the latter are found on monocotyledonous hosts (Hawksworth 1981, Hyde & Fröhlich, 1998; Hyde et al., 2000b, Zhang et al., 2008a).

Astrosphaeriella stellata (Pat.) Sacc., Syll. fung. (Abellini) 24(2): 938 (1928)

Basionym: *Amphisphaeria stellata* Pat., Bull. Soc. Mycol. Fr. 29: 223 (30 May 1913)

Synonyms: *Astrosphaeriella fusispora* Syd. & P. Syd., Ann Mycol. 11(3): 260 (June 1913)

Microthelia fusispora (Syd. & P. Syd.) E. Müll., in Müller & von Arx, Beitr. Kryptfl. Schweiz 11(2): 285 (1962)

Microthelia fuscomaculans (W. Yamam.) E. Müll., in Müller & von Arx, Beitr. Kryptfl. Schweiz 11(no. 2): 286 (1962)

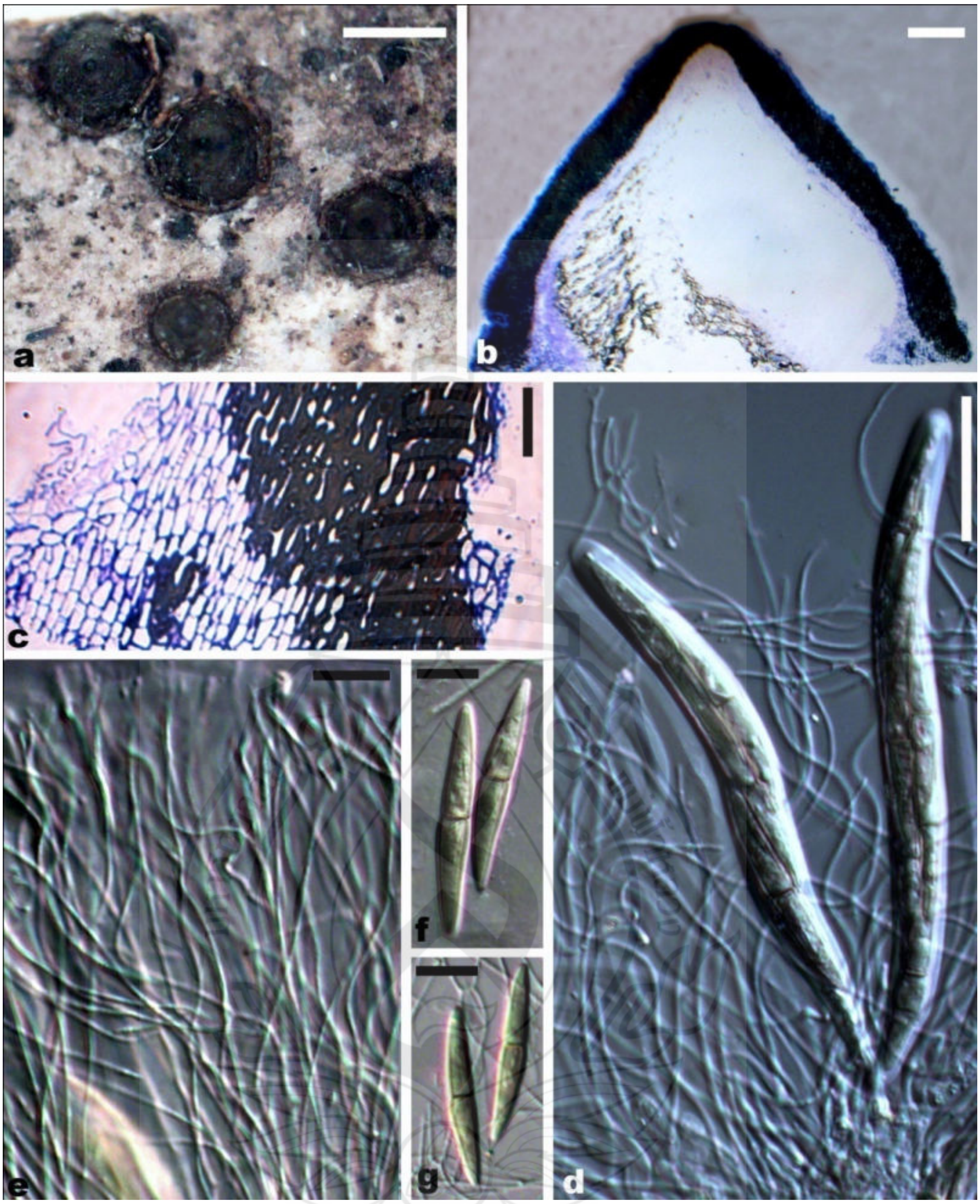
Ascomata 716−1066 µm wide, 500−683 µm high, dark brown to black, scattered, sometimes clustered, erumpent through the host tissue, becoming superficial, flattened at the base, apex non-papillate, with ruptured reflexed tooth-like host remnants around the base. *Peridium* 36.5−100 µm wide, carbonaceous, poorly developed at base, composed of opaque and melanized cells. *Pseudoparaphyses* 0.5−1.0 µm wide, trabeculate, numerous, anastomosing and frequently branched, embedded in a hyaline gelatinous matrix. *Asci* 120−201 × 8.5−14.5 µm ($\bar{x}$= 175 × 11 µm, n = 20), 8−spored, bitunicate, fissitunicate, cylindrical or cylindric-clavate, pedicellate, pedicel distinct, apically rounded with an ocular chamber (0.5−1.5 µm). *Ascospores* 36−50 × 5−7.5 µm ($\bar{x}$ = 44 × 6 µm, n = 30), uniseriate at the base and partially biseriate at the apex of ascus, ellipsoid to elongate-fusiform, hyaline when young, pale brown to brown when mature, smooth walled, constricted at the septum, cell above septum larger than lower cell, surrounded by a sheath, sheath truncate or sometimes concave at the ends.

Culture: Ascospores germinating on WA within 24 hours. Colony on MEA slow-growing, with a dense mycelium on surface of media, dark grey and dark in reverse with a blackish margin, with 5-10 mm diam., growth at 14 days.

Distribution: Australia, China, French, French Guiana, India, Indonesia (Java), Japan, Papua New Guinea, Philippines, Thailand and Vietnam.

Material examined: Thailand, Chiang Mai Prov., Doi Su Thep, on dead bamboo, 9 December 2008, Saranyaphat Boonmee (MFLU10–0025), living culture MFLUCC10-0095; JAPAN, Mino Prov., Kawauyemura, on *Phyllostachis bambusoides*, 24 September 1912, leg. K. Hara, no. 67 (S 11298, holotype of *Astrosphaeriella fusispora*).

Notes: *Astrosphaeriella stellata* is widely distributed at low elevations on bamboo and palms (Hawksworth 1981; Hyde & Fröhlich, 1998; Hsieh et al., 2000). Hyde and Fröhlich (1998) suggested that there is a wide range of ascospore size in this species. However, the ascospores sheath with truncated ends is a striking character of the species. Additionally, ascomata are relatively short compared with other species with superficial ascomata (Chen & Hsieh, 2004). Examination of type material of *A. fusispora* show that it is similar to *A. stellata*, their morphology is consistent and all specimens are considered to represent one variable species.



Note. a Ascomata on the host. b Vertical section of ascoma. c Peridium. d Asci and pseudoparaphyses. e Pseudoparaphyses. f−g Ascospores. Scale bars: a = 1 mm, b = 100 μm, c =10 μm, d = 20 μm, e−g = 10 μm.

Figure 6.2 *Astrosphaeriella fusispora* (S 18036, holotype)

Astrosphaeriella bakeriana (Sacc.) K.D. Hyde & J. Fröhl., Sydowia 50(1): 93 (1998)

Basionym: *Winterina bakeriana* Sacc., Bull. Orto Bot. Univ. Napoli 6: 45 (1918)

Synonyms: *Astrosphaeriella aosimensis* I. Hino & Katum., Bull. Fac. Agric. Yamaguchi Univ 7: 261 (1956)

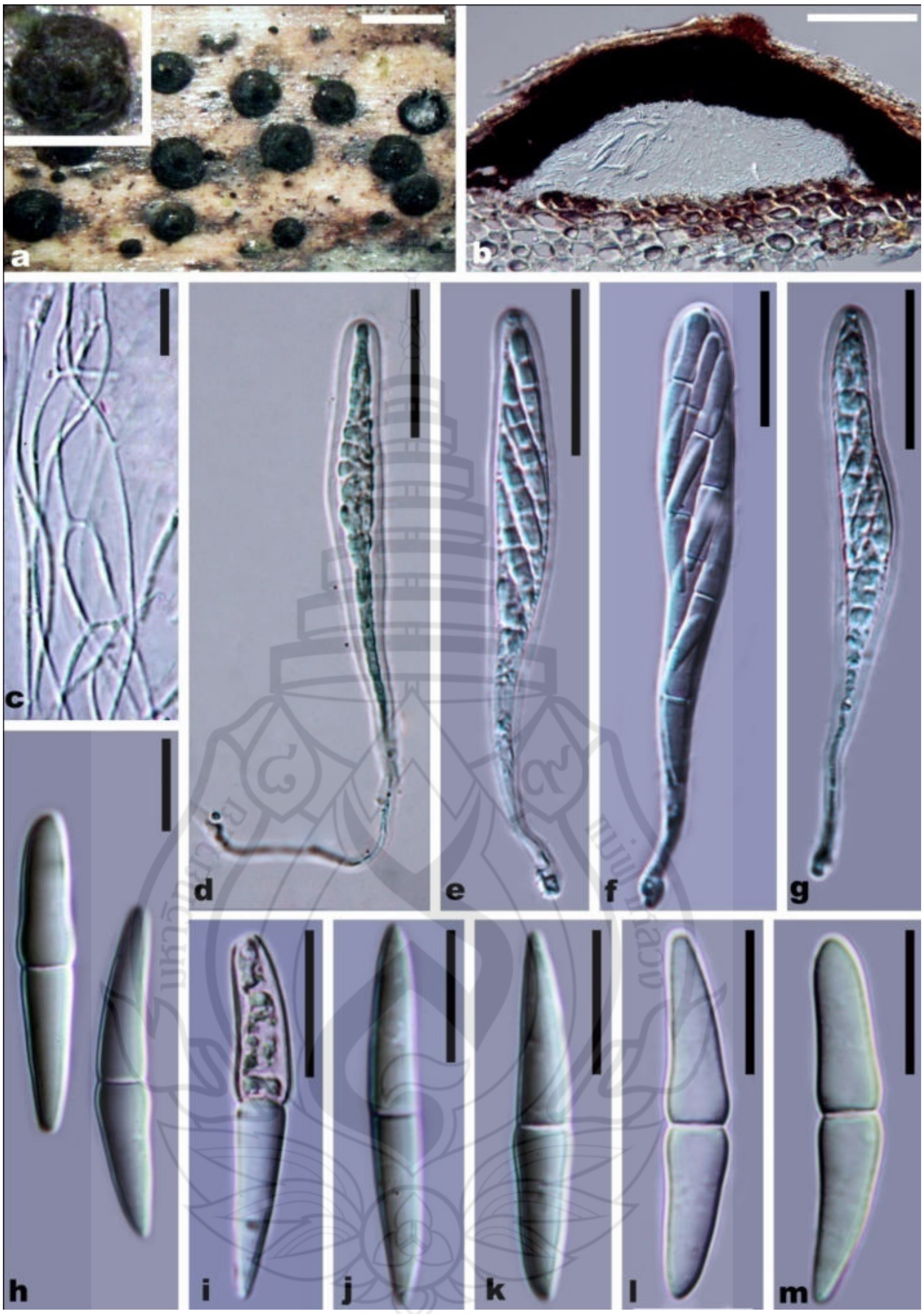
Microthelia aosimensis (I. Hino & Katum.) E. Müll., in Müller & von Arx., Beitr. Kryptfl. Schweiz 11(2): 286 (1962)

Ascomata 450−750 µm diam., 135−250 µm high, black, scattered, rarely clustered, immersed beneath host tissue, developing under hemispherical projections, carbonaceous domes, base applanate, with a central vertical short papilla. *Peridium* 35-60 µm thick, carbonaceous, uneven in thickness, composed of dark brown thick-walled cells. *Pseudoparaphyses* 1−1.5 µm wide, trabeculate, filiform, hyaline, persistent, numerous, septate, anastomosing and branched, embedded in a gelatinous matrix. *Asci* 95−155 × 10.5−17 µm ($\bar{x}$ = 120 × 13 µm, n = 20), 8−spored, bitunicate, fissitunicate, cylindric-clavate, long pedicellate, apex wide and rounded, with an ocular chamber. *Ascospores* 32−40 × 5−6.5 µm ($\bar{x}$ = 36 × 5.5 µm, n = 30), 2-3−seriate, fusiform, hyaline, old spores brown, smooth-walled, 1−septate, upper cell slightly shorter and wider, constricted at the septum, with an inconspicuous mucilaginous sheath.

Distribution: China, Ecuador, Hong Kong, Japan, Papua New Guinea, Singapore and Thailand.

Material examined: THAILAND, Krabi Prov., Nuea Khlong District, on petiole of *Borassus* sp., 26 September 2010, J.K. Liu, JKA0053 (MFLU11-1149) − living culture MFLUCC11-0027.

Notes: Hyde and Fröhlich (1998) introduced the new combination *Astrosphaeriella bakeriana* (Sacc.) K.D. Hyde & J. Fröhl. based on an examination of the holotype of *Winterina bakeriana* Sacc. They also treated *A. aosimensis* I. Hino & Katumoto. as a synonym of *A. bakeriana* (Sacc.) K.D. Hyde & J. Fröhl.



Note. a Ascomata on host surface. b Vertical section of the ascoma. c Pseudoparaphyses d−g Asci. h−m Ascospores. Scale bars: a = 1 mm, b = 100 µm, c = 10 µm, d−g = 30 µm, h−m = 10 µm.

