The Botryosphaeriaceae: genera and species known from culture

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Abstract: In this paper we give an account of the genera and species in the Botryosphaeriaceae. We consider morphological characters alone as inadequate to define genera or identify species, given the confusion it has repeatedly introduced in the past, their variation during development, and inevitable overlap as representation grows. Thus it seems likely that all of the older taxa linked to the Botryosphaeriaceae, and for which cultures or DNA sequence data are not available, cannot be linked to the species in this family that are known from culture. Such older taxa will have to be disregarded for future use unless they are epitypified. We therefore focus this paper on the 17 genera that can now be recognised phylogenetically, which concentrates on the species that are presently known from culture. Included is a historical overview of the family, the morphological features that define the genera and species and detailed descriptions of the 17 genera and 110 species. Keys to the genera and species are also provided. Phylogenetic relationships of the genera are given in a multi-locus tree based on combined SSU, ITS, LSU, EF1-α and β-tubulin sequences. The morphological descriptions are supplemented by phylogenetic trees (ITS alone or ITS + EF1-α) for the species in each genus.

Key words: Botryosphaeriaceae, canker pathogens, Diplodia, Fusicoccum, Lasiodiplodia, Multi-Locus Sequence Analysis, Sphaeropsis, systematics.

Taxonomic novelties: New species – Neoeutypium botanarium Begoude, J. Roux & Slippers. New combinations – Botryosphaeria fabicerciana (S.F. Chen, D. Pavlic, M.J. Wingf. & X.D. Zhou) A.J.L. Phillips & A. Alves, Botryosphaeria ramosa (Pavlic, T.I. Burgess, M.J. Wingf.) A.J.L. Phillips & A. Alves, Cophinotrema atrovirens (Mehl & Slippers) A. Alves & A.J.L. Phillips, Cophinotrema mammante (D.E. Gardner) A.J.L. Phillips & A. Alves, Dothiorella pretoriensis (Jami, Gryzenh., Slippers & M.J. Wingf.) Abdollahz. & A.J.L. Phillips, Dothiorella thailandica (D.Q. Dai, J.K. Liu & K.D. Hyde) Abdollahz., A.J.L. Phillips & A. Alves, Dothiorella uruguayensis (C.A. Pérez, Blanchette, Slippers & M.J. Wingf.) Abdollahz. & A.J.L. Phillips, Lasiodiplodia lignicola (Araya-wansa, J.K. Liu & K.D. Hyde) A.J.L. Phillips, A. Alves & Abdollahz., Neoscytalidium hyalinum (C.K. Campb. & J.L. Mulder) A.J.L. Phillips, Groenewald & Crous, Sphaeropsis citrigena (A.J.L. Phillips, P.R. Johnst. & Pennycook) A.J.L. Phillips & A. Alves, Sphaeropsis eucalypticola (Doilom, J.K. Liu, & K.D. Hyde) A.J.L. Phillips, Sphaeropsis porosa (Van Niekerk & Crous) A.J.L. Phillips & A. Alves.

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INTRODUCTION

The Botryosphaeriaceae encompasses a range of morphologically diverse fungi that are either pathogens, endophytes or saprobes, mainly on woody hosts. They are found in all geographical and climatic areas of the world, with the exception of the polar regions. Their frequent association with plant diseases has stimulated substantial interest in these fungi, and much of this interest has been focussed on the systematics of species and genera.

Historical overview

The Botryosphaeriaceae was introduced by Theissen & Sydow (1918) as a sub-family in the Pseudosphaeriaceae. Although Theissen (1916) had earlier allocated the Pseudosphaeriaceae to the Myriangiales, Theissen & Sydow (1917) believed that the Pseudosphaeriaceae should be united with the Dothideaceae (Luttrell 1951). Theissen & Sydow (1918) established the sub-class the Dothideineae to accommodate the order Pseudosphaeriales, family Botryosphaeriaceae, and the genus Botryosphaeria. Petruk (1923) rejected Theissen & Sydow’s (1918) classification and placed Botryosphaeria in the sub-family Pseudosphaeriaceae, which he placed in the Pleosporaceae (Sphaeriales).

Miller (1928) showed that there was a fundamental difference between the tissues forming the ascoma and those forming the boundary of the locules. He also showed how these different tissue types were correlated with features of the ascomic centrum. Taxa allocated to the Sphaeriales had true perithecial ascocarps and paraphyses, while those assigned to the Dothideales had ascostromatic ascocarps lacking paraphyses. Thus, Botryosphaeria species (Pseudosphaeriaceae) were allocated to the Dothideales because they lacked true perithecial walls (Miller 1928).

Nannfeldt (1932) re-grouped the Euascomycetes into three orders. The ascostromatic forms, where ascospore formation in cavities in pre-formed stromata, were accommodated in the Ascoloculares. The true Sphaeriales, i.e., species in which the ascospore develop in a hymenium, were accommodated in the Ascochyromiales. Although these groups were not widely accepted at the time, they were consistent with the bitunicate and unitunicate groups later proposed by Luttrell (1955).

Concepts based on morphological features resulting from the ontogeny of the perithecial wall and the development of centrum...
tissues were further developed by Miller (1938) and three orders were recognised. The Sphaeriales had perithecia and paraphyses, and the Dothideales encompassed ascostromatic forms with interthecal threads that appeared in the ascomatal cavity before the ascus developed. Miller (1938) retained Botryosphaeria in the family Pseudosphaeriaceae. Thus, Botryosphaeria was accommodated in the Pseudosphaeriales and not in the Dothideales.

Luttrell (1951) recognised two major morphological groups in the pyrenomycetous fungi. He also emphasised the significance of ontogenetic characters of the ascomata in classification. The two major groups were those with single-walled asci or the unitunicate ascomycetes, and the loculoascomycetes, commonly referred to as the bitunicate ascomycetes (Luttrell 1955). Luttrell also identified eight forms of centrum development and highlighted the taxonomic value of sterile interthecal tissues. Since the type of the family Pseudosphaeriaceae, and the type of the genus Pseudosphaeria had been transferred to the Dothideales, the order Pseudosphaeriales was no longer tenable. Therefore, Luttrell (1955) replaced the name Pseudosphaeriaceae with Pleosporales, based on the most important genus in the group with that type of centrum development, and assigned Botryosphaeria to the Pleosporales.

In Barr’s earlier work (1972, 1976), she had not studied specimens of B. dothidea in which the interthecal tissues were clearly visible, and despite the clear demonstration by Parguey-Leduc (1966) that B. dothidea exhibited a Pleospora centrum type, she classified Botryosphaeria in the Dothideales. Later, however, Barr (1979) acknowledged that Botryosphaeria species had a centrum typical of the Pleosporales and she concluded that the genus should reside in this order. This view was retained in subsequent publications (Barr 1983, 1987).

According to von Arx & Müller (1975) and von Arx (1981, 1987) the orders proposed by Luttrell (1955, 1973) and Barr (1972, 1987) comprised a collection of unrelated genera and the taxonomic characters used to separate the orders overlapped. Moreover, von Arx & Müller (1975) did not support the placement of closely related genera such as Guignardia and Botryosphaeria in different orders, i.e. the Dothideales and Pleosporales respectively (Luttrell 1973). For this reason von Arx & Müller (1975) placed all bitunicate ascomycetes in the single order Dothideales, comprising two suborders and 34 families, including the Botryosphaeriaceae. To complicate matters further, Sivanesan (1984) placed both Botryosphaeria and Guignardia in the Dothideales whereas Hawksworth et al. (1995) listed Botryosphaeria under the Botryosphaeriaceae and Guignardia under the Mycosphaerellaceae, both in the Dothideales. Hence the two major systems of classification were those of Barr (1987) in which Botryosphaeria is placed in the Pleosporales, and von Arx & Müller (1975) who placed the genus in the Dothideales. Eriksson (1981), however, emphasised that Botryosphaeria species have a centrum typical of the Pleosporales with pseudoparaphyses and pseudothecia.

The advent of DNA sequencing methods provided taxonomists with powerful tools to determine phylogenetic relationships in fungi at various taxonomic levels from species to orders. Berbee (1996) used gene sequences of the 18S rRNA gene (SSU) to study phylogenetic relationships amongst genera and orders of loculoascomycetes. However, the positions of the two Botryosphaeria species included in that study changed depending on the analysis used. Thus, in the neighbour-joining trees of Berbee (1966) these species usually clustered with species of Dothidea in the Dothideales, but in a single maximum likelihood tree they clustered in the Pleosporales. In a subsequent study of 18S rRNA sequence data, Silva-Hanlin & Hanlin (1999) could not determine whether the Botryosphaeria-Guignardia clade corresponded to the Dothideales or the Pleosporales.

Schroch et al. (2006) constructed a multigene phylogeny based on SSU, 28S rRNA gene (LSU), translation elongation factor 1-alpha (EF1-α) and RNA polymerase second largest subunit (RPB2) sequence data for 96 taxa in the Dothideomycetes. Species of Botryosphaeria and Guignardia formed a clade that could not be associated with any other order. For this reason they proposed a new order Botryosphaeriaceae accommodating the single family, the Botryosphaeriaceae.

**Characteristics of the Botryosphaeriaceae**

Detailed descriptions of the family Botryosphaeriaceae have been presented by several authors (von Arx & Müller 1954, 1975, Hawksworth et al. 1995, Eriksson 1981, Sivanesan 1984, Barr 1987). Members of the family are pathogenic, necrotrophic or saprobic, especially on woody plants.

The Botryosphaeriaceae were characterised primarily on the basis of their large, ovoid to oblong, usually hyaline, ascosporic ascospores. Although this could appear to be an inadequate basis for recognition of a family, ascospores with this morphology have been considered as an unusual spore type among loculoascomycetes (Luttrell 1973, Eriksson 1981, Sivanesan 1984, Barr 1987). More recently, however, at least six lineages in the family have been recognised as having pigmented ascospores, and in three of these genera the ascospores are septate (Phillips et al. 2008). Therefore, this simple circumscription can no longer be considered suitable for the Botryosphaeriaceae. Liu et al. (2012) recently provided a comprehensive definition of the family in which they considered ascospores to be hyaline and aspatate, but that could become pigmented and septate with age. This is an equally unsuitable definition because ascospores in some genera become pigmented and 1-septate at an early stage of their development, long before they can be considered aged. Furthermore, a circumscription based solely on the sexual state is not suitable especially since some species are known only from their asexual state, while in others the sexual state is extremely uncommon. Given these conditions a modified circumscription of the family is provided by Slippers et al. (2013, this volume).

**Genera in the Botryosphaeriaceae**

When Theissen & Sydow (1918) introduced the Botryosphaeriaceae they included three genera, namely Botryosphaeria, Phaeobotryon and Dibotryon. Further genera were included over the years and the addition of separate generic names for asexual and sexual morphs resulted in the inclusion of at least 78 genera in the family (MycoBank, http://www.mycobank.org, accessed May 2013). Many of these genera have been determined to be synonyms, some new genera have been introduced, some of the older genera have been resurrected, yet others have been removed to other families. Liu et al. (2012) recognised 29 genera of which 17 are known in culture. The application of DNA sequence analysis and phylogenetic inference has had a major impact on the systematics of the Botryosphaeriaceae. Crous et al. (2006) used DNA sequence data of the 28S rRNA gene to resolve 10 lineages within the family. The phylogenetic clades correlated with distinct morphological features and corresponded to separate genera. However, the LSU dataset that Crous et al. (2006) used could not resolve a large clade
that comprised Diplodia, Lasiodiplodia and related genera with pigmented conidia.

Phillips et al. (2008) attempted to resolve the phylogenetic and taxonomic status of species of Botryosphaeriaceae with pigmented ascospores. In a phylogeny based on SSU, the internal transcribed spacers and intervening 5.8S rRNA gene (ITS) and LSU together with EF-1α and B-tubulin sequence data they resolved six clades in the Diplodia/Lasiodiplodia complex and an additional four clades in the Botryosphaeriaceae. Damm et al. (2007) showed that Aplosporella represents yet another genus in the Botryosphaeriaceae while Rojas et al. (2008) determined that Endomelanconiopsis also resides in this family. Phillips & Alves (2009) considered Melanops to be a genus in the Botryosphaeriaceae. In a phylogeny based on SSU, ITS, LSU and RNA polymerase largest subunit (RPB1) sequences, Minnis et al. (2012) included Kellermania in the Planistromellaceae, sister to the Botryosphaeriaceae. Furthermore, Wikee et al. (2013, this volume) reinstated the Phyllostictaceae to accommodate Phylllosticta (= Guignardia), which they recognised as distinct from the Botryosphaeriaceae. Finally, Slippers et al. (2013, this volume) introduced new families to accommodate Saccharata (Saccharataceae), Melanops (Melanopsaceae), Aplosporella and Bagnisiella (Aplosporellaceae). Thus, 17 genera can now be recognised phylogenetically in the Botryosphaeriaceae. We consider morphological characters alone as inadequate to define genera or identify species, given the confusion it has caused in the past. Phillips et al. (2013, this volume) also illustrates how misleading some of the prominent conidial and ascospore characters can be to reflect evolutionary origin, given independent origins or losses of these characters over time. We therefore focus this paper on the 17 genera that can now be recognised phylogenetically, which concentrates on the species that are presently known from culture.

Circumscription of genera

Characters that are used to differentiate genera in the Botryosphaeriaceae have largely relied on the morphological features of the ascospores (Barr 1987, 1989, Hsieh & Chen 1994, Phillips et al. 2008) and especially the conidial states (Crous et al. 2006, Phillips et al. 2008). The most informative characters are conidial features such as pigmentation, wall thickness, and septation, but other characters such as presence or absence of paraphyses in the conidiomata can be useful. The phylogenetic value of these characters can only be meaningfully interpreted, however, in combination with additional data (e.g. sequence based molecular data), as illustrated by their misinterpretation in the past, and the multiple independent origins and losses of shared characters throughout the evolutionary history of the family (see Slippers et al. 2013, this volume).

Sexual morph morphology

Ascomata

Ascomata range from uniloculate, discrete structures (Fig. 1A, B) through to relatively large multiloculate structures (Fig. 1C, D). The uniloculate forms occur either individually and scattered over the host (Fig. 1E), or they can be aggregated in botryose clusters (Fig. 1F) of several hundred ascomata that are often united on a submerged basal stroma. In the species with multiloculate ascomata, conidiomata can occur within the same stroma. Sometimes the ascomata develop at the periphery of a central conidioma (Fig. 1G) and are united with the conidioma in a single stroma. When cut through horizontally the contents are typically brilliant white (Fig. 1H). Irrespective of the form they take, ascomata in Botryosphaeria species are typical of the loculosascomycetes in which the ascii are formed within locules that develop in a pre-formed stroma. The tissues of the stromata are of textura angularis and made up of brown, thick-walled cells that turn blue-black in KOH and red-brown in lactic acid. The thickness of the stroma varies considerably not only between species but also with any given species. The walls can be as thin as just 5 or 6 cells layers, or it can be up to 30 or even more. The locules are lined with thinned-walled, hyaline, flattened cells.

The centrum of the Pleospora type in which the ascii are interspersed with pseudoparaphyses that grow downwards and fuse at the base of the locule. The form of the ascomata is of little taxonomic value since even within a species ascomata can vary from uniloculate with relatively thin walls to complex multiloculate with thick walls and extensive stromatic tissue. This variation is probably in response to the substrate or the conditions under which the ascomata are formed. For example, ascomata in B. dothidea can be either simple, uniloculate structures scattered individually over the surface of the host tissue, or they can be aggregated in large botryose clusters. They can also be formed in large multiloculate stromata united with conidiomata. Furthermore, there does not appear to be any correlation between the form of the ascomata and the asexual genus associated with a particular species.

Asci

Asci are bitunicate of the fissitunicate type with a relatively thin ectotunica and a thick endotunica (Fig. 2A–C). The apex of the endotunica (Fig. 2D) is modified to form a well-defined apical chamber, which results from a displacement of the endotunica by the cytoplasm within the body of the ascus. No other structures can be detected in the ascus apex. Asci are clavate to elongate-clavate approaching cylindrical, but they are never truly cylindrical. They often have a short, indistinct stipe that terminates in a hoof-shaped cell attached to the inner wall of the base of the ascoma. Asci arise from a basal hymenium and grow up through the pseudoparaphyses (Fig. 2E). Ascospores are discharged forcibly by what has become known as the “Jack-in-the-box” process whereby the ectotunica splits transversely near the middle of the ascus and the endotunica elongates expelling the spores.

Ascospores

Ascospores are arranged within the asci in an irregular, overlapping biseriate manner (Fig. 2A–C). Typically they are hyaline and aseptate (Fig. 2H–J), but they can be pale or dark brown (Fig. 2F, G), sometimes 1-septate, and may have an apiculus at one or both ends (Fig. 2G). The walls are smooth and in most species they are usually thin, but in some, notably those species with Diplodia asexual morphs, it can be moderately thick. Ascospores can be hyaline or coloured, aseptate or 1–2-septate. In species with hyaline, aseptate ascospores the spores can become translucent brown and 1–2-septate with age (Fig. 2K), and the walls may appear roughened (Fig. 2L) due to the deposition of melanin granules on the inner surface, giving the spores a somewhat verruculose appearance. Shapes range from fusiform to ovoid. They are usually widest in the middle part and the ends are subobtusely rounded.

Pseudoparaphyses

Pseudoparaphyses are hyphal-like, hyaline with thin walls and frequent septa (Fig. 2E), branched, frequently anastomosing. Often they are constricted at the septa. As the asci develop and mature,
Fig. 1. Ascomata characters. A–D. Vertical sections through ascomata. E. Ascomata erumpent through host bark. F. Botryose clusters of ascomata. G. Transverse section through a central conidioma surrounded by ascomata. H. Ascomata cut through horizontally revealing the brilliant white contents. Scale bars: A–D, G = 100 μm, E = 1 mm, F, H = 500 μm.
the pseudoparaphyses gradually dissolve and only traces can be found in older ascomata.

Asexual morph morphology

**Conidiomata**

As with ascomata, conidiomata take on a variety of forms ranging from thin-walled uniloculate pycnidial to large, complex multiloculate forms. Irrespective of the form, the conidiomata are stromatic, that is, the pycnidial cavity develops within a preformed stroma (Fig. 3). The tissues that make up the stromatal and conidiomata walls are identical to those found in the ascostroma.

**Conidiophores**

Conidiophores are not always present in all species. Even within a species, conidiophores may be present or absent. When present,
they are hyaline, thin-walled and more or less cylindrical. Mostly they are not branched, but branched, septate conidiophores do occur.

Conidiogenesis
The first conidia are formed holoblastically at the tips of conidiogenous cells. Subsequent conidia are formed either by internal proliferation of the conidiogenous cells resulting in periclinal thickenings, or they may proliferate percurrently giving rise to two or three close or widely spaced annellations. Both types of proliferation can sometimes be seen on a single conidiogenous cell.

Conidiogenous cells are hyaline with a smooth, thin wall. Shapes vary from long cylindrical to short lageniform or ampulliform. In species with fusicoccum-like asexual morphs, the conidiogenous cells are generally smaller and more slender than the more robust types found in species with diplodia-like asexual morphs (Fig. 4).

Conidia
Conidia of the Botryosphaeriaceae display the greatest variation between genera and species. Although variation between species is wide, variability within a species can also be quite considerable. Two basic types of conidia can be distinguished, namely those that are thin-walled, narrow and fusicoccum-like, and the thick-walled, wider, diplodia-like conidia. In addition to these two basic types of conidia, coloured, muriform conidia are found in the Dichomera synsexual morph of some Botryosphaeria and Neofusicoccum...
Fig. 4. Conidiogenous cells and conidia. A–K. Conidiogenous cells with periclinal thickenings (B, K) and annellations (A, C, D), the annellate cell in E has formed a secondary conidiogenous cell. F. Coloured, aseptate conidium of Diplodia intermedia attached to a conidiogenous cell. G, H, I. Coloured, 1-septate conidia of Dothiorella sp. attached to conidiogenous cells. L. Paraphyses arising between developing conidia in a Lasiodiplodia species. M. Hyaline, aseptate, thin-walled conidia of Botryosphaeria dothidea. N. Hyaline, aseptate, thin-walled conida of Neofusicoccum arabii. O. Coloured, septate conidia of B. dothidea. P. Hyaline, aseptate, thick-walled conidia of Diplodia mutila. Q. Hyaline, aseptate, coloured, 1-septate conidia of Diplodia malorum. R. Coloured, aseptate conidia of Diplodia sapinea. S. Striate, mature and immature conidia of Barriopsis iraniana. T. Striate, coloured, 1-septate conidia of a Lasiodiplodia species. Scale bars A, G = 10 μm. Scale bar in A applies to B–F, J, K, M–O. Scale bar in G applies to H–I, L, P–T.
species. Furthermore, arthic chains of dry, powdery conidia are a prominent feature of *Neoscytalidium* species.

The thin-walled, fuscococcum-like conidia range from fusiform to ovoid or elliptical, and typically they are hyaline and aseptate. However, the wall can become thicker and pale brown, and this may be related to aging. Other changes can take place just before germination when the normally hyaline, aseptate conidia can develop one or two septa and in some species they may become pale brown. In others, only the central cell becomes pigmented.

The diplodia-like conidia are relatively thick-walled and they can be hyaline or brown. Furthermore, they may be aseptate or 1-septate, sometimes two or even more septa can form. They are mostly ovoid with both ends broadly rounded. Externally the walls are smooth, but melanin deposits on the inner surface of the walls often give the conidia a verruculose appearance. In some species, especially those that have been assigned to the genus *Lasiodiplodia*, these deposits are arranged in longitudinal rows giving the conidia a striate appearance.

The timing of the onset of pigmentation varies considerably. In most *Diplodia* species, the conidia remain hyaline for a long time, and indeed they may never become brown. However, if they do become brown and septate, this occurs only after they have been discharged from the conidiomata, and in this case large numbers of brown, 1-septate conidia can be found on the surface of the host, surrounding the pycnidia. Nevertheless, in the group of species characterised by their brown, aseptate conidia (such as *D. seriata* and *D. sapinea*) pigmented conidia can be seen within the pycnidia, and often while the conidia are attached to the conidiogenous cells. In *Lasiodiplodia*, the conidia usually remain hyaline for a long time after they are formed, but they can become brown and 1-septate whilst enclosed within the pycnidia. Normally, however, pigmentation and septation happen after they have been discharged. Furthermore, in *Lasiodiplodia* the conidia invariably take on a striate appearance.

Conidia of some diplodia-like species become brown at an early stage of their development. For example, conidia of *D. seriata* become brown before they are discharged from the pycnidia. This pattern of development is also seen in *D. sapinea* and its close relative *D. scrobiculata*. In these three species (*D. sapinea*, *D. scrobiculata* and *D. seriata*) the conidia do not form septa, although one or more can develop at the time of germination. In one group of diplodia-like species the conidia become brown and septate at a very early stage, even before they are released from the conidiogenous cells. The genus *Dothiorella* was resurrected to accommodate these species (Phillips et al. 2005) and later *Spermatina*: was introduced to accommodate species with apiculate ascospores (Phillips et al. 2008).

Conidia of some species, both those in the diplodia-like group and the fuscococcum-like group, undergo morphological changes just before they germinate, and these changes can have diagnostic value. Thus, normally hyaline, aseptate conidia can develop one or two septa and become pale translucent brown just before germination. This pigmentation can be either uniform over the entire conidium, or one or more cells may be differentially pigmented. However, this aspect of morphological and colour changes at the time of germination has not been standardised, nor has it been studied for all species. Similarly, as the conidia age they may become darker and some develop septa. The effect of aging on morphological features of these fungi is even less well standardised and can be difficult to interpret.

**Paraphyses**

The presence or absence of paraphyses can be a useful character for differentiating genera in the *Botryosphaeriaceae*. However, in practice this can be difficult to apply because paraphyses are not well-defined. In this work we refer to paraphyses as sterile hyphal elements that form between and intermingled with conidiogenous cells. We further regard paraphyses as only those elements that extend beyond the height of conidiogenous cells and this helps to distinguish paraphyses from immature, or developing conidiogenous cells. In working through published descriptions of species, any mention of paraphyses was critically re-examined and only those that comply with the above definition were accepted.

An example where paraphyses are useful taxonomic characters is in the differentiation of *Lasiodiplodia* from *Neodeightonia*. Both *Lasiodiplodia* and *Neodeightonia* have striate conidia, but only *Lasiodiplodia* species have paraphyses. Likewise, presence of paraphyses in *Sphaeropsis* differentiates this genus from *Diplodia*, which does not have pycnidial paraphyses. Length of the paraphyses and their morphology, especially the presence or absence of a swelling at the tip can also aid in the differentiation of species.

**Spermatogonia**

Spermatial states are common in the *Dothideomycetes*, and also known in several species in the *Botryosphaeriaceae*. However, where seen they are not consistently formed by all isolates of a particular species, that is, they can be present or absent. Thus, their importance in the taxonomy and discrimination of species and genera is of questionable value.

The aim of the current paper was to consider all the genera and species in the *Botryosphaeriaceae* known from culture, based on their morphological characters and DNA sequence based phylogenetic relationships. The intention is to provide a comprehensive and up to date document that can serve as a foundation on which future descriptions of species and other genera can build. Of the older taxa linked to the *Botryosphaeriaceae*, and for which cultures or DNA sequence data are not available, very few, if any, can be linked to the current species that are known from culture. Such older taxa will have to be disregarded for future use unless they are epitypified. The current document will serve as a starting point for that process.

**MATERIALS AND METHODS**

**Morphology**

Fresh collections and type specimens were examined for most of the species included in this study. However, where the type (or other suitable specimens) could not be obtained, and no fresh collections were available, the descriptions were adapted from the original published descriptions. Isolations were made directly from ascomata or conidiomata on the host whenever possible. The sporocarps were cut through vertically with a sterile scalpel, one half was crushed in a drop of sterile water and then spread over the surface of a plate of 1/2 strength Difco potato-dextrose agar (PDA; Becton, Dickinson & Co, Sparks, USA). After incubation for up to 24 h, single germinating spores were transferred to fresh plates of PDA. The other half of the fruit body was placed in a drop of water on a microscope slide and the fertile tissues (asci or conidiogenous layer) were dissected and mounted in 100 %...
was amplified using the primers ITS1 (White et al. 1990) and NL4 (O’Donnell 1993) as described by Alves et al. (2005). Nucleotide sequences of the ITS and D1/D2 regions were determined as described previously (Alves et al. 2004, 2005) using the primers ITS4 (White et al. 1990) and NL1 (O’Donnell 1993) as internal sequencing primers.

The primers EF1-688F (Alves et al. 2008) and EF1-986R (Carbone & Kohn 1999) and B12a and B12b (Glass & Donaldson 1995) were used to amplify and sequence part of the translation elongation factor 1-alpha (EF1-α) 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 previously (Alves et al. 2006, 2008).

The amplified PCR fragments were purified with the JETQUICK PCR Purification Spin Kit (GENOMED, Löhne, Germany). Both strands of the PCR products were sequenced at STAB Vida Lda (Portugal) or GATC Biotech (Germany). The nucleotide sequences were read and edited with FinchTV v. 1.4.0 (Geospiza Inc.). All sequences were checked manually and nucleotide arrangements at ambiguous positions were clarified using both primer direction sequences.

### DNA sequencing and phylogenetic analysis

A phylogenetic analysis based on sequence data from five loci, namely SSU, ITS, LSU, EF1-α and β-tubulin, was done to define the phylogenetic position of genera in the Botryosphaeriaceae. Phylogenetic analyses based on ITS or ITS+EF1-α sequences were done for the species in each of the genera, except where there are few species in the genus.

Sequences were aligned with ClustalX v. 1.83 (Thompson et al. 1997), using the following parameters: pairwise alignment parameters (gap opening = 10, gap extension = 0.1) and multiple alignment parameters (gap opening = 10, gap extension = 0.2, transition weight = 0.5, delay divergent sequences = 25 %). Alignments were checked and manual adjustments were made where necessary.

Phylogenetic analyses of sequence data were done using PAUP v. 4.0b10 (Swofford 2003) for Maximum- Parsimony (MP) analyses and MEGA v. 5 (Tamura et al. 2011) for Maximum-Likelihood (ML) analyses. The general time reversible model of evolution (Rodriguez et al. 1990), including estimation of invariable sites and assuming a discrete gamma distribution with six rate categories (GTR+Γ+G) was used for the ML analysis. Trees were rooted using an outgroup and visualised with TreeView (Page 1996).

MP analyses were performed using the heuristic search option with 1 000 random taxon 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. Maxtrees were set to 500, branches of zero length were collapsed, and all multiple equally most parsimonious trees were saved. The robustness of the most parsimonious trees was evaluated from 1 000 bootstrap replications. Other measures used were consistency index (CI), retention index (RI) and homoplasy index (HI).

ML analyses were performed on a MP starting tree automatically generated by the software. Nearest-Neighbour-Interchange (NNI) was used as the heuristic method for tree inference and 1 000 bootstrap replicates were performed.

### DNA isolation

Isolates were grown on PDA plates in darkness at 25 °C until they completely covered the medium surface. The mycelium was then scraped off and collected in a 2 mL Eppendorf tube with 50 μL of autoclaved glass micro spheres (230–320 μm diam). The tubes were then placed in liquid nitrogen for 5 min and transferred to ice. To separate organic and aqueous phases, 250 μL of phenol and 250 μL of chloroform were added, together with 500 μL of lysis buffer (100 mM NaCl, 10 mM Tris-HCl pH 8.0, 1 mM EDTA, 2 % Triton X-100, 1 % SDS). Tubes were vortexed for 20 min and then centrifuged (19 000 × g, 4 °C, 25 min). The aqueous phase was transferred to a new 1.5 mL tube and the nucleic acids precipitated with an equal volume of cold absolute isopropanol. The tubes were centrifuged again (19 000 × g, 4 °C, 10 min), the supernatants discarded and the pellets washed with 1 mL of cold 70 % ethanol. After a further centrifugation (19 000 × g, 4 °C, 5 min), the supernatants were discarded and the pellets dried at RT with the tubes open in an inverted position. RNA was digested by incubating the pellets with 50 μL of TE (10 mM Tris, 1 mM EDTA) + RNAse A (Sigma®) (50 μg/mL) at 55 °C for 15 min.

### DNA sequencing

A portion of the nuclear ribosomal 18S RNA gene (SSU) was amplified with primers NS1 and NS4 (White et al. 1990). The nucleotide sequence was determined using the above primers along with the internal sequencing primers NS2 and NS3 (White et al. 1990). The amplification and sequencing were done as described by Phillips et al. (2008).

Part of the nuclear rRNA cluster comprising the ITS region plus the D1/D2 variable domains of the ribosomal 28S RNA gene (LSU)
Table 1. GenBank and culture collection accession numbers of species treated in the phylogenies.

| Species         | Cultures             | SSU     | ITS      | LSU      | EF1-α   | β-tubulin |
|-----------------|----------------------|---------|----------|----------|---------|-----------|
| *Barriopsis fusca* | CBS 174.26 ex-type | EU673182| EU673330 | DG377857 | EU673296| EU673109  |
| *Barriopsis iraniana* | CBS 124698 ex-type | N/A     | FJ919665 | N/A      | FJ919652| N/A       |
|                  | IRAN 1449C          | N/A     | FJ919665 | N/A      | FJ919654| N/A       |
| *Botryobambusa fusicoccum* | CBS 134113 ex-type | JX646826| JX646792 | JX646809 | JX646857| N/A       |
|                  | MFLUCC 11-0057      | JX646827| JX646793 | JX646810 | JX646858| N/A       |
| *Botryosphaeria agaves* | CBS 133992 ex-neotype | JX646825| JX646791 | JX646808 | JX646856| JX646841  |
|                  | MFLUCC 10-0051      | JX646824| JX646790 | JX646807 | JX646855| JX646840  |
| *Botryosphaeria corticis* | CBS 119047 ex-epitype | EU673175| DQ299245 | EU673244 | EU017539| EU673107  |
|                  | ATCC 22927          | EU673176| DQ299247 | EU673245 | EU673291| EU673108  |
| *Botryosphaeria dothidea* | CBS 115476 ex-epitype | EU673173| AY236949 | AY928047 | AY23698 | AY236927  |
|                  | CBS 110302          | EU673174| AY259092 | EU673243 | AY573218| EU673106  |
| *Botryosphaeria fabicerciana* | CBS 127193 ex-type | N/A     | HQ332197 | N/A      | HQ332213| N/A       |
|                  | CMW 27108           | N/A     | HQ332200 | N/A      | HQ332216| N/A       |
| *Botryosphaeria fusispora* | MFLUCC 10-0098 ex-type | JX646823| JX646789 | JX646806 | JX646854| JX646839  |
|                  | MFLUCC 11-0507      | JX646822| JX646788 | JX646805 | JX646853| JX646838  |
| *Botryosphaeria ramosa* | CBS 122069 ex-type | N/A     | EU144055 | N/A      | EU144070| N/A       |
|                  | CBS 124703          | N/A     | JQ772020 | N/A      | JQ772057| N/A       |
|                  | CBS 124702          | N/A     | JQ772019 | N/A      | JQ772056| N/A       |
| *Botryosphaeria scharifii* | CBS 124934 ex-type | N/A     | FJ888473 | N/A      | FJ888456| N/A       |
|                  | CBS 124935          | N/A     | FJ888476 | N/A      | FJ888457| N/A       |
| *Cophinforma atrovirens* | CBS 117444          | KF531821| KF531822 | DQ377855 | KF531801| KF531802  |
|                  | CBS 117450          | N/A     | EF118051 | N/A      | GU134937| N/A       |
| *Diplodia africana* | CBS 120835 ex-type | N/A     | EF445343 | N/A      | EF445382| N/A       |
|                  | CBS 121104          | N/A     | EF445344 | N/A      | EF445383| N/A       |
| *Diplodia alatafructa* | CBS 124931 ex-type | N/A     | FJ888460 | N/A      | FJ888444| N/A       |
|                  | CBS 124933 ex-paratype | N/A | FJ888478 | N/A      | FJ888446| N/A       |
| *Diplodia allocellula* | CBS 130408 ex-type | N/A     | JQ239397 | N/A      | JQ239378| JQ239380  |
|                  | CBS 130410 ex-paratype | N/A | JQ239399 | N/A      | JQ239386| JQ239380  |
| *Diplodia agrifolia* | CBS 132777 ex-type | N/A     | JN693507 | N/A      | JQ517317| JQ411459  |
|                  | UCROK 1429          | N/A     | JQ411412 | N/A      | JQ512121| JQ411443  |
| *Diplodia bulgarica* | CBS 124254 ex-type | N/A     | GQ923853 | N/A      | GQ923821| N/A       |
|                  | CBS 124135          | N/A     | GQ923852 | N/A      | GQ923820| N/A       |
| *Diplodia corticola* | CBS 112549 ex-type | N/A     | AY259100 | N/A      | AY928051| DQ458853  |
|                  | CBS 112546          | N/A     | AY259110 | N/A      | AY673262| DQ458872 | EU673117  |
| *Diplodia cupressi* | CBS 168.87 ex-type | EU673209| DQ458893 | EU673263 | DQ458878| DQ458861  |
|                  | CBS 261.85          | EU673210| DQ458894 | EU673264 | DQ458879| DQ458862  |
| *Diplodia intermedia* | CBS 124462 ex-type | N/A     | GQ923858 | N/A      | GQ923826| N/A       |
|                  | CBS 124134          | N/A     | HM036528 | N/A      | GQ923851| N/A       |
| *Diplodia malorum* | CBS 124130 ex-epitype | N/A | GQ923865 | N/A      | GQ923833| N/A       |
|                  | CBS 112554          | N/A     | AY259095 | N/A      | DQ458870| N/A       |
| *Diplodia mutila* | CBS 112553          | EU673213| AY259093 | AY928049| AY573219| DQ458850  |
|                  | CBS 230.30          | EU673214| DQ458886 | EU673265 | DQ458869| DQ458849  |
| *Diplodia olivarum* | CBS 121887 ex-type | N/A     | EU392302 | N/A      | EU392279| HG660079  |
|                  | CBS 121886          | N/A     | EU392297 | N/A      | EU392274| N/A       |
| *Diplodia pseudoseriata* | CBS 124906 ex-type | N/A     | EU080927 | N/A      | EU863181| N/A       |
|                  | CBS 124907 ex-paratype | N/A | EU080922 | N/A      | EU863179| N/A       |
| *Diplodia quercivora* | CBS 133852 ex-type | N/A     | JX894205 | N/A      | JX894229| N/A       |
|                  | CBS 133853          | N/A     | JX894206 | N/A      | JX894230| N/A       |
### Table 1. (Continued).

| Species          | Cultures          | SSU       | ITS       | LSU       | EF-1α   | β-tubulin |
|------------------|-------------------|-----------|-----------|-----------|---------|-----------|
| *Diplodia rosulata* CBS 116470 ex-type | EU673211 | EU430285 | DG377896 | EU430267 | EU673132 |
| *Diplodia sapinea* CBS 116472 | EU673212 | EU430266 | DG377897 | EU430268 | EU673131 |
| *Diplodia acroiculata* CBS 116110 ex-type | N/A       | AY253292 | N/A       | AS624523 | AS624528 |
| *Diplodia seriata* CBS 109944 | EU673218 | DG458899 | DG377893 | DG458880 | DG458863 |
| *Diplodia seriata* CBS 113423 | EU673217 | DG458900 | EU673267 | DG458885 | DG458868 |
| *Diplodia tsugae* CBS 418.64 ex-isotype | EU673208 | DG458888 | DG377867 | DG458873 | DG458856 |
| *Dothiorella americana* CBS 128309 ex-type | N/A       | HQ288218 | N/A       | HQ288262 | HQ288297 |
| *Dothiorella brevicollis* CBS 130411 ex-type | N/A       | JQ239403 | JQ239416  | JQ239390 | JQ239371 |
| *Dothiorella casuarinae* CBS 120688 ex-type | N/A       | HQ288219 | N/A       | HQ288263 | HQ288298 |
| *Dothiorella scrobiculata* CBS 120690 | N/A       | HQ288217 | DQ458899  | DQ458880 | DQ458863 |
| *Dothiorella seriata* CBS 112555 ex-epitype | EU673215 | AY259094 | AY928050  | AY573220 | AY573206 |
| *Dothiorella sp.1* CBS 164708 ex-type | N/A       | EU144054 | N/A       | EU144069 | N/A     |
| *Dothiorella sp.2* CBS 113043 ex-type | N/A       | EU144052 | N/A       | EU144067 | N/A     |
| *Dothiorella sp.2* CBS 121765 | N/A       | EU101299 | N/A       | EU101344 | N/A     |
| *Dothiorella sp.4* CBS 113188 | EU673155 | AY573202 | AY928053  | AY573222 | AY573206 |
| *Dothiorella sp.5* CBS 122068 ex-paratype | N/A       | EU144054 | N/A       | EU144067 | N/A     |
| *Dothiorella sp.5* CBS 121765 | N/A       | EU101299 | N/A       | EU101345 | N/A     |
| *Dothiorella sp.5* CBS 121766 | N/A       | EU101300 | N/A       | EU101345 | N/A     |
| *Dothiorella sp.6* CBS 115041 ex-type | N/A       | EU673161 | AY573212  | AY928052 | AY573235 |
| *Dothiorella sp.6* CBS 113188 | EU673156 | AY573198 | EU673230  | EU673278 | EU673097 |
| *Dothiorella sp.7* CBS 120688 ex-type | N/A       | EU144054 | N/A       | EU144069 | N/A     |
| *Dothiorella sp.7* CBS 121765 | N/A       | EU101299 | N/A       | EU101345 | N/A     |
| *Dothiorella sp.7* CBS 121766 | N/A       | EU101300 | N/A       | EU101345 | N/A     |
| *Dothiorella sp.7* CBS 121767 | N/A       | EU101300 | N/A       | EU101345 | N/A     |
| *Dothiorella sp.8* CBS 115041 ex-type | N/A       | EU673161 | AY573212  | AY928052 | AY573235 |
| *Dothiorella sp.8* CBS 113188 | EU673156 | AY573198 | EU673230  | EU673278 | EU673097 |
| *Dothiorella sp.9* CBS 120690 | N/A       | EU673161 | AY573212  | AY928052 | AY573235 |
| *Dothiorella sp.9* CBS 113188 | EU673156 | AY573198 | EU673230  | EU673278 | EU673097 |
| *Dothiorella sp.10* CBS 121765 | N/A       | EU673161 | AY573212  | AY928052 | AY573235 |
| *Dothiorella sp.10* CBS 113188 | EU673156 | AY573198 | EU673230  | EU673278 | EU673097 |
| *Endomelanconiopsis endophylica* CBS 120397 ex-type | N/A       | EU683656 | EU683829  | EU683637 | N/A     |
| *Endomelanconiopsis microspora* CBS 122550 | N/A       | EU683664 | EU683834  | EU683645 | N/A     |
| *Lasiodiplodia citricola* CBS 116741 ex-type | N/A       | DG103550 | N/A       | DG103551 | N/A     |
| *Lasiodiplodia crassispisa* CBS 116741 ex-type | N/A       | DG103550 | N/A       | DG103551 | N/A     |
| Species                     | Cultures          | GenBank accession numbers |
|-----------------------------|-------------------|--------------------------|
|                             | SSU               | ITS                      | LSU            | EF1-α        | β-tubulin    |
| Lasiodiplodia egyptiaca     | CBS 110492        | EU673189                 | EF622086       | EU673251     | EF622066     | EU673134     |
|                             | CBS 130992 ex-type| N/A                      | JN814397       | N/A          | JN814424     | N/A          |
|                             | CBS 124704 ex-type| N/A                      | GU945351       | N/A          | GU945342     | N/A          |
|                             | CBS 124705        | N/A                      | GU945352       | N/A          | GU945341     | N/A          |
| Lasiodiplodia gilanensis    | CBS 124709 ex-type| N/A                      | GU945355       | N/A          | GU945343     | N/A          |
|                             | CBS 124708        | N/A                      | GU945356       | N/A          | GU945344     | N/A          |
| Lasiodiplodia iraniiensis   | CBS 124710 ex-type| N/A                      | GU945346       | N/A          | GU945334     | N/A          |
| Lasiodiplodia lignicola     | CBS 124711        | N/A                      | GU945347       | N/A          | GU945335     | N/A          |
| Lasiodiplodia theobromae    | CBS 128311 ex-type| N/A                      | HQ288225       | N/A          | HQ288267     | N/A          |
|                             | CBS 128312        | N/A                      | HQ288226       | N/A          | HQ288268     | N/A          |
| Lasiodiplodia parva         | CBS 1244.78       | N/A                      | EF622083       | N/A          | EF622063     | N/A          |
|                             | CBS 494.78        | EU673201                 | EF622084       | EU673258     | EF622064     | EU673114     |
|                             | CBS 356.59        | EU673200                 | EF622082       | EU673257     | EF622062     | EU673113     |
| Lasiodiplodia plurivora     | CBS 120832 ex-type| N/A                      | EF445362       | N/A          | EF445395     | N/A          |
|                             | CBS 121103        | N/A                      | AY343882       | N/A          | EF445396     | N/A          |
| Lasiodiplodia pseudothebromae| CBS 116459 ex-type| N/A                      | EU673199       | N/A          | EU673256     | EF622057     | EU673111     |
| Lasiodiplodia rubropurpurea  | CBS 118740 ex-type| N/A                      | EU673191       | DQ103553     | DQ377903     | EU673304     | EU673136     |
|                             | WAC 12536         | N/A                      | DQ103554       | N/A          | DQ103572     | N/A          |
| Lasiodiplodia theobromae    | CBS 164.96 ex-neotype| N/A                      | EU673196       | AY640255     | EU673253     | AY640258     | EU673110     |
|                             | CBS 124.13        | EU673195                 | DQ458809       | AY928054     | DQ458875     | DQ458858     |
|                             | CBS 111530        | N/A                      | EF622074       | N/A          | EF622054     | N/A          |
| Lasiodiplodia venezuelensis | CBS 118739 ex-type| N/A                      | EU673192       | DQ103547     | DQ377904     | EU673305     | EU673129     |
|                             | WAC 12540         | N/A                      | DQ103548       | N/A          | DQ103569     | N/A          |
| Lasiodiplodia viticola      | CBS 128313 ex-type| N/A                      | HQ288227       | N/A          | HQ288269     | HQ288306     |
|                             | CBS 128315        | N/A                      | HQ288228       | N/A          | HQ288270     | HQ288307     |
| Macrophomina phaseolina     | CBS 227.33        | KF531823                 | KF531825       | KF377906     | KF531804     | KF531806     |
|                             | CBS 162.25        | KF531824                 | KF531826       | KF377905     | KF531803     | KF531805     |
| Neodeightonia palmicola     | MFLUCC 10-0822 ex-type| HQ199223                 | HQ199221       | HQ199222     | N/A          | N/A          |
| Neodeightonia phoenicum     | CBS 122528 ex-type| EU673205                 | EU673340       | EU673261     | EU673309     | EU673116     |
|                             | CBS 169.34        | EU673203                 | EU673338       | EU673259     | EU673307     | EU673138     |
| Neodeightonia subglobosa    | CBS 448.91 ex-type| EU673202                 | EU673337       | DQ377866     | EU673306     | EU673137     |
| Neofusicoccum andinum       | CBS 117453 ex-type| N/A                      | AY693976       | N/A          | AY693977     | N/A          |
| Neofusicoccum arbuti        | CBS 117452        | N/A                      | DQ306263       | N/A          | DQ206264     | N/A          |
| Neofusicoccum australi      | CBS 116131 ex-type| KF531814                 | AY819720       | DQ377915     | KF531792     | KF531793     |
|                             | CBS 110700        | KF531813                 | AY819724       | DQ377919     | KF531791     | KF531794     |
| Neofusicoccum viticola      | CMW 6837 ex-type  | N/A                      | AY339262       | N/A          | AY339270     | AY339254     |
| Neofusicoccum australi      | CMW 6853          | N/A                      | AY339263       | N/A          | AY339271     | AY339255     |
| Species | Cultures | GenBank accession numbers |
|---------|----------|--------------------------|
| Neofusicoccum batangarum | CBS 124924 ex-type | N/A FJ900607 N/A FJ900653 |
| Neofusicoccum corticola | CBS 123634 ex-type | N/A EU821898 N/A EU821868 |
| Neofusicoccum corticosae | CBS 12365 ex-type | N/A EU821903 N/A EU821873 |
| Neofusicoccum eucalypticola | CBS 120081 ex-type | N/A DQ923533 N/A N/A |
| Neofusicoccum grevilleae | CBS 129518 ex-type | N/A JF951137 N/A N/A |
| Neofusicoccum kwambonambiense | CBS 123639 ex-type | N/A EU821900 N/A EU821870 |
| Neofusicoccum luteum | CBS 120099 ex-type sexual morph | EU673148 AY259091 AY928043 |
| Neofusicoccum macroclavatum | CBS 118223 ex-type | N/A DQ093196 N/A DQ093217 |
| Neofusicoccum mediterraneum | CBS 121718 ex-type | N/A GU251176 N/A GU251308 |
| Neofusicoccum nonquaesitum | CBS 126655 ex-type | N/A EU673150 AY259098 AY928046 |
| Neofusicoccum pacificum | CBS 120080 ex-type | N/A EU301030 N/A EU339509 |
| Neofusicoccum pennatisporum | CBS 122071 ex-type | N/A AF196295 N/A N/A |
| Neofusicoccum protearum | CBS 121176 ex-type | N/A GU251176 N/A GU251308 |
| Neofusicoccum ribis | CBS 115475 ex-type | N/A AY236935 N/A AY236906 |
| Neofusicoccum umdonicola | CBS 123645 ex-type | N/A EU821900 N/A EU821870 |
| Neofusicoccum viticlavatum | CBS 123641 | N/A EU821919 N/A EU821899 |
| Neofusicoccum vitifusiforme | CBS 112878 ex-type | N/A EU343381 N/A EU343343 |
| Neoscytalidium hyalinum | CBS 499.66 | KF531818 KF531820 |
| Neoscytalidium novaehollandiae | CBS 122071 ex-type | N/A EF585540 N/A EF585580 |
| Phaeobotryon cercidis | CBS 124700 ex-type | N/A FJ919672 N/A FJ919661 |
| Phaeobotryon cupressi | CBS 115475 ex-type | N/A AF196295 N/A N/A |
| Phaeobotryon mamane | CBS 122980 ex-type | EU673184 EU673322 EU673248 |
| Pseudofusicoccum adansoniae | CBS 122055 ex-type | N/A EF585523 N/A EF585571 |

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RESULTS

DNA phylogeny

After alignment the combined five-locus dataset consisted of 3 362 characters (including alignment gaps) for 94 ingroup taxa and one outgroup taxon. Of the 3 362 characters, 2 418 were constant and 159 were variable and parsimony-uninformative. Maximum parsimony analysis of the remaining 785 parsimony-informative characters resulted in 16 equally most parsimonious trees of 3 010 steps (CI = 0.499, RI = 0.846, HI = 0.501), one of which is shown in Fig. 5. The phylogenetic tree resulting from ML analyses using the general time reversible model of DNA evolution (Rodriguez et al. 1990), including estimation of invariable sites and assuming a discrete gamma distribution with six rate categories (GTR+Γ+G), had a topology identical to the MP tree presented.

In both analyses (MP and ML) a clade corresponding to the family Botryosphaeriaceae received a bootstrap support of 100%. The genera Saccharata (used as outgroup) and Melanos are clearly excluded from the family. Within the Botryosphaeriaceae 17 clades corresponding to an equal number of genera could be readily recognised. All clades received moderate to high bootstrap support (> 70%).
Fig. 5. One of 16 equally most parsimonious trees obtained from the combined analysis of 5 loci (SSU, LSU, ITS, EF-1α and β-tubulin). for all genera in the Botryosphaeriaceae that are known from culture. Gaps were treated as missing data. MP/ML values (> 50 %) resulting from 1000 bootstrap replicates are given at the nodes. The tree was rooted to Saccharata proteae CBS 115206. Clades corresponding to genera within the family Botryosphaeriaceae are highlighted.
Although Liu et al. (2012) included *Auerswaldia* in the *Botryosphaeriaceae*, our analysis of the sequences of their isolates revealed that *A. dothiorella* is in fact a species of *Dothiorella* while *A. lignicola* appears to be best placed in *Lasiodiplodia*. Thus, at this stage there is no evidence to indicate that *Auerswaldia* should be considered as a genus in the *Botryosphaeriaceae*. Therefore, we accept 17 genera in the *Botryosphaeriaceae*. These genera, defined as clades in the five-locus phylogeny, are also supported by morphological characteristics. These morphological characters provide the basis for the following key to the genera.