Figure 6.3 *Astrosphaeriella bakeriana* (MFLU11-1152)

Aigialaceae Suetrong, Sakay., E.B.G. Jones, Kohlm., Volkm.-Kohlm. & C.L. Schoch., Stud.Mycol. 64: 166 (2009)

Suetrong et al. (2009) established this family with three genera *Aigialus*, *Ascocratera* and *Rimora*, all of which are all marine fungi and found in mangrove habitats. The study by Schoch et al. (2009) and Zhang et al. (2009a) showed that *Astrosphaeriella aggregata* (I. Hino & Katum.) Kaz. Tanaka & Y. Harada clustered in the *Aigialaceae*. In our study, the phylogenetic tree (Fig. 6.1.) showed that seven strains of *Astrosphaeriella* with slit-like ascomata clustered into two sister groups, *Fissuroma* and *Neoastrosphaeriella* in the clade *Aigialaceae*, while the generic type (*A. stellata*) formed a sister group to *Aigialaceae* (Fig. 6.1). Therefore, two new genera including the species with slit-like ascomata are introduced in *Aigialaceae*.

Fissuroma J.K. Liu., R. Phookamsak., E.B.G. Jones & K.D. Hyde., Fungal Diversity 51: 145 (2011)

MycoBank MB 563456.

Ascomata erumpentia, partim immersa vel superficialia, ostiolo fissuriforma, periphysata, nigra. Hamathecis pseudoparaphysibus ramosibis. Asci octospori, fissitunicati cylindrici, pedunculati, pachydermi. Ascosporae, fusiformes, hyalinae, septum, constrictae, tunica gelatinosa tectae.

Ascomata black, scattered, rarely clustered, immersed to superficial, erumpent, opening with a slit-like ostiole. *Peridium* carbonaceous, uneven in thickness, composed of dark brown thick-walled cells. *Pseudoparaphyses* trabeculate, hyaline, anastomosing, embedded in a gelatinous matrix. *Asci* 8−spored, fissitunicate, obclavate to cylindrical, pedicellate, with a small ocular chamber. *Ascospores* fusiform, hyaline, smooth-walled, 1−septate, slightly constricted at the septum, surrounded by a mucilaginous sheath.

Type species: *Fissuroma maculans* (Rehm) J.K. Liu., E.B.G. Jones & K.D. Hyde.

Notes: Hyde et al. (2000a) proposed a broad genetic concept of *Astrosphaeriella* to include *Massarina*-like species having ascomata with slit-like ostioles, and included six species: *A. aggregata*, *A. asiana*, *A. daemonoropis*, *A. fissuristoma*, *A. maculans* and *Lophiostoma mangrovis*. The two species *Astrosphaeriella asiana* and *Lophiostoma mangrovis* were described from mangroves with ascomata developing on a thin black stromatic crust (Kohlmeyer & Vittal, 1986; Hyde 1995); Suetrong et al. (2009) established the genus *Rimora* in the family *Aigialaceae* for the single species *Rimora mangrovis.* In this study, seven strains with slit-like ostioles in the ascomata clustered in two separate clades (Clade A, B) in the *Aigialaceae*. Therefore, a new genus *Fissuroma* was introduced (Liu et al., 2011) to accommodate the two species *Astrosphaeriella aggregata* and *A. maculans* which are a sister groups in Clade A.

Fissuroma aggregata (I. Hino & Katum) R. Phookamsak., J.K. Liu, E.B.G. Jones & K.D. Hyde., Fungal Diversity 51: 145 (2011)
MycoBank MB 563460.

Basionym: *Melanopsamma aggregata* I. Hino & Katum., Bull. Fac. Agric. Yamaguchi Univ., 6: 53 (1955)

Synonym: *Astrosphaeriella aggregata* (I. Hino & Katum.) Kaz. Tanaka & Y. Harada, Mycoscience 46: 115 (2005)

Ascomata 296−413 µm high, 873−1055 µm diam, black, scattered, rarely clustered, immersed below the epidermis, slightly raised, retaining several layers of host cells within the upper peridium, base flattened, with a long, central slit-like ostiole. *Peridium* 47−67 µm wide, black, carbonaceous, thick-walled, comprising several layers with host cells interdispersed with fungal tissue. *Pseudoparaphyses* 0.5−1 µm wide, trabeculate, persistent, numerous and anastomosing, embedded in a hyaline gelatinous matrix. *Asci* 155−197 × 15−18.5 µm ($\bar{x}$ = 177 × 16.5 µm, n = 20), 8−spored, bitunicate, fissitunicate, cylindric-clavate or obclavate, short pedicellate, apically rounded with an ocular chamber. *Ascospores* 38.5−54 × 7−10.5 µm ($\bar{x}$ = 47.5 × 8.5 µm, n= 30), elongate-fusiform, hyaline, smooth-walled, straight, guttulate, gradually tapering towards the rounded apices, 1−septate, constricted at the septum, with a mucilaginous sheath.

Distribution: Japan, Thailand.

Material examined: THAILAND, Chiang Rai Prov., Muang District, Huai Mae Sai Waterfall, on dead stem of bamboo, 10 March 2010, R. Phookamsak, RP0025 (MFLU11-0146) — living culture MFLUCC10-0554; *Ibid*., Mae Jun District, Huai Kang Pla Waterfall, on dead branch of bamboo, 25 October 2010, R. Phookamsak, RP0035 (MFLU11-0156) − living culture MFLUCC11-0206.

Notes: This species was originally introduced in the genus *Melanopsamma* by Hino and Katumoto (1955), but the placement is not suitable, as *Melanopsamma* is characterised by unitunicate asci and ellipsoid ascospores. Tanaka and Harada (2005) transferred this taxon to *Astrosphaeriella* based a broad generic concept as suggested by Hyde et al. (2000a) which includes *Massarina*-like species having ascomata with slit-like ostioles. Placement of this species in *Fissuroma* is supported by the molecular data.

Fissuroma maculans (Rehm) J.K. Liu., E.B.G. Jones & K.D. Hyde., Fungal Diversity 51: 145 (2011) MycoBank MB 563461. (Fig. 6.4)

Basionym: *Metasphaeria maculans* Rehm, Philipp. J. Sci., C, Bot. 8(5): 401 (1913)

Synonym: *Zignoëlla arengae* Rehm. Leaflets of Philippine Botany 6: 1938 (1913)

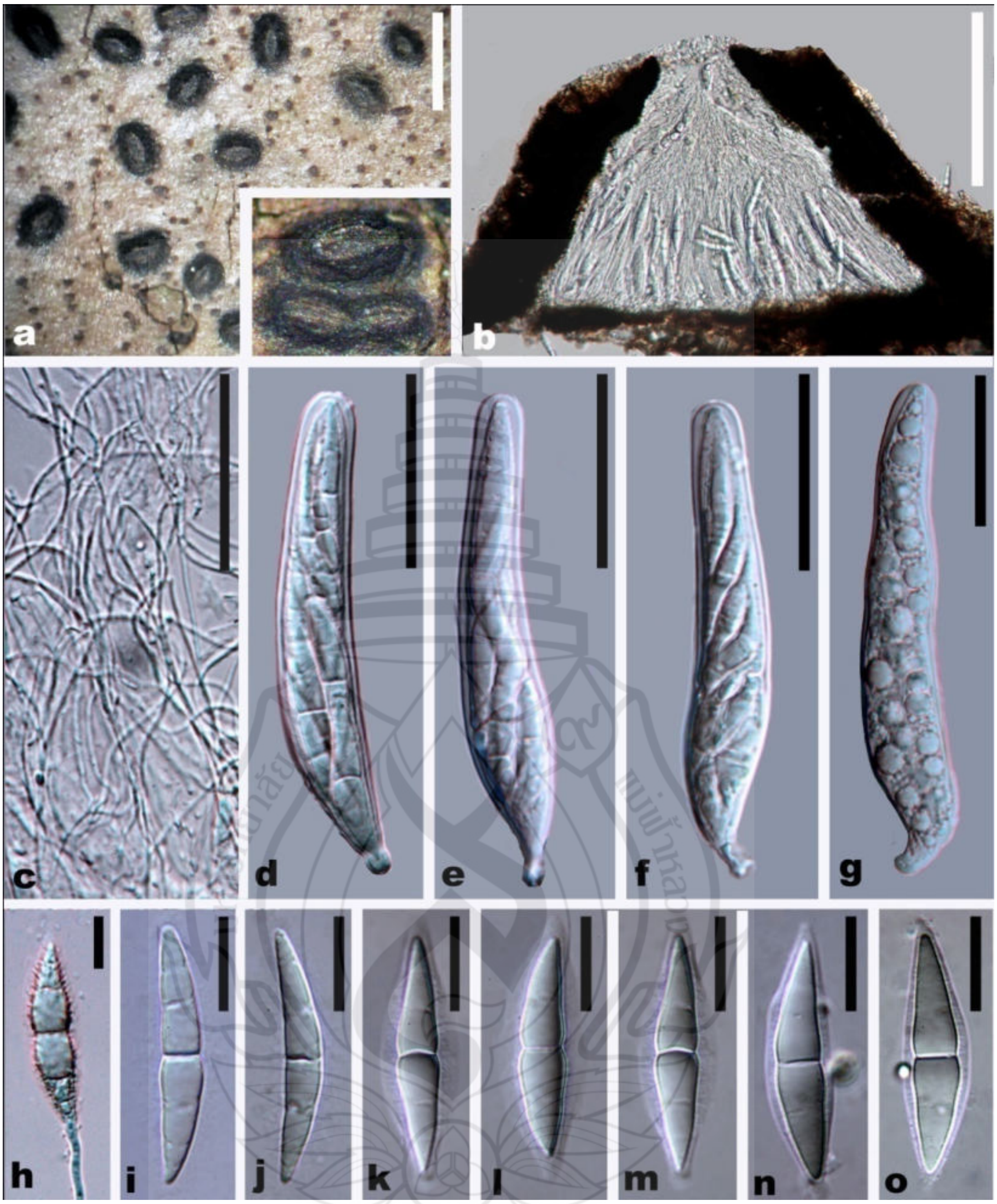
Astrosphaeriella maculans (Rehm) Aptroot, K.D. Hyde & Joanne E. Taylor., Nova Hedwigia 70(1-2): 152 (2000)

Ascomata 450−700 µm long, 300−450 µm diam., 95−185 µm high, in vertical section 110−245 µm high × 530−920 µm long, black, carbonaceous, conical, hemispherical, unilocular, scattered, rarely clustered, semi-immersed, forming beneath the host surface, base applanate and immersed, retaining several layers of host cells within the upper peridium, with a central flattened base and slit-like ostioles over almost the entire length. *Ostioles* slit-like, central, periphysate. *Peridium* up to 65 µm thick, black, carbonaceous; base and corners comprising a mixture of host cells and dark brown to black fungal hyphae. *Pseudoparaphyses* up to 1 µm wide, trabeculate, hyaline, anastomosing, embedded in a gelatinous matrix. *Asci* 65−125 × 10−17 µm ($\bar{x}$ = 85 × 13 µm, n=20), 8−spored, bitunicate, fissitunicate, cylindric-clavate or obclavate, short pedicellate, apex narrow and rounded, with a small ocular chamber. *Ascospores* 29−38 × 4−8 µm ($\bar{x}$ = 30 × 6.5 µm, n = 30), 1-2 seriate, fusiform, hyaline, smooth-walled, tapering to pointed apices, 1−septate, slightly constricted at the septum, surrounded by a mucilaginous sheath 2−3 µm wide, which is slightly drawn out at the apices.

Distribution: Australia, Philippines and Thailand.

Material examined: THAILAND, Chiang Rai Prov., Muang District, Khun Korn Waterfall, on dead leaves of *Arenga westerhoutii*, 6 September 2010, J.K. Liu, JKA0036 (MFLU11-1143 holotype) – living culture MFLUCC10-0886; Krabi Prov., Krabi College of Agriculture and Technology, on petiole of *Metroxylon sagu*, 26 September 2010, K.D. Hyde, JKA0041 (MFLU11-1145) − living culture MFLUCC10-0887; *Ibid.,* Bang Thao Mae Waterfall, on dead rhachis of *Arenga* sp., 26 September 2010, J.K. Liu, JKA0042 (MFLU11-1146) − living culture MFLUCC10-0888; JKA0044 (MFLU11-1147) − living culture MFLUCC11-0023.

Notes: Hyde et al. (2000a) examined the type material of both *Metasphaeria maculans* and *Zignoëlla arengae*. However, examination has revealed that the ascospores only have one septum, instead of the 3-5 septate conditaion reported in the descriptions (Rehm 1913a, b). Because the consistent morphology of both these two species, they were considered to represent one variable species. Thus a new combination was introduced and *Zignoëlla arengae* was treated as the synonym of *Astrosphaeriella.* The collections examined in our study are morphologically similar to *Astrosphaeriella maculans*. In this study, the molecular phylogeny obtained shows that this species should be excluded from *Astrosphaeriella* and transferred to *Fissuroma*.



Note. a Ascomata on host surface. b Section of the ascoma. c Pseudoparaphyses. d−g Asci. h Germinating ascospore. i−o Ascospores. Note the sheath of the ascospores. Scale bars: a = 1 mm, b = 100 μm, c−g = 30 μm, h−o = 10 μm.

Figure 6.4 *Fissuroma maculans* (MFLU11-1146)

Neoastrosphaeriella J.K. Liu., E.B.G. Jones & K.D. Hyde., Fungal Diversity 51: 148 (2011) MycoBank MB 563462

Ascomata erumpentia, immersa vel partim immersa, ostiolo fissuriforma, periphysata, nigra, gregaria. Hamathecia pseudoparaphysibus ramosiba. Asci octospori, fissitunicati, obclavati, pedunculati, pachydermi, sine apparatu apicali. Ascosporae triseptatae, distichae, fusiformes, hyalinae ad brunneae, verrucosae, septum constrictae, tunica gelatinosa tectae.

Ascomata black, scattered, immersed to semi-immersed, erumpent, usually beneath host tissue, opening with a slit-like ostiole. *Peridium* carbonaceous, uneven in thickness, composed of dark brown thick-walled cells. *Pseudoparaphyses* trabeculate, hyaline, anastomosing, embedded in a gelatinous matrix. *Asci* 8−spored, bitunicate, fissitunicate, obclavate to cylindrical, pedicellate, with a small ocular chamber. *Ascospores* fusiform, hyaline when young, and becoming brown to dark brown, spore wall verrucose when mature, 1−septate, constricted at the septum, surrounded by a mucilaginous sheath.

Type species: *Neoastrosphaeriella krabiensis* J.K. Liu., E.B.G. Jones & K.D. Hyde.

Notes: The three genera *Aigialus*, *Ascocratera* and *Rimora* in *Aigialaceae* share a number of features such as being carbonaceous, and characterized by apapillate ascomata, trabeculate pseudoparaphyses, cylindrical asci and ascospores with a sheath (Suetrong et al., 2009). In this study, our new collections conform to the characters in this family. Moreover, the molecular results show this fungus clusters in a sister group with the three genera in *Aigialaceae* but is distinct in having immersed ascomata and brown, verrucose ascospores.

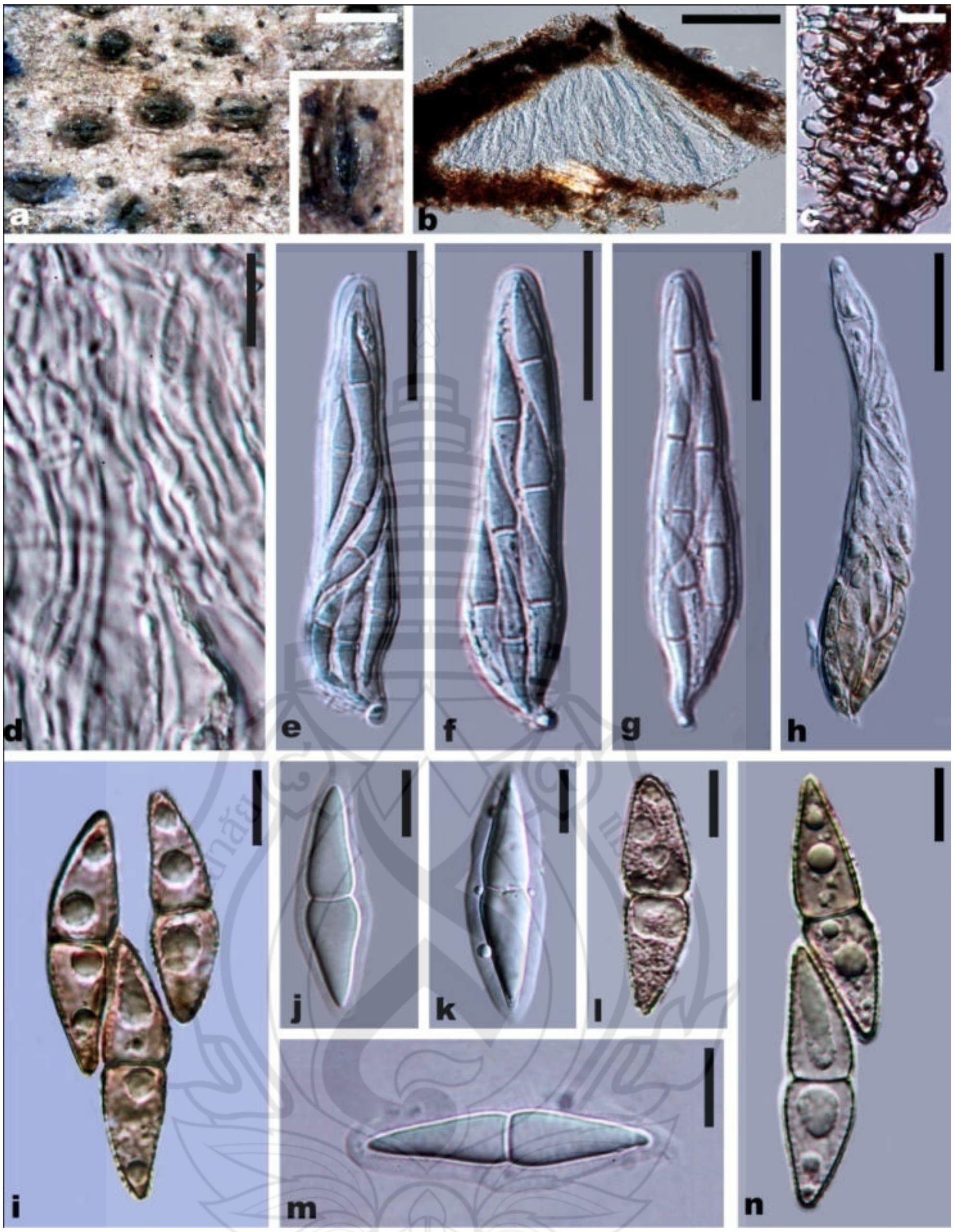
Neoastrosphaeriella krabiensis J.K. Liu., E.B.G. Jones & K.D. Hyde., Fungal Diversity 51: 148 (2011). MycoBank MB 563463 (Fig. 6.5)

Ascomata 350−600 μm longa, 200−400 μm diametro, 90−135 μm alta, immersa vel partim immersa, erumpentia, ostiolo fissuriforma, periphysata, nigra, gregaria. Pseudoparaphysibus filiformes, hyalines, septatis, ramosibis. Asci 85−135 × 15−23 μm, 8−spori, bitunicati, fissitunicati, octospori, obclavati, pedunculati, pachydermi, sine apparatu apicali. Ascosporae 32−40 × 6−9 µm, distichae, triseptatae, fusiformes, hyalinae ad brunneae, verrucosae, septae, constrictae, tunica gelatinosa tectae.

Ascomata 350−600 µm long, 200−400 µm diam., 90−135 µm high, in vertical section 115−260 µm high × 450−860 µm long, black, carbonaceous, unilocular, hemispherical, scattered, erumpent, semi-immersed to immersed, with a flattened base, forming beneath the host surface, retaining several layers of host cells within the upper peridium, with a central slit-like ostiole over almost the entire length, base applanate and immersed. *Ostioles* slit-like, central, periphysate. *Peridium* up to 55 µm wide, black, carbonaceous, composed of cells of dark brown thick-walled *textura angularis*, base and corners comprising a mixture of host and fungal cells. *Pseudoparaphyses* 1−1.5 µm wide, trabeculate, hyaline, anastomosing, embedded in a gelatinous matrix. *Asci* 85−135 × 15−23 µm ($\overline{x}$ = 100 × 18 µm, n = 20), 8−spored, fissitunicate, obclavate, short pedicellate, apex narrow and rounded, with a small ocular chamber. *Ascospores* 32−40 × 6−9 µm ($\overline{x}$ = 35.5 × 7 µm, n = 50), 1−2 seriate, uniform, hyaline when young, becoming brown to dark brown and verrucose when mature, tapering to pointed apices, 1−septate, constricted at the septum, surrounded by an mucilaginous sheath 1−2 µm wide, which is slightly drawn out at the apices.

Material examined: THAILAND, Krabi Prov., Krabi College of Agriculture and Technology, on petiole of *Metroxylon sagu*, 26 September 2010, J.K. Liu, JKA0050 (MFLU11-1148, holotype) – living culture MFLUCC11-0025; Phang Nga Prov., Mueang Phangnga, on the petiole of *Elaeis guineensis*, 26 September 2010, K.D. Hyde, JKA0040 (MFLU11-1144) − living culture MFLUCC11-0022.

Notes: *Neoastrosphaeriella* was described as a monotypic genus represented by *N. krabiensis* (Liu et al., 2011), collected on a petiole of *Metroxylon sagu* in Thailand. This taxon is characterized by its semi-immersed to immersed ascomata with slit-like ostioles, obclavate asci and brown, verrucose ascospores. It forms a sister group with the other four genera in the family *Aigialaceae* in the molecular analysis (Fig. 6.1). The genus differs from *Fissuroma* in having smaller obclavate asci and brown verrucose ascospores, while *Fissuroma* has cylindro-clavate asci and hyaline ascospores.



Note. a Appearance of ascomata on host surface. b Section of the ascoma. c Structure of peridium d Pseudoparaphyses. e–h Asci. i–n Ascospores. Note the sheath in young ascospores. Scale bars: a = 1 mm, b = 100 μm, c–d = 10 μm, e–h = 30 μm, i–n = 10 μm.

Figure 6.5 *Neoastrosphaeriella krabiensis* (MFLU11-1151, holotype)

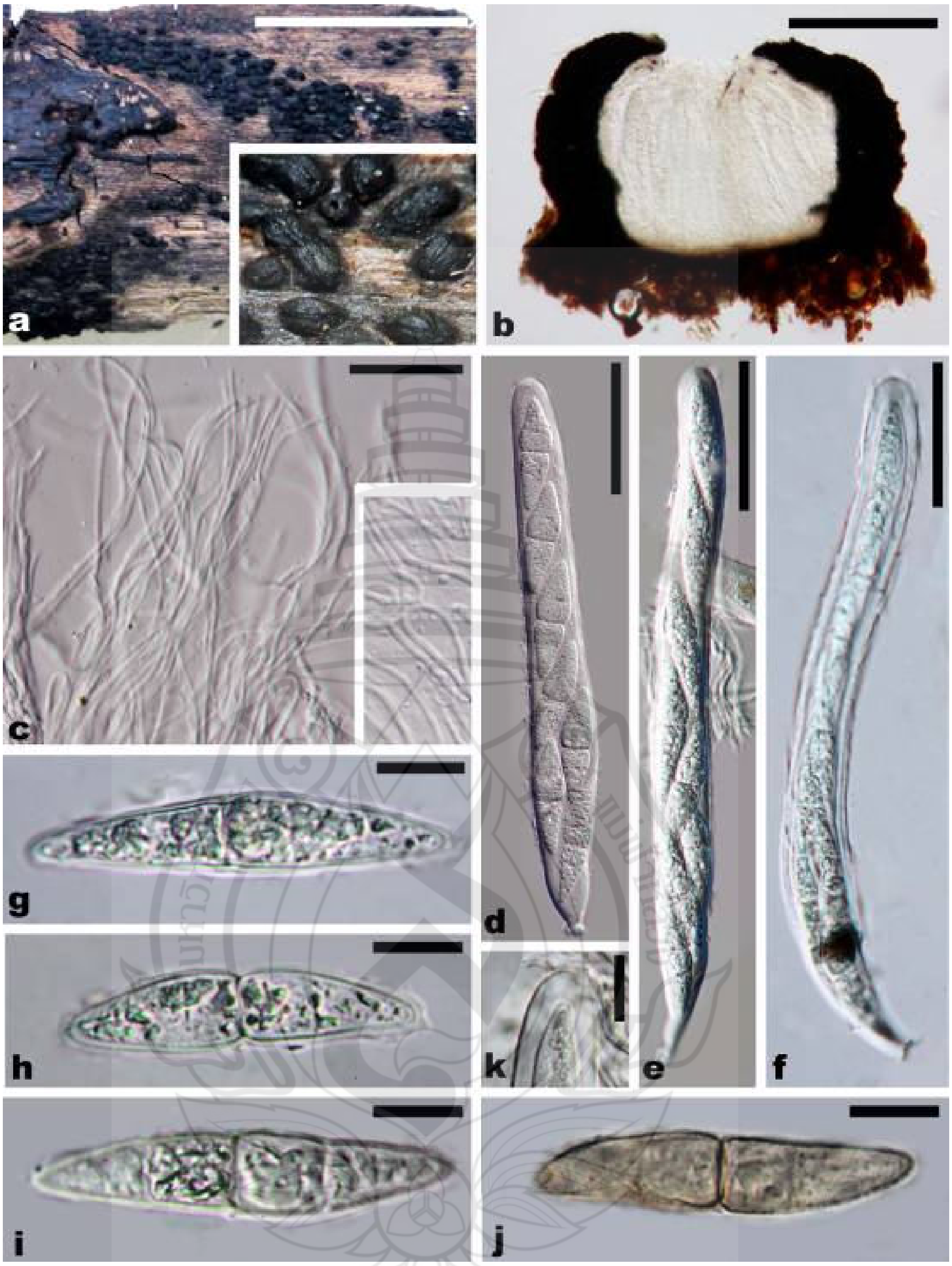
Rimora mangrovei (Kohlm. & Vittal) Kohlm., Volkm-Kohlm., Suetrong, Sakayaroj & E.B.G. Jones., Stud.Mycol. 64:166 (2009)

Ascomata 217−436 µm high, 278−557.5 µm wide, black, carbonaceous, gregarious, forming on a black stromatic crust, broadly oblong with a flat top in frontal view, opening with an cleft-like ostiolum at the flattened top, apapillate, immersed to erumpent or superficial. *Ostiole* cleft-like, central, periphysate. *Peridium* up to 140 µm thick, black, base comprising a mixture of fungal and host cells. *Pseudoparaphyses* up to 2 µm, trabeculate, numerous, branched. *Asci* 145.5−232 µm × 14.5−20.5 µm ($\bar{x}$ = 193 × 17 µm, n = 20), 8−spored, bitunicate, fissitunicate, cylindrical, short pedicellate, thick-walled, without an apical apparatus. *Ascospores* 43.5−52 µm × 7−12 µm ($\bar{x}$ = 47 × 8.5 µm, n = 30), fusiform, hyaline, initially 1−septate, later becoming 3−septate, pale brown or brown, constricted at the central primary septum, biseriate, surrounded by an evanescent sheath.

Distribution: Belize, India, Thailand.

Material examined: BELIZE, Man-of-War Cay, on old prop root of *Rhizophora mangle*, 27 March 1985, J. Kohlmeyer. 4553a (holotype from NY); *Ibid*., Wee-Wee Cay, old prop root of *Rhizophora mangle*, 29 March 1983, 24 November 1984, J. Kohlmeyer. 4631, (NY).