### Key to the genera

|   | Conidia formed within a pycnidium | Conidia formed as dry powdery arthric chains | Neoscytalaydium |
|---|-----------------------------------|---------------------------------------------|-----------------|
| 1. | Conidia hyaline (only rarely turn brown with age) | Conidia brown (can remain hyaline for some time before becoming brown) | 2 |
| 2. | Conidia hyaline, with persistent mucous sheath | Conidia hyaline, mucous sheath absent | 3 |
| 3. | Conidia cylindrical, not reaching 50 μm long | Conidia fuzzy with apical mucoid appendages | 4 |
| 4. | Conidia fusiform with apical mucoid appendages | Conidia, with persistent mucous sheath | Pseudofusicoccum |
| 5. | Conidia thin-walled | Conidia brown (can remain hyaline for some time before becoming brown) | 6 |
| 6. | Conidia mostly fusoid to ellipsoidal | Conidia cylindrical to cylindro-clavate | 7 |
| 7. | Most conidia longer than 30 μm | Conidia mostly less that 30 μm long | Botryobambusa |
| 8. | Conidia with a single germ slit | Germ slit absent | 9 |
| 9. | Conidia with longitudinal striations | Conidia not striate | 10 |
| 10. | Immature, hyaline conidia striate | Lasiodiplodia | 11 |
| 11. | Pycnial paraphyses present | Neodeightonia | 12 |
| 12. | Conidia aseptate | Sphaeropsis | 13 |
| 13. | Conidia with 1 or more septa | Pseudofusicoccum | 14 |
| 14. | Conidiogenous cells and conidia enclosed in mucoid sheath | Mucoid sheath absent | Diplodia |
| 15. | Conidia become brown and 1-septate only after dehiscence | Conidia become brown and 1-septate while attached to the conidiogenous cells before dehiscence | Dothiorella/Spencermartinsia |
| 16. | Conidia frequently 2-septate | Conidia 1-septate only rarely becoming 2-septate | Phaeobotryon |

1This key is based on morphology of the asexual morph because the sexual morph is not known for some genera, is very uncommon for others and has not been induced in culture for many of the genera.

2It is difficult to separate these two genera morphologically but phylogenetically they are distinct.

3These two genera cannot be separated on the morphology of the conidial states but the presence of apiculi on the ascospores of *Spencermartinsia* distinguishes it from *Dothiorella*.
Generic and species descriptions

**Barriopsis** A.J.L. Phillips, A. Alves & Crous, Persoonia 21: 39. 2008. MycoBank MB511712.

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

Ascomata pseudothecial, scattered or clustered, brown to black, wall composed of several layers of *textura angularis*, ostiole central. *Pseudoparaphyses* hyaline, smooth, multiseptate, constricted at septa. Asci bitunicate, clavate, stipitate, thick-walled with thick endotunica and well-developed apical chamber. Ascospores aseptate, ellipsoid to ovoid, brown when mature, without terminal apiculi. *Conidiomata* stromatic, pycnidial, superficial, dark brown to black, un- or multilocular. *Ostiole* central, circular, non-papillate. *Paraphyses* arising from the conidiogenous layer, extending above the level of developing conidia, thin-walled, hyaline, mostly aseptate. *Conidiophores* absent. *Conidiogenous cells* hyaline, thin-walled, smooth, cylindrical, holoblastic, proliferating at the same level forming periclinal thickenings. *Conidia* thick-walled, initially hyaline, aseptate with longitudinal striations, striations visible on immature hyaline conidia even while attached to conidiogenous cells, oval, both ends broadly rounded, becoming brown, aseptate or 1–3-septate, with prominent longitudinal striations, wall smooth. *Chlamydoascus* catenate, intercalary, brown, smooth, thick-walled, formed within the agar medium.

Notes: The absence of apiculi on the ascospores differentiate this genus from *Sphaeropsis* and *Physalospora*. The aseptate, brown ascospores without apiculi are unique in the *Botryosphaeriaceae*, as are the striae immature conidia. The genus is currently represented by two species that can be distinguished based on their conidial dimensions. Thus, *conidia* of *B. fusca* (20–28 × 11–16 μm) are smaller than those of *B. iraniana* (23–30 × 13–21.5 μm).

**Species descriptions**

**Barriopsis fusca** (N.E. Stevens) A.J.L. Phillips, A. Alves & Crous, Persoonia 21: 39. 2008. MycoBank MB511713. See Phillips et al. (2008) for illustrations.

*Basionym*: *Physalospora fusca* N.E. Stevens, Mycologia 18: 210. 1926.

≡ *Physalospora fusca* N.E. Stevens (N.E. Stevens) Petr., Sydowia 6: 317. 1952.
≡ *Sphaeria disrupta* Berk. & M.A. Curtis, Grevillea 4 (no. 32): 149. 1876.
≡ *Physalospora disrupta* Berk. & M.A. Curtis Sacc., Syll. fung. (Abellini) 1: 438. 1882.
≡ *Physarospora disruptum* (Berk. & M.A. Curtis) Petr. & Syd., Annls mycol. 23(3/6): 255. 1925.
≡ *Botryosphaeria disrupta* (Berk. & Curtis) Ax & Müller. Beitr. Kryptfl. Schweiz 11(1): 37. 1954.

*Ascomata* pseuothecial, scattered, immersed, brown to black, separate or aggregated, wall composed of *textura angularis*, uniloculate, ostiole single, central. *Pseudoparaphyses* hyaline, smooth, 3–4.5 μm wide, multiseptate with septa 14–18 μm apart. *Asci* bitunicate, clavate, 8-spored, stipitate, thick-walled with thick endotunica and well-developed apical chamber, 125–180 × 30–36 μm. *Ascospores* biseriate, aseptate, ellipsoid to oval, straight or slightly curved, apex and base obtuse, without terminal apiculi, wall externally smooth, internally finely verruculose, brown, widest in the middle, (30–)31–36.5(–38.5) × (15.5–)16–18.5(–21) μm, 95 % confidence limits = 32.6–33.4 × 17.0–17.5 μm (av. ± S.D. = 33.0 ± 1.5 ± 17.2 ± 1.0 μm), L/W ratio = 1.9 ± 0.15.

*Type*: *Cuba*. Herradura, on twigs of *Citrus* sp., 15 Jan. 1925, N.E. Stevens, *holotype* BPI 599052.

*Culture*: CBS 174.26 (ex-type).

*Host*: *Citrus* sp. (Stevens 1926, pathogenicity not known).

*Known distribution*: USA; *Cuba* (Stevens 1926), Florida (BPI 500054 collected by Shear 1923, determined by N.E. Stevens).

Notes: Von Arx & Müller (1954) placed *P. fusca* as a synonym of *Botryosphaeria disrupta*, along with various species in *Physalospora* and *Physalospora*. However, the broad concept of *Botryosphaeria* followed by von Arx & Müller (1954) encompassed such genera as *Physalospora* and *Physalospora.* Phillips et al. (2008) showed to be phylogenetically distinct from *Physalospora*.

Phillips et al. (2008) could not induce the ex-type culture to sporulate, no doubt because it had been in culture for more than 80 years. According to Stevens (1926) the asexual morph is lasiodiplodia-like and he described it as, "Conidia initially hyaline, aseptate and thick-walled becoming dark brown and septate with irregular longitudinal striations, (20–)25(–28) × (11–)12–13(–16) μm". Stevens (1926) placed this species in *Physalospora*, but he was obviously hesitant to do so, judging from his statement, "To place in the genus *Physalospora* a fungus with colored ascospores is of course to do violence to the ideas of that genus*. On account of the bitunicate asci and brown ascospores of this species, *Physalospora* is clearly unsuitable for it. Petrak & Deighton (1952) transferred this species to *Physalospora Spig.* as *Physalospora* *fusca* (N.E. Stevens) Petr., presumably because it has dark ascospores. Phillips et al. (2008) examined the type species of *Physalospora* *P. yerbae* and found that it had terminal apiculi on the ascospores. Therefore, *Phaeobotryosphaeria* was also unsuitable and for that reason they proposed the new genus *Barriopsis* for this fungus.

**Barriopsis iraniana** Abdollahz. Zare & A.J.L. Phillips, Persoonia 23: 4. 2009. MycoBank MB513235. Fig. 6.

*Ascomata* not reported. *Conidiomata* stromatic, pycnidial, superficial, dark brown to black, covered with dense mycelium, on pine needles mainly unilocular and up to 600 μm diam, on *Populus* twigs mostly multilocular, individual or aggregated, thick-walled, ostiole. *Ostiole* central, circular, non-papillate. *Paraphyses* arising from the conidiogenous layer, extending above the level of developing conidia, up to 70 μm long, 3.5 μm wide, thin-walled, hyaline, usually aseptate, sometimes becoming up to 2–3-septate, not constricted at the septa, tip rounded, occasionally branched. *Conidiophores* absent. *Conidiogenous cells* 7–12 × 3–5 μm, hyaline, thin-walled, smooth, cylindrical, holoblastic, proliferating at the same level, with visible periclinal thickening. *Conidia* thick-walled, initially hyaline, aseptate with longitudinal striations, striations visible on hyaline conidia even while attached to conidiogenous cells, oval, both ends broadly rounded, becoming brown, aseptate or 1–3-septate, with prominent longitudinal striations, wall smooth, (22.5–)24–30 × (12.8–)14–18(–21.5) μm, 95 % confidence limits
= 27–27.4 × 16.2–16.6 μm (av. ± S.D. = 27.2 ± 1.8 × 16.4 ± 1.3 μm), L/W ratio = 1.7 ± 0.16. Chlamydosporae catenate, intercalary, brown, smooth, thick-walled, formed within the agar medium.

Culture characteristics: Colonies with appressed mycelial mat and fluffy aerial mycelium in the middle, becoming dull green to olivaceous-black at the surface, and dull green to grey-olivaceous at the reverse after 2 wk in the dark at 25 °C. Colonies reaching 45–50 mm diam on MEA after 4 d in the dark at 25 °C. Cardinal temperatures for growth: min 5 °C, max > 35 °C, opt 25–30 °C.

Type: Iran, Hormozgan Province, Minab, Hajikhademi, on twigs of Mangifera indica, 27 Feb. 2007, J. Abdollahzadeh & A. Javadi, holotype IRAN 13939F.

Cultures: IRAN 1448C = CBS 124698 (ex-type).

Hosts: Endophytic in stems of Citrus sp., Mangifera indica and Olea sp. (Abdollahzadeh et al. 2009).

Known distribution: Iran (Hormozgan Province) (Abdollahzadeh et al. 2009).

Notes: Conidia of Barriopsis iraniana are significantly larger than those reported by Stevens (1926) for B. fusca, the only other species known in this genus. The only available culture of B. fusca (CBS 174.26, ex-type) has lost its ability to sporulate. According to Stevens (1926) the asexual morph is lasiodiplodia-like with hyaline conidia that become dark-brown and septate with irregular longitudinal striations. However, in contrast to Lasiodiplodia, the conidia of Barriopsis are

**Fig. 6.** Barriopsis iraniana. A. Conidiomata on pine needles in culture. B, C. Conidia developing on conidiogenous cells between paraphyses. D. Young, immature conidium attached to a conidiogenous cell, longitudinal striations are visible on the conidium. E. Hyaline, immature, striate conidia. F–I. Hyaline and brown, striate conidia, 1- and 3-septate conidia can be seen in F and G. J. Catenulate chlamydospores formed within the agar medium. Scale bars: A = 250 μm, B, C, E–I = 10 μm, D = 5 μm, J = 40 μm.
The Botryosphaeriaceae: genera and species known from culture

The Botryosphaeriaceae: genera and species known from culture

The sexual morph of B. iraniana has not been seen.

Botryobambusa R. Phookamsak, J.K. Liu & K.D. Hyde, Fungal Divers. 57: 166. 2012. MycoBank MB801313.
Type species: Botryobambusa fusicoccum R. Phookamsak, J.K. Liu & K.D. Hyde, Fungal Divers. 57: 166. 2012.

Ascomata dark brown to black, immersed under host epidermis to erumpent, gregarious, multiloculate, locules individual globose to subglobose or fused, vertical to the host surface, with a central, papillate, periphysate ostiole. Asci 8-spored, bitunicate, fissitunicate, clavate to cylindro-clavate, pedicellate, with well-developed ocular chamber. Ascospores hyaline, aseptate, smooth-walled, ellipsoidal to obovoid, thick-walled, surrounded by a mucilagenous sheath.

Conidiomata developing in stromatic clusters, fused, multiloculate, globose to subglobose, wall composed of several layers of textura angularis, outer layers dark 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.

Type: Thailand, Lampang Province, Jae Hom District, Mae Yuag Forestry Plantation, on dead culms of Bambusa sp., 19 Aug. 2010, R. Phookamsak, holotype MFLU 11-0179.

Cultures: CBS 134113 = MFLUCC 11-0143 (ex-type), MFLUCC 11-0657.

Host: Bambusa sp. (Liu et al. 2012).

Known distribution: Thailand (Liu et al. 2012).

Notes: The genus Botryobambusa is presently monotypic, and only known from Bambusa sp. in Thailand. The sexual morph is characterised by having ascospores surrounded by an irregular sheath, while the asexual morph is fusicoccum-like in morphology (Liu et al. 2012).

Botryosphaeria Ces. & De Not., Comm. Soc. crittog. Ital. 1: 211. 1863; emend. Sacc., Michelia 1: 42. 1877. MycoBank MB6355.

= Fusicoccum Corda, in Sturm, Deutschl. Flora, III (Pilze) 2: 111. 1829.
= Thuemenia Rehm, Flora 62: 123. 1878.
= Coutinia J.V. Almeida & Sousa da Câmara, Rev. Agron. Lisboa 1: 392. 1903.
= Cryptosporina Höhn. Öst. bot. Z. 55: 54. 1905.
= Amerodothis Theiss. & Syd., Ann. mycol. 13: 295. 1915.
PhilliPs et al.

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

Mycelium immersed, consisting of branched, septate, smooth, hyaline hyphae. Ascomata eusomatic, scattered, solitary, aggregated or forming botryose clusters, externally black, uniloculate, with a thick pseudoparenchymatous wall composed of textura angularis or textura globosa with the outer layers blackened and their cells more thickened, ostiole, embedded in the substrate and partially erumpent at maturity. Pseudoparaphyses thin-walled, hyaline, frequently septate, constricted at the septa, deliquescent from the basal parts when the asc i mature. Asci clavate or cylindric-clavate, stipitate, bitunicate, echinocysta thin, endotunica rather thick, 3-layered (sensu Erikssoon 1981), with a prominent apical chamber, 8-spored, developing on a broad basal hymenial layer. Ascospores irregularly biseriate in the ascus, hyaline, sometimes becoming pale brown with age, thin-walled, ovoid, fusoid, fusoid-ellipsoidal, usually widest in the middle, straight or inequilateral, smooth, one-celled sometimes becoming 1–2 septate with age, contents smooth or granular, may be guttulate. Conidiomata stromatic, pycnidial, solitary or aggregated, often occurring within the same stroma as the ascomata, walls composed of dark brown, thick-walled textura angularis, becoming thin-walled and hyaline towards the inner layer. Ostioles indistinct to well-defined, round or irregular. Paraphyses hyaline, cylindrical, tapering to rounded ends, septate, arising between the conidiophores and conidiogenous cells. Conidiophores when present hyaline, cylindrical, branched at the base, smooth, 0–1 septate. Conidiogenous cells enteroblastic, integrated, hyaline, smooth, cylindrical, first-formed conidium holoblastic, determinate or proliferating percurrently with 1–2 indistinct annihilations, or proliferating at the same level resulting in typical phialides (sensu Sutton 1980) with periclinal thickenings. Conidia hyaline, sometimes becoming oливaceous or darker with age, thin-walled, smooth, aseptate, occasionally forming one or two septa with age or before germination, with shapes varying from elliptical to fusiform or clavate, finely guttulate, apex subobtuse to obtuse, base conspicuously truncate with a minute marginal basi frill.

Notes: When Cesati & De Notaris (1863) introduced Botryosphaeria Ces. & De Not. they listed nine species (plus another six that they did not recombine in the genus) but they did not designate a type. Subsequently, Saccardo (1877) emended the genus to exclude hypocreaceous species. Von Höhnel (1909) designated B. berengeriana De Not. as the type, but this species was not included in the original description of the genus, although it was published soon after (De Notaris 1864). Theissen & Sydow (1915) suggested B. quercuum (Schwein.) Sacc. as the type since it was typical of Saccardo’s (1877) emendation of Botryosphaeria, and this was accepted by von Arx & Müller (1954). However, B. quercuum also was not one of the original species of the genus and therefore is unsuitable as the type. Barr (1972) proposed B. dothidea (Moug.: Fr.) Ces. & De Not. as lectotype because it was one of the original species described, it conforms with Saccardo’s (1877) emendation and it is an earlier synonym of B. berengeriana, von Höhnel’s (1909) designated type. The proposal of Barr (1972) has been accepted generally, and Slippers et al. (2004a) provided a revised description of this species based on the type specimen and fresh collections, and they designated a neotype and epitype.

Species in Botryosphaeria were described largely on the basis of the morphology of their ascocar and host associations, and this led to a proliferation of names. Von Arx and Müller (1954) examined 183 taxa and reduced them to 11 species, with extensive synonymies under B. dothidea and B. quercuum, together with nine new combinations. However, because von Arx and Müller (1954) did not take into account the characters of the asexual morphs and because species of Botryosphaeria are difficult to separate on the basis of sexual morph characters, these synonyms have not always been accepted (Shoemaker 1964, Sivanesan 1984, Slippers et al. 2004a).

The genus Botryosphaeria, based on the type species B. dothidea, typically has ascospores that are hyaline and aseptate, although they can become pale brown and septate with age (Shoemaker 1964, Sivanesan 1984, Denman et al. 2000, Alves et al. 2004, Phillips et al. 2005). Because some species of Botryosphaeria have ascospores that become brown with age, von Arx & Müller (1954) placed Dothidea visci with brown ascospores in Botryosphaeria as B. visci, and later they (von Arx & Müller 1975) also placed the dark-spored Neodeightonia subglobosa in Botryosphaeria. Since it is the type species of Neodeightonia, this genus was reduced to synonymy with Botryosphaeria. In recognising these synonyms, von Arx & Müller (1954, 1975) broadened the concept of Botryosphaeria to include species with brown ascospores.

Phillips et al. (2005) resurrected the genus Dothiorella for species with 1-septate conidia that darken at an early stage of development, and have sexual morphs with brown, 1-septate ascospores. Phylogenetically (ITS+EF1-α) the two species studied by Phillips et al. (2005) fell within Botryosphaeria as defined by the broad morphological concept recognised by von Arx & Müller (1954, 1975). For these reasons, Phillips et al. (2005) described the sexual morphs of Dothiorella as two new species of Botryosphaeria with brown, 1-septate ascospores. Subsequently, Luque et al. (2005) described another dark-spored Botryosphaeria, namely B. viticola, with a Dothiorella asexual morph.

At least 18 asexual genera have been associated with Botryosphaeria s. lat. (Denman et al. 2000) including Diplodia, Dothiorella, Fusicoccum, and Lasiodiplodia. The morphological diversity of the asexual morphs linked to species of Botryosphaeria, together with the broad concept of the sexual genus was clear evidence that Botryosphaeria encompassed several distinct genera. Thus, through a study of partial sequences of the LSU gene, Crous et al. (2006) showed that Botryosphaeria s. lat. is composed of 10 phylogenetic lineages, each of which corresponds to different asexual genera. To avoid the unnecessary introduction of new generic names, these authors chose to use existing asexual generic names for most of the lineages, and restricted the use of Botryosphaeria to B. dothidea and B. corticis. Seven species are currently recognised in Botryosphaeria.

DNA phylogeny

In an ITS phylogeny the ex-type isolate of B. mamane and isolates previously regarded as B. mamane clustered in Cophiforma together with C. atrovirens (Fig. 8). Based on combined ITS and EF1-α sequence data seven species are currently recognised in Botryosphaeria (Fig. 8). Apart from B. fabicerciana all species clades are supported by high bootstrap values.
Fig. 8. One of 18 equally most parsimonious trees obtained from the combined analysis of ITS and EF1-α sequences from species of the genera Botryosphaeria, Cophinforma, Macrophomina and Neoscytalidium. The phylogenetic tree resulting from ML analysis using the general time reversible model of DNA evolution and assuming a discrete gamma distribution (GTR+G) had a topology identical to the MP tree presented. MP/ML values (>50%) resulting from 1000 bootstrap replicates are given at the nodes. The tree was rooted to N. parvum and N. luteum. Clades corresponding to genera and species are highlighted.
Key to *Botryosopheria* spp.

1. Conidia 12–17 μm long ................................................................. 2
2. Most conidia longer than 18 μm ................................................. 3
3. Conidia 16–22 μm long ............................................................... 4
4. Conidia mostly longer than 20 μm ................................................ 5
5. Conidial L/W ratio greater than 4.5 .............................................. 5

| Species descriptions |
|----------------------|
| *Botryosopheria agaves* (Henn.) E.J. Butler, Ann. Mycol. 9: 415. 1911. MycoBank MB119799. See Liu et al. (2012) for illustrations. |
| **Ascomata** | 140–260 μm high × 600–800 μm diam, circular blackened areas on host tissue, immersed to erumpent on host, uniloculate, aggregated, individually globose to subglobose, wall composed of several layers of dark brown walled cells of textura angularis. Ostiole circular, central, papillate. Pseudoparaphyses 3–5 μm wide, as epicate. Asci 91–122 × 27–38 μm, 8-spored, bitunicate with a thick endotunica, fissitunicate, clavate to cylindro-clavate, short pedicellate, with well-developed apical chamber. Ascospores 21–43 × 8–12 μm, biseriate in the ascus, hyaline, aseptate, ellipsoidal, fusiform, or inequilateral, usually wider at the middle, wall rough, surrounded by a mucilaginous sheath. Condidiomata not reported. |
| **Type:** Tanzania, Zanzibar, on leaves of *Agave sisalana* sp., 16 Jun. 2010, R. Phookamsak, neotype designated here MFLUCC 11–0161; MFLUCC 10-0051. |
| **Colonies** | MFLUCC 11–0125 = CBS 133992 (ex-neotype), MFLUCC 10-0051. |
| **Host:** Agave sp. (Liu et al. 2012). |
| **Known distribution:** Thailand (Liu et al. 2012). |
| **Notes:** Liu et al. (2012) proposed a specimen from Agave sp. collected in Thailand (MFLUCC 11-0161) to serve as epitype for *B. agaves*. However, as they did not cite nor examine the holotype, their epitypification is invalid. We have also been unable to trace the holotype, thus designate the Thailand specimen as neotype to rectify this situation. |

| Species descriptions |
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| *Botryosopheria corticis* (Demaree & Wilcox) Arx & E. Müll., Beitr. Kryptfl. Schweiz 11(1): 43. 1954. MycoBank MB293807. Figs 9, 10. Basionym: *Physalospora corticis* Demaree & Wilcox, Phytopathology 32: 1074. 1942. |
| **Ascomata** | Abundant, embedded in the host becoming partially erumpent at maturity, up to 250 μm diam, conical with a dark brown to black wall composed of up to six cell layers of thick-walled textura angularis giving way to hyaline, thinner-walled cells lining the ascomata. Asci hyaline, clavate and stipitate, bitunicate with a thick endotunica and well-developed apical chamber, eight-spored, 145–165 × 25–28 μm, irregularly biseriate, formed amongst hyaline, thin-walled, septate pseudoparaphyses. Ascospores ellipsoid to fusoid, (24–)25.5–33(–34.5) × (9.5–)10–12.5(–13.5) μm, 95 % confidence limits = 28.5–30.1 × 11.2–11.9 μm (av. ± S.D. of 32 conidia = 29.3 ± 2.4 × 11.6 ± 1.0 μm). L/W = 2.5 ± 0.23. Ascospores germinate within 24 h at 25 °C and form unbranched germ tubes. Condidiomata developing in culture on pieces of poplar twigs after 14 d and producing conidia after 28 d, solitary to aggregated, dark brown to black, globose, up to 450 μm diam. Condidiophores cylindrical, hyaline, smooth, thin-walled, septate, branched in the upper parts, 7.5–14 × 3.5–4.5 μm, lining the entire inner surface of the condidiomata. Condidiogenous cells lageniform, hyaline, thin-walled, smooth, 12.5–17.5 × 2.5–4.5 μm, holoblastic producing a single conidium at the tip, rarely proliferating at the same level giving rise to periclinal thickenings. Conidia fusiform, widest in the middle to upper third, hyaline, thin-walled, smooth, apex acute, base truncate with a minute marginal frill and persistent mucous sheath, (20.5–)23.5–32.5(–34.5) × (5.0–)5.5–7(–7.5) μm, 95 % confidence limits = 27.7–30.2 × 6.2–6.7 μm (av. ± S.D. of 26 conidia = 28.9 ± 3.4 × 6.4 ± 0.7 μm). L/W = 4.5 ± 0.46. Spermatogonia globose, dark brown to black. Spermatophores cylindrical, hyaline, branched, 11–14 × 2–3 μm. Spermatogenous cells hyaline, thin-walled, smooth, 14.5–20.5 × 1.5–2.3 μm, producing conidia at their tips, proliferating internally to form periclinal thickenings. Spermata rod-shaped with obtuse ends, hyaline, thin-walled, smooth, 4–6 × 1.5–2 μm. |
| **Culture characteristics:** Colonies on CMA reaching 28–40 mm diam after 7 d at 25 °C, initially white becoming olive-green with clumps of loosely aggregated hyphae. |
Type: **USA**, North Carolina, Atkinson, *Vaccinium corymbosum*, 14 Feb. 1940, J.B. Demaree, **holotype** BPI 598729; New Jersey, Hammonton, on cankered stems of *V. corymbosum*, May 2005, P.V. Oudemans, CBS H-19706 **epitype** (designated by Phillips et al. 2006a).

**Cultures**: CBS 119047, CBS 119048 (ex-epitype).

**Hosts**: *Vaccinium* species including *V. corymbosum*, *V. ashei*, *V. tenellum* and *V. virgatum* (Phillips et al. 2006, Wright & Harmon 2010).

**Known distribution**: USA (Florida, Georgia, Maryland, Mississippi, New Jersey, North Carolina) (Phillips et al. 2006, Wright & Harmon 2010).

**Notes**: This species appears to be restricted to *Vaccinium* spp. and has not been reported outside of the continental USA. The mucilaginous sheath surrounding the conidia is unusual in *Botryosphaeria*.
**Botryosphaeria dothidea** (Moug.: Fr.) Ces. & De Not., Comm. Soc. Crittog. Ital. 1: 212. 1863. MycoBank MB183247. Figs 11, 12.

**Basionym**: *Sphaeria dothidea* Moug., In: Fries, Syst. Mycol. (Lundae) 2(2): 423. 1823.

≡ *Sphaeria coronillae* Desm., Annls Sci. Nat., Bot., sér. 2 13: 188. 1840.

≡ *Macrophoma coronillae* (Desm.) Höhn., Ber. Deutsch. Bot. Ges. 28: 479. 1910.

≡ *Fusicoccum coronillae* (Desm.) Petr., Sydowia 16(1–6): 188. 1963.

≡ *Dothiorella coronillae* (Desm.) Petr., Annls mycol. 22(1/2): 108. 1924.

≡ *Phyllosticta divergens* Sacc., Malpighia 5: 274. 1891.

Ascostroma erumpent, 200–500 μm diam. Ascomata pseudothecial, forming a botryose aggregate of up to 100, sometimes solitary, globose with a central ostiole, ¼ to ½ emergent, rarely embedded, papillate or not, brown to black, pseudothecial wall comprising 5–15

*Fig. 10. Botryosphaeria corticis. A. Conidiomata formed on poplar twigs in culture. B–E. Conidiogenous cells and paraphyses. F. Conidia with mucous sheath (arrowheads). G–J. Spermatogenous cells. J. Spermatia. Scale bars: A = 0.5 mm, B–J = 10 μm.*
layers of textura angularis, outer region of dark brown cells, inner region of 2–4 layers of hyaline cells lining the locule. Asci bitunicate, clavate, 63–125 × 16–20 μm, forming between pseudoparaphyses. Pseudoparaphyses filiform, septate, constricted at the septa, rarely branched, 2–4 μm wide. Ascospores fusoid to ovoid, sometimes with tapered ends and appearing spindle-shaped, biseriate in the ascus, (17–)19–24(–32) × (6–)7–8(–10) μm (av. of 102 ascospores = 22.7 × 7.8 μm), L/W = 2.9. Conidiomata stromatic, morphologically indistinguishable from the ascomata. Paraphyses, when present hyaline, septate, up to 110 μm long, 2.5–6 μm wide at the base tapering to acutely rounded apices, 2–2.5 μm wide at the tip. Conidiophores hyaline, smooth, thin-walled, rarely branched at the base, cylindrical, formed from the cells lining the locule wall, 23–35 × 4–5 μm, or reduced to conidiogenous cells. Conidiogenous cells holoblastic, hyaline, sub-cylindrical, 6–20 × 2–5 μm, proliferating percurrently to produce 1–2 annellations or proliferating internally resulting in periclinal thickenings and typical "phialides" (sensu Sutton 1980). Conidia narrowly fusiform, or irregularly fusiform, base subtruncate to bluntly rounded, (17–) 19.5–30(–34) × 4–6(–7.5) μm, 95 % confidence limits of 350 conidia = 25.8–26.5 × 5.3–5.4 μm (av. ± S.D. of 350 conidia = 26.2 ± 3.1 × 5.4 ± 0.7 μm), L/W = 4.9 ± 0.96 with 95 % confidence limits of 4.8–5.0, rarely forming a septum before germination, smooth with granular contents, in some isolates becoming dark-walled and septate with age, (9.5–) 10.5–20(–23) × (3–)4–6(–6.5) μm (av. ± S.D. of 150 conidia = 15.5 ± 2.7 × 5.1 ± 0.6 μm). Spermatophores hyaline, smooth, occasionally branched, cylindrical to subcylindrical septate, 4–15 × 1–3.5 μm. Spermatogenous cells discrete or integrated, hyaline, smooth, cylindrical, holoblastic or proliferating via phialides with periclinal thickenings, 7–10 × 2–3 μm. Spermatia unicellular, hyaline, allantoid to rod-shaped, 3–6 × 1.5–2 μm.

Fig. 11. Botryosphaeria dothidea. A. Botryose clusters of ascomata erumpent through the bark of a poplar twig. B. Transverse section through ascomata revealing brilliant white contents. C. Section through ascomata. D. Ascus with ascospores. E. Septate pseudoparaphyses. F. Ascospores. G, H. Ascus tip showing apical chamber as seen by interference contrast (G) or phase contrast (H). I. Ascospores. Scale bars: A, B = 0.5 mm, C = 100 μm, D–I = 10 μm.

Culture characteristics: Colonies oliveaceous becoming grey with reverse black. Mycelial mat moderately dense, margin smooth. Optimum temperature for growth 25(–30) °C, colony on ½ PDA reaching 50 mm radius after 4 d at 25 °C in the dark.
Type: France, Rosa sp., 1823, Fries ex Mougeot. Herbarium S (neotype of Sphaeria dothidea designated by Slippers et al. 2004a). Switzerland, Ticino, Crocifisso, Prunus sp., Oct. 2000, B. Slippers, PREM 57372 (epitype designated by Slippers et al. 2004a). Italy, on branches of Aesculus sp., P.A. Saccardo, PAD, (neotype of asexual morph designated by Crous & Palm 1999).

Cultures: CBS 115476 = CMW 8000 (ex-epitype).

Hosts: Woody plants in numerous families. Reports of hosts prior to 2000 are unreliable because the concept of this species was not clear until Slippers et al. (2004a) redefined it and proposed neotype, epitype and ex-epitype cultures. It is highly probable that before that time some of the host associations may have been of species of Neofusicoccum. However, some recent reports can confirm the following hosts: Cistus ladanifer (Sánchez et al. 2002), Fraxinus, Ostrya, Prunus, Populus, (Slippers et al. 2004a), Acacia rostellifera, Eucalyptus marginata (Taylor et al. 2009) Vitis vinifera, Olea europaea (Phillips et al. 2005, Lazzizera et al. 2008b), Quercus suber, Q. ilex (Sánchez et al. 2003), Cistus ladanifer (Sánchez et al., 2002), Juniperus communis, Acer sp., Actinidia deliciosa, C. limon, Fagus sp., Juglans regia, Mangifera indica, Olea europaea, Picea sp., Populus nigra, Prunus persica, Quercus sp., Rubus sp., Salix sp., V. vinifera (Abdollahzadeh et al. 2013).

Known distribution: Probably worldwide and cosmopolitan.

Notes: The description of S. dothidea (Fries 1823) refers to a fungus on twigs of Fraxinus sp. According to Slippers et al. (2004a) the specimen of S. dothidea in the Fries collection that has been cited as the holotype (von Arx & Müller 1954) is on what appears to be a Rosa sp. and thus cannot be the holotype. Phillips & Lucas (1997) and Slippers et al. (2004a) examined the only other specimen of S. dothidea in the Fries herbarium and found it to be immature with no spores. Slippers et al. (2004a) designated that specimen as the neotype and also designated an epitype (PREM 57372) on Prunus sp. collected from Crocifisso, Switzerland, with an ex-epitype culture (CBS 115476 = CMW 8000).
Pennycook & Samuels (1985) described two new species of *Botryosphaeria* (*B. parva* and *F. luteum*) on kiwifruit, and suggested that *B. dothidea* may be a complex of species. This suggestion led to doubts about the earlier identifications of *B. dothidea*. However, the name *B. dothidea* continued to be used in a broad sense. Only after gene sequence data were used to clarify species concepts in the genus (e.g. Phillips et al. 2002, Slippers et al. 2004a) it became apparent that some of the earlier reports of *B. dothidea* in association with plant diseases may have been misidentifications. Thus, the earlier reports of *B. dothidea* prior to 2004 should be interpreted with circumspection.

*B. fabicerciana* (S.F. Chen, D. Pavlic, M.J. Wingf. & X.D. Zhou) A.J.L. Phillips & A. Alves, *comb. nov.* MycoBank MB805457. See Chen et al. (2011) for illustrations. *Basionym: Fusicoccum fabicercianum* S.F. Chen, D. Pavlic, M.J. Wingf. & X.D. Zhou, *Plant Pathol.* 60: 746. 2011.

**Ascomata** not reported. **Conidiomata** developing in culture on pine needles after 10 d and producing conidia after 14 d, superficial, solitary to aggregated, dark brown, globose, covered by hypheae, (245–)346–470(–525) μm, wall composed of three layers: an outer of thick-walled dark to light brown *textura angularis*, a middle layer of thin-walled light brown cells, and an inner layer of thin-walled hyaline cells. **Conidiophores** absent. **Conidigenous cells** cylindrical to lageniform, hyaline, smooth, thin-walled, holoblastic producing a single conidium at the tip, rarely proliferating at the same level giving rise to pericilial thickenings, (6.5–)10.5–13.5(–16) × (2–)2.5–3.5(–4.5) μm (av. of 50 conidiogenous cells = 12 × 3 μm). **Paraphyses** not seen. **Conidia** hyaline, thin-walled, smooth with granular contents, unicellular, aseptate, fusiform, widest in the middle to upper third, apex acute, base truncate with a minute marginal frill, forming one or two septa before germination, (16.5–)19.5–24.5(–26) × (4.5–)5–6.5(–7.5) μm (av. of 100 conidia = 22.0 × 5.8 μm), L/W = 3.8.

**Culture characteristics:** Colonies with fluffy mycelium, initially white turning smoke-grey from the middle of colonies within 4–6 d, with an appressed mycelial mat, sparse to moderately dense. Cotony aerial mycelium toward the edge of colony, becoming pale olivaceous-grey, and greenish black (reverse) within 12–16 d. Optimal temperature for growth 25(–30) °C, colony covering the 90 mm diam Petri dish after 5 d in the dark at 25 °C.

**Type:** *China*, FuJian Province, from senescing twigs of an unknown *Eucalyptus* sp., Aug. 2007, M.J. Wingfield, *holotype* PREM 60449.

**Cultures:** CBS 127193 = CMW 27094 (ex-type).

**Hosts:** *Eucalyptus* sp., *E. urophylla* × *E. tereticornis*, *Eucalyptus grandis* hybrid (Chen et al. 2011).

**Known distribution:** China (FuJian, HaiNan and GuangXi Provinces) (Chen et al. 2011).

**Notes:** *Botryosphaeria fabicerciana* is morphologically similar to *B. dothidea* (size of conidia = 24.5 × 5 μm in culture, 19.5 × 5 μm on a natural *Prunus* sp. (Slippers et al. 2004a), but differs from other species in the genus. Conidia of *B. fabicerciana* are larger than those of *B. ramosa* (av. size of conidia = 13.4 × 5.7 μm in culture; Pavlic et al. 2008) and *B. scharifii* (av. size of conidia = 15.4 × 5.2 μm; Abdollahzadeh et al. 2013), but smaller than those of *Botryosphaeria corticis* (av. size of conidia = 28.9 × 6.4 μm; Phillips et al. 2006).

**Botryosphaeria fusispora** Boonmee, J.K. Liu & K.D. Hyde, *Fungal Divers.* 57: 171. 2012. MycoBank MB801319. See Liu et al. (2012) for illustrations.

**Ascomata** dark brown to black, immersed in the host, becoming erumpent, clustered, gragarious or scattered, subglobose with indistinct ostiole, 137–210 μm high × 160–230 μm diam, wall composed of 3–4 layers of dark brown cells of *textura angularis*. **Pseudoparaphyses** 2.5–5 μm wide, aseptate. **Asci** 8-spored, bitunicate, broadly cylindrical, short pedicellate with a well-developed apical chamber, 77.5–112.5 × 20–25 μm. **Ascospores** biseriate, partially overlapping, hyaline, aseptate, ellipsoid to fusiform, smooth-walled, thin-walled, 20–27.5 × 10–12.5 μm. **Conidiomata** stromatic, solitary, semi-immersed, dark brown to black, 140–180 × 160–210 μm, walls composed of thick-walled dark brown cells of *textura angularis*, becoming thinner-walled and hyaline towards the inner region. **Conidiophores** hyaline, septe, cylindrical, smooth, 2–4.5 μm wide. **Conidigenous cells** holoblastic, hyaline, cylindrical, integrated, producing a single apical conidium. **Conidia** hyaline, thin-walled, aseptate, fusiform to ellipsoid, sometimes irregular ellipsoid, smooth, apex obtuse, base truncate or bluntly rounded, 16–22 × 4–5.5 μm.

**Culture characteristics:** Colonies on MEA growing rapidly, reaching 9 cm diam within 7 d at room temperature, aerial mycelium at first white becoming dark grey to black.

**Type:** *Thailand*, Chiang Rai, Doi Tung, on dried bark of *Entada* sp., 10 Jun. 2008, S. Boonmee, *holotype* MFLU 10-0028.

**Culture:** MFLUCC 10-0098 (ex-type).

**Hosts:** Caryota sp., *Entada* sp. (Liu et al. 2012).

**Known distribution:** Thailand (Liu et al. 2012).

**Notes:** The shorter conidia separate this species from *B. corticis*. *B. dothidea* and *B. fabicerciana*. Conidia of *B. fusispora* are larger than those of *B. ramosa* and *B. scharifii*.

**Botryosphaeria ramosa** (Pavlic, T.I. Burgess, M.J. Wingf.) A.J.L. Phillips & A. Alves, *comb. nov.* MycoBank MB805458. Fig. 13. *Basionym:* Fusicoccum ramosum Pavlic, T.I. Burgess & M.J. Wingf., *Mycologia* 100: 861. 2008.

**Ascomata** not reported. **Conidiomata** semi-immersed, solitary, globose, papillate, chestnut, covered by hyphal hairs, up to 510 μm diam, sometimes with a neck to 1.7 mm long, arising from the substrate. **Conidiophores** reduced to conidigenous cells. **Conidigenous cells** smooth, cylindrical to subcylindrical, hyaline, the first conidium produced holoblastically and subsequent conidia enteroblastically, (6–)7.5–10(–11) × (2–)2–3(–3.5) μm. **Conidia** fusiform to ellipsoid to oval, rounded at apex, base truncate,
smooth with fine granular contents, hyaline, thin-walled, aseptate, (11–)12–15(–16) × (4.7–)5–6(–7) μm, L/W ratio = 2.3.

Culture characteristics: Colonies initially white turning grey-olivaceous from the middle of colonies within 5–7 d, with appressed mycelial mat and white moderately dense, cottony aerial mycelium toward the edge of colony, becoming smoke grey to olivaceous-grey (surface) and iron grey (beneath) within 10–14 d. Optimum growth at 25 °C, covering the 9 cm diam Petri dish after 4 d in the dark.

Type: Australia, Western Australia, Bell Gorge, on Eucalyptus camaldulensis, Jul. 2006, T.I. Burgess, holotype PREM 59846.

Cultures: CBS 122069 = CMW 26167 (ex-type).

Host: Asymptomatic branches of Eucalyptus camaldulensis (Pavlic et al. 2008).

Known distribution: Western Australia (Pavlic et al. 2008).

Notes: No sexual morph has been reported, but phylogenetically this is clearly a species of Botryosphaeria. Only one culture of B. ramosa is known. Although Pavlic et al. (2008) reported long, branched conidiophores, we could not find such structures in the holotype. No Dichomera synasexual morph was reported by Pavlic et al. (2008). The conidia of B. ramosa are significantly shorter than those of any other species in this genus, although they are of a similar length to B. scharifii.

Botryosphaeria scharifii Abdollahz., Zare, A.J.L. Phillips, Mycologia 105: 213. 2013. MycoBank MB564800. Fig. 14.

Ascomata not reported. Conidiomata stromatic, pycnidial, produced on pine needles on WA within 2–4 wk, solitary or aggregated, dark brown to black, globose, up to 760 μm diam, superficial, mostly

Fig. 13. Botryosphaeria ramosa. A–C. Conidia developing on conidiogenous cells. Scale bars = 10 μm.

Fig. 14. Botryosphaeria scharifii. A. Conidiomata on pine needles in culture. B. Conidia developing on conidiogenous cells. C. Conidiogenous cells with periclinal thickenings. D, E. Conidiogenous cells and conidiophores. F. Conidia. Scale bars: A = 1 mm, B–E = 5 μm, F = 10 μm.
uniloculate, thick-walled, non-papillate with a central ostiole. Conidiophores cylindrical, hyaline, smooth, thin-walled, septate, branched at apex, 7.5–33.5 × 2–4.5 μm, lining the entire inner surface of the conidiomata. Conidiogenous cells cylindrical to lageniform, hyaline, thin-walled, smooth, 7–15 × 1.5–3.5 μm, holoblastic, phialidic with periclinal thickening. Conidia fusiform, unicellular, hyaline, thin-walled, smooth, apex obtuse, base subtruncate to bluntly rounded, (11.5–)13–17(–19) × 4–6.5 μm, 95% confidence limits = 15.2–15.6 × 5.2–5.4 μm (av. ± S.D. = 15.4 ± 1.4 × 5.2 ± 0.5 μm), L/W ratio = 2.7.

Culture characteristics: Colonies with abundant aerial mycelium reaching to the lid of Petri dishes, aerial mycelium becoming smoke-grey to olivaceous-grey at the surface and greenish olivaceous to dull green at the reverse after 2 wk in the dark at 25 °C. Colonies reaching 84 mm on MEA after 3 d in the dark at 25 °C. Cardinal temperatures for growth: min ≤ 5 °C, max ≥ 35 °C, opt 25 °C.

Type: Iran, Tehran, on fruits of Mangifera indica imported from Pakistan, Aug. 2006, J. Abdollahzadeh, holotype IRAN 14275F.

Cultures: CBS 124703 = IRAN 1528C (ex-type).

Host: On twigs and fruits of Mangifera indica (Abdollahzadeh et al. 2013).

Known distribution: Iran (Hormozgan and Kurdistan Provinces and Tehran) (Abdollahzadeh et al. 2013).

Notes: Botryosphaeria scharifii is phylogenetically closely related to B. ramosa. Conidia of B. scharifii and B. ramosa are considerably shorter than all other species in the Botryosphaeria clade. However, the slightly longer conidia of B. scharifii distinguish it from B. ramosa. This species was found on twigs of mango trees in Hormozgan Province (Minab) and from mango fruits, imported from Pakistan, in Kurdistan Province (Sanandaj) and Tehran.

Cophinforma Doilom, J.K. Liu & K.D. Hyde, Fungal Divers. 57: 174, 2012. MycoBank MB801315. Type species: Cophinforma atrovirens (Mehl & Slippers) A. Alves & A.J.L. Phillips, comb. nov.

Ascomata initially immersed under host epidermis, becoming semi-immersed to erumpent, gregarious and fused, uniloculate, globose to subglobose ostiolate. Ostiole central, papillate, periphysate. Asci 8-spored, bitunicate, fissitunicate, clavate to cylindro-clavate, pedicellate, apex rounded with well-developed ocular chamber. Ascospore overlapping uniseriate to biseriate, hyaline, aseptate, smooth-walled, ellipsoidal to obovoid, slightly wider above the centre. Conidiomata indistinguishable from ascomata. Paraphyses absent. Conidiogenous cells enteroblastic, integrated, hyaline, smooth, cylindrical, first-formed conidium holoblastic, proliferating at the same level resulting in typical phialides (sensu Sutton 1980) with periclinal thickenings. Conidia hyaline, thin-walled, smooth, aseptate, fusiform. Spermaphores reduced to conidiogenous cells, occurring intermingled among conidiogenous cells in same conidioma, subcylindrical, hyaline, smooth. Spermata hyaline, smooth, granular, subcylindrical.

DNA phylogeny

The first 87 bases of the ITS sequences of the two C. atrovires species appear to have many sequencing errors and were excluded from the analyses. In the ITS + EF1-α phylogeny (Fig. 8) the two isolates of C. atrovires clustered with C. eucalypti and since the sequences were identical we consider this to represent a single species. The oldest epithet is atrovires, thus C. eucalypti becomes a synonym. Unfortunately, no EF-α sequences are available for C. mamane and no cultures are extant, and thus we could not include C. mamane in the combined ITS + EF-α phylogeny. Nevertheless, in the ITS phylogeny (Fig. 15), 3 bp differences separate C. mamane from C. atrovires and for this reason we consider these to represent two distinct species.
**Key to Cophinforma spp.**

The two species are morphologically very similar, with significant overlap in conidial dimensions, suggesting that they can only clearly be distinguished based on DNA data.

1. Conidia 30–40 × 8–9 μm .................................................................................................................. C. mamane
   1. Conidia 31–36 × 7–10 μm ............................................................................................................. C. atrovirens

**Species descriptions**

*Cophinforma atrovirens* (Mehl & Slippers) A. Alves & A.J.L. Phillips, *comb. nov*. MycoBank MB805459. Fig. 16.

*Basionym*: *Fusicoccum atrovirens* Mehl & Slippers, *Mycologia* 103: 543. 2011.

- *Cophinforma eucalypti* Doilom, J.K. Liu & K.D. Hyde, *Fungal Divers.* 57: 174. 2012.

Ascomata not reported. Conidiomata on pine needles and host material pycnial, superficial, multilocular, dark brown to black, eumycetous, complex, effuse, globose, covered with hyphae; wall composed of three layers, an outer of thick-walled dark to light brown texture angularis, a middle layer of thin-walled light brown cells, and an inner layer of thin-walled hyaline cells, (180–)215–275(–285) μm diam. *Conidiomata* indistinguishable from ascomata. *Conidiophores* absent. *Conidiogenous* cells hyaline, holoblastic, smooth, discrete, cylindrical, proliferating percurrently to form one or two distinct annellations, or proliferating at the same level giving rise to pericinal thickenings (10.5–)13.5–19(–22) × (2–)3.5–4.5(–5.5) μm (av. of 50 conidiogenous cells = 16.3 × 3.8 μm). *Paraphyses* absent. Conidia hyaline, thin-walled, unicellular, aseptate, rarely becoming septate on germination, granular, ellipsoid to obovoid, (27–)31–36(–40) × (6–)7–10(–12) μm (av. of 50 conidia = 33.5 × 8.5 μm). *Spermatophores* reduced to *Spermatogenous* cells, occurring intermingled among conidiogenous cells in same conidioma, subcylindrical, hyaline, smooth, 5–20 × 3–5 μm. *Spermatia* hyaline, smooth, granular, subcylindrical, straight or slightly curved, apex obtuse, base truncate, 5–8 × 3–4 μm.

Culture characteristics: Colonies fluffy, initially white to olivaceous in the center, edges becoming olivaceous to greenish black with age. Submerged mycelia (reverse) initially white to dark amber in the center, edges becoming olivaceous to greenish black with age. Optimum temperature for growth 30 °C. On the edges to olivaceous in the center, becoming olivaceous to greenish black with age. Submerged mycelia (reverse) initially white to dark amber in the center, edges becoming olivaceous to greenish black with age. Optimum temperature for growth 30 °C.

**Type**: South Africa, Mpumalanga Province, Mawewe Nature Reserve, from an asymptomatic branch of *Pterocarpus angolensis*, Dec. 2005, J.W.M. Mehl & J. Roux, holotype PREM 60341; paratype PREM 60342.

**Cultures**: CBS 124934 = CMW 22674 (ex-holotype), CBS 124935 = CMW 22682 (ex-paratype).

**Hosts**: Asymptomatic branches and twigs of *Pterocarpus angolensis* (Mehl et al. 2011), on dead branch of *Eucalyptus* sp. (Liu et al. 2012) as *C. eucalypti*.

**Known distribution**: South Africa (Mehl et al. 2011), Thailand (Liu et al. 2012).

**Notes**: Morphologically this species is closely related to *C. mamane* but the highly divergent ITS phylogeny and several morphological characters separate the two species. Conidia can be 1- or 2-septate in *C. mamane* (Mohali et al. 2007) but remain aseptate until germination in *C. atrovirens*.

*Cophinforma mamane* (D.E. Gardner) A.J.L. Phillips & A. Alves, *comb. nov*. MycoBank MB805460. See Gardner (1997) for illustrations.

*Basionym*: *Botryosphaeria mamane* D.E. Gardner, *Mycologia* 89: 299. 1997.