Notes: *Rimora mangrovei* was described as a species of *Lophiostoma* discovered on the bark and wood of mangrove trees from Belize and India (Kohlmeyer & Vittal, 1986). Hyde et al. (2000a) transferred it to the genus *Astrosphaeriella* based on the trabeculate pseudoparaphyses, while Suetrong et al. (2009) established the genus *Rimora* to accommodate this species based on molecular phylogeny.



Note. a Ascomata on host surface. b Vertical section of the ascoma. c Pseudoparaphyses. d–f Asci. g–j Ascospores. k Ocular chamber of ascus. Scale bars: a = 1 cm, b = 200 μm, c = 30 μm, d–f = 50 μm, g–k = 10 μm.

Figure 6.6 *Rimora mangrovei* (NY 4553a, holotype of *Lophiostoma mangrovei*)

This study deals with the genus *Astrosphaeriella* which is shown to be polyphyletic. *Fissuroma* and *Neoastrosphaeriella* were introduced to accommodate some species excluded from *Astrosphaeriella* but belonging in *Pleosporales*, an order recently detailed by Zhang et al. (2012) based on both morphology and phylogeny. *Astrosphaeriella* has previously been used to include species with cone-shaped and immersed to erumpent ascomata, composed of a carbonaceous firm, thick peridium, often with star-like flanges of ruptured host tissue around the base; the hamathecium comprised of numerous narrow trabeculate pseudoparaphyses embedded in a gelatinous matrix and asci that are bitunicate and cylindro-clavate with hyaline or brown ascospores (Hawksworth 1981; Hawksworth & Boise, 1985; Barr 1990; Hyde & Fröhlich, 1998; Fröhlich & Hyde, 2000). Zhang et al. (2009b) have shown that the value given to certain morphological characters, even in higher-level classification, can be overstated. The similar situation may occur in *Astrosphaeriella*. In this study, eleven new strains of *Astrosphaeriella*, including the generic type *A. stellata*, have been sequenced, and the sequences compared with those from other members of the *Pleosporales*. These eleven strains are shown to be polyphyletic within *Pleosporales* and the results confirm that *Astrosphaeriella* is polyphyletic, but a suitable family is needed to accommodate the genus. Some species, such as *A. africana* and *A. bakeriana* may need to be removed from *Astrosphaeriella* if further supporting data are available.

The family *Aigialaceae* was established by Suetrong et al. (2009) to accommodate members of the *Pleosporales* having rounded or cleft-like ostioles, black, carbonaceous to coriaceous ascomata, trabeculate pseudoparaphyses embedded in a gelatinous matrix, and hyaline to brown, septate to muriform ascospores with a gelatinous sheath or cap. Three genera *Aigialus, Ascocratera and Rimora* were included. *Fissuroma* and *Neoastrosphaeriella*, have morphological characters that fit *Aigialaceae* well. All of the previous members of *Aigialaceae* are marine fungi found in mangrove habitats while the two new genera described herein expand the habitats of the *Aigialaceae* to terrestrial examples. *Astrosphaeriella africana* which has striate ascospores appears to be basal to the *Pleosporales* and probably represents another genus; however more collections are needed to confirm this. Seven species with striate ascospores (*Astrosphaeriella aequatoriensis, A. africana, A. macrospora, A.*

pallidipolaris, A. papuana, A. striaspora and A. striataspora) were included in *Astrosphaeriella* (Müller & Dennis, 1965; Hawksworth & Boise, 1985; Aptroot 1995a; Hyde et al., 2000a; Chen & Hsieh, 2004), and this group needs further study.

Because of the difficulty in obtaining cultures of species of *Astrosphaeriella*, their culture characteristics are poorly known. A species of *Pleurophomopsis* has been recorded as the anamorph of *Astrosphaeriella* in Kirk et al. (2008) and Hyde et al. (2011). The features of a colony of *A. stellata* were reported by Tsui et al. (2001), but no anamorph was formed, and this was the case in our cultures. The *Pleurophomopsis*-like microconidial state of *Fissuroma aggregata* (as *Astrosphaeriella aggregata*) and *A. stellata* were recorded by Tanaka and Harada (2005). It seems probable that we will eventually need to introduce a new family to accommodate *Astrosphaeriella* and similar genera. However, the data presented herein do not provide strong enough support for us to propose such a new family in this study.

6.4 Conclusion

In this study, we re-evaluate the taxonomic and phylogenetic status of *Astrosphaeriella* species based on the multi-gene phylogenetic analysis and examination of type species. 11 fresh *Astrosphaeriella*-like taxa were sequenced to investigate the phylogenetic relationships of *Astrosphaeriella* with other genera or families of *Pleosporales*. The results showed that *Astrosphaeriella* is polyphyletic with species in *Fissuroma* and *Neoastrosphaeriella,* and *Astrosphaeriella*-like taxa clustering in four clades, two clades, including species with slit-like ostioles, clustered in *Aigialaceae*; the clade that includes the generic type clustered together with *Delitschia*; and *Astrosphaeriella afrocana*, which has striate ascospores, deviated from these three clades and had a basal position in the Pleosporales.

CHAPTER 7

OVERALL CONCLUSIONS

7.1 Diversity and Checklist of Non-Lichenized Palm Ascomycetes

Palm fungi are a taxonomically diverse group, with more than 1770 described species (340 basidiomycetes, 1430 ascomycetes have been described from palm substrate), with representatives from almost all major fungal classes. The ascomycetes (non-lichenized) which have been described from palms are a very diverse assemblage with 1059 species distributed in 436 genera and 121 families. The *Xylariaceae* and *Amphisphaeriaceae* are the best represented families, with 118 species in thirteen genera, and 111 species in thirteen genera respectively. The *Hypocreaceae* is also represented by thirteen genera, but by substantially fewer species (27). The *Nectriaceae* and *Phyllachoraceae* are the next most common families in terms of genera (ten each). The most common genus on palms is *Oxydothis* with 60 of its 65 species described from palm tissues. The second genus is *Anthostomella* with 63 of its 85 accepted species. The following common genera are *Astrosphaeriella* (twenty-seven species), *Linocarpon* (nineteen species), *Astrosphaeriella* (thirteen species), *Leptosphaeria* (fourteen species), *Xylaria* (eleven species) and *Guignardia* (ten species). A checklist of palm fungi (non-lichenized Ascomycetes) is given in this study including known distribution, hosts and family (the placement of each genus based on the *Index Fungorum*), and the notes (if the types were examined) are also provided.

7.2 Results of The Selected Fungal Groups

7.2.1 A Phylogenetic Assessment of Dothideomycetes

A class-wide phylogenetic assessment of Dothidoemycetes was carried out in order to provide a natural classification. This has involved selecting and clarifying the types and ex-types of most genera in the class, making new collections from Europe and Thailand and using existing and novel sequence data in our phylogenies. We present an expanded multi-gene (LSU, SSU, *TEF1* and *RPB2*) phylogeny for more than 400 isolates and 22 orders including 64 families (the current accepted families are 105) in Dothideomycetes. This study is providing a working document on Dothideomycetes which can be modified as new data comes to light. Based on the reconstructions resulted from the molecular analyses, 7 orders, *Dyfrolomycetales*, *Lichenoconiales*, *Lichenotheliales*, *Monoblastiales*, *Natipusillales*, *Phaeotrichales* and *Strigulales* were newly recognized, including 10 families *Anteagloniaceae*, *Bambusicolaceae*, *Biatriosporaceae*, *Lichenoconiaceae*, *Muyocopronaceae*, *Paranectriellaceae*, *Roussoellaceae*, *Salsugineaceae*, *Seynesiopeltidaceae* and *Thyridariaceae*. The relationships between asexual and sexual morphs were linked for some groups, and a multi-gene phylogeny that exposes the highly diverse nature of Dothideomycetes was presented.

7.2.2 *Botryosphaeriales*

The *Botryosphaeriales* was introduced by Schoch et al. (2006), following molecular analysis, and comprises a single family *Botryosphaeriaceae*. Currently the order *Botryosphaeriales* includes six families, *Aplosporellaceae*, *Botryosphaeriaceae*, *Melanopsaceae*, *Phyllostictaceae*, *Planistromellaceae* and *Saccharataceae* (Minnis et al., 2012; Wikee et al., 2013; Phillips et al., 2013; Slippers et al., 2013). With examinations of the types of *Auerswaldia*, *Auerswaldiella*, *Barriopsis*, *Botryosphaeria*, *Leptoguignardia*, *Melanops*, *Neodeightonia*, *Phaeobotryon, Phaeobotryosphaeria, Phyllachorella, Pyrenostigme, Saccharata*, *Sivanesania*, *Spencermartinsia* and *Vestergrenia*, 29 genera were accepted in *Botryosphaeriales*, and a phylogenetic tree representing 20 genera was presented based on the multi-gene phylogeny analyses. Our data advances the understanding of *Botryosphaeriales,* there is, however, still much research to be carried out with resolution of families and genera, linkage of sexual and asexual morphs and differentiation of cryptic species.

7.2.3 *Roussoellaceae*

Roussoella and *Roussoellopsis* species are mostly known from monocotyledons (bamboo and palms), and detailed phylogenies for this group are limited and thus their family placement and relationships with other genera are unclear. Samples of *Rossoulla*-like taxa were collected from bamboo and palms in northern Thailand during 2009 to 2012. Based on morphological examination (type specimens) and phylogenetic analyses (15 target strains), a new family *Roussoellaceae* (in *Pleosporales*) was introduced to accommodate these two genera. However, the relationship between *Roussoella* and *Roussoellopsis* is still not quite clear, this may due to the few available molecular data compare to the high diversity of this group. There is, of course, a needed in getting more taxa of this interesting group. Therefore a better understanding of *Roussoella*-like species in the order *Pleosporales* would be presented in further study.

7.2.4 *Astrosphaeriella*

As the third richest genus which follows *Oxydothis* and *Anthostomella*, *Astrosphaeriella* is a typical palm fungal genus (which is also found on bamboo). However, its family placement has been unsolved since it was introduced. To re-evaluate the taxonomic and phylogenetic status of *Astrosphaeriella* species, collections of this group were made from bamboo and palms in Thailand during 2008 to 2010. Multi-gene phylogenetic analyses with 11 fresh isolates were carried out to investigate the phylogenetic relationships with other genera or families of *Pleosporales*. *Astrosphaeriella* has been shown to be polyphyletic with species in *Fissuroma* and *Neoastrosphaeriella.* The recent studies are carried out by other researchers (Phookamsak et al., Pers.), it seems probable that a new family would need to be introduced to accommodate *Astrosphaeriella* and similar genera, and their data also support this assignment. A list of accepted species of *Astrosphaeriella* seems needed for in the further study when the new family is introduced.

7. 3 Future Work

In this study, I mainly used molecular sequences data to investigate the taxonomy and phylogeny relationship of some un-resolved groups, as well as the examination of type species. The molecular approach has been shown to be a powerful tool to improve and broad our knowledge and understanding on the fungal taxonomy, phylogeny and systematic. To update our understanding on this interesting fungal group (palm fungi), I would like to suggest further research on the following topics:

7.3.1 The checklist of palm fungi would be a reference book for those would like to do the research on biodiversity, palm pathogen and fungal diversity investigation. We would update this checklist biannually.

7.3.2 Extract DNA from the specimens which we cannot get from culture. There are many groups, such as *Linocarpon*, *Oxydothis* and *Astrosphaeriella*; the spores are difficult to germinate on media. This will help resolve the phylogenetic relationships for those groups.

7.3.3 The fungal genomes would be a powerful approach to help us to understand the phylogenetic relationship in both high (phylum, class, order and family) and low ranks (genus, species and sub-species). It would be possible to find suitable markers for the fungal taxonomy and phylogeny in different levels.

7.3.4 Discover the effective genes for some groups which include the species complex and cryptic species, especially in the Botryosphaeriales, as well as some methods, such as Genealogical Sorting Index (GSI). These would become necessary methods when detailed phylogenetic and taxonomic studies are carried out for these fungal groups.

7.3.5 Establish the relationship of some host specification (*Oxydothis* and *Linocarpon*) and investigate their host biogeography.

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APPENDICES

APPENDIX A

TAXONOMY OF FAMILIES *Polystomellaceae*, *Pyrenothrichaceae* AND *Vizellaceae*

Polystomellaceae Theiss. & P. Syd., Ann Mycol. 13: 158 (1915)

MycoBank: MB 81205

Biotrophic or *parasitic* on leaves, confined to tropical zones. Sexual state:*Ascostromata* black, immersed or well-developed, erumpent, pulvinate, and circular to suborbicular, elliptical or elongate, rugulose, comprising mostly fungal tissue, globose to subglobose, uniloculate or multi-loculate (with 5– numerous locules), with individual central ostioles. *Cells of ascostromata* dark brown-walled *textura angularis*. *Peridium* of locules composed of small heavily pigmented thick-walled cells of *textura angularis*. *Hamathecium* of numerous, hyaline, septate or non-septate,cellular pseudoparaphyses without branching, often deliquescent at maturity. *Asci* 8-spored, bitunicate, fissitunicate, oblong, cylindro-clavate or occasionally obclavate, often ventricose, with a short pedicel, apically rounded, with a small ocular chamber. *Ascospores* uni- to bi-seriate, hyaline, yellowish to olive brown, fusiform to ellipsoidal or obpyriform, one to two celled, upper cell wider and shorter than the lower cell, euseptate, septate near the lower end or middle, with or without constrictions at the septum, lacking a sheath. Asexual state: coelomycetous, acervular, linked to *Lasmenia* and *Stictochorella* (Wakefield 1940; Swart 1987; Kirk et al., 2008).