**Stromata** erumpent through host tissue, black, 0.5–1.25 mm diam, multiloculate, locules spherical to ovoid, ostiolate, 100–200 μm diam. *Ascomata*, *conidiomata* and *Spermatogonia* distinct but often formed in the same stroma. *Ascomata* with a short neck, opening through a nonperiphysate ostiolar canal. *Asci* bitunicate, clavate, 8-spored, 100–180 × 25–35 μm, associated with filamentous *pseudoparaphyses*. *Ascospores* aseptate, hyaline, with granular or reticulately textured contents, oval to broadly fusiform, 25–39 × 15–20 μm. *Conidiogenous* cells simple, uniformly lining the locule wall. *Conidia* at first produced holoblastically, later enteroblastically, hyaline, 1-celled, fusiform, with truncate base when newly formed, (19–)30–44(–55) × (7–)8–9(–10) μm. *Spermatia* hyaline, rod-like to allantoid, 3–9 × 2–4 μm.

**Type**: USA, Hawaii, Hawaii Island, Hawaii Volcanoes National Park, Kipuka Ki, on bark of a swollen branch of *Sophora chrysophylla*, 1 May 1996, D.E. Gardner, holotype BISH 644614; isotype BISH 737731; paratypes BPI 737732, BPI 737733.

**Cultures**: No ex-type cultures are known to be extant. *CBS* 117444 and *CBS* 117450 are reportedly *B. mamane* but they were isolated from *Eucalyptus* and *Acacia* in Venezuela and their ITS sequences differ by 3 bp from the ex-type isolate of *B. mamane* collected by Gardner in 1996 and thus represent a different species.

**Hosts**: *Sophora chrysophylla* (Gardner 1997).

**Diseases**: Witch's brooms (Gardner 1997).

**Known distribution**: USA (Hawaii) (Gardner 1997).

**Notes**: Originally reported from Hawaii, this species is thought to be restricted to *Sophora chrysophylla*. Mohali et al. (2007) reported what they considered to be *B. mamane* on *Acacia mangium* (*CBS* 117445/ *CBS* 117450) and *Eucalyptus urophylla* (*CBS* 117444/ *CBS* 117917) in Venezuela. They based this conclusion on an ITS phylogeny and similarity in conidial characters and dimensions of their isolates with those of the ex-type strains of *B. mamane*. Unfortunately, the ex-type isolates of *B. mamane* no longer exist. Apparently D.E. Gardner sent sub-cultures to G. Stanosz at the
University of Wisconsin and these were given the codes 97-58 and 97-59. Zhou & Stanosz (2001) sequenced ITS of these two strains and the sequences are available in GenBank as AF246929 and AF246930. Unfortunately no other sequences were generated and these two isolates have since been lost.

In the ITS phylogeny generated by Mohali et al. (2007) isolates from E. urophylla and A. mangium clustered with the two ex-type isolates of B. mamane. However, three base pairs in ITS separate the ex-type isolates of C. mamane from the Venezuelan isolates. Furthermore, ITS sequences of the Venezuelan isolates of C. mamane are exactly the same as the ITS sequence of C. atrovirens. Therefore we consider the Venezuelan isolates to represent C. atrovirens.

_Diplodia_ Fr., _In_ Mont., Ann. Sci. Nat. Bot., sér. 2, 1: 302. 1834. MycoBank MB80477.
_Type species:_ Diplodia mutila Fr., _In_ Mont., Ann. Sci. Nat. Bot., sér. 2, 1: 302. 1834.

Ascomata unilocular, solitary or clustered, immersed, partially erumpent when mature, dark brown to black, thick-walled, wall composed of outer layers of thick-walled, dark brown textura angularis, inner layers of thin-walled, hyaline textura angularis. **Ostiole** central, circular, papillate. **Pseudoparaphyses** hyaline, branched, septate. **Asci** clavate, stipitate, bitunicate, containing eight, biseriate ascospores. **Ascospores** fusiform, hyaline, thin-walled, smooth, aseptate, rarely becoming light brown and 1–2-septate with age. **Mycelium** immersed or superficial, branched, septate, melanised, dark brown. **Conidiomata** pycnidial, ostiolate, formed in uni- or multiloculate stromata, immersed, becoming erumpent at maturity. **Ostiole** central, circular, papillate. **Paraphyses** lacking. **Conidiophores** (when present) hyaline, simple, occasionally septate, rarely branched, cylindrical, arising from the cells lining the pycnidial cavity. **Conidiogenous cells** holoblastic, hyaline, cylindrical, determinate or proliferating at the same level giving rise to periclinal thickenings, or proliferating percurrently and forming two or three annellations. **Conidia** initially hyaline, aseptate, thick-walled, becoming 1–2-septate and pale.
translucent brown after discharge from the pycnidia, but the
colouration is often delayed or never occurs, in some species the
conidia become pigmented while still enclosed in the conidioma
and in these species the conidia rarely become septate.

Notes: Two distinct conidial morphologies are seen in Diplodia
species. In one type the conidia are initially hyaline and aseptate
and later become pale to dark brown and 1-septate. Pigmentation
is often delayed and in some species dark conidia are never seen.
In the other type, the conidia become pigmented at an early stage
of development, even while they are still enclosed within the
pycnidia. These conidia only rarely become septate. These two
morphological groups are supported by two distinct phylogenetic
lineages.

Key to Diplodia spp.

1. Conidia hyaline and aseptate, becoming brown and 1-septate only with age ................................................................. 2
1. Conidia dark brown and aseptate before discharge from pycnidia ........................................................................................................... 11

2. Av. conidial length greater than 29 μm ........................................................................................................................... 3
2. Av. conidial length less than 29 μm ........................................................................................................................... 5

3. Conidia 18–22 μm wide ........................................................................................................................................... D. tsugae
3. Conidia not more than 16 μm wide ........................................................................................................................................ 4

4. On Quercus, av. conidial length 29.9 × 13.5 μm .................................................................................................................. D. corticola
4. On hosts other than Quercus, colonies rosulate ................................................................................................................. D. rosulata

5. Conidia pale brown .................................................................................................................................................. D. buigaria
5. Conidia hyaline, becoming pigmented and 1-septate with age ................................................................................................. 6

6. On Cupressus or Juniperus spp. ........................................................................................................................................ D. cupressi
6. On other hosts .................................................................................................................................................. D. africana

7. Av. conidial length 28 μm or longer ........................................................................................................................................ 8
7. Av. conidial length less than 28 μm ........................................................................................................................................ 9

8. Conidia up to 17 or more μm wide ........................................................................................................................................ D. malorum
8. Conidia never reach 17 μm wide ......................................................................................................................................... 10

9. On Quercus .................................................................................................................................................. D. africana
9. On other hosts .................................................................................................................................................. D. africana

10. Av. conidial length greater than 27 μm (27.7 μm) .................................................................................................................. D. agrifolia
10. Av. conidial length less than 27 μm ......................................................................................................................................... 11

11. Av. conidial size 24.5 × 12.5 μm, on Olea ............................................................................................................................... D. olivarum
11. Av. conidial size 25.5 × 13.5 μm, on other hosts ...................................................................................................................... D. mutila

12. Av. conidial length greater than 35 μm ......................................................................................................................................... 13
12. Av. conidial length less than 35 μm ......................................................................................................................................... 14

13. Conidial length exceeding 50 μm (up to 54 μm) ...................................................................................................................... D. sapineae
13. Conidial length never exceeding 50 μm (up to 41.5 μm) ........................................................................................................ D. scrobiculata

14. Av. conidial length greater than 28 μm ......................................................................................................................................... 15
14. Av. conidial length less than 28 μm ......................................................................................................................................... 15

15. Av. conidial length greater than or equal to 25 μm .................................................................................................................. 16
15. Av. conidial length less than 25 μm ........................................................................................................................................ 16

16. Conidial length never exceeding 30 μm ......................................................................................................................................... D. seriate
16. Conidial length exceeding 30 μm ......................................................................................................................................... D. alafafructa/D. pseudoseriata

*These two species cannot be distinguished based on their morphology.
DNA phylogeny

Phylogenetic analysis based on combined ITS and EF1-α sequences revealed three major clades, A, B and C (Fig. 17). Most of the species in clade A have hyaline conidia that become pigmented and 1-septate only some time after discharge from the pycnidia. The exception is *D. bulgarica*, which has pale brown conidia, but these become more darkly pigmented and 1-septate with time. Eleven species can be distinguished in this clade and all are supported by moderate to high bootstrap values. In clade B the species all have conidia that become pigmented soon after they have formed, sometimes while still attached to the conidiogenous cell and usually before discharge from the pycnidia. Only rarely do they become septate. Bootstrap support for some of the species,
such as *D. pinea* and *D. intermedia*, is quite low. *Diplodia alatafructa* and *D. pseudoseriata* could not be separated clearly because none of the polymorphisms between isolates in this clade are fixed or consistent within a species. Clade C contains only two species, *D. corticola* and *D. quercivora*, and the conidia of these species have a morphology similar to that found in clade A, but they tend to be larger.

**Species descriptions**

*Diplodia africana* Damm & Crous, Mycologia 99: 671. 2008. MycoBank MB501323. See Damm *et al.* (2007) for illustrations.

Ascomata not reported. *Conidiomata* pycnidial, stromatic, produced on pine needles on SNA in 2–4 wk, solitary, globose to ovoid, dark brown, up to 500 μm wide, semi-erumpent to erumpent, unilocular, sometimes multilocular in vitro, with a short neck and a central ostiole, wall 6–8 cell layers thick, outer layers composed of dark-brown texture angularis, becoming thin-walled and hyaline toward the inner region. *Conidiophores* 1–2 celled, hyaline, 10–25 × 3.5–6 μm. *Conidiogenous cells* holoblastic, hyaline, cylindrical, sometimes ampulliform, proliferating percurrently near the apex, sometimes with periclinal thickening, 3–15 × 3–6 μm. *Conidia* aseptate, hyaline, thick-walled, smooth, subcylindrical to oblong-elliptical, sometimes slightly curved, with rounded ends, hyaline after discharge from pycnidia, a few of them becoming brown, septate and finely verruculose with age, (17–)25.5–33(–34) × (10–)12–14(–15) μm (av. ± SD = 29.2 ± 3.6 × 13 ± 1.1 μm), L/W ratio = 2.2.

**Culture characteristics:** Colonies on PDA in the dark: mycelium and surface olivaceous-grey to dark grey-olivaceous; reverse olivaceous-black, umbonate with irregular zonation and lobate edges. Colonies under near ultraviolet: mycelium and surface pale olivaceous-grey, reverse olivaceous-black, umbonate with irregular zonation and lobate edges. Colonies under near ultraviolet: mycelium and surface pale olivaceous-grey, reverse olivaceous-black, umbonate with irregular zonation and lobate edges. Colonies reaching 26.8 mm diam after 2 d, reaching the edge the Petri dish within 5 d. Cardinal temperatures for growth: min 5 °C, max 35 °C, opt 20 °C.

**Type:** South Africa. Western Cape Province, Paarl, from wood section close to pruning wound of *Prunus persica*, 10 Jun. 2004, U. Damm, holotype CBS H-19843.

**Cultures:** CBS 120835 = STE-U 5908 (ex-type), STE-U 6289.

**Host:** Prunus persica (Damm *et al.* 2007).

**Known distribution:** South Africa (Western Cape Province) (Damm *et al.* 2007).

**Notes:** Conidia of *D. africana* are hyaline and thick-walled even after discharge from conidiomata and only a few conidia become brown and septate with age. It shares these features with *D. mutila*, *D. corticola*, *D. cupressi*, *D. rosulata*, *D. quercivora* and *D. tsugae*.

*Diplodia agrifolia* S.C. Lynch, A. Eskalen, Mycologia 105: 135. 2013. MycoBank MB800443. See Lynch *et al.* (2013) for illustrations.

Ascomata not reported. *Conidiomata* single or in groups, immersed to erumpent when mature, black and globose, 189 × 171–836 × 721 μm, wall composed of three layers; an outer layer of dark, thick-walled cells, middle layer with dark brown, thin-walled cells, and an inner layer of thin-walled hyaline cells. Ostiole central, circular, appallate to papillate. *Conidiophores* absent. *Conidiogenous cells* holoblastic, discrete, cylindrical, hyaline, smooth, indeterminate, proliferating at the same level giving rise to periclinal thickenings or proliferating percurrently to form one to two indistinct annellations, 18.0 ± 7.4 × 8.1 ± 2.4 μm. *Conidia* in equal proportions hyaline, aseptate and pale to dark brown and 1-septate before and after discharge, smooth, thick-walled, obovoid to ovoid, straight, both ends broadly rounded, (21.5–)27–36.5 × (12–)14.5–18 μm (av. ± S.D. = 27.7 ± 2.2 × 14.7 ± 1.2 μm), L/W = 1.9.

**Type:** USA. California, San Diego County, Mataguay Scout Camp, on cankered branch of *Quercus agrifolia*, 23 Feb. 2010, S.C. Lynch & A. Eskalen, holotype BPI 884095 (dried culture of *D. agrifolia*).

**Cultures:** CBS 132777 = ATCC MYA-4895 = UCROK 732 (ex-type).

**Hosts:** Quercus agrifolia and *Q. kelloggii* (Lynch *et al.* 2013).

**Known distribution:** USA, Coast range of north-central California southward to northern Baja California, with *Q. kelloggii* extending as far north as Eugene, Oregon (Lynch *et al.* 2013).

**Notes:** Phylogenetically, *D. agrifolia* is distinct from but closely related to *D. mutila*. *Diplodia agrifolia* differs from *D. mutila* in the conidia that are longer and wider than *D. mutila*. Conidia of *D. agrifolia* are hyaline and aseptate, but most become dark brown and 1-septate before discharge from pycnidia, whereas conidia of *D. mutila* are hyaline, aseptate, rarely becoming pale brown and 1-septate with age.

*Diplodia alatafructa* Mehl & Slippers, Mycologia 103: 542. 2011. MycoBank MB513498. See Mehl *et al.* (2011) for illustrations.

Ascomata not reported. *Conidiomata* on both pine needles and host material stromatic, superficial, unilocular, dark brown to black, mostly solitary, more or less globose/circular, covered with mycelium/hyphae, wall composed of three layers; an outer thick-walled dark brown texture angularis, a middle layer of light brown to reddish brown thin-walled cells, and an inner layer of hyaline thin-walled cells, (114–)130–155(–160) μm diam (av. of 50 conidioma = 141.4 μm). Ostiole central, circular. *Conidiophores* absent. *Conidiogenous cells* holoblastic, hyaline, discrete, spherical to cylindrical, proliferating percurrently to form two or three distinct annellations, or proliferating at same level giving rise to periclinal thickenings, (10–)12.5–18(–23) × (8–)11–14(–15.5) μm (av. of 40 conidiogenous cells = 15.4 × 12.5 μm). *Conidia* initially hyaline becoming pigmented and dark brown with age, unicellular, rarely septate or bisepctate, rarely striate, ellipsoid to obovoid, thick-walled, granular, rounded at apices, eguttulate, smooth, (22.5–)24.5–29(–33) × (9.5–)11–14(–16) μm (av. of 50 conidia = 26.9 × 12.4 μm).

**Culture characteristics:** Colonies with fluffy mycelium, initially white to amber in the centre turning dark amber within 7 d and becoming white to dark amber, almost olivaceous with age; submerged
mycelium (reverse) same except becoming white to dark amber, almost olivaceous, at the periphery, and olivaceous in the centre with age. Optimum temperature for growth 25 °C.

Type: South Africa, Mpumalanga Province, Sudwala Caves area, from a stem wound on *Pterocarpus angolensis*, Dec. 2005, J.W.M. Mehli & J. Roux, holotype PREM 60337.

Culture: CBS 124931 (ex-type).

Host: *Pterocarpus angolensis* (Mehli et al. 2011).

Known distribution: South Africa (Mehli et al. 2011).

Note: See notes to *D. pseudoseriata*.

*Diplodia allocellula* Jami, Gryzenh., Slippers & M.J. Wingf., Cryptogamie Mycol. 33: 257. 2012. MycoBank MB564140. See Jami et al. (2012) for illustrations.

Ascomata not reported. *Conidionata* immersed on MEA, solitary, globose, brown, up to 100 μm diam. *Conidigenous cells* holoblastic, smooth, unicellular, cylindrical to sub-cylindrical, hyaline (4–)4.5–5–5.5) × (10.5–)13.5–23.5(–27.5) μm. *Conidia* ovoid to ellipsoid, smooth with fine granular contents, apex rounded, base truncate, thick-walled, aseptate, initially hyaline, becoming dark brown, aseptate (20–)21.5–25–(30) × (9–)10–12.5–(14.5) μm.

Type: South Africa, Gauteng Province, Pretoria, from branch of *Acacia karroo* with dieback, Nov. 2009, M. Gryzenhout & F. Jami, holotype PREM 60701.

 Cultures: CBS 130408 (ex-type) CBS 130409, CBS 130410 (paratype).

Host: *Acacia karroo* (Jami et al. 2012).

Known distribution: South Africa (Gauteng Province) (Jami et al. 2012).

Notes: Phylogenetically *D. allocellula* falls within the group of species with conidia that become brown and aseptate at an early stage of their development. Morphologically it is most similar to *D. seriata* and *D. alatafructa/D. pseudoseriata* but can be distinguished from these species on account of its generally smaller conidia.

*Diplodia bulgarica* A.J.L. Phillips, J. Lopes & S.G. Bobev, Persoonia 29: 33. 2012. MycoBank MB19632. Fig 18.

Ascomata not reported. *Conidionata* pycnidial, stromatic, produced on pine needles on WA after 7–21 d, solitary, immersed, partially erumpent when mature, dark brown to black, globose to ovoid, up to 600 μm diam and 700 μm high, wall composed of an outer layer of dark brown, thick-walled *textura angularis*, a middle layer of dark brown thin-walled cells, an inner layer of thin-walled hyaline cells. Ostiole central, circular, papillate. *Conidiophores* absent. *Conidigenous cells* hyaline, cylindrical, holoblastic, forming a single conidiom in the tip, discrete, smooth, indeterminate, proliferating internally giving rise to periclinal thickenings, or proliferating percurrently to form 1–5 annellations, 9–18 × 2–5 μm. *Conidia* aseptate, smooth, thick-walled, oblong to ovoid, straight, both ends broadly rounded, (22.5–)24–27(–28) × (14.5–)15.5–18(–18.5) μm, 95 % confidence limits = 25.0–25.7 × 16.6–17.0 μm (av. ± S.D. of 50 conidia = 25.4 ± 1.2 × 16.8 ± 0.7 μm), L/W ratio = 1.5.

Type: Bulgaria, Plovdiv, on dead twigs of *Malus sylvestris*, 2005, S.G. Bobev, holotype CBS H-20189 (a dried culture of CBS 124254 grown on pine needles).

Culture: CBS 124254 (ex-type).

Hosts: *Malus* spp. (Phillips et al. 2012).

Known distribution: Bulgaria, Iran (Phillips et al. 2012).

Notes: This species is morphologically distinct from all other *Diplodia* species reported from apples. Conidia are shorter and wider than both *D. malorum* and *D. intermedia*. Furthermore, the conidia are distinctive in that they become pale brown soon after they are formed. Phylogenetically this species is closely related to *D. cupressi* and *D. tsugae*.

*Diplodia corticola* A.J.L. Phillips, A. Alves & J. Luque, Mycologia 96: 603. 2004. MycoBank MB488568. Figs 19, 20. = *Botryosphaeria corticola* A.J.L. Phillips, A. Alves & J. Luque, Mycologia 96: 603. 2004.

Pseudothecia stromatic, immersed, partially erumpent when mature, dark brown to black, more or less circular, up 1 mm diam, multiloculate, individual locules 200–300 μm diam, thick-walled, wall composed of outer layers of thick-walled, dark brown *textura angularis*, inner layers of thin-walled, hyaline *textura angularis*. Ostiole central, circular, papillate, periphysate. *Pseudoparaphyses* hyaline, branched, septate, 2–3 μm wide. *Asci* clavate, stipitate, bitunicate, containing eight, biseriate *Asci*. *Pseudothecia* eustromatic, immersed, partially erumpent when mature, dark brown to black, more or less circular, up to 1 mm diam, multiloculate, individual locules 200–300 μm diam, wall composed of three layers, an outer of dark brown, *textura angularis*, and an inner layer of thin-walled hyaline cells. Ostiole central, circular, papillate. *Conidiophores* reduced to conidiogenous cells. *Conidigenous cells* holoblastic, discrete, cylindrical, hyaline, smooth, indeterminate, proliferating at the same level giving rise to periclinal thickenings, or proliferating percurrently to form one or two indistinct annellations, 12–19(–24) × 4–6 μm. *Conidia* hyaline, aseptate, eguttulate or sometimes with a large central guttule, contents granular, smooth, thick-walled, oblong to cylindrical, straight, both ends broadly rounded, rarely becoming brown and septate when aged, (23.5–)26–34.5(–46) × (9–)12–16–(18.5) μm, 95 % confidence limits = 29.6–30.3 × 13.4–13.8 μm (av. ± S.D. of 250 conidia = 29.9 ± 2.5 × 13.6 ± 1.4 μm), L/W ratio = 2.2.
Culture characteristics: Colonies reaching 36–44 mm diam on PDA after 4 d in the dark at 25 °C. Cardinal temperatures for growth: min 5 °C, max < 35 °C, opt 20–25 °C.

Type: Portugal, Beira Littoral, Requeixo near Aveiro, on dead branches of Quercus suber, Feb. 2002, A. Alves, holotype LISE 94839.

Culture: CBS 112549 (ex-type).

Hosts: Quercus spp. (Alves et al. 2004).

Known distribution: Iberian Peninsula, Italy, N. America (Alves et al. 2004).

Notes: Conidia of this species are larger than in any other species of Diplodia. Phylogenetically D. corticola groups with D. quercivora (also an oak pathogen) in a distinct clade. It is responsible for dieback and cankers on Q. suber and Q. ilex and has been implicated as contributing to the general decline of cork oaks in the Iberian Peninsula and other regions of the Mediterranean.
Fig. 19. Diploida corticola. A. Ascomata partially erumpent through the host bark. B. Multilocular ascoma cut through horizontally revealing the brilliant white contents. C. Vertical section through an ascoma showing the thick wall and three locules opening through periphysate ostioles. D, E. Ascus tip as seen by interference contrast (D) and phase contrast (E) showing the well-developed apical chamber. F. Mature ascus containing ascospores, several immature asci and pseudoparaphyses. G. Pseudoparaphyses. H–J. Ascospores. K, L. Brown, 2-septate ascospores. Scale bars: A = 1 mm, B = 500 μm, C = 100 μm, D, E, G = 10 μm, F = 20 μm, H–L = 5 μm.
**Diplodia cupressi** A.J.L. Phillips & A. Alves, Fungal Divers. 23: 9. 2006. MycoBank MB510136. Fig. 21.

Ascomata not reported. **Conidiomata** up to 300 μm diam, solitary, separate, uniloculate, dark brown to black, globose, ostiolate, wall composed of thick-walled *textura angularis*, becoming thin-walled and hyaline toward the inner region. **Conidiophores** reduced to conidiogenous cells. Conidiogenous cells hyaline, smooth, holoblastic forming conidia at their tips, proliferating internally giving rise to periclinal thickenings or proliferating percurrently with 1–4 close or widely spaced annellations, formed from the inner wall of the pycnidium, 12.5–20 × 4–4.5 μm. Conidia thick-walled, wall up to 2 μm wide, ovoid with both ends rounded, aseptate, hyaline and remaining so for a long time, becoming brown and 1-septate after discharge from the pycnidium, (21.5–)23.5–28.5(–30.5) × (12–) 13.5–15(–16) μm, 95 % confidence limits = 24.4–25.4 × 13.9–14.5 μm, (av. ± S.D. of 50 conidia = 24.9 ± 1.9 × 14.2 ± 0.9 μm), L/W = 1.76. Spermatophores hyaline, smooth, cylindrical, up to 10 μm long, 2.5–3 μm wide. Spermatogenous cells discrete or integrated, hyaline, smooth, cylindrical, holoblastic or proliferating via determinate phialides with periclinal thickening, 10–14 × 2–2.5 μm. Spermatia hyaline, smooth, aseptate, rod-shaped with rounded ends, 4–5 × 1.5 μm.

**Type:** Israel, Bet Dagan, dried culture from cankered stems of *Cupressus sempervirens*, 1986, Z. Solel, holotype IMI 303475.

**Culture:** CBS 168.87 (ex-type).

**Hosts:** *Cupressus* and *Juniperus* spp. (Alves et al. 2006, Solel et al. 1987).

**Known distribution:** Cyprus, Greece, Israel, Italy, Morocco, South Africa, Tunisia, USA (De Wet et al. 2009, Alves et al. 2006, Solel et al. 1987).

**Notes:** Solel et al. (1987) considered this fungus to be a sub-population of *Diplodia pinea* and named it *Diplodia pinea* f. sp. *cupressi*. Swart et al. (1993) challenged this assumption and showed that *D. pinea* f. sp. *cupressi* differed morphologically from *D. pinea* in terms of conidial dimensions, shape, colouration and this was supported by isozyme profiles. The observations of Swart et al. (1993) were supported by ITS sequence data by Zhou & Stanosz (2001). Finally, Alves et al. (2006) introduced the name *D. cupressi* for the Cypress pathogen. This species is morphologically similar to *D. mutila* but the conidia of *D. cupressi* are wider than are typical for *D. mutila* (Alves et al. 2004).

**Diplodia intermedia** A.J.L. Phillips, J. Lopes & A. Alves, Persoonia 29: 33. 2012. MycoBank MB19633. Fig. 22.

Ascomata unilocular, solitary or clustered, immersed, partially erumpent when mature, globose, up to 400 μm diam, dark brown to
black, thick-walled, wall composed of outer layers of thick-walled, dark brown *textura angularis*, inner layers of thin-walled, hyaline *textura angularis*. Ostiole central, circular, nonpapillate, periphysate. *Pseudoparaphyses* hyaline, branched, septate, constricted at the septum, 2–3 μm wide. *Asci* clavate, stipitate, bitunicate, containing eight ascospores biseriate in the ascus, 85–160 × 22–28 μm. *Ascospores* fusiform, widest in the upper third, hyaline, thin-walled, smooth, asceptate, 32–37(–40) × 6–8 μm. *Conidiomata* pycnidial, stromatic, solitary or clustered, immersed in the host, partially erumpent at maturity, dark brown to black, ostiolate, nonpapillate, thick-walled, outer and inner layers composed of dark brown and thin-walled hyaline *textura angularis*, respectively. *Conidiogenous cells* hyaline, thin-walled, smooth, cylindrical, swollen at the base, discrete, producing a single conidium at the tip, indeterminate, proliferating internally giving rise to periclinal thickenings or proliferating percurrently forming 2–3 annellations. *Conidia* asceptate, ovoid, widest in the middle, with obtuse apex and truncate or rounded base, initially hyaline, becoming dark brown before release from the pycnidium, wall moderately thick, externally smooth, internally roughened, (24.5–)29–33.5(–37) × (10–)11–16(–17.5) μm, with 95 % confidence limits = 30.2–31.1 × 13–13.6 μm (av. ± S.D. of 150 conidia = 30.6 ± 1.9 × 13.3 ± 1.8 μm), L/W = 2.3. *Spermatia* hyaline, aseptate, smooth, oblong, ends rounded, 5.5–9.5 × 4–6.5 μm. *Spermatogenous cells* not seen.

**Type:** Portugal, Setúbal, Monte da Caparica, dead twigs of *Malus sylvestris*, Mar. 2006, A.J.L. Phillips, **holotype** CBS H-20190.

Culture: CBS 124462 (ex-type).

**Hosts:** *Cydonia, Malus* (Phillips et al. 2012).

**Known distribution:** Portugal (Phillips et al. 2012).

**Notes:** Phylogenetically this species is very closely related to *D. sapinea*. However, on account of its smaller conidia, apparent preference for *Rosaceae* hosts, and the distinct clade it forms in the ITS + EF1-α phylogenies, Phillips et al. (2012) considered it to represent a distinct and separate species.

### Diplodia malorum

Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 395. 1870. MycoBank MB 246351. Fig. 23.

*Ascomata* not reported. *Conidiomata* pycnidial, stromatic, immersed, erumpent, dark brown to black, aggregated, internally white, ostiolate, ostiole circular, central, short papilla. *Conidiophores* absent. *Conidiogenous cells* cylindrical, thin-walled, hyaline, holoblastic, indeterminate, proliferating at the same level to produce periclinal thickenings, or proliferating percurrently giving rise to 2–3 indistinct annellations. *Conidia* oblong with broadly rounded ends, smooth-walled, thick walled, hyaline, eguttulate, asceptate, becoming dark brown and 1-septate soon after release from the pycnidium, (24–)26–32(–36) × (12–)13–17.5(–18.5) μm, 95 % confidence limits = 28.0–28.3 × 14.3–14.5 μm (av. ± S.D. = 28.1 ± 2.4 × 14.4 ± 1.4 μm), L/W = 1.9.

**Fig. 21. Diplodia cupressi.** A. Conidiomata on host bark. B–E. Conidiogenous cells. F. Spermatogenous cells. G. Spermatia. H. Hyaline, aseptate conidia. I. Mature dark-walled, 1-septate conidia. Scale bars: A = 1 mm, B, H = 10 μm. Scale bar of B applies to C–G. Scale bar of H applies to I.
Type: Germany, Rhineland, on Malus sp., 1870, J. Fuckel, Fuckel, Fungi rhenani No. 1706, holotype in G, isotypes K and M. Portugal, Setúbal, Monte da Caparica, Malus sylvestris, Feb. 2006, A.J.L. Phillips, epitype CBS H-201888.

Culture: CBS 124130 (ex-epitype).

Hosts: Malus spp. (Phillips et al. 2012).

Known distribution: Germany, Portugal (Phillips et al. 2012).

Notes: Since the time that it was introduced by Fuckel (1870), the name D. malorum has been used infrequently, while the name D. mutila was applied to the apple pathogen. However, D. malorum is morphologically and phylogenetically distinct from D. mutila. The conidia are larger than those of D. mutila and they frequently become brown and 1-septate soon after discharge from the conidioma.

Diplodia mutila (Fr.) Mont., Ann. Sci. nat., sér. 2, 1: 302. 1834. MycoBank MB201741. Fig. 24.

Basionym: Sphaeria mutila Fr., Syst. Mycol. (Lundae) 2: 424. 1823. ≡ Physalospora mutila (Fr.) N.E. Stevens, Mycologia 28: 333. 1936. = Botryosphaeria stevensii Shoemaker, Canad. J. Bot. 42: 1299. 1964. Further synonyms are given by Stevens (1933).

Ascomata unilocular, solitary or clustered, immersed, partially erumpent when mature, globose, up to 300 μm diam, dark brown to black, thick-walled, wall composed of outer layers of thick-walled,
dark brown *textura angularis*, inner layers of thin-walled, hyaline *textura angularis*. Ostiole central, circular, papillate, periphysate. *Pseudoparaphyses* hyaline, branched, septate, 2–3 μm wide. *Asci* clavate, stipitate, bitunicate, containing eight, biseriate ascospore, 100–160 × 14–22 μm (including stipe). Ascospores fusiform, widest in the middle, both ends obtuse, hyaline, thin-walled, smooth, aseptate, rarely becoming light brown and 1–2-septate with age, 

\[(24.5−)28−35(−36) \times (9.5−)10−13(−13.5) \text{ μm}, 95 \% \text{ confidence limits} = 30.8–32.1 \times 11.2–11.7 \text{ μm (av. ± S.D. of 50 ascospores} = 31.5 ± 2.3 \times 11.4 ± 0.9 \text{ μm), } \text{L/W = 2.8. Conidiomata solitary or aggregated in clusters of up to five or more, immersed, partially erumpent when mature, dark brown to black, more or less globose, up to 600 μm diam, wall composed of three layers, an outer of dark brown, thick-walled *textura angularis*, a middle layer of dark brown thin-walled cells, an inner layer of thin-walled hyaline cells. Ostiole central, circular, papillate. Conidiophores absent. \]
Fig. 24. Diplodia mutila. A. Sectioned ascoma. B. Immature asci and pseudoparaphyses. C, D. Asci with ascospores. E, F. Ascospores. G. Conidiomata partially erumpent through host. H. Sectioned conidioma. I–L. Conidiogenous cells. M–P. Conidia. M. Hyaline, aseptate conidia of CBS 112553. N. Pale brown, 1-septate conidia of CBS 112553. O. Hyaline, aseptate conidia of BPI 599153. P. Hyaline, aseptate conidia of K(M) 99664. Scale bars: A = 100 μm, B = 10 μm, E, F = 10 μm, G = 500 μm, H = 100 μm, I, L = 10 μm, M = 10 μm. Scale bar in B applies to C, D. Scale bar in I applies to J, K. Scale bar in M applies to N–P.
Conidiogenous cells holoblastic, discrete, cylindrical, hyaline, smooth, indeterminate, proliferating at the same level giving rise to periclinal thickenings, or proliferating percurrently to form one or two indistinct annellations, 11−15 × 4–5 μm. Conidia hyaline, aseptate, smooth, thick-walled, oblong to ovoid, straight, both ends broadly rounded, rarely becoming pale brown and septate when aged, (23.5−)24.5−27(−27.5) × (12.5−)13−14(−14.5) μm, 95 % confidence limits = 25.1−25.7 × 13.2−13.5 μm (av. ± S.D. of 50 conidia = 25.4 ± 1.0 × 13.4 ± 0.5 μm), L/W ratio = 1.9.

Type: of Physalospora mutila (designated by Alves et al. 2004):
UK, England, Cornwall, Saltash, on bark of Malus sp., 22 Aug. 1935, N.E. Stevens, lectotype BPI 599153. Of Diplodia mutila: France, Ardenne, Sedan, on bark of Populus nigra, date unknown, Montagne sp., isotype K(M)99664.

Cultures: No ex-type, or authentic cultures of either state are known. CBS 112553 has been regarded, unofficially, as a standard isolate of D. mutila (Alves et al. 2004, Damm et al. 2008).

Hosts: While Farr et al. (2013) list 55 hosts for D. mutila it is now clear that many of the earlier reports of this fungus could be misidentifications (Alves et al. 2004, Alves et al. 2006, Lazzizera et al. 2008, Phillips et al. 2012). The following are confirmed hosts: Chamaecyparis lawsoniana, Fraxinus, Malus, Populus, Taxus baccata, Vitis vinifera.

Known distribution: England, France, Italy, Portugal, South Africa, USA (California).

Notes: The taxonomic history of D. mutila and the controversy surrounding the characters that define this fungus have been explained by Sutton (1980) and Alves et al. (2004). However, in the interests of presenting a comprehensive analysis, these explanations are repeated here.

Fries (1823) described Spheeria mutila and distributed two exsiccati under that name as Scler. Suec. 164 and 385, Alves et al. (2004) examined material of these two exsiccati in STR and found both to be devoid of spores. Stevens (1933) and Sutton (1980) also reported that these two exsiccati in BPI and K had no spores. Sutton (1980) reported that 164 was an ascospore of the Botryosphaeriaceae type and pointed out that Spheeria mutila should be adopted for the ascomycetous element it represents. Montagne sent Fries a fungus that was identified as S. mutila. The record was listed under S. mutila Fr. by Montagne (1834) with the note that this species would become the type of a new genus, Diplodia, later characterised by Fries (1849). Therefore, the name of the pycnidial fungus dates from Montagne (1834); it is typified by its material and the correct citation is Diplodia mutila Fr. in Montagne (1834).

Montagne distributed this fungus in his exsiccatus No. 498. According to Françoise Deluzarche of the Institut de Botanique, Strasbourg, France, no material of this could be found in STR (Alves et al. 2004). However, according to Alves et al. (2004), Montagne’s specimen of D. mutila in Kew, K(M)99664 (isotype), agrees in all aspects with Stevens’ (1933) account of Montagne’s exs. 498 but differs from the description given by Sutton (1980). While Sutton (1980) referred to the conidia as initially hyaline with a large central guttule, later becoming dark brown and medially one eusepate, Alves et al. (2004) reported that the vast majority of conidia in K(M)99664 are hyaline and aseptate, although pale brown and one- or two-septate conidia are seen rarely. The conidia usually have a large central guttule. Furthermore, the dimensions that Sutton (1980) reported (27−31 × 12−13.5 μm) are somewhat larger than Alves et al. (2004) found (23.5–27.5 × 12–14 μm). Stevens (1933) reported the conidia as (20–)25–27 × 10–12(−16) μm.

In the original description, Montagne (1834) described the conidia as “Asci [conidia] elliptico-oblongi, didymi, sporidiis binis referiti.” Stevens (1933) studied slides of Montagne’s exsiccatus in STR and described the conidia as hyaline and aseptate with a thick smooth, glassy wall, although pale brown, 1-septate conidia sometimes were present. Both Shoemaker (1964) and Laundon (1973) agreed with Stevens’ concept. Sutton (1980), however, described the conidia as hyaline at first but becoming dark brown and 1-septate when mature. In his illustration of this species he depicts a predominance of dark conidia. Alves et al. (2004) re-examined the type in K and concluded that the conidia are predominantly hyaline, although some are dark and 1-septate. The consensus was that conidia of D. mutila are (20−)25–27.5 × 10–12 μm (Stevens 1933, Shoemaker 1964, Laundon 1973, Sivanesan 1984), but Sutton (1980) considered they can be up to 31 μm long.

Stevens (1936) reported on the sexual morph of D. mutila that he found on apple and ash in England. The connection between this fungus and D. mutila was established through single ascospore isolations and Stevens applied the name Physalospora mutila (Fr.) N.E. Stevens. Shoemaker (1964) considered this to be a species of Botryosphaeria and applied the new name B. stevensii Shoemaker because the name Botryosphaeria mutila was already taken. Stevens (1936) referred to a specimen on cut sticks of Fraxinus excelsior as the type.

When Alves et al. (2004) examined the type specimen of P. mutila in BPI 599151 they could find no ascocyme. There was, however, ample material of the sexual morph on BPI 599153, which is a specimen of P. mutila on apple collected by Stevens from the same locality and at the same time that he collected BPI 599151. Since this specimen conformed in all ways with the protologue, Alves et al. (2004) designated this specimen as lectotype. Unfortunately, no ex-type cultures exist. The type host of P. mutila is Fraxinus excelsior whereas the type host of Diplodia mutila is a Populus sp.

Diplodia olivarum A.J.L. Phillips, Frisullo & Lazzizera, Fungal Divers. 31: 67. 2008. MycoBank MB511402. Fig. 25.

Ascomata not reported. Conidiomata pycnidial,stromatic, produced on pine needles on WA after 7−14 d, solitary, globose to ovoid, dark brown to black, up to 150 μm wide, wall composed of dark brown, thick-walled textura angularis, becoming thin-walled and hyaline towards the inner region, semi-immersed to erumpent, unilocular, with a short neck. Ostiole circular, central. Conidiophores hyaline, cylindrical, 10−15 × 3.5−5 μm. Conidiogenous cells hyaline, cylindrical, holoblastic forming a single conidium at the tip, proliferating internally to form periclinal thickenings or proliferating percurrently giving rise to 2−3 annellations, 8−12 × 3−6 μm. Conidia hyaline, aseptate, smooth, thick-walled, oblong to oval, widest in the middle, apex broadly rounded, base rounded or truncate, rarely becoming pale brown, internally verruculose, 1-septate after discharge from the pycnidia, (21.5−)22−27.5(−28.5) × (10−)11−13.5(−14.5) μm, 95 % confidence limits = 23.9–24.8 × 12.2–12.7 μm, av. ± S.D. = 24.4 ± 1.6 × 12.4 ± 1 μm), L/W = 2.0.

Type: Italy, Puglia, Lecce, Scorrano, Basco Belvedere, on rotting drupes of Olea europaea, Dec. 2004, S. Frisullo, holotype CBS H-19914.
Culture: CBS 121887 (ex-type).

Host: *Olea europaea* (Lazzizera et al. 2008).

Known distribution: Italy (Lazzizera et al. 2008), Spain (Gramaje et al. 2012).

Notes: This species is similar to *D. mutila* but the two can be distinguished based on minor differences in the dimensions of their conidia. Although the ranges of dimensions overlap considerably, mean dimensions of conidia of *D. olivarum* are smaller than *D. mutila*.

*Diplodia pseudoseriata* C.A. Pérez, Blanchette, Slippers & M.J. Wingf., Fungal Divers. 41: 63. 2010. MycoBank MB513545. Fig. 26.

Ascomata not reported. Conidiomata (formed in culture on sterilised pine needles) semi-immersed or superficial, solitary, globose, black, covered by mycelium, up to 430 μm diam. Conidiogenous cells cylindrical, discrete, producing a single conidium at the tip, with no evident annellations. Conidia initially hyaline becoming dark brown, wall externally smooth, roughened on the inner surface, sometimes 1-septate, ovoid, apex obtuse, base truncate, (23–)25.5–26.5(–30.5) × (10–)11.5–12(–14) μm.

Type: *Uruguay*, Paysandu, Guaviyu, isolated from asymptomatic twig of *Blepharocalyx salicifolius*, Aug. 2006, C. Pérez, holotype PREM 60264.

Culture: CBS 124906 (ex-type).

Hosts: *Acca sellowiana*, *Blepharocalyx salicifolius*, *Eugenia uniflora*, *Eugenia involucrata*, *Hexachlamis edulis*, *Myrciaria euosma*, *Myrcianthes cisplatensis* (Pérez et al. 2010).

Known distribution: Uruguay (Pérez et al. 2010).

Notes: *Diplodia pseudoseriata* was described from native *Myrtaceae* trees in Uruguay (Pérez et al. 2010) while *D. alatafructa* was described from *Pterocarpus angolensis* in South Africa (Mehl et al. 2011). In the phylogeny constructed by Phillips et al. (2012) and in the present work, isolates of both of these species formed a cluster suggesting that they represent several phylogenetic species. Nevertheless, sequences of the ex-type isolates are divergent and indicate two separate species. Thus, it seems likely that either cultures or sequences of the other isolates of these two species have been mislabelled. Furthermore, the isolates in this cluster should be studied in detail to determine if they represent a complex of species.

*Diplodia quercivora* Linaldeddu & A.J.L. Phillips, Mycologia 105: 1269. 2013. MycoBank MB801757. Fig 27.

Ascomata not reported. Conidiomata pycnidial, stromatic, produced on poplar twigs on PDA within 14 d, superficial, dark brown to black, mostly uniloculate, solitary, globose, thick-
walled, non-papillate with a central ostiole. Paraphyses not seen. Conidiogenous cells hyaline, smooth, cylindrical, sometimes slightly swollen at the base, holoblastic forming conidia at their tips, proliferating internally giving rise to periclinal thickenings, 9.1–13.5 × 3.5–6 μm. Conidia hyaline, aseptate, smooth, thick-walled, subcylindrical to oblong-elliptical, widest at the middle, both ends broadly rounded, rarely becoming brown and 1-septate with age, (23–)28(–30.5) × (11.5–)14(–14.5) μm, 95 % confidence limits = 27.7–28.5 × 12.9–13.2 μm (av. ± S.D. of 50 conidia = 28.1 ± 1.4 × 13.8 ± 0.6 μm), L/W = 2.16.

**Culture characteristics:** Cardinal temperatures for growth: min < 5 ºC, max > 35 ºC and opt 20–25 ºC. All isolates failed to grow at 40 ºC, but mycelium resumed growth when plates were moved to 25 ºC.

**Type:** Tunisia, Tabarka, isolated from branch cankers of *Quercus canariensis*, 20 Sep. 2006, B.T. Linaldeddu, holotype LI-SE 96110 (a dried culture sporulating on holm oak twigs).

**Culture:** CBS 133852 (ex-type).

**Host:** *Quercus canariensis* (Linaldeddu et al. 2013).

**Known distribution:** North-west Tunisia (Linaldeddu et al. 2013).

Note: Diplodia quercivora is similar to *D. corticola* but the two species are readily distinguishable by conidial shape and size.

**Diplodia rosulata** Gure, Slippers & Stenlid, Mycol. Res. 109: 1010. 2005. MycoBank MB344348. Fig. 28.

Ascomata not reported. Conidiomata (formed on WA on sterilised pine needles and seeds after 45 d), pycnidial, stromatic, erumpent, solitary, globose with a central ostiole, papillate, wall composed of outer layers of thick-walled, dark brown textura angularis, becoming thin-walled and hyaline towards the inner layers. Conidiogenous cells holoblastic, hyaline, cylindrical, proliferating percurrently with indistinct annellations, 8–12 × 2–4 μm. Conidia oval to ellipsoid or ovoid, ends obtuse, initially hyaline, aseptate, granular contents, wall 1.5–2 μm thick and smooth, often turning light brown and 1-septate after discharge, (21–)25–32(–36) × (10–)11–17.5(–19.5) μm (av. size of 106 conidia = 28 × 14.5 μm), L/W ratio = 1.93.

**Culture characteristics:** Colonies initially beige to whitish (upper surface), becoming greenish grey from above, bluish-grey with whitish centre from below, cultures partially translucent after 2 wk, becoming opaque after 3 wk. Colony margin forming a concentric ring after 3–4 d with smooth margins, followed by additional rings forming as small sectors along the circumference of the colony, creating a lobed rosette appearance after 4–5 d. Mycelium dense,
forming an appressed mat, average growth rate approximately 7 and 8.5 mm filling the 9 cm Petri dishes within 12 and 10 d at 20 °C and 25 °C, respectively.

**Type**: Ethiopia, Southeastern Oromia, Gambo, Munessa-Shashamane Forest Enterprise, from seeds of *Prunus africana*, 20 Jul. 2001, A. Gure, holotype CBS H-12357.

**Culture**: CBS 116470 (ex-type).

**Host**: *Prunus africana* (Gure et al. 2005).

**Known distribution**: Ethiopia (Gure et al. 2005).

**Notes**: *Diplodia rosulata* has a distinct rosulate colony morphology, which separates it from all other *Diplodia* spp. including the closely related *D. africana* and *D. olivarum*. Iranian isolates of *D. bulgarica* have also rosulate colonies, but the conidia of *D. rosulata* (28 × 14.5 μm, L/W = 1.93) are longer and narrower than those of *D. bulgarica* (25.4 × 16.8 μm, L/W = 1.5).

**Diplodia sapinea** (Fr.) Fuckel, J. nassau. Ver. Naturk. 23–24: 393. 1870. MycoBank MB146913. Fig. 29. Basionym: *Sphaeria sapinea* Fr., Syst. Mycol. 2: 491. 1823.

**Basionym**: *Sphaeria sapinea* Fr., Syst. Mycol. 2: 491. 1823.

**Synonyms** see Sutton & Dyko (1989).

**Ascomata** not reported. **Conidiomata** pycnidial, stromatic, globose, immersed, sometimes appearing superficial, separate or aggregated, dark brown to black, unilocular, 0.3–0.5 mm diam, wall 6–8 layers, 30–60 μm thick, outer wall of dark brown thick-walled textura angularis, cells darker around the the ostiole. **Ostiole** central, circular single. **Conidiophores** absent. **Conidiogenous cells** lageniform to cylindrical, occasionally proliferating percurrently, discrete, indeterminate, hyaline, smooth, arising from the inner wall of the locule, 8.5–15 × 4–7.5 μm. **Conidia** oblong to clavate, straight to slightly curved, at first aseptate, sometimes much later becoming 1-euseptate, walls 0.5–1 μm thick, outer surface of wall smooth, or appearing pitted, apex obtuse, base truncate, (25.5–)30.5–52.5(–54) × (10–)12.5–20(–21) μm (av. ± S.D. of 200 conidia = 40.8 ± 4.9 × 15.5 ± 2.1 μm).

**Type**: Sweden, Suecia Smaland, Femsjo, on *Pinus* sp., E. Fries, *Scleromyceti Sueciae Exsiccati* No 126, *Sphaeria sapinea* Fries, lectotype: B, isotypes: G, K, E, UPS, C, BR, FH. **The Netherlands**, Gelderland, Schovenhorst, Putten, Pinetum, on cones of *Pinus nigra*, June 1984, H.A. van der Aa. epitype designated here CBS H-18340; MBT176178, culture ex-epitype CBS 393.84.

**Cultures**: CBS 393.84 (ex-epitype), CBS 109725.
Hosts: Host range includes Abies, Larix, Picea, Thuja, Pseudotsuga, and 33 species of Pinus (Palmer et al. 1987).

Known distribution: Worldwide wherever pines are grown (Palmer et al. 1987).

Notes: The history of this species has been explained by Sutton & Dyko (1989). Briefly, the pine pathogen was known for many years as Diplodia pinea (Desm.) Kickx. and later as Sphaeropsis sapinea (Fr.) Dyko & Sutton. According to Sutton & Dyko (1989) S. sapinea is based on Sphaeria sapinea Fr. and they proposed the specimen of Fries exsicata in B as lectotype. Sutton & Dyko (1989) give extensive synonymies for S. sapinea including Diplodia pinea. We examined Sphaeria pinea (Desm.) (Desmaziéres No 1277 in PC) and found that the conidia are smaller (25–32 × 12–15 μm) than those reported by Sutton & Dyko (1989) for the type of S. sapinea and thus they represent two distinct species. Furthermore, average conidial dimensions of the common pine pathogen fall within the range of 33–39 × 11.5–13 μm (Palmer et al. 1987, Swart et al. 1991), thus corresponding to S. sapinea. Therefore we consider that the correct name to apply to the common pine pathogen is Diplodia sapinea based on Sphaeria sapinea.

Differences in colony appearance and growth rate were reported for isolates of D. sapinea from the north central United States and these two colony types were referred to as morphotypes A and B (Palmer et al. 1987). Isolates of the A morphotype were described as producing fluffy, white to grey-green mycelium and faster growth on PDA than isolates of the B morphotypes which produced white to black mycelium closely appressed to the agar (Palmer et al. 1987). Other differences between the two morphotypes have been suggested including differences in radial growth, conidial dimensions and conidial septation (Palmer et al. 1987), and texture of the conidium wall (Wang et al. 1985). However, each of these differences has been shown to vary substantially within each group, or to be similar for each group. Nevertheless, according to Palmer et al. (1987) conidia of type A isolates are larger than conidia of type B isolates. They also considered that although conidia of both morphotypes were mostly aseptate, when septa were present the type B isolates had up to three septa while the type A isolates only ever formed a single septum.

De Wet et al. (2002) used RAPD markers and morphological characters to distinguish a third morphotype, which they referred to as the C morphotype. The C morphotypes had considerably larger conidia than the A morphotypes (De Wet et al. 2002) and were significantly more virulent than the A and B morphotypes (De Wet et al. 2002). Also see the notes for D. scrobiculata below.