Notes: This family was introduced by Theissen and Sydow (1915) for *Munkiella*, *Parmularia* and *Polystomella* (the type species). However, other names used for this family include *Stigmateaceae* (Theissen 1916), and *Munkiellaceae* (Luttrell 1973). The *Polystomellaceae* include taxa with superficial ascomata, while in the *Munkiellaceae* ascomata are subcuticular, but the two families were combined by Eriksson (1981). Barr (1987) accepted *Polystomellaceae* as a family in the *Pleosporales* with the genera *Atopospora*, *Hormotheca* (currently referred to the *Venturiaceae*) and *Ellisiodothis* (currently referred to the *Microthyriaceae*). Lumbsch and Huhndorf

(2010) included three genera *Dothidella* (= *Polystomella*), *Munkiella* and *Parastigmatea* in the *Polystomellaceae* under Dothideomycetes, family *incertae sedis*, and this followed by Index Fungorum (2013) and MycoBank (2013). They share similar characters such as a stromatic ascomata resulting from ascolocular ontogeny, with uni- to multi-locular ascostromata, and hyaline ascospores, with one or two cells. Von Arx and Müller (1954) placed *Parastigmatea* under *Botryosphaeriaceae*, while in a recent review of the family, Liu et al. (2012) did not include the genus in this family. The three genera placed in *Polystomellaceae* were described before 1965 (Index Fungorum 2013) and no molecular sequence data are available; thus fresh collections are needed to established the phylogenetic relationships of the genera and family *Polystomellaceae*. *Munkiella* and *Parastigmatea* are presently listed in *Polystomellaceae*, but their inclusion is tentative for the purpose of keying out the genera.

Type: *Dothidella* Speg.,Anal. Soc. Cient. Argent. 9: 9 (1880), MycoBank: MB 1695

Possible synonyms:

Pluriporus F. Stevens & R.W. Ryan, in Stevens, Bulletin of the Bernice P. Bishop Museum, Honolulu, Hawaii 19: 65 (1925)

Polystomella Speg., Anal. Soc. cient. argent. 26(1): 53 (1888)

Biotrophic or *parasitic* on leaves, confined to tropical areas. Sexual state:*Ascostromata* black, well-developed, erumpent, pulvinate, and circular to suborbicular, elliptical or elongate, rugulose, comprising mostly fungal tissue, globose to subglobose, with five to numerous locules, with individual central ostioles, cells of ascostromata dark brown-walled *textura angularis*. *Peridium* of locules composed of small heavily pigmented thick-walled cells of *textura angularis*. *Hamathecium* of numerous, hyaline, septate or non-septatepseudoparaphyses without branching. *Asci* 8-spored, bitunicate, fissitunicate, oblong, cylindro-clavate or occasionally obclavate, often ventricose, with a short pedicel, apically rounded, with a small ocular chamber. *Ascospores* biseriate, hyaline, septate, ellipsoidal or obpyriform, 1-septate, upper cell wider and shorter than the lower cell, euseptate, with a constricted at the septum, lacking a sheath. Asexual state: linked linked to *Stictochorella* (Wakefield 1940; Swart 1987).

Notes: *Dothidella* was introduced by Spegazzini (1880) with *D. australis* as the type species. Many species of *Dothidella* were transferred to *Endodothella*, *Microcyclus*, *Phyllachora*, *Rehmiodothis* and *Stigmochora* which belong to *Mycosphaerellaceae* and *Phyllachoraceae* (Index Fungorum, 2014). They share similar characters such as being *biotrophic* or *parasitic* on leaves, and 1–2-celled hyaline ascospores. However, *Dothidella* differs from other genera by its multi-loculate ascostromata and ellipsoidal hyaline two celled ascospores, while *Phyllachora* (*Phyllachoraceae*) has unilocular ascostromata, unitunicate asci and one celled, hyaline ascospores, and *Microcyclus* (*Mycosphaerellaceae*) has multi-loculate ascostromata with two celled hyaline obovoid ascospores (Liu et al., 2012; Monkai et al., 2013).

Type species: *Dothidella australis* Speg., Anal. Soc. Cient. Argent. 10: 21 (1880), MycoBank: MB 233978

Other genera included

Dermatodothella Viégas, Bragantia 4(1-6): 150 (1944)

Type species: *Dermatodothella multiseptata* Viegas, Bragantia 4(1-6): 150 (1944)

Munkiella Speg., Anal. Soc. Cient. Argent. 19(6): 248 (1885)

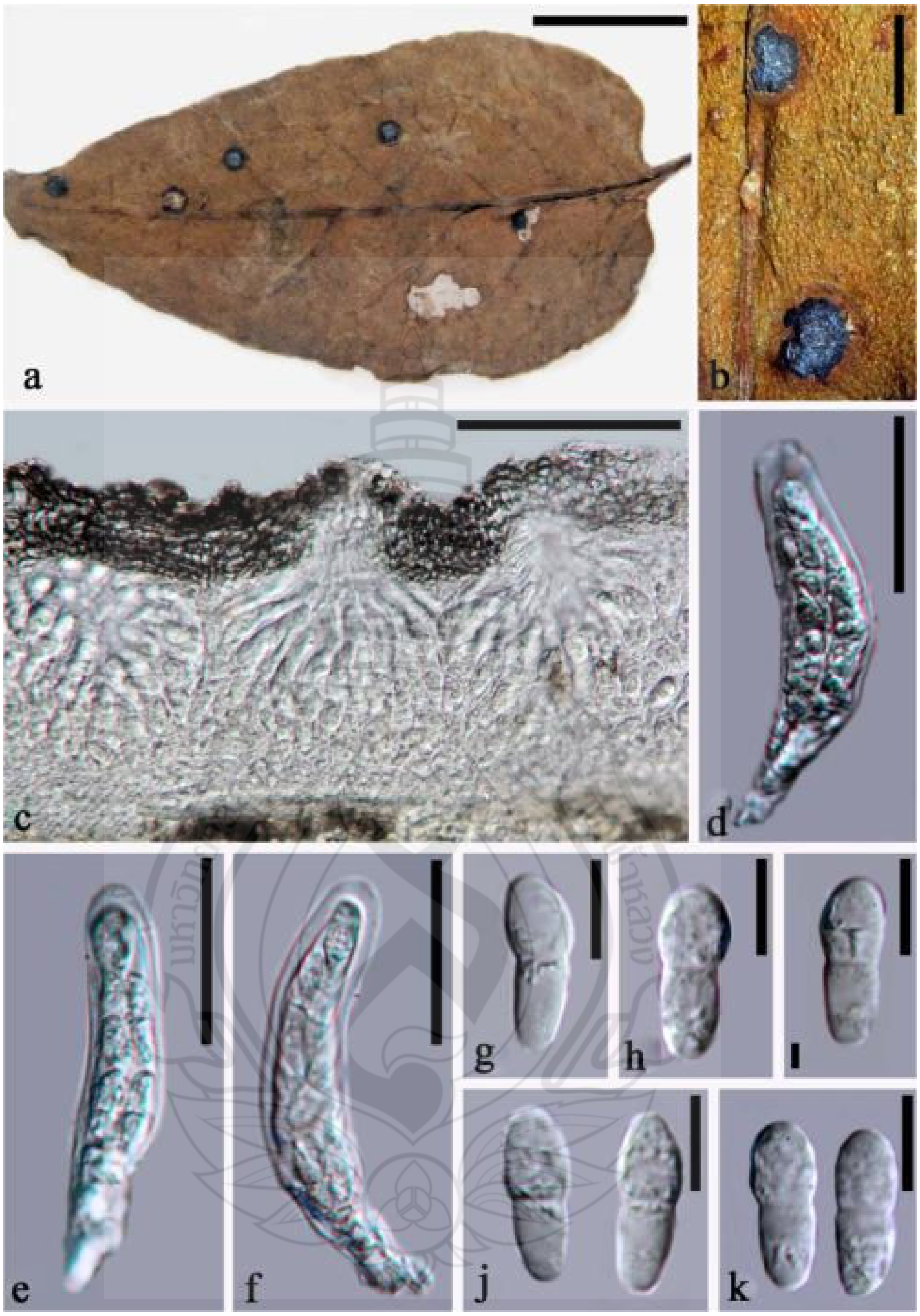
Type species: *Munkiella caa-guazu* Speg., Anal. Soc. cient. argent. 19: 248 (1885)

Parastigmatea Doidge, Bothalia 1(1): 22 (1921)

Type species: *Parastigmatea nervisita* Doidge, Bothalia 1(1): 22 (1921)

Key to genera of *Polystomellaceae*

1. Ascospores 2-celled 2
1. Ascospores non 2-celled 3
2. Ascospores septate near the middle .... *Dothidella*
2. Ascospores septate near the lower end .... *Munkiella*
3. Ascospores 1-celled ....*Parastigmatea*
3. Ascospores with small apical cells or 5–7-septate when mature .... *Dermatodothella*



Note. a, b Ascostromata on leaves. c Section through stroma. d-f Asci. g-k Ascospores. Scale Bars: a=1 cm, b= 2mm, c=100 µm, d-f=30 µm, g-k=10 µm.

Figure A1 *Dothidella australis* (LPS 318, holotype)

Pyrenothrichaceae Zahlbr. (as *Pyrenothricaceae*) in Engler & Prantl, Nat. Pflanzenfam., Edn 2 (Leipzig) 8: 91 (1926), MycoBank: MB 515946

Sexual state: *Thallus* corticolous or foliicolous, composed of densely arranged, but not conglutinated, appressed filaments, filaments formed by unbranched or falsely branched photobiont threads wrapped in a sheath of fungal hyphae; hyphae branched and anastomosing, formed by elongate, often strongly curved and terminally inflated, pale brownish cells. *Ascomata* perithecioid, sessile or immersed between thallus filaments, globose to pear-shaped with short neck or only with ostiole, glabrous. *Excipulum* (*peridium*) thin, paraplectenchymatous, grayish brown. *Hamathecium* aparaphysate (but empty asci resembling paraphyses often present). *Asci* 8-spored, bitunicate, broadly clavate to saccate, pedicellate. *Ascospores* transversally septate to muriform, pale to dark grayish brown. Asexual state: Unknown.

Notes: The family *Pyrenothrichaceae* (as *Pyrenothricaceae*) was established to accommodate *Pyrenothrix* (the type) and *Cyanoporina* Groenh by Zahlbruckner (1926). Based on the type species producing perithecia, Henssen (1964) placed *Pyrenothrichaceae* in *Pleosporales*. Eriksson (1981) suggested this taxon is close to *Coccodiniaceae*, sooty molds placed in *Capnodiales*. Eriksson et al. (2004) listed *Pyrenothrichaceae* under Chaetothyriomycetes and Dothideomycetes *incertae sedis*, but Lumbsch and Huhndorf (2010) listed the family in Dothideomycetes *incertae sedis*. Recent phylogenetic studies have shown that Dothideomycetes and Chaetothyriomycetes are not closely related, with Chaetothyriomycetes clustering together with Eurotiomycetes and Lecanoromycetes, while Dothideomycetes are basal Pezizomycotina. Morphologically, *Chaetothyriales* and *Verrucariales* are the most likely two orders to place *Pyrenothrichaceae*, as they share a typically hemiamyloid, rarely amyloid hamathecium lacking paraphyses, usually producing long periphysoids. However, *Verrucariales* are mainly lichenized, and *Chaetothyriales* are mostly non-lichenized. There are no molecular data for lichenized fungi currently placed in *Chaetothyriales* to confirm this placement. Herrera-Campos et al. (2005) suggested placing *Pyrenothrichaceae* within Chaetothyriales based on the simple perithecial wall characteristic of *Pyrenothrix*. *Cyanoporina* was introduced as a monotypic genus by Groenhart (1951) for *Cyanoporina granulosa* Groenh. This genus is presently monotypic. Although it seems unlikely that this genus is related to *Pyrenothrix* we include it in the *Pyrenothrichaceae* for convenience of keying out.

Type: *Pyrenothrix* Riddle. Bot. Gaz. 64: 513 (1917), MycoBank: MB 4608

Possible synonyms:

Lichenothrix Henssen, Ber. dt. bot. Ges. 77: 318 (1964)

Sexual state: *Thallus* corticolous or foliicolous, composed of densely arranged, but not conglutinated, appressed filaments, up to 100 µm, filaments formed by unbranched or falsely branched photobiont threads wrapped in a sheath of fungal hyphae; hyphae branched and anastomosing, formed by elongate, often strongly curved and terminally inflated, pale brownish cells. *Ascomata* solitary or in botryose clusters, dark greyish brown to black, coriaceous, with individual ostioles. *Ostiole* circular, central, papillate, periphyses absent from ostiolar channel. *Peridium* paraplectenchymatous, grayish brown, inner most 2–3 layers composed of narrow, thin-walled and periclinally elongate, almost hyaline cells, median 1–2 layers composed of broader, rather large, thick-walled and strongly pigmented cells, and outer most 2–3 layers composed of isodiametric to irregular, thin-walled and paler cells.*Hamathecium* of hypha-like, septate, pseudoparaphyses, which are slightly constricted at septum, rather long, hyaline periphysoids reaching down from below ostiolar channel into perithecial chamber. *Asci* 8-spored, bitunicate, fissitunicate, clavate, pedicellate. *Ascospores* 2–3-seriate, fusiform to clavate, muriform with (3–)5 transverse and 0–1 longitudinal septa per segment, brown to dark brown, slightly constricted at septum, terminal cells paler to almost hyaline, wall smooth. Asexual state: not established.

Notes: *Pyrenothrix* was introduced as a monotypic genus by Riddle (1917) based on *P. nigra*. This lichen fungus is characterized by perithecioid ascomata and anappressed filamentous thallus with cyanobacterialphotobiont (*Scytonema*). Henssen (1964) re-studied the type *Pyrenothrix* and described two new species namely, *Lichenothrixriddlei* A. Henssenas filamentous lichen and *Pleosphaeria lichenothricis* A. Henssenas parasymbiontic fungus, and suggested the type species*P. nigra* to be composed of two distinct elements: a filamentous, sterile lichen resembling a *Cystocoleus*, and a pyrenocarpous, parasymbiontic fungus. Eriksson (1981) synonymized both *Lichenothrix riddlei* and *Pleosphaeria lichenothricis* under *Pyrenothrixnigra* based on all the elements which are originally assigned to *P. nigra*. Herrera-Campos et al. (2005)

examined the types with designating a lectotype, and introduced a new species *Pyrenothrix mexicana* Herrera-Campos, Huhndorf & Lücking. A modern treatment based on molecular data isrequired for this family.