Diplodia scrobiculata J. de Wet, Slippers & M.J. Wingf., Mycol. Res. 107: 562. 2003. MycoBank MB372427. Fig. 30.

Ascomata not reported. Conidiomata pycnidial, stromatic, covered in mycelium, dark, immersed in pine needles or in the agar, single, papillate ostiole, (100–)150(–250) μm diam. Conidiogenous cells
Fig. 29. Diplodia sapinea. A. Anellate conidiogenous cells. B–E. Conidia developing on conidiogenous cells. F–I. Conidia, the ones in H have up to 2 septa. J, K. Conidium in two different focal planes to show verruculose inner side of the wall. Scale bars = 10 μm. Scale bar in A applies to B. Scale bar in C applies to D–K.

Fig. 30. Diplodia scrobiculata. A, B. Conidiogenous layer with developing conidia. C. Conidia. Scale bar = 10 μm. Scale bar in A applies to B and C.
discrete, dark, smooth, 10 mm in diameter, holoblastic with limited percurrent proliferation forming a small number of annellations. Conidia clavate to truncate, dark mouse grey, (37.5–)39.5(–41.5) × (13–)14(–15.5) μm, 1–3 septa, thick, pitted walls (Wang et al. 1985).

Culture characteristics: Colonies pale mouse-grey to mouse-grey viewed from the top of the Petri dish, dark mouse-grey to fuscos black viewed from the bottom of the Petri dish, colonies with sinuate edges. Optimal growth at 25 °C, covering the medium surface (9 cm Petri dishes) in 8 d. Mycelium dark, septate, appressed to the agar surface.

Type: USA, Wisconsin, Jackson County, Pinus banksiana, 1987, M.A. Palmer, holotype PREM 57461.

Cultures: CMW 189 = CBS 118110 (ex-type). Other authentic culture CBS 117836.

Hosts: Pinus banksiana, P. resinosa, and P. greggii (De Wet et al. 2003).

Known distribution: Europe (France, Italy), Mexico and, USA (California, Minnesota, Wisconsin) (De Wet et al. 2003).

Notes: The differences in morphology and behaviour of the various morphotypes of D. sapinea were considered insufficient to justify separation into distinct species. However, De Wet et al. (2003) showed that differences in partial sequences of six protein coding genes and six microsatellite markers were consistent between the A and B morphotypes and they considered this to be sufficient evidence to consider them as two distinct species. On this basis they described the B morphotypes as Diplodia scrobiculata, while the A and C morphotypes were regarded as Diplodia pinea, now treated as D. sapinea.

Diplodia seriata De Not., Micr. Ital. Dec. 4: 6. 1942. MycoBank MB180468, Fig. 31.

≡ Sphaeria obtusa Schwein., Trans. Amer. Phil. Soc. II, 4: 220. 1832.
≡ Physalospora obtusa (Schwein.) Cooke, Grevillea 20: 86. 1892.
≡ Botryosphaeria obtusa (Schwein.) Shoemaker, Canad. J. Bot. 42: 1298. 1964.
= Diplodia pseudodiplodia Fuckel, Jb. Nassau. Ver. Naturk. 23–24: 393. 1870.
≡ Physalospora cydoniae G. Arnaud, Annales d’École National d’Agric. de Montpellier, Série 2, 12(1): 9. 1911.
≡ Physalospora malorum Shear, N.E. Stevens & Wilcox, J. Agric. Res. 28: 596. 1924.
≡ Diplodia profusa De Not., Micr. Ital. Dec. 4: No 8. 1842.

Ascomata stromatic, immersed, solitary or botryose up to 3 mm wide. Ascii bitunicate, fissitunicate, clavate, 90–120 × 17μm. Pseudoparaphyses hyaline, branched, septate, 2–3μm wide. Ascid clavate, stipitate, bitunicate, containing eight, biseriate ascospores, 95–100 × 15–20 μm (including stipe). Ascospores irregularly biseriate in the ascus, broadly fusoid, widest in the middle, smooth, hyaline, aseptate, 25–33 × 7–12 μm. Conidiomata stromatic, separate or aggregated and confluent, immersed in the host, partially emergent at maturity, dark brown to black, ostiolate, non-papillate, thick-walled, outer layers composed of dark brown textura angularis, inner layers of thin-walled hyaline textura angularis. Conidigenous cells hyaline, thin-walled, smooth, cylindrical, swollen at the base, discrete, producing a single conidium at the tip, indeterminate, proliferating internally giving rise to periclinal thickenings or proliferating percurrently forming 2–3 annellations, 3–5.5 × 7–10(–15) μm. Conidia initially hyaline, becoming dark brown, moderately thick-walled (ca. 0.5 μm thick), wall externally smooth, roughened on the inner surface, aseptate, ovoid, widest in the middle, apex obtruse, base truncate or rounded, (21.5–)22–27(–28) × (11–)11.5–14.5(–15.5) μm, 95 % confidence limits = 24.3–25.4 × 12.6–13.2 μm (av. ± S.D. of 50 conidia = 24.9 ± 1.9 × 12.9 ± 1.1 μm), LW = 1.9.

Type: Italy, on dead stems of Jasminium sp., 18 Aug. 1837, De Notaris, holotype HERB RO. Portugal, Montemor-o-Novo, on dead stems of Vitis vinifera, 31 Jul. 1997, A.J.L. Phillips, epitype CBS H-19809.

Culture: CBS 112555 (ex-epitype).

Hosts: Apparently plurivorous.

Known distribution: Apparently worldwide.

Notes: The connection between the sexual and asexual morph was established by Hesler (1916) and confirmed by Shear, Stevens and Wilcox (1925) and Stevens (1936). When Shoemaker transferred this name to Botryosphaeria he decided not to apply a name to the asexual morph and for many years it was referred to as B. obtusa. After Crous et al. (2005) transferred this species to Diplodia, no valid name was available.

A great deal of controversy has surrounded the correct name for this fungus. Peck (1881) found what he considered to be the conidial state of this species in New York, and reported it as Sphaeropsis malorum (Berk.) Berk. According to Stevens (1933), S. malorum (Berk.) Berk. is a synonym of Diplodia mutila Fr., which has hyaline conidia. Stevens (1933) studied Peck’s collection and confirmed that the conidia are dark and asperate.

This fungus has also been referred to as S. malorum Peck. This name came about when Saccardo (1884) transferred S. malorum (Berk.) Berk. to the genus Phoma on account of its hyaline conidia. Because Peck’s collection had brown conidia, Saccardo considered it not the same as Berkley’s collection, and used the name S. malorum Peck. Thus, Peck did not name a new species and even if he had proposed the name S. malorum in 1880, it would be an illegitimate later homonym of S. malorum (Berk.) Berk. (1860). Since S. malorum Peck is illegitimate and S. malorum (Berk.) Berk. is a synonym of D. mutila, neither of these names can be used for this species.

Slippers et al. (2007) initially regarded Diplodia malorum Fuckel to be a more appropriate name for this fungus. However, after studying the type specimen in G (Fungi rhenani 1706) they rejected this possibility. Therefore, D. malorum is not the asexual morph of Botryosphaeria obtusa. Finally, through a study of type specimens Phillips et al. (2007) determined that D. seriata was the oldest name available for the asexual morph of what had been referred to as ”B." obtusa.

Diplodia tsugae (A. Funk) A.J.L. Phillips & A. Alves, Persoonia 29: 35. 2012. MycoBank MB801409. See Funk (1964) for illustrations.

Basionym: Botryosphaeria tsugae A. Funk, Canad. J. Bot. 42: 770. 1964.
Ascomata pseudothecial, black, globose or subglobose, immersed, uniloculate, with a short apical beak which becomes ostiolate and breaks through the periderm, 360–540 μm diam, wall pseudoparenchymatous, large-celled, 60–70 μm thick. Asci clavate, short-stalked, bitunicate, formed between pseudoparaphyses, 140–180 × 30–36 μm. Ascospores ellipsoid to fusoid-ellipsoid, sometimes inequilateral, one-celled, hyaline, 42–47 × 13–18 μm. Conidiomata pycnidial, stromatic, black, immersed, globose or subglobose, uniloculate, with a short papilla which breaks through the periderm, 400–540 μm diam, wall pseudoparenchymatous, 35–45 μm thick. Conidiophores simple, bearing a single conidium at the tip. Conidia oblong to ovoid, one-celled, hyaline, 36–41 × 18–22 μm.

Type: Canada, British Columbia, near Coola (Snootli Creek), on branches of Tsuga heterophylla, 11 Sep. 1963, A. Funk, holotype DAVFP 15485. Lake Cowichan, 1 Nov. 1962, A. Funk, isotype CBS H-6790.
Culture: CBS 418.64 = IMI 197143 (ex-isotype).

Host: Tsuga heterophylla (Funk 1964).

Known distribution: Canada (British Columbia) (Funk 1964).

Notes: When Funk (1964) introduced B. tsugae he did not name the asexual morph, but referred to it as a species of Macrophoma. However, morphologically and phylogenetically it is undoubtedly a species in Diplodia and for this reason Phillips et al. (2012) transferred it to Diplodia as D. tsugae.

Dothiorella Sacc., Michelia 2: 5. 1880. MycoBank MB8098. Type species: Dothiorella pyrenophora Sacc., Michelia 2: 5. 1880.

Ascomata immersed becoming erumpent, finally appearing superficial, usually aggregated, often in rows or in small rounded groups, at times connected at sides, globose, sphaeroid or ovoid, medium sized, rarely small; apex rounded, with short or well developed papilla, often opening widely by rounded ostiole, lined with hyaline cells; surface smooth or roughened with protruding cells or bearing short to elongate hyphal appendages; peridium wide, composed externally of rows of large, brown-walled, pseudoparenchymatous cells, often blackened over surface, internally of more compressed rows of pallid cells, at times wedge-shaped groups of cells extending from lower sides, or basal portion of peridium thickened and hypostromatic, hyphae dark brown, coarse, forming slight or well-developed subiculum beneath and connecting ascomata. Asci bitunicate, basal, clavate or oblong, endotunica thickened. Pseudoparaphyses cellular, usually wide. Ascospores dull brown or dark reddish brown, ellipsoid, fusoid, obovoid, ends obtuse or somewhat acute, straight, inequilateral or slightly curved, one- to two-septate, infrequently one-celled, not or slightly constricted at septum; contents minutely granular; wall thick, smooth or verruculose at times; overlapping biseriate in the ascus. Conidiomata stromatic, ostiolate, individual or in loose clusters of up to 10 conidiomata, immersed, breaking through the bark when mature. Ostiole circular, central, non-papillate or papillate. Paraphyses absent. Conidiophores absent. Conidigenous cells holoblastic, hyaline, smooth-walled, cylindrical and slightly swollen at the base, determinate or indeterminate and proliferating at the same level to form pericinal thickenings, rarely proliferating percurrently to produce two or three indistinct annellations, borne directly on the cells lining the pycnidial cavity. Conidia initially hyaline, becoming dark brown and one-euseptate within the pycnidial cavity often while still attached to the conidiogenous cell, ellipsoid to ovoid, thick-walled, externally smooth or striate, internally verruculose.

Notes: The genus Dothiorella has been the source of much confusion in the past and the name has been used in more than one sense. Dothiorella has been used for asexual morphs with hyaline, aseptate conidia similar to those normally associated with Fusicoccum and Neofusicoccum. Presumably this confusion started when Petrak (1922) transferred F. aesculi to Dothiorella, citing the species as the conidial state of B. berengeriana (Sutton 1980). In later years, Dothiorella was used for fusicoccum-like asexual morphs with multiloculate conidiomata (Grossenbacher & Duggar 1911, Barr 1987, Rayachhetry et al. 1996). Sivanesan (1984) confused matters further by reducing Dothiorella pyrenophora to synonymy with Dothichiza sorbi, which has small, hyaline, aseptate conidia and is the asexual morph of Dothiora pyrenophora (Fr.) Fr. However, he was referring to Dothiorella pyrenophora Sacc. (1884), which is a later homonym of Dothiorella pyrenophora Sacc. 1880 (Sutton 1977). The taxonomic history of Dothiorella has been explained by Sutton (1977) and Crous & Palm (1999), and is illustrated by Crous & Palm (1999).

Dothiorella was reduced to synonymy under Diplodia by Crous & Palm (1999), who used a broad morphological concept for Diplodia. Phillips et al. (2005) re-examined the type of Dothiorella pyrenophora Sacc. (K 54912) and found that it differed from Diplodia by having conidia that are brown and 1-septate early in their development, while they are still attached to the conidiogenous cells. In Diplodia conidial darkening and septation takes place after discharge from the conidioma. Crous et al. (2006) re-examined the types of both Diplodia and Dothiorella and confirmed these morphological differences.

Sexual morphs of Dothiorella have pigmented, septate ascospores. Phillips et al. (2005) and Luque et al. (2005) broadened the concept of Botryosphaeria to include species with brown, 1-septate ascospores. Their reasons for doing this were based on the fact that ITS phylogenies placed D. sarmentorum and D. iberica within the boundaries of Botryosphaeria as it was circumscribed at that time. In a phylogeny based on partial sequences of the LSU gene Crous et al. (2006) revealed that Botryosphaeria sensu lato is composed of a number of distinct lineages that represent different genera. They suggested that the species with dark brown, 1-septate ascospores should be accommodated in Dothidotthia. Phillips et al. (2008) showed that Dothidotthia symphoricarpa (the type species of Dothidotthia) belongs in a distinct family within the Pleosporales while D. sarmentorum, D. iberica and D. viticola fall within two separate genera in the Botryosphaeriaceae and a new genus, Spencermartinsia was introduced to accommodate D. viticola.

More than 350 species names exist in Dothiorella, but presently cultures are available for only 17 species in fungal collections. Of these, ten species are known in Dothiorella, two species introduced in Spencermartinsia should be transferred to Dothiorella, Auerswaldia dothiorella is re-combined here as D. thailandica and the other four species remain unnamed. All of these, except D. sarmentorum, have been introduced since 2005. Considering the earlier problems surrounding the circumscription of this genus especially the confusion with Diplodia, it is likely that many more species will be found. The sexual stage of the species is rarely encountered in nature and under experimental conditions and no ascomata have been observed for any of the species, except for D. sarmentorum and D. iberica. Therefore, differentiation of species has mostly been done based on asexual morphs and cultural characteristics.

**Key to Dothiorella species**

1. Conidiomata papillate ......................................................................................................................................................................................... 2
2. Conidiomata non-papillate ......................................................................................................................................................................................... 6
2. Conidiomata with long necks (up to 1.5 mm) ............................................................ D. longicollis
3. Conidiomata with short necks (less than 0.5 mm) .................................................. 3

5. Colony growth rate on MEA in the dark at 25 °C < 20 mm/d .......................................................... 5

6. Conidial length less than 16 μm (av. length 15 μm) .................................................. D. americana
7. Average length of conidia less than 20 μm ........................................................................ 7

8. Conidia 23–23.4 × 10.8–11 μm (av. 23.2 × 10.9 μm) .................................................. D. thripsita
9. Average width of conidia greater than 10 μm ............................................................. 8

10. Conidial L/W ratio 2.4 ..................................................................................................... 12

11. Conidia smooth ............................................................................................................. D. thailandica
12. Conidial L/W ratio 2 ....................................................................................................... 12

13. Conidial L/W ratio 2.4 ..................................................................................................... D. moneti

It is difficult to distinguish these two species in terms of morphology but phylogenetically they are distinct.

DNA phylogeny
Phylogenetic analyses revealed two main clades representing the two distinct genera Dothiorella and Spencermartinsia. These two genera cannot be separated based on ITS sequence data and it is necessary to combine the ITS with EF1-α or other protein coding genes. The phylogeny based on ITS and EF1-α sequence data revealed 16 subclades representing 16 distinct species in Dothiorella. Most of these sub-clades received high bootstrap support (BS) in the MP analysis. But, these values are quite low for some internal nodes that can be improved with more sampling and gene loci (Fig. 32).

It is important to note that all of the known species of Dothiorella in culture and studied here can be separated based solely on ITS, although bootstrap support values for some of the internal nodes are quite low (Fig. 33). Based on multi-gene phylogenies, Auerswaldia dothiorella, a species recently described by Liu et al. (2013) was found to reside in Dothiorella closely related to D. dulcispinae and a new subclade was introduced here. Spencermartinsia pretoriensis and S. uruguayensis, two recently described species were also found to reside in Dothiorella, and are treated below.

Species descriptions
Dothiorella americana Úrbez-Torres, Peduto & Gubler, Fungal Divers. 52: 184. 2011. MycoBank MB519956. See Úrbez-Torres et al. (2011) for illustrations.

Ascomata not reported. Conidiomata pycnidial, stromatic, produced on PDA within 2 wk, solitary, globose, black, covered with moderate mycelium, up to 650 μm wide, thick-walled, unicellular, with a central ostiole. Conidiophores absent. Conidiogenous cells holoblastic, hyaline, cylindrical to subcylindrical 7–16 × 4–6 μm. Conidia initially hyaline, unicellular, becoming light brown to dark brown and 1-septate while still attached to the conidiogenous cells, light to dark brown, thin-walled, oval to ovoid, round apex and truncate base, (13.5–)14–156(–17) × (5–)5.5–6.5(–8) μm (av. of 60 conidia = 15 × 6.1), L/W ratio = 2.4.

Culture characteristics: Colonies on PDA suppressed, initially olivaceous buff in the centre of the colony and white at the edge, becoming olivaceous within 7 d, turning dark green within 28 d on the surface, violaceous grey at the reverse after 28 d. Colonies reaching 90 mm diam on PDA after 5 d in the dark at 25 °C. Cardinal temperatures for growth: min 10 °C, max 35 °C, opt 20–25 °C.

Type: USA, Missouri, Purdy, on diseased interspecific grape cultivar Vignoles (Ravat51), R.K. Striegler & G.M. Leavitt, holotype UCD2252MO.

Cultures: CBS 128309 (ex-type), CBS 128310.

Hosts: Vitis spp. (Úrbez-Torres et al. 2011).

Known distribution: USA (Missouri) (Úrbez-Torres et al. 2011).
Notes: Based on ITS and EF1-α sequence data, *D. americana* is closely related to *D. iberica* and *D. sarentorum*. But, morphologically conidia of this species are smaller than those in any other in *Dothiorella* sp. and obviously is a distinct species. Úrbez-Torres et al. (2011) considered this species to be a weak pathogen on grapevines.

**Dothiorella brevicollis** Jami, Gryzenh., Slippers & M.J. Wingf., Cryptog. Mycol. 33: 260. 2012. MycoBank MB564142. See Jami et al. (2012) for illustrations.

Ascomata not reported. Conidiomata pycnidial, stromatic, produced on *Acacia karroo* twigs on MEA within 2–4 wk, brown, solitary, up
Fig. 33. Single most parsimonious tree obtained from ITS sequence data for species in Dothiorella. MP bootstrap values are given based on 1000 pseudoreplicates on the nodes. The tree is rooted to Neofusicoccum luteum (CBS 110299, CBS 110497).
to 200 μm wide, semi-immersed, unilocular, globose, papillate with a short neck, wall 5–7 cell layers, outer layers composed of dark-brown textura angularis, becoming thin-walled and hyaline toward the inner region. Conidiophores absent. Conidiogenous cells holoblastic, hyaline, cylindrical, (3–)5–7.5–(9) × (3–)3.5–4 μm. Conidia initially hyaline and aseptate, becoming dark brown and 1-septate, with 2 cells of equal length, thick-walled, ovoid, smooth with fine granular content, rounded apices, (20–)21.5–26–(27) × (8–)9–12–(13) μm.

**Culture characteristics:** Colonies on MEA appressed, conidio mata emerging after 9–10 d under near UV light, becoming pale olivaceous-grey to dark olivaceous-grey at the surface, and olivaceous-black to iron-grey at the reverse, with irregular edges. Colonies reaching 90 mm diam on PDA after 6 d (17.6 mm/d) in the dark at 25 °C. Cardinal temperatures for growth: min 5 °C, max 35 °C, opt 25 °C.

**Type:** South Africa, Gauteng Province, Pretoria, from healthy wood section of *Acacia karroo*, Nov. 2009, F. Jami, holotype PREM 60704.

**Cultures:** CBS 130411 = CMW 36463 (ex-type), CBS 130412 = CMW 36464.

**Host:** Acacia karroo (Jami et al. 2012).

**Known distribution:** South Africa (Gauteng Province) (Jami et al. 2012).

**Notes:** Phylogenetically this species is closely related to *D. longicollis* and *D. dulcispinae* and in terms of morphology it resembles *D. thripsita* and *D. dulcispinae*. All of these species produce papillate conidiomata. *Dothiorella longicollis* differs from the other three species by having very long necks (up to 1.5 mm). Moreover, conidia of *D. longicollis* (20.4 × 8.7 μm) are smaller than those of *D. brevicollis* (21.5–26 × 9–12 μm) and longer than those of *D. dulcispinae* (16–22 × 7–10 μm). Conidia of *D. brevicollis* are clearly larger (21.5–26 × 9–12 μm) than those of *D. dulcispinae* (16–22 × 7–10 μm). It is difficult to distinguish *D. brevicollis* from *D. thripsita* (av. size of conidia 20–25 × 8.5–11.5 μm) but phylogenetically, based on ITS sequence data, they are distinct (Fig. 33).

**Dothiorella dulcispinae** Jami, Gryzenh., Slippers & M.J. Wingf., Mycologia 101: 505. 2009. MycoBank MB564141. See Jami et al. (2012) for illustrations.

Ascomata not reported. Conidiomata pycnidial, stromatic, few produced on pine needles, black, globose, solitary, scattered and immersed in water agar, ostiolate. Conidiophores absent. Conidiogenous cells emerging directly from cells lining the pycnidial cavity, holoblastic, hyaline, smooth-walled, subcylindrical, determinate or indeterminate and proliferating at the same level resulting in periclinal thickening, very rarely proliferating percurrenty to produce two or three indistinct annellations. Conidia initially aseptate and hyaline, becoming brown to dark brown or sepia and 1-septate within the conidiomata, rarely 2–3-septate, ellipsoid to ovoid, rarely narrow ellipsoid, apex obtuse, base truncate, (22–)23–31–(38) × (8–)9–12–(13.5) μm (av. of 60 conidia = 27.1 × 10.8 μm).

**Culture characteristics:** Colonies smooth to fluffy, pale greenish grey to greenish grey from above, becoming lighter or white around the edges, light bluish or sky grey from below, colony margins irregular, rosette-like. *Mycelium* thick-walled, branched, septate, melanised, pale to dark brown, with strings of dark brown chlamydospore-like hyphal swellings.

**Type:** Australia, Canberra, Cotter River, on *Casuarina* sp., 2000, M.J. Wingfield, holotype PREM 59650.

**Cultures:** CBS 120688 = CMW 4855 (ex-type), CBS 120690 = CMW 4857.

**Host:** Casuarina sp. (De Wet et al. 2009).

**Known distribution:** Australia (Canberra) (De Wet et al. 2009).

**Notes:** Phylogenetically this species formed a distinct highly supported clade and morphologically conidia of *D. casuarini* are longer (27.1 × 10.8 μm) than those of any other *Dothiorella* species.
**Dothiorella iberica** A.J.L. Phillips, J. Luque & A. Alves, Mycologia 97: 524. 2005. MycoBank MB344530. Fig. 34.

Ascomata dark brown to black, globose pseudothecial, up to 350 μm diam, submerged in the substrate, partly erumpent at maturity, ostiole circular, central, papillate, wall up to 50 μm thick, composed of dark brown thick-walled *textura angularis*, cells 8–17 × 6–10 μm and lined with thinner-walled, hyaline, *textura angularis*. *Pseudoparaphyses* thin walled, hyaline, frequently septate, slightly constricted at the septum, 2.5–3.5(–4) μm wide. Asci 100–125 × 18–25 μm, stipitate, arising from the base of the ascoma, clavate, thick-walled, bitunicate with a well-developed apical chamber, stipitate, (4–)8–spored, irregularly biseriate. Ascospores oblong, ovate to sub-clavate, (6–)1-septate, slightly constricted at the septum, dark brown, moderately thick-walled, finely verruculose on the inner surface, straight or inequilateral, widest in the lower 1/3 to middle of the apical cell, basal cell tapering towards the rounded end, (17.5–)22.5–23.5(–29) × (8.5–)10–10.5(–12.5) μm (av. ± S.D. of 50 ascospores = 23.1 ± 2.1 × 10.2 ± 0.8 μm). *Conidiomata* pycnidial, stromatic, solitary, globose, up to 450 μm wide, thick walled, composed of dark brown thick-walled *textura angularis*, becoming thin-walled and hyaline towards the inner region. *Conidiophores* absent. *Conidiogenous cells* lining the pycnidial cavity, holoblastic, hyaline, subcylindrical, 8–15 × 3–5(–6.5) μm, proliferating at the same level giving rise to periclinal thickenings, or rarely proliferating percurrently forming one or two indistinct annellations. *Conidia* initially hyaline, becoming dark brown and one-euseptate often while still attached to the conidiogenous cell, ovoid with a broadly rounded apex and becoming dark brown-grey, cylindrical, mostly solitary, covered in mycelium, within 7 d, iron-grey (surface) and black (reverse) with age, with suppressed, moderately fluffy mycelium, edges smooth appearing sinuate as the colony darkens with age. Conidiomata readily formed from the middle of colony within 7–10 d, covering the entire surface of the colony and immersed in the medium (seen as round black structures on the reverse side of Petri dishes) 14 d after incubation. Optimum growth at 25 °C, covering 90 mm diam Petri dishes after 4 d in the dark.

**Type:** Spain, Zaragoza province, Aragon, Tarazona, on dead twigs of Quercus *ilex*, Dec. 2002, J. Luque, **holotype** LISE 94944.

**Cultures:** CBS 115041 (ex-type), CBS 113188.

**Hosts:** Asymptomatic branches of *Asymptomatic branches of L. cunninghamii* (Pavlic et al. 2008).

**Known distribution:** Western Australia (Pavlic et al. 2008).

**Notes:** This species differs from all other *Dothiorella* species by having papillate pycnidia with very long necks (up to 1.5 mm). Also see notes for *D. brevicollis*.

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**Dothiorella longicollis** Pavlic, T.I. Burgess & M.J. Wingf., Mycologia 100: 859. 2008. MycoBank MB512053. See Pavlic et al. (2008) for illustrations.

Ascomata not reported. *Conidiomata* semi-immersed, mostly solitary, with globose base (up to 550 μm diam), papillate with long neck (sometimes branching) up to 1.5 mm, arising from the substrate. *Conidiophores* absent. *Conidiogenous cells* holoblastic, cylindrical to subcylindrical, hyaline, the first conidium produced holoblastically and subsequent conidia enteroblastically, (5–)6–8(–10) × (2.5–)3–(4–4.5) μm (av. of 30 conidiogenous cells = 7.3 ± 3.4 μm). *Conidia* initially hyaline, unicellular, becoming cinnamon to sepia and 1-septate while still attached to conidiogenous cells, oval to ovoid, apices rounded and base truncate, (17–)19–22(–23) × (7–)8–9.5(–10.5) μm (av. of 50 conidia = 20.4 × 8.7 μm), L/W ratio = 2.3.

**Culture characteristics:** Colonies initially white to olivaceous buff, becoming greenish olivaceous to citrine from the middle of colonies within 7 d, iron-grey (surface) and black (reverse) with age, with suppressed, moderately fluffy mycelium, edges smooth appearing sinuate as the colony darkens with age. Conidiomata readily formed from the middle of colony within 7–10 d, covering the entire surface of the colony and immersed in the medium (seen as round black structures on the reverse side of Petri dishes) 14 d after incubation. Optimum growth at 25 °C, covering 90 mm diam Petri dishes after 4 d in the dark.

**Type:** Australia. Western Australia, Tunnel Creek National Park, on healthy branches of Lysiphylleum cunninghamii, Jul. 2006, T.I. Burgess, **holotype** PREM 59485.

**Cultures:** CMW 26166 = CBS 122068 (ex-type), CMW 26165 = CBS 122067.

**Hosts:** Asymptomatic branches of *L. cunninghamii* (Caesalpiniaceae) and *Terminalia* sp. (Combretaceae) (Pavlic et al. 2008).

**Known distribution:** Australia (Western Australia) (Pavlic et al. 2008).

**Notes:** This species differs from all other *Dothiorella* species by having papillate pycnidia with very long necks (up to 1.5 mm). Also see notes for *D. brevicollis*.

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**Dothiorella moneti** K. Taylor, Barber, G.E. Hardy & T.I. Burgess, Mycol. Res. 113: 342. 2009. MycoBank MB511825. See Taylor et al. (2009) for illustrations.

Ascomata not reported. *Conidiomata* pycnidial, stromatic, superficial, dark brown-grey, cylindrical, mostly solitary, covered in mycelium, 0.5–1.5 mm in length and 0.1–0.5 mm in diam. *Conidiophores* absent. *Conidiogenous cells* holoblastic, hyaline, cylindrical to flask shaped, (4–)6–12(–16) × 2–4(–5) μm (av. of 150 conidiogenous cells = 8.4 ± 2.6 μm). *Conidia* initially hyaline and aseptate becoming dark brown and 1-septate sometimes while still attached to conidiogenous cell, ellipsoid, smooth-walled, apex obtuse, frequently base truncate, often strongly constricted at the septum, usually widest at the middle of apical cell, (13–)17–22(–32) × (6–)7–10(–11) μm (av. of 300 conidia = 19.8 × 8.4 μm), L/W ratio = 2.4.
Fig. 34. Dothiorella iberica. A. Vertical section through an ascoma. B. Ascus with brown, 1-septate ascospores. C. Immature asci and one ascus with four ascospores. D. Details of the ascoma wall. E. Pseudoparaphyses. F. Ascospores. G. Ascospore. H. Young conidiogenous cells. I. Conidiogenous cells with developing conidia. J, K. Conidia viewed at two different focal planes to show verruculose inner surface of the wall. L, M. Conidia. N. Germinating conidia. Scale bars: A = 50 μm, B–N = 10 μm.
Culture characteristics: Colonies composed of appressed mycelial mat with diffuse irregular edges, initially white, edge remaining white, centre turning olive-grey to dark greenish grey and entire culture becoming dark olive-grey by day 8 and very dark greenish grey with age. Conidiomata produced profusely in the centre of culture within 8 d. Cardinal temperatures for growth: min 5 °C, max < 35 °C, opt 25 °C.

Type: Australia, Western Australia, Yalgogup National Park, from healthy stem of Acacia rostellifera, Jun. 2005, K.M. Taylor, holotype PERTH 07692978.

Cultures: MUCC 505 = WAC 13154 (ex-type), MUCC 506.

Host: Acacia rostellifera (Taylor et al. 2009).

Known distribution: Australia (Western Australia) (Taylor et al. 2009).

Notes: In the original description, Taylor et al. (2009) mention that pycnidial paraphyses are very rare, but they did not provide an illustration of these structures although they do show young conidiogenous cells. Since pycnidial paraphyses have not been reported in any other Dothiorella species, other than D. santali, it is possible that Taylor et al. (2009) were referring to immature conidiogenous cells rather than paraphyses. Morphologically and phylogenetically, D. moneti is closely related to D. santali. This species is quite different in nucleotide sequences from D. santali (6–7 substitutions in ITS, 11 substitutions and 9 insertions/deletions in EF1-α) and thus are easily separated based on ITS sequence data (Fig. 33). Moreover, it can be distinguished by having longer conidia (19.8 × 8.4 μm, L/W ratio = 2.4) compare with D. santali (18.2 × 9 μm, L/W ratio = 2).

Dothiorella pretoriensis (Jami, Gryzenh., Slippers & M.J. Wingf.) Abdollahz. & A.J.L. Phillips, comb. nov. Mycologia MB803995. See Jami et al. (2012) for illustrations.

Basionym: Spencermartinsia pretoriensis Jami, Gryzenh., Slippers & M.J. Wingf., Cryptogam. Mycol. 33(3): 261. 2012.

Conidiomata (on sterile twigs of Acacia karroo) pycnidial, up to 200 μm diam, semi-immersed, unilocular, with short necks; wall of 5–7 layers of thick, dark-brown cells of textura angularis. Conidiophores reduced to conidiogenous cells, or a supporting cell. Conidiogenous cells 1–2-celled, hyaline, subcylindrical, proliferating percurrently near apex, (3–)3.5–7.5(–9) × (3–)3.5–4 μm. Conidia ovoid, smooth, granular, apices rounded, thick-walled, initially hyaline, aseptate, becoming dark brown and 1-septate, apex obtuse, base bluntly rounded, (18–)20–28(–33) × (6.5–)7–14(–11) μm (Jami et al. 2012).

Culture characteristics: Colonies on MEA appressed; surface pale olivaceous to dark greenish olivaceous; reverse olivaceous-black, with regular zonation and lobate margins. Colonies growing at 5–25 °C, reaching up to 22.5 mm / d at 25 °C. Cardinal temperatures for growth: min 5 °C, opt 25 °C.

Type: South Africa. Gauteng, Pretoria, from wood of Acacia karroo with die-back symptoms, Nov. 2009, F. Jami, holotype PREM 60709.

Cultures: CMW 36481 = CBS 130404 (ex-type).

Host: Acacia karroo (Jami et al. 2012).

Known distribution: South Africa (Gauteng Province) (Jami et al. 2012).

Note: Dothiorella pretoriensis induced dieback when inoculated into healthy branches of A. karroo, suggesting that it is a pathogen of this host (Jami et al. 2012).

Dothiorella santali K. Taylor, Barber & T.I. Burgess, Mycol. Res. 113: 345. 2009. MycoBank MB511828. See Taylor et al. (2009) for illustrations.

Ascomata not reported. Conidiomata pycnidial, stromatic, mostly superficial, dark brown to black, globose, solitary, occasionally covered in mycelium, 100–600 μm in length and 50–650 μm in diam. Conidiophores absent. Conidiogenous cells holoblastic, hyaline, cylindrical to flask-shaped, (4–)6–12(–17) × 2–3(–4) (av. of 50 conidiogenous cells = 8.6 × 2.4 μm). Conidia initially hyaline and aseptate becoming pigmented brown and 1-septate often while still attached to conidiogenous cell, ellipsoid, apex obtuse, sometimes base truncate, sometimes slightly constricted at the septum, usually widest at the middle of apical cell, (15–)16–20(–22) × 7–11(–13) μm (av. of 100 conidia = 18.2 × 9.0 μm), L/W ratio = 2.0.

Culture characteristics: Colonies initially white, appressed mycelial mat, within 8 d turning greenish to dark greenish grey and fluffy, becoming very dark greenish grey to black with age. Conidiomata produced on the agar. Cardinal temperatures for growth: min 5 °C, max < 35 °C, opt 25 °C.

Type: Australia, Western Australia, Yalgogup National Park, from healthy stem of Santalum acuminatum, Jun. 2005, K.M. Taylor, holotype PERTH 07693028.

Cultures: MUCC 509 = WAC 13155 (ex-type), MUCC 508.

Host: S. acuminatum (Taylor et al. 2009).

Known distribution: Australia (Western Australia) (Taylor et al. 2009).

Note: See notes for D. moneti.

Dothiorella sarmentorum (Fr.) A.J.L. Phillips, J. Luque & A. Alves, Mycologia 97: 522. 2005. MycoBank MB501403. Fig. 35.

Basionym: Sphaeria sarmentorum Fr., K. svenska Vetensk-Acad. Handl. 39: 107. 1818.

≡ Diplodia sarmentorum (Fr.) Fr., Summ. veg. Scand. (Stockholm) 2: 417. 1849.
≡ Diplodia pruni Fuckel, Jahrb. Nassausischen Vereins Naturk., 23–24: 169. 1870 [1869].
≡ Botryosphaeria sarmentorum A.J.L. Phillips, J. Luque & A. Alves, Mycologia 97: 522. 2005.

Ascomata dark brown to black, globose pseudeothecial, 350–400 μm diam, submerged in the substrate, partially erumpent at maturity, ostiolate; ostiole circular, central, papillate; wall 50–75 μm thick, composed of dark brown thick-walled textura angularis, cells 10–
17 × 6–9 μm, lined with thinner-walled, hyaline, textura angularis. Pseudoparaphyses thin-walled, hyaline, frequently septate, often constricted at the septa, 3–4 μm wide. Asci 140–210 × 17–24 μm, stipitate, arising from the base of the ascoma, cylindrical-clavate, bitunicate, endotunica thick-walled, with a well-developed apical chamber, 4–6(–8)-spored, obliquely uniseriate or irregularly biserate. Ascospores oblong to ovate, widest in the middle part, straight, (0–)1-septate, slightly constricted at the septum, dark brown, moderately thick-walled, surface smooth, finely verruculose on the inner surface, (21–)24.5–25.5(–30.5) × (10–)11.5–12.5(–14) μm (av. ± S.D. = 25.0 ± 2.0 × 12.1 ± 0.9 μm). Conidiomata pycnidial, stromatic, solitary, globose, up to 450 μm wide, wall 5–8 cell layers thick, composed of dark brown thick-walled textura angularis, becoming thin-walled and hyaline towards the inner region. Conidiophores absent. Conidiogenous cells lining the pycnidial cavity, holoblastic, hyaline, subcylindrical, 7–15 × 3–7 μm, proliferating at the same level giving rise to periclinal thickenings, or rarely proliferating percurrently to form one or two close, indistinct annellations. Conidia initially hyaline and aseptate becoming pigmented brown and 1-septate often while still attached to conidiogenous cell, brown walled, slightly constricted at the septum, ovoid with a broadly rounded apex and truncate base, (17.5–)21.5–22(–25) × (8–)9.5–10(–11.5) μm (av. ± S.D. = 21.6 ± 1.5 × 9.8 ± 0.9 μm), L/W ratio = 2.2. Spermatogenous cells discrete or integrated, hyaline, smooth, cylindrical, holoblastic or proliferating via phialides with periclinal thickenings, 7–10 × 2–3 μm. Spermatia hyaline, smooth, aseptate, rod-shaped with rounded ends, 4–5.5 × 2 μm. Cardinal temperatures for growth: min 5 °C, max < 35 °C, opt 20–25 °C.

Type: Of the sexual morph: UK, England, Warwickshire, on Ulmus sp., Aug. 1956, E.A. Ellis, holotype IMI 63581b (as Otthia spiraeae); of the asexual morph; Sweden, Lund, Botanical Garden, on Menispermum canadense, 1818, E.M. Fries Scleromyc. Suec. 18, holotype UPS-FRIES (as Sphaeria sarmentorum); isotype of the asexual morph, K(M) 104852.

Cultures: IMI 63581b (ex-type), CBS 115038.

Hosts: Dothiorella sarmentorum is a plurivorous species and has been isolated from 34 different host species including Malus, Menispermum, Prunus, Pyrus, Ulmus, etc.

Known distribution: This species is cosmopolitan distributed worldwide and has been found across six continents.

Notes: In proposing 145 species as synonyms of D. sarmentorum, Wollenweber (1941) reported a wide range of dimensions for the conidia, namely, (15–)20–24(–35) × (7–)9.5–11.5(–15) μm. Some species in Dothiorella are separated by minor differences in conidium dimensions. It is therefore possible that some of Wollenweber’s synonyms are in fact distinct species. Also see notes for D. americana and D. iberica.
Dothiorella thailandica (D.Q. Dai., J.K. Liu & K.D. Hyde) Abdollahz., A.J.L. Phillips & A. Alves, comb. nov. MycoBank MB805461. See Liu et al. (2012) for illustrations. Basionym: Auerswaldia dothiorella D.Q. Dai., J.K. Liu & K.D. Hyde, Fungal Divers. 57: 162, 2012.

Saprobic on dead bamboo. Ascomata not reported. Conidiomata pycnidial, 400–800 μm wide, 200–250 μm high, 250–500 μm diam, immersed in the host tissue and emerging at rumpuntum, globose, coriaceous, and brown in the erumpent part. Conidiomata wall 15–50 μm wide, with brown to dark brown outer layers and hyaline to light brown inner layers, comprising several layers with cells of textura angularis, cells 3–9.5 × 2–6 μm. Conidiophores reduced to conidiogenous cells which are 2–5.5 × 1.5–4.5 μm, holoblastic, discrete, hyaline, cylindrical to ellipsoidal, smooth, straight or curved, formed from cells lining the innermost layer of the pycnidium. Conidia 15–20 × 6.5–8 μm (av. 20 conidia = 18.5 × 7 μm), 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, occasionally curved, lower cell smaller, thick-walled.

Culture characteristics: Colonies on PDA, slow growing, 15 mm diam after 45 d at 23–25 °C, circular, with uneven margin, greyish brown after 7 d, becoming cottony and brown at the centre and dark brown towards the edge. Chlamydospores produced after 30 d.

Type: Thailand, Chiang Rai Province, Doi Pui, on dead bamboo culm, 1 Sep. 2011, D.Q. Dai, holotype MFLUCC 12–0751.

Culture: MFLUCC 11-0438 = CBS 133991 (ex-type).

Host: Bamboo (Liu et al. 2012).

Known distribution: Thailand (Liu et al. 2012).

Notes: This species is phylogenetically closely related to D. dulcispanae. Furthermore, in terms of morphology it resembles D. santali and D. moneti. But D. thailandica can easily be separated from those three species by its striate conidia.

Dothiorella thripsita R.G. Shivas & D.J. Tree, Fungal Planet No. 32. 2009. MycoBank MB513166. See Shivas et al. (2009) for illustrations.

Ascomata not reported. Conidiomata pycnidial, stromatic, solitary, immersed, partially erumpent when mature, dark brown, globose to ellipsoidal, papillate with a central ostiole, up to 300 × 200 μm diam, uniloculate, wall composed of an outer layer of dark brown, thick-walled textura angularis, and an inner layer of thin-walled hyaline cells. Conidiophores absent. Conidiogenous cells 10–15 × 3–6 μm, holoblastic, discrete, cylindrical, hyaline, smooth, indeterminate. Conidia initially hyaline, becoming dark brown and 1-euseptate often while still attached to the conidiogenous cell, aseptate and pale brown when young, becoming septate and brown when mature, often with a guttule in each cell, cylindrical to clavate, straight, both ends broadly rounded, 20–25 × 8.5–11.5 μm, conidial wall densely and minutely verruculose, profile smooth in LM, verruculose in SEM.

Culture characteristics: Colonies on 10 % potato-dextrose agar (Difco) reaching to 65 mm diam after 5 d in the dark at 23 °C, covered the entire plate after 3 wk in the dark followed by 5 d under black light, and were olivaceous-black to charcoal with sparse aerial mycelium, reverse greyish black to charcoal. Abundant conidia produced on Sachs’ agar supporting sterilised pieces of maize leaf.

Type: Australia, Queensland, Tallegalla, on dead stems and phylloids of Acacia harpophylla, Mar. 2008, D.J. Tree & C.E.C. Tree, holotype BRIP 51876.

Culture: BRIP 51876 (ex-type).

Host: Acacia harpophylla (Shivas et al. 2009).

Known distribution: Australia (Queensland) (Shivas et al. 2009).

Notes: Larvae and adults of the thrips Meconthrips hardyi feed almost exclusively on conidia of D. thripsita (Shivas et al. 2009). Only ITS sequence data are available for the single isolate of this species. Based on ITS sequence data D. thripsita constitutes a completely distinct clade from all other species in Dothiorella (Fig. 33). In morphology it resembles D. brevicollis.

Dothiorella uruguayensis (C.A. Pérez, Blanchette, Slippers & M.J. Wingf.) Abdollahz. & A.J.L. Phillips, comb. nov. MycoBank MB803999. For illustrations see Pérez et al. (2010). Basionym: Spencermartinsia uruguayensis C.A. Pérez, Blanchette, Slippers & M.J. Wingf., Fungal Divers. 41: 65. 2010.

Conidiomata (on PNA) pycnidial, superficial, solitary, globose, black, non-papillate, covered with mycelium, up to 350 μm diam. Conidiogenous cells hyaline, subcylindrical. Conidia (17–)22–22.5–(26.5) × (7–)9.5–(12) μm, dark brown, 1-septate, slightly constricted at septum, ovoid with broadly rounded apex and truncate base (from Pérez et al. 2010).

Type: Uruguay, Paysandu, Tres Bocas, endophytic on twigs of Hexachlamis edulis, Aug. 2006, C.A. Pérez, holotype PREM 60268.

Cultures: UY672 = CMW 26763 = CBS 124908 (ex-type).

Host: Hexachlamis edulis (Pérez et al. 2010).

Known distribution: Uruguay (Pérez et al. 2010).

Notes: Inoculation results suggest that D. uruguayensis is a weak pathogen on Hexachlamis edulis. It also proved to be uncommon in the area, and not pathogenic to Eucalyptus (Pérez et al. 2010).

Endomelanconiopsis Rojas & Samuels, Mycologia 100: 770. 2008. MycoBank MB511837. Type species: Endomelanconiopsis endophytica Rojas & Samuels, Mycologia 100: 770. 2008.

Mycelium immersed, branched, septate, hyaline to pale brown. Conidiomata stromatic, immersed, peridermal to subepidermal,
separate, irregularly multilocular, walls composed of small-celled, pale brown, thin-walled textura angularis, becoming hyaline towards the conidiogenous region. Dehiscence irregular. Conidiophores absent. Conidiogenous cells holoblastic, determinate, discrete, cylindrical, tapered markedly or gradually towards the apices, hyaline, smooth, thin-walled, formed from the walls of the locules. Conidia aseptate, pyriform to limoniform, dark brown, thick-walled, smooth, base often protruding and papillate, often with a central guttule and a single germ slit.

Notes: *Endomelanconiosis* was introduced by Rojas *et al.* (2008) for *E. endophytica* and *E. microspora*. The genus is similar to *Endomelanconium* Petrak but belongs to the *Botryosphaeriaceae* and the conidia are non-papillate. Only two species are currently known in culture and the main difference between them is that chlamydospores are abundant in *E. microspora* but absent in *E. endophytica*.

**Species descriptions**

**Endomelanconiosis endophytica** Rojas & Samuels, Mycologia 100: 770. 2008. MycoBank MB511838. See Rojas *et al.* (2008) for illustrations.

Conidiomata stromatic, scattered throughout colony, varying from globose to cylindrical, 1–3 cylindrical necks, superficial or immersed in the agar; often cylindrical papillae protruding from the agar in groups of a few; wall composed of pale brown and black angular cells, becoming hyaline and more hyphal toward the conidiogenous cells; locale convoluted, completely lined with conidiogenous cells. Conidiogenous cells formed from the inner cells all over the conidiomata wall, discrete, determinate, cylindrical, tapered toward the apex, hyaline, holoblastic, rarely with a single percurrent proliferation, mostly 6–10 × 5–7 μm. Conidia ellipsoidal to pyriform, apex rounded, base with an inconspicuous scar, aseptate, smooth, hyaline when liberated, soon becoming dark brown with a single longitudinal hyaline slit, containing one large and a few smaller oil droplets, (4.5–)5.5–6.5(–7) × (3.5–)4.5(–6) μm. Chlamydospores abundant in immersed mycelium, intercalary and terminal, when intercalary, subglobose to fusiform, single or catenate (2–5), when terminal, globose to clavate-pyriform, occasionally with a small basal, apophysis-like cell or an apical papilla, thick-walled, brown, often verruculose, filled with oil droplets, mostly 9–17 × 6–10 μm. In older cultures additional chlamydospores forming in basipetal succession behind the terminal ones.

**Culture characteristics:** Colonies at first colourless with hyaline immersed hyphae, after 4 d colonies olivaceous in center and concentric rings with irregular shape, after 10 d aerial mycelium dense dark olivaceous or grey or shiny black with little aerial mycelium. Optimum temperature at 30–37 °C; colony radius 43–55 mm after 5 d on PDA.

Type: **Panama**, Nombre de Dios, isolated from leaves of *Theobroma cacao*, 2000, E. Rojas, L. Mejia & Z. Maynard, holotype BPI 878370.

Culture: CBS 120379 (ex-type).

**Hosts:** *Heisteria concinna, Theobroma cacao* (Rojas *et al.* 2008).

**Distribution:** Panama (Rojas *et al.* 2008).

Notes: The germ slit in the conidia of *E. endophytica* and *E. microspora* is an unusual feature in the *Botryosphaeriaceae*. While Neodeightonia subglobosa was reported to have conidia with germ slits (Punithalingam 1969), and these were interpreted by Crous *et al.* (2006) as striations similar to those seen in *Lasiodiplodia*.

**Endomelanconiosis microspora** (Verkley & Aa) E.I. Rojas & Samuels, Mycologia 100: 772. 2008. MycoBank MB511839.

Basionym: *Endomelanconium microsporum* Verkley & Aa, Mycologia, 89: 967. 1997.

Conidiomata stromatic, solitary and globose to subglobose, or convoluted with merging cavities, superficial or immersed in the agar, at first pale olivaceous, later black, glabrous, often with an apical papilla but seldom a functional ostiole, mostly dehiscing by bursting or partial dissolution of upper wall tissue, 200–500 μm diam. Conidialat wall composed of two layers, an outer layer of brown to olivaceous textura epidermoidea-angularis, and an inner layer variable in thickness of hyaline textura angularis-globulosa. Conidiogenous cells formed from the inner cells all over the conidiomatal wall, discrete, determinate, cylindrical, but tapering towards the apex, hyaline, holoblastic, rarely with a single percurrent proliferation, mostly 6–10 × 5–7 μm. Conidia ellipsoidal to pyriform, apex rounded, base with an inconspicuous scar, aseptate, smooth, hyaline when liberated, soon becoming dark brown with a single longitudinal hyaline slit, containing one large and a few smaller oil droplets, (4.5–)5.5–6.5(–7) × (3.5–)4.5(–6) μm. Chlamydospores abundant in immersed mycelium, intercalary and terminal, when intercalary, subglobose to fusiform, single or catenate (2–5), when terminal, globose to clavate-pyriform, occasionally with a small basal, apophysis-like cell or an apical papilla, thick-walled, brown, often verruculose, filled with oil droplets, mostly 9–17 × 6–10 μm. In older cultures additional chlamydospores forming in basipetal succession behind the terminal ones.

Type: **Papua New Guinea**, Central Province, 22 km E of Port Moresby, Varirata National Park near Varirata Lookout, soil in dry secondary forest with *Casuarina* and *Eucalyptus*, and conglomerate rock outcrops, 23 Oct. 1995, A. Aptroot, H.A. van der Aa 12183 (a dried culture on oatmeal agar), **holotype** CBS H-12183.