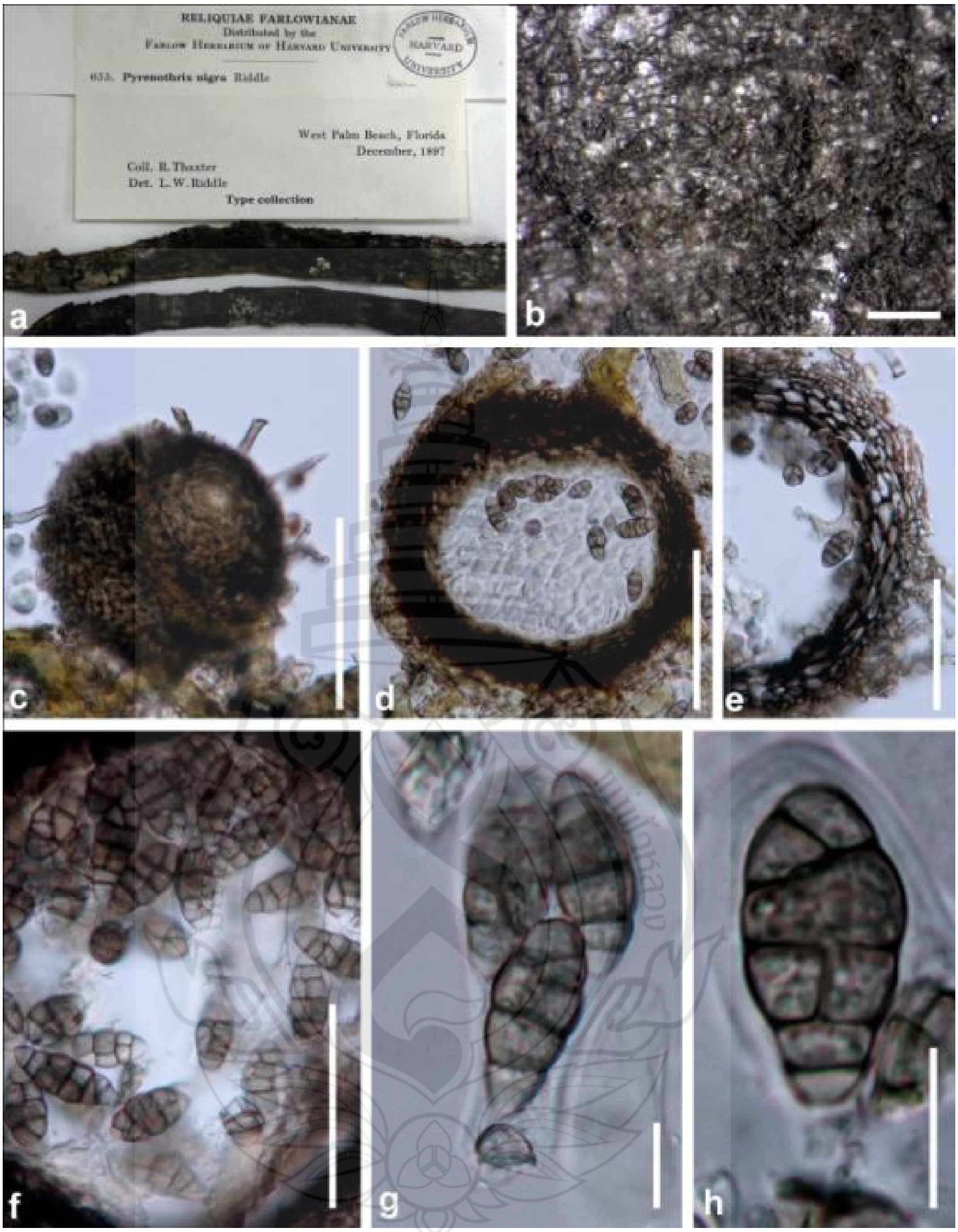
Type species: *Pyrenothrix nigra* Riddle, Bot. Gaz. 64: 513 (1917), MycoBank: MB 403162

Other genus accepted

Cyanoporina Groenh., Reinwardtia 1: 198 (1951)

Type species: *Cyanoporina granulosa* Groenh., Reinwardtia 1: 198 (1951)

Notes: *Cyanoporina* was introduced as monotypic genus for *C.granulosa*by Groenhart (1951), from the original description; this likely is a *Psoroglaena* (*Verrucariaceae*). We were unable to examine the type, however this is most unlikely a Dothideomycete.



Note. a Herbarium material. b Appressed filamentous thallus with perithecia c Ascoma. d Section of ascoma. e Peridium. f–h Ascospores. Scale bars: b=500 μm, c–d=100 μm, e–f=50 μm, g–h=10 μm.

Figure A2 *Pyrenothrix nigra* (FH, lectotype)

Vizellaceae H.J. Swart, Trans. Br. mycol. Soc. 57: 456 (1971), MycoBank: MB 81519

Possible synonyms:

Entopeltidaceae Arx & E. Müll. [as 'Entopeltaceae'], Beitr. Kryptfl. Schweiz 11(no. 1): 98 (1954)

Haplosporaceae Räsänen, Acta bot. fenn. 33: 31 (1943)

Parasitic or *saprobic* on leaves, tropical and subtropical in distribution, developing in or beneath the cuticle, often forming an intracuticular mycelium, without superficial hyphae. Sexual state:*Ascostromata* dimidiate, scutate or crustose, roundish or elongated in outline, with a thin wall composed of small, dark cells, opening by a fissure or dehiscence, central part of loculus may be sterile. *Hamathecium* comprising filamentous pseudoparaphyses, often filling the central part of the loculus or may be sparse or absent. *Asci* 6–8-spored, bitunicate, probably evanescent, broadly clavate or nearly cylindrical, short pedicellate or apedicellate, apically rounded with ocular chamber. *Ascospores* 2–3 overlapping seriate, hyaline to brown, 1–2-celled or apiosporous with small cell at the base, brown, with a light transverse band. Asexual state: linked to *Manginula* and *Chrysogloeum* (Hughes 1953; Petrak 1953). *Pycnidia* disc-shaped with upper wall of irregularly arranged cells, subglobose, dark brown to black, scutate or crustose. *Conidiogenous cells* hyaline, cylindrical, holoblastic. *Conidia* ovoid to ellipsoidal or rarely subglobose, brown to dark brown, with transverse hyaline band, formed on phialidic, hyaline cells lining the inner cavity of the upper wall.

Notes: *Vizellaceae* was established to accommodate *Blasdalea* and *Vizella* by Swart (1971), with *Vizella* as the type species. The position of *Vizella* within the ascomycetes is not clear, as different authors place it in various orders and families. Following the classification proposed by von Arx and Müller (1954) and Müller and von Arx (1962), the genus is placed in the order *Dothideales*. Within the order, von Arx & Müller (1954) proposed the new family *Entopeltaceae* to include *Vizella*, *Entopeltis* and *Blasdalea*. Publication of this family name was not valid, because no Latin diagnosis was given (Cooke & Hawksworth, 1970). Swart (1971) proposed the same family under a different name *Vizellaceae*, choosing *Vizella* as the type and treated *Entopeltis* as the synonym of *Vizella*. Species of *Vizella* are leaf parasites. They are either subcuticular or grow in the thick cuticle of their host. The mycelium is very characteristic; hyphae are ribbon-like. Walls are generally thin and, when hyaline, almost invisible. Septa are usually thickened and dark. Swart (1971) suggested that the mycelium might well be of diagnostic value, but several authors failed to observe this. Hughes (1953) described the mycelium of the type species from the type collection and confirmed the presence of characteristic mycelium composed of hyaline to light brown hyphae with thick, with dark brown cross walls. Swart (1971) proposed that it is possible that in species where no mycelium had been observed, these are present, but entirely hyaline and thus very difficult to see. In most species the mycelium branches frequently at fairly wide angles, and so forms a network without radial orientation.

Vizella was introduced by Saccardo (1883) with *V. conferta* (Cooke) Sacc. as the type species, and is characterized by dimidiate, superficial ascomata and one-celled, brown ascospores. Later, Höhnel (1910) established the new genus *Entopeltis* which he distinguished from *Vizella* mainly based on the subcuticular position of the mycelium and ascomata in the type species, *E. interrupta*. Studies were carried out on the type species of both genera by several mycologists (Theissen 1914; Theissen & Sydow, 1917; Petrak & Sydow, 1929). Hughes (1953) re-examined the type species of *Vizella* and *Entopeltis*, and confirmed the presence of characteristic mycelium composed of hyaline to light brown hyphae with thick, dark brown cross walls in both genera. He found the ascospores of *Entopeltis* to be continuous with a remarkable transverse hyaline band, while those of *Vizella* were composed of a large upper cell with a hyaline transverse band and a small hyaline to brown basal cell. Some one-celled ascospores lacking the basal cell were, however, also seen in the type collection of *V. conferta*. Because of these observations, Hughes (1953) placed *Entopeltis* in synonymy with *Vizella*. Von Arx and Müller (1954) were not in agreement with Hughes (1953) and reinstated *Entopeltis*, which they distinguished from *Vizella* as having intracuticular mycelium and ascomata with the upper wall composed a single layer of cells, while in *Vizella*, the upper wall is composed of several cell layers and the presence of a central column of sterile tissue in the ascomata. In addition, von Arx and Müller (1975) insisted that the two genera can be distinguished by the arrangement of the asci in a ring around a central column of sterile tissue in the ascomata of *Vizella* and also by the ascospores which are one-celled in *Entopeltis*, but having a basal cell in *Vizella*. By studying the type species and other *Entopeltis* and *Vizella* species,Van Wyk (1976) suggested that 1): the types of the mycelium; 2): the cell layers of the upper wall of ascomata; 3): the presence/absence of a central column of sterile tissue in the ascomata; 4): 1–2-celled ascospores and the presence/absence of a basal cells in the ascospores are inconsistent features which cannot be used to separate *Entopeltis* from *Vizella*. *Blasdalea* is also similar to the above genera. This monotypic genus was introduced by Saccardo and Sydow (1902) for *Blasdalea disciformis*and has remained monotypic. Von Arx and Müller (1954) illustrated the type species which had cylindrical asci and abundant pseudoparaphyses and ascomata opening by a large ostiole. We were unable to find the sexual state in the holotype which was described in Rehm (1900). The same holotype specimens (S F793) was examined by J.K. Liu and S. Boonmee separately, who found one-celled brown conidia with a hyaline transverse band, some two-celled, hyaline to brown, with a medium lighter septum. *Blasdalea* may be related with *Fasciatispora* which has unitunicate asci but the nature of the asci in the illustration provided in von Arx and Müller (1954) is not clear. In this paper we treat *Mycerema* as a synonym of *Vizella*. *Blasdalea* is maintained as a distinct genus in *Vizellaceae* pending fresh collections and molecular studies.

The asexual states are unknown for most species in the family except three *Vizella* species and *Blasdalea disciformis*. Hughes (1953) described a conidial form associated with *Vizella hendrickxii* (Hansf.) S. Hughes. He referred to the genus *Manginula* as apparently being the asexual state of an unknown *Vizella* species. However, Kirk et al. (2008) stated that the generic concept of *Manginula* is uncertain (i.e. *nom. dub*.). Swart (1971) introduced two new species to this genus from Australia with conidial states. The asexual state of *Blasdalea* is *Chrysogloeum* (Petrak 1953) and this is also illustrated here (from the type of *Blasdalea disciformis*) below. *Perizomella inquinans* Syd. has similar conidia (Sutton 1980).

Wijayawardene et al. (2012) listed the asexual states as *Chrysogloeum* and *Manginula*. *Chrysogloeum* was established to accommodate the coelomycetous asexual states of *Blasdalea* (as *Singeriella*). According to Sivanesan (1984) *Vizella* has *Manginula* or “Manginula”-like asexual states.

Type:*Vizella*Sacc., Syll. Fung. (Abellini) **2**: 662 (1883), MycoBank: MB 5747

Possible synonyms:

Entopeltis Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1 119: 420 (1910)

Mycerema Bat. et al.*,* Publções Inst. Micol. Recife 392: 5 (1963)

For other possible synonyms see Index Fungorum

Colonies epiphyllous, developing under the cuticle. Sexual state:*Hyphae* ribbon-like consisting of hyaline cells alternating usually in pairs with much shorter dark cells or without thickened septa. *Ascostromata* disc-shaped with upper wall of irregularly arranged cells, scutate or crustose, roundish or elongate. *Hamathecium* comprising pseudoparaphyses in young ascostromata. *Asci* 8-spored, ovoid or saccate, short pedicellate or apedicellate, apically rounded with a inconspicuous ocular chamber, arranged radially around a central column. *Ascospores* biseriate, one celled or with a small appendage-like basal cell, brown, with a light coloured band around the middle or just above the middle septum (the description follows Sivanesan 1984). Asexual state: *Pycnidia* disc-shaped with upper wall of irregularly arranged cells, scutate or crustose. *Conidiogenous cells* phialidic, hyaline, lining the inner cavity of the upper wall. *Conidia* ovoid, brown, with transverse hyaline band.

Notes: *Vizella* presently comprises 33 species all with light bands in the ascospores and three are linked to asexual states (Hughes 1953; Swart 1971). The confusion between *Entopeltis* and *Vizella* is discussed in the family notes. The genus *Mycerema* was introduced by Batista et al. (1963) and is presently monotypic based on *M. vochysiacearum*. This species has ascospores that resemble *Vizella* in having a light band in the upper part of the ascospores, but with a small, brown basal cell (hyaline in *Vizella*) and similar pseudoparaphyses. The ascomata have thin walls as in *Entopeltis*.This intermediate form between *Vizella* and *Entopeltis* further indicates they all three genera may be congeneric. *Vizella vochysiacearum* (New combination: *Vizella vochysiacearum*(Bat., J.L. Bezerra & Cavalc) J.K. Liu, R. Phookamsak & K.D. Hyde, comb. nov., basionym: *Mycerema vochysiacearum* Bat. et al.,in Batista et al., Publicações. Instituto de Micologia da Universidade do Recife & Instituto Nacional de Pesquis 392: 7 (1963).