**Culture:** CBS 353.97 (ex-type).

**Substrate:** Soil (Verkley & van der Aa 1997).

**Known distribution:** Papua New Guinea (Verkley & van der Aa 1997).

Note: *Endomelanconiosis microspora* is characterised by having stromatic conidiomata that give rise to brown, aseptate conidia, and abundant terminal, and intercalary chlamydospore-like structures that are formed in culture (Verkley & van der Aa 1997).

**Lasiodiplodia** Ellis & Everh., Bot. Gaz. 21: 92. 1896. MycoBank MB8708.

Type species: *Lasiodiplodia theobromae* (Pat.) Griff. & Maubl., Bull. trimest. Soc. Mycol. Fr. 25: 57. 1909.
**Key to Lasiodiplodia spp.**

1. Conidia sub-globose, L/W ratio less than 1.5 ................................................................. 2
   1. Conidia ellipsoidal to ovoid, L/W ratio greater than 1.5 .............................................. 3

2. Conidia 13.5–21.5 × 10–14 μm (av. length 17.5 μm) ..................................................... L. mahajangana
   2. Conidia 12–19 × 10–12.5 μm (av. length 15.3 μm) ...................................................... L. margaritacea

3. L/W ratio greater than 2.0 .................................................................................................. 4
   3. L/W ratio less than 2.0 .................................................................................................... 5

4. Conidia 26–33 × 12–15 μm (av. length 28.4 μm) .............................................................. L. venezuelensis
   4. Conidia 17–23 × 8–11 μm (av. length 19.5 μm) ............................................................. L. viticola

5. Longest paraphyses more than 100 μm long .................................................................... 6
   5. Longest paraphyses less than 100 μm long ................................................................. 9

6. Average conidial length less than 25 μm ........................................................................ 7
   6. Average conidial length greater than 25 μm ............................................................... 8

7. Average conidial width = 13 μm .................................................................................... L. iraniensis
   7. Conidia average width = 11.5 μm .............................................................................. L. parva

8. Conidia 22–35 μm long (av. 29.6 μm), L/W ratio = 1.9 ............................................... L. plurivora
   8. Conidia 20–31 μm long (av. 24.5 μm), L/W ratio = 1.6 .............................................. L. citricola

9. Average width of conidia less than 16 μm .................................................................... 10
   9. Average width of conidia 16 μm or more ................................................................... 15

10. Conidia small, mostly less than 25 μm long .................................................................. 11

11. Conidia large, mostly longer than 25 μm, up to 30 μm or more ............................... 14

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Mycolium immersed or superficial, branched, septate, dark brown. Ascormata eustromatic, dark brown to black, uniloculate with thick pseudoparenchymatic wall, ostiolate, embedded in the substrate and partially erumpent at maturity. Pseudoparaphyses hyaline, septate. Ascii bitunicate with thick endotunic and well-developed apical chamber, clavate, stipitate, 8-spored. Ascospores irregularly biseriate, initially hyaline, becoming dark brown, aseptate. Conidiomata stromatic, immersed or superficial, separate or aggregated and confluent, globose, dark brown, uni- or multilocular; wall of dark brown, thick-walled textura angularis, paler and thinner-walled towards the conidiogenous region, often with dark brown superficial hyphae over the surface. Ostiole central, single, papillate. Conidiophores often reduced to conidiogenous cells, if present hyaline, simple, sometimes septate, rarely branched, cylindrical, arising from the inner layers of cells lining the locules. Conidiogenous cells hyaline, smooth, cylindrical to subobpyriform, holoblastic, discrete, determinate or indeterminate and proliferating percurrently with one or two distinct annellations, or proliferating at the same level giving rise to periclinal thickenings, formed from cells lining the inner wall of the conidiomata. Conidia hyaline when young, later becoming medianly 1-euseptate, dark brown with longitudinal striations, thick-walled, oblong to ellipsoid, straight, broadly rounded at the apex, base truncate. Paraphyses hyaline, cylindrical, septate.

Notes: Lasiodiplodia was introduced by Ellis in 1894 with L. tubericola as the type species. Although Ellis did not describe it, Clendenin (1896) provided a description of the genus and the species, attributing both to Ellis and Everhardt. Griffin & Maublanc (1909) considered that on account of the pycnidial paraphyses, the cocoa pathogen, Botryodiplodia theobromae, was more suitably accommodated in Lasiodiplodia. Since the epithet theobromae (1892) is older than tubericola (1896), L. theobromae should be regarded as the type species of Lasiodiplodia. Unfortunately, neither Patouillard (1892) nor Clendenin (1896) referred to any type or other specimens of the genus or species. Pavlic et al. (2004) could not locate the types, and they also could not find any specimens from the original hosts or origins.

It has been thought that Lasiodiplodia could represent a possible synonym of Diplodia (Denman et al. 2000). However, phylogenetic studies by Zhou & Stanosz (2001), Slippers et al. (2004) and Phillips et al. (2008) show that it clusters separately from Diplodia. On account of the phylogenetic and morphological differences there is no reason to consider the two as synonymous. Morphologically the two genera are also clearly distinct. Thus, striations on the conidia distinguish Lasiodiplodia from Diplodia, the conidial paraphyses distinguish it from Neodeigna, which also has striate conidia. Although Barriopsis has striate conidia, they are unique in the Botryosphaeriaceae because they are also present on immature, hyaline conidia. The sexual morph has been reported only for L. theobromae, but the connection with the asexual morph has not been confirmed (see notes under L. theobromae). While 27 species names are listed in MycoBank, only 18 species are currently known in culture and all, except L. theobromae, have been introduced since 2004. Species can be differentiated based on conidial morphology (especially dimensions) and morphology of the paraphyses.
DNA phylogeny

Combined analysis of ITS and EF1-α separates the 18 species currently recognised in this genus (Fig. 36). Some of the species, such as *L. citricola* / *L. parva* / *L. hormozganensis*, are distinguishable mainly from differences in their EF1-α sequences. Furthermore, bootstrap support for some of the inner branches is quite low. This would suggest that a reappraisal of the species in *Lasiodiplodia* based on more gene loci should be undertaken.

*Lasiodiplodia citricola* Abdollahz., Javadi & A.J.L. Phillips, Persoonia 25: 4. 2010. MycoBank MB167777. Fig. 37.

Ascomata not reported. *Conidiomata* stromatic, produced on pine needles on WA within 2–4 wk, superficial, dark brown to black, covered with dense mycelium, mostly uniloculate, up to 2 mm diam, solitary, globose, thick-walled, non-papillate with a central ostiole. Paraphyses hyaline, cylindrical, thin-walled, initially aseptate, becoming up to 1–5 septate when mature, occasionally branched, rounded at apex, occasionally basal, middle or apical cells swollen, up to 125 μm long, 3–4 μm wide. *Conidiophores* absent. *Conidiogenous cells* holoblastic, discrete, hyaline, smooth, thin-walled, cylindrical, proliferating percurrently, (20–)22–27(–31) × (11–)12–17(–19) μm, 95 % confidence limits = 24.1–24.9 × 15–15.7 μm (av. ± S.D. = 24.5 ± 29.6 μm). This species produces a pink pigment in PDA cultures at 35 °C.

*Lasiodiplodia crassisspora* T.I. Burgess & Barber, Mycologia 98: 425. 2006. MycoBank MB500235. Fig. 38.

Ascomata not reported. *Conidiomata* stromatic, superficial, mostly solitary, conical, smooth, iron grey, 0.5–1 mm diam. *Paraphyses* cylindrical, sepalate, hyaline, (21–)30–62(–66) × 2–3.5(–4) μm (av. of 50 paraphyses = 45.7 × 2.7 μm). *Conidiophores* absent. *Conidiogenous cells* holoblastic, hyaline, subcylindrical to cylindrical to ampulliform, proliferating percurrently, (6–)8–16(–19) × 3–7 μm (av. of 50 conidiogenous cells = 11.8 × 5 μm). *Conidia* produced in culture initially hyaline, unicellular, ellipsoid to obvoid, thick-walled (2–3 μm, av. of 50 conidia = 2.6 μm) with granular content, round at apex, occasionally truncate at base, becoming pigmented with one septum when mature or before germination, developing longitudinal striations when mature, 27–30(–33) × 14–17 μm (av. ± S.D. = 28.8 × 16.0 μm, L/W ratio = 1.8).
Culture characteristics: Colonies moderately dense, with appressed mycelial mat, initially white to buff turning pale olivaceous-grey within 7 d and darkening with age. After 7 d the submerged mycelia are olivaceous-grey, becoming black with age. Optimum temperature for growth 30 °C, reaching 74 mm on PDA after 3 d at 30 °C in the dark.

Fig. 36. One of the two equally most parsimonious trees obtained from combined ITS and EF-1α sequence data for species in Lasiodiplodia. MP bootstrap values are given based on 1000 pseudoreplicates on the nodes. The tree is rooted to Diplodia mutila (CBS 112553) and D. seriata (CBS 112555).
Fig. 37. Lasiodiplodia citricola. A. Conidiomata on pine needles in culture. B. Conidia developing on conidiogenous cells. C. Annellations on conidiogenous cell. D. Conidia developing on conidiogenous cells between paraphyses. E. Septate paraphyses. F. Hyaline, immature conidia. G, H. Mature conidia in two different focal planes to show the longitudinal striations. Scale bars: A = 1 mm, B, C = 5 μm, D–H = 10 μm.

Fig. 38. Lasiodiplodia crassispora. A. Hyaline, aseptate conidia. B, C. Dark brown, 1-septate conidia in two focal planes to show the longitudinal striations. Scale bar A = 10 μm. Scale bar in A applies to B and C.
Type: **Australia**. Western Australia, Kununurra, from canker on *Santalum album*, Dec. 2003, T.I. Burgess, holotype MURU 407.

**Cultures**: WAC 12533 = CMW 14691 (ex-type), CMW 13448.

**Hosts**: *Santalum album* (Burgess et al. 2006), *Eucalyptus urophylla* (Perez et al. 2010), *Vitis vinifera* (Úrbez-Torres et al. 2010, van Niekerk et al. 2010).

**Known distribution**: Australia (Western Australia) (Burgess et al. 2006), South Africa (van Niekerk et al. 2010), Uruguay (Perez et al. 2010), USA (California) (Úrbez-Torres et al. 2010).

**Notes**: This species is phylogenetically closely related to *L. rubropurpurea* and *L. venezuelensis*, but can be distinguished from *L. rubropurpurea* by the absence of red-purple conidiomata. Furthermore, conidia of *L. crassispora* (av. = 28.8 × 16 μm) are wider than those of *L. venezuelensis* (av. = 28.4 × 13.5 μm). In terms of morphology *L. crassispora* resembles *L. pseudotheobromae* and the only feature that distinguishes the two species is that in *L. crassispora* the pseudoparaphyses are mostly septate, while in *L. pseudotheobromae* they are mostly aseptate.

**Lasiodiplodia egyptiacae** A.M. Ismail, L. Lombard & Crous, Australas. Plant Path. 41: 655. 2012. MycoBank MB564516. Fig. 39.

Ascomata not reported. **Conidiomata** stromatic, mostly solitary, dark-grey to black, globose to subglobe. **Paraphyses** hyaline, subcylindrical, aseptate, up to 57 μm long, 2–3 μm wide. **Conidiophores** absent. **Conidiogenous cells** holoblastic, discrete, hyaline, smooth, thin-walled, cylindrical, 11–18 × 3–5 μm. **Conidia** initially hyaline, aseptate, ellipsoid to ovoid, with granular content, rounded at apex, base mostly truncate, wall < 2 μm, becoming pigmented, verruculose, ellipsoid to ovoid, 1-septate with longitudinal striations, (25–)28–35(–39) × (14.5–)15–18(–19) μm, 95 % confidence limits = 30.6–31.4 × 16.5–16.7 μm (av. ± S.D. = 31 ± 2.4 × 16.6 ± 1 μm, L/W ratio = 1.9).

**Culture characteristics**: Colonies on PDA with moderately dense, raised mycelium mat, initially white to smoke-grey, turning greenish grey on the surface and greenish grey in reverse, becoming dark slate-blue with age. Cardinal temperatures for growth: min 15 °C, max 35 °C, opt 25 °C.

Type: **Egypt**. Sharkia Province, El Menayar, from *M. indica* leaf, Feb. 2010, A.M. Ismail, holotype CBS H-20736.

**Cultures**: BOT-10 = CBS 130992 (ex-type), BOT-29.

**Host**: *Mangifera indica* (Ismail et al. 2012).

**Known distribution**: Brazil (Marques et al. 2013), Egypt (Ismail et al. 2012).

**Notes**: This species is morphologically and phylogenetically closely related to *L. citricola*, *L. hormozganensis*, *L. parva* and *L. pseudotheobromae*, but can be distinguished based on the dimensions of conidia and paraphyses.

**Lasiodiplodia gilanensis** Abdollahz., Javadi & A.J.L. Phillips, Persoonia 25: 5. 2010. MycoBank MB16778. Fig. 40.

Ascomata not reported. **Conidiomata** stromatic, produced on pine needles on WA within 2–4 wk, superficial, dark brown to black, covered with dense mycelium, mostly uniloculate, up to 940 μm diam, solitary, globose, thick-walled, non-papillate with a central ostiole. **Paraphyses**, hyaline, cylindrical, thin-walled, initially aseptate, becoming up to 1–3 septate when mature, rarely branched, rounded at apex, up to 95 μm long, 2–4 μm wide. **Conidiophores** absent. **Conidiogenous cells** holoblastic, discrete, hyaline, smooth, thin-walled, cylindrical, 11–18 × 3–5 μm. **Conidia** initially hyaline, aseptate, ellipsoid to ovoid, with granular content, rounded at apex, base mostly truncate, wall < 2 μm, becoming pigmented, verruculose, ellipsoid to ovoid, 1-septate with longitudinal striations, (25–)28–35(–39) × (14.5–)15–18(–19) μm, 95 % confidence limits = 30.6–31.4 × 16.5–16.7 μm (av. ± S.D. = 31 ± 2.4 × 16.6 ± 1 μm, L/W ratio = 1.9).

**Culture characteristics**: Colonies with abundant aerial mycelia reaching to the lid of Petri plate, aerial mycelia becoming smoke-grey to olivaceous-grey at the surface and greenish grey to dark
slate blue at the reverse after 2 wk in the dark at 25 °C. Colonies reaching 80 mm on MEA after 2 d in the dark at 25 °C. Cardinal temperatures for growth: min ≤ 10 °C, max ≥ 35 °C, opt 25–30 °C.  

Type: Iran, Gilan Province, Rahimabad-Garmabdost, on twigs of unknown woody plant, Jun. 2007, J. Abdollahzadeh & A. Javadi, holotype IRAN 14272F.  

Cultures: IRAN 1523C = CBS 124704 (ex-type), IRAN 1501C = CBS 124705.  

Hosts: Unknown (isolated from twigs of an unknown woody plant).  

Known distribution: Rahimabad-Garmabdost, Gilan Province, Northern Iran (Abdollahzadeh et al. 2010).  

Notes: Phylogenetically, L. gilanensis is closely related to L. plurivora and L. missouriana, but the three species can be distinguished on average conidial dimensions. Moreover, the paraphyses of L. gilanensis are up to 95 μm long and 4 μm wide, whereas paraphyses of L. plurivora are up to 130 μm long and 10 μm wide (Damm et al. 2007). Also, the 1–3 basal cells of L. plurivora paraphyses often are broader than the apical cells whereas, in L. gilanensis they are the same as the apical cells. In terms of morphology, L. gilanensis is similar to L. gonubiensis, but paraphyses of L. gilanensis (up to 95 μm) are longer than those of L. gonubiensis (up to 65 μm). Moreover, conidia of L. gilanensis (av. ± S.D. = 31 × 16.6 μm) are slightly shorter than in L. gonubiensis (av. ± S.D. = 33.8 × 17.3 μm). This species produces a pink pigment in PDA cultures at 35 °C.  

Lasiodiplodia gonubiensis Pavlic, Slippers & M.J. Wingf., Stud. Mycol. 50: 318. 2004. MycoBank MB500079. See Pavlic et al. (2004) for illustrations.  

Ascomata not reported. Conidiomata stromatic, formed on WA on sterilised pine needles within 7–21 d, semi-immersed, solitary, globose, papillate, leaden-black, covered by mycelium, up to 460 μm diam. Paraphyses cylindrical, aseptate, hyaline, (14–)26.5–47(–65) × (1.5–)2–2.5(–3) μm. Conidiophores absent. Conidiogenous cells holoblastic, cylindrical, hyaline, (6.5–)10–15(–18) × (1–)2–4(–4.5) μm. Conidia initially hyaline, unicellular, ellipsoid to obvoid, thick-walled with granular content, rounded at apex, occasionally truncate at base becoming cinnamon to sepia with longitudinal striations, forming one to three septa, (28–)32–36(–39) × (14–)16–18.5(–21) μm (av. of 100 conidia = 33.8 × 17.3 μm, L/W ratio = 1.9).  

Culture characteristics: Colonies initially white to smoke-grey with fluffy, aerial mycelium, becoming olivaceous-grey on the surface after 3–4 d, with dense aerial mycelium, margins slightly irregular; reverse side of the colonies dark slate-blue. Optimum temperature for growth 25 °C, covering the medium surface (90 mm Petri dish) after 5 d in the dark. Isolates growing at 35 °C produced a coral red pigment within 4 d.  

Type: South Africa, Eastern Cape Province, Gonubie, isolated from Syzygium cordatum, Jul. 2002, D. Pavlic, holotype PREM 58127 (conidiomata on needles of Pinus sp. on WA).
Cultures: CMW 14077 = CBS 115812 (ex-type), CMW 14078 = CBS 116355.

Hosts: Syzygium cordatum (Pavlic et al. 2004).

Known distribution: South Africa (Gonubie, Eastern Cape Province) (Pavlic et al. 2004).

Notes: Phylogenetically this species is clearly distinct from all other Lasiodiplodia species. In terms of morphology, conidia of L gonubiensis are larger than those of any other species presently known in the genus.

Lasiodiplodia hormozganensis Abdollahz., Zare & A.J.L. Phillips, Persoonia 25: 6. 2010. MycoBank MB16779. Fig 41.

Ascomata not reported. Conidiomata stromatic, produced on pine needles on WA within 2–4 wk, superficial, dark brown to black, covered with dense mycelium, mostly uniloculate, up to 950 μm diam, solitary, globose, thick-walled, non-papillate with a central ostiole. Paraphyses, hyaline, cylindrical, thin-walled, initially aseptate, becoming up to 1–7-septate when mature, rarely branched, occasionally basal, middle or apical cells swollen, rounded at apex, up to 83 μm long, 2–4 μm wide. Conidiophores absent. Conidiogenous cells holoblastic, discrete, hyaline, smooth, thin-walled, cylindrical, 9–15 × 3–5 μm. Conidia initially hyaline, aseptate, ellipsoid to cylindrical, with granular contents, rounded at apex, base round or truncate, wall < 2 μm, becoming pigmented, verruculose, ellipsoid to ovoid, 1-septate with longitudinal striations, (15.5–)18–24 (–25) × 11–14 μm, 95 % confidence limits = 21.2–21.7 × 12.4–12.6 μm (av. ± S.D. = 21.5 ± 1.9 × 12.5 ± 0.8 μm, L/W ratio = 1.7).

Culture characteristics: Colonies with abundant aerial mycelia reaching to the lid of Petri dish, aerial mycelia becoming smoke grey to olivaceous-grey at the surface and greenish grey to dark slate blue at the reverse after 2 wk in the dark at 25 °C. Colonies reaching 83 mm on MEA after 2 d in the dark at 25 °C. Cardinal temperatures for growth: min ≤ 10 °C, max ≥ 35 °C, opt 25–30 °C.

Fig. 41. Lasiodiplodia hormozganensis. A. Conidiomata on pine needles in culture. B, C. Conidia developing on conidiogenous cells between paraphyses. D, E. Septate and aseptate paraphyses. F. Hyaline immature conidia. G, H. Mature conidia in two different focal planes to show the longitudinal striations. Scale bars: A = 1 mm, B, C = 5 μm, D–H = 10 μm.
**Lasiodiplodia iraniensis** Abdollahz., Zare & A.J.L. Phillips, Persoonia 25: 8. 2010. MycoBank MB16780. Fig 42.

Ascomata not reported. Conidiomata stromatic, produced on pine needles on WA within 2–4 wk, superficial, dark brown to black, covered with dense mycelium, mostly uniloculate, up to 980 μm diam, solitary, globose, thick-walled, non-papillate with a central ostiole. Paraphyses, hyaline, cylindrical, thin-walled, initially aseptate, becoming up to 1–6 septate when mature, rarely branched, occasionally basal, middle or apical cells swollen, rounded at apex, up to 127 μm long, 2–4 μm wide. Conidiophores absent. Conidiogenous cells holoblastic, discrete, hyaline, smooth, thin-walled, cylindrical, 9–16 × 3–5 μm. Conidia initially hyaline, aseptate, subglobose to subcylindrical with granular content, both ends rounded, wall < 2 μm, becoming pigmented, verruculose, ellipsoid to ovoid, 1-septate with longitudinal striations, (15.5–) 17–23(–29.5) × 11–14 μm, 95 % confidence.
Cylindrical, 6–12 × 2.5–3 μm.

Asci bitunicate, fissitunicate, clavate. Pseudoparaphyses textura angularis, inner layers of thin-walled cells of textura angularis. Peridium of locules 30–60 μm diam, thick-walled, papillate ostioles.

Textura angularis locules, with individual ostioles, cells of ascostromata brown-walled immersed, globose to subglobose, coriaceous, multiloculate, with 4–5 mm high, dark brown to black, developing on host tissue, semi-terete to ovoid, becoming dark brown with longitudinal striations, (15–)16–17.5 × (8–)9.5–10–11(–12) μm, L/W ratio = 1.7.

Type: Iran. Hormozgan Province, Bandar Abbas, Geno mountain, on twigs of Salvadora persica, Mar. 2007, J. Abdollahzadeh & A. Javadi, holotype IRAN 14268F.

Cultures: IRAN 1520C = CBS 124710 (ex-type), IRAN 1519C.

Hosts: Citrus sp., Eucalyptus sp., Juglans sp., Mangifera indica, Salvadora persica, Terminalia catapa (Abdollahzadeh et al. 2010).

Known distribution: Brazil (Marques et al. 2013), Iran (Hormozgan & Golestan Provinces) (Abdollahzadeh et al. 2010).

Notes: Phylogenetically this species is closely related to L. mahajangana, L. theobromae and L. viticola. This species can be easily separated from the first two species based on conidial dimensions. Conidia of L. iraniensis (av. = 20.7 × 13 μm) are larger and smaller than those of L. mahajangana (av. = 17.5 × 11.5 μm) and smaller than L. theobromae (av. = 26.2 × 14.2 μm). Conidia of L. viticola (av. = 19.5 × 9.5 μm) are shorter and narrower than those of L. iraniensis. Furthermore, the paraphyses in L. iraniensis are longer than 100 μm, while they are less than 100 μm in L. viticola. Although, conidial dimensions of L. iraniensis are similar to those of L. parva, the average width of conidia of L. iraniensis (13 μm) is greater than in L. parva (av. width = 11.5 μm). This species produces a pink pigment in PDA cultures at 35 °C.

Lasiodiplodia lignicola (Ariyawansa, J.K. Liu & K.D. Hyde) A.J.L. Phillips, A. Alves & Abdollahzadeh, comb. nov. MycoBank MB805462. Fig. 43. Basionym: Auerswaldia lignicola Ariyawansa, J.K. Liu & K.D. Hyde, Fungal Divers. 57: 161. 2012.

Saprobic on dead wood. Ascomata 0.5–0.75 mm diam, 0.75–1 mm high, dark brown to black, developing on host tissue, semi-immersed, globose to subglobose, conicose, multiloculate, with 4–5 locules, with individual ostioles, cells of ascostromata brown-walled textura angularis. Locules 100–130 × 110–130 μm, with individual papillate ostioles. Peridium of locules 30–60 μm diam, 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 bitunicate, fissitunicate, clavate to broadly clavate, with short and narrow pedicel, rounded at the apex with an ocular chamber, 80–90 × 15–25 μm. Ascospores uniseriate or partially overlapping, reddish brown to dark brown, aseptate, fusiform to ellipsoidal with narrowly rounded ends, smooth-walled, 15–20 × 8–10 μm (av. of 40 ascospores = 19 × 9 μm). Conidiomata indistinguishable from ascomata. Paraphyses aseptate, thin-walled, with slightly bulbous tip up to 15 μm long. Conidiophores hyaline, thin-walled, cylindrical, 6–12 × 2.5–3 μm. Conidiogenous cells hyaline, thin-walled, smooth, cylindrical, forming a single conidium at the tip, holoblastic, proliferating at the same level giving rise to periclinial thickenings, 10–15 × 2.5–3.5 μm. Conidium hyaline, smooth, thick-walled, globose to ovoid, becoming dark brown with longitudinal striations, (15–)16–17.5 × (8–)9.5–10.5–11(–12) μm, L/W ratio = 1.7.

Culture characteristics: Colonies with abundant aerial mycelia reaching to the lid of Petri dish, aerial mycelia becoming smoke grey to olivaceous-grey at the surface and greenish grey to dark slate blue at the reverse after 2 wk in the dark at 25 °C. Colonies reaching 80 mm on MEA after 2 d in the dark at 25 °C. Cardinal temperatures for growth: min ≤ 10 °C, max ≥ 35 °C, opt 25–30 °C.

Type: Thailand. Chiang Rai Province, Muang District, Bandu, on dead wood, 30 Sep. 2011, A.D. Ariyawansa, holotype MFLU 12–0750.

Cultures: MFLUCC 11-0435 = CBS 134112 (ex-type), MFLUCC 11-0656.

Hosts: Dead wood of unknown host (Liu et al. 2012).

Known distribution: Thailand (Liu et al. 2012).

Notes: This species was introduced by Liu et al. (2012) under Auerswaldia lignicola. However, in the phylogenies presented here, it is obviously a distinct species in Lasiodiplodia and formed a clade as a group basal to all other species. This is one of the few species in which the asexual morph and sexual have been definitively linked, and the dark brown ascospores (Liu et al. 2012) are assumed to be a typical feature of the genus.

Lasiodiplodia mahajangana Begoude, Jol. Roux & Slippers, Mycol. Prog. 9: 110. 2010. MycoBank MB514012. See Didier Begoude et al. (2010) for illustrations.

Ascomata not reported. Conidiomata stromatic, produced on pine needles on MEA within 2 wk, up to 300 μm diam, solitary and covered by mycelium, superficial, conical, unilocular, with long necks (up to 200 μm) and single ostioles at the tips, dark brown to black, walls thick, consisting of two layers: an outer dark brown textura angularis, lined with thin-walled, hyaline cells. Paraphyses rare, cylindrical, hyaline, aseptate 1-celled, (27.5–)33.5–52.5(–66) × (2–)2.5–3.5(–5(–6) μm, (av. of 50 paraphyses = 43 × 3 μm), rounded at the tips, unbranched. Conidiophores absent. Conidiogenous cells holoblastic, discrete, hyaline, cylindrical, (10–)10.5–18–(26) × (3–)3.5–5.5(–6) μm (av. of 50 conidiogenous cells = 14.5 × 4.5 μm, L/W ratio = 3.2). Conidia initially aseptate, hyaline, ellipsoidal to ovoid, thick-walled (< 2.5 μm), smooth, having a brownish-black layer, becoming brown with age, with a brown septum at maturity. (13.5–)15.5–19–(21.5) × (10–)11.5–13–(14) μm (av. of 50 conidia = 17.5 × 11.5 μm, L/W ratio = 1.4).

Culture characteristics: Colonies initially white, fluffy with abundant aerial mycelium, becoming pale olivaceous-grey after 4 d, with the reverse sides of the colonies olivaceous-grey. Optimum temperature for growth 25–30 °C, covering a 90 mm Petri dish after 3 d on MEA in the dark, no growth observed at 10 °C.

Type: Madagascar, Mahajanga, isolated from healthy branches of Terminalia catappa, Oct. 2007, J. Roux, PREM 60288 holotype (a dry culture of CMW 27801 = CBS 124925 on pine needles); isolated from healthy branches of Terminalia catappa, Oct. 2007, J. Roux, paratype PREM 60289.
**Lasiodiplodia lignicola** Pavlic, T.I. Burgess & M.J. Wingf., Mycologia 100: 860. 2008. MycoBank MB512052. See Pavlic et al. (2008) for illustrations.

Cultures: CMW 27820 = CBS 124927, CMW 27801 = CBS 124925 (ex-type).

Host: *Terminalia catappa* (Didier Begoude et al. 2010).

Known distribution: Madagascar (Mahajanga) (Didier Begoude et al. 2010).

Notes: Conidia of *L. mahajangana* are smaller than those of its closest relative, *L. theobromae*. Paraphyses of *L. mahajangana* are aseptate while those of *L. theobromae* are septate. In terms of morphology it is similar to *L. margaritacea* and the two can be distinguished only on the average lengths of their conidia (*L. mahajangana* = 17.5 μm, *L. margaritacea* = 15.3 μm).

**Lasiodiplodia margaritacea** Pavlic, T.I. Burgess & M.J. Wingf., Mycologia 100: 860. 2008. MycoBank MB512052. See Pavlic et al. (2008) for illustrations.

Ascomata not reported. Conidiomata stromatic, semi-immersed, solitary, globose, papillate, black, covered by hyphal hairs, up to 520 μm diam. Paraphyses cylindrical, 1–2-septate, hyaline, (19–) 28–46(–54) × (1.5–)2–2.5(–3) μm (av. = 37.1 × 2.2 μm), formed among conidiogenous cells. Conidiophores absent. Conidiogenous cells holoblastic, cylindrical to subcylindrical, hyaline, the first conidium produced holoblastically and subsequent conidia enteroblastically, (6–)10–11(–19.5) × (2–)3(–4)(–4.5) μm (av. = 10.3 × 3.3 μm). Conidia globose to subglobose to obovoid, (12–)14–17(–19) × (10–)11–12(–12.5) μm (av. of 50 conidia = 15.3 × 11.4 μm, L/W ratio = 1.3), with granular content, thick-walled (1–2 μm), initially unicellular, hyaline, becoming cinnamon to sepia, forming one septum and longitudinal striations with maturation.

Culture characteristics: Colonies initially white to smoke grey with woolly aerial mycelium, becoming pale olivaceous-grey within 5–7 d, olivaceous-grey to iron-grey with age, margins regular. Submerged mycelium dense, reverse grey olivaceous to olivaceous-black after 7 d, becoming black with age. Optimum growth at 30 °C, covering the 90 mm Petri dish after 3 d in the dark.

Type: Australia, Western Australia, Tunnel Creek Gorge, on *Adansonia gibbosa*, Jul. 2006, T.I. Burgess, holotype PREM 59844 (a dry culture of CMW 26162 on pine needles).
Cultures: CMW 26162 = CBS 122519 (ex-type), CMW 26163 = CBS 122065.

Host: Asymptomatic branches of Adansonia gibbosa (Pavlic et al. 2008).

Known distribution: Australia (Western Australia) (Pavlic et al. 2008).

Notes: The small sub-globose conidia clearly distinguish this species from all other species of L. mahajangana, and these two can be separated morphologically only on average conidial lengths (L. mahajangana = 17.5 μm, L. margaritacea = 15.3 μm). Phylogenetically, however, they are clearly two distinct species.

Lasiodiplodia missouriana Úrbez-Torres, Peduto & Gubler, Fungal Divers. 52: 181. 2012. MycoBank MB519954. See Úrbez-Torres et al. (2012) for illustrations.

Ascomata not reported. Conidiomata stromatic, superficial, formed on PDA within 2–3 wk, black, covered with mycelium, up to 320 μm diam, globose to ovoid, thick-walled, unilocular, with a central ostiole, often oozing conidia. Paraphyses hyaline, cylindrical, asperate, not branched, round at apex, up to 55 μm long, 2–3 μm wide. Conidiophores absent. Conidiogenous cells holoblastic, hyaline, not branched, round at apex, up to 55 μm long, 2–3 μm wide. Conidiomata produced in culture initially hyaline, unicellular, ellipsoid to ovoid, thick-walled (1–2 μm), contents granular, smooth, cylindrical. Produced in culture eventually hyaline and asperate and remaining so for a long time, becoming 1-septate and dark-walled only some time after release from the conidiomata, with melanin deposits on the inner surface of the wall arranged longitudinally giving a striate appearance to the conidia, (15.5–)16–23.5(–24.5) × (10–)10.5–13(–14.5) μm, 95% confidence limits = 19.8–20.5 × 11.4–11.7 μm (av. ± S.D. = 20.2 ± 1.9 × 11.5 ± 0.8 μm, L/W ratio = 1.8).

Culture characteristics: Colonies on PDA with moderately dense aerial mycelium, initially white becoming olivaceous-grey within 7 d and turning iron grey to greenish black within 28 d; reverse dark slate blue after 28 d. Colonies covering the dish on PDA after 48 h in the dark at 25 °C. Cardinal temperatures for growth: min 10 °C, max 35 °C, opt 25–30 °C.

Type: USA, Saint James, on Vitis vinifera × V. labrusca hybrid cv. Catawba, Jun. 2006, R.K. Striegler & G.M. Leavitt, holotype UCD2193MO.

Cultures: UCD2193MO = CBS 128311 (ex-type), UCD2199MO = CBS128312.

Hosts: Vitis spp. (Úrbez-Torres et al. 2012).

Known distribution: USA (Missouri) (Úrbez-Torres et al. 2012).

Notes: The small conidia of this species distinguish it morphologically from all others except L. hormozganensis and these two can be distinguished only by small differences in conidial widths (L. missouriana = 8–12 μm, L. hormozganensis = 11–14 μm). Nevertheless, phylogenetically they are clearly two distinct species.

Lasiodiplodia parva A.J.L. Phillips, A. Alves & Crous, Fungal Divers. 28: 9. 2007. MycoBank MB510942. Fig. 44.

Ascomata not reported. Conidiomata stromatic, formed on poplar twigs in culture, uniloculate, dark brown to black, immersed in the host becoming erumpent when mature. Paraphyses hyaline, cylindrical, septate, ends rounded, up to 105 μm long, 3–4 μm wide arising amongst the conidiogenous cells. Conidiophores absent. Conidiogenous cells hyaline, smooth, cylindrical, slightly swollen at the base, holoblastic, proliferating percurrently to form one or two annellations, or proliferating at the same level giving rise to periconidal thickenings. Conidia ovoid, apex broadly rounded, base rounded or truncate, widest in the middle or upper third, thick-walled, initially hyaline and asperate and remaining so for a long time, becoming 1-septate and dark-walled only some time after release from the conidiomata, with melanin deposits on the inner surface of the wall arranged longitudinally giving a striate appearance to the conidia, (15.5–)16–23.5(–24.5) × (10–)10.5–13(–14.5) μm, 95% confidence limits = 19.8–20.5 × 11.4–11.7 μm (av. ± S.D. = 20.2 ± 1.9 × 11.5 ± 0.8 μm, L/W ratio = 1.8).

Type: Colombia. Dep. Meta, Villavicencio, cassava field soil, 1978, O. Rangel, holotype CBS H-19915.

Cultures: CBS 456.78 (ex-type), CBS 494.78.

Hosts: Cassava-field soil, Theobroma cacao (Alves et al. 2008).

Known distribution: Colombia, Sri Lanka (Alves et al. 2008).

Notes: This species can be separated from its closest relatives, L. citricola, L. egypticae, L. hormozganensis and L. pseudotheobromae based on conidial and paraphyses dimensions. In terms of morphology it is similar to L. iraniensis and the two species can be separated only on the average width of conidia, but phylogenetically they are clearly distinct.

Lasiodiplodia plurivora Damm & Crous, Mycologia 99: 674. 2007. MycoBank MB501322. See Damm et al. (2007) for illustrations.

Ascomata not reported. Conidiomata stromatic, produced on pine needles on SNA within 2–4 wk, solitary, globose to ovoid, dark brown, up to 400 μm diam, embedded in needle tissue, semi-immersed, unilocular, with a central ostiole; wall 4–7 cell layers thick, outer layers composed of dark brown textura angularis, becoming thin-walled and hyaline toward the inner region. Paraphyses absent. Conidiogenous cells holoblastic, discrete, hyaline, cylindrical, proliferating percurrently several times near the apex, 8–13 × 4–7 μm. Paraphyses hyaline, cylindrical, 2–7-celled, the 1–3 basal cells often broader than the apical cells, apical cell with rounded tip, sometimes branched, up to 130 μm long, 2–5 μm broad at the upper part and up to 10 μm broad at the lower part (basal cells). Conidia initially asperate, thick-walled (≈ 3 μm), hyaline, ellipsoidal to obovate, sometimes somewhat irregular, with granular content, becoming 1-septate after release, brown, obovate, verruculose and with longitudinal striations, (22–)26.5–32.5(–35) × (13–)14.5–17(–18.5) μm (av. ± S.D. = 29.6 ± 2.9 × 15.6 ± 1.2 μm, L/W ratio = 1.9).

Culture characteristics: Colonies on PDA in the dark: mycelium and surface white to pale olivaceous-grey, reverse pale olivaceous-buff to pale grey-olivaceous, flat with undulate margins. Under near-ultraviolet light: mycelium and surface white to pale mouse-grey, reverse pale olivaceous-buff to smoke-grey. Colonies 76 mm after 2
d, reaching the edge the Petri dish after 3 d. Cardinal temperatures for growth: min 10 °C, max ≥ 35 °C, opt 30 °C.

**Type:** South Africa, Western Cape Province, Stellenbosch, from V-shaped necrotic lesion of *P. salicina*, May 2004, U. Damm, **holotype** CBS H-19844.

**Cultures:** CBS 120832 = STE-U 5803 (ex-type), CBS 121103 = STE-U 4583.

**Hosts:** *Prunus salicina*, *Vitis vinifera* (Damm et al. 2007).

**Known distribution:** South Africa (Western Cape Province) (Damm et al. 2007).

**Notes:** Phylogenetically this species is close to *L. gilanensis* and *L. missouriana*, but it can be separated from that species based on conidial dimensions and paraphyses length and shape. Conidia of *L. gilanensis* (av. = 29.6 × 15.6 μm) are larger than those of *L. missouriana* (av. = 18.5 × 9.8 μm), but compared to *L. gilanensis* they are slightly shorter. Moreover, paraphyses of *L. plurivora* (up to 130 μm) are longer than 100 μm, while in *L. gilanensis* and *L. missouriana* they are consistently less than 100 μm. In terms of morphology it is close to *L. citricola*, but conidia of *L. citricola* (av. = 24.5 × 15.4 μm) are quite small compared with *L. plurivora* (av. = 29.6 × 15.6 μm).

**Lasiodiplodia pseudotheobromae** A.J.L. Phillips, A. Alves & Crous, Fungal Divers. 28: 8. 2007. MycoBank MB510941. Fig. 45.

Ascomata not reported. Conidiomata stromatic, formed on poplar twigs in culture, uniloculate, dark brown to black, immersed in the host becoming erumpent when mature. Paraphyses hyaline, cylindrical, mostly aseptate, sometimes branched, ends rounded, up to 58 μm long, 3–4 μm wide arising amongst the conidiogenous cells. Conidiophores absent. Conidiogenous cells hyaline, smooth, cylindrical, slightly swollen at the base, holoblastic, proliferating percurrently to form one or two closely spaced annellations. Conidia ellipsoidal, apex and base rounded, widest at the middle, thick-walled, initially hyaline and aseptate and remaining so for a long time, becoming 1-septate and dark brown only some time after release from the conidiomata, with melanin deposits on the inner surface of the wall arranged longitudinally giving a striate appearance to the conidia, (22.5–)23.5–32(–33) × (13.5–)14–18(–20) μm, 95 % confidence limits = 27.5–28.5 × 15.5–16.5 μm (av. ± S.D. = 28.0 ± 2.5 × 16.0 ± 1.2 μm, LW ratio = 1.7).

**Type:** Costa Rica, San Carlos, on *Gmelina arborea*, J. Carranza-Velazquez, **holotype** CBS H-19916.

**Cultures:** CBS 116459 (ex-type), CBS 447.62.

**Hosts:** *Acacia mangium*, *Citrus aurantium*, *Coffea* sp., *Gmelina arborea*, *Rosa* sp. (Alves et al. 2008).
Known distribution: Costa Rica, Netherlands, Suriname, Zaire (Alves et al. 2008).

Notes: This species can be separated from its closest relatives, L. citricola, L. egypticae, L. hormozganensis and L. parva and as previously mentioned under L. plurivora. In terms of morphology it is close to L. crassispora but the two species differ in that the pseudoparaphyses of L. crassispora are mostly septate, while in L. pseudotheobromae they are mostly aseptate.

Lasiodiplodia rubropurpurea Burgess, Barber & Pegg, Mycologia 98: 431. 2006. MycoBank MB500236. See Burgess et al. (2006) for illustrations.

Ascomata not reported. Conidiomata stromatic, superficial, globose, red to dark vinaceous, mostly solitary, 0.5–1.5 mm diam and covered with mycelium. Paraphyses cylindrical, aseptate, hyaline (30–)32–52(–58) × 1.5–3.5 μm (av. of 50 paraphyses = 42.4 × 2.6 μm). Conidiophores reduced to conidiogenous cells. Conidiogenous cells holoblastic, hyaline, subcylindrical to ampulliform, 7–13(–15) × 3–5 μm (av. of 50 conidiogenous cells = 10.2 × 4 μm), proliferating percurrently with a single annellation. Conidia initially hyaline, unicellular, ellipsoid to obovoid, thick-walled (1 μm) with granular contents, rounded at apex, occasionally truncate at base, initially hyaline and unicellular, becoming pigmented with one septum when mature or before germination, longitudinal striations observed at maturation, 24–33 × 13–17 μm (av. of 100 conidia = 28.2 × 14.6 μm, L/W ratio = 1.9).

Culture characteristics: Colonies moderately dense, with appressed mycelial mat, colonies initially white to buff turning to pale olivaceous-grey within 7 d and becoming darker with age. After 7 d submerged mycelia olivaceous-grey, becoming black with age. Optimum temperature for growth 25–30 °C, reaching 76 mm on PDA after 3 d at both 25 °C and 30 °C in the dark.

Type: Australia, Queensland, Tully, from canker on Eucalyptus grandis, May 2003, T.I. Burgess, holotype MURU 409.

Cultures: WAC12535 = CMW 14700 = CBS 118740 (ex-type), WAC12536 = CMW 15207.

Host: Eucalyptus grandis (Burgess et al. 2006).

Known distribution: Australia (Queensland) (Burgess et al. 2006).

Note: The red-purple conidiomata of L. rubropurpurea are unique in this genus and distancing it from all other species (Burgess et al. 2006).

Lasiodiplodia theobromae (Pat.) Griff. & Maubl., Bull. Soc. Mycol. Fr. 25: 57. 1909. MycoBank MB188476. Fig. 46, Basionym: Botryodiplodia theobromae Pat., Bull. Soc. Mycol. Fr. 8: 136. 1892.

≡ Diplodia theobromae (Pat.) W. Nowell, Diseases of Crop Plants in the Lesser Antilles: 158. 1923.
≡ Sphaeria glandicola Schwein., Trans. Am. phil. Soc., Ser. 2 4(2): 214. 1832.
≡ Physalospora glandicola (Schwein.) N.E. Stevens, Mycologia 25: 504. 1933.
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Physalospora rhodina Berk. & M.A. Curtis, Grevillea 17: 92. 1889.
≡ Botryosphaeria rhodina (Berk. & M.A. Curtis) Arx, Gen. Fungi Sporul. Cult. (Lehr): 143. 1970.
≡ Diplodia gossypina Cooke, Grevillea 7: 95. 1879.
≡ Macrophoma vestita Prill. & Delacr., Bull. Soc. Mycol. Fr. 10: 165. 1894.
≡ Diplodia caecaicola Henn., Bot. Jb. 22: 80. 1895.
≡ Lasiodiplodia tubercicola Ellis & Everh., Bot. Gaz. 21: 92. 1896.
≡ Diplodia tubercicola (Ellis & Everh.) Taubenr., Am. J. Bot. 2: 328. 1915.
≡ Botryodiplodia tubercicola (Ellis & Everh.) Petr., Ann. Mycol. 21: 332. 1923.
≡ Botryodiplodia gossypii Ellis & Barth., J. Mycol. 8: 175–176. 1902.
≡ Botryodiplodia elasticae Petch., Ann. R. Bot. Gdns Peradeniya 3: 7. 1906.
≡ Diplodia arachidis Petch., Ann. R. Bot. Gdns Peradeniya 3: 6. 1906.
≡ Chaetodiplodia grisea Petch., Ann. R. Bot. Gdns Peradeniya 3: 6. 1906.
≡ Lasiodiplodia nigra Appel & Laubert, Biol. Anst. Ld.-u. Forsch. 5: 147. 1907.
≡ Diplodia rapax Massree, Bull. Misc. Inf. Kew. 3. 1910.
≡ Diplodia natalensis Pole-Evans Transvaal Dept. of Agricult. Sci. Bull. 4: 15. 1911 (1910).
≡ Diplodia manihoti Sacc. (as “maniothi”), Ann. Mycol. 12: 310. 1914.
≡ Botryodiplodia manihoti (Sacc.) Petr. (as “maniothi”), Ann. Mycol. 22: 83. 1924.
≡ Botryodiplodia manihotis Syd. & P. Syd., Ann. Mycol. 14: 202. 1916.
≡ Diplodia corchorii Syd. & P. Syd., Ann. Mycol. 14: 196. 1916.
≡ Diplodia musae Died., Ann. Mycol. 14: 200. 1916.
≡ Lasiodiplodia frigidae B.B. Higgins, Bull. Georgia Exp. Stn 118: 16. 1916.
≡ Diplodia ananassae Sacc., Atti R. Sci. Ven-Trefl-Inst. 10: 75. 1917.
≡ Botryodiplodia ananassae (Sacc.) Petr., Ann. Mycol. 27: 365. 1929.
≡ Physalospora gossypina N.E. Stevens, Mycologia 17: 198. 1925.
≡ Botryodiplodia manihoticola Petr., In: Petrak & Syd., Feddes Repert., Beih. 42: 143. 1926.

Ascomata dark brown to black, aggregated, thick-walled, wall composed of dark brown, thick-walled textura angularis, becoming thinner and hyaline towards the inner layers, 250–400 μm diam. Asci bitunicate, clavate, stipitate, 8-spored, 90–120 μm long. Ascospores irregularly biseriate, hyaline, aseptate (24–)30–35–42 × (7–)11–14–17 μm. Conidiomata stromatic, simple or aggregated, immersed in the host becoming erumpent when mature, dark brown, unilocular, thick- or thin-walled, wall formed of dark brown thick-walled textura angularis, frequently setose, up to 5 mm wide, ostiole central, single, papillate. Paraphyses hyaline, cylindrical, septate, occasionally branched, ends rounded, up to 55μm long, 3–4 μm wide. Conidiophores hyaline, simple, sometimes septate, rarely branched, cylindrical, arising from the inner layers of...
cells lining the locules. Conidiogenous cells hyaline, thin-walled, smooth, cylindrical to sub-oblanceolate, holoblastic, discrete, determinate or indeterminate and proliferating percurrently with one or two distinct anellations, or proliferating at the same level, giving rise to periclinally thickened. Conidia subovoid to ellipsoid-ovoid, apex broadly rounded, tapering to truncate base, widest in middle to upper third, thick-walled, contents granular, initially hyaline and aseptate, remaining hyaline for a long time, becoming dark brown and 1-septate only a long time after discharge from the conidiomata, with melanin deposits on the inner surface of the wall arranged longitudinally giving a striate appearance to the conidia, (19–)21.5–31.5(–32.5) × (12–)13–17 (–18.5) μm, 95% confidence limits = 26.2–27 × 14–14.4 μm (av. ± S.D. = 26.2 ± 2.6 × 14.2 ± 1.2 μm, L/W ratio = 1.9).

Type: Ecuador, on Theobroma cacao, Lagerheim, holotype not found, and presumably lost. Papua New Guinea, Madang, Jais Aben, from unidentified fruit along coral reef coast, No. 1995, A. Aptroot, CBS H-21411, neotype designated here; MBT176098, culture ex-neotype CBS 164.96.

Cultures: CBS 164.96 (ex-neotype), CBS 111530.

Hosts: Punithalingam (1976) refers to a wide host range. Considering that the original concept of L. theobromae now refers to a complex of species (Alves et al. 2008), many of the older records of this fungus are unreliable.

Known distribution: Widely distributed in tropical and subtropical regions (Punithalingam 1976).

Notes: Botryodiplotia theobromae was originally described from Theobroma cacao in Ecuador. In spite of searching through the literature and many herbaria, we have been unable to locate the holotype specimen. In recent years numerous new species have been described, but in spite of this, the generic application of L. theobromae has not been resolved. To address this issue, we thus designate CBS 164.96 as ex-neotype culture, and have deposited a dried specimen as neotype. Although this isolate, from an unidentified fruit on a coral reef coast in Papua New Guinea, is from neither the type locality (Equador) nor the type substrate (cocoa plant), it has long been regarded as a reference strain for L. theobromae. For this reason we consider that it best serves to stabilise this species by continuing to use this isolate as a reference strain and to elevate its status to ex-neotype.

The connection between L. theobromae and its sexual morph has not been proven conclusively. Stevens (1925) made single ascospore cultures from a fungus that he referred to as Physalospora gossypina on cotton stems in Florida, and from Hicoria, Ilex, Liquidambar, Quercus and Vitis. In all cases the conidia formed in these cultures were morphologically identical to those of L. theobromae. Stevens (1926) then determined that the fungus he called P. gossypina was in fact Physalospora rhodina Cooke, which was later transferred by von Arch (1970) to Botryosphaeria as B. rhodina (Cooke) Arch. However, there have been no subsequent reports to confirm this connection, leaving some doubts about its authenticity. Thus the connection between the sexual morph and asexual morph has not been established beyond all doubt and the value of the above description of the sexual morph is questionable. Phylogenetically this species is close to L. mahajangana, but it is easily separated by its larger conidia (av. = 26.2 × 14.2 μm) compared with L. mahajangana (av. = 17.5 × 11.5 μm). In terms of morphology L. theobromae is similar to L. rubropurpurea, but it differs from L. rubropurpurea by the absence of red-purple conidiomata. Moreover, conidial length of this species (av. length = 26.2 μm) is slightly shorter than in L. rubropurpurea (av. length = 28.2 μm).

Lasiodiplodia venezuelensis T.I. Burgess, Barber & Mohali, Mycologia 98: 432. 2006. MycoBank MB500237. See Burgess et al. (2006) for illustrations.

Ascomata not reported. Conidiomata stromatic, superficial, smooth, cylindrical, mostly solitary, 0.5–1 mm diam, often oozeering immature conidia. Paraphyses cylindrical, septate, hyaline (12–)16–41(–45) × (1.5–)2–5 μm (av. of 50 paraphyses = 28.3 × 3.5 μm). Conidiophores absent. Conidiogenous cells holoblastic, hyaline, subcylindrical to cylindrical to ampulliform, (5–)7–14(–15) × 3–4.5(–5), proliferating percurrently. Conidia initially hyaline, unicellular, ellipsoid to obovoid, thick-walled (1.5–)2.5(–3) μm, av. of 50 conidia = 1.96 μm) with granular contents, rounded at apex, occasionally truncate at base, becoming pigmented with one septum when mature or before germination, developing longitudinal striations when mature, 26–33 × 12–15 μm (av. of 75 conidia = 28.4 × 13.5 μm, L/W ratio = 2.1).

Culture characteristics: Colonies moderately dense, with appressed mycelial mat, initially white to buff turning pale olivaceous-grey within 7 d and becoming darker with age. After 7 d submerged mycelia olivaceous-grey, becoming black with age. Optimum temperature for growth 25 °C, reaching 75 mm on PDA after 3 d at 25 °C in the dark.

Type: Venezuela, Estado Portuguesa, Acarigua, from wood of living Acacia mangium, Oct. 2003, S. Mohali, holotype MURU 413.

Cultures: WAC12539 = CMW 13511 = CBS 118739 (ex-type), WAC12540 = CMW 13512.

Host: Acacia mangium (Burgess et al. 2006).

Known distribution: Venezuela (Burgess et al. 2006).

Notes: Phylogenetically, this species is closely related to L. crassispora and L. rubropurpurea, but can be distinguished from L. rubropurpurea by the absence of red-purple conidiomata. Furthermore, conidia of L. venezuelensis are narrower (av. = 28.4 × 13.5 μm) than those of L. crassispora (av. = 28.8 × 16 μm). In terms of morphology this species is similar to L. viticola, but conidia of L. venezuelensis (av. = 28.4 × 13.5 μm) are considerably larger than those of L. viticola (av. = 19.5 × 9.5 μm).

Lasiodiplodia viticola Úrbez-Torres, Peduto & Gubler, Fungal Divers. 52: 183. 2011. MycoBank MB519966. See Úrbez-Torres et al. (2010) for illustrations.

Ascomata not reported. Conidiomata stromatic, solitary, formed on PDA within 3–4 wk, black, covered with moderately dense mycelium, up to 900 μm wide, globose to ovoid, thick-walled, unilocular, with a central ostiole, often oozeering conidia. Paraphyses hyaline, cylindrical, aseptate, not branched, round at apex, up to
60 μm long, 2–3 μm wide. Conidiophores absent. Conidiogenous cells holoblastic, hyaline, smooth, cylindrical. Conidia produced in culture initially hyaline, uniseriate, ellipsoidal, base rounded or truncate, thick-walled (1–2 μm), granular content, becoming dark brown, 1-septate, with longitudinal striations while still inside the conidiomata, (16.5–18–20.5(–23) × (8–9–10.1(–10.5) μm (av. of 60 conidia = 19.5 × 9.5 μm, L/W ratio = 2.05). Colonies on PDA with dense aerial mycelium, mycelium initially white becoming pale olive-buff within 7 d and turning iron grey to greenish black within 28 d, reverse dark slate blue after 28 d, reaching 90 mm on PDA after 48 h in the dark at 25 °C. Cardinal temperatures for growth: min 10 °C, max 35 °C, opt 25–30 °C.

Type: USA, Arkansas, Altus, on interspecific hybrid grape Vignoles cv. Ravat 51R, D. Cartwright & W. D. Gubler, holotype UCD2553AR.

Cultures: UCD2553AR = CBS 128313 (ex-type), UCD2604MO = CBS 128314.

Hosts: Vitis hybrids (Úrbez-Torres et al. 2010).

Known distribution: USA (Arkansas and Missouri) (Úrbez-Torres et al. 2010).

Note: Phylogenetically this species is closely related to L. mahajangana, L. theobromae and L. iraniensis, but can be easily distinguished based on conidial and paraphyses dimensions (see notes for L. iraniensis).

Macrophomina Petr. Ann. Mycol. 21: 314. 1923. MycoBank MB8814.

Type species: Macrophomina phaseolina (Tassi) Goid., Annali Sper. agr. N.S. 1: 457. 1947.

Mycelium superficial or immersed, brown to hyaline, branched, septate, often dendroid in culture. Ascomata not reported. Conidiomata pycnidial, stromatic, separate, globose, dark brown, immersed, unilocular, thick-walled, wall consisting of an outer layer of dark brown thick-walled texture angularis, becoming hyaline towards the inside. Ostiole central, circular, papillate. Conidiophores absent. Conidiogenous cells enteroblastic, phialidic, determinate, discrete, reduced to conidiogenous cells, holoblastic, hyaline, aseptate, cylindrical to sub-cylindrical. Conidia hyaline, aseptate, cylindrical to sub-cylindrical.

Note: Of the five species listed in MycoBank, only one (M. phaseolina) is known in culture.

Macrophomina phaseolina (Tassi) Goid., Annali Sper. agr. N.S. 1: 457. 1947. MycoBank MB300023. See Crous et al. (2006) for illustrations.

Basionym: Macrophoma phaseolina Tassi, Bull. Lab. Ort. bot. Siena 4: 9. 1901.

≡ Tiarosporella phaseolina (Tassi) Aa, Ir. von Arx, Gen. Fungi Sporul. Cult., Edn 3 (Vaduz): 208. 1981.

Additional synonyms listed by Holiday & Punithalingam (1988).

Sclerotia occurring in host tissue or in soil, black, smooth, hard, 100–1000 μm diam. Ascomata not reported. Conidiomata pycnidial, stromatic, dark brown to black, solitary or gregarious, up to 200 μm diam, opening by a central ostiole, wall multilayered, cells dark brown, thick-walled. Conidiophores reduced to conidiogenous cells that are arranged along the inner lining of the conidioma, hyaline, short obpyriform to sub-cylindrical, proliferating several times percurrently near the apex, 6–12 × 4–6 μm, young conidiogenous cells having a mucous layer that extends over the apex of the developing conidium. Conidia ellipsoid to obovoid, (16–20–24–32) × (6–7–9–11) μm; immature conidia hyaline, enclosed in a mucous sheath that upon dehiscence encloses the top half of the conidium, becoming two lateral tentaculiform, apical mucoid appendages (type C, Nag Raj 1993); mature conidia becoming medium to dark brown, with a granular outer layer that in some cases appears pitted, without any mucoidal appendages; conidium hilum frequently with a marginal frill.

Cultures: Niger, Vigna minima, M. Ndiaye, CPC 11052, 11070. Senegal, soil, M. Ndiaye, CPC 11079, 11105, 11106, 11108. Uganda, Eucalyptus sp., Jan. 1925, CBS 162.25; Unknown, Zea mays, Jun. 1933, S.F. Ashby, CBS 227.33.

Hosts: Plurivorous.

Known distribution: Cosmopolitan.

Notes: Although Macrophomina phaseolina can have apical mucoid appendages as found in Tiarosporella (Sutton & Marasas 1976), it is distinguished by having percurrently proliferating conidiogenous cells, which are not seen in any species of Tiarosporella sensu Nag Raj (1993), nor in those investigated by Crous et al. (2006), and conidia that become dark brown at maturity, and the presence of microsclerotia. Based on these differences (and in the absence of authentic cultures of T. paludosa), Crous et al. (2006) chose to retain the genus Macrophomina and the name M. phaseolina.

Neodeightonia Booth, in Punithalingam, Mycol. Pap. 19: 17. 1970 [1969]. MycoBank MB3450.

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

Ascostomata immersed, dark brown to black, with a single aparyaphysate locule, wall composed of pseudoparenchymatous cells many layers thick, asci developing amongst partially disintegrating sterile thin-walled tissue in locule. Neck of ascostomata narrow, opening by an apical ostiole, formed by the disintegration of the central thin-walled cells. Pseudoparaphyses hyphae-like, septate, constricted at the septa. Asci parallel, more or less separated from one another by stromatic tissue, clavate to cylindric-clavate, 8-spored, bitunicate with a thick endotunica. Ascospores biseriate, initially hyaline, brown when mature, oval to broadly ellipsoidal with a single transverse septum, surrounding or not by a mucilaginous sheath. Conidiomata brown to black, solitary or aggregated, sometimes intermixed with ascomata, globose, uni- to multicellular, stromatic, wall composed of dark-brown thick-walled texture angularis. Paraphyses absent. Conidiogenous cells holoblastic, hyaline, aseptate, cylindrical to sub-cylindrical. Conidia spherical to globose, initially hyaline, pale to dark brown when mature, thick-walled, smooth to finely rough-walled with fine striations.
Notes: *Neodeightonia* was introduced by Booth (Punithalingam 1969). Von Arx & Müller (1975) transferred *N. subglobosa* to *Botryosphaeria*, and because this is the type species of the genus, they reduced *Neodeightonia* to synonymy under *Botryosphaeria*. However, morphologically (based on the dark, 1-septate ascospores) and phylogenetically (Phillips et al. 2008), this genus is distinguishable from *Botryosphaeria*, and the genus was reinstated by Phillips et al. (2008). Punithalingam (1969) referred to germ slits in the conidia. Crous et al. (2006) suggested that these were in fact striations on the conidial wall, and that more than one could occur per conidium, a feature confirmed by Phillips et al. (2008). The striate walls suggest an affinity to *Lasiodiplodia*. Nevertheless, *Neodeightonia* can be distinguished from *Lasiodiplodia* by the absence of conidiomatal paraphyses. Thus, conidial striations distinguish *Neodeightonia* from *Diplodia*, and the absence of conidiomatal paraphyses distinguishes it from *Lasiodiplodia*.

**DNA phylogeny**

The three species fall in three clades with *N. palmicola* distantly related to the other two known species (Fig. 47).

**Key to Neodeightonia** spp.

The three species known in culture can be separated on conidial length:

1. Conidia less than 15 μm long, 9–12 μm long .......................................................... .............................. *N. subglobosa*
2. Conidia longer than 15 μm .................................................................................. 2
3. Conidia 15.5–21.5 μm long .................................................................................. *N. phoenicum*
4. Conidia never shorter than 17 μm, 17.5–24.5 μm long ........................................... *N. palmicola*

**Species descriptions**

*Neodeightonia palmicola* J.K. Liu, Phookamsak & K.D. Hyde, Sydowia 62: 268. 2010. MycoBank MB518804. Fig. 48.

Ascomata uniloculate, immersed to erumpent in host tissue, globose to subglobose, brown to dark brown, rounded at the base, 180–230 μm high (excluding the neck), 270–420 μm diam. Ostiole circular, central, papillate. Peridium 26–55 μm wide, comprising several layers of brown-walled cells, the outer stratum of 1–3 cells comprising thick, dark brown walls, the inner layer 3–5 cells, *textura angularis* comprising pale brown to hyaline, thin-walled cells. *Pseudoparaphyses* thin-walled, hyaline, frequently septate, often constricted at the septa, up to 3–5 μm diam. *Asci* 8-spored, bitunicate, fissitunicate, with thick endotunica, clavate to cylindrical-clavate, stipitate, apically rounded, with a well-developed ocular apical chamber, arising from the base of ascoma, (80–)110–210(–225) × 17–22.5(–24) μm (av. = 154.2 × 20.5 μm). Ascospores obliquely uniseriate or irregularly biseriate, ellipsoidal-fusiform or fusiform, widest in the middle, both ends obtuse, 1-celled, aseptate, hyaline, smooth, thin-walled, with bipolar germ pores, surrounded by a wing-like hyaline sheath, 23–31.5 × 8.5–12.5 μm (av. = 27 × 10 μm). *Conidioma* (formed on WA on sterilised pine needles within 21–28 d) 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. *Conidiogenous cells* holoblastic, cylindrical to subcylindrical, hyaline, 9–20 × 3–6 μm. *Conidia* initially hyaline, unicellular, ellipsoid to obovoid, thick-walled with granular content, rounded at apex, occasionally truncate at base, aging conidia becoming cinnamon to sepia, forming a single septum, 17.5–24.5 × 9.5–12.5 μm (av. of 50 conidia = 21.5 × 11.0 μm).

**Type**: Thailand, Chiang Rai, Muang District, Khun Kom Waterfall, on dead leaves of *Arenga westerhoutii*, 18 Dec. 2009, Jian-Kui Liu, holotype MFLU10 0407.

**Culture**: MFLUCC10 0822 = CBS 136074 (ex-type).

**Host**: *Arenga westerhoutii* (Liu et al. 2010).

**Known distribution**: Thailand (Liu et al. 2010).

**Notes**: This species is unusual in having ascospores surrounded by a mucilaginous sheath and pycnidial paraphyses, features not seen in other species of *Neodeightonia*. Furthermore, there are no striations on the conidia and it is also phylogenetically somewhat divergent from other *Neodeightonia* species.
Neodeightonia phoenicum  A.J.L. Phillips & Crous, Persoonia 21: 43. 2008. MycoBank MB511708. Fig. 49.
≡ Diplodia phoenicum (Sacc.) H.S. Fawc. & Klotz, Bull. Calif. Agric. Exp. Sta. 52: 8. 1932.
≡ Sirophomadiploidea phoenicum (Sacc.) Zambett., Bull. trimest. Soc. mycol. Fr. 70: 235. 1955 (1954).

Ascomata not reported. Conidiomata formed on pine needles in culture pycnidial, stromatic, multiloculate, dark brown to black, immersed in the host becoming erumpent when mature. Paraphyses absent. Conidiogenous cells hyaline, smooth, cylindrical, swollen at the base, holoblastic, proliferating percurrently to form one or two annellations, or proliferating at the same level giving rise to periclinal thickenings. Conidia ovoid to ellipsoid, apex and base broadly rounded, widest in the middle to upper third, thick-walled, initially hyaline and aseptate, becoming brown and 1-septate some time after discharge from the pycnidia, with melanin deposits on the inner surface of the wall arranged longitudinally giving a striate appearance to the conidia, (14.5–)15.5–21.5(–24) × (9–)10–12(–14) μm, 95 % confidence limits = 18.6–19.5 × 11.2–11.8 μm (av. ± S.D. = 19.1 ± 1.7 × 11.5 ± 1.1 μm), L/W ratio = 1.7.

Type: Spain, Catalonia, Tarragona, Salou, on Phoenix sp., F. Garcia, holotype CBS H-20108.

Cultures: CBS 122528 (ex-type), CBS 123168, CBS 169.34.

Hosts: Phoenix spp. (Phillips et al. 2008).

Known distribution: Spain, USA (California) (Phillips et al. 2008).

Neodeightonia subglobosa  C. Booth, Mycol. Pap. 119: 19. 1970 (1969). MycoBank MB318601. Fig. 50.
≡ Sphaeropsis subglobosa (C. Booth) Arx & E. Müll., Stud. Mycol. 9: 15. 1975.
≡ Sphacelotheca subglobosa Cooke, Grevillea 7: 95. 1879.
≡ Macrodidiplodia globulosa (Cooke) Kuntze, Revis. gen. pl. 3: 492. 1898.
≡ Coniothyrium globulosa (Cooke) Tassi, Bulletin Labor. Orto Bot. de R. Univ. Siena 5: 25. 1902.

Ascomata immersed, up to 300 μm wide, dark brown to black with a single locule, aparaphysate, locule filled with disintegrating sterile thin-walled tissue, amongst which the asci develop, neck narrow, cone-shaped, opening by an apical ostiole. Asci bitunicate, clavate, with well-developed apical chamber, 110–140 × 16–20 μm, 8-spored. Ascomata hyaline, aseptate, becoming brown and 1-septate, ovoid to broadly ellipsoidal, smooth or with a finely roughened surface, 20–26 × 7–10 μm. Conidiomata brown to black, solitary or aggregated, sometimes intermixed with ascomata, globose, uni- to multicellular, stromatic, up to 200 μm broad. Paraphyses absent. Conidiogenous cells holoblastic, simple, hyaline. Conidia spherical to globose, pale to dark brown when mature, smooth to finely rough-walled, 9–12 × 6–9 μm.

Type: Sierra Leone, Njala (Kori), on dead culms of Bambusa arundinacea, 17 Aug. 1954, F.C. Deighton, holotype IMI 57769(f).

Culture: CBS 448.91 (ex-type).

Host: Bambusa arundinacea (Punithalingam 1969).

Known distribution: Sierra Leone (Punithalingam 1969).

Notes: According to Phillips et al. (2008) the type specimen of Neodeightonia subglobosa contains only immature asci with hyaline ascospores. However, Punithalingam (1969) clearly described and illustrated the ascospores as brown and 1-septate. According to Punithalingam (1969) this species is homothallic and forms asci in culture.

Neofusicoccum  Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 247. 2006. MycoBank MB500870.

Type species: Neofusicoccum parvum (Pennycook & Samuels) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 248. 2006.

Synasexual morph: Dichomera-like.

Notes: Neofusicoccum was introduced by Crous et al. (2006) for species that are morphologically similar to, but phylogenetically distinct from Botryosphaeria and thus could no longer be accommodated in that genus. Morphologically Neofusicoccum...
resembles Botryosphaeria and it can be difficult to separate the two genera. The presence of a Dichomera synasexual morph in Neofusicoccum has been used to differentiate it from Botryosphaeria. However, not all Neofusicoccum species, or even
all isolates of any given species form such a synasexual morph, and some isolates of B. dothidea have been reported to form dichomera-like conidia (Phillips et al. 2005, Barber et al. 2005). Paraphyses have not been reported in conidiomata of any Neofusicoccum species, but have been seen in most of the currently accepted Botryosphaeria species. However, the similarity of paraphyses to developing conidigenous cells makes this feature difficult to apply as a general rule to separate the two genera. Conidial L/W ratios of the fusicoccum-like state are normally less than 4 and the conidia are more ellipsoidal than in the definitely fusiform ones of Fusicoccum s. str.

Currently 22 species are recognised in Neofusicoccum and they have been separated on the basis of conidial dimensions and pigmentation, pigment production in culture media and ITS sequence data, although taxonomic significance of some of these characters have recently been questioned (Abdollahzadeh et al. 2013). Species in some of the species complexes are morphologically indistinguishable and are defined almost exclusively on sequence of ITS often together with loci of other genes. In some cases, multi-gene sequence data are essential to unambiguously identify the species.

Species in Neofusicoccum appear to be evolving quite rapidly and this is reflected in the appearance of distinct groups of isolates in various geographic regions with fixed nucleotide differences in ITS and EF1-α and other regions of the genome. Some have already been described as new species (Pavlic et al. 2009) while others are regarded as local variants (e.g. Lazzizera et al. 2008, Spagnolo et al. 2010). Many of the species in Neofusicoccum are morphologically similar and can be very difficult to distinguish from one another. Neofusicoccum species are notoriously variable and the full range of variability within species has not been determined for most of the species. Nevertheless, an attempt has been made to differentiate all species in the key presented here, but it must be stressed that the outcome should be checked carefully against the description of that species. Host association has been used in this key for some species that have thus far not been found on any other host. However, it must be borne in mind that this apparent host specialisation may not be absolute. For example, N. vitisifforme was originally considered to be restricted to Vitis (van Niekerk et al. 2004), but was later isolated from rotting olive drupes in Southern Italy (Lazzizera et al. 2008) and shown to be pathogenic on that host. Some species may well be truly host specific, such as N. arbuti (Farr et al. 2005) and N. protearum (Denman et al. 2003), which have not yet been found on any other host since they were first described.

Some species can be determined relatively easily. For example, the conidia of N. macroclavatum and N. pennatosporum are far longer than any other species in the genus and these two species are easily differentiated on the shape and dimensions of their conidia.

**Key to Neofusicoccum spp.**

| 1. Average length of conidia 30 μm or more | N. pennatosporum |
| 2. Conidia fusiform, up to 50 μm long | N. macroclavatum |
| 3. Average length of conidia 25 μm or more | N. andinum |
| 4. Average conidial width less than 6 μm | N. eucalypticola |
| 5. On Eucalyptus spp. | N. grevilleae |
| 6. On hosts other than Eucalyptus | N. protearum |
| 7. Average length of conidia 20 μm or more | N. mediterraneum |
| 8. Conidial L/W ratio 4 or more | N. cordaticola |
| 9. Average conidial width 6 μm, L/W ratio 4 | N. australe |
| 10. No yellow pigment, on Syzygium cordatum | N. nonquaeus |
13. Broad host range, average conidial width less than 6 μm .................................................................................................................. N. ribis
13. Narrow host range, average conidial width greater than 6 μm ............................................................................................................ N. arbuti
14. On Syzygium cordatum, from South Africa ................................................................................................................................................ N. kwambonambiense
14. On hosts other than Syzygium, from outside Africa .............................................................................................................................. N. arbuti
15. Average conidial length less than 15 μm .................................................................................................................................................. N. mangiferae
15. Average conidial length greater than 15 μm .......................................................................................................................................... N. umdonicola
16. Conidial L/W ratio less than 3 .............................................................................................................................................................. N. vitisclavatum
17. Conidia fusoid to ovoid, L/W ratio 2.9 ....................................................................................................................................................... N. batangarum
17. Conidia ellipsoid to clavate, L/W ratio 2.4 ............................................................................................................................................... N. viticlavatum
18. Average conidial length less than 18 μm ............................................................................................................................................... N. parvum
18. Average conidial length greater than 18 μm ........................................................................................................................................... N. occulatum
19. Yellow pigment on PDA ........................................................................................................................................................................ N. luteum
19. No yellow pigment ................................................................................................................................................................................. N. umdonicola
20. Conidia L/W ratio 3.3 ................................................................................................................................................................................ N. vitifusiforme
20. Conidia L/W ratio 3.5 ................................................................................................................................................................................ N. vitifusiforme
21. Conidia fusiform to oval, average length greater than 19 μm ........................................................................................................... N. umdonicola
21. Conidia fusiform to ellipsoid, average length less than 19 μm ........................................................................................................ N. occulatum

Notes: In this key we have used conidial morphology and dimensions, cultural characteristics, host association and geographic distribution to separate all the 22 described Neofusicoccum species. But, it is important to consider that there is overlap between species in some of those characters. Furthermore, some characters are not stable between populations or individuals of a given species. For example, not all isolates of N. luteum and N. australe produce a yellow pigment in culture media and recently we found this pigment production in some isolates of N. parvum. Thus, definitive identification of most of the species is dependent on the use sequence data for the ITS region alone, or more often in combination with EF1-α sequence data.

DNA phylogeny

Phylogenetic analyses were done using ITS alone and ITS combined with EF1-α. No EF1-α sequences are available for N. protearum, N. corticosae and N. grevilleae. Thus, the phylogenetic position of these species was deduced based on ITS phylogeny. Phylogenetic analysis using ITS sequence data revealed 21 Neofusicoccum species (Fig. 51). With the exception of N. ribis and N. occulatum, all of the species in the N. ribis / N. parvum species complex can be separated based on ITS alone (Fig. 51). However, the bootstrap support was quite low for most of them. In the ITS phylogeny, D. eucalypti and N. corticosae were grouped with N. vitifusiforme in a single clade but with only 63 % support. On the other hand, in the phylogenetic analysis based on ITS and EF1-α, D. eucalypti was grouped with N. vitifusiforme (Fig. 52), which suggests that D. eucalypti is a synasexual morph of N. vitifusiforme. Despite the absence of N. corticosae in the ITS/EF1-α phylogeny, in the ITS phylogenetic tree it is clear that N. corticosae is a synonym of N. vitifusiforme.

Species descriptions

Neofusicoccum andinum (Mohali, Slippers & M.J. Wingf.) Mohali, Slippers & M.J. Wingf., Stud. Mycol. 55: 247. 2006. MycoBank MB500871. See Mohali et al. (2006) for illustrations. Basionym: Fusicoccum andinum Mohali, Slippers & M.J. Wingf., Mycol. Res. 110: 408. 2006. Ascomata not reported. Conidiomata stromatic, superficial, produced abundantly on the surface of MEA at 25 °C, oozing conidia after 30 d at 25 °C on MEA, solitary or botryose, globose, (331–)374–597–(740) × (302–)339–557–(671) μm (av. of 50 conidiomata = 486 × 484 μm); conidiomata wall, composed of brown textura angularis, 6–8 cell layers thick. Conidiogenous cells holoblastic, hyaline, smooth, cylindrical, producing a single apical conidium, proliferating enteroblastically, (8–)11–17–(23) × (1.5–)2.5–(3) μm. Conidia hyaline, granular, clavate to slightly navicular, apex obtuse and base truncate, 0–1 septa, (19–)23–31–(40) × (4–)5–6–(8) μm (av. of 50 conidia = 27 ± 5.5 mm), L/W ratio = 4.84. Dichomera synasexual morph not reported.

Culture characteristics: Colonies on MEA at 25 °C in darkness for 15 d fluffy and flat becoming pale olivaceous-grey (surface) and olivaceous buff (reverse), producing columns of mycelium reaching the Petri dish lid after 30 d at 25 °C, reaching 80 mm diam on MEA after 4 d in the dark at 25 °C. Cardinal temperatures for growth: min 15 °C (reaching an average 24 mm diam), max < 35 °C, opt 20–30 °C.

Type: Venezuela, Mérida State, Merida, Mucuchies (3140 m), Cordillera of Los Andes, on branches of Eucalyptus sp., Feb. 2003, S. Mohali, holotype PREM 58238.
Fig. 51. Single most parsimonious tree obtained from ITS sequence data of Neofusicoccum species. MP bootstrap values from 1000 pseudoreplicates are given at the nodes. The tree is rooted to Botryosphaeria dothidea (CBS 115476) and B. corticis (CBS 119047).
Fig. 52. Single most parsimonious tree obtained from combined ITS and EF-1α sequence data of Neofusicoccum species. MP bootstrap values from 1000 pseudoreplicates are given at the nodes. The tree is rooted to Botryosphaeria dothidea (CBS 115476) and B. corticis (CBS 119047).
The Botryosphaeriaceae: genera and species known from culture

**Cultures:** CBS 117453 = CMW 13445 (ex-type), CBS 117452 = CMW 13446.

**Host:** Eucalyptus sp. (Mohali et al. 2006).

**Known distribution:** Venezuela (Mohali et al. 2006).

**Notes:** Neofusicoccum andinum was introduced by Mohali et al. (2006) for isolates from Eucalyptus sp. in Venezuela. There have been no subsequent reports of this species. Based on phylogenetic inference, (ITS, EF1-α) it is most closely related to N. arbuti and N. nonquaesitum. The clavate to slightly navicular conidia of N. andinum separate it from N. arbuti, which has obovoid to fusiform conidia. Conidia of N. andinum are longer and narrower (27 × 5.5 μm) than those of N. nonquaesitum (23 × 7.5 μm).

**Neofusicoccum arbuti** (D.F. Farr & M. Elliott) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 247. 2006. MycoBank MB500872. Fig. 53.

**Basionym:** Fusicoccum arbuti D.F. Farr & M. Elliott, Mycologia 97: 731. 2005.

Ascomata not reported. Conidiomata black, scattered, uniloculate to multiloculate, 0.5–1.5 × 1.5–3 mm, becoming clumped irregular in shape, papillate, stromata in longitudinal section of dark brown textura intricata, locule walls of several layers of thick-walled, dark-brown textura angularis, becoming hyaline towards conidiogenous region. Conidiophores reduced to conidiogenous cells. Conidiogenous cells holoblastic, cylindrical to subobpyriform, hyaline, discrete, determinate, occasionally indeterminate and proliferating percurrently resulting in periclinal thickenings or rarely indistinct annellations, lining inner wall of pycnidium, 9–16.5 × 2.5–3.5 μm. Conidia obovoid, fusiform, base truncate, apex obtuse to subobtuse, hyaline, guttulate, non-spatulate, older conidia may become brownish and septate before germination, on sterile twig 18.5–27.5 × 5.5–7.5 μm (av. of 235 conidia = 22.8 × 6.4 μm), L/W ratio = 3.6. Spermatia cylindrical to allantoid, flexuous or somewhat dumbbell-shaped, hyaline, smooth, aseptate, 3.4–6.3 × 1–1.5 μm, av. of 37 spermatia = 4.3 ± 0.6 × 1.2 ± 0.14 μm. Dichomera synasexual morph not reported.

Ascomata erumpent through the host bark, 1.2 mm diam. Ascostromata pseudothecial, forming botryose aggregates of 2–10,

**Culture characteristics:** Mycelium immersed, of branched, septate, smooth, hyaline hyphae, becoming brown, constricted with age, forming sparse, brown, thick-walled, intercalary, serial chlamydospores. Colonies on PDA at 25 °C in darkness for 8 d, light yellow to olive-grey or olive-brown, darkest around plug, pigmentation extending about 2/3 of the colony width, outer area of colony white, reverse same, surface mycelium cottony except around plug where the mycelium is appressed, obscurely zonate, margin irregular, not producing yellow pigments diffusing into the agar. Cardinal temperatures for growth: opt. 25 °C, max. < 35 °C (25 mm at 15 °C, 63 mm at 20 °C, 70 mm at 25 °C, 37 mm at 30 °C, no growth at 35 °C).

**Type:** USA, Washington, King Co., Seattle, Magnolia Bluffs, isolated from cankers of Arbutus menziesii, Oct. 2003, collected by M. Elliott, isolated by A. Rossman, holotype BPI 843970.

**Cultures:** AR 4036 = CBS 116131 (ex-type), CBS 117090 = UW 13.

**Hosts:** Arbutus menziesii (Pacific madrone) (Farr et al. 2005), Vaccinium spp. (Espinoza et al. 2009).

**Known distribution:** Western USA and Canada from British Columbia to California (Farr et al. 2005), Chile (Espinoza et al. 2009).

**Notes:** This species is phylogenetically most closely related to N. andinum and N. nonquaesitum. The three species can be distinguished on the shapes and dimensions of their conidia. See notes for N. andinum.

**Neofusicoccum australe** (Slippers, Crous & M.J. Wingf.) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 248. 2006. MycoBank MB500873. Fig. 54.

**Basionym:** Fusicoccum australe Slippers, Crous & M.J. Wingf., Mycologia 96: 1035. 2004.

= Botryosphaeria australis Slippers, Crous & M.J. Wingf., Mycologia 96: 1035. 2004.

Ascomata erumpent through the host bark, 1.2 mm diam. Ascostromata pseudothecial, forming botryose aggregates of 2–10,
sometimes solitary, globose with a central ostiole, papillate or not, embedded with only the papilla emerging up to 2/3 emergent, black, 100–300 μm; pseudothecial wall comprising 5–8 layers of \textit{textura angularis}, outer region of dark brown or brown cells, inner region 3–6 layers of hyaline cells lining the locules. Asci bitunicate, clavate, 8-spored, 60–125 × 16–26 μm. \textit{Pseudoparaphyses} filiform, septate, rarely branched, 3–4 μm wide. Ascospores fusoid to ovoid, unicellular, hyaline, smooth with granular contents, biseriate in the ascus, 20−23(−25) × 7−8(−9) μm (av. of 50 ascospores = 21.9 × 7.6 μm), L/W = 2.9. 

Conidiomata stromatic, superficial, globose, mostly solitary. Conidiogenous cells holoblastic, hyaline, subcylindrical, phialidic with periclinal thickenings or proliferating percurrently with 1−4 annellations, 10−14 × 2−3 μm. Conidia hyaline, fusiform, base subtruncate to bluntly rounded, non-septate, rarely forming a septum before germination, smooth with granular contents, (18−)23−26(−30) × 5−6(−7.5) μm (av. of 240 conidia = 24.7 × 5.1 μm), L/W ratio = 4.8. Spermatia not seen. \textit{Dichomera} synasexual morph: Conidia subglobose, opyriiform or obvoid, apex obtuse, base truncate to bluntly rounded, (9.5−)10.5−14.5−17.5) × (7−) 9−11 μm, pale brown when immature with 1−2 transverse septa, 0−1 longitudinal septa, and 0−2 oblique septa, becoming dark brown and muriform when mature with 1−3 transverse septa, 1−4 longitudinal septa, and 0−3 oblique septa.

Culture characteristics: Colonies buff to light primrose, light yellowish pigment diffusing into the medium, most noticeably at 15−20 °C in the dark, becoming olivaceous buff to olivaceous-grey after 5−6 d with sparse to moderately dense, appressed mycelial mat in centre with sparse tufts of aerial mycelium around the edges, margin smooth. Optimum temperature for growth 25 °C, colony reaching 48 mm diam on PDA after 4 d at 25 °C in the dark.

Type: \textit{Australia}, Victoria, Batemans Bay, \textit{Acacia} sp., M.J. Wingfield, \textit{holotype} PREM 57589.

Cultures: CMW 8837 (ex-type), CMW 8853.

Hosts: \textit{Acacia} sp. (Slippers et al. 2004c), \textit{Acacia cochlearis}, \textit{Acacia rostellifera}, \textit{Agonis flexuosa} (Dakin et al. 2010), \textit{Allocasuarina fraseriana}, \textit{Banksia grandis}, \textit{Callitris preissii}, \textit{Citrus} sp. (Adesemoye & Eskalen 2011), \textit{Chamaecyparis lawsoniana}, \textit{Picea abies}, \textit{Pinus pinaster}, \textit{P . pinea}, \textit{Sequoia sempervirens}, \textit{Taxus baccata}, \textit{Thuja plicata}, \textit{Thujopsis dolabrata} (Alves et al. 2013) \textit{Elaeocarpus holopetalus} (Cunnington et al. 2007), \textit{Eucalyptus gomphocephala}, \textit{Eucalyptus marginata}, \textit{Santalum acuminatum} (Taylor et al. 2009), \textit{Eucalyptus globulus} (Burgess et al. 2005, 2006), \textit{Eucalyptus diversicolor} (Barber et al. 2005), \textit{Malus domestica}, \textit{Prunus domesticca}, \textit{Prunus dulcis}, \textit{Prunus persica}, \textit{Pyrus communis} (Damm et al. 2007, Slippers et al. 2007, Gramaje et al. 2012), \textit{Olea europaea} (Lazzizera et al. 2008), \textit{Persea americana} (McDonald et al. 2009, Auger et al. 2013), \textit{Phoenix canariensis} (Cunnington et al. 2007), \textit{Pistacia vera} (Armengol et al. 2008), \textit{Protea cynaroides}, \textit{Protea sp.} (Denman et al. 2003 as \textit{N. luteum}), \textit{Marincowitz et al. 2008}, \textit{Quercus robur} (Barradas et al. 2013), \textit{Rubus} sp. (Phillips et al. 2006), \textit{Salix} sp. (Cunnington et al. 2007), \textit{Syzygium cordatum} (Pavic et al. 2007), \textit{Vaccinium corybosum} (Cunnington et al. 2007, Espinoza et al. 2009); \textit{Vitis vinifera} (van Niekerk et al. 2004, Úrbez-Torres et al. 2006a, Úrbez-Torres &...
Gubler 2009, Martin et al. 2011, White et al. 2011, Besoain et al. 2013), Widdringtonia nodiflora (Slippers et al. 2005b).

Known distribution: Australia (Slippers et al. 2004c, Barber et al. 2005, Burgess et al. 2005, Cunnnington et al. 2007, Taylor et al. 2009), Chile (Espinosa et al. 2009, Auger et al. 2013, Besoain et al. 2013), Italy (Lazzizera et al. 2008), Portugal (van Nierkerk et al. 2004, Phillips et al. 2006, Alves et al. 2013, Barradas et al. 2013), South Africa (Damm et al. 2007, Dennman et al. 2003, Slippers et al. 2005b, Pavlic et al. 2007, Slippers et al. 2007, White et al. 2011), Spain (Armenegol et al. 2008, Marincowitz et al. 2008, Martin et al. 2011, Gramaje et al. 2012), Spain (Tenerife) (Marincowitz et al. 2008), Uruguay (Perez et al. 2010), USA (California) (Urbéz-Torres et al. 2006b, McDonald et al. 2009, Urbéz-Torres & Gubler 2009, Adesemoye & Eskalen 2011).

Notes: This is a sister species to N. luteum and the two differ mainly in the intensity of the yellow pigment produced in culture, although conidia of N. australae are generally larger (24.7 × 5.1 μm, LW ratio = 4.8) than those of N. luteum (19.7 × 5.6 μm, LW ratio = 3.6). Slippers et al. (2004) first reported this species from Australia and South Africa, and mentioned a single isolate from pistachio in Italy. Nevertheless, they regarded this as a species restricted to the Southern Hemisphere. In their study of Botryosphaeria species on grapevines, van Nierkerk et al. (2004) included an isolate of N. australae from Robinia pseudoacacia collected in Portugal. An isolate of a Botryosphaeria from Rubus sp., also in Portugal was also identified as N. australae (Phillips et al. 2006) and it has been isolated frequently from Olea europaea in southern Italy (Lazzizera et al. 2008). These reports thus suggest that N. australae is a widespread and plurivorous species. Interestingly, N. australae is the dominant associate of natural woody vegetation in the south-west of Western Australia, while N. parvum, a species commonly isolated elsewhere in the world, is only found associated with dying trees in the peri-urban landscape. Isolates from olives in southern Italy consistently differ from typical isolates of N. australae by 1 bp in their ITS and 3 bp in their EF1-α sequences (Lazzizera et al. 2008).

Neofusicoccum batangarum Begoude, Jol. Roux & Slippers, sp. nov. MycoBank MB514013. See Didier Begoude et al. (2010) for illustrations.

≡ Neofusicoccum batangarum Begoude, Jol. Roux & Slippers, Mycol. Prog. 9: 113. 2010. Nom. inval., Art 37.7.

Ascomata not reported. Conidiomata stromatic produced on pine needles within 14 d, solid and covered by mycelium, initially embedded, 3/4 erumpent through the pine needles at maturity, covered by mycelium, initially embedded, 3/4 erumpent through the pine needles at maturity, cylindrical, proliferating percurrently, sometimes forming a periclinal thickening, (11–)12.5–19(–27) × (2–)2.5–3(–3.5) μm. Conidia non-septate, hyaline, smooth, fusoid to ovoid, thin-walled, (12–)14–17.5(–20) × (4–)4.5–(6–)6.5 μm (av. of 50 conidia = 15.5 × 5.5 μm), L/W ratio = 2.9. Spermatia not reported. Dichomera synsexual morph not reported.

Culture characteristics: Colonies on MEA forming concentric rings, mycelium white and immersed at the leading edge, becoming smokey grey to grey-olivaceous from the old ring after 5 d on MEA. Cardinal temperatures for growth: opt 25 °C (covering the 90 mm diam Petri plate after 4 d on MEA in the dark), little growth observed at 10 and 35 °C.

Type: Cameroon, Kribi, Beach, isolated from healthy branches of Terminalia catappa, Dec. 2007. D. Begoude & J. Roux, a dry culture on pine needles, holotype PREM 60285.

Cultures: CMW 28363 = CBS 124924 (ex-type), CMW 28320 = CBS 124923.

Hosts: Terminalia catappa (Didier Begoude et al. 2010), Schinus terebinthifolius (Shetty et al. 2011).

Known distribution: Kribi, Cameroon (Didier Begoude et al. 2010), Florida, USA (Shetty et al. 2011).

Notes: The original description of N. batangarum is invalid, as no type specimen was designated, only an "ex-paratype specimen", which was in fact a typing error, as it should have read "holotype". This issue is now addressed, and the name validly published.

Based on ITS and EF1-α sequence data, N. batangarum is most closely related to N. ribis and can be distinguished from it based only on four fixed unique single nucleotide polymorphisms (SNPs) in four gene regions (ITS, EF1-α, β-tubulin and BOTF15). It can be discriminated from other species in the N. ribis / N. parvum complex by the formation of concentric rings on MEA, a characteristic that has not been observed in any other species of the complex. Furthermore, the small conidia (15.5 × 5.5 μm, L/W ratio = 2.9) clearly distinguish this species from all other species in the N. ribis / N. parvum complex. Shetty et al. (2011) isolated N. batangarum from seeds of Schinus terebinthifolius and showed that it is an aggressive pathogen and potential biocontrol agent of this invasive exotic tree.

Neofusicoccum cordaticola Pavlic, Slippers & M.J. Wingf., Mycologia 101: 643. 2009. MycoBank MB512498. See Pavlic et al. (2009) for illustrations.

Ascomata not reported. Neofusicoccum cordaticola is morphologically similar to other species in the N. parvum / N. ribis species complex. Conidia hyaline, unicellular, narrowly fusiform to oval, apices rounded, 18–28 × 4.5–7 μm (av. of 150 conidia = 23.3 × 5.3 μm), L/W = 4.3. It differs from other species in the N. parvum / N. ribis complex by uniquely fixed nucleotides in five nuclear loci: ITS (EU821898) position 141 (C), 372 (G) and 416 (C); EF1-α (EU821868) positions 58 (C) and 221 (C); β-tubulin (EU821838) position 32 (T), 96 (T) and 316 (G); locus BotF15 (EU821802) position 121 (T) and 122 (C); RNA polymerase II subunit (EU821928) positions 100 (A), 112 (T), 265 (A) and 409 (C).

Type: South Africa, Kwazulu-Natal Province, Sodwana Bay, on symptomless branches and leaves, drying branches and pulp of ripe fruits of Syzygium cordatum, Mar. 2002. D. Pavlic, a dry culture on pine needles holotype PREM 60066.

Cultures: CMW 13992 = CBS 123634 (ex-type), CMW 14056 = CBS 123635.
Host: Syzygium cordatum (Pavlic et al. 2009).

Known distribution: South Africa (Pavlic et al. 2009).

Notes: Although variation in conidial dimensions is evident in the N. parvum / N. ribis complex, it is difficult to separate all the species in this complex. Furthermore, precise identification of these species is dependent on DNA sequence comparisons.

**Neofusicoccum eucalypticola** (Slippers, Crous & M.J. Wingf.) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 248. MycoBank MB500874. See Slippers et al. (2004) for illustrations.

**Basionym:** Fusisococcum eucalypticola Slippers, Crous & M.J. Wingf., Stud. Mycol. 50: 351. 2004.

Ascomata pseudothecia, mostly solitary, sometimes forming a botryose aggregate of 2–3 structures, globose with a central ostiole, papillate, embedded with 1/3–2/3 emerging, black, 160–340 μm diam pseudothecial wall comprising 5–8 layers of textura angularis, outer region of dark or medium brown cells, inner region of hyaline cells lining the locule. Ascii bitunicate, clavate, 8-spored, 70–110 × 20–25 μm. Pseudoparaphyses filiform, septate, rarely branched in the upper parts, 2–4 μm wide. Ascospores fusoid to ovoid, unicellular, hyaline, smooth with finely granular contents, biseriate in the ascus, 20–22 (–23.5) × 7–8 μm.

**Ascospores:** irregularly biseriate, hyaline, aseptate, granular contents, becoming light brown with age, prominently inequilateral when young, less so when mature, fusoid, widest in the middle, base obtuse, apex obtuse or subobtuse, (20–)23–26–28 × (7–)8–9–(11) μm. Conidionoma embedded in host tissue, solitary or botryose, stromatic, globose, up to 450 μm diam, wall 6–8 layers thick, composed of brown textura angularis, becoming hyaline towards the inner region. Conidiogenous cells holoblastic, hyaline, subcylinodindrical, proliferating percurrently with 1–3 annellations, or proliferating at the same level with minute periclinal thickenings, 10–25 × 3.5–6 μm. Conidia hyaline, granular, ovoid to slightly clavate, apex obtuse, tapers towards a subtruncate or bluntly rounded base, sometimes with a minute marginal frill visible on younger conidia, (20–)22–25–28 × (6–)7–8–(9) μm **in vivo**, (18–)20–23–(25) × 7–8–(12) μm **in vitro**. Spermatia not reported. Dichomera synasexual morph not reported.

**Culture characteristics:** Colonies white to buff or olivaceous-grey, sometimes becoming olivaceous-black at the centre after 7 d, with a dense mat of aerial mycelium, edges smooth to crenulate, sometimes not reaching the edge of the plate. Optimum temperature for growth 25 °C, reaching 34–43 mm radius on PDA after 4 d at 25 °C in the dark.

**Type:** Australia, Victoria, Orrobat, on Eucalyptus grandis, 2001, M.J. Wingfield, holotype PREM 57848.

**Culture:** CBS 115679 = CMW 6539 (ex-type), CBS 115766 = CMW 6217.

**Hosts:** Eucalyptus spp. (Slippers et al. 2004, Burgess et al. 2006).

**Known distribution:** Australia (Slippers et al. 2004).

Notes: Neofusicoccum eucalypticola is phylogenetically most closely related to N. eucalyptorum, and the two species can be separated on the shapes and dimensions of their conidia in culture. Thus, conidia of N. eucalypticola are fusiform and longer (25–27 μm) than the ovoid to clavate conidia of N. eucalyptorum, which are 20–23 μm long. Slippers et al. (2004) found that N. eucalyptorum was the dominant species collected from Eucalyptus species in eastern Australia.

**Neofusicoccum eucalypticorum** (Crous, H. Sm. ter. & M.J. Wingf.) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 248. 2006. MycoBank MB500875. See Smith et al. (2001) for illustrations.

**Basionym:** Fusisococcum eucalypticorum Crous, H. Sm. ter. & M.J. Wingf., Mycologia 93: 280. 2001.

Ascomata embedded in host tissue, up to 300 μm diam, becoming erumpent, solitary or botryose, stromatic, dark brown to black, with central, black ostioles. Ascii clavate, 8-sored, bitunicate with a well-developed apical chamber, 70–140 × 15–21 μm. Pseudoparaphyses filiform. Ascospores irregularly biseriate, hyaline, aseptate, granular contents, becoming light brown with age, prominently inequilateral when young, less so when mature, fusoid, widest in the middle, base obtuse, apex obtuse or subobtuse, (20–)23–26–28 × (7–)8–9–(11) μm. Conidionoma embedded in host tissue, solitary or botryose, stromatic, globose, up to 450 μm diam, wall 6–8 layers thick, composed of brown textura angularis, becoming hyaline towards the inner region. Conidiogenous cells holoblastic, hyaline, subcylinodindrical, proliferating percurrently with 1–3 annellations, or proliferating at the same level with minute periclinal thickenings, 10–25 × 3.5–6 μm. Conidia hyaline, granular, ovoid to slightly clavate, apex obtuse, tapers towards a subtruncate or bluntly rounded base, sometimes with a minute marginal frill visible on younger conidia, (20–)22–25–28 × (6–)7–8–(9) μm **in vivo**, (18–)20–23–(25) × 7–8–(12) μm **in vitro**. Spermatia not reported. Dichomera synasexual morph not reported.

**Culture characteristics:** Colonies on MEA iron-grey (reverse) and olivaceous-grey (surface) with extensive grey aerial mycelium, and smooth margins, attaining a radius of 21–24 mm after 4 d in darkness at 25 °C. Cardinal temperatures for growth: min > 5 °C, max < 35 °C, opt 25 °C.

**Type:** of sexual morph: South Africa, Mpumalanga, Sabie, Eucalyptus grandis, 1995, H. Smith, holotype PREM 56603; of asexual morph: South Africa, Mpumalanga, Sabie, E. grandis, 1995, H. Smith, holotype PREM 56604.

**Cultures:** The ex-type isolate was not designated in the original publication and could not be traced. Slippers et al. (2004b) regarded the following as representatives CBS 115791 = CMW10125, CMW 10126.

**Hosts:** Eucalyptus spp. (Burgess et al. 2006, Smith et al. 2001, Slippers et al. 2004b, Perez et al. 2010), Myrceugenia glaucescens, Myrrhinium atropurpureum var. octandrum, Blepharocalyx salicifolius (Perez et al. 2010).

**Known distribution:** Australia (Slippers et al. 2004b), South Africa (Smith et al. 2001), Uruguay (Perez et al. 2010).
Notes: Neofusicoccum eucalyptorum is a sister species to *N. eucalypticola* and the two can be separated on the shapes and dimensions of conidia formed in culture. See notes for *N. eucalypticola*.

**Neofusicoccum grevilleae** Crous & R.G. Shivas, Persoonia 26: 117. 2011. MycoBank MB560162. See Crous et al. (2011) for illustrations.

Leaf spots medium brown, situated along leaf margins, surrounded by a dark red-brown border, spots extending to the midrib, up to 7 mm diam, and up to 2 cm long. *Conidiomata* amphiogenous, stromatic, up to 200 μm diam (on sterilised pine needles). Wall consisting of 3–5 layers of brown *textura angularis*. *Conidiophores* lining the inner layer of conidioma, hyaline, smooth, 0–1-septate, 15–30 × 3–5 μm. *Conidiogenous cells* holoblastic, integrated, doliform to subcylindrical, phialidic, proliferating 2–3 times percurrently near apex, 15–25 × 3–4 μm. *Conidia* hyaline, smooth, thin-walled, with granular cytoplasm, fusoid-ellipsoidal, widest in middle or in upper third of conidium, apex subobtuse, base truncate, (20–)25–28(–32) × (6–)7–8(–10) μm (av. size of conidia = 25.7 × 7.5 μm), L/W = 3.4.

Culture characteristics: Colonies after 14 d at 25 °C in darkness flat, spreading, with abundant, grey aerial mycelium, covering the dish after 7 d, on PDA, OA and MEA iron-grey, sporulating poorly on water agar supplemented with sterile pine needles. *Spermatia* not reported. *Dichomera* synasexual morph not reported.

**Neofusicoccum kwambonambiense** Pavlic, Slippers & M.J. Wingf., Mycologia 101: 643. 2009. MycoBank MB512499. See Pavlic et al. (2009) for illustrations.

Ascomata not reported. *Neofusicoccum kwambonambiense* is morphologically similar to other related species in the *N. parvum* / *N. ribis* species complex. *Conidia* hyaline, unicellular, fusiform to ellipsoidal, apices rounded 16–28 × 5–8 mm (av. 140 conidia 22.3 × 6.3 μm), L/W = 3.6. It differs from other species in the *N. parvum* / *N. ribis* complex by uniquely fixed nucleotides in four nuclear loci: ITS (EU821900) position 163 (T) and 173 (G); β-tubulin (EU821840) position 175 (T), 235 (A) and 251 (A); locus BotF15 (EU821804) position 87, and 172; RNA polymerase II subunit (EU821930) positions 49 (G), 382 (A), 421 (A) and 526 (C). *Spermatia* not reported. *Dichomera* synasexual morph not reported.