MycoBank: MB 803658 is illustrated for this family.

Type species: *Vizella conferta* (Cooke) Sacc., Syll. Fung. (Abellini) 2: 661 (1883), MycoBank: MB 207415

≡ *Micropeltis conferta* Cooke, Grevillea 6: 118 (1878)

Other genera included

Blasdalea Sacc. & P. Syd., Syll. Fung, 16: 634 (1902), MycoBank: MB 592

Possible synonyms:

Singeriella Petr., Sydowia, 12: 252 (1959)

Chrysogloeum Petr., Sydowia 12: 254 (1959) [1958] (see Wijayawardene et al. 2013)

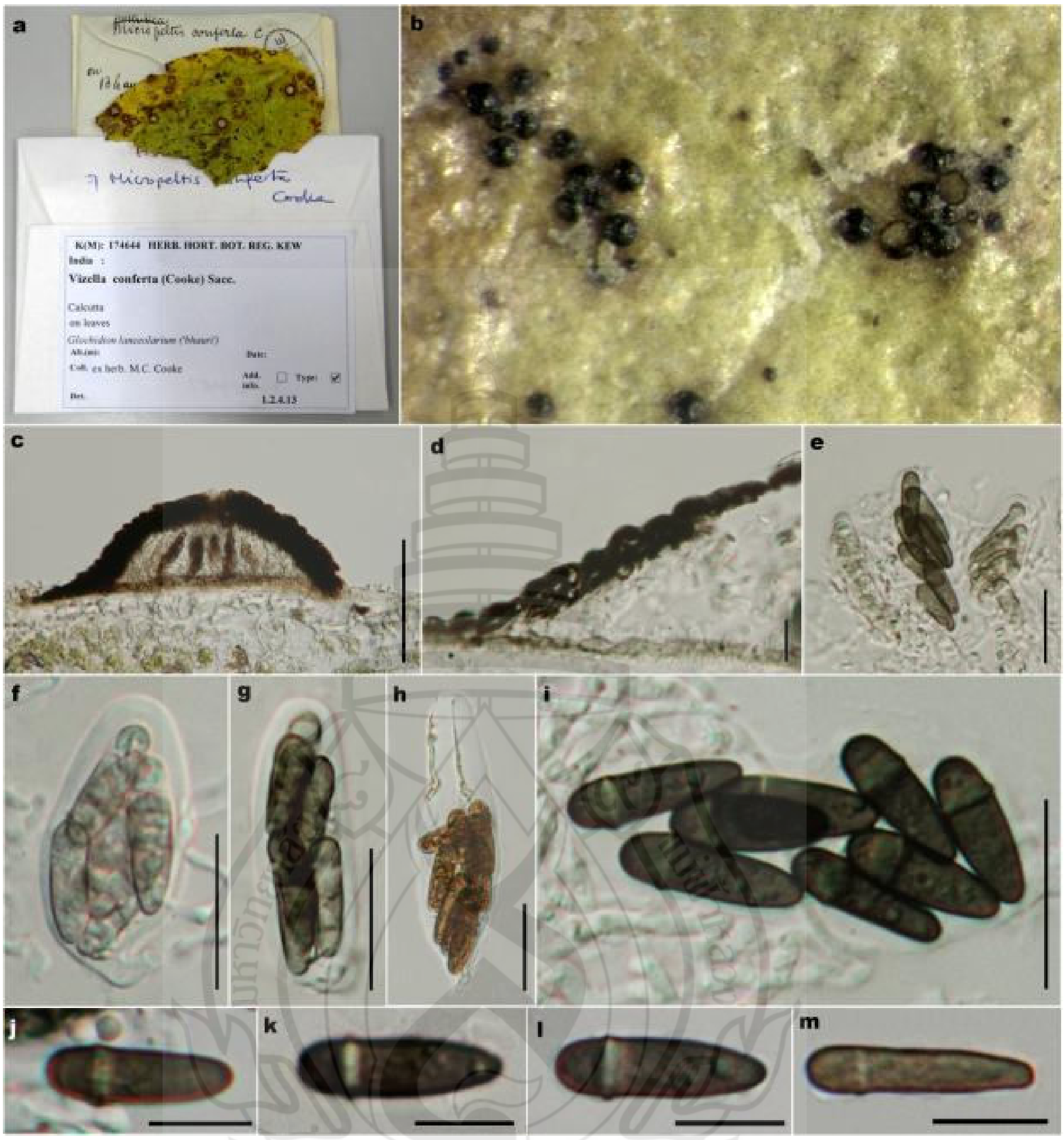
Sexual state: *Ascostromata* stromatic, with ring-like or linear loculus; subcuticular hyphae inconspicuous, scutate. *Peridium* composed of pigmented thick-walled cells of *textura angularis.Hamathecium* comprising hyaline, filiform pseudoparaphyses. *Asci* 8-spored, bitunicate, oblong to clavate, short pedicellate or apedicellate, apically rounded with a well-developed ocular chamber, not arranged in a ring surrounding a central column of sterile tissues. *Ascospores* hyaline, subglobose.Asexual state:*Pycnidia* up to 300 µm diam., occurring on leaf surface, subglobose, dark brown to black, shiny, solitary, gregarious, papilla. *Conidiophores*up to 10 µm long, hyaline. *Conidiogenous cells* hyaline, cylindrical, holoblastic.*Conidia* 9–12 × 5–7 µm, ellipsoidal or rarely subglobose, 1-celled, brown to dark brown, with colourless or light brownish band around median cell, smooth-walled (the sexual morph description follows Rehm 1900).

Type species: *Blasdalea disciformis* (Rehm) Sacc. & P. Syd., Syll. Fung. (Abellini) 16: 634 (1902), MycoBank: MB 144897

≡ *Vizella disciformis* Rehm, Hedwigia 39: 227 (1900)

Key to genera of *Vizellaceae*

1. Ascospores hyaline to brown, subglobose, with one to two cells; if asexual morphs present, with 1-celled, brown to dark brown, colorless or light brownish band around median cell conidia ....*Blasdalea*
2. Ascospores brown, fusiform to ellipsoidal, one to two-celled, with a light transverse band at the upper cell, sometimes with a small hyaline to brown basal cell .... *Vizella*



Note. a Herbarium material. b Ascostromata on host substrate.c Section of ascoma. d Peridium. e–h Asci. i–m Ascospores. Scale Bars: c=100 µm, d–i=20 µm, j–m=10 µm.

Figure A3 *Vizella conferta* (IMI 174644, holotype)

APPENDIX B

ABSTRACT OF PUBLICATIONS

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Towards a natural classification of *Botryosphaeriales*

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Abstract The type specimens of *Auerswaldia*, *Auerswaldiella*, *Barriopsis*, *Botryosphaeria*, *Leptoguignardia*, *Melanops*, *Neodeightonia*, *Phaeobotryon*, *Phaeobotryosphaeria*, *Phyllachorella*, *Pyrenostigme*, *Saccharata*, *Sivanesania*, *Spencermartinsia* and *Vestergrenia* were examined and fresh specimens of *Botryosphaeriales* were collected from Thailand. This material is used to provide a systematic treatment of *Botryosphaeriales* based on morphology and phylogeny. Two new genera, *Botryobambusa* and *Cophinforma* are introduced and compared with existing genera. Four species new to science, *Auerswaldia dothiorella*, *A. lignicola*, *Botryosphaeria fusispora* and *Phaeobotryosphaeria eucalypti*, are also described and justified. We accept 29 genera in *Botryosphaeriales*, with *Macrovalsaria* being newly placed. In the phylogenetic tree, the 114 strains of *Botyrosphaeriales* included in the analysis cluster into two major clades with 80 %, 96 % and 1.00 (MP, ML and BY) support, with Clade A containing the family type of *Botryosphaeriaceae*, and Clade B containing *Phyllosticta*, *Saccharata* and *Melanops* species. This group may represent *Phyllostictaceae*. In Clade A the taxa analyzed cluster in eight sub-clades (Clades A1–8). Clade A1 comprises three distinct subclusters corresponding to the genera *Diplodia* (*Diplodia* Clade), *Neodeightonia* (*Neodeightonia* Clade) and *Lasiodiplodia* (*Lasiodiplodia* Clade). Clade A2 clusters into

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Astrosphaeriella is polyphyletic, with species in *Fissuroma* gen. nov., and *Neoastrosphaeriella* gen. nov.

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Abstract Collections of fungi from bamboo and palm plants in Thailand resulted in the identification of several species of *Astrosphaeriella*, including the type species *A. fusispora*, which is a synonym of *A. stellata*. Species of *Astrosphaeriella* have been previously circumscribed on the basis of morphology and, to a lesser extent, on host affiliation. In order to obtain a phylogenetic understanding of the genus, eleven strains of *Astrosphaeriella sensu lato* were sequenced in this study. Molecular analyses based on a combined dataset of 18S and 28S nrDNA sequences were carried out to infer the phylogenetic placement of these strains in the *Pleosporales*. The phylogenetic analyses showed that *Astrosphaeriella* is polyphyletic, with *Astrosphaeriella* species clustering in four clades, two clades, including species with slit-like ostioles, clustered in *Aigialaceae*; the clade that includes the generic type clustered together with *Delitschia*; and *A. Africana*, which has striate ascospores, deviated from these three clades and had a basal position in the *Pleosporales*. A new combination in *Fissuroma* gen. nov. and new genus *Neoastrosphaeriella* are introduced in *Aigialaceae* to include the species with slit-like ascomata.

Keywords *Aigialaceae* · Phylogeny · *Pleosporales* · Taxonomy · Type study

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Lignincola conchicola from palms with a key to the species of *Lignincola*

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Abstract — During studies of palm fungi, a new *Lignincola* species was found in Thailand. It differs from other members of the genus in ascospore dimensions and the occurrence of its ascomata on the adhesive pad of a marine invertebrate. *Lignincola conchicola* is described and illustrated, and a key to *Lignincola* species is provided. The palm *Phoenix* is a new substratum for marine fungi.

Key words — *Halosphaeriaceae*, mangrove, taxonomy, tropic

Introduction

During research on palm fungi in Thailand (Pinnoi et al. 2004, 2006, 2009, 2010, Pilantanapak et al. 2005, Pinruan et al. 2004a,b, 2007, 2010a,b, Rungjindamai et al. 2008, Liu et al. 2010) a new taxon collected on *Phoenix paludosa* in Ranong mangrove, was discovered. The taxon is characteristic of *Lignincola* (*Halosphaeriaceae*).

Höhnk (1955) introduced *Lignincola* for a single species *L. laevis* Höhnk, which was characterized by black perithecioid ascomata, persistent clavate to fusiform, thin-walled asci lacking an apical apparatus, and 1-septate hyaline ascospores lacking appendages. The genus differs from *Aniptodera*, *Halosarpheia,* and *Phaeonectriella* in lacking appendaged ascospores (Pang et al. 2003a,b, Jones et al. 2009). Three other *Lignincola* species have been described.

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Roussoellaceae, a new pleosporalean family to accommodate the genera *Neoroussoella* gen. nov., *Roussoella* and *Roussoellopsis*

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Abstract

Roussoella and *Roussoellopsis* species are mostly known from monocotyledons (large grasses, bamboo and palms). Detailed phylogenies for this group are lacking and thus their family placement and relationships with other genera are unclear. Fresh collections of several *Roussoella*-like species, including the type species *Roussoella nitidula* were made from bamboo and palms in Thailand. In order to obtain a phylogenetic understanding of *Roussoella*-like species within the order *Pleosporales*, we carried out the phylogenetic analyses of ITS, LSU, *TEF1α* and *RPB2* loci. The 15 target strains formed a well-supported clade (100% BS/1.00 PP) in phylogenetic reconstructions of individual and combined datasets, supporting the introduction of a new family *Roussoellaceae*. The *Roussoellaceae* clade can be distinguished into three well-supported sections, namely *Roussoella*/*Roussoellopsis* (93% BS/1.00 PP), *Roussoella* (88% BS/1.00 PP) and *Neoroussoella*. Based on both morphology and phylogenetic analyses, we introduce *Neoroussoella* gen. nov., epitypify *Roussoella nitidula* which is the type species of the genus, and introduce the new species *Neoroussoella bambusae*, *Roussoella chiangraina*, *R. japanensis*, *R. neopustulans*, *R. siamensis*, *R. thailandica* and *R. verrucispora*.

Key words: Asexual morphs, Epitype, Phylogeny, Pleosporales, Taxonomy, Type

Introduction

The *Pleosporales* is the largest order in the class *Dothideomycetes*, including 43 families, 332 genera and more than 4 700 species (Kirk *et al.* 2008, Lumbsch and Huhndorf 2009, Schoch *et al.* 2009a, b, Hyde *et al.* 2013). Most taxa were previously included in *Dothideomycetes* based on morphology. Many important taxonomic studies on this large and difficult group of *Ascomycota* incorporating molecular phylogeny have been published (Crous *et al.* 2006, 2009, 2012, Zhang *et al.* 2008, 2009a, 2009b, 2012, 2013, Schoch *et al.* 2009a, 2009b, Tanaka *et al.* 2009, Gruyter *et al.* 2010, 2012, Boonmee *et al.* 2011, Chomnunti *et al.* 2011, Liu *et al.* 2011, 2012, Manamgoda *et al.* 2011, Hyde *et al.* 2013, Woudenberg *et al.* 2013). However, several groups are not well-resolved because of few collections, lack of recent studies, and most importantly lack of molecular sequence data.