**Neofusicoccum luteum** (Pennycook & Samuels) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 248. 2006. MycoBank MB500876. Fig. 55. Basionym: *Fusicoccum luteum* Pennycook & Samuels, Mycotaxon 24: 456. 1985. = *Botryosphaeria lutea* A.J.L. Phillips, Sydowia 54: 70. 2002.

Ascomata initially immersed, later becoming erumpent through the host tissue, black, <0.5 mm diam, uni- or multilocular, locules spherical to ovoid, 150–200 μm diam, ascomata and conidiomata often formed in the same stroma, opening through a nonperiphysate ostiole, with a short neck, wall consisting of 8–12 layers of dark brown to black, thick-walled cells, forming pseudoparenchymatous *textura angularis*, up to 60 μm thick, with 3–4 layers of thin-walled, hyaline cells lining the cavity. *Asci* bitunicate, cylindrical, to clavate, stipitate, 84–176 × 16–24 μm, 8-spored, associated with filamentous pseudoparaphyses. *Pseudoparaphyses* hyaline, septate, branched, 2–3.5 μm wide. *Ascospores* irregularly biseriate in the ascus, hyaline, guttulate, smooth, asperate, oval to broadly fusiform, widest in the middle or upper third of the ascospore, tapering to the obtuse base and apex 18–22.5(–24) × 7–12 μm. *Conidiomata* frequently formed on the same stroma as the ascomata, stromatic, separate or confluent, dark brown to black, uni- or multilocular immersed in the host, sub-peridermal, locules up to 150 μm diam, walls consisting of a dark brown *textura angularis*, becoming smaller, thinner-walled and hyaline towards the conidiogenous region. *Ostioles* papillate, circular. *Conidiophores* hyaline, smooth, thin-walled, rarely branched at the base, cylindrical, formed from the cells of the inner locule wall, 8–19 × 3–4 μm. *Conidiogenous cells* holoblastic, discrete, integrated, hyaline, smooth, cylindrical, producing the first conidium holoblastically and subsequent conidia enteroblastically, proliferating percurrently with 2–3 indistinct percurrent proliferations, or proliferating internally forming typical phialides (*sensu* Sutton, 1980) and periclinal thickening, (6–)8–16(–18) × (2.5–)3–4(–4.5) μm. *Conidia* hyaline, thin-walled, asperate, smooth, ellipsoidal, widest in the middle or upper third of the conidium, apex subobtuse, base truncate (15–)16.5–22.5(–24) × 4.5–6(–7.5) μm, 95 % confidence limits of 224 conidia = 19.4–19.9 μm (av. ± S.D. of 224 conidia = 19.7 ± 1.8 × 5.6 ± 0.6 μm), L/W ratio = 3.6 ± 0.5 with 95 % confidence limits = 3.5, often with a minute basal frill. *Spermatia* hyaline, rod-shaped to reniform with either truncate or rounded ends 3–5 × 1 μm. *Dichomera* synasexual morph not reported.

**Type:** South Africa, Kwazulu-Natal Province, Kwambonambi, on symptomless branches and leaves, dying branches and pulp of ripe fruits of *Syzygium cordatum*, Mar 2002, D. Pavlic, a dry culture on pine needles, *holotype* PREM 60067.

Cultures: CMW 14023 = CBS 123639 (ex-type), CMW 14140 = CBS 123641. 

Host: *Syzygium cordatum* (Pavlic et al. 2009).

Known distribution: South Africa (Pavlic et al. 2009).

Note: See notes for *N. cordatolina*.
1996, A.J.L. Phillips, **holotype** LIS 94070; of asexual morph: New Zealand, Bay of Plenty, Te Puke, No 1 Road, DSIR Research Orchard, from lesions on ripe fruit of *Actinidia deliciosa*, 6 Oct. 1982, S.R. Pennycook, **holotype** PDD 45400.

**Cultures**: PDDCC 8004 = ATCC 58193 (ex-type of asexual morph) / CBS 110299 (ex-type of sexual morph), CAP037.

**Hosts**: Plurivorous including *Actinidia chinensis*, *Actinidia deliciosa* (Gadgil et al. 2005, Pennycook & Samuels 1985), *Banksia* sp., *Buckinghamia* sp. (Denman et al. 2003), *Chamaecyparis lawsoniana*, *Cupressus sempervirens*, *C. lusitanica*, *Juniperus communis*, *Pinus pinea*, *Sequoia sempervirens*, *Thujopsis dolabrata*, *Thuja plicata* (Alves et al. 2013), *Chrysanthemoides monilifera* (Cunnington et al. 2007), *Crataegus mexicana* (Adesmoye et al. 2013), *Diospyros kaki* (Gadgil et al. 2005), *Eucalyptus* sp. (Denman et al. 2003), *Ficus microcarpa* (Mayorquin et al. 2012), *Fraxinus angustifolia* (Phillips et al. 2002), *Malus domestica* (Gadgil et al. 2005), *Olea europaea* (Sergeeva et al. 2009), *Persea americana* (McDonald & Eskalen 2011), *Protea cynaroides* (Denman et al. 2003), *Pyrus communis* (Gadgil et al. 2005), *Pyrus pyrifolia* (Gadgil et al. 2005), *Quercus robur* (Barradas et al. 2013), *Rhododendron* sp. (Varela et al. 2011), *Salix fragilis* (Cunnington et al. 2007), *Salix magnifica* (Gadgil et al. 2005), *Sophora japonica* (Phillips et al. 2002), *Syzygium cordatum* (Pavlic et al. 2007), *Vitis vinifera* (van Niekerk et al. 2004, Úrbez-Torres et al. 2006b), *Malus domestica* (Gadgil et al. 2005), *Olea europaea* (Sergeeva et al. 2009), *Persea americana* (McDonald & Eskalen 2011), *Protea cynaroides* (Denman et al. 2003), *Pyrus communis* (Gadgil et al. 2005), *Pyrus pyrifolia* (Gadgil et al. 2005), *Quercus robur* (Barradas et al. 2013), *Rhododendron* sp. (Varela et al. 2011), *Salix fragilis* (Cunnington et al. 2007), *Salix magnifica* (Gadgil et al. 2005), *Sophora japonica* (Phillips et al. 2002), *Syzygium cordatum* (Pavlic et al. 2007), *Vitis vinifera* (van Niekerk et al. 2004, Úrbez-Torres et al. 2006b).

**Known distribution**: eastern Australia (Denman et al. 2003, Cunnington et al. 2007, Sergeeva et al. 2009), USA (California) (Úrbez-Torres et al. 2006b, McDonald & Eskelen 2011, Mayorquin et al. 2012), Italy (Lazzizera et al. 2008), New Zealand (Gadgil et al. 2005, Pennycook & Samuels 1985), Portugal (Phillips et al. 2002, Alves et al. 2013, Barradas et al. 2013), South Africa (Denman et al. 2003, van Niekerk et al. 2004, Pavlic et al. 2007), Spain (Varela et al. 2011), Uruguay (Peréz et al. 2010).

**Notes**: The morphology of the conidiomata varies depending on the substrate on which this species is found. Thus, Phillips et al. (2002) reported that on grapevine canes they were thick-walled and eustromatic while on leaves they were thin-walled and globose. Phylogenetically it groups with *N. australe*. See notes for *N. australe*.

**Neofusicoccum macroclavatum** (T.I. Burgess, Barber & Hardy) T.I. Burgess, Barber & Hardy, Stud. Mycol. 55: 248. 2006. MycoBank MB500877. See Burgess et al. (2005) for illustrations.

**Basionym**: *Fusicoccum macroclavatum* T.I. Burgess, Barber & Hardy, Austr. Pl. Pathol. 34: 562. 2005.

**Ascomata not reported. Conidiomata stromatic, formed on water agar on sterilised pine needles within 21 d, superficial, globose, mostly solitary, 1–2 mm diam, covered with mycelium, single or multiloculate. Conidiogenous cells holoblastic, hyaline, sub-cylindrical to cylindrical to ampulliform, proliferating percurrenty with up to 2 annellations, (4.5–)5.5–10.5(–13) × 2–3.5(–4.5) μm.
Conidia produced in culture on pine needles elongate-clavate to fusiform, base subtruncate to bluntly rounded, hyaline, unicellular, occasionally 1–4-septate when mature or before germination, smooth wall with fine granular contents, (19–)25–35(–41) × (5–)6–9(–10) μm (av. of 125 conidia = 30.3 × 7.1 μm), L/W = 4.2. Spermatozoides observed in culture hyaline, cylindrical, sub-cylindrical or clavate, base truncate with rounded apex, 4.5–9.5(–13) × 2–3.5(–4.5) μm (av. of 50 spermatozoides = 7.7 × 2.6 μm). Dichomera synasexual morph not reported.

Culture characteristics: Colonies on half strength PDA initially white to buff turning olivaceous-grey within 7 d and becoming black with age, moderately dense, appressed mycelial mat with irregular very dense aerial aggregations. Optimum temperature for growth 25 °C, reaching 53 mm in diameter on half strength PDA after 4 d at 25 °C in the dark.

Type: Australia, Western Australia, Denmark, from wood of living Eucalyptus globulus, Oct. 2002, T.I. Burgess, holotype MURU 400.

Cultures: WAC 12444 = CBS 118223 (ex-type), WAC 12445 = CMW 15948.

Hosts: Eucalyptus globulus, E. saligna (Burgess et al. 2005).

Known distribution: Western Australia (Burgess et al. 2005).

Notes: Phylogenetically N. macroclavatum is closely related to N. andinum, N. nonquasitum and N. arbuti. It can be distinguished from all other species in Neofusicoccum on the characteristic shape of its conidia that are considerably larger than most other known species in this genus; only N. pennatilisporum has longer conidia.

Neofusicoccum mangiferae (Syd. & P. Syd.) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 248. 2006. MycoBank MB500878. See Slippers et al. (2005) for illustrations.

Basionym: Dothiarella mangiferae Syd. & P. Syd., Ann. Mycol., 14: 192. 1916.

≡ Nattrassia mangiferae (Syd. & P. Syd.) S. Sutton & Dyko, Mycol. Res. 93: 484. 1989.
≡ Fusccomcccum mangiferae (Syd. & P. Syd.) Johnson, Slippers & M.J. Wingfield, Mycologia 97 (1): 106. 2005.
≡ Fusccomcccum mangiferae (Syd. & P. Syd.) G.I. Johnson, Slippers & M.J. Wingfield (as “mangiferae”), Mycologia 97 (1): 106. 2005.
≡ Henderccomcccum crypta Nattrass, A first list of Cyprus fungi: 43. 1937.
≡ Exosporina fawcettii E.E. Wilson, Hilgardia 17 (12): 427. 1947.

Ascomata not reported. Conidiomata amphigenous, stromatic, brown to black, unil- to multi-loculate; walls composed of thick-walled, brown textura angularis, locules opening by means of separate ostioles; spherical, 150–400 μm diam. Conidiophores absent. Conidiogenous cells lageniform to ampulliform, hyaline, discrete, arising from the inner wall of the stroma, producing a succession of conidia at one level, collarate absent, pericinal thickening and cytoplasmic channel wide, 6.5–14 × 2.5–4 μm. Conidia holoblastic, ellipsoid to nearly fusiform, at first aseptate, then becoming 1–2 euseptate, central cell dark brown, end cells hyaline to pale brown, smooth (11–)12–15(–17.5) × 5–6.6 μm (av. of 54 conidia = 13.6 × 5.4 μm).

Type: India. Lucknow, on Magnifera indica, F. Bahadur (E.J. Butler 1724), 22 Oct. 1908, holotype HCIO.

Cultures: Cultures linked to the type could not be located and probably do not exist. Slippers et al. (2005) regarded the following as representatives: CBS 118531 = CMW7024, CBS 118532 = CMW7797.

Host: Mangifera indica (Slippers et al. 2005).

Known distribution: Australia, India (Slippers et al. 2005).

Notes: Phylogenetically this species is closely related to N. eucalypticolina and N. eucalyptorum, but the conidia of N. mangiferae are distinct from all other Neofusicoccum spp. in their shorter average length (~13–14 mm) and smaller length/width ratio (2–2.5). The conidia often become 1- or 2-septate, light brown with distinctly darker middle cells. This feature is shared with N. parvum and N. mediterraneum, but is not seen in all isolates of these two latter species.

Neofusicoccum mediterraneum Crous, M.J. Wingfield & A.J.L. Phillips, Fungal Planet No. 19: 2. 2007. MycoBank MB504461. Fig. 56.

Ascomata not reported. Conidiomata amphigenous, stromatic, brown, up to 450 μm diam on pine needles, ostiolate, exuding conidia in a white mucoid wall, consisting of 3–5 layers of brown textura angularis. Conidiophores lining the inner layer of the conidioma, hyaline, smooth, 0–1-septate, 15–40 × 3–5 μm. Conidiogenous cells holoblastic, hyaline, integrated, phialidic, subcylindrical, rarely ampulliform, proliferating several times percurrently near apex, rarely with minute periclinal thickening, 15–30 × 3–5 μm. Conidia hyaline, smooth, thin-walled, fusoid-ellipsoidal, widest in the middle or in the upper third, apex subobtuse, base subtruncate, somewhat flattened with minute marginal frill, with granular cytoplasm, (19–)22–26(–27) × (5.5–)6(–6.5) μm in vitro (av. size of conidia = 24 × 6 μm), L/W = 4. Spermatozoides not reported. Dichomera synasexual morph not reported.

Culture characteristics: Colonies on 2 % MEA fluffy, iron-grey, with abundant grey aerial mycelium, fertile on water agar overlaid with autoclaved pine needles.

Type: Greece, Rhodes, Rhodes Palace Hotel parking lot, on branches and leaves of Eucalyptus sp., 12 Jun. 2006, collected by P.W. Crous, M.J. Wingfield & A.J.L. Phillips, holotype CBS H-19921.

Cultures: CBS 121718 (ex-type), CBS 121558.

Hosts: Citrus sp. (Inderbitzin et al. 2010, Abdollahzadeh et al. 2013), Ficus microcarpa (Mayorquin et al. 2012), Fortunella sp., Fraxinus sp., Juniperus sp., Persia americana, Pisticia vera, Prunus dulcis, Rubus sp., Sequoiodendron giganteum (Inderbitzin et al. 2010), Eucalyptus (Crous et al. 2007, Inderbitzin et al. 2010), Juglans regia (Inderbitzin et al. 2010, Trouillas et al. 2010), Mangifera indica (Abdollahzadeh et al. 2013), Olea europaea (Lazzizzera et al. 2008), Vitis vinifera (Úrbez-Torres et al. 2010, Inderbitzin et al. 2010, Martin et al. 2011, Pintos Varela et al. 2011).

Known distribution: USA (California) (Úrbez-Torres et al. 2010, Trouillas et al. 2010, Inderbitzin et al. 2010, Mayorquin et al. 2012),
Notes: *Neofusicoccum mediterraneum* is phylogenetically most closely related to *N. viticlavatum* and *N. vitifusiforme*, but it can be separated by having larger conidia (24 × 6 μm) than those of *N. viticlavatum* (16–18 × 6.5–7.5 μm) and *N. vitifusiforme* (19–21 × 5.5–6.5 μm). Conidia in some isolates become septate, light brown with distinctly darker middle cells; a feature seen in *N. mangiferum* and *N. parvum*, but can be distinguished from these two species in having larger conidia.

A search of GenBank revealed a wide range of variation amongst the ITS sequences for isolates of *N. mediterraneum*. Furthermore, in the six-locus phylogeny of Inderbitzin et al. (2010), two distinct clades were resolved for this species. Therefore, as mentioned by Abdollahzadeh et al. (2013), it seems that *N. mediterraneum* is a complex of species that should be examined in more detail using greater numbers of isolates and additional gene loci.

*Neofusicoccum nonquaesitum* Inderb., Trouillas, Bostock & Michailides, Mycologia 102: 1360. 2010. MycoBank MB518135. See Inderbitzin et al. (2010) for illustrations.

Ascomata not reported. *Conidiomata* stromatic, single or in groups, immersed or immersed-erumpent, lenticular to subglobose, 200–500 × 150–400 μm, sometimes with a short neck, wall up to 50 μm wide, three-layered, outer layer composed of dark, thick-walled cells, intermediate layer lighter pigmented, cells smaller, inner layer hyaline, cells thin-walled. *Conidiophores* short, undifferentiated, originating from the inner pycnidial wall, branching at times, up to 30 μm long, 1.5–2 μm wide, bearing single, unbranched conidiogenous cells, of similar dimensions as conidiophores. Conidiogenous cells holoblastic proliferating percurrently with up to five proliferations. *Conidia* hyaline, fusiform to oval, base truncate, rarely 1–3-septate, sometimes becoming pigmented, 17–29 × 5.5–10.5 μm (av. size of conidia = 23.2 × 7.6 μm), LW ratio = 3.1. *Spermatia* when present most abundant in upper part of pycnidium, cylindrical, with rounded or truncate apices, curved at times, 4–10 × 2–4 μm, rarely up to 15 × 5 μm. *Dichomera* synasexual morph not reported.

**Culture characteristics**: Colonies on half strength PDA plate with cork oak or pistachio leaf after 12 d under continuous light on a laboratory bench white to olive-brown or olivaceous-black, reverse white to olivaceous-black, conidioma forming mainly on leaf, black, some covered by mycelium, immersed-erumpent, up to 600 μm diam and of variable shape, conidia and spermatia present.

**Type**: USA, California, Napa County, St Helena, on cankered branch of *Umbellularia californica*, 12 Nov. 2004, F.P. Trouillas, holotype UC1946389 (dried branch of *U. californica* inoculated with PD484).

**Cultures**: CBS 126655 = PD484 (ex-type), PD301.

**Hosts**: *Umbellularia californica*, *Prunus dulcis* (Inderbitzin et al. 2010), *Vaccinium corymbosum* (Espinoza et al. 2009) *Sequoiadendron giganteum* (Rooney-Latham et al. 2012).

**Known distribution**: USA (California) (Inderbitzin et al. 2010), Chile (Espinoza et al. 2009), North America (Rooney-Latham et al. 2012).

**Note**: See notes for *N. andinum*.
**Neofusicoccom occulatum** Sakalidis & T.I. Burgess, Mol. Phylogenet. Evol. 60: 340. 2011. MycoBank MB518777. See Sakalidis et al. (2011) for illustrations.

Ascomata not reported. **Conidiomata** on *Populus* sp. twigs stromatic, solitary often or in groups, rapidly covered with mycelium, superficial, conical or spherical or obpyriform, unilocular. **Conidiogenous cells** holoblastic, hyaline, oval to fusiform, 4–14 × 0.5–2.5 μm (av. size = 8 × 1 μm). *Conidia* hyaline, unicellular, fusiform to ellipsoid to cymbiform, apices obtuse, base truncate, sometime both apices taper, aseptate, smooth-walled, 14–22 × 3.5–7.5 μm (av. size of conidia = 18.3 × 5.2 μm), L/W = 3.5. Dichomera synasexual morph: **Conidiogenous cells** holoblastic, hyaline, globose to turbinate 11.5 × 1.5 μm. *Conidia* two forms observed “irregular long” and “irregular round” both brown and muriform “irregular round” 1–3 transverse septa, 0–1 long septa and 0–3 oblique septa, 7.5–13.5 × 5.5–8.5 μm (av. size of conidia = 9.8 × 7 μm), L/W = 1.4, rarely found “irregular long” 1–5 transverse septa, 0–2 oblique septa, 11.5–20.5 × 4–7.5 μm (av. of 20 conidia = 15.5 × 5.8 μm), L/W = 2.7.

**Culture characteristics**: Colonies white, flattened with tufts of white mycelium, becoming very to dark greenish grey colour after 14 d with the reverse side of the colonies greenish black. Optimal temperature for growth 30 ºC, covering a 90 mm Petri dish on MEA in 3–4 d, limited growth occurred at 4 ºC and 10 ºC.

**Type**: Australia, Queensland, Karanda, symptomless branches of *Eucalyptus grandis* hybrid, Mar 2002, T.I. Burgess, dried culture spourulating on *Populus* sp. twigs, **holotype** MURU467.

**Cultures**: MUCC 227 = CBS 128008 (ex-type), MUCC 286 = WAC 12395.

**Host**: *Eucalyptus* (Sakalidis et al. 2011).

**Known distribution**: Australia (Sakalidis et al. 2011).

**Notes**: A pale yellowish pigment was observed once in the media of three isolates MUCC 270 and MUCC 296 and MUCC 232 (Sakalidis et al. 2011). *Neofusicoccom occulatum* is morphologically similar to other closely related species in the *N. parvum* / *N. ribis* species complex and differs from other species in the complex by one uniquely fixed nucleotide difference in partial EF-1α (EU339509) position 164 (A). See notes for *N. cordaticola*.

**Neofusicoccom parvum** (Pennycook & Samuels) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 248. 2006. MycoBank MB500879. Fig. 57.

**Basionym**: *Fusioccoccom parvum* Pennycook & Samuels, Mycotaxon 24: 455. 1985.

= *Botryosphaeria parva* Pennycook & Samuels, Mycotaxon 24: 455. 1985.

Ascomata forming botryose clusters 2–5 mm diam, each comprising up to 100 ascomata, erumpent through the bark, globose, with a short, conical papilla, dark brown to black, smooth, thick-walled, wall composed of dark brown thick-walled cells, lined with thin-walled, hyaline cells, locules 150–250 μm diam, contents conspicuous white when dry. *Asci* clavate, 8-spored, bitunicate, 75–143(–210) × 17–21 μm. Ascospores broadly ellipsoidal to fusoid, often with an apiculus at each end, hyaline, smooth, aseptate, occasionally becoming 1-septate, (14–)18–23(–26) × (7–)8–10(–11) μm (av. of 73 ascospores = 20.8 × 9.2 μm), L/W = 2.2. Conidial types morphologically indistinguishable from ascomatal types. **Conidiomata** globose and non-papillate to pyriform with a short, acute papilla, entire locule lined with conidiogenous cells. **Conidiogenous cells** holoblastic, hyaline, subpyriform, proliferating percurrently to form 1–2 annellations, or proliferating at the same level to form periclinal thickenings. Conidia ellipsoidal with apex round and base flat, unicellular, hyaline, old conidia becoming 1–2-septate hyaline, or light brown with the middle cell darker than the terminal cells, (12–)13.5–21(–24) × 4–6(–10) μm, 95% confidence limits of 320 conidia = 16.9–17.3 × 5.4–5.5 μm (av. ± S.D. of 320 conidia = 17.1 ± 2.1 × 5.5 ± 0.8 μm), L/W ratio = 3.2 ± 0.6 with 95% confidence limits of 3.1–3.2. **Dichomera** synasexual morph: Conidia subglobose to obpyriform, brown, apex obtuse, base truncate, 8–10.5(–12) × (6.5–)7–8(–9) μm, 1–3 transverse septa, 1–2 longitudinal septa, and 1–2 oblique septa.

**Type**: New Zealand, Bay of Plenty, Te Puke, No 3 Road, Baldwin Orchard, on small dead branch of *Populus nigra*, 17 Dec. 1981, S.R. Pennycook, **holotype** PDD 45438.

**Cultures**: PDDCC 8003 = ATCC 58191 (ex-type) = ICMP 8003 = CMW 9081.

**Hosts**: Plurivorous including Actinidia delicosa (Pennycook & Samuels 1985, Abdollahzadeh et al. 2013), Araucaria heterophylla (Slippers et al. 2005b), Citrus sinensis (Cunnington et al. 2007), Citrus sp. (Adesemoye et al. 2011), Cupressus funebris (Li et al. 2010), Diospyros kaki (Gadgil et al. 2005), Erithobrya japonica (Gadgil et al. 2005), Eucalyptus citriodora, Eucalyptus globulus, Eucalyptus grandis, *Eucalyptus saligna* (Gezahgne et al. 2004), Eucalyptus pellita (Barber et al. 2005), Eucalyptus urophylla (Mohali et al. 2007), Ficus microcarpa (Mayorquin et al. 2012), Grevillea robusta (Toljander et al. 2007), Heteropyxis natalensis (Slippers et al. 2004a), Juglans regia (Inderbitzin et al. 2010, Abdollahzadeh et al. 2013), Juniperus communis, Pinus pinea, Thuja plicata, Thujopsis dolabrata (Alves et al. 2013), Kolkwitzia amabilis (Cunnington et al. 2007), Leucadendron sp. (Marincowitz et al. 2008), Leucospermum sp. (Marincowitz et al. 2008), Lilium lancifolium (Woodward et al. 2008), Malus domestica (Pennycook & Samuels 1985), Mangifera indica (Javier-Alva et al. 2009), Olea africana (Cunnington et al. 2007), Olea europaea (Lazzizzera et al. 2008), Persea americana (Hartill 1991, Cunningham et al. 2007, Zea-Bonilla et al. 2007, McDonald & Eskalen 2011, Molina-Gayosso et al. 2012), Pistacia vera (Cunnington et al. 2007, Inderbitzin et al. 2010), Populus sp. (Gadgil et al. 2005), Protea cynaroides (Marincowitz et al. 2008), Prunus armeniaca (Gramaje et al. 2012), Prunus dulcis (Inderbitzin et al. 2010), Prunus persica (Cunnington et al. 2007), Prunus avium (Abdollahzadeh et al. 2013), Pseudoxanthes laetus (Gadgil et al. 2005), Psidium guajava (Mohali et al. 2007), Pyrus sp. (Abdollahzadeh et al. 2013), Pyrus communis (Gadgil et al. 2005), Pyrus pyrifolia (Shen et al. 2010), Pinus sp. (Abdollahzadeh et al. 2013), Quercus suber (Linaldeddu et al. 2007), Rhododendron sp. (Varela et al. 2011), Ribes sp. (Slippers et al. 2004a), Rubus fruticosus (Abdollahzadeh et al. 2013), Salix sp. (Abdollahzadeh et al. 2013), Sequoia gigantea (Slippers et al. 2004a), Syzygium cordatum (Pavic et al. 2007), Syzygium paniculatum (Ploetz et al. 2008), Terminalia catappa (Dieder Begoude et al. 2010), Trachycarpus fortunei (Taylor & Hyde 2003), unknown, palm (Taylor & Hyde 2003), Vaccinium
corymbosum (Espinoza et al. 2009), Vitis vinifera (Cunnington et al. 2007, Mohammadi et al. 2008, Phillips, et al. 2006, Úrbez-Torres et al. 2006, Díaz et al. 2011, White et al. 2011).

**Known distribution:** Probably worldwide. Australia (Barber et al. 2005, Cunnington et al. 2007, Slippers et al. 2004a, Taylor & Hyde 2003), USA (California) (Úrbez-Torres et al. 2006b, Adesemoye & Eskalen 2011, Inderbitzin et al. 2010, McDonald & Eskalen 2011, Mayorquin et al. 2012), Chile (Díaz et al. 2011, Espinoza et al. 2009), China (Li et al. 2010, Taylor & Hyde 2003), Ethiopia (Gezahgne et al. 2004), USA (Florida) (Ploetz et al. 2008), USA (Georgia) (Woodward et al. 2006), Greece (Inderbitzin et al. 2010), USA (Hawaii) (Marincowitz et al. 2008), Iran (Mohammadi et al. 2008, Abdollahzadeh et al. 2013), Italy (Lazzizera et al. 2008, Linaldeddu et al. 2007), Mexico (Molina-Gayoso et al. 2012), New Zealand (Gadgil et al. 2005, Hartill 1991, Pennycook & Samuels 1985, Slippers et al. 2005b), Peru (Javier-Alva et al. 2009), Portugal (Phillips et al. 2006, Alves et al. 2013), South Africa (Didier Begoude et al. 2010, Pavlic et al. 2007, Slippers et al. 2004a, Slippers et al. 2004b, White et al. 2011), Spain (Úrbez-Torres et al. 2006a, Zea-Bonilla et al. 2007, Varela et al. 2011, Gramaje et al. 2012), Taiwan (Shen et al. 2010), Uganda (Toljander et al. 2007), Venezuela (Mohali et al. 2007).

**Notes:** Phylogenetically, this species lies within a cluster of morphologically highly similar species that can be distinguished
only on the basis of ITS and EF1-α sequence data. Neofusicoccum parvum has, however, been distinguished by different researchers from other species in this cluster based on the colour and septation of conidia at the time of germination. Thus, the conidia become 2-septate and the central cells become pale brown in N. parvum, while in the other species there is no colouration of the conidia at the time of germination. But recently, in a phylogenetic study on Neofusicoccum and Botryosphaeria species in Iran, Abdollahazadeh et al. (2013) studied 34 N. parvum isolates and found that in all of them the old conidia remained hyaline even after 10 wk. Furthermore, the production of a yellow pigment on PDA was reported in some isolates of an Iranian population of N. parvum, which is a feature never seen previously. Neofusicoccum parvum is emerging as a common and cosmopolitan species on a wide variety of hosts. It is now recognised as an aggressive pathogen of grapevines (e.g., Phillips 1998) as B. dothisidea, van Niekerk et al. 2004), and possibly other woody hosts.

Neofusicoccum pennatisporum K. Taylor, Barber & T.I. Burgess, Mycol. Res. 113: 346. 2009. MycoBank MB511826. See Taylor et al. (2009) for illustrations.

Ascomata not reported. Conidiomata stromatic, superficial, dark-brown to black, cylindrical to triangular to irregular, mostly solitary, rough with some mycelium, 300–1000 μm long and 100–500 μm diam on pine needles but up to 2 mm long on agar. Conidiogenous cells holoblastic, hyaline, cylindrical to flask shaped, 4–10×(12) × (1)–2–3–(4) μm. Conidia hyaline, usually aseptate, often with 1 septum but can have up to 5 septa with age, typically fusiform, smooth-walled, apex obtuse, base frequently truncate but sometimes rounded, (31)–40–50–(64) × 6–10–(12) μm (av. of 100 conidia = 45.4 × 9.7 μm), L/W ratio = 4.6. Spermatia hyaline, aseptate, fusiform, either rounded or truncate at both ends, (2)–3–(6)–7 × 1–2 μm (av. of 100 spermatia = 4.4 × 1.5 μm). Dichomera synasexual morph not reported.

Culture characteristics: Colonies composed of appressed mycelial mat with diffuse irregular edges, white centre, darkening slightly with age, pycnidia produced profusely.

Type: Australia, Western Australia, Yalgurup National Park, from healthy stem of Allocasuarina fraseriana, Jun. 2005, K.M. Taylor, holotype PERTH 07693044.

Cultures: WAC 13153 = MUCC 510 (ex-type).

Host: Allocasuarina fraseriana (Taylor et al. 2009).

Known distribution: Western Australia (Taylor et al. 2009).

Notes: The conidia of N. pennatisporum are unusually long (40–50 × 6–10 μm), when compared with other Neofusicoccum spp., including N. macroclavatum (25–35 × 6–8 μm), which is also found in Western Australia, and N. protearum (25–30 × 7–8 μm), which is the most closely related species to N. pennatisporum based on ITS sequence data. In the phylogeny based on ITS and EF1-α sequences, this species resides in a distinct clade as a sister group to all other Neofusicoccum species. According to Taylor et al. (2009), an isolate of N. pennatisporum produced the sexual morph once on pine needles in culture. The ascospores have distinctive protrusions at either end unlike ascospores of other Neofusicoccum spp.

Neofusicoccum protearum (Denman & Crous) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 249. 2006. MycoBank MB500880. See Denman et al. (2003) for illustrations.

Basionym: Fusicoccum protearum Denman & Crous, Mycologia 95: 301. 2003.

= Botryosphaeria protearum Denman & Crous, Mycologia 95: 301. 2003.

Ascomata pseudohothelial, embedded in host tissue, up to 600 μm diam, becoming erumpent, soliatry or botryose, stromatic, dark brown to black, with central, black ostioles; pseudohothelial wall 6–15 layers thick, composed of brown textura angularis. Asci clavate to subcyindrical, 8-spored, bitunicate, with a well-developed apical chamber that becomes inconspicuous at maturity, 110–200 × 15–21 μm. Pseudoparaphyses filiform, branched, septate, 3–5 μm wide. Ascospores irregularly biseriate, hyaline, nonseptate, granular, becoming light brown with age, fusiform, widest in the middle with obtuse ends, sometimes inequilateral, (25)–26–33–(37) × (9)–10–12–(13) μm. Conidiomata stromatic, embedded in host tissue, solitary or botryose, stromatic, globose, up to 500 μm diam, wall 4–8 layers thick, composed of brown textura angularis, becoming hyaline towards the inner region. Conidiophores 0–1-septate, hyaline, subcyindrical, rarely branched, 7–20–(30) × 3–5 μm. Conidiogenous cells holoblastic, hyaline, subcyindrical, rarely proliferating percurrently with 1–2 anellations, proliferating predominantly at the same level with minute periclinal thickenings, which become more prominent in older conidiogenous cells, 7–12 × 3–5 μm. Conidia hyaline, granular, ovoid to clavate when young, becoming irregularly fusoid when mature, widest in the middle with an obtuse apex and bluntly rounded or slightly flattened base, (20)–25–30–(40) × 7–8–(10) μm in vivo. Spermatia produced in same conidiomata as conidia, or in separate conidiomata. Spermatophores hyaline, smooth, branched, cylindrical, 0–2-septate, straight, unbranched or branched above, 12–17 × 2–3 μm. Spermatogenous cells discrete or integrated, hyaline, smooth, cylindrical, proliferating via phialides with periclinal thickenings, 5–12 × 1.5–2.5 μm. Spermatia hyaline, smooth, aseptate, rod-shaped with rounded ends, 3–6 × 1.5–1.5 μm. Dichomera synasexual morph not reported.

Type: Of sexual morph: South Africa, Western Cape, Porterville, Baanbreek Farm, on stems of Protea magnifica, 27 Jul. 1997, S. Denman, holotype PREM 57329; of asexual morph: South Africa, Western Cape, Devon Valley, Protea Heights Farm, on stems of Leucadendron salignum, 31 Oct. 1997, S. Denman & J. Taylor, holotype PREM 57330.

Cultures: STE-U 4361 = CPC 4361 (ex-type culture of sexual morph), STE-U 1775 = CBS 114176 (ex-type culture of asexual morph).

Hosts: Protea and Leucadendron spp. (Denman et al. 2000, 2003, Marincowitz et al. 2008), Santalum acuminatum (Taylor et al. 2009).

Known distribution: Australia, Portugal (continental and Madeira), South Africa, Spain (Tenerife), USA (Hawaii) (Denman et al. 2000, 2003, Marincowitz et al. 2008, Taylor et al. 2009).
**Notes:** Neofusicoccum protearum was originally thought to be restricted to Proteaceae, but it was recently isolated from Santalum acuminatum (Taylor et al. 2009). See notes for N. pennisporum.

**Neofusicoccum ribis** (Slippers, Crous & M.J. Wingf.) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 249. 2006. MycoBank MB500881. See Slippers et al. (2004) for illustrations.

*Basionym:* Fusicoccum ribis Slippers, Crous & M.J. Wingf., Mycologia 96: 96. 2004.

*Textura angularis* black, 175–250 μm, pseudothecial wall comprising 5–15 layers of up to 5–50, globose with central ostiole, papillate or not, brown to diam.

*Ascomata:* 

*Hosts:* Ribes, Ribes vulgare, New York, Geneva, on Ribes vulgare, 2000, D. Pavlic, a dry culture on pine needles, holotype PREM 60068.

*Cultures:* CMW 115475 = CBS 123645 (ex-type), CMW 115477 = CBS 123646.

*Host:* Syzygium cordatum (Pavlic et al. 2009).

*Known distribution:* South Africa (Pavlic et al. 2009).

*Notes:* For many years, B. ribis was was regarded as a synonym of B. dothidea (e.g., Witcher & Clayton 1963, Barr 1972, English et al. 1975, Maas & Uecker 1984, Penncook & Samuels 1985, Brown & Britton 1986, Smith et al. 1994), while others regarded them as distinct species (e.g., Punithalingam & Holliday 1973, Morgan-Jones & White 1987, Rayachhetry et al. 1996, Smith & Stanosz 2001). The debate was finally settled when Slippers et al. (2004) demonstrated that the two were phylogenetically and morphologically distinct and Crous et al. (2006) showed that B. dothidea and N. ribis reside in two distinct phylogenetic lineages. Phylogenetically N. ribis resides in a cluster of cryptic species that are difficult to separate based on morphology.

**Neofusicoccum umdonicola** Pavlic, Slippers & M.J. Wingf., Mycologia 101: 644. 2009. MycoBank MB512500. See Pavlic et al. (2009) for illustrations.

*Ascomata* not reported. Neofusicoccum umdonicola is morphologically similar to other related species in the N. parvum / N. ribis species complex. *Conidia* hyaline, unicellular, fusiform to oval, apices tapered 15–23× 4.5–6.5 μm (av. of 310 conidia = 19.4 × 5.5 μm), L/W = 3.5. Neofusicoccum umdonicola differs from other species in the N. parvum / N. ribis complex by uniquely fixed nucleotides in four nuclear loci: ITS (EU821904) position 168 (C); EF1-α (EU821874) positions 62 (T); β-tubulin (EU821844) position 40 (A); RNA polymerase II subunit (EU821934) position 280 (T).

*Type:* South Africa, Kwazulu-Natal Province, Kosi Bay from symptomless branches and leaves, dying branches and pulp of ripe fruits of Syzygium cordatum, Mar. 2002, D. Pavlic, a dry culture on pine needles, holotype PREM 60068.

*Cultures:* CMW 14058 = CBS 123645 (ex-type), CMW 14060 = CBS 123646.

*Host:* Syzygium cordatum (Pavlic et al. 2009).

*Known distribution:* South Africa (Pavlic et al. 2009).

*Notes:* See notes for N. cordaticola.

**Neofusicoccum viticlavatum** (Van Niekerk & Crous) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 249. 2006. MycoBank MB500882. See van Niekerk et al. (2004) for illustrations.

*Basionym:* Fusicoccum viticlavatum Van Niekerk & Crous, Mycologia 96: 792. 2004.

*Ascomata* not reported. Conidiomata stromatic, embedded in host tissue, solitary, stromatic, globose, up to 450 μm wide, wall 4–8 cell layers thick, of brown textura angularis, becoming hyaline toward inner region. Conidiophores 0–1-septate, hyaline, subcylindric, 10–20 × 2.5–3.5 μm. Conidiogenous cells holoblastic, hyaline, subcylindrical, proliferating percurrently with 1–3 proliferations, or proliferating at same level (phialidic) with minute periclinal thickening, 7–15 × 2.5–3.5 μm. *Conidia* hyaline, guttulate, ellipsoid to clavate, widest in upper third, with an obtuse apex and flattened, subtruncate base, aseptate, (15–)16–18–(20) × (6–)6.5–7.5(–8)
**Neofusicoccum vitifusiforme** (Van Niekerk & Crous) Crous, Slippers & A.J.L. Phillips, Stud. Mycol. 55: 249. 2006.  
**Basionym:** Fusicoccum vitifusiforme Van Niekerk & Crous, Mycologia 96: 793. 2004.  
**Synasexual morph:** Dichomera eucalypti (G. Winter) B. Sutton, Mycol. Pap. 138: 182 1975.  
**Basionym:** Camarosporium eucalypti G. Winter, Revue Mycol., Toulouse 8 (32): 212. 1886.  
= Neofusicoccum corticosae Crous & Summerell, Fungal Divers. 23: 337. 2006.  

Ascomata not reported. **Conidiomata** stromatic, solitary, globose to obpyriform, up to 450 μm diam, conidioma wall 6–15 cell layers thick, of brown textura angularis, becoming hyaline toward inner region. Conidiophores 0–1-septate, hyaline, subcylindrical, 10–45 × 2.5–5 μm. **Conidiogenous cells** holoblastic, hyaline, subcylindrical, proliferating percurrently with numerous proliferations, or proliferating at the same level (phialidic) with minute periclinal thickening, 10–30 × 2.5–3.5 μm. **Conidia** hyaline, granular, fusoid to ellipsoid, widest in the upper third with an obtuse apex and flattened, subtruncate base, (18–)19–21–(22) × (4.5–)5.5–6.5(–8) μm in vitro, L/W ratio = 3.3. Spermatia not reported. **Dichomera synasexual morph:** Conidia subglobose, obpyriform or obovoid, apex obtuse, base truncate to bluntly rounded, (9–)9.5–13–(14.5) × (6.5–)8–10.5(–11) μm, hyaline to pale brown when immature with 0–3 transverse septa, 0–2 longitudinal septa, and 0–2 oblique septa, becoming brown when mature with 1–3 transverse septa, 0–3 longitudinal septa, and 0–2 oblique septa.

**Culture characteristics:** Colonies effuse with even, smooth margins, white on the surface, and greenish olivaceous underneath, reaching a radius of 31 mm after 3 d at 25 °C. Cardinal temperatures for growth: min 10 °C, max 35 °C, opt 30 °C.

**Type:** South Africa, Western Cape Province, Stellenbosch, on V. vinifera, 2002, F. Halleen, *holotype* CBS H-7755.

**Cultures:** STE-U 5044 = CBS 112878 (ex-type), STE-U 5041 = CBS 112977.

**Host:** Vitis vinifera (van Niekerk et al. 2004).

**Known distribution:** South Africa (Western Cape Province) (van Niekerk et al. 2004).

**Notes:** *Neofusicoccum vitilavatum* is closely related to *N. mediterraneum* and *N. vitifusiforme.* It can be differentiated from *N. vitifusiforme* based on the characteristic clavate conidia of *N. vitilavatum* and its smaller conidia. Conidia of this species are much smaller (16–18 × 6.5–7.5 μm) than those of *N. mediterraneum* (24 × 6 μm).

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**Fig. 58.** Neofusicoccum vitifusiforme. A. Conidiomata on pine needles in culture. B. Conidiogenous cells. C. Conidia. Scale bars: A = 1 mm, B, C = 10 μm.
This species was originally thought to be restricted to *Vitis* species, but it was later isolated from *Olea europaea* in Italy (Lazzizera *et al.* 2008). The same authors showed that it is phylogenetically indistinguishable from *Dichomera eucalypti*, which was confirmed in the present study based on ITS and EF1-α. Thus, *D. eucalypti* becomes a synonym and *Eucalyptus* can be regarded as an additional host for the fungus. Furthermore, as mentioned earlier, in the ITS phylogeny, *N. corticosae* grouped with *N. vitifusiforme* and *D. eucalypti* and despite the lack of EF1-α sequence data for *N. corticosae* it would appear that these three species are synonyms, more information is needed to confirm this.

**Neoscytalidium Crous & Slippers, Stud. Mycol. 55: 244. 2006. MycoBank MB500868.**

*Type species:* *Neoscytalidium hyalinum* (C.K. Campb. & J.L. Mulder) A.J.L. Phillips, Groenewald & Crous.

**Coelomycetous synsexual morph:** *Hendersonula* Spec., Anal. Soc. Cient. Arg. 10: 160. 1880.

**Ascomata** not reported. *Conidia* occurring in arthric chains in aerial mycelium, powdery to the touch, disarticulating, cylindrical-truncate, oblong-obtuse to doliform, dark brown, thick-walled, 0–2-septate. Coelomycetous synsexual morph: *Mycelium* immers, branched, septate, hyaline. *Conidiomata* stromatic and irregularly multilocular, or pycnidial and unilocular, blackish brown. *Conidiophores* absent. *Conidiogenous cells* discrete, determinate or indeterminate, hyaline, smooth, ampulliform, doliform or cylindrical, proliferating enteroblastically with conidia seceding at the inner wall of the locules, 6.5–14 × 2.5–6.5 μm. *Conidia* holoblastic, pale brown, 10–16(–21) × 3.5–6.5 μm.

**Lectotype:** United Kingdom, sole of human foot, 20 Nov. 1973, C.K. Campbell, CBS H-7745 (isotype of *Scytalidium hyalinum*).

**Cultures:** CBS 145.78 (ex-isotype).

**Hosts:** Human skin and nails (Campbell & Mulder 1977). According to Sutton & Dyko (1989) it is plurivorous causing gummosis, dieback, wilt and cankers on *Acacia auriculiformis*, *Agathis palmerstoni*, *Agave americana*, *Agave sisalana*, *Ananas comosus*, *Ananas sativa*, *Citrus sinensis*, *Eucalyptus*, *Eucalyptus globulus*, *Ficus carica*, *Fucraea sp.*, *Ipomoea batatas*, *Juglans regia*, *Malus pumila*, *Mangifera indica*, *Melia azaderach*, *Morus alba*, *Musa*, *Philidendron bipinnatifidum*, *Plumeria obtusa*, *Populus alba*, *Prunus amenica*, *Sanseveria guineensis*.

**Known distribution:** Tropical and sub-tropical regions of Europe, Africa, Asia, North and South America.

**Notes:** Nattrass (1933) first described this fungus under the name *Hendersonula toruloidea*. Gentles and Evans (1971) reported the same fungus from a dermatomycosis in patients from tropical areas and a few years later, Campbell and Mulder (1977) introduced the new species *S. hyalinum* as the cause of the same clinical lesions as *H. toruloidea*. Since these first descriptions, the production of both arthroconidial and pycnidial synanamorphs has been shown and led to several controversies in the nomenclature. Sutton and Dyko (1989) transferred *H. toruloidea* to *Nattrassia mangiferae* with the mycelial synanamorph named *Scytalidium dimidiatum* based on *Torula dimidiata*. Farr *et al.* (2005) concluded from a phylogenetic analysis that *Nattrassia mangiferae* and *Scytalidium dimidiatum* belong in *Fusicoccum* and introduced the name *Fusicoccum dimidiatum* to replace *Scytalidium dimidiatum*. Crous *et al.* (2006) in a taxonomic revision of the *Botryosphaeriaceae* concluded that *Scytalidium* is polyphyletic and proposed the genus *Neoscytalidium* to accommodate *S. dimidiatum* as *N. dimidiatum*. It has been suggested that *S. dimidiatum* and *S. hyalinum* might be conspecific and a new name (*N. dimidiatum var. hyalinum*) has been suggested (Madrida *et al.* 2009). Although Crous *et al.* (2006) included an isolate of *S. hyalinum* in their study, they were not aware at the time that the isolate is in fact linked to the isotype of *S. hyalinum*. Since *S. hyalinum* is phylogenetically indistinguishable from *N. dimidiatum* and is the older epithet we transfer *S. hyalinum* to *Neoscytalidium* and reduce *N. dimidiatum* to synonymy. Diseases reported to be associated with this fungus tend to be more common in tropical countries. It has been associated with freeze-damaged limbs of *Citrus* spp. in California, and appears to be a wound pathogen of this host. In Italy, it causes a shoot blight, canker and gummosis disease of *Citrus* (Polizzi *et al.* 2009, 2011).

**Neoscytalidium novaehollandiae** Pavlic, T.I. Burgess, M.J. Wingf., Mycologia 100: 862. 2008. MycoBank MB512103. See Pavlic *et al.* (2008) for illustrations.
Ascomata not reported. Conidiomata semi-immersed or superficial, solitary or in multilocular stromata, black, with globose base, up to 300 μm diam and long neck, up to 600 μm long. Conidiogenous cells holoblastic, cylindrical to subcylindrical, hyaline, the first conidium produced holoblastically and subsequent conidia enteroblastically, (6–)7–10(–11) × (2–)2–3(–4) μm (av. = 8.6 × 2.5 μm). Conidia of two types: (i) ellipsoidal to oval, apices rounded, initially hyaline, unicellular, becoming cinnamon to sepia, and 0–1-septate or 2-septate with darker central cell, (8–)10.5–12.5(–14) × (3–)4–5(–5) μm (av. = 11.5 × 4.4 μm, L/W = 2.6); (ii) variable in shape, globose, subglobose to obpyriform with muriform septa, initially hyaline becoming cinnamon to sepia, (8–)8.5–12.5(–15.5) × (5–)5.5–7.5(–8) μm (av. = 10.6 × 6.9 μm, L/W = 1.5). Aerial mycelium forms chains of arthroconidia, (5–)5.5–7.5(–9.5) × (3–)3.5–4.5(–5) μm (av. = 6.5 × 4 μm, L/W = 1.6), unicellular, powdery to the touch, disarticulating, cylindrical, oblong to obtuse to doliiform, thick-walled, initially hyaline becoming becoming cinnamon to sepia and 0–1-septate.

Culture characteristics: Colonies initially white to olivaceous-buff, becoming greenish olivaceous to citrine from the middle of colonies within 7 d, and black (surface and beneath) with age, with suppressed, moderately fluffy mycelium, edges smooth. Optimum growth at 35 °C, covering the 90 mm diam Petri dish after 3 d in 0–1-septate or 2-septate with darker central cell, (8–)10.5–12.5(–14) × (3–)4–5(–5) μm (av. = 11.5 × 4.4 μm, L/W = 2.6); (ii) variable in shape, globose, subglobose to obpyriform with muriform septa, initially hyaline becoming cinnamon to sepia, (8–)8.5–12.5(–15.5) × (5–)5.5–7.5(–8) μm (av. = 10.6 × 6.9 μm, L/W = 1.5). Aerial mycelium forms chains of arthroconidia, (5–)5.5–7.5(–9.5) × (3–)3.5–4.5(–5) μm (av. = 6.5 × 4 μm, L/W = 1.6), unicellular, powdery to the touch, disarticulating, cylindrical, oblong to obtuse to doliiform, thick-walled, initially hyaline becoming becoming cinnamon to sepia and 0–1-septate.

Type: Australia, Western Australia, Bell Gorge, on Crotalaria medicaginae, Jul. 2006, T.I. Burgess, holotype PREM 60069.

Cultures: CMW 26170 = CBS 122071 (ex-type).

Hosts: Asymptomatic branches (sapwood) of Acacia synchronica, Adansonia gibbosa, Crotalaria medicaginae and Grevillia agrifolia (Pavlic et al. 2008). Pathogen of Mangifera indica and Ficus carica (Ray et al. 2010).

Known distribution: northern Western Australia.

Notes: Although N. novaehollandiae is morphologically and phylogenetically similar to N. dimidiatum (Punithalingam & Waterston 1970, Crous et al. 2006), Pavlic et al. (2008) reported muriform, dichomera-like conidia in the isolates that they studied and for this reason they regarded it as a distinct species.

Phaeobotryon Theiss. & Syd., Ann. Mycol. 13: 664. 1915. MycoBank MB3892.

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

Ascomata black, immersed to erumpent, subglobose to ovoid, multilocular, wall composed of layers of dark brown textura angularis. Pseudoparaphyses hyphae-like, septate, constricted at septa. Asci 8-spored, bitunicate, fissitunicate, clavate to cylindro-clavate, short-pedicellate, apically rounded with an ocular chamber. Ascospores hyaline to brown, 2-septate, ellipsoid to broad fusiform, with an apiculus at each end, immature ascus surrounded by a mucilagenous sheath. Conidiomata pycnidial, stromatic, black, ostiolate, separate or aggregated, immersed to erumpent, unilocular or multilocular, ostiolate. Ostiole circular, central, papillate. Paraphyses hyaline, thin-walled, usually asceptate, sometimes becoming 1–2-septate. Conidiogenous cells holoblastic, hyaline, thin-walled, smooth, cylindrical to doliiform. Conidia ellipsoidal to oblong or obovoid, mostly 2-septate at maturity.

Notes: Phaeobotryon was introduced by Theissen & Sydow (1915) to accommodate Dothidea cercidis. This taxon was considered a distinct genus on account of its pale brown, 2-septate ascospores, which were reported as hyaline in the original description. In their broad concept of Botryosphaeria, von Arx & Müller (1954, 1975) considered Phaeobotryon as a synonym of Botryosphaeria. Phillips et al. (2008) reinstated Phaeobotryon after they showed that it is morphologically and phylogenetically distinct from all other genera in the Botryosphaeriaceae. The 2-septate, brown ascospores with an apiculus at each end are characteristic for the genus. Only two species (P. mamane and P. cupressi) are currently known in culture and they can be separated on the size of their conidia.

Species descriptions

**Phaeobotryon mamane** Crous & A.J.L. Phillips, Persoonia 21: 45. 2008. MycoBank MB506581. See Phillips et al. (2008) for illustrations.

Ascomata pseudothecial, dark brown to black, stromatic, globose, aggregated in botryose clusters or separate, immersed, becoming erumpent, ostiolate, up to 350 μm diam, wall consisting of 4–6 cell...
layers of dark brown textura angularis. 
Pseudoparaphyses hyaline, smooth, multiseptate, with septa 10–23 μm apart, constricted at septa, 3–4 μm wide. Asci bitunicate, 8-spored, stipitate, thick-walled with thick endotunica and well-developed apical chamber, 120–150(–200) × 25–30 μm, with biseriate ascospores. Ascospores ellipsoid to ovate, (30–)37–40(–45) × (11–)13–15(–16) μm, 2-septate, with three cells of equal length, not constricted at septa, finely verruculose, widest in middle with conical apiculus at one or both ends. Spermatogonia morphologically similar to conidiomata, also formed in culture. Spermatia hyaline, rod-shaped with rounded ends, 3–5 × 2 μm. Conidiomata pycnidial, stromatic, ostiolate, separate or aggregated, globose, black, immersed to erumpent, unilocular, up to 350 μm diam, wall consisting of 4–6 layers of brown textura angularis. Conidiogenous cells cylindrical to doliform, hyaline, smooth, proliferating percurrently near apex, 10–14 × 4–8 μm. Conidia ellipsoid to oblong or subcylindrical or obovoid, brown, smooth to finely verruculose, moderately thick-walled, granular, guttulate, ends rounded, 1(–2)-septate, base with inconspicuous scar, slightly flattened, (30–)35–38(–43) × (12–)14–15(–16) μm.

Type: USA, Hawaii, Manna Koa Park, Saddle Road, on stems of Sophora chrysophylla, Jul. 2005, W. Gams, holotype CBS H-20109.

Cultures: CPC 12440 = CBS 122980 (ex-type).

Host: Sophora chrysophylla (Phillips et al. 2008).

Known distribution: USA (Hawaii) (Phillips et al. 2008).

Note: Asexual morph dothiorella/spencermartinsia-like, but with up to two transverse septa and apiculi at either end of the ascospores.

Phaeobotryon cupressi Abdollahz., Zare & A.J.L. Phillips, Persoonia 23: 6. 2009. MycoBank MB513236. Fig. 60.

Ascomata not reported. Conidiomata pycnidial, stromatic, superficial, dark-brown to black, mostly unilocular on pine needles and up to 650 μm diam, mostly multilocular on Populus twigs, individual or aggregated, thick-walled, ostiolate. Ostiole central, circular, non-papillate. Paraphyses hyaline, thin-walled, arising from the conidiogenous layer, extending above the level of developing conidia, up to 42 μm long, 4.8 μm wide, usually aseptate, sometimes becoming up to 2-septate, tip rounded, occasionally branched. Conidiophores absent. Conidiogenous cells hyaline, smooth, thin-walled, cylindrical, holoblastic, phialidic, proliferating internally with visible periclinal thickening, 7–14 × 2–5 μm.
**The Botryosphaeriaceae: genera and species known from culture**

Conidia thick-walled, initially hyaline, oval, both ends broadly rounded, aseptate, forming a single septum at germination, rarely becoming brown and 1-septate, internally verruculose when aged, (19.5–)21–28(–30) × (10–)11–15(–17) μm, 95 % confidence limits = 24–25 × 12–12.5 μm (av. ± S.D. = 24.8 ± 1.9 × 12.4 ± 1.3 μm), L/W ratio = 2. Spermatogonia globose, dark-brown to black, superficial, occasionally immersed in pine needle or *Populus* tissue. Spermatophores cylindrical, hyaline, aseptate becoming 1–2-septate, branched, 7–13 × 1.5–2.5 μm. Spermatogenous cells hyaline, thin-walled, phialidic, proliferating internally, giving rise to periclinal thickening, 6–10 × 1–2 μm. *Spermatia* oval, thin-walled, hyaline, aseptate 2–4 × 1–2 μm. *Chlamydores* intercalary, brown, smooth, thick-walled, formed within the agar medium.

**Culture characteristics:** Colonies on PDA with abundant aerial mycelium towards appressed, in the centre, becoming grey-olivaceous to olivaceous-grey at the surface, and grey-olivaceous in reverse after 2 wk in the dark at 25 °C, reaching 46–53 mm diam after 4 d in the dark at 25 °C. Cardinal temperatures for growth: min 5 °C, max > 35 °C, opt 25 °C.

**Type:** Iran, Golestan Province, Gorgan, City Park, on twigs of *Cupressus sempervirens*, 15 Aug. 2006, M.A. Aghajani, holotype IRAN 13940F.

**Cultures:** IRAN 1455C = CBS 124700 (ex-type).

**Host:** *Cupressus sempervirens* (Abdollahzadeh et al. 2009), *Juniperus scopulorum* (Alves et al. 2013).

**Known distribution:** Iran (Abdollahzadeh et al. 2009), USA (Alves et al. 2013).

### Key to *Pseudofusicoccum* spp.

1. Forms a violet pigment in culture ............................................................................................................... 2
2. No violet pigment in cultures .......................................................................................................................... 3
3. Conidia on average greater than 30 μm long ................................................................................................. *Ps. violaceum*
4. Conidia on average smaller than 25 μm long ............................................................................................... *Ps. adansoniae*
5. Conidia on average smaller than 30 μm long .......................................................................................... *Ps. kimberleyense*
6. Conidia on average = 30 μm or more long ................................................................................................. *Ps. stromaticum*
7. Conidia on average 7 μm or more wide ........................................................................................................ *Ps. violaceum*
8. Conidia on average smaller than 7 μm wide ............................................................................................... *Ps. adansoniae*
9. Conidia 20–26 × 6.5–7.5 μm .................................................................................................................. *Ps. stromaticum*
10. Conidia 21–29 × 7–8 μm ............................................................................................................................ *Ps. adansiaum*

**DNA phylogeny**

Six species can be distinguished in the ITS phylogeny (Fig. 61). Support for *Ps. adansiaum* and *Ps. kimberleyensis* is very low and the branch lengths for these two species are very short. Morphologically they are also very similar, although conidia of *Ps. kimberleyensis* are, on average, longer than those of *Ps. adansiaum*.

**Notes:** This species differs from *P. quercicola* and *P. mamane* in its smaller conidia, and has been collected only from *Cupressus* species. The hyaline, aseptate conidia of *P. cupressi* are superficially similar to those of other *Diplodia* species with hyaline conidia. Furthermore, conidial dimensions of *P. cupressi* are similar to those of *Diplodia cupressi* (21.5–30.5 × 12–16 μm) as reported by Alves et al. (2006). It is thus possible that *P. cupressi* has been mistaken for *D. cupressi* in the past. Pycnidial paraphyses in *Phaeobotrya* clearly distinguish this genus from *Diplodia*.

**Species descriptions**

*Pseudofusicoccum adansoniae* Pavlic, T.I. Burgess, M.J. Wingf., *Mycologia* 100: 855. 2008. MycoBank MB512048. See Pavlic et al. (2008) for illustrations.

Ascomata not seen. Conidiomata semi-immersed, solitary, globose, papillate, chestnut, covered by hyphal hairs, up to 500 μm diam. *Conidiogenous cells* holoblastic, smooth, cylindrical, hyaline, the first conidium produced holoblastically and subsequent conidia enteroblastically, (9–)10–15(–16) × (1.5–)2–
3 (–3.5) μm (av. 12.7 × 2.4 μm). Conidia ellipsoid, occasionally slight or irregularly shaped, apices rounded, smooth with fine granular content, hyaline, thin-walled, covered with a persistent mucus layer, unicellular, forming 1 or 2 septa before germination, (19–)21–24(–26) × (3.5–) 4.5–6(–6.5) μm (av. size of conidia = 22.5 × 5.2 μm), L/W = 4.3.

Culture characteristics: Colonies initially white with moderately dense, appressed mycelial mat, submerged mycelium turning grey-olivaceous to olivaceous-black from the middle of colony after 3–5 d and becoming dark slate-blue with age, aerial mycelium slightly fluffy, becoming dense, cottony with age, sometimes remaining white to smoke-grey, usually turning pale olivaceous-grey within 7 d and becoming olivaceous-grey to iron grey with age; conidiomata readily formed from the middle of colony within 7–10 d, covering the entire surface of the colony and immersed in the medium. Optimum growth at 30 °C, covering the 90 mm diam Petri dish after 4 d in the dark.

Type: Australia. Western Australia, Derby, on Adansonia gibbosa, Jul. 2006, T.I. Burgess, holotype PREM 59843 (a dry culture on pine needles).

Cultures: CMW 26159 = CBS 122062 (ex-type).

Hosts: Adansonia gibbosa, Acacia synchronica, Eucalyptus sp., Ficus opposita (Pavlic et al. 2008), Adansonia gregorii, Grevillea agrifolia (Sakalidis et al. 2011).

Known distribution: Australia (Pavlic et al. 2008, Sakalidis et al. 2011).
with fine granular content, hyaline, thin-walled, covered with a persistent mucus layer, unicellular, forming 1–4 septa before germination, (24–)28–33(–34) × (6.5–)7–8(–8.5) μm (av. = 30.7 × 7.4 μm), L/W = 4.1.

Culture characteristics: Colonies slightly irregular with sinuate edges, initially white, forming a moderately dense, appressed mycelial mat, submerged mycelium citrine to grey-olivaceous, becoming olivaceous-black to black with age, aerial mycelium slightly fluffy, becoming dense, cottony with age, smoke-grey to pale olivaceous-grey. Optimum temperature for growth 30 °C, covering a 90 mm diam Petri dish after 4 d in the dark.

Type: Australia, Western Australia, Tunnel Creek National Park, on Acacia synchronica, Jul. 2006, T.I. Burgess, holotype PREM 59842 (a dry culture on pine needles).

Cultures: CMW 26156 = CBS 122058 (ex-type).

Hosts: Adansonia gibbosa, Acacia synchronica, Eucalyptus sp. and Ficus opposita (Pavlic et al. 2008).

Known distribution: Western Australia (Pavlic et al. 2008).

Note: The wide range of hosts and absence of symptoms on the hosts suggest that this species is a non-specialised endophyte known only in Australia.

**Pseudofusicoccum olivaceum** Mehl & Slippers

*Mycologia* 103: 537. 2011. MycoBank MB513501. See Mehl et al. (2011) for illustrations.

Ascomata not seen. **Conidiomata** on host and on pine needles on water agar pycnidial, stromatic, subcuticular, unilocular, cylindrical, dark brown, mostly solitary, apllanate, covered with hyphae/mycelium, wall composed of three layers: an outer layer of thick-walled dark to light brown *textura angularis*, a middle layer of thin-walled light brown cells; an inner layer of thin-walled hyaline cells, (480–)530–650(–690) μm diam. **Ostiole** central, circular, papillate. **Conidiogenous cells** hyaline, holoblastic, smooth, cylindrical, guttulate, proliferating percurrently to form one or two indistinct annellations, or proliferating at the same level giving rise to periclinal thickenings. **Paraphyses** (3–)4.5–8.5(–12.5) × (1.5–)3–4.5(–6.5) μm (av. = 6.8 × 3.7 μm). Conidia hyaline, thin-walled, unicellular, aseptate, occasionally granular, guttulate, surrounded by a persistent mucoid sheath, apex and base blunt to broadly rounded, bacilliform, (18–)20–25.5(–30.5) × (6–)6.5–7.5(–9) μm (av. = 22.8 × 7.0 μm).

Culture characteristics: Cultures fluffy, initially white to amber at the centre, olivaceous at the edges, becoming white to olivaceous with age. Optimum temperature for growth 25 °C.

Type: South Africa, Mpumalanga Province, Kruger National Park, Pretoriuskop, on an asymptomatic branch of *Pterocarpus angolensis*, Sep. 2005, J. Roux, holotype PREM 60328.

Cultures: CMW 20881 = CBS 124939 (ex-type), CMW 22637 = CBS 124940, CMW 22643 = CBS 124941 (ex-paratype).

Host: *Pterocarpus angolensis* (Mehl et al. 2011).

Known distribution: South Africa (Mehl et al. 2011).

Notes: In addition to the host on which it was described, this species has also been found on *Terminalia sericea* (Mehl et al. 2011), suggesting it is a common endophyte on other tree species.

**Pseudofusicoccum stromaticum** (Mohali, Slippers & M.J. Wingf.) Mohali, Slippers & M.J. Wingf., *Stud. Mycol.* 55: 249. 2006. MycoBank MB500885. Fig. 62.

Basionym: *Fusicoccum stromaticum* (Mohali, Slippers & M.J. Wingf.) Mohali, Slippers & M.J. Wingf., *Stud. Mycol.* 55: 249. 2006. MycoBank MB500885. Fig. 62.

Ascomata not seen. **Conidiomata** on host and on pine needles on water agar pycnidial, stromatic, subcuticular, unilocular, dark brown, mostly solitary, apllanate, covered with hyphae/mycelium, wall composed of three layers: an outer layer of thick-walled dark to light brown *textura angularis*, a middle layer of thin-walled light brown cells; an inner layer of thin-walled hyaline cells, (480–)530–650(–690) μm diam. **Ostiole** central, circular, papillate. **Conidiogenous cells** hyaline, holoblastic, smooth, cylindrical, guttulate, proliferating percurrently to form one or two indistinct annellations, or proliferating at the same level giving rise to periclinal thickenings. **Paraphyses** (3–)4.5–8.5(–12.5) × (1.5–)3–4.5(–6.5) μm (av. = 6.8 × 3.7 μm). Conidia hyaline, thin-walled, unicellular, aseptate, occasionally granular, guttulate, surrounded by a persistent mucoid sheath, apex and base blunt to broadly rounded, bacilliform, (18–)20–25.5(–30.5) × (6–)6.5–7.5(–9) μm (av. = 22.8 × 7.0 μm).

Culture characteristics: Cultures fluffy, initially white to amber at the centre, olivaceous at the edges, becoming white to olivaceous with age. Optimum temperature for growth 25 °C.

Type: South Africa, Mpumalanga Province, Kruger National Park, Pretoriuskop, on an asymptomatic branch of *Pterocarpus angolensis*, Sep. 2005, J. Roux, holotype PREM 60328.

Cultures: CMW 20881 = CBS 124939 (ex-type), CMW 22637 = CBS 124940, CMW 22643 = CBS 124941 (ex-paratype).

Host: *Pterocarpus angolensis* (Mehl et al. 2011).

Known distribution: South Africa (Mehl et al. 2011).

Notes: In addition to the host on which it was described, this species has also been found on *Terminalia sericea* (Mehl et al. 2011), suggesting it is a common endophyte on other tree species.
**Pseudofusicoccum violaceum** Mehl & Slippers, Mycologia 103: 542. 2011. MycoBank MB513500. See Mehl et al. (2011) for illustrations.

Ascomata not seen. Conidiomata on the host and on pine needles on water agar pycnidal, stromatic, superficial, unicellular, dark brown, mostly solitary, more or less globose/circular, covered with hyphae/mycelium, wall composed of three layers: an outer layer of thick-walled, dark to light brown textura angularis, a middle layer of thin-walled light brown cells, and an inner layer of thick-walled, dark to light brown, mostly solitary, more or less globose/circular, covered with a persistent mucoid sheath, apex and base blunt to broadly rounded, walled, unicellular, aseptate, granular, guttulate, surrounded by a cavity often while still attached to the conidiogenous cell, thick-walled, externally smooth, internally verruculose, broadly rounded at the apex, base truncate.

Notes: *Pseudofusicoccum stromaticum* was originally isolated from asymptomatic as well as dead and dying branches and stems of *Eucalyptus* and *Acacia mangium* trees in Venezuela. The presence of the fungus in asymptomatic branches of two different host genera suggests that it is a generalist endophyte. However, it has been reported to cause die-back of *Mangifera indica* in Brazil (Marques et al. 2013).

**Ascomata** pseudothecial, ostiolate. *Pseudoparaphyses* thin-walled, hyaline, septate, constricted at septa. *Asci* bitunicate, 8-spored, clavate, stipitate, developing amongst thin-walled, septate pseudoparaphyses, with biseriate ascospores. Ascospores hyaline when young, brown when mature, uniseptate with an apiculus at each end. *Conidiumata* pycnidial, stromatic. *Conidiophores* absent. *Conidiogenous cells* lining inner surface of conidioma, holoblastic, proliferating internally producing periclinal thickenings, or proliferating percurrently to form annellations. *Conidia* initially hyaline, becoming dark brown and 1-euseptate within the pycnidial cavity often while still attached to the conidiogenous cell, thick-walled, externally smooth, internally verruculose, broadly rounded at the apex, base truncate.

Notes: *Spencermartinsia viticola* was introduced by Phillips et al. (2008) for species similar to *Dothiorella* but that differ in having 2-celled ascospores with an apiculus at either end of the ascospores. This minor difference was considered to be taxonomically meaningful since the presence or lack of apiculi on ascospores also separates other genera in this family, such as *Barriopis* (no apiculus) from *Sphaeropsis* (apiculus present), and this was supported phylogenetically. Nevertheless, this is a tenuous and difficult morphological character to apply, especially since a sexual morph has been reported only for *S. viticola* and it is not clear whether this is a consistent character for the genus. Furthermore, with the addition of further species in *Dothiorella*, the phylogenetic distinction between the two genera is becoming less obvious. However, we continue to recognise *Spencermartinsia* as a separate genus pending further phylogenetic and morphological studies including additional species. *Spencermartinsia* is presently monotypic based on *S. viticola*. Based on phylogenetic analyses, two recently described species, *S. uruguayensis* and *S. pretoriensis* have been re-combined in *Dothiorella* (see above).

**DNA phylogeny**

Based on ITS and EF1-α sequence data, *Spencermartinsia* is clearly separated from *Dothiorella*. In the phylogenetic analyses two main clades are recognised in *Spencermartinsia* (Figs 32, 33). The first clade constitutes *S. viticola* while the other includes three sub-clades including four isolates CBS 500.72 (*Diplodia medicaginis*), CBS 117006, ICMP 16827 and ICMP 16828, representatives of three distinct species. Isolate CBS 117006 identified by Luque
et al. (2005) as *B. viticola*, exhibited some differences in culture morphology and sequence data from the ex-type strain and other strains as discussed by Phillips et al. (2008), reside in a distinct clade. The two isolates ICMP 16827 and ICMP 16828 on *Citrus sinensis* from New Zealand constitute a distinct clade as representatives of a new species. Furthermore, isolate CBS 500.72
previously characterised as Diplodia medicaginis formed another distinct clade and is clearly a misidentification. These species are not described here due to their uncertain taxonomic status.

Species descriptions

Spencermartinsia viticola (A.J.L. Phillips & J. Luque) A.J.L. Phillips, A. Alves & Crous, Persoonia 21: 51. 2008. MycoBank MB511763. Fig. 63.  
Basionym: Dothiorella viticola A.J.L. Phillips & J. Luque, Mycologia 97: 1116. 2005.  
= Botryosphaeria viticola A.J.L. Phillips & J. Luque, Mycologia 97: 1116. 2005.  

Ascomata dark brown to black, stromatic, pyriform, pseudoeothelial, isolated or in botryose clusters up to 2 mm diam, initially immersed in host, partially erumpent at maturity, up to 240 μm diam, ostiole circular, central, papillate, wall up to 60 μm thick, of dark brown thick-walled textura angularis, and lined with thin-walled, hyaline cells. Pseudoparaphyses thin-walled, hyaline, frequently septate, slightly constricted at septum, 3.5–4.5(–5) μm wide. Asci arising from base of ascoma, stipitate, clavate, thick-walled, bitunicate with a thick endotunica and a well-developed apical chamber, 8-spored, irregularly biseriate, 100–110 × 25–30 μm. Ascospores oblong, ovate to sub-clavate, mostly 1-septate, slightly constricted at septum, brown, moderately thick-walled, finely verruculose on inner surface, often inequilateral, widest in lower 1/3 to middle of apical cell, often with a small rounded projection at tip and base of spore, basal cell tapering towards obtuse base, (19–) 22.5–23.5(–27) × (8.5–)10.5–11(–14.5) μm (av. ± S.D. = 23.1 ± 0.2 × 10.9 ± 0.1 μm). Conidiomata pycnidial, stromatic, separate or aggregated into botryose clusters up to 2 mm diam, individual conidiomata spherical to globose, black, immersed, partially erumpent when mature, unilocular, 200–360 μm diam, thick-walled, wall consisting of three layers: an outer layer of dark brown, thick-walled textura angularis, a median layer of dark brown thin-walled cells textura angularis, and an inner layer of thin-walled, hyaline cells. Ostiole single, central, circular, papillate. Conidiophores absent. Conidigenous cells discrete or integrated, cylindrical to broad lageniform, (5–)8.5–10(–14) × (3–)14.5–5(–7) μm, hyaline, smooth, holoblastic, indeterminate, proliferating at same level to form periclinal thickening or rarely proliferating percurrently giving rise to 1–2 annellations. Conidia brown, oblong to subcylindrical, septe, occasionally slightly constricted at septum, moderately thick-walled, externally smooth, internally finely verruculose, ends rounded, often with a truncate base, (16–)20–20.5(–26) × (7–)9–9.5(–12) μm (av. ± S.D. = 20.4 ± 0.1 × 9.3 ± 0.1 μm), L/W ratio = 2.2.

Culture characteristics: Colonies on PDA reaching 40 mm in radius after 3 d at 25 °C. Aerial mycelium present, colonies cottony, dark olive to greyish, darkening from the center of the colony after 3 d, colony fully darkened after 6–10 d. Conidiomata produced after 20–30 d in culture at 23 °C under near UV black light (12/12 h photoperiod). Cardinal temperatures for growth: min 5 °C, max < 35 °C, opt 20–25 °C.

Type: Spain, Catalonia, Vim-bodi, near the Monastery of Poblet, on pruned canes of Vitis vinifera cv. Garnatxa Negra, Aug. 2004, J. Luque & S. Martos, holotype LISE 95177.

Cultures: CBS 117009 (ex-type), CBS 302.75.

Hosts: Citrus sp. (Adesemoye & Eskalen 2011, Inderbitzin et al. 2010), Populus cathayana (Zhang et al. 2009), Ponciana gilliesii (Phillips et al. 2008), Prunus persica and P. salicina (Damm et al. 2007), Vitis vinifera (de Wet et al. 2009, Luque et al. 2005, Qiu et al. 2011, Úrbez-Torres et al. 2007).

Known distribution: Australia (Qiu et al. 2011), China (Zhang et al. 2009), France (Phillips et al. 2008), South Africa (Damm et al. 2007, de Wet et al. 2009), Spain (Luque et al. 2005) and USA (Adesemoye & Eskalen 2011, Inderbitzin et al. 2010, Úrbez-Torres et al. 2007).

Notes: The sexual morph is extremely rare compared to the abundant asexual morph. The ex-type isolate of Spencermartinsia viticola (CBS 117009) clustered with an isolate previously identified as Diplodia spegazziniana (CBS 302.75), which is clearly a misidentification.

Sphaeropsis Sacc., Michelia 2: 105. 1880. MycoBank MB99992.  
= Phaeobotryosphaeria Spagn., Ann. Inst. Rech. Agron. 17, 10: 120. 1908.  
Type species: Sphaeropsis visci (Alb. & Schwein.) Sacc., Michelia 2: 105. 1880.

Ascomata pseudoeothelial, brown to black, unilocular, thick-walled. Pseudoparaphyses hyaline, septe, 8-spored, thick-walled with thick endotunica and well-developed apical chamber. Ascospores brown, aseptate with small apiculus at either end. Conidiomata pycnidial, stromatic, immersed to erumpent, thick-walled, wall composed of several layers of dark-brown textura angularis. Ostiole single, central, papillate. Paraphyses hyaline, asepte, thin-walled. Conidigenous cells hyaline, discrete, proliferating internally to form periclinal thickenings. Conidia oval, oblong or clavate, straight, asepte, moderately thick-walled.

Notes: Sphaeropsis was introduced by Saccardo (1880) for species of Diplodia with brown, aseptate conidia with S. visci as the type species. Since then more than 600 species have been described (MycoBank accessed 10 Jul. 2013) mostly on the basis of host association. However, few of these names are currently in use and cultures are not available for the species that define them. The well-known pine pathogen that has been known as Sphaeropsis sapinae is clearly not a species of Sphaeropsis and is retained in Diplodia.

Phillips et al. (2008) established the connection between the asexual and the sexual morph in S. visci. A bitunicate ascomycete, with characters corresponding to Phaeobotryosphaeria, occurring on Viscum album produced in culture a coelomycete with large, brown, aseptate conidia typical of Sphaeropsis and corresponding to the current concept of S. visci. Phillips et al. (2008) applied the one fungus-one name concept and chose Phaeobotryosphaeria in favour of Sphaeropsis. However, following the amendments to the ICBN ratified at the 18th Botanical Congress in Melbourne, it is now clear that priority of names will no longer be based on the life stage of the fungus. Thus, the older name Sphaeropsis (1880) takes priority over Phaeobotryosphaeria (1908). To correct this, new combinations are introduced here together with the descriptions of the species considered by Phillips et al. (2008). Pycnidial paraphyses distinguish Sphaeropsis morphologically
from *Diplodia* while the striate conidia of *Lasiodiplodia* differentiate it from *Sphaeropsis*, which has smooth-walled conidia. Although more than 600 names exist in *Sphaeropsis*, only four species are currently known in culture. The distinctly pitted conidial walls of *S. porosum* distinguish it from the other two species. The paraphyses with swollen tips and conidia that soon become pigmented distinguish *S. visci* from *S. citrigena* in which conidia remain hyaline for long periods, rarely become pigmented and paraphyses tips are not swollen. The only known cultures of *S. eucalypti* have not sporulated and thus could not be included in the key, which relies on characters of the asexual morph.

**Fig. 64.** *Sphaeropsis citrigena*. A–C. Asci with brown ascospores. D. Pseudoparaphyses. E–G. Brown, aseptate ascospores with apiculi (arrows). H. Conidium developing on a conidiogenous cell with periclinal thickenings. I. Hyaline, aseptate conidium. J. Conidiomatal paraphyses. Scale bars A = 50 μm, B–D = 20 μm, E–J = 10 μm.
Sphaeropsis citrigena (A.J.L. Phillips, P.R. Johnst. & Pennycook) A.J.L. Phillips & A. Alves, *comb. nov.* MycoBank MB805463. Fig. 64.

**Basionym:** *Phaeobotryosphaeria citrigena* A.J.L. Phillips, P.R. Johnst. & Pennycook, *Persoonia* 21: 50. 2008.

Ascomata pseudothecial, brown to black, separate or aggregated, immersed, becoming erumpent, ostiolate, wall composed of several layers of dark brown *textura angularis*. Pseudoparaphyses hyaline, 4–6 μm wide, multiseptate, with septa 11–26 μm apart, constricted at septa. Asci bitunicate, 8-spored, stipitate, thick-walled with thick endotunica and well-developed apical chamber, 180–230 × 35–43(–50) μm, with biseriate ascospores. Ascospores reddish-brown when mature, ellipsoid to ovoid with both ends rounded, with an apiculus at either end, aseptate, externally smooth, internally finely verruculose, widest in middle to upper third, (27.5–)29–37.5(–38.5) × (14.5–)15.5–18(–19.5) μm.

Conidiomata immersed to erumpent and superficial, unilocular, up to 500 μm wide, wall composed of several layers of dark brown *textura angularis*. Paraphyses hyaline, aseptate, up to 25 μm long and 3–3.5 μm wide, apex not swollen. Conidiogenous cells hyaline, discrete, proliferating internally to form periclinal thickenings, 8–11 × 4–6.5 μm. *Conidia* oval, apex obtuse, base obtuse or truncate, moderately thick-walled, initially hyaline, becoming brown, externally smooth, internally finely verruculose, aseptate, (27–)28–33(–34) × (14.5–)15–18.5(–19) μm.

**Type:** New Zealand, Northland, Kerikeri, Davies Orchard (#2), Inlet Road, on recently dead bark-covered twigs of *Citrus sinensis*, 6 Sep. 2006, S.R. Pennycook, P.R. Johnston & B.C. Paulus, holotype PDD 89238.

**Culture:** ICMP 16812 (ex-type).

**Notes:** Conidia of *P. citrigena* remain hyaline for long periods and dark conidia are rarely encountered. Conidial dimensions of this species are similar to those of *S. visci*, but its ascospores are reddish-brown in contrast to the pale brown ones of *S. visci*. Furthermore, *S. visci* appears to be specific to *Viscum* species while *S. citrigena* has been found only on *Citrus* species.

**Sphaeropsis eucalypticola** (Doilom, J.K. Liu, & K.D. Hyde) A.J.L. Phillips, *comb. nov.* MycoBank MB805464. Fig. 65.

**Basionym:** *Phaeobotryosphaeria eucalypti* Doilom, J.K. Liu & K.D. Hyde, *Fungal Divers.* 57: 190. 2012.

Ascomata black, dark brown, aggregated, immersed, becoming erumpent, ostiolate, wall composed of several layers of dark brown *textura angularis*. Pseudoparaphyses 3–4 μm wide, septate, constricted at septa. Asci 8-spored, bitunicate, fissitunicate, cylindro-clavate or clavate, with a short pedicel, apically rounded with an ocular chamber, (90–)97–110(–125) × 28–30 μm (av. = 106 × 29 μm). Ascospores overlapping biseriate, hyaline when young, becoming dark brown when mature, aseptate, ellipsoid to ovoid, ends rounded, with a minute apiculus at each end, smooth, widest in the middle, 27–35 × 11–14 μm (av. = 30 × 12 μm). Asexual state not seen.

**Type:** Thailand, Chiang Rai Province, Muang District, on dead twig of *Eucalyptus* sp., 8 Aug. 2011, M. Doilom, holotype MFLU 12-0753.

**Cultures:** MFLUCC 11-0579 = CBS 133993.
Hosts: Eucalyptus sp. (Liu et al. 2012).

Known distribution: Thailand (Liu et al. 2012).

Notes: Liu et al. (2012) could not induce asexual sporulation of *S. eucalypti* in culture and our attempts with the ex-type culture were also unsuccessful.

*Sphaeropsis porosa* (Van Niekerk & Crous) A.J.L. Phillips & A. Alves, comb. nov. MycoBank MB805465. Fig. 66.

Basionym: *Diplodia porosum* Van Niekerk & Crous, Mycologia 96: 790. 2004.

≡ *Phaeobotryosphaeria porosa* (Van Niekerk & Crous) Crous & A.J.L. Phillips, Persoonia 21: 51. 2008.

Ascomata not reported. Conidioma solitary, unilocular, ostiolate, globose to obpyriform, up to 400 μm wide, conidioma wall 4–8 cell layers thick, of dark brown *textura angularis*, becoming hyaline toward inner region. Conidiophores reduced to conidiogenous cells. Conidiogenous cells lining cavity, holoblastic, hyaline, subcylindrical to ampulliform, 6–10 × 5–7 μm, rarely proliferating percurrently. Conidia hyaline, guttulate, ovoid to broadly ellipsoid with a bluntly rounded apex, and flattened base, wall 2 μm thick, with pores 1 μm wide, becoming medium brown with age, (38–)42–45–(47) × (20–)22–25–(30) μm in vitro, L/W = 1.9.

Culture characteristics: Colonies flat with undulating margins, dark green on the surface and dull green underneath, reaching a radius of 32 mm after 3 d at 25 °C. Cardinal temperatures for growth: min 10 °C, max 30 °C, opt 25 °C.

Type: South Africa, Western Cape Province, Stellenbosch, on Vitis vinifera, 2002, J.M. van Niekerk, holotype CBS H-12039.

Cultures: STE-U 5132 = CBS 110496 (ex-type).

Host: *Vitis vinifera* (van Niekerk et al. 2004).

Known distribution: South Africa (Western Cape Province) (van Niekerk et al. 2004).

Notes: Van Niekerk et al. (2004) did not mention pycnidial paraphyses in *Diplodia porosum*, but they were clearly seen when their isolates were re-examined (Fig. 3). This species is unique within the *Botryosphaeriaceae* because of its large, thick-walled conidia with large pores (1 μm wide) that are easily seen by light microscopy. However, the pitted walls, although unique and distinctive, should be regarded as informative at the species level in the same way that this character was regarded in the original description.

*Sphaeropsis visci* (Alb. & Schwein.) Sacc., Michelia 2: 105. 1880. MycoBank MB281898. Fig. 67.

Basionym: *Sphaeria atrovirens* var. *visci* Alb. & Schwein., Consp. fung. (Leipzig): 48. 1805.

≡ *Ceuthospora visci* (Alb. & Schwein.) Sollm., Hedwiga 2: 189. 1863.

≡ *Sphaeropsis visci* (Alb. & Schwein.) Sacc., Michelia 2(no. 6): 105. 1880.

≡ *Sphaeropsis visci* (Alb. & Schwein.) Sacc. f. *visci*, Michelia 2(no. 6):
Fig. 67. Sphaeropsis visci. A. Immature asci. B. Mature ascus with brown, aseptate ascospores. C–F. Brown, aseptate ascospores with apiculi (arrows). G. Conidioma formed in culture on a pine needle. H, I. Conidia forming on conidiogenous cells between paraphyses (arrows). J. Developing conidia. K. Paraphyses. L. Brown, aseptate mature conidia. Scale bars: A, B = 20 μm, C–F, H–L = 10 μm, G = 50 μm.
Ascomata pseudothecial, brown to black, uni- or multiloculate, separate, immersed, ostiolate, up to 500 μm diam, wall composed of several layers of dark brown textura angularis. Pseudoparaphyses hyaline, 4–6 μm wide, multiseptate, with septa 11–19 (–26) μm apart, constricted at septa. Ascii bitunicate, 8-spored, ascospores biseriate in the ascus, stipitate, thick-walled with thick endotunica and well-developed apical chamber, 180–230 × 26 (5–6) μm apart, constricted at septa.

Characterised by having conidia formed from smooth, hyaline conidiogenous cells that lack periclinal thickenings and percurrent proliferations. The hyaline, subcylindrical to fusiform conidia have irregular mucoid appendages.

**Holotype** Germany, on *Viscum album*, Albertini & Schweinitz, holotype not found and presumably lost. Ukraine, National Nature Park 'Syvatie Gory', on branches of *Viscum album*, 10 Mar. 2007, A. Akulov, neotype here designated CWU (MYC) AS 2271 (MBT176099).

**Cultures** CBS 122526, CBS 122527 (ex-neotype).

**Host** *Viscum album* (Sutton 1980, Phillips et al. 2008).

**Known distribution**: Austria, Czechoslovakia, Egypt, Romania (Sutton 1980), Ukraine (Phillips et al. 2008).

**Notes**: *Sphaeropsis* was introduced by Saccardo (1880) for *Diplodia* species with brown, aseptate conidia. He designated *S. visci*, based on *Sphaeria atrovirens* var. *visci*, as the type species. The connection between the asexual and sexual morphs was established by Phillips et al. (2008). Single ascospore isolations from a botryosphaeria-like ascomycete on CWU (MYC) AS 2271 resulted in cultures of a coelomycete indistinguishable from *S. visci*, thus proving the connection between the two states. This specimen is herein designated as neotype. Features that distinguish the sexual morph from others with brown ascospores in the *Botryosphaeriaceae* are the aseptate ascospores with an apiculus at either end.

**Tiarospora** Hohn, Ber. Deutsch. Bot. Ges. 37: 159. 1919. MycoBank MB10233.

**Type species**: *Tiarospora paludosa* (Sacc. & Fiori ex P. Syd.) Hohn., in: Weese, Mitt. bot. Inst. tech. Hochsch. Wien 1(3): 83. 1924.

**Aerial mycelium** composed of hyaline to light brown, septate, branched, smooth, encrusted, thin-walled hyphae and strands of coarse, thick-walled, dark brown, smooth or verrucose hyphae, 6–12 μm wide and consisting of cylindrical cells, 12–45 μm long which sometimes round off to form chains of goblets, 1-celled, thick-walled, dark brown, chlamydospore-like cells. Pycnidia begin to develop after 7 d, embedded in the surface of the agar, single or in small groups, dark brown to black, rostrate and the elongate necks are covered with grey-olivaceous to brown, simple, septate, smooth or verrucose, straight or flexuous pycnidial hairs with obtuse ends. Conidiogenous cells formed from the cells lining the inner walls of the pycnidia, holoblastic, determinate, simple, cylindrical and slightly tapered towards the apex, hyaline, 12–18 × 1.5–2.5 μm. Conidia acrogenous, solitary, hyaline, smooth, thin-walled, straight, fusiform with truncate base and obtuse apex, 21–28 × 5–8 μm. During development, conidia are enclosed in a gelatinous sheath that may remain as an apical, hyaline, cone-like appendage.

**Type** *South Africa*, Cape Province, Colesberg, on *Eriocephali* sp., 16 Feb. 1971, W.F.O. Marasas, holotype IMI 186782. MycoBank MB353200. For illustrations see Sutton & Marasas (1976).

**Cultures** IMI 186783 = CBS 118718.

**Hosts**: *Eriocephalus* sp., *Nestlera* sp., *Tribulus terrestris* (Sutton & Marasas 1976)

**Known distribution**: South Africa (Sutton & Marasas 1976)

**Notes**: Conidia of *T. graminis* var. *graminis* resemble those of *T. graminis* var. *karroo* in shape, though they are somewhat larger (20–29.5 × 7–9 μm), than those of *T. graminis* var. *karroo* (21–28 × 5–8 μm) (Sutton & Marasas 1976).
very coarse, thick-walled, dark brown to black, verrucose hypheae 7.5–16.5 μm wide and consisting of chains of intercalary, globose, thick-walled, smooth or verruculose chlamydospore-like cells, 8–14 μm diam. Immersed mycelium dark brown to black. Pycnidia begin to develop after 7 d and numerous mature pycnidia are present throughout the Petri dish after 14 d, particularly on PDA, semi-immersed in the surface of the agar, single or 2–15 aggregated in large, pulvinate, botryose, stromatioid groups up to 3 mm diam, dark brown to black, globose, rostrate, unilocular or multilocular, up to 200 μm diam, walls thick, composed of large, thick-walled, dark brown pseudoparenchymatous cells that become paler and thin-walled towards the inner conidiogenous region, ostiole circular, up to 65 μm diam, formed at the apex of an apical beak that is up to 400 μm long and covered with hyaline to light brown, simple, septate, straight or flexuous, smooth or verruculose pycnidial hairs with obtuse ends. Conidiogenous cells formed from the cells lining the inner wall of the pycnidia, holoblastic, determinate, simple, hyaline, cylindrical, 9–14 × 4–5 μm. Conidia acrogenous, solitary, hyaline, smooth, thin-walled, eguttulate, straight, oval to fusiform, apex obtuse, base truncate, 29–38 × 12–17 μm. During development some conidia are enclosed in a gelatinous sheath that later becomes everted into an apical, irregularly infundibuliform appendage up to 23 μm long and 29 μm wide.

**Type:** South Africa. Orange Free State, Heilbron, dried culture isolated from dead stems of *Triticum aestivum*, 18 Jan. 1973, W.F.O. Marasas, *holotype* PREM 44966.

**Cultures:** IMI 186786 = CBS 118719 (ex-type).

**Host:** *Triticum aestivum* (Sutton & Marasas 1976)

**Known distribution:** Free State Province, South Africa (Sutton & Marasas 1976).

**Notes:** Conidia of *T. tritici* are much larger than those of all other known species of *Tiarosporella* and the shape of the appendage is also different. Of the 14 species of *Tiarosporella* that have been named to date, DNA sequence data are only available for *T. graminis*, *T. madereya*, *T. tritici* and *T. urbis-rosarum* (Crous et al. 2006, Jami et al. 2012).

**Tiarosporella urbis-rosarum** Jami, Gryzenh., Slippers & M.J. Wingf., Cryptogam. Mycol. 33: 256. 2012. For illustrations see Jami et al. (2012).

Conidiomata (on sterile twigs of *Acacia karroo*) pycnidial, dark black, up to 200 μm diam, immersed, unilocular, with long necks (4–9 mm); wall of 5–7 layers of dark brown textura angularis, becoming thin-walled towards inner region. Conidiogenous cells holoblastic, hyaline, cylindrical, (5–)5.5–9.5(–11) × (3–)3.5–4(–5) μm. Conidia ovoid, smooth, granular, thin-walled, aseptate, apices rounded, (21–)23.5–29.5(–34) × (8–)9–10(–11) μm (from Jami et al. 2012).

**Culture characteristics:** Colonies on MEA appressed, centres dirty white, becoming dark grey at the edges; reverse dark grey to black. Growth at 5–35 °C, with optimal growth rate of 14.4 mm / d at 25 °C.

**Type:** South Africa. Free State Province, Bloemfontein, on healthy wood of *Acacia karroo*, Jun. 2008, M. Gryzenhout, *holotype* PREM 60698.

**Cultures:** CMW 36477 = CBS 130405 (ex-type).

**Host:** *Acacia karroo*.

**Known distribution:** Free State and Gauteng Provinces of South Africa.

**Note:** *Tiarosporella urbis-rosarum* is morphologically similar to *T. tritici* (conidia 29–38 × 12–17 μm), but has smaller conidia (23.5–29.5 × 9–10 μm).

**DISCUSSION**

In this paper we considered only those genera and species of the *Botryosphaeriaceae* that are known to exist in culture, and thus accept 17 genera in the family. These genera are characterised based on 17 lineages in a multi-locus phylogeny. In a recent phylogenetic study of the *Botryosphaeriaceae*, Liu et al. (2012) included *Auerswaldia* in the *Botryosphaeriaceae* based on fresh collections of *A. lignicola* and *A. dothiorella*. However, they did not include ITS sequence data in their analyses because they claimed that it was not suitable to segregate taxa at the generic and species level. In our analyses, *A. lignicola* clustered within *Lasiodiplodia* and *A. dothiorella* in *Dothiorella*. For this reason, we argue that there is no evidence to suggest that *Auerswaldia* should be regarded as a distinct genus in the *Botryosphaeriaceae*. Indeed, Liu et al. (2012) state that depending on the method used to generate the phylogeny, *A. lignicola* clustered in the *Diplodia* / *Lasiodiplodia* clade in the RAxML analysis, but in *Dothiorella* when Maximum Parsimony was used. Furthermore, in the combined EF1-α and β-tubulin analysis, this species always clustered in *Dothiorella* irrespective of the phylogenetic method used. In the present paper we found that a combination of SSU, ITS, LSU, EF1-α and β-tubulin gave a clear separation of the genera and this was consistent between the different phylogenetic methods (MP, ML). This is also consistent with a previous multi-locus phylogeny (Phillips et al. 2008) of a smaller sub-set of the family.

Most of the genera revealed by the multi-locus phylogeny in this study can be distinguished based on their morphology. This is especially true for characteristics of the conidia and to a lesser extent on the presence or absence of paraphyses in the conidiomata. However, some genera cannot be separated using morphological characters. For example, conidia of *Botryosphaeria* are indistinguishable from those of *Neofusicoccum* when the range of variation for each genus is taken into consideration. Although there is some evidence that pycnidial paraphyses are found only in *Botryosphaeria*, this has not been confirmed for all the species. Nevertheless, paraphyses have never been reported in any *Neofusicoccum* species.

Another difficult pair of genera to distinguish is *Spencermartinsia* and *Dothiorella*. The conidial characters of species in both of these genera are identical, being pigmented and 1-septate. In both genera, the conidia become pigmented and septate even while they are attached to conidiogenous cells, and this character distinguishes them from *Diplodia*. Phillips et al. (2008) introduced *Spencermartinsia* for species similar to *Dothiorella* but differed in the presence of an apiculus on the ascospores, which is absent
from Spencermartinsia species. Although this is a small difference, it is supported by phylogenetic data and is also a useful character to separate Barriopsis (no apiculus) from Phaeobotryosphaeria (apiculus present). However, the status of these two genera needs to be re-evaluated in the light of the multi-locus analysis presented here and by Slippers et al. (2013, this volume), in which the phylogenetic distinction is unclear.

Although ITS alone was usually sufficient to separate species within each genus of the Botryosphaeriaceae, inclusion of EF1-α resulted in a more robust separation, and was considered essential in some genera such as Diplodia, Lasiodiplodia and Neofusicoccum. We therefore recommend at least these two loci for species separation within the Botryosphaeriaceae. With the increase in the number of species recognised in phylogenetic studies, the use of morphological data for species identification is becoming less useful. Although we have provided keys for species identification in each genus, the resulting identification should be interpreted with caution. For example, in Neofusicoccum the range of variation within a species is becoming more apparent as additional isolates are studied and often the variation overlaps considerably with other species. Furthermore, phylogenetic inference is revealing cryptic species complexes that cannot be distinguished based on morphology alone (see for example Pavlic et al. 2009a, b, Sakalis et al. 2011). In this regard, in addition to ITS and EF1-α sequence data, data from the β-tubulin, RPB2 and other loci have been useful, and were at times necessary to provide convincing evidence of multigene phylogenetic concordance to separate cryptic species (see also Sakalis et al. 2012).

Recognising the isolate identified by Liu et al. (2012) as A. liginicola in fact a species in Lasiodiplodia has helped to resolve a long-standing problem regarding the connection between the asexual and the sexual morphs in Lasiodiplodia. As explained in the notes for L. theobromae, the connection between the asexual and sexual morphs of L. theobromae has not been definitively confirmed, and thus the characteristics of the sexual morph are also not clear. Liu et al. (2012) clearly demonstrate the asexual / sexual morph connection for L. liginicola and confirmed that mature ascospores are dark brown. This has also recently been observed for other species of Lasiodiplodia (Crous, unpubl. data). For this reason, we have amended the description of Lasiodiplodia to include brown ascospores. In recent studies, several new species have been introduced in Lasiodiplodia, and frequently these species are recognised based on minor differences in ITS sequences with great emphasis placed on EF1-α sequence data (Abdollahzadeh et al. 2010). It would seem that this genus should be the subject of a more detailed analysis based on additional gene loci to provide a robust phylogenetic basis for species definitions.

In each genus of the Botryosphaeriaceae the species share a common general morphology, which complies to a great extent with the definition of a genus (Singer 1975, Booth 1978, Crous et al. 2009). However, in Diplodia, several different morphologies are seen and these lie within separate phylogenetic lineages. The typical morphology, as seen in D. mutila and related species, consists of hyaline, aseptate, thick-walled conidia that become dark brown and 1-septate. Another major group, which includes D. seriata, D. pinea and their relatives, has conidia that turn brown at an early stage of development and remain aseptate. These two morphological groups cluster in two well-supported clades. This would give the impression that Diplodia consists of two separate genera. However, D. corticola and D. queroviora have the characteristics typical of the D. mutila group, but form a clade near the root of the Diplodia phylogenetic tree. Furthermore, D. cupressi and D. tsugae with conidia indistinguishable from D. mutila, cluster with D. bulgarica (pale brown, aseptate conidia) in another clade that lies between the D. mutila and D. seriata clades. Thus, for the present, we have chosen to consider Diplodia as a genus with two morphologies rather than to provide separate genera or sections for them.

Following the recent changes to the nomenclature of pleomorphic fungi, and in particular the abolition of dual nomenclature for a single fungus, we have introduced some new combinations. With regard to Botryosphaeria / Fusicoccum, the oldest genus is Fusicoccum Corda (1829), not Botryosphaeria Ces. & De Not. (1863). However, Botryosphaeria is the type genus of Botryosphaeriaceae and Botryosphaeriales, and is well entrenched in the user community. For these reasons we have retained Botryosphaeria and have made several recombinations of Fusicoccum species.

Phillips et al. (2008) reinstated Phaeobotryosphaeria for species with dark brown, aseptate ascospores that have a hyaline apiculus at either end, and asexual morphs in Sphaeropsis. In the present paper we decided to revert to using the generic name Sphaeropsis for these species. Sphaeropsis Sacc. (1880) is an older name than Phaeobotryosphaeria Spec. (1908), and is also better established with the plant pathological community. Although Sphaeropsis has been applied incorrectly in the past, we believe that the confusion has now been resolved and the genus is clearly circumscribed.

Ever since Crous et al. (2006) sub-divided Botryosphaeria the position of B. mamane has been uncertain, apparently residing outside of Botryosphaeria. Furthermore, conidia of B. mamane are considerably larger than those of any other species in Botryosphaeria. In our ITS phylogenies the ex-type cultures of B. mamane formed a clade within Cophiniforma confirming that this is a suitable genus for it.

The present study provides the first phylogenetic overview and morphological synthesis of the species of Botryosphaeriaceae that are presently known from culture. We trust that this will provide a stable platform to accommodate the numerous undescribed species that still await description, or re-collection and epitypification to ensure a stable genetic application of names in the family.

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