Roussoella was introduced with the type species *R. nitidula* Sacc. & Paol., recorded from the bamboo in Malacca, Malaysia (Saccardo and Paoletti 1888). Höhnel (1919) proposed *Roussoella hysterioides* as the type species of *Roussoella* as an earlier name was found in *Dothidea hysterioides*; this combination was accepted by Müller and Arx (1962). The latter authors assigned *Roussoella* to *Amphisphaeriaceae*, a family characterized by broad, cylindrical, unitunicate asci, immersed ascostromata, and two-celled, brown ascospores. Aptroot (1995a) described the asci in *Roussoella* as unitunicate and transferred three species to this genus. Aptroot (1995b), however, modified his concept of *Roussoella* and considered the asci to be bitunicate.

Ascomycetes on bamboo and palms are commonly observed with immersed ascomata containing long, cylindrical, thin asci and brown, two-celled, ornamented ascospores; this might have caused the confusion that *Roussoella* belonged *Amphisphaeriaceae*. Hyde *et al.* (1996) discussed these fungi, and two groups with such characteristics were

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Phylogeny and morphology of *Leptosphaerulina saccharicola* sp. nov. and *Pleosphaerulina oryzae* and relationships with *Pithomyces*

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Abstract – A Dothideomycete species, associated with leaf spots of sugarcane (*Saccharum officinarum*), was collected from Nakhonratchasima Province, Thailand. A single ascospore isolate was obtained and formed the asexual morph in culture. ITS, LSU, *RPB2* and *TEF1α* gene regions were sequenced and analyzed with molecular data from related taxa. In a phylogenetic analysis the new isolate clustered with *Leptosphaerulina americana*, *L. arachidicola*, *L. australis* and *L. trifolii* (*Didymellaceae*) and the morphology was also comparable with *Leptosphaerulina* species. *Leptosphaerulina saccharicola* is introduced to accommodate this new collection which is morphologically and phylogenetically distinct from other species of *Leptosphaerulina*. A detailed description and illustration is provided for the new species, which is compared with similar taxa. The type specimen of *Pleosphaerulina oryzae*, is transferred to *Leptosphaerulina*. It is redescribed and is a distinct species from *L. australis*, with which it was formerly synonymized. *Leptosphaerulina* species have been linked to *Pithomyces* but the lack of phylogenetic support for this link is discussed. The character of the asexual morph of *Leptosphaerulina*, which is similar to *Pithomyces*, may to have evolved on separate occasions.

Asexual morph / *Didymellaceae* / Phylogeny / Plant disease / Taxonomy

INTRODUCTION

Dothideomycetes are the largest and most varied class of Ascomycota comprising 22 orders, 105 families, 678 genera and more than 19,000 species (Kirk *et al.*, 2008; Schoch *et al.*, 2006, 2009; Lumbsch & Huhndorf, 2010; Hyde *et al.*, 2013). Species of Dothideomycetes and their asexual morphs are found as endophytes, epiphytes or pathogens on living plants and as saprobes on decaying organic matter including dicotyledons, grasses and other monocotyledons (Schoch

An outline of the family Cucurbitariaceae

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Doilom M., Liu J. K., Jaklitsch W. M., Ariyawansa H., Wijayawardene N. N., Chukeatirote E., Zhang M., Roux J., McKenzie E. H. C., Geml J., Voglmayr H., Hyde K. D. (2013) An outline of the family Cucurbitariaceae. – Sydowia 65 (1): 167–192.

The Cucurbitariaceae is a relatively poorly known family of Dothideomycetes. *Cucurbitaria berberidis*, the type species of *Cucurbitaria*, was collected on dead twigs of *Berberis vulgaris* in Austria and this new collection is used to epitypify the taxon and described and illustrated in detail with regard to its sexual and asexual state. Sequence data from 18S nrDNA (SSU) and 28S nrDNA (LSU) gene regions of several isolates of the epitype or isoepitype specimens were compared with representative isolates of *C. berberidis* and closely related sequences in GenBank. The phylogenetic results show that Cucurbitariaceae is a well-resolved family within *Pleosporineae*. A *Pyrenochaeta*-like coelomycetous asexual state formed in the *Cucurbitaria* culture, and is illustrated here. The types of *Curreya, Rhytidiella* and *Syncarpella* are also studied and illustrated. Taxonomic placements of each genus with their asexual states are discussed. We provisionally accept six genera in Cucurbitariaceae i.e. *Cucurbitaria* with *Pyrenochaeta*-like asexual states, *Curreya* (including *Cucurbidothis*) with *Coniothyrium*-like asexual states, *Rhytidiella* with *Phaeoseptoria*-like asexual states, *Syncarpella* and the asexual genera *Pyrenochaeta* and *Pyrenochaetopsis*. Placement of *Syntholus* in Cucurbitariaceae is uncertain as the generic type has not been linked and further studies are needed.

Keywords: asexual morphs, *Cucurbidothis, Cucurbitaria berberidis, Curreya, Pyrenochaeta berberidis*, phylogeny, *Rhytidiella, Syncarpella*, taxonomy, types.

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Phylogeny and morphology of *Neodeightonia palmicola* sp. nov. from palms

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Liu J.K., Chomnunti P., Cai L., Phookamsak R., Chukeatirote R., Jones E.B.G., Moslem M. & Hyde K.D. (2010) Phylogeny and morphology of *Neodeightonia palmicola* sp. nov. from palms. – Sydowia 62 (2): 261–276.

Palm fungi are a taxonomically diverse group. Recent collections of fungi from palms in northern Thailand resulted in the discovery of a new species of *Neodeightonia*, herein described as *N. palmicola*. This new species is distinct in having hyaline, aseptate ascospores surrounded by a remarkable sheath. This study compares this new species with related taxa of *Botryosphaeria* and *Neodeightonia* using morphological and molecular characteristics. Sequence data show our species is more closely related to *Neodeightonia subglobosa* (the type species of the genus) than to *Botryosphaeria* species. Morphological and molecular features of the new species are described.

Keywords: ascomycetes, Botryosphaeriaceae, ITS, LSU, SSU, taxonomy.

Palm fungi are a taxonomically diverse group, with more than 1500 described species, which include representatives from almost all major fungal classes (Fröhlich & Hyde 2000, Taylor & Hyde 2003). The ascomycetes which have been described from palms are a very diverse assemblage. In 2000, 794 species of ascomycetes distributed in 278 genera and 79 families had been described from palms (Fröhlich & Hyde 2000, Hyde *et al.* 2000, Taylor & Hyde 2003) and many more have recently been described (Pinruan *et al.* 2008, 2010, Pinnoi *et al.* 2010).

Botryosphaeria–like species and their anamorphs have previously been recorded from palms (Fröhlich & Hyde 1995, 2000, Hyde *et al.* 2000, Taylor & Hyde 2003, Phillips *et al.* 2008), including six *Botryosphaeria* species (Taylor & Hyde 2003). *Botryosphaeria* Ces. & De Not. was introduced by Cesati & De Notaris (1863). Species of *Botryosphaeria* are cosmopolitan and occur on a wide range of monocotyle-

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Four species of *Oudemansiella* and *Xerula* newly recorded from Thailand

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Abstract – Three species of *Oudemansiella* and one species of *Xerula* collected from northern Thailand are described and illustrated with line drawings. They are *O. canarii*, *O.* aff. *crassifolia*, *O. submucida* and *X. sinopudens*, all of which are first records for Thailand.

***Oudemansiella* / *Xerula* / new records / Thailand**

INTRODUCTION

We are studying the macrofungi at the Mushroom Research Centre in northern Thailand (Le et. al 2007a, b) and in this paper deal with the genus *Oudmansiella* and *Xerula*. Studies on the genera *Oudemansiella* and *Xerula* have been carried out in Africa (Petersen, 2008), America (Singer, 1964; Redhead et al. 1987; Corner, 1994; Baroni & Ortiz, 2002; Petersen et al. 2008), Asia (Natarajan & Purushothama 1992; Yang & Zang, 1993; Corner, 1994; Yang, 2000; Yang & Zhang 2003; Mizuta, 2006; Petersen & Nagasawa, 2006; Wang et al. 2008; Yang et al. 2009), Europe (Patouillard, 1887; Moser, 1955; Dörfelt, 1979, 1985; Boekhout & Bas, 1986; Pegler & Young, 1987; Rexer & Kost, 1989; Ronikier, 2003; Mats & Mikael, 2005), and Oceania (Petersen, 2008). However, only 2 species of these genera, *Xerula chiangmaiae* R.H. Petersen & Nagas. And *X. chiangmaiae* var. *raphanipes* (Berk.) R.H. Petersen & Nagas., have been reported from Thailand (Petersen & Nagasawa, 2006).

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Families of Dothideomycetes

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

Kevin D. Hyde · E. B. Gareth Jones · Jian-Kui Liu · Hiran Ariyawansa · Eric Boehm · Saranyaphat Boonmee · Uwe Braun · Putarak Chomnunti · Pedro W. Crous · Dong-Qin Dai · Paul Diederich · Asha Dissanayake · Mingkhuan Doilom · Francesco Doveri · Singang Hongsanan · Ruvishika Jayawardena · James D. Lawrey · Yan-Mei Li · Yong-Xiang Liu · Robert Lücking · Jutamart Monkai · Lucia Muggia · Matthew P. Nelsen · Ka-Lai Pang · Rungtiwa Phookamsak · Indunil C. Senanayake · Carol A. Shearer · Satinee Suetrong · Kazuaki Tanaka · Kasun M. Thambugala · Nalin N. Wijayawardene · Saowanee Wikee · Hai-Xia Wu · Ying Zhang · Begoña Aguirre-Hudson · S. Aisyah Alias · André Aptroot · Ali H. Bahkali · Jose L. Bezerra · D. Jayarama Bhat · Erio Camporesi · Ekachai Chukeatirote · Cécile Gueidan · David L. Hawksworth · Kazuyuki Hirayama · Sybren De Hoog · Ji-Chuan Kang · Kerry Knudsen · Wen-Jing Li · Xing-Hong Li · Zou-Yi Liu · Ausana Mapook · Eric H. C. McKenzie · Andrew N. Miller · Peter E. Mortimer · Alan J. L. Phillips · Huzefa A. Raja · Christian Scheuer · Felix Schumm · Joanne E. Taylor · Qing Tian · Saowaluck Tibpromma · Dhanushka N. Wanasinghe · Yong Wang · Jian-Chu Xu · Supalak Yacharoen · Ji-Ye Yan · Min Zhang

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Abstract Dothideomycetes comprise a highly diverse range of fungi characterized mainly by asci with two wall layers (bitunicate asci) and often with fissitunicate dehiscence. Many species are saprobes, with many asexual states comprising important plant pathogens. They are also endophytes, epiphytes, fungicolous, lichenized, or lichenicolous fungi. They occur in terrestrial, freshwater and marine habitats in almost every part of the world. We accept 105 families in Dothideomycetes with the new families *Anteagloniaceae*, *Bambusicolaceae*, *Biatriosporaceae*, *Lichenoconiaceae*, *Muyocopronaceae*, *Paranectriellaceae*, *Roussoellaceae*, *Salsugineaceae*, *Seynesiopeltidaceae* and *Thyridariaceae* introduced in this paper. Each family is provided with a description and notes, including asexual and asexual states, and if more than one genus is included, the type genus is also characterized. Each family is provided with at least one figure-plate, usually illustrating the type genus, a list of accepted genera, including asexual genera, and a key to these genera. A phylogenetic tree based on four gene combined analysis add support for 64 of the families and 22 orders, including the novel orders, *Dyfrolomycetales*, *Lichenoconiales*, *Lichenotheliales*, *Monoblastiales*, *Natipusillales*, *Phaeotrichales* and *Strigulales*. The paper is expected to provide a working document on Dothideomycetes which can be modified as new data comes to light. It is hoped that by illustrating types we provide stimulation and interest so that more work is carried out in this remarkable group of fungi.

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

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Planistromellaceae (Botryosphaeriales)

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Abstract – In this paper, we re-examine, re-describe and illustrate all sexual generic type specimens of *Planistromellaceae* including *Comminutispora agavacearum, Eruptio acicola, Loratospora aestuarii, Microcyclus angolensis, Mycosphaerellopsis myricariae, Planistroma yuccigenum* and *Planistromella yuccifoliorum*. We also use molecular data from GenBank to show the taxonomic placement of some of these genera. Members of family *Planistromellaceae* (*Botryosphaeriales*) are saprobes or pathogens on various plants and characterized by multi or uniloculate ascostromata which are erumpent through cracking or splitting of host tissues and have periphysate ostioles. The ascostromata comprise several layers of brown to black thick-walled cells, pseudoparaphyses are not obvious in mature specimens, and asci are bitunicate. The asexual morphs were previously reported to be found in the genera *Aposphaeria*-like, *Fusicladium, Hyphospora, Kellermania, Lecanosticta, Pazschkeella* and *Piptarthron*. Following this study, phylogenetic analyses based on molecular data from LSU and ITS genes provide strong support for the monophyly of the *Planistromellaceae* in the *Botryosphaeriales*, while the *Planistromellaceae* clade separates into three different groups represented by the type species of *Piptarthron, Planistroma* and *Kellermania*, respectively. We accept *Kellermania* (= *Planistromella* and possibly *Piptarthron*), *Planistroma* and *Mycosphaerellopsis* (the latter with no molecular support) in *Planistromellaceae*, while four other genera are redisposed of as follows: *Comminutispora* clusters in *Capnodiales*, *Eruptio* and *Microcyclus* have been shown to be members of *Mycosphaerellaceae*, and *Loratospora* has been shown to belong in *Phaeosphaeriaceae*.

***Aposphaeria*-like / *Comminutispora* / *Eruptio* / *Fusicladium* / *Hyphospora* / *Kellermania* / *Lecanosticta* / *Loratospora* / *Microcyclus* / molecular phylogeny / *Mycosphaerellopsis* / *Pazschkeella* / *Piptarthron* / *Planistroma* / *Planistromella* / taxonomy / type specimens**

INTRODUCTION

The class *Dothideomycetes* contains the largest species numbers and is the most phylogenetically diverse group in the phylum *Ascomycota*. Development in this group is ascolocular and asci are bitunicate (Kirk *et al.*, 2008). Previously, the classification of *Dothideomycetes* was determined using morphological characters

